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CANADA

DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

MEMOIR 67

No. 49, GEOLOGICAL SERIES

The Yukon-Alaska International Boundary, between Porcupine and Yukon Rivers

BY

D. D. Cairnes

OTTAWA
GOVERNMENT PRINTING BUREAU
1914

No. 1461

Frontispiece. PLATE I.

PLATE I.

New Rampart House, Yukon Territory. This is an important trading post situated on the north bank of Porcupine river, just east of the 141st meridian.

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The Yukon-Alaska International Boundary, between Porcupine and Yukon Rivers.

CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT.

For a number of years geological workers both in Alaska and Yukon have realized the desirability of having an international investigation made of the geological formations along the 141st meridian, particularly to the north of Yukon river. This was especially required since no geological work had been performed in the vicinity of the Boundary line, either in Alaska or Yukon, between Yukon river and the Arctic ocean, except in the immediate vicinity of Yukon and Porcupine rivers, and along the Arctic coast. Such an investigation along the 141st meridian would not only help very materially in correlating the geology of Alaska with that of Yukon, British Columbia, and the North West Territories, but, in addition, would give a northern geological section through the great western Cordillera of the continent. This would thus constitute a valuable addition to our geological knowledge as no detailed geological section had been made through any considerable portion of the Cordillera north of the main line of the Canadian Pacific railway. Accordingly the Geological Surveys of the United States and Canada undertook the northern portion of this work, agreeing to map and study the geology along the 141st meridian between Yukon river and the Arctic ocean, a distance of about 340 miles.

There were two main reasons for first undertaking the northern rather than the southern part of this work; in the first place, less was known concerning the geological formations to the north than to the south of Yukon river, and secondly a number of International Boundary Survey parties were to be engaged along the 141st meridian north of Yukon river during the summers of 1911 and 1912, and it was possible for geological workers to co-operate with the Boundary surveyors in the matter of transportation which is a very important item in connexion with such work. The geological work could thus be performed to the north of Yukon river during these seasons at considerably less expense and with much greater convenience, possibly, than for many years to come.

The work to the north of Porcupine river was undertaken by the United States Geological Survey, and that to the south of the Porcupine by the Canadian Geological Survey, each department to be responsible for the geology on both sides of the boundary line. A commencement was made in the spring of 1911 and the undertaking was completed during the past summer (1912), Mr. A. G. Maddren[1] and the writer[2] having had charge of the portions of this work performed respectively by the United States and Canadian governments.

During both seasons, the writer and the different members of his party, accompanied the Boundary Survey parties to the field, and in this way, special travelling facilities were obtained. During 1911 also, the writer with an assistant was attached throughout the season to one of the Canadian line-cutting parties. In 1912, however, after reaching the field the writer outfitted and worked independently of the International Boundary Survey.

Topographic sheets were furnished by the International

[1]Maddren, A. G., "Geologic investigations along Canada-Alaska Boundary": U.S. Geol. Surv., Bull. 520K, 1912.

[2]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. 17-33.

"Geology of a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers": Geol. Surv., Can., Sum. Rept. for 1912, pp. 9-11.

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

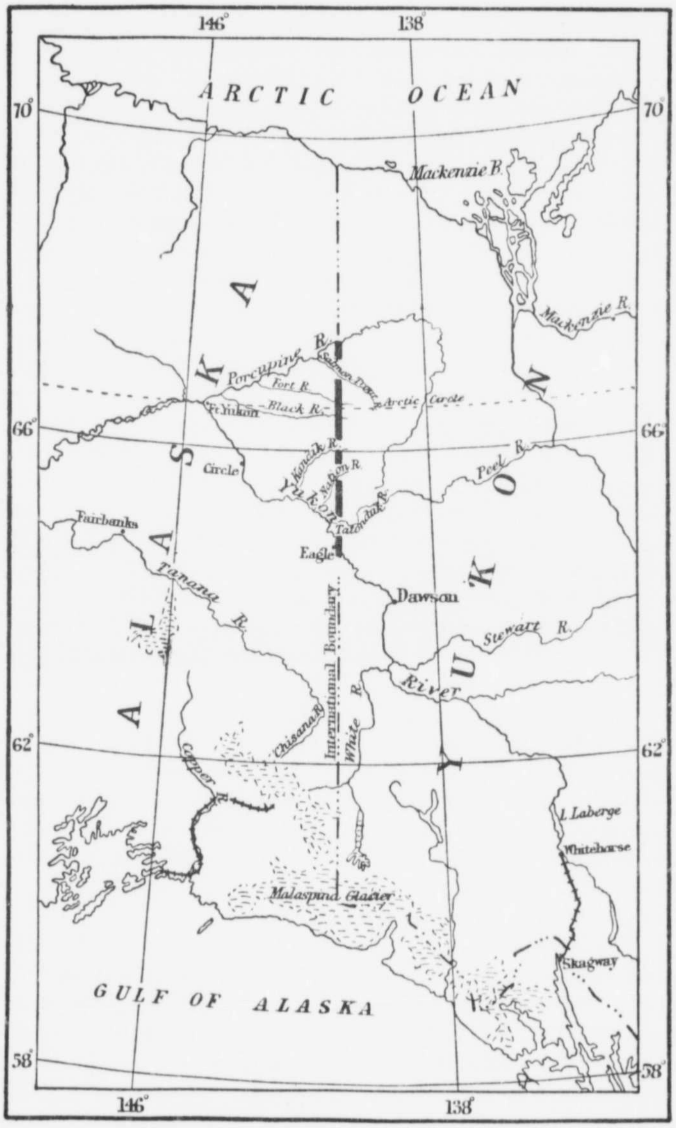

Figure 1. Index map showing position of map-area.

Boundary Surveys, which greatly facilitated the geological work. The topography had been mapped for a distance of 2 or 3 miles or more on each side of the Boundary line; and the geological mapping and investigations south of Porcupine river were restricted, almost entirely, to this belt which has an average width of at least 5 miles. The topographic mapping was performed by the plane-table method, and was plotted in the field to the scale of 1:45,000 and is to be published to the scale of 1:62,500 or about one mile to the inch, with a contour interval of 100 feet. The sheets furnished for geological purposes were partly on the field scale and partly on the scale of publication.

The writer desires to express his indebtedness to the various members of the International Boundary Survey with whom he came in contact, all of whom were most courteous and obliging. Particular thanks are due Messrs. J. D. Craig, D.L.S., and Thos. Riggs, Jr., who had charge respectively of the Canadian and United States parties during 1911 and 1912. These gentlemen rendered numerous favours to the different members of the writer's party and to himself, during both summers, and facilitated the geological work in every way in their power.

During the summer of 1911, the geology along the Boundary line south of Porcupine river, was mapped from Orange creek at latitude 66°10′ north to latitude 67°00′, a distance of about 58 miles. In 1912, the writer commenced work at Porcupine river at latitude 67°25′, and worked south, a distance of 28·8 miles, to latitude 67°00′ where mapping had been discontinued at the close of the previous season. Camp was then moved southward to Orange creek, traversing longitudinally in so doing, the entire belt worked during 1911. Geological work was then resumed and continued to Yukon river, a distance of 104 miles from Orange creek.

Due to the short summer season at this northern latitude, and owing also to the fact that so much time was necessarily consumed each year in travelling to the area to be investigated and returning therefrom, only about 65 days in 1911 and 80 days in 1912 were spent actually in the field of work, and these included a number of days during which climatic conditions rendered impossible any kind of geological field work. During 1911, the field season was also somewhat curtailed due to a severe and widespread outbreak of smallpox among the Porcupine River Indians. This greatly hampered the movements of the International Boundary Survey parties, and due to certain necessary quarantine regulations and owing also to the uncertain availability of further supplies, an early cessation of the work of the party to which the writer's assistant and himself were attached, was rendered necessary.

Further, even during these short seasons, quite a number of large streams had to be crossed, which are subject to sudden high floods during the summer, and delays were thus liable to occur at different points, as during high water it is impossible to ford these streams. Advantage, therefore, had to be taken of every opportunity to cross the streams during a low stage of water even at the sacrifice of the geology, as a prolonged enforced wait at different points would have been disastrous to the party, due to lack of provisions and horse feed. Supplies were packed along the Boundary line from Porcupine river as far south as possible. Thence the writer had to depend for provisions and oats on polers who were able with great difficulty to get up certain of the larger tributaries of Yukon and Porcupine rivers which cross the Boundary line. Unexpected delays or accidents to the polers working on these cold, rapid, somewhat treacherous streams would have proved very serious to the geological party.

The geological work was, therefore, all necessarily performed with rapidity, and often under very adverse conditions, it being unsafe to delay long at any particular point. Thus, no matter how interesting, instructive, or obscure the phenomena at any certain locality might prove to be, only a limited amount of time was available for their investigation. Further, it was useless to make large collections of fossils or other geological or natural history specimens, as no means were available for transporting them out of the district. In fact, in most places, it was only possible to carry the absolute essentials of equipment and supplies. In 1910, some of the Boundary Survey parties lost a considerable number of their horses, and those which finally reached Yukon river were too weak to carry even their saddles. Thus practically everything was discarded in the field but note books and instruments. Most of the clothing and bedding even were left, the men being thankful in most cases to reach the Yukon on foot and empty-handed.

The geological work performed by the writer, along the 141st meridian south of Porcupine river, is thus strictly that of the pioneer, and leaves much in the way of detail to be desired. Many interesting problems remain unsolved which might have become understood had more time in the field been available; and doubtless points of considerable significance were unnoticed by the geological workers which under more favourable circumstances would have been observed. Nevertheless, although in some cases detailed studies were not possible, the broader geological units and their relationships were carefully investigated throughout the belt and a great amount of valuable information concerning these terranes has been obtained.

The writer was assisted during 1911 by Mr. M. Y. Williams of this Department, and during 1912 by Messrs F. J. Barlow, S. E. Slipper, and W. S. McCann, all of whom discharged the duties assigned them in a highly satisfactory and capable manner.

MEANS OF COMMUNICATION.

The portion of the Yukon-Alaska International Boundary line here under consideration, is accessible either from Yukon river at the southern end, or from Porcupine river at the northern extremity. In addition, it is possible to reach this portion of the International Boundary at a number of intermediate points by following up certain of the larger westerly flowing tributaries of Yukon and Porcupine rivers, which are crossed by the Boundary line. These streams include Black, Kandik[1], Nation, and Tatonduk[2] rivers.

During the summer months large, commodious steamers ply regularly up and down Yukon river and its main tributary

[1]Known locally as Charlie creek.
[2]" " " Sheep creek.

the Lewes, between the mouth of the Yukon on Bering sea and Whitehorse at the head of navigation on the Lewes, a distance of about 2,060 miles measured along the river. There is no regular steamboat traffic on Porcupine river, but during 1910, 1911, and 1912, steamers were engaged to take the members of Survey parties, their horses, equipment, and supplies upstream from Fort Yukon at the mouth of the Porcupine, and to return for the parties again in the autumn.

The first power boat to go up the Porcupine was a small gasoline launch which went as far as New Rampart House with a small advance reconnaissance International Boundary Survey party in 1909. In 1910, the first steamer to go up this river was taken up on behalf of the Boundary Surveys. It was found that the smaller type of Yukon River steamboat, under exceptionally high, favourable stages of water, can get up the Porcupine as far at least as New Rampart House which is situated on the north bank of the river only a few yards east of the Boundary line (Frontispiece).

The period of highest water on the river and the most favourable time to go up this stream is generally between May 24 and June 10, immediately after the last ice comes down the river. A lesser rise generally occurs about August 20 and another is expected in September. In the spring of 1912, the steamer Tanana was chartered so as to be at Fort Yukon by the time the last ice had come down the Porcupine. Taking advantage of the temporary high water immediately after the break-up, the steamer started up Porcupine river with a scow on May 25 and was very fortunate in reaching New Rampart House in about 56 hours without mishap, having aboard the members of the different United States and Canadian International Boundary and Geological Survey parties, about 85 men in all, as well as their supplies, equipment, and 160 horses. Within 8 or 10 days, the water had fallen 6 or 7 feet, making it impossible for the same steamer to have then come upstream past Camp Tittman, 65 miles below New Rampart House.

On the larger tributaries of the Yukon and Porcupine which cross the 141st meridian, an attempt was made to use specially designed gasoline launches, but it was found that these could be employed to advantage only on Black river and even on this stream were used only a short distance upstream from the Porcupine. Thence to the Boundary on the Black, and on the other larger tributaries including Kandik, Nation, and Tatonduk rivers, poling boats were employed to transport supplies to the Boundary line.

To reach Whitehorse, at the head of navigation on the Lewes, the main tributary of Yukon river, it is customary to go by steamer from Vancouver or Seattle to Skagway, distances respectively of about 870 and 1,000 miles. Thence, the White Pass and Yukon railway proceeds over the White pass to Whitehorse, a distance from Skagway of 110 miles. Steamers also ply during the summer months from Seattle, by the outside, open-sea route to Nome and St. Michael which are situated near the mouth of the Yukon about 2,310 and 2,360 miles respectively from Seattle. Stages make regular trips between Whitehorse and Dawson during the winter, but otherwise there is relatively little travel along the Yukon except during the season of open navigation on the river.

PREVIOUS WORK.

Previous to the summer of 1911 when the work described in this memoir was commenced, no geological work had been performed along the 141st meridian between the Porcupine and the Yukon except in the immediate vicinity of these rivers. McConnell came down Porcupine river in 1888 making a geological reconnaissance en route,[1] and Kindle made a geological examination of the rock formations along the Porcupine below New Rampart House for the United States Geological Survey during the summer of 1907[2]. In addition a number of geol-

[1]McConnell, R. G., "Report on an exploration in the Yukon and Mackenzie basins, N.W.T.": Geol. and Nat. Hist. Surv. of Can., Ann. Rept., Vol. IV, 1888-89, Part D, pp. 129-134.

[2]Kindle, E. M., "Geologic reconnaissance of the Porcupine valley, Alaska": Bull., Geol. Soc. Amer., Vol. XIX, 1908, pp. 310-338.

ogists including McConnell[1], Spurr[2], Prindle[3], Brooks, and Kindle[4], and others have reported on the geological formations along Yukon river in the vicinity of the International Boundary. With the exception, thus, of this work along Yukon and Porcupine rivers, practically nothing was known geologically concerning the belt, nearly 200 miles in length, in which the writer was engaged during the summers of 1911 and 1912.

CLIMATE.

The climate throughout this belt between Yukon and Porcupine rivers, has quite an appreciable range from north to south, a distance of practically 200 miles. To the south, the temperature, precipitation, and other climatic conditions, are practically the same as at Dawson, but on Porcupine river, which is about 60 miles north of the Arctic circle, Arctic conditions are to be expected.

The precipitation throughout the area varies greatly in different years. During the summer of 1911, from June 1 to September 15, only a few showers occurred and these were generally light and seldom of more than 3 or 4 hours duration. In fact, the weather conditions were almost ideal. In 1912, from June until September, the precipitation was exceptionally heavy, the climate much resembling what might be expected along the northern Pacific coast. Rain or snow fell during more than half of the days, and frequently continued almost incessantly for several days at a time.

The most striking characteristic of this district, however, in common with all Arctic regions, is the varying length of the

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[1]Op. cit., pp. 134D-143D.

[2]Spurr, J. E., "Geology of the Yukon Gold district, Alaska": U.S. Geol. Surv., 18th. Ann. Rept., Part III, 1896-97, pp. 89-392.

[3]Prindle, L. M., "The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska": U.S. Geol. Surv., Bull. No. 251, 1905.

"A geologic reconnaissance of the Fairbanks quadrangle, Alaska": U.S. Geol. Surv., Bull. 525, 1913.

[4]Brooks, Alfred H., and Kindle, E. M., "Palæozoic and associated rocks of the Upper Yukon, Alaska": Bull. Geol. Soc. Amer., Vol. XIX, 1908, pp. 255-314.

day. During the months of May, June, and July, there is almost continuous daylight, and throughout the corresponding winter months, the sun is very little seen. During the intervening seasons, consequently, the length of the day varies rapidly. For four months of each year, warm, summer weather is generally experienced, and this season is particularly delightful owing to the extreme length of the days. The winters, however, as is to be expected, are rather severe.

The rivers and creeks in the different portions of this belt generally open between the 1st and 20th of May, but on some of the lakes, the ice remains until the first or second week in June. Slack water stretches freeze over any time after October 1, but occasionally the rivers remain open until the end of November.

Any description of the climate of this district, however, seems incomplete without some mention of the mosquitoes and black flies, although these insects are not properly a climatic condition, and should strictly speaking be discussed in the section dealing with "fauna." However, the average traveller to this district during the summer months invariably associates these insects with the climate, the two being seemingly so intimately related. The mosquitoes are the real summer pest of the region. For from two to three months they are exceedingly abundant, the air being seemingly dense with them, and throughout this time they are night and day most active and aggressive. During the latter part of the summer small black flies are often also very troublesome and their bite appears to be much more poisonous than that of the mosquitoes.

FLORA.

Proceeding northward from Yukon river, along the Alaska-Yukon Boundary, the forest growth becomes gradually more sparse, and by the time Porcupine river is reached, timber is much less plentiful, and the average individual forest members are noticeably smaller in size than corresponding specimens in the southern portion of the district. The valley bottoms are in most places fairly well timbered, but nowhere can the forest growth be considered dense in the sense in which it is in British

Columbia, Ontario, or other more southerly and easterly portions of Canada (Plates II, III, VII, IX).

In the vicinity of Yukon river, about one-third of the land-surface is forest clad, but as the Porcupine is approached, this amount becomes reduced to about one-fourth or less, and the timber is noticeably more sparse. Throughout the district, the southern and western slopes are considerably better forested than the northern and eastern hillsides. To the south, timber ceases in most places at an elevation of about 3,000 feet above sea-level, but trees grow in protected draws up to 3,500 feet. In the northern portion of this belt, trees seldom occur at an elevation exceeding 2,000 feet.

Five principal forest members occur that attain the dimensions of trees, and ten species of shrubs were noted. The five main varieties of trees are,[1] white spruce, *Picea canadensis*, aspen poplar, *Populus tremuloides*, balsam poplar, *Populus balsamifera*, northern canoe birch, *Betula resinifera*, and tamarack or American larch, *Larix laricina;* and the more important shrubs include juniper, *Juniperus nana*, dwarf birch, *Betula glandulosa*, "soapollali", *Sherpherdia canadensis*, five species of willow, *Salix*, and two species of alder.

The spruce is the most important of the trees, and constitutes about one-half of the forest growth of the district; specimens having 21-inch stumps were noted in some of the valley bottoms, but the larger individuals range generally only from about 12 to 16 inches, and a tree 18 inches in diameter, 3 feet from the ground, is somewhat exceptional. The two varieties of poplar are very plentiful both in the valley bottoms and on the hill-sides; these have stumps rarely exceeding, and generally less than 10 inches in diameter. Northern canoe birch occurs in occasional small groves both in the valleys and on the mountain sides, but individuals of this species of tree rarely exceed 10 inches in diameter. Larch is of rare occurrence and no specimens were noted north of Bern creek at about latitute 66°25′. Willow,

[1]During the seasons of 1911 and 1912, the writer collected specimens of all the plants, including trees and shrubs, that were noted in this district, and these were delivered to Mr. J. M. Macoun of this Department, from whose report the names here used are taken.

alder, and dwarf birch are very plentiful, reaching everywhere to timber line, and in places constituting quite dense thickets. The dwarf birch extends probably the highest and grows prevailingly near timber line, forming in places a dense growth on the upland surface. Soapollali and juniper are not nearly so plentiful as the other above-mentioned species of shrub.

Eleven principal varieties of wild fruits were noted, some of which grow in great abundance. These are blueberry or bog bilberry, *Vaccinium uliginosum*, alpine bearberry, *Arctostaphylos alpina*, crowberry, *Empetrum nigrum*, bog apple or yellow berry, *Rubus Chamaemorus*, northern comandra, *Comandra livida*, red currant, *Ribes triste*, black currant, *Ribes hudsonianum*, Arctic raspberry, *Rubus arcticus*, "soapollali," *Sherpherdia canadensis*, foxberry or northern cranberry, *Vaccinium Vitis-Idaea*, and high-bush cranberry, *Viburnum pauciflorum*. Of these the blueberry, bog apple, crowberry, northern cranberry, and bearberry, are particularly abundant, and in places extend over entire hillsides and ridge tops. The high-bush cranberries, red and black currants, and raspberries occur only in occasional patches; the comandra and soapollali berries are fairly abundant but are not very palatable.

The following is from Mr. J. M. Macoun's report on the plant specimens collected during 1911:—

"Several species are quite unknown to either my father or myself, and these with a few others about which we are uncertain, have been sent to specialists. Your collection is valuable in the first place as being the only one that has been brought from that region, and even did it contain nothing new either to Canada, or science, it would constitute a valuable addition to our knowledge of the flora of northern Canada. However, there are at least ten species that have not before been collected in Canada, and there are at least five new species of which one will, I believe, constitute a new genus. As I have already told you, the specimens through sometimes few in number are all excellent in quality."

The following is a list of the plants collected during 1911 and 1912,[1] as prepared by Mr. Macoun.

Polypodiaceae

Aspidium fragrans Sw.

Equisetaceae

Equisetum sylvaticum L.
" *pratense* L.
" *fluviatile* L.

Lycopodiaceae

Lycopodium Selago Desv.
" *annotinum* L. var. *pungens* Desv.
" *alpinum* L.
" *clavatum* L.

Pinaceae

Juniperus nana Willd.
Picea canadensis (Mill.) BSP.
Larix laricina (Du Roi) Koch.

Gramineae

Hierochloa alpina R. and S.
Poa crocata Rydb.
Agropyrum violaceum Lange.
Bromus Pumpellianus Scribn.
Arctogrostis latifolia Griseb.
Calamagrostis Langsdorfii Trin.
" *purpurascens* R. Br.
Festuca saximontana Rydb.
" *altaica* Trin.
" *rubra* L.
Trisetum spicatum (L.) Richter.

Cyperaceae

Eriophorum vaginatum L.
Carex microchæta Holm.
" *rigida* Good. ?
" *rariflora* Smith.
" *scopulorum* L.

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[1]For further details concerning these plants specimens see:—
Cairnes, D. D., Geol. Surv., Can., Sum. Rept. for 1911, pp. 21-26.
Macoun, J. M., Geol. Surv., Can., Sum. Rept., for 1912, pp. 438-40.

Juncaceae

Luzula glabrata Hoppe.

Liliaceae

Zygadenus elegans Pursh.
Lloydia serotina (L.) Sweet.

Orchidaceae

Cypripedium guttatum Sw.
Cypripedium pubescens Willd.
Not before recorded in the north, west of the Rocky mountains.

Salicaceae

Populus tremuloides Mx.
" *balsamifera*, L.
Salix anglorum Cham.
" *orbicularis* Andr.
" *phyllicifolia* Andr.
" *Richardsoni* Hook.
" *Seemanii* Rydb.

Betulaceae

Betula glandulosa Mx.
" *resinifera* (Regel.) Britton.
Alnus tenuifolia Nutt.
" *sinuata* (Regel.) Rydb.

Polygonaceae

Polygonum alpinum var. *alaskanum* Small.
" *plumosum* Small.

Santalaceae

Comandra livida Rich.

Caryophyllaceae

Silene acaulis L.
" *repens* Patrin.
Stellaria longipes Goldie var. *laeta* T. and G.
New to the region.
Stellaria longipes var. *Edwardsii* T. and G.
Arenaria lateriflora L.
" *arctica* Stev.
Merckia physodes Fisch.

Ranunculaceae

Anemone Richardsoni Hook.
" *parviflora* Michx.
" *narcissiflora* L.
Pulsatilla Cairnesiana (Greene) J. M.Macoun.
" *patens* L., var. *Wolfgangiana* (Bess.) Koch.
Ranunculus lapponicus L.
" *nivalis* L.
" *Eschscholtzii* Schlecht.
" *affinis* R. Br.
Aquilegia brevistyla Hook.
Delphinium glaucum S. Wats.
Aconitum delphinifolium DC.

Fumariaceae

Corydalis sempervirens (L.) Pers.

Papaveraceae

Papaver radicatum Rottb.

Cruciferae

Cardamine purpurea Ch. and Sch.
" *digitata* Rich.
Known only from Bear lake and Herschel island.
Parrya macrocarpa R. Br.
Lesquerella arctica (Rich.) Watson.
Melandion boreale Greene.

Perfect specimens were collected at lat. 67°N., 42 miles north of the locality at which the type of this genus was collected by Dr. Cairnes in 1911.

Crassulaceae.

Sedum Rhodiola DC.

Saxifragaceae

Saxifraga tricuspidata Retz.
" *flagellaris* Willd.
New to the region.
Saxifraga Nelsoniana Don.
Theophron Richardsoni (Hook.) Wheelock.
Parnassia palustris L.
Ribes triste Pall.
" *hudsonianum* Rich.

Rosaceae

Spiraea betulifolia Pallas.
Potentilla nivea L.
" *fruticosa* L.
Rubus Chamaemorus L.
" *arcticus* L.
" *stellatus* Smith.
Dryas integrifolia Ch. and Sch.
Sieversia glacialis R. Br.
Rosa acicularis Lindl.

Leguminoseae

Lupinus Yukonensis Greene.
Oxytropis podocarpa Gray.
Hedysarum boreale Nutt.

Empetraceae

Empetrum nigrum L.

Violaceae

Viola palustris L.

Elaeagnaceae

Shepherdia canadensis Nutt.

Onagraceae

Epilobium angustifolium (L.) Scop.
" *latifolium* L.

Cornaceae

Cornus canadensis L.

Ericaceae

Ledum palustre L.
Rhododendron lapponicum Wahl.
Loiseleuria procumbens Desv.
Andromeda Polifolia L.
Cassiope Mertensiana (Bong.) Don.
Arctostaphylos alpina Spreng.
Vaccinium uliginosum L.
" *Vitis-Idaea* L.

Diapensaceae

Diapensia lapponica L.

Gentianaceae

Gentiana glauca Pall.
" *arctophila* Griseb.
" *prostrata* Haenke.
" *frigida* Haenke.

All three of the above gentians are additions to the known flora of the region. *G. prostrata* has only been recorded once before from the Alaska Boundary, and *G. frigida* not at all from the interior of Yukon region.

Polemoniaceae.

Phlox sibirica L.

Borraginaceae

Mertensia alaskana Britton.
Myosotis sylvatica Hoffm. var. *alpestris* Koch.
Eritrichium nanum Schrad, var. *Chamissonis* DC.

Selaginaceae

Gynandra Stelleri Ch. and Sch.

Scrophulariaceae

Castilleja pallida Kunth, var. *septentrionalis* Gray.
Pedicularis flammea L.
" *capitata* Adans.
" *Langsdorfii* Fisch, var. *lanata* Gray.
" *sudetica* Willd.

Lentibulariaceae

Pinguicula villosa L.

Orabanchaceae

Boschniakia glabrata C. A. Meyer.

Rubiaceae

Galium boreale L.

Caprifoliaceae

Viburnum pauciflorum Pylaie.
Linnaea borealis Gronov. var. *americana* (Forbes) Rehder.

Valerianaceae

Valeriana bracteosa Britton.

Campanulaceae

Campanula lasiocarpa Cham.
" undescribed species.

Compositae

Crepis elegans Hook.
Solidago multiradiata Ait.
Aster sibiricus L.
Erigeron undescribed species.
Antennaria " "
Chrysanthemum integrifolium Rich.
Artemisia undescribed species.
Petasites frigida (L.) Fries.
Arnica angustifolia Vahl.
" *alpina* Olin.
" undescribed species.
Saussurea remotiflora (Hook.) Rydb.

"Five new species from this region have yet to be described, three collected in 1911 and two in 1912. They are an *Artemisia*, an *Arnica*, and an *Antennaria* from the 1911 collection and a *Campanula* and an *Erigeron* collected in 1912."

The characteristic mosses and lichens are:—

Sphagnum acutifolium
" " var. *rubrum*
" " " *versicolor*
" *compactum*
Dicranum fuscescens
" *Bergeri*
Polystichum strictum
Splachnum luteum
Nephroma arctica
Cladonia sylvatica
" *rangiferina*
" *cornuta*

FAUNA.

Big game is plentiful throughout a great part of this belt between Yukon and Porcupine rivers. In fact, were certain localities within this belt only somewhat more accessible and slightly better known, few places on the continent would be more attractive to the sport loving hunter. Moose, caribou, and sheep occur throughout the district and are very numerous in certain localities. The moose are the large giant moose, *Alces gigas*; these magnificant animals are very plentiful particularly to the south of Black river, one or more individuals being seen practically every day by some member of the party, while working in this southern portion of the district. One large bull which was shot by the writer just north of Bern creek, and which was far from being a record animal for the district, had a spread of antlers of just 60 inches and was estimated to weigh at least 1,500 pounds live weight. The caribou are of two varieties, the Barren Lands caribou and the giant or Osborn's caribou, *Rangifer osborni*. The giant caribou were frequently seen either one or two at a time or in small herds of 20 or 30 individuals. They were particularly numerous between Ettrain creek and Tatonduk river i.e. south latitude 65°25′, and when seen are generally quite easy to procure, as their curiosity is greater than their fear. They will even occasionally follow or watch a man or horse for hours, coming within 50 or 100 yards at times, until finally scent gives them warning. Between Porcupine river and the Arctic ocean, there are also vast herds of Barren Lands caribou which trek to the south of the Porcupine after the "freeze-up" in the autumn. The sheep have been thought to be all Dall's Mountain sheep, the variety common to Yukon and Alaska, and undoubtedly some if not all are of this species; numerous individuals were seen, however, in different places and within distances of 100 yards or less, which appeared to be smaller and lighter in colour than Dall's sheep. The sheep live in the summers on the high limestone mountains and were noted in several places in flocks of 60 or 70 or even more. Black, brown, and grizzly bears are also plentiful throughout the belt and with wolves, wolverine, martin, lynx, ermine, and fox, constitute the chief fur-bearing animals of the district. Rabbits in 1911 and 1912 were also very numerous.

The chief game birds are—rock ptarmigan, *Lagopus rupestris rupestris* (Gmelin); willow ptarmigan, *Lagopus lagopus;* Alaska spruce partridge, *Canachites Canadensis osgoode* (Bishop); Hutchin geese, *Branta Canadensis hutchinsi* (Rich), and several varieties of ducks. The ptarmigan are very plentiful and are to be found on nearly every high hill. The partridge are fairly abundant as are also the ducks and geese in certain seasons.

The rivers are generally well supplied with fish, mainly a variety of grayling, white fish, King salmon, and pike. The smaller streams as a rule, contain only the grayling which, however, are very plentiful in most places.

The writer also collected during 1912 about 160 specimens of butterflies and moths which appeared to include most of the varieties common in the district. These have been examined by Mr. Arthur Gibson, Chief Assistant Entomologist, Dominion Experimental Farm, Ottawa, who has kindly furnished the following preliminary list of identified varieties:—

Colias pelidne
Colias boothi
Argynnis charichea
Argynnis freya
Erebia rossii
Erebia fasciata
Grapto faunus
Chrysophanus helloides
Papilio
Pamphila mandan
Pieris rapoe
Pieris?
Vanessa antiopa
Lycoena?

CHAPTER II.

TOPOGRAPHY.

REGIONAL.

GENERAL FEATURES.

The greater part of Yukon and adjoining portions of Alaska 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).

The belt along the 141st meridian between Yukon and Porcupine rivers, here being considered, lies for the greater part at least, within the northern portion of the Yukon plateau which constitutes the most northerly of the major divisions of the Interior system. This belt also includes, however, a section across the Ogilvie mountains which appear to constitute an outlying portion in the Rocky Mountain system.

ROCKY MOUNTAIN SYSTEM.

The Rocky Mountain system extends northward from the western United States through Canada to near the Arctic, where,

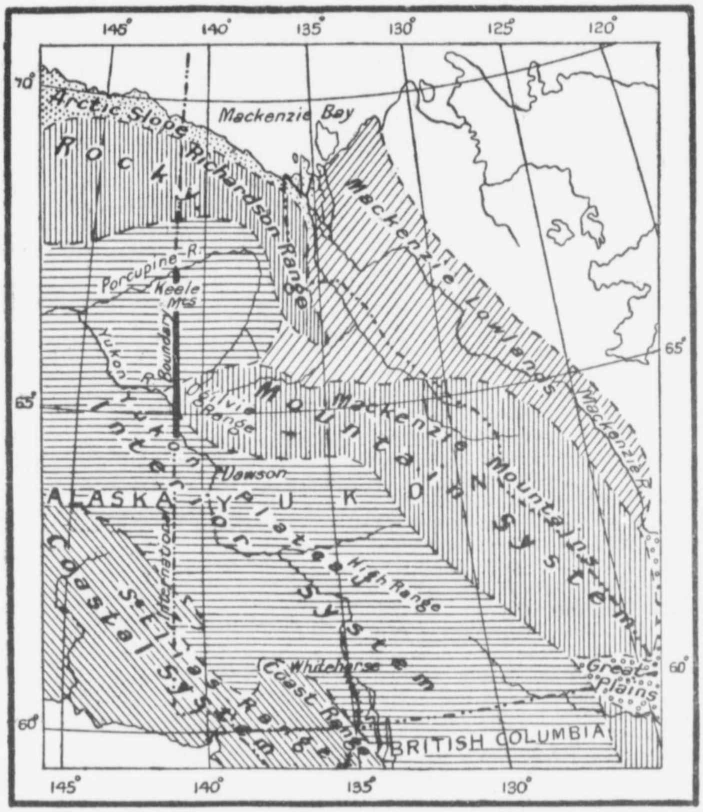

Figure 2. Physiographic provinces of Yukon and adjoining portions of Alaska.

south of Mackenzie bay, it 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 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]

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, have en échelon 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[2] 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. The Ogilvie mountains, which are crossed by the 141st meridian just north of Yukon river, appear to constitute a northwesterly lobe of the Mackenzie mountains.

INTERIOR SYSTEM.

The Interior system in Yukon and Alaska is comprised entirely of the most northerly of its larger divisions, the Yukon

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

[2]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.

plateau.[1] 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 where not too much dissected, and when seen from a summit having an elevation corresponding to that of the general upland, 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 plain, however, bears no relation to rock structure, erosion having bevelled the upturned edges of the hard as well as the soft strata, and its surface is thus entirely discordant to the highly contorted, metamorphic rocks that make up much of the plateau.

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

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[1]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.

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 the pre-Pliocene post-Eocene time, and that the planated tract was uplifted to nearly its present position during late Miocene, Pliocene, or early 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 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.

LOCAL.

GENERAL FEATURES.

The district traversed by the 141st meridian between Yukon and Porcupine rivers, is, for the greater part at least, included within the Yukon Plateau province. This physiographic terrane, as before mentioned, constitutes the most northerly of the major divisions of the great Interior system of mountains and plateaus which trends in a northwesterly direction through central British Columbia and Yukon, and continues westward through the central portion of Alaska to Bering sea. From about latitude 58° in northern British Columbia to Bering sea, the Interior system embraces only the Yukon plateau which in

[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.

Yukon and Alaska thus constitutes the entire Interior system and has a width of from 200 to 400 miles, stretching from the inner members of the Coastal system which fringes the Pacific ocean, to the ranges of the Rocky Mountain system.

The Yukon plateau itself is divided longitudinally into two similar and nearly equal parts by Yukon river which from its headwaters to Bering sea occupies within this terrane a median position. One portion of this plateau province so divided, adjoins the mountains of the Coastal system, and the other reaches from the valley of the Yukon to the Rocky Mountain ranges; and it is within this latter division of the Yukon plateau that the particular area under consideration in this report, for the greater part, at least, is situated. The 141st meridian between Yukon and Porcupine rivers, however, crosses two prominent ranges or groups of mountains, which consist dominantly of white to greyish Devono-Cambrian limestones and dolomites; and the more southerly of these mountain groups appears to constitute an outlying lobe or extension of the Rocky Mountain system to the east.

The more northerly of these mountain groups or ranges has been named by the writer, the "Keele mountains"[1] These mountains, where crossed by the International Boundary line, have a width of about 32 miles, their northern edge being situated about 18 miles south of Porcupine river. About 90 miles south of Keele mountains, another rugged and prominent mountainous belt is encountered which has a width from north to south measured along the 141st meridian of about 35 miles, and constitutes, evidently, a western extension of the Ogilvie range to the east. Since Keele mountains have undoubtedly had the same physiographic history as the surrounding portion of the Yukon plateau, as will be more fully discussed later, they are considered to constitute a portion of this terrane. The Ogilvie mountains, however, are thought to probably constitute an outlying portion or lobe of the Rocky Mountain system to the east.

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[1]Named after Mr. Joseph Keele of the Geological Survey, Canada, who has done a great amount of extremely valuable geological and exploratory work in Yukon and adjoining portions of the North West Territories.

The Yukon plateau has been studied by a number of geological observers, among whom there is a consensus of opinion that this terrane contains ample evidence for the belief that it represents a region that 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 but gently undulating lowland became an upland. This uplift rejuvenated the streams which immediately commenced trenching their valleys in the upland and a new physiographic cycle was inaugurated.[1] There is some difference of opinion as to the exact date of this planation and subsequent uplift, and the belt along the 141st meridian here under consideration affords no evidence on this point, as within it no geological formations of Tertiary age occur. The bulk of the evidence obtainable in other portions of Yukon and Alaska, however, goes to show that the region was planated during pre-Pliocene post-Eocene time, and that this planated tract was uplifted to nearly its present position during late Miocene, Pliocene, or early Pleistocene time.[2]

Along the Yukon-Alaska Boundary between Porcupine and Yukon rivers, remnants of the old plateau surface are in places still well preserved, and in Keele mountains, in particular, considerable areas of plain-like upland occur, the surface of which bears no relation to the bedrock structures (Plates IV, V, VI). In other localities the occurrence of occasional hills with flat summits, and here and there a long, straight-topped ridge, (Plate VIII) all rising to a nearly uniform elevation, serve as a reminder that extending over the region there once existed a plateau surface at that elevation, which truncated equally the various geological formations regardless of their attitude or character. Throughout the greater part of the district, however, with the exception of the areas included by Keele and Ogilvie mountain, above mentioned, the original upland sur-

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[1]Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 9-23.
[2]Cairnes, D. D., Op. cit., pp. 83-84.

face has become entirely destroyed and the topography is characterized by low, irregularly distributed, moss or forest clad hills with gentle slopes (Plate VII). In such localities, the topography is entirely dependent on the bedrock structure, the summits of the higher hills being invariably composed of some hard, resistant rock, and the valleys being underlain by softer formations less able to withstand the various subaërial destructive forces.

No evidence of glaciation was detected within this belt, and the valleys are practically everywhere V-shaped and characterized by interlocking spurs and other features common to non-glaciated districts (Plate IX). A number of the streams, however, have canyon-like valleys indicating a rather widespread and recent uplift of from 300 to 500 feet.

DETAILED DESCRIPTIONS.

The more interesting of the topographic features will now be described somewhat in detail commencing at Porcupine river in the north and proceeding southward to the Yukon. Porcupine river in the vicinity of New Rampart House flows in a canyon-like valley known as the Upper Ramparts of the Porcupine (Plate III). These ramparts commence about 20 or 25 miles above the crossing of the Porcupine by the 141st meridian, and continue downstream thence about 60 miles.[1] The bed of the river near New Rampart House has an elevation of between 700 and 800 feet above sea-level, and within a distance of 2 or 3 miles in either direction, has an average width of 700 to 800 feet. The valley walls rise abruptly for about 500 feet to the surface of a gently sloping upland, and to the south, elevations of 2,000 to 2,300 feet are reached within 2 to 3 miles from the river.

Proceeding southward, the land surface for about 18 miles from the Porcupine is characterized by low, well-rounded, irregularly distributed hills with gentle slopes, which rise to occasional elevations of from 2,000 to 2,300 feet above the sea.

[1]McConnell, R. G., "Report on an exploration in the Yukon and Mackenzie basins, N.W.T.": Geol. and Nat. Hist. Surv. of Can., Ann. Rept., Vol. IV, 1888-89, Part D, Sheet 8, and pp. 129-134.

A rather sudden change in the topography marks the northern limits of Keele mountains which have a width where crossed by the Boundary line of about 32 miles, and which are composed dominantly of white to grey Devono-Cambrian limestones and dolomites. These mountains are characterized by two striking features viz., their deep, canyon-like valleys, and the included, inter-valley, plain-like upland areas. The rugged, craggy, steeply inclined valley walls rise abruptly for 1,500 feet or more to the upland above, and viewed from the edge of one of these incision-like drainage ways, the topography appears to be rugged in the extreme (Plate IV). Standing on the upland, however, well back from the valley walls, a plain-like surface is presented with only occasional small, well-rounded, summits rising above the general level. Such a nearly base-levelled or peneplanated and typically old topography was apparently produced when the region stood much nearer sea-level than at present (Plate V). In accordance with this assumption the planating process must have been interrupted by a regional uplift while occasional hills still remained to relieve the monotony of the former landscape, and these now constitute monadnocks or residuals rising above the general plateau surface. This uplift rejuvenated the streams which quickly trenched their valleys in the upland, but the limestones and dolomites composing Keele mountains have proved to be extremely resistant to the ordinary subaërial erosive agencies, and the old upland surface of the Yukon plateau is better preserved in this locality than elsewhere between Porcupine and Yukon rivers.

To the north of Keele mountains these limestone-dolomite rocks also constitute the majority of the bedrock outcrops for over 15 miles, but, nevertheless, they are not thought to have formed part of the original upland. Instead these rocks are believed to have been formerly covered by Mesozoic or Upper Carboniferous arenaceous and argillaceous beds as is indicated by the presence, still, of occasional remnants of these formations overlying the Devono-Cambrian limestones and dolomites. These more recent formations are thought to have formerly extended up to the plateau level and to have constituted the planated surface in this area to the north of Keele mountains. Subsequent to the uplift of the district, according to this theory, the cover of readily destructible rocks overlying the limestone-dolomite beds was rapidly removed by erosion, and the underlying rocks soon became exposed, and now form the low, irregular hills immediately to the north of Keele mountains.

Within these northern latitudes where the rock formations are subjected to an Arctic or sub-Arctic climate, all chemical action, including solution, is reduced to a minimum and the dominant subaërial destructive processes are apparently frost action, stream and river action, nivation, and wind action. Accordingly, limestones and dolomites, which are among the most readily soluble of rocks and which are thus quickly eroded in more southerly zones, become in the north among the most resistant of materials to subaërial destructive agencies, due mainly to the fact that they are relatively very compact. Less compact and, particularly, finely cleavable rocks, collect a great amount of water which upon being frozen, fractures or breaks the containing materials; and as districts in the vicinity of the Arctic circle are particularly subjected to rapid and considerable variations in temperature, frost action becomes in such regions among the most effective of destructive agencies. Shales, slates, phyllites, sandstones, and related rocks which are so extensively developed to the south of Keele mountains, are much less soluble than the limestones and dolomites and would consequently be relatively much more resistant to destructive forces in certain warmer climates. These rocks are here, however, quickly destroyed on account of the great amount of interbedding and other water-containing spaces which they contain. The various destructive processes have been described elsewhere[1] by the writer in more detail.

Keele mountains are thus decidedly included within the Yukon plateau and their upland surface constitutes a particularly striking and well preserved remnant of the former Yukon plateau upland. These mountains thus also owe their prom-

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

inence to the character of the geological beds composing them rather than to any uplift such as would raise them above the surrounding region.

On the uplands, particularly in Keele mountains, another process is engaged, which is quite the reverse in its tendencies to the destructive deplanating[1] process just described. There, the materials eroded from the residuals rising above the plateau surface are, to a great extent, deposited in the intervening slight depressions, and become frozen and held there, thus being prevented from escaping from the upland to the drainage ways of the district. By this process of equiplanation,[2] the already plain-like upland is becoming more and more even in contour, and in so doing there is no perceptible loss or gain of material to the areas concerned, i.e. the amount of material remains practically constant (Plate VI).

Between Keele and Ogilvie mountains, a distance of approximately 90 miles, the rocks consist dominantly of shales, slates, phyllites, sandstones, quartzites, and conglomerates, and the topography is characterized by generally well rounded, irregularly distributed hills (Plate VII). Occasional flat-topped hills and long straight ridges which are composed of hard resistant rocks, occur in places, however, and rise to nearly uniform elevations. These have had their summits planated regardless of bedrock structure, and are the only remnants of the old plateau surface in evidence in this portion of the district (Plate VIII). To the south of Orange creek in particular, and within 5 or 6 miles of this stream, several such typical prominent flat-topped hills occur, the summits of which all stand at an elevation of about 3,700 feet above sea-level and indicate the position of the former upland. Throughout the greater part of this area, between Keele and Ogilvie mountains, the topography is thus entirely dependent on bedrock structure, the higher summits being almost invariably composed of quartzite,

[1]Cairnes, D. D., "Some suggested new physiographic terms": Amer. Jour. of Sci., Vol. XXXIV, July, 1912, pp. 83-85.
[2]Cairnes, D. D., "Op. cit., pp. 76-83.
"Differential erosion and equiplanation in portions of Yukon and Alaska": Bull. Geol. Soc. Amer., Vol. XXIII, 1912, pp. 344-348.

cherty conglomerate, or other hard resistant materials, and the valleys being prevailingly underlain by softer and more readily destructible shales, slates, and similar rocks.

Within this belt between Keele and Ogilvie mountains, the more prominent hills range in altitude from 2,500 to 4,300 feet above sea-level, and the main stream valleys where crossed by the Boundary line have elevations ranging from 1,100 to 1,700 feet. The larger streams crossed, commencing at the north, are Black river, Bern creek (Plate IX), Orange creek, Siwash creek, Kandik river, Sitdown creek, Nation river, Jungle creek, and Ettrain creek. These are all streams of considerable size, and are difficult or impossible to ford with horses during high water. Their valleys range from one-half to 5 miles or more in width, the valley of Black river being over 5 miles wide.

The greater number of these streams have canyon-like valleys from 300 to 500 feet in depth, suggesting a recent and widespread uplift of about this amount. These steep walled valleys, as in the case of Kandik river, are in most places sunk in the bottoms of wider valleys with flaring sides, which appear to belong to a previous cycle of erosion. In some cases, the slopes of the present valleys are largely controlled by the bed-rock structures. The shales, slates, phyllites and related rocks, which constitute the bedrock formation to the south of Black river, for instance, dip at low angles in a northerly direction, causing the land-surface to slope gradually down to the valley bottom throughout a distance of over 4 miles, while to the north the river is bounded by precipitous walls due to the easy and abrupt breaking of the brittle slaty beds, across the bedding planes.

The valley bottoms nearly everywhere between Porcupine and Yukon rivers, contain considerable accumulations of gravels, sands, etc., mainly of local origin, that have been deposited during wet seasons; and the main streams all possess wide flood channels showing that they are subjected to occasional extremely high water.

The western extension of Ogilvie mountains where crossed by the 141st meridian, has a width of about 35 miles, and extends in places to within 5 or 10 miles of the Yukon or to within 16 miles of the crossing of the Boundary line by this river. These mountains are decidedly rugged in character, and consist dominantly of Devono-Cambrian limestones and dolomites similar to those composing Keele mountains to the north. They contain, in addition, however, a considerable development of possibly Pre-Cambrian rocks comprising mainly dolomites, quartzites, greenstones, slates, and shales. With the exception of the shales and slates these rocks are relatively compact, massive, firm, and hard, and consequently are nearly as resistant to erosive processes as the limestone-dolomite beds which, however, compose the more lofty summits and more prominent mountains.

Several summits included within the section of the Ogilvie mountains, mapped along the Boundary line, rise to elevations of 5,000 feet or more above the sea, and of these, Mt. Slipper is the highest (Plates X, XIII). This mountain, which is situated about 2 miles east of the 141st meridian and 4 miles north of Cathedral creek, rises to an elevation of 5,555 feet, and is the most lofty peak within the area mapped between Yukon and Porcupine rivers.

Cathedral and Tindir creeks traverse this westerly extension of the Ogilvie range, flowing almost due west in the vicinity of the Boundary line. These streams have typical V-shaped steep-walled valleys about 2,000 feet deep, the valley bottoms being about 2,200 feet above sea-level.

The mountains of the Ogilvie range, except that they exhibit a certain uniformity of summit level, show no evidence of any kind, so far as could be observed, which might be interpreted as indicating a former base-levelled upland surface, such as is so strikingly preserved in Keele mountains (Plates X, XI, XV). It would appear, therefore, considering the high elevations of these mountains, that the belt including them constituted a mountainous area of considerable relief at the close of the period during which the Yukon plateau province was base-levelled. The mountains thus appear to have had a physiographic history somewhat distinct from that of the district immediately to the north and south, and are considered to probably constitute an outlying lobe of the Rocky Mountain system (Figure 2).

To the south and southwest of these mountains, and within

5 to 10 miles of their base, lies the tortuous, meandering Yukon, the fifth largest river on the North American continent. Throughout this intervening distance, between mountains and river, the bedrock formations consist dominantly of arenaceous and argillaceous sediments ranging from pre-Middle Cambrian to Carboniferous or possibly Mesozoic in age. These comprise mainly shales, slates, phyllites, sandstones, and conglomerates. In addition some Pre-Cambrian (?) schistose rocks are also developed along Yukon river. The hills or mountain masses within this belt, being composed thus of materials which are relatively quite readily destructible when subjected to this northern climate, gradually become less prominent as Yukon river, the centre of the Yukon plateau, is reached. The hills are also irregularly distributed and have characteristically gentle, moss or forest clad slopes, rising to summits having elevations of from 2,300 to 3,500 feet above the sea, Yukon river at the crossing of the 141st meridian, having an elevation of between 800 and 900 feet.

CHAPTER III.

GENERAL GEOLOGY.

GENERAL STATEMENT.

The geological formations along the 141st meridian between Yukon and Porcupine rivers are dominantly of sedimentary origin, but include some intrusives and also a group of metamorphic rocks, the origin of some of the members of which is uncertain. The sedimentary rocks range in age from Recent to Middle Cambrian, and include as well a great part of the Tindir group, the members of which are either Lower Cambrian or, possibly, Pre-Cambrian in age; and not only are Mesozoic and these possibly Pre-Cambrian beds somewhat extensively developed, but, in addition, each of the five systems of the Palæozoic from the Cambrian to the Carboniferous is represented. The district is thus stratigraphically of particular interest and importance, as nowhere else in the entire Rocky Mountain region of Canada and the United States, is so complete a section of the Palæozoic known within so limited an area. The metamorphic rocks are dominantly schistose in character, and within the area here being considered, are mainly, at least, of sedimentary origin. These are developed only along Yukon river, and are thought to be the oldest rocks in the district. Occasional dykes and small intrusive bodies pierce the Palæozoic beds in places, and greenstones of various types have a considerable development in association with certain of the Lower Cambrian or Pre-Cambrian members, and occur as sills, dykes, or larger irregular intrusive masses.

The metamorphic schistose rocks are all included under the term Yukon group, the members of which, within the belt here particularly under consideration, consist dominantly of schistose amphibolites, quartzite schists, mica schists, and occasional beds of limestone. The evidence obtainable concerning these rocks, indicates rather conclusively that they are all of Pre-Cambrian age. The members of the Tindir group may also prove to be of Pre-Cambrian age, and are at least older than Middle Cambrian. This group of rocks is composed mainly of dolomites, quartzites, shales, slates, phyllites, and associated greenstones, which are considered to be, almost undoubtedly, all younger than the members of the Yukon group. The Tindir group is overlain unconformably by a thick series of limestone-dolomite beds which range in age in places from Cambrian to Carboniferous. In the northern portion of the belt, sediments of this character, all lithologically very similar, overlie the Tindir members, and include beds ranging from Middle and possibly also Lower Cambrian age to Pennsylvanian—all the Palæozoic systems being represented. Toward the south, the upper limestone and dolomite members are gradually eliminated, and the time interval becomes represented by more argillaceous, arenaceous, and siliceous beds, including mainly shales, cherts, and sandstones with occasional intercalated beds of conglomerate and limestone. Thus by the time Harrington creek is reached at latitude 65°05′, the limestone-dolomite beds still range upward from Cambrian to and include Devonian members which are overlain by Devonian and Carboniferous shales, cherts, sandstones, cherty conglomerates, and thinly bedded limestones. About 10 miles farther south, however, these shales, cherts, and associated rocks range in age from Carboniferous down to and include Ordovician members which there overlie Ordovician and Cambrian limestones and dolomites. Thus, toward the south, the argillaceous and arenaceous members are more persistent, and the limestone-dolomite members represent a much shorter time interval than farther north. All these beds throughout a great part of the district are overlain by the Nation River formation which comprises a thick series of sediments composed dominantly of shales, sandstones, and conglomerates with occasional intercalated beds of limestones, that are of Pennsylvanian or Permian age. These Nation River beds are in turn overlain, apparently conformably, by an extensive and also thick series of Mesozoic beds including mainly shales, sandstones, greywackes, conglomerates, slates, and quartzites, in which Cretaceous fossils were found at a number of points. More recent than all these consolidated rock formations are the superficial deposits of Recent and Pleistocene times, which constitute a mantle obscuring the older geological terranes, more or less, throughout the entire district.

On the accompanying geological map the units used leave much to be desired, but they represent as high a degree of stratigraphic refinement as the information at hand warrants. For instance, the Mesozoic and Carboniferous Nation River sediments are mapped together, and all the limestone-dolomite beds ranging from Devonian to Cambrian in age are included under a single colour. Even the cartographic representation of these large divisions is in places, also, rather indefinite. The chief difficulty in the mapping, in addition to the notable scarcity of outcrops in many places, lies in the fact that lithologic phases of one division often closely resemble those of another. Particularly is this so in connexion with the argillaceous sediments. Lithology alone is, therefore, often an unsafe criterion of stratigraphic position, and although a great number of fossils were collected, in many localities none occur, or if they occur, could not be found. The Tindir group affords a striking example of an extensive formation dominantly composed of unfossiliferous sed ments. Thus in the delimiting of these beds, lithology alone was in many places the only available criterion. Consequently these rocks may possibly have in places become confused with other somewhat similar unfossiliferous beds in the district.

On the accompanying table of formations three typical sections are shown, which are characteristic of the geological succession, so far as this is known, in the northern, intermediate, and southern portions of this belt along the 141st meridian. Since, however, the stratigraphy changes much more rapidly toward the south than farther north, the northern section applies to considerably the greater part of the belt, the intermediate and southern sections referring only to the southern portion of the area. Also, although the stratigraphy of the Palæozoic era varies so greatly in that district, there appear to be all gradations between the different sections, as illustrated in the table of formations, the three sections there shown having been selected as being typical of extreme phases. The rapid changes in stratigraphy, particularly to the south of Harrington creek, are thought to be largely accounted for by the fact that the 141st meridian, along which the sections were measured, lies practically at right angles to the general trend of the geological structures and developments of the region.

DETAILED DESCRIPTIONS OF FORMATIONS.

METAMORPHIC ROCKS.

PRE-CAMBRIAN (?) —YUKON GROUP.

Distribution.

The members of the Yukon group are exposed along the northern side of Yukon river, throughout an area which, within the belt mapped along the 141st meridian, has an extent of from 3 to 5 square miles. This constitutes the only known occurrence of these rocks exposed along the Yukon-Alaska Boundary line between Porcupine and Yukon rivers, but this exposure forms a peripheral portion of an extensive development of these rocks to the south of the river.

Lithological Characters.

The members of this group are dominantly schistose in structure, and within this particular area consist mainly of quartzite schists, schistose amphibolites, and mica schists, but also include occasional thin beds of limestone. All these rocks are much folded, faulted, and distorted, and are so metamorphosed that in places it is difficult or impossible to determine their origin or original characters.

The quartzite-schists are characteristically light to dark green, finely textured rocks which have a decidedly schistose structure, but which cleave imperfectly along the planes of schistosity, and break prevailingly into rough, somewhat platy,

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TABLE OF FORMATIONS

Era	Period	Northern Section: Formation	Northern Section: Thickness in feet	Northern Section: Lithological character	Intermediate Section: Formation	Intermediate Section: Thickness in feet	Intermediate Section: Lithological character	Southern Section: Formation	Southern Section: Thickness in feet	Southern Section: Lithological Characters	REMARKS
DOMINANTLY SEDIMENTARY ROCKS											
Quaternary	Recent and Pleistocene	Superficial deposits		Gravels, sands, clays, peat, muck, soil, and ground-ice	Superficial deposits		Gravels, sands, clays, peat, muck, soil, and ground-ice	Superficial deposits		Gravels, sands, clays, peat, muck, soil, and ground-ice	
Mesozoic	Probably mainly Cretaceous		4000 ±	Sandstones, greywackes, conglomerates, shales, slates, and quartzites							The Mesozoic beds probably correspond to the Laberge series of Yukon Territory, and contain invertebrate remains. The Nation River formation near Yukon river, contains abundance of plant remains. The Mesozoic beds and members of Nation River formation and superjacent beds are mapped together.
Palæozoic	Carboniferous (The Permian is also possibly represented)	Nation River formation and superjacent beds	2000 ±	Conglomerates, sandstones, shales, slates, and limestones		800+	Reddish conglomerate containing considerable iron in places. Probably consolidated boulder clay	Nation River formation	4000+	Conglomerates, sandstones, and shales	The reddish conglomerate may represent a Permo-Carboniferous glacial period, the beds were found in only one locality.
		Racquet group–Limestone-chert group	1500+	Dominantly white to greyish limestones, containing considerable chert in places. Also includes some intercalated dark shales and cherty conglomerate beds	Shale group	800+	Interbedded limestones and shales, dominantly calcareous	Shale group	0 to 100 ±	Shales, in places calcareous	All Carboniferous limestones in the Intermediate section contain abundance of invertebrate remains.
	Devonian	Salmontrout limestone and associated beds	300+	Light to dark grey crystalline limestone	Shale-chert group	500+	Interbedded black, grey, and red shales and cherts	Shale-chert group	1400+	Interbedded black, grey, and red shales and cherts	The Devonian, Silurian, Ordovician, and Upper and Middle Cambrian beds are only slightly metamorphosed and are fossiliferous. Several hundred feet of apparently unfossiliferous limestones and dolomites which are considered to be probably of Lower Cambrian age, underlie the beds in which the Middle Cambrian fossils occur.
						100+	Light to dark grey crystalline limestone				
	Silurian Ordovician Cambrian		4000+	Limestones and dolomites, dominantly very siliceous		4000+	Limestones and dolomites, dominantly very siliceous		3000+	Limestones and dolomites, dominantly very siliceous	
Unconformity											
Possibly all or in part Pre-Cambrian	Pre-Cambrian or Lower Cambrian	Tindir group	5000+	Quartzites, dolomites, shales, slates, phyllites, and some magnesite and greenstone	Tindir group	5000+	Dolomites, quartzites, slates, phyllites, shales, and greenstones	Tindir group	1000+	Phyllites, quartzites, slates, and conglomerates	Unfossiliferous. Indurated, but only slightly metamorphosed.
Unconformity (?)											
METAMORPHIC ROCKS											
Pre-Cambrian(?)								Yukon group	?	Schistose amphibolites, quartzite schists, and mica schists—also occasional limestone beds	Highly metamorphosed. It is from the members of the Yukon group that the placer gold in the Klondike and other important mining districts in Yukon and Alaska has been derived.
IGNEOUS ROCKS											
	Resemble Coast Range intrusives which are Jurassic and Cretaceous in age			Granitic rocks ranging in character from granites to diorites, or possibly even more basic types						Granitic rocks, ranging in character from granites to diorites or possibly even more basic types.	Only found cutting members of Tindir and Yukon group. Found at only a few points and developments all small. Occur only as dykes and small intrusive masses.
	Range in age from probably Devonian to Pre-Cambrian (?)			Diabase, diorites, andesites, and other basic intrusives			Diabases, diorites, andesites, and other basic intrusives			Diabase, diorites, andesites, and other basic intrusives.	Occur dominantly associated with the members of the Tindir and Yukon groups. Similar appearing rocks, however, cut the lower Palæozoic limestones and dolomites and appear to be of about Devonian age.

[illegible]

or occasionally into prismatic fragments, due to more than one set of cleavage surfaces being developed. Under the microscope, these rocks are seen to consist dominantly of intergrown and interfingered quartz grains associated with which are varying amounts of chlorite, calcite, and iron-ore. Genetically, these schists are sheared and metamorphosed quartzites and related sediments, and might in some cases be aptly termed schistose quartzites or quartz schist, rather than quartzite schists, which term is here applied in a general sense to include all these highly siliceous schistose rocks.

The amphibolites are characteristically finely-textured, dark green rocks with a marked schistose structure, which cleave only imperfectly, however, along the planes of schistosity and break as a rule 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. These amphibolites are evidently impure sandstones, greywackes, or arkoses, that have become much altered.

Mica schist was found in only one locality, and is there, a greyish, medium textured, schistose rock, exhibiting an abundance of mica, particularly on cleavage faces. This rock cleaves readily along the planes of schistosity, and generally breaks into fairly regular plates one-eighth of an inch or more in thickness. When examined under the microscope, specimens of this mica schist are seen to consist mainly of biotite and quartz, with varying minor amounts of chlorite, sericite, and accessory iron ore. The quartz grains are intergrown, and in places, the rock has a decidedly quartzitic appearance, and is probably an altered sediment.

The limestones included in these schistose rocks occur as occasional beds or small, irregular masses which in places appear to represent infolded portions of more recent beds that formerly overlay the older rocks. At one point, at least, on the south side of Yukon river, such proved to be the case, as there the limestone was found to contain an abundance of Palæozoic crinoid stems. In other places, however, the limestone is intercalated somewhat regularly, and has every appearance of being, and probably is contemporaneous with the schistose members. This limestone has become completely altered into marble, and is in most places much sheared and brecciated.

Age and Correlation.

The name Yukon group[1] was first employed by the writer to designate these rocks along the 141st meridian,[2] and is intended to include all these older metamorphosed, schistose, and gneissoid rocks of both sedimentary and igneous origin. Similar schistose and gneissoid rocks are extensively developed in portions of Yukon and Alaska, and practically all geological workers who have recently studied them, have considered these rocks to constitute the oldest geological terrane in the particular district investigated. These rocks have thus been variously classed as pre-Devonian, pre-Silurian, and pre-Ordovician, according to the age or supposed age of the oldest overlying beds. In summing up the information concerning these rocks in the Upper Yukon basin, Brooks and Kindle state:[3] "The data at hand justify the statement that, below the rocks of known age (certainly older than Devonian and probably than the Ordovician), there is a complex of metamorphic sediments and igneous rocks which is widely distributed in the Upper Yukon basin." These writers class these rocks as pre-Ordovician.[4]

The small development of schistose rocks included in the belt along the 141st meridian, here being considered, constitutes a peripheral portion of an extensive development of these older metamorphic rocks described by the above-mentioned authors,

[1]It is realized that the term "Yukon silts" has been previously applied to the silts of the Yukon basin, still it is not considered that this will conflict with the use of the term "Yukon group" for the Pre-Cambrian(?) metamorphic rocks of the North.

[2]Cairnes, D. D., Geology of a portion of the Yukon-Alaska Boundary, between Porcupine and Yukon rivers: Geol. Surv., Can., Sum. Rept. for 1912, p. 11.

[3]Brooks, A. H., and Kindle, E. M., "Palæozoic and associated rocks of the Upper Yukon, Alaska": Bull., Geol. Soc. Am., vol. XIX, 1908, p. 270.

[4]Idem, pp. 264-271.

the extent of these rocks along the Upper Yukon, Alaska, being indicated approximately on Figures 1 and 2 in the paper to which reference has just been made. These rocks are considered by Brooks and Kindle to be pre-Ordovician, as the oldest fossil remains found in the overlying limestones are of Ordovician age. The finding by the writer of Middle Cambrian fossils in the corresponding limestones along the 141st meridian thus throws additional light on the age of these metamorphic rocks. As is mentioned in describing the Tindir group, these rocks along the northern side of Jones ridge underlie a thick series of limestone-dolomite beds, and Middle Cambrian fossils occur in the limestones some distance from the bottom of the series. It would thus appear as possible that the Lower Cambrian is represented there by the lowest beds of the limestone-dolomite series. In any case the Tindir group is thus either Lower Cambrian or Pre-Cambrian. There is no place also in the complete Palæozoic section found to occur in the district, for the extensive, thick, Yukon group, and it is difficult to conceive how the Yukon group could be a metamorphosed phase of the Tindir group, considering the compositions of the component members of the two groups, and considering further that the two groups are extensively developed and both preserve, wherever found, their peculiar, distinctive, and very different lithological characteristics. Further, just north of Yukon river, along the 141st meridian, some phyllites, quartzites, slates, and conglomerates occur overlying the members of the Yukon group, and as these phyllites and slates are lithologically identical with certain members of the Tindir group farther north and are unlike any of the other rocks seen along the Boundary, they would seem to be undoubtedly Tindir beds and have been mapped as such. The members of the Yukon group are decidedly older than these rocks.

Therefore, although the most typical and definitely identifiable members of the Tindir group were not found by the writer in actual contact with the rocks of the Yukon group, still for the reasons above mentioned, it seems as if there could remain little if any doubt that the members of the Yukon group are the oldest rocks in the Yukon valley and that they are of Pre-Cambrian age.

The schistose rocks of the Yukon valley have been subdivided by various writers and have been given a number of formational names; and it seems probable that the greater number of these divisions are included by the term Yukon group. This group thus probably includes the Nasina series, as described by Brooks[1] and McConnell[2], and also McConnell's Klondike series[3] and Pelly gneisses[4], as well, possibly, as his Moosehide diabase[5]. McConnell has also correlated the Indian River formation together with the Birch Creek[6] series and Forty-mile series,[7] as described by Spurr, with the Nasina series, so these rocks are also probably included.

The Tanana schists as described by Brooks[8] and Mendenhall[9] may also be included in the Yukon group, as well probably as the Greenstone schists[10] described by these writers and others. Brooks has also used the name Kotlo series[11] in a general way to include all the older sedimentary rocks which he regards as of lower Palæozoic or Pre-Cambrian age, but

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[1]Brooks, A. H., "A reconnaissance in the White and Tanana River basins, Alaska, in 1898": U.S. Geol. Surv., 20th. Ann. Rept., Pt. VII, pp. 465-467.

[2]McConnell, R. G., "Report on the Klondike Gold Fields": Geol. Surv., Can., Ann. Rept., vol. XIV, Pt. B, 1901, pp. 12B-15B.

[3]Idem, 15B-22B.

[4]Brooks, A. H., Op. cit, pp. 460-463.
McConnell, R. G., "Note on the so-called basal granite of Yukon valley" The American Geologist, vol. XXX, July, 1902, pp. 55-62.

[5]McConnell, R. G., "Report on the Klondike Gold Fields": Geol. Surv. Can., Ann. Rept., vol. XIV, Pt. B., 1901, pp. 22B-23B.

[6]Spurr, J. E., "Geology of the Yukon Gold district, Alaska": U.S. Geol. Surv., 18th. Ann. Rept., Part III, 1896-97, pp. 140-145.

[7]Idem, pp. 145-155.

[8]Brooks, A. H., "A reconnaissance in the White and Tanana River basins, Alaska, in 1898": U.S. Geol. Surv., 20th. Ann. Rept., Part VII, 1898-99, pp. 468-470.

[9]Mendenhall, W. C., "A reconnaissance from Resurrection bay to the Tanana river, Alaska, in 1898": U.S. Geol. Surv., 20th. Ann. Rept., 1898-99, pp. 313-315.

[10]Brooks, A. H., Op. cit., p. 470.

[11]Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S. Geol. Surv., 21st. Ann. Rept., Part II, 1899-1900, pp. 357-358.

also adds that "This series is of especial interest, because it probably embraces all the gold-bearing rocks of the Upper Yukon".[1] McConnell has shown, however, that the Klondike series are the principal gold-bearing rocks of the Klondike district, and are dominantly of igneous origin. From the descriptions of the Kotlo series, therefore, it seems somewhat doubtful whether or not only rocks of sedimentary origin are intended to be included. Thus the name Kotlo series may be synonymous with the term Yukon group, but it would appear as more probable that the latter name is the more comprehensive and includes the former.

The term Mt. Stevens group has also been employed in southern Yukon[2] and northern British Columbia[3] and is used to include all the older schistose and gneissoid rocks which there occur. This term is thus possibly synonymous with Yukon group, but since the areas in which the name Mt. Stevens group has been employed are somewhat widely separated from the portion of the Boundary belt here considered, there is some doubt as to the accuracy of the correlation. Further, even were the correlation established, it would seem best not to apply the term Mt. Stevens group to so important a geological terrane, owing to the possibility of confusing this Mt. Stevens in Yukon with the better known Mt. Stephen along the Canadian Pacific railway in British Columbia.

The members of the Yukon group occurring within the particular belt along the 141st meridian, described in this paper, are, dominantly at least, of sedimentary origin, and thus belong to the Nasina series. The name Yukon group is used, however, to avoid chance of error in correlation, as to be able to apply the other formational names that have been employed except the term Mt. Stevens group, it is necessary to know the origin of the schistose member. In connexion with the term Mt. Stevens group there are the other objections, above indi-

[1]Idem, p. 358.

[2]Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 40-51.

[3]Cairnes, D.D., "Atlin Mining district, British Columbia": Geol. Surv., Can., Memoir No. 37, 1913, pp. 48-51.

cated. It is thus thought that the term Yukon group should be a useful field name, as under this group may be included all the older metamorphic, probably Pre-Cambrian, schistose and gneissoid rocks that are encountered regardless of their origin, which is often difficult or impossible to determine.

The writer recognizes the difficulty that exists in dealing with these older rocks, and also realizes that in many places there exists a great amount of uncertainty concerning their age and origin. Still it seems fairly certain that there does exist a Pre-Cambrian(?) metamorphic complex underlying all the sedimentary rocks of known age in the upper Yukon valley and other portions of Yukon and Alaska; also these rocks which have previously been considered to be pre-Ordovician or younger would now appear to be all or at least dominantly of Pre-Cambrian age.

DOMINANTLY SEDIMENTARY ROCKS.

PRE-MIDDLE CAMBRIAN—TINDIR GROUP.

Distribution.

The various geological members here included in the Tindir group, are extensively developed along the 141st meridian between Porcupine and Yukon rivers. These rocks extend along both sides of the Porcupine for a number of miles both above and below the mapped 5 mile Boundary belt, and continue to the south of the river along the Boundary line for a distance of between 4 and 5 miles, where they become overlain by Devono-Cambrian limestones and dolomites. In the vicinity of Fort creek, about 40 miles south of Porcupine river, the Tindir rocks again appear, and thence southward along the International Boundary for about 40 miles, to a few miles south of Orange creek, they comprise the greater number of rock outcrops. Farther south, these rocks again come within the boundaries of the mapped area at a point about 5 miles south of Ettrain creek, and continue southward along the eastern edge of this belt to within half a mile of Cathedral creek, a distance of 10 miles. From Cathedral creek southward for from 4 to 7 miles, these rocks extend over the entire width of the mapped belt, and to the east of this belt they were seen to be extensively developed. These rocks are again exposed on Yukon river in the vicinity of Eagle creek, and are there developed throughout an area which has an average width of about a mile and extends in a southeasterly direction across the mapped belt.

Lithological Characters.

The Tindir group is composed dominantly of sedimentary rocks, but includes also, in most places, some basic volcanics which are in a general way designated as greenstones and are locally very intimately associated with the sediments. The sedimentary rocks include, mainly, quartzites, dolomites, shales, slates, phyllites, and also occasional beds of conglomerate and magnesite which have in most places an aggregate thickness of several thousand feet. This group thus embraces a considerable diversity of rock types, and in the different somewhat widely separated localities in which its members are developed the formation varies greatly in its general lithological aspect due to the predominance of certain members at different points. Along Porcupine river for instance, dolomites, quartzites, and dark friable shales predominate; north of Orange creek in places, vari-coloured slates and phyllites are the most conspicuous members; and south of Cathedral creek the greenstones and dolomites members are possibly the most prominent. Everywhere, however, these rocks all appear to be of pre-Middle Cambrian age, and are thus grouped together. Since, however, these beds are unfossiliferous and the grouping, mapping, and correlations are entirely dependent on lithological characters, which are nowhere in this district overtrustworthy, it is possible that in places, small areas of more recent beds have been included in this group, or on the other hand, that some of the less altered or typical members which rightly belong to the Tindir group may have been considered as belonging to the newer formations.

Along Porcupine river, the members of the Tindir group consist dominantly of quartzites, dolomites, and shales, with which are associated some intrusive greenstones. Wherever any considerable section of these rocks is exposed, as along Darcy creek a tributary of the Porcupine, the different members present a bright vari-coloured appearance—yellow, red, grey, and black beds being most prominent. Also, along Porcupine river the sharp contrast between the exposures of the intensely black shales, and the white greyish quartzites and dolomites which weather to a creamy or yellowish colour in places, constitutes one of the most striking scenic features of the Upper Rampart gorge in the vicinity of the Boundary line (Plates III, XII).

The quartzites are dominantly white to light grey in colour, giving them a resemblance to limestone. They are also almost universally finely textured and thinly bedded, the strata ranging in most places from less than 1 inch to about 4 feet in thickness. These quartzites disintegrate readily and form a white to yellowish impalpable powder which covers the steep slopes in many places where vegetation is absent. Under the microscope, these rocks are seen to consist dominantly of interlocking and intergrown quartz and feldspar grains, with which is always associated a certain amount of sericite that occurs as a binder or matrix filling the comparatively slight amount of interstitial space throughout the rock mass. Some specimens also contain a certain amount of carbonate, either calcite or dolomite, which with the sericite constitutes a cement for the quartz and feldspar grains, and occasionally this carbonate so increases in amount as to comprise a considerable percentage of the entire rock; in places, there thus appears to be a transition from quartzites to dolomites. The quartzites, accordingly, vary considerably in hardness, depending upon the relative percentages of the different materials they contain.

In addition to these light coloured quartzites, there also occur occasional brownish, greenish, or reddish quartzites which, however, constitute only a small percentage of the beds comprising the Tindir group on Porcupine river.

The dolomites much resemble the fine-grained, greyish quartzites in appearance, so much so that it often requires careful examination of hand specimens to distinguish them, the hardness of the dolomites being similar to that of the sericitic quartzites containing considerable feldspar. The dolomites are dominantly light grey to yellowish in colour, and are nearly everywhere thinly bedded, the strata ranging in thickness in most places from 1 to 4 feet, but throughout portions of the section, the beds are less than 2 inches in thickness. The dolomites also contain, in places, numerous intercalated seams of chert and quartzites from 0·25 to 1 inch thick.

The shales include greyish to black, thinly bedded, flaky, non-calcareous members, as well as other less thinly bedded, black, soft shales which readily decompose to form black mud. Other black shales also occur which are finely interleaved with limestone, causing these rocks to appear very calcareous throughout. Occasional beds of reddish to yellowish shales and clays also occur.

This entire group of rocks has been considerably folded, faulted, and distorted, so that it is difficult to estimate the aggregate thickness of the beds in sight, and the bottom of the group was not observed. It would appear, therefore, that this group of rocks on the Porcupine has a thickness of at least 5,000 feet, and may be several times this thickness, in places.

The shales being softer and less competent to resist the various stresses and strains to which they have been subjected, have become much more crumpled, mashed, broken, and distorted than the dolomites and quartzites, and within a few feet in places, folds may be observed in all attitudes ranging from upright to completely reversed, with numerous faults of varying displacement intersecting the beds in different directions. Although these beds are so greatly disturbed, metamorphism is not pronounced in the different members of the group, and the rocks themselves, although considerably indurated, have nowhere, for instance, a schistose or gneissoid structure, and seldom, if anywhere, possess a slaty cleavage. They are thus very different in this respect from the members of the Yukon group.

Occasional dykes and small intrusive masses of diabase pierce these rocks, in places, and since the dykes rarely extend up into the overlying Palæozoic rocks to the south, the diabase is probably dominantly also of pre-Middle Cambrian age.

The following represents an approximate section of these Tindir rocks along the Porcupine, as far as could be estimated from the exposures within the mapped area. The lower members of the group, however, were not observed, and on account of close folding and faulting it is very difficult in places to measure a section even of the observable beds.

	Thickness
Shales, dominantly dark grey to black in colour, calcareous in places, and prevailingly soft, thinly bedded, and friable, weathering readily to a black mud....	1000+ft.
Quartzites, white to greyish in colour, thinly bedded, and weathering readily to form a fine yellowish sand....	1200+ft.
Black and greyish shales....	150 "
Intercalated soft, greyish, thinly bedded and black, fissile shales....	150 "
Brick-red clays and shales....	75 "
Dolomites—soft, light grey, thinly bedded, and containing thin intercalated chert laminæ....	1500 "

The shales comprising the upper 1000 feet in the above section contain considerable iron, and streams traversing these rocks have a very acrid taste and cannot be used for drinking purposes. A small sample of about a quart was taken from a stream which flows through these shales, and joins the Porcupine on the south side about half a mile below the Boundary line. This was analysed by Mr. F. G. Wait of the Department of Mines, Ottawa, who reports:—

"The following facts were noted in the course of a qualitative examination of the sample submitted.

Specific gravity at 15·5°C....	1·008
Taste....	acrid, styptic
Reaction....	faintly acid
Colour....	faint brownish yellow

"It was found to contain sulphates of iron—both ferrous and ferric—of alumina, of lime and of magnesia. The quantity of water at my disposal did not admit of a test being made for the presence of potassium or sodium. These latter are most probably present—as sulphates.

"Chlorides and carbonates were found to be absent.

"The "acid" reaction of the water does not necessarily indicate the presence of free sulphuric acid, as both ferrous and ferric sulphates and also aluminium sulphate redden moistened blue litmus paper.

"The sides of the containing bottle were coated with ferric hydrate, resulting from the partial decomposition of the ferric sulphate.

"The filtered water was submitted to a proximate analysis and found to contain: (in 1,000 cubic centimetres).

Ferrous sulphate	0·81	gramme
Ferric sulphate	1·52	"
Aluminium sulphate	1·02	"
Calcium sulphate	0·27	"
Magnesium sulphate	3·10	"
Sulphuric anhydride	1·12	"

(Probably present in major part in combination with sodium and potassium, and possibly in small measure as free sulphuric acid.)"

In the vicinity of Fort creek and for some 40 miles to the south along the Boundary, throughout which distance the members of the Tindir group are extensively developed, these rocks include mainly slates, phyllites, quartzites, sandstones, shales, dolomites, and occasional beds of magnesite (Plates VII, VIII).

The slates vary greatly in colour, being generally, however, black or various shades of grey, green, red, or brown. They have everywhere a decided secondarily induced cleavage and generally break readily into plates from one to several feet in diameter and as thin as one-sixteenth of an inch or even less (Plate XIV). Probably the most noticeable and persistent beds are certain beautifully banded red and green slates, the alternate bands of which are in places extremely thin and delicate and not more than one-quarter to 2 inches in thickness and frequently much less, presenting thus a decidedly ribbonlike appearance. The colours are apparently due to the various stages in oxidation of the sediment before it settled from suspension, which is thought to be the result of changing climate. Writing on "the colours of variegated shales"[1] Professor Joseph Barrell of Yale University, states:[2] "This is mainly dependent upon the oxidation of the iron and the presence or absence of carbon: and in marine sediments I think it is generally due to the nature of the sediment before it comes to rest. I think it is typical of intermediate climatic states. Arid climates tend to give red shades, both marine and continental; semi-arid or seasonably arid tend to give uniform red or brown shades, more especially to continental river deposits; humid climates favour deoxidation and give uniform grey to black shades; climates oscillating about the mean will give variegated shades. Of course, with any climate, the physiographic factors are also fundamental."

The phyllites[3] also vary considerably in colour, but are generally some shade of grey, although occasional greenish, brownish, or black members were noted. These rocks are distinguished from the slates by containing more mica, and in general are somewhat coarser textured. In places, the phyllites are much crinkled, folded, and distorted—monoclinal or even closed folds being exhibited in hand specimens; these rocks, also, wherever found, break readily along the cleavage planes and frequently large thin slabs are procurable.

The quartzites range from nearly white to dark grey in colour, and are typically massive with a sugar-grained texture. Occasionally, however, beds occur that contain a certain amount of mica, chlorite, and related materials, which in places are

[1]Barrell, Joseph, "Criteria for the recognition of ancient delta deposits": Bull. Geol. Soc. Amer., vol. XXIII, Sept. 12, 1912, pp. 416-425.

[2]Personal communication.

[3]The term phyllite is here used in the sense in which it is intended by Rosenbusch, i.e., it includes all those rocks that resemble slates in structure, origin, and composition, but differ from these in containing noticeably more mica which gives a decidedly glistening appearance to the cleavage surfaces. A typical phyllite (Tonglimmerschiefer) is also somewhat coarser textured than the ordinary slate.

arranged in definite streaks between layers of purer quartzite, giving to the rocks a distinctly gneissoid habit and appearance.

Sandstones and shales only rarely occur, and are the less metamorphosed phases of the slates, phyllites, and quartzites. The sandstones are dominantly medium textured and greyish, greenish, reddish, or brownish in colour, while the shales range in colour from grey to black and are in places closely interbedded with the sandstones. In a few localities large slabs of finely textured, brownish sandstones were noted which exhibited beautifully preserved ripple marks, showing that these beds, at least, are shallow water deposits.

The dolomites and magnesites almost invariably weather with a rough surface, and on exposed faces have prevailingly a reddish colour due to the oxidation of the considerable amount of iron they contain. These reddish dolomite beds thus resemble those along Porcupine river and elsewhere where Tindir beds are exposed; and as they are among the most persistent and easily recognizable members of the Tindir group they serve as one of the most useful and diagnostic lithological horizon markers in this district. These dolomites south of Fort creek, although generally reddish on weathered surfaces, are dominantly very dark grey to greenish or bluish grey on fresh fractures. They also are dominantly crystalline, being in some places quite coarsely textured, and in addition to being much folded and contorted are often extremely brecciated. They are in most places distinctly bedded and break into slabs 2 inches to 2 feet in thickness. Near the summit of Rover mountain these dolomites were also noted finely interbedded with slates, and at one point a thickness of about 50 feet of beds consists of interlayered slates and dolomites, the dolomite beds ranging in thickness from one-quarter of an inch to about 2 feet, and the slate bands from one-eighth of an inch up to several feet. No great developments of these dolomite beds, however, are exposed in this area to the south of Fort creek. The outcrops are in most places small and the beds in sight have rarely an aggregate thickness of more than 100 to 200 feet. The magnesites are in places composed almost entirely of a very pure grade of magnesite, and occur in beds which do not in most places exceed 10 feet in thickness. In places also they occur interbanded with the slates and dolomites in layers less than 2 feet in thickness.

No accurate estimate could be formed as to the aggregate thickness of the Tindir beds between Orange and Fort creeks, as these rocks are there so deformed, metamorphosed, and indurated, that it was difficult in most places to determine their dips or strikes or even their relative stratigraphic positions. This group is in that portion of the belt, however, at least 6000 feet in thickness and may be considerably more. Being unfossiliferous, certain members of the Tindir group between Orange and Fort creeks when first examined were confused with the lithologically somewhat similar Mesozoic and Carboniferous beds. Further studies of these formations, however, have shown these various rocks to belong to the groups to which they are here assigned.

The Tindir section exposed still farther south along Tindir creek, and between Ettrain and Harrington creeks, particularly resembles that observed along Porcupine river, the members including mainly dolomites, limestones, quartzites, slates, shales, and greenstones. Here, however, the greenstones are developed to a much greater extent than to the north of Orange creek and along the Porcupine, and the quartzites instead of being dominantly white to greyish, include more greenish, reddish, and dark coloured members, even quite black quartzites being prominent in some places.

The dolomites weather characteristically rough and reddish to brownish as elsewhere, and are generally definitely bedded, the strata ranging in places from a fraction of an inch to a foot or more in thickness. They also include numerous bands of chert 1 to 2 inches thick. Intercalated with these dolomites, also, are occasional greyish limestone beds, and also some of black slate. These dolomites appear to be at least 700 feet in thickness.

Mt. Slipper is capped by Devono-Cambrian limestones and dolomites, which are underlain by the members of the Tindir group. Thus around the western and southern faces in particular of this mountain a splendid section of a part of the

Tindir rocks is exhibited (Plate XIII). There these beds include mainly dark to black calcareous shales, limestones, and quartzites, all invaded by greenstones which occur both as dykes and sills. The quartzites are dominantly thinly bedded, and nearly black, but weather in places to a dark reddish or reddish brown colour. The limestones are prevailingly also thinly bedded and dark to nearly black in colour, and grade into very soft, thinly bedded, friable, black, calcareous shales, the beds of the upper 500 feet at least of the section being very calcareous. The Tindir beds exposed here on Mt. Slipper evidently constitute the upper portion of the Tindir group in this locality, and very closely resemble the shale member comprising the upper 1,000 feet in the section measured along Porcupine river.

A typical member of the Tindir beds south of Tindir creek, also, is a finely laminated rock consisting of alternating white and black bands, there being on an average about 20 laminæ to the inch. The light bands consist dominantly of quartz, and the dark bands of argillaceous shaly material.

Certain shales and quartzites also exhibit considerable hematite, and in places portions of these beds contain up to 30 per cent or even possibly 40 per cent metallic iron.

The greenstones are dominantly diabases and occur as sills, dykes, and irregular intrusive masses, and in places constitute a considerable portion of the entire formation. The sills are in places as much as 100 feet and the dykes 200 feet in thickness. Since these intrusives were rarely noted intruding the overlying Devono-Cambrian limestones and dolomites, it is concluded that they are dominantly at least older than these rocks.

The Tindir rocks here, in the vicinity of Tindir creek and between Ettrain and Harrington creeks, as farther north, are characteristically much indurated, folded, and contorted, and are also brightly and vari-coloured, black and shades of red, grey, and yellow being conspicuous. A single sidehill, in places, may exhibit, reddish to brownish dolomites, yellow to black quartzites, grey limestone beds, grey, red, or black shales or slates, and black to bright red iron-ore containing beds, all ribboned and intersected by irregular, brownish weathering, greenstone dykes and sills. The hills on which these rocks outcrop are dominantly lofty and irregularly distributed, and are characterized by long, sharp, steep-sided ridges, with smooth slopes covered with a fine talus. The bright and contrasted colours which they exhibit also constitute one of the most striking pictorial features of the landscape of the district.

The members of the Tindir group occurring in the belt adjoining Yukon river in the vicinity of Eagle creek consist mainly of phyllites, slates, quartzites, and conglomerates. The most prominent of these rocks are the phyllites. These are dominantly greyish to light greenish in colour, but some dark bluish grey to black beds resembling typical slates occur. These phyllites are also firm, finely textured rocks which have a pronounced secondary cleavage and break into regular slabs one-eighth to one-half inch in thickness. Under the microscope they are seen to be decidedly of sedimentary origin and prove to be composed dominantly of quartz, feldspar, and mica. The mica occurs in the form of occasional large irregular shreds and also as finely disseminated sericite peppered plentifully throughout the entire mass. Interbedded with the phyllites are occasional beds of quartzite and indurated conglomerate which range in thickness from less than an inch to 20 feet or more in thickness, and are composed apparently of the same materials as the phyllites, but in a less comminuted condition. In places, also, some of the banded red and green slates also occur, such as have been described as being so prominent farther north, particularly between Orange and Fort creeks. Occasional beds of grey and black slates also occur. These phyllites, slates, quartzites, and conglomerates are all much indurated, contorted, folded, broken, and somewhat metamorphosed, so much so that it is very difficult here as elsewhere to measure or estimate the thickness of the Tindir section, or even to determine the relative stratigraphic positions of the various component members.

Age and Correlation.

The Tindir rocks along Porcupine river were noted in 1888 by McConnell[1] who did not venture to assign them to any

[1]McConnell, R. G., "Report on an exploration in the Yukon and Mackenzie basins, N.W.T.": Geol. and Nat. Hist. Surv. of Can., Ann. Rept., Vol. IV, 1888-89, Part D, pp. 129-134.

definite stratigraphic position. These rocks have since, however, been described somewhat in detail by Kindle[1] and Maddren[2] who classed them as pre-Ordovician but did not give them any formation name. Concerning the age of these Tindir beds along Porcupine river Kindle has briefly summed up the available evidence by stating: "No fossils have been found in these rocks; consequently their age can only be stated with reference to that of the oldest palæontologically determined beds of the section—the Ordovician. That they antedate the Ordovician in age is indicated by the fact that no series corresponding to them in lithologic features occurs in the portion of the geologic section lying above the Ordovician. The several main divisions of the Palæozoic section from the Ordovician to the Carboniferous have been recognized on the Porcupine by their fossils."[3] Since Kindle investigated the geology along the Porcupine, the writer has found Middle Cambrian fossils in the beds supposed formerly to be no older than Ordovician in age. Thus these Tindir rocks may now for the reasons above cited, be classed as pre-Middle Cambrian.

Also in the vicinity of Racquet and Bern creeks the Tindir beds decidedly underlie the Carboniferous limestones, and between Black river and Fort creek wherever these rocks were observed in contact with the Devono-Cambrian limestones and dolomites they appear to underlie these beds.

On Mt. Slipper, also, just north of Cathedral creek, Devono-Cambrian limestones and dolomites distinctly overlie the members of the Tindir group (Plate XIII).

Also along the northern side of Jones ridge, just north of Harrington creek, the members of the Tindir group distinctly underlie unconformably a limestone-dolomite series in which Middle Cambrian fossils were found. Below the horizon from which these Middle Cambrian remains were obtained there occur in places several hundred feet of lithologically similar,

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[1]Kindle, E. M., "Geological reconnaissance of the Porcupine valley, Alaska": Bull. Geol. Soc. Amer., Vol. XIX, 1908, pp. 320-322.

[2]Maddren, A.G., "Geologic investigations along the Canada-Alaska Boundary" U.S. Geol. Surv., Bull. 520K, 1912, pp. 6-11.

[3]Kindle, E. M., Idem. p. 322.

but unfossiliferous, limestones and dolomites, which in all probability represent the Lower Cambrian; and underlying these beds unconformably occur the Tindir rocks. The members of the Tindir group are thus either of Lower Cambrian or Pre-Cambrian age. Considering, however, the great thickness of these rocks; the fact that they differ so greatly, lithologically, from the overlying beds of Middle and Upper Cambrian age; and that the Lower Cambrian is probably represented by the lowest beds of the overlying limestone-dolomite formation, from which lowest beds no fossils have as yet been obtained, it would seem to the writer very probable either that the Tindir rocks are entirely of Pre-Cambrian age, or that this group includes both Lower Cambrian and Pre-Cambrian members.

The Tindir group seems to correspond lithologically somewhat closely with the Tatalina group of the Fairbanks quadrangle, Alaska, as described by Prindle[1]. There appears to be considerable doubt, however, concerning the age of the members of the Tatalina group, but they are considered by Prindle to be possibly of Ordovician age. Concerning these rocks Prindle states: "The Tatalina group rests unconformably on the Birch Creek schist and is overlain in the White mountains by limestones ranging in age from Ordovician to Devonian."[2] Thus in the Fairbanks district these Tatalina rocks overlie directly the Birch Creek schists which are included in the Yukon group of the Boundary section, and are overlain by a heavy limestone series. Thus the Tindir and Tatalina groups appear to possess many points in common. Both directly overlie the older schistose rocks, and both are overlain by a heavy series of limestones beds. Along the Boundary these limestone-dolomite beds are now known to contain Middle Cambrian fossils, and thus the Tindir beds are pre-Middle Cambrian in age.

The Tindir group, it may be noted, appears to correspond

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[1]Prindle, E. M., "A geologic reconnaissance of the Fairbanks quadrangle, Alaska": U. S. Geol. Surv., Bull. 525, 1912, pp. 37-39.

[2]Op. cit., p. 38.

to the Belt Terrane[1] of British Columbia and the Western States, officially considered by the United States Geological Survey to represent the latest Algonkian. As the age of these Beltian rocks is still disputed, and as correlations between formations so widely separated geographically are always open to criticism, the writer has adopted the new term Tindir group for these rocks along the Alaska-Yukon Boundary, although lithologically they appear to be strikingly similar to the Beltian rocks of British Columbia and the Western States; these latter are thought by most writers to occupy a position stratigraphically corresponding to that assigned here to the Tindir group.

As the members of the Tindir group are only slightly metamorphosed, and as the rocks of the Yukon group are so highly metamorphosed, and since, also, as previously explained, the Yukon group is thought to be almost undoubtedly older than the Tindir group, an unconformity is supposed to exist between these formational groups. As before mentioned, however, the writer did not observe the members of the Yukon group in direct contact with rocks that could be positively identified as belonging to the Tindir group. If the phyllites, slates, and related rocks along Yukon river prove to belong to the Tindir group, as the writer is fairly certain they do, the supposed unconformity is established, as these phyllites and associated rocks rest unconformably on the members of the Yukon group. Further, if the Tindir group proves to correspond to the Tatalina group as mentioned above, and as seems quite probable, this unconformity also becomes a certainty, as the Tatalina beds rest unconformably on the underlying Birch Creek schists.

It would thus appear as very probable that the Pre-Cambrian is extensively developed in portions of Yukon valley and elsewhere in Yukon and Alaska, and that these rocks are divisible into an upper but slightly metamorphosed division, the

[1]Daly, R. A., Geol. Surv., Can., Memoir No. 38, 1912, pp. 179-191.
Scohfield, S. J., Reconnaissance in East Kootenay, British Columbia: Sum. Rept., 1912, Geol. Surv., Can., pp. 221-225.
Van Hise, C. R., and Leith, C. K., "Pre-Cambrian geology of North America": U. S. Geol. Surv., Bull. 360, 1909, pp. 98, 852, 856-857, 858, 860-864, 881.

Tindir group, and a lower highly metamorphosed division, the Yukon group. The writer is quite well aware, however, of the difficulties that may possibly arise in attempting to use a classification of this kind with the information at hand, and also realizes the uncertainty attending any attempt to measure the ages of rock groups by the mystic scale of metamorphism; still it is thought that this classification, owing to its simplicity, may prove useful in case the Pre-Cambrian age of the Tindir and Yukon groups becomes established. It is realized, however, that the problem concerning these older rocks is yet far from being solved, and that a great amount of work still remains to be performed before the intricacies of this extremely interesting problem will be understood.

SILURIAN-CAMBRIAN LIMESTONE-DOLOMITE GROUP.

Distribution.

A great thickness of beds including, dominantly, limestones and dolomites ranging in age from Cambrian to Silurian, is developed throughout a considerable portion of the Boundary belt here under consideration. These rocks along the Boundary line commence about 4 miles south of Porcupine river and extend southward for over 40 miles to near Black river; and throughout this distance, which includes a section across Keele mountains, they comprise the greater number of the rock exposures (Plate V). About 70 miles farther south these beds again appear in the vicinity of Ettrain creek, and thence south across the western extension of the Ogilvie mountains to Yukon river they constitute the most extensively developed geological terrane within the mapped Boundary belt (Plates X, XI, XIII, XV). These rocks thus, in a general way, tend to be restricted to the higher more mountainous tracts, being mainly developed in Keele and Ogilvie mountains and in their vicinity.

Lithological Characters.

These rocks are prevailingly white to light grey in colour, but occasional beds occur having a dark grey to nearly black, or even a pink or reddish appearance. Nearly everywhere, however, on weathered surfaces the different members have the peculiar greyish to bluish grey, rough appearance characteristic of limestones. The rocks are dominantly crystalline and in places beds of particularly beautiful marble occur, which prevailingly range in colour from pure white through various shades of grey, occasional reddish beds being, however, noted in places.

In texture these limestone-dolomite rocks vary from firm, dense dolomites to coarsely crystalline almost pure limestones. They are also characteristically somewhat massive in appearance, due largely to the degree of metamorphism which they have suffered; but where the bedding planes are discernible the strata are dominantly from 1 to 6 feet in thickness, although much thinner beds from 1 to 6 inches thick, are locally characteristic of the series. Beds of limestone having an oolitic structure also occur to the south of Tatonduk river and elsewhere, the oolitic grains being generally about one-tenth of an inch or less in diameter.

In composition these beds range from limestones to dolomites, but appear to be all dominantly more or less magnesian. They were frequently tested in the field with cold acid, and only rarely was a member of this group found that effervesced freely, but nevertheless nearly all were more or less attacked. It would thus seem that these rocks are prevailingly transitional in composition between pure limestones and true dolomites, either of these forms being of somewhat exceptional occurrence. The more dolomitic beds are prevailingly harder and finer-textured than the limestones and are dominantly white to light grey in colour, none of the very dark colours occurring such as characterize the limestones in places. Further, the dolomites in places, as on Mt. Barlow and elsewhere in Ogilvie mountains, are more or less porous and contain numerous cavities which are generally quite small, but range in size from microscopic to several inches in diameter. These cause the containing rocks to be very rough on weathered surfaces. The cavities are dominantly lined with well defined crystals mainly of quartz and calcite, and are considered to indicate rather conclusively that the dolomites are of secondary origin and are derived from limestones, the amount of pore space representing the decrease in volume during the replacement process. Also, as fossils were very rarely if ever found in the dolomites, and are quite plentiful in places in the adjoining limestones, this would also seem to indicate that some change had occurred in the dolomite beds since originally deposited, which destroyed any contained organic forms.

In a few places, greyish, yellowish, to nearly black shales are intercalated with these limestone-dolomite beds, and at one point, on the western side of Mt. Slipper, over 200 feet of thinly bedded shales occur with dolomites above and below them. Shales, however, are of very minor importance quantitively, in this Silurian-Cambrian terrane.

The entire series is prevailingly siliceous, and toward the south, the beds contain a great amount of translucent to semi-transculent chalcedonic quartz or chert which in places considerably exceeds the limestones and dolomites in amount. This chert has, in places, been deposited largely along the bedding planes of the containing rocks in seams ranging from microscopic up to 8 or 10 inches in thickness, and thus gives the rocks, in general, a decidedly banded appearance. When somewhat regularly deposited along the bedding planes in this way, the chert has in places the appearance of being contemporaneous with the containing beds, but when more closely examined, it may be seen to intersect the strata; in fact seams or masses of chert occur cutting the limestone and dolomite beds at all angles, and the smaller seams are frequently distinctly traceable back to larger seams or irregular bodies (Plates X, XI).

This entire series of rocks ranging through the Silurian, Ordovician, and Cambrian, appears to be conformable throughout, and it was found to be impracticable, if not impossible to differentiate and map separately the beds of the different ages. The rocks are all so much folded and faulted that only in a few places could the positions of the different beds within the series be even approximately determined stratigraphically; and unless fossils could be found it was impossible, even in these places, to draw the geological age-boundaries, as no distinctive persistent lithological horizon markers could be distinguished such as occur in less uniform formations in many districts, and serve to indicate the positions of geological boundaries in the absence of fossil remains. Fossils, moreover, are of somewhat rare occurrence in these beds, particularly in the lower members, so that a great amount of detailed palæontological and stratigraphical work would be required to subdivide these rocks and map them according to their respective ages.

These beds in the northern portion of the belt have an aggregate thickness of at least 4000 feet and possibly very much more than this amount, but no section of them was at all closely measured at any one point, it being found very difficult to do so on account of folding and faulting, and owing also to the fact that the beds are lithologically very similar throughout, and thus include practically no stratigraphical horizon markers. To the south these beds do not appear to be so thick, but even there, they have an aggregate thickness of at least 3000 feet.

Age and Correlation.

These limestones and dolomites, as shown on the accompanying table of formations, include in the northern portion of the belt, Silurian, Ordovician, and Cambrian members and are overlain by Devonian limestones, which are in turn overlain by Carboniferous limestones, cherts, and related rocks. Toward the south, however, the limestone-dolomite beds gradually give place to more argillaceous and arenaceous beds, so that in the vicinity of Harrington creek, the limestones and dolomites are overlain by middle or lower Devonian limestones which underlie Devonian shales of the shale-chert group. Less than 10 miles farther south the limestone-dolomite beds include only Cambrian and lower Ordovician members and are overlain by the shale-chert rocks which there persist downward in an age sense from Devonian to upper Ordovician, including thus, Devonian, Silurian, and Ordovician members (Plate XV). Wherever the lowest beds of this group were seen they overlie the members of the Tindir group (Plate XIII).

These limestone-dolomite rocks in the northern portion of the belt, appear to correspond somewhat closely to the Port

Clarence limestone[1] according to Dr. E. M. Kindle who examined the fossils from both of these districts. The Port Clarence limestone is typically developed in the western part of Seward peninsula, Alaska, and the faunas of this terrane represent the nearest geographic approach of American fossil faunas to those of Asia. These Silurian-Cambrian limestones and dolomites also correspond lithologically very closely with the Palæozoic limestone section described by Prindle[2] as occurring in the Fairbanks quadrangle, Alaska, except that there no Cambrian beds were identified.

The fossils obtained from this limestone-dolomite series along the Boundary are of particular interest on account of the Cambrian remains as well as the graptolites which they include. Cambrian fossils were found in several localities along the Boundary, but had not previously been reported from Yukon Territory, and have been found in only one locality in Alaska, which is situated in Seward peninsula over 700 miles to the west.[3] The nearest Canadian locality in which Cambrian fossils are known to have been discovered is on Gravel river in the North West Territories over 400 miles to the southeast.[4] Graptolites are believed to have been previously found in only two localities in Alaska, viz., in the Mount McKinley region[5] and on Porcupine river,[6] and had been discovered in place in Yukon in only one locality.[7]

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[1]Collier, A. J., "A reconnaissance of the northwestern portion of Seward peninsula, Alaska": U.S. Geol. Surv. Prof. Paper, No. 2, 1902, pp. 18-21.
Kindle, Edward, M., "The faunal succession in the Port Clarence limestone, Alaska": Amer. Jour. Sci., Vol. XXXII, Nov., 1911, pp. 335-349.

[2]Prindle, E. M., "A geologic reconnaissance of the Fairbanks quadrangle, Alaska": U.S. Geol. Surv., Bull. 525, 1913, pp. 39-47.

[3]Kindle, Edward, M., Idem, pp. 340-343.

[4]Keele, Joseph, "A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories": Geol. Surv., Can., No. 1097, 1910, pp. 36, 37.

[5]Brooks, Alfred, H., "The Mount McKinley region, Alaska, with descriptions of the igneous rocks and of the Bonnifield and Kautishna districts by L. M. Prindle": U.S. Geol. Surv., Prof. Paper 70, 1911, pp. 72-73.

[6]Kindle, E. M., "Geologic reconnaissance of the Porcupine valley, Alaska": Bull. Geol. Soc. Amer., Vol. XIX, 1908, pp. 325-326.

[7]Keele, Joseph, Op. cit., p. 35.

All the fossils collected by the writer from along the 141st meridian have been examined by specialists whose reports are here incorporated. The invertebrate remains collected from these limestones and dolomites have been examined and reported on by Dr. Edward M. Kindle, Mr. Lawrence Lamb, and Mr. L. D. Burling, all of this Department, by Dr. Rudolf Ruedemann, Assistant State Palæontologist of New York, and by Professor W. A. Parks of the University of Toronto.

The Cambrian remains have all been examined by Mr. L. D. Burling who has identified several horizons within the Upper and Middle Cambrian (Plate XV). Mr. Burling reports "The older faunas included in the collection from the International Boundary bear no close resemblance to any of the described faunas of the Upper Cambrian or lower Ordovician.

"XXi34[1] is to be referred to the Cambrian and may even be upper Middle Cambrian in age, a statement which would also hold for XIXj32 if it were not for the presence of *Illaenus* in that locality. So far as our present information goes, however, all of the localities, with the exception of XXi34, are referred to the upper part of the Upper Cambrian (XIXj9, 17 and 18, and 31 being especially comparable), but it will be necessary for us to await the measurement and careful collection of fossils from one definite section along the Boundary, or for further collections from the localities already represented before we can be certain of this correlation. The faunas of the Cambrian localities are as follows:—

XIXj9

Obolus sp.
Lingulella sp.
Acrothele cf. *coriacea* Linnarsson.
Acrotreta 2 sp.
Agnostus 2 sp.
Ptychoparia sp.
Anomocare sp.
Liostracus sp.
Levisia sp.

[1]These numbers all refer to positions on the map used in the field, showing locations from which the fossils were obtained.

XIXj17, 18

Obolus (*Westonia*) cf. *stoneanus* (Whitfield).
Lingulella sp.
Acrothele cf. *coriacea* Linnarsson.
Schizambon cf. *typicalis* Walcott.
Undetermined trilobite.

XIXj31

Foraminifera ? undetermined.
Obolus 2 sp.
Obolus (*Westonia*) cf. *stoneanus* (Whitfield).
Lingulella 2 sp.
Dicellomus? sp.
Curticia? sp.
Acrothele cf. *coriacea* Linnarsson.
Acrotreta sp.
Orthoid.
Coral ?
Ostracod.
Agnostus sp.
Eurycare? sp.
3 unidentified trilobites.

XIXj32

Micromitra (*Iphidella*) *pannula* (White) ?
Obolus 2 sp.
Obolella? sp.
Acrothele cf. *coriacea* Linnarsson.
Acrotreta 2 sp.
Ostracod.
Illaenus? sp.

XIXp20

Obolus 2 sp.
Lingula sp.
Acrotreta 2 sp.
Asaphus? sp.

XXc29

Obolus sp.
Acrotreta sp.
Agraulos sp.

Ptychoparia sp.
Anomocare sp.
Solenopleura sp.

XXe39

Curticia? sp.
Acrotreta sp.
Agnostus sp.
Dicellocephalus? sp.

XXi34

Foraminifera.
Hyolithellus? sp.
Stenotheca 2 sp.
Conularia sp.
Micromitra (*Iphidella*) *pannula* (White).
Acrotreta 4 sp.
Ostracods 4 sp.
Agnostus 3 sp.
Agraulos 3 sp
Ptychoparia 2–3 sp.
Anomocare sp.
Dorypyge? sp.
Neolenus? sp.
Solenopleura 3 sp.

During 1913 Mr. Burling made a detailed study of the sections exposed along the 141st meridian in the vicinity of Tatonduk river, and collected a large number of Palæozoic fossils, the material from the Middle and Upper Cambrian and lower Ordovician being especially abundant. These collections are now being studied in the palæontological laboratory of this department.

Of the Ordovician remains, the graptolites were sent to Dr. Ruedemann and the other specimens were examined by Dr. Kindle and Mr. Burling. Dr. Ruedemann reports as follows:—

"While the specimens were not so excellently preserved that one would be very positive in their determination, I am fairly sure that the three following forms are present:—

Dicranograptus cf. *ramosus* (Hall).
Retiograptus geinitizianus Hall.
Diplograptus foliaceus incisus Lapworth.

The *Dicranograptus* is only represented by broken fragments of branches. These show, however, in one or two places the strongly introverted thecae of the later Dicranograpti. The *Retiograptus* shows a number of interesting structural features, as the straight and zigzag axes, and it would be hardly more than varietally different from Hall's species.

The *Diplograptus* is rather poorly preserved. It resembles most, in my opinion, the form previously referred to as a variety of *foliaceus*, viz. *D. foliaceus incisus*.

From the aspect of this faunule, especially the *Retiograptus* and the branches of *Dicranograptus*, I would place it in the Normanskill or a little younger. In our fauna these two occur only in the Normanskill."

Mr. Burling reports as follows:—

"Two of the collections are to be referred to the Ordovician but it is only possible to give a close correlation for the one containing the graptolites, XXi25. This material was separated, the graptolites going to Dr. R. Ruedemann and the other forms to the writer. The horizon has been determined to be comparable with that of the Normanskill of the Ordovician, the following genera and species being identified:—

XXi25

By Ruedemann:—

Dicranograptus cf. *ramosus* (Hall).
Retiograptus geinitzianus Hall.
Diplograptus foliaceus incisus Lapworth.

By Burling:—

Obolus sp.
Ostracod.
Ptychoparia sp.
Isotelus ?
Harpes ?

XXIo44

Referred to the Ordovician after considerable discussion by Messrs. Kindle, Ulrich, and the writer. It has been found impossible from present information to make a closer correlation, as no identifiable species have been found. The following will give an indication of the forms represented:—

Ostracod.
Monticuliporoid coral.
Atrypa ?
Proetus-like tribolite."

Dr. Kindle reports as follows concerning the Ordovician fossils collected in 1912 and the Ordovician and Silurian remains obtained in 1911. Concerning the 1912 collection he states:—

"Two small lots of fossils composed almost entirely of corals are referred to the upper Ordovician. One of these (XIk46) includes two species of corals which are identical with forms collected by the writer in the Seward peninsula, Alaska,[1] where the middle or upper Ordovician age of the fauna is fully established by a long list of Ordovician brachiopods and gasteropods. The two lots listed below are believed to represent the same horizon as these western Alaskan collections which occur in the upper part of the Port Clarence limestone, and belong to the same Ordovician fauna which was collected along the 141st meridian by Dr. Cairnes during the season of 1911. This is a later horizon of the Ordovician than that represented by the fauna of the graptolite beds on which Messrs. Burling and Ruedemann have reported.

Lot XIk46.

Columnaria alveolata Goldf.
Calapoecia canadensis Bill.
Favosites aspera ? d'Orbigny.
Halysites catenulatus var. *gracilis* Hall.
Endoceras cf. *proteiforme* Hall.

A second lot, XIIx37, contains a badly preserved shell which appears to represent a *Maclurea*. This lot should also be referred to the Ordovician if this provisional generic determination is correct."

Concerning the 1911 Ordovician and Silurian remains Dr. Kindle reports:—

"Lot VIIj5[2]. This lot contains in addition to an un-

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[1]Kindle, Edward, M., "The faunal succession in the Port Clarence limestone, Alaska": Am. Jour. of Sci., Vol. XXXII, 1911, pp. 344-346.

[2]The lot number refers to localities on the map used in the performance of the field work.

determined sponge and a poorly preserved *Cladopora*-like coral two well marked species which strongly suggest the Silurian age of the faunule. One of these is a *Meristella* sp. undet. which, so far as can be judged by external characters, is identical with a species in the Wright collection from Glacier bay, Alaska, which has been referred to a late Silurian horizon. The other is a large ostracode valve belonging to an undetermined species of *Leperditia*. This ostracode represents a form distinct from any of the very large species of this group in the Glacier Bay fauna. The evidence afforded by these two species is not, of course, entirely conclusive, but it is sufficient to suggest provisional reference of this fauna to a late Silurian horizon.

"Lot VI148. The collection from this locality includes a small number of species which are listed as follows:—

Favosites cf. *niagarensis* Hall.
Camarotoechia cf. *neglecta* Hall.
Conchidium cf. *greenei* Hall and Clarke.
Conchidium sp. undet.

"In addition to the species listed above two or three species of undetermined bryozoa are present. The *Conchidium* which is comparable with *C. greenei* outranks all of the others combined as regards number of individuals represented. This dominant species of the fauna has, however, more numerous and finer striæ as well as other features which distinguish it from *C. greenei* and doubtless characterize a new species. Although none of the species have been definitely identified with described species the assemblage is of such a character as to leave no doubt as to its Silurian age. It probably represents a middle Silurian horizon and may belong to the Silurian fauna which the writer listed from the Porcupine River valley.[1] A larger collection of fossils would be required to determine the latter point.

"Lot VIc22. The following species in addition to some undetermined corals represent this lot.

Streptelasma sp.
Cladopora sp.
Halysites catenulatus Linn.

———

[1]Kindle, E. M., Bull. Geol. Soc., America, Vol. 19, 1908, p. 325.

Trematospira cf. *camura* Hall.
Bronteus sp.

"With the exception of *H. catenulatus* none of the species has thus far been recognized in the Alaskan faunas. I consider the fauna to be probably of early Silurian age. It appears to be somewhat older than the fauna which has been listed from the Porcupine River locality.[1]

"Lot VIn48. The oldest fauna in the collection is represented by this lot which includes the following species together with some undetermined forms.

Favosites sp.
Calapoecia canadensis Billings.
Halysites catenulatus Linn. var.
Diphyphyllum sp.
Columnaria alveolata Goldfuss ?
Labechia sp.
Striatopora sp.
Dinorthis proavita Winchell and Schuchert.
Murchisonia sp.
Maclurina manitobensis Whiteaves.
Leperditella ? sp.

"There appears to be no species common to the above fauna and the previously listed Silurian faunas. The *Halysites catenulatus* var. of Lot VIn48 is characterized by much smaller corallites than *H. catenulatus* of Lot VIc22. The Favosite coral also has much smaller corallites than the *Favosites* cf. *niagarensis* which has been listed in one of the Silurian faunas of this collection. The poor state of preservation of the material representing this coral does not indicate whether or not it can be discriminated from the Silurian species of *Favosites*. The genera *Favosites*, *Striatopora*, and *Diphyphyllum* have not previously been found associated together in a pre-Silurian fauna so far as the writer is aware. The presence in the fauna, however, of such characteristic Ordovician fossils as *Calapoecia canadensis*, *Maclurina manitobensis*, and *Dinorthis proavita* seems clearly to place the fauna in the Ordovician. The last named species resembles somewhat the Silurian shell *Orthis flabellites* but Mr.

[1]Kindle, E. M., Bull. Geol. Soc. Amer. Vol. 19, 1908, p. 325.

E. O. Ulrich who has examined the specimens considers them identical with the Minnesota representatives of *D. proavita. M. manitobensis* is a characteristic and widely distributed species in the Ordovician of Alaska, occurring in both the extreme eastern and western parts of the territory. *Calapoecia canadensis* is another Ordovician species which has a wide distribution in the northern part of the continent. It is one of the abundant corals in the Ordovician of the Seward peninsula.[1]"

Of the Silurian remains the Stromatoporoids were sent to Professor Parks of Toronto University, certain of the corals were studied by Mr. Lawrence Lambe, and the remaining forms were examined by Dr. Kindle. Professor Parks reports as follows:—

"I find that the material is so badly silicified that exact determinations are questionable, although six out of seven specimens show some evidence of their structure. You will understand that the determinations are provisional only, as such poor material is not to be relied upon.

"VI148. In all probability this form is *Clathrodictyon vesiculosum* Nich. and Murie. It is very widespread, occurring in the Silurian of Europe, the Niagara of America, the Arctic islands and now in the Rocky Mountains.

VIIu11 "*Clathrodictyon vesiculosum* also. This specimen has the laminae rather more widely spaced than typical examples of the species and it approaches somewhat to the variety which is described as *var. minutum* in Niagara Stromatoporoids.

VI148 "This specimen is very badly preserved but it shows some of the structure which is typical of *Clathrodictyon striatellum* d'Orb. I would refer it provisionally to that species.

VI148 "I think this is a new species and offer the following brief description:—

"Coenosteum probably large. Horizontal laminae very thin and slightly undulating. Interlaminar space wide—in most of the section it is only about one-half mm. Vertical elements very badly preserved; they appear to be fairly close together and to present, in places, the double-headed origin characteristic of *C. striatellum*. I know of no other Silurian *Clathrodictyon*

[1]Kindle, E. M., Amer. Jour. Sci., vol. 321, 1911, pp. 344-345.

with the lamina so widely spaced and it is on this feature alone that a new species is proposed—*Clathrodictyon monte*, sp. nov.

VI148 "*Clathrodictyon vesiculosum* Nich. and Murie.

VI148 "The major portion of this specimen shows the structure of *C. vesiculosum* but the fibre is considerably coarser than that of the type specimen. The white superficial portion of the specimen is very badly silicified but it is doubtless referable to the genus *Labechia*; the species is indeterminable.

VI148 "Quite structureless and indeterminable.

"It is rather remarkable that all the specimens with the one exception of the *Labechia* are species of the genus *Clathrodictyon*."

Mr. Lambe reports as follows:—

"Three fragments of fossil coralla, from Dr. Cairnes' Yukon-Alaska Boundary collection of 1911, are determined by me as follows:—

"From locality VIc22.

One specimen of *Favosites gothlandica* Lamarck.

The corallites in this specimen average about 3 mm in diameter, there are numerous flat tabulae, and pores can be obscurely seen in the sides of the walls, but neither in transverse nor in longitudinal sections of the coral can spiniform septa be detected. The species represented is with little doubt *F. gothlandica*.

One specimen which probably is referable to *Favosites* but in which the absence of clearly defined structure renders a definite determination impossible.

"From locality VIu11,

One specimen which apparently belongs to the genus *Boreaster* Lambe.

"This genus has hitherto been known only from the Silurian of Beechey island, Lancaster sound, where it occurs with *Favosites gothlandica* (vide "Notes on the fossil corals collected by Mr. A. P. Low at Beechey islands, Southampton island and Cape Chidley, in 1904," by Lawrence M. Lambe, appendix IV, The Cruise of the Neptune, by A. P. Low.)

"Dr. Cairnes' specimen reveals the presence of septa apparently of the nature of those found in Boreaster, and of mural pores arranged in vertical series. Flat tabulae are numerous and the walls of the corallites are thick with their line of junction in contiguous corallites distinctly shewn in longitudinal sections. In consequence of a decided thickening of the walls the connecting pores are conspicuously lengthened and they appear in longitudinal sections as mural passages whose length is four or five times their diameter. The corallites are generally five or six sided, and their calicular edges are ornamented with a single series of tubercles in which each tubercle represents the union of the upper ends of two septa of contiguous corallites.

"This specimen differs from *Boreaster lowi*, Lambe, the type species of the genus from Beechey island, in the following particulars—the corallites have twice the diameter, the walls of the corallites are much thicker, the tabulae appear to be more numerous as do also the mural pores which are, however, relatively smaller. Dr. Cairnes' specimen may represent a species distinct from *B. lowi* and should be further studied with this possibility in view.

"The horizon indicated by the above fossils is probably a Silurian one. *Favosites gothlandica* is a common Silurian form and the genus *Boreaster* is typically Silurian. As already mentioned *Favosites gothlandica* and *Boreaster lowi* form part of the Silurian fauna of Beechey island. The discovery of *B. lowi* (or a nearly allied species of the genus) in northern Yukon is of interest as it implies that similar conditions affecting marine life prevailed in the north over a very extensive area during Silurian times."

Dr. Kindle reports as follows:—

"The lots which follow represent a fauna which is comparable with the Middle Silurian fauna found in the States adjacent to the Great Lakes. The presence in it of an *Illaenus* closely related to it if not identical with *I. imperator*, *Spherexochus romingeri* and *Spirifer niagarensis*, suggest that a larger collection would show still other resemblances to the Silurian limestone fauna of Indiana and Illinois. This fauna represents the same general horizon as the Silurian fauna which was discovered in eastern Alaska on the Porcupine river.[1] The principal species

[1]Kindle, E. M., "Geologic reconnaissance of the Porcupine valley, Alaska": Bull. Geol. Soc. Am., Vol. XIX, p. 325, 1908.

in the several lots which are considered to represent this general fauna will be listed separately.

Lot XIn44

Conchidium knighti (Sowerby).

Lot XIo45

Camarotoechia cf. *indianensis* Hall.
Camarotoechia? sp.

Lot XIXs28

Pholidops cf. *squamiformis* Hall.
Atrypa sp.
Atrypa cf. *marginalis* Dalman.
Orthis flabellites Foerste.
Dalmanella cf. *elegantula* (Dalman).
Whitfieldella cf. *nitida* Hall.
Anoplotheca sp.
Illaenus cf. *armatus* Hall.

Lot XIXf31

Stropheodonta sp.
Rhipidomella n. sp.
Gypidula? sp.
Clorinda cf. *fornicata* (Hall).
Sphaerexochus sp.
Illaenus cf. *imperator* Hall.

Lot XIXh31

Stropheodonta sp.
Orthis flabellites Foerste.
Dalmanella cf. *elegantula* (Dalman).
Meristina sp.
Spirifer radiatus Sowerby.
Spirifer sp.
Sphaerexochus romingeri Hall.
Illaenus cf. *imperator* Hall.
Brontiopsis sp.

Lot XIXm6

Cladopora sp.
Favosites sp.
Zaphrentis sp.
Camarotoechia (?) cf. *acinus* Hall.

Camarotoechia (?) cf. *indianensis* (Hall).
Atrypa sp.
Atrypina sp.
Nucleospira cf. *pisiformis* Hall.
Trematospira cf. *camura* Hall.
Sieberella n. sp.
Mytilarca (?) cf. *sigilla* Hall.
Platyceras sp.
Orthoceras sp.
Dalmanites sp.

Lot XVIIh13

Camarotoechia cf. *indianensis* (Hall).
Stropheodonta sp.
Atrypa reticularis (Linn.) var.
Spirifer radiatus Sowerby.
Reticularia cf. *proxima* Kindle.
Pterinea, small sp.
Proetus sp.

Lot XIIl30

Favosites gothlandicus Lamark.
Heliolites interstincta (Linn.).
Halysites catenulatus (Linn.) var.
Cyathophyllum sp.

Lots XIIv30, XIIt32, XIIn32, XIIv34, XIIv37, XIIv42, XIIr45

"The preceding small lots of fossils, each representing usually only two or three species, appear to represent the same geologic horizon. They are referred provisionally to a late Silurian horizon chiefly on the evidence of two or three large species of ostracodes which are believed to be of Silurian age. This reference, however, needs the confirmation of additional evidence since the *Martinias* which are in one case associated with the ostracodes suggest a Devonian horizon.

"The fossils represented in these lots include the following.

Stropheodonta, small species.
Meristella sp.
Retzia? sp.
Martinia sp.
Leperditia sp.
Isochilina sp.

"Four other lots and their included fossils which probably represent a late Silurian horizon follow:—

Lot XIh43
 Diphyphyllum sp.
Lot XIr43
 Diphyphyllum sp.
 Encrinurus sp.
Lot XIIv29
 Cyathophyllum sp.
 Alveolites ? sp.
 Leperditia sp.
Lot XIX 27t
 Represented by *Whitfieldella* sp., and *Atrypa reticularis* Linn."

DEVONIAN LIMESTONES.

Distribution.

The Devonian limestones occur mainly in Keele and Ogilvie mountains where they are intimately associated with the Silurian-Cambrian limestone-dolomite beds. These Devonian rocks were identified palæontologically at a considerable number of points and in addition to being rather erratically though not extensively distributed throughout Keele mountains and the areas immediately to the north and south, they have a somewhat extensive development in Ogilvie mountains particularly on the hills immediately south of Ettrain creek and also on the mountains south of Harrington creek.

Lithological Characters.

The Devonian limestones resemble very closely the limestone beds of the Silurian-Cambrian group, and except where fossils can be found it is difficult or impossible in many places, to distinguish these rocks from the older limestones. They are, however, as a rule somewhat more homogeneous and darker in appearance, being typically dark, bluish grey in colour. They are also in most places characteristically coarsely crystalline, and when broken, they generally emit a strong oily odour which was seldom noted in connexion with the underlying formations. In places, a heavy bed or series of beds of white to light grey, sugar-grained quartzite occurs at the base of this limestone series, as in the vicinity of Tindir creek, but this quartzite appears to be only locally developed. These Devonian limestones appear to have an aggregate thickness of from 300 to 500 feet and wherever a contact was observed with the underlying Silurian beds, they overlie these unconformably.

Age and Correlation.

In the northern portion of the belt along the 141st meridian, here under consideration, these Devonian limestones rest upon Silurian limestones and dolomites and are overlain by Carboniferous limestones, cherts, and related rocks, and thus appear to represent a considerable part of, or the entire Devonian period. To the south, however, in the vicinity of Harrington creek, they include only middle or lower Devonian beds. These overlie Silurian-Cambrian limestones and dolomites, as to the north, but they are overlain by Devonian shales, cherts, and related beds presumably of upper or middle Devonian age. The Devonian limestones were not identified more than a short distance south of Harrington creek, whence southward the Devonian is represented by shales, cherts, and related sediments. The calcareous beds, toward the south, thus gradually give place in a time sense to more argillaceous, arenaceous, and siliceous sediments.

These Devonian limestones, particularly in Keele mountains, correspond closely to the Salmontrout limestone on Porcupine river as described by Kindle[1], and the two formations may be the same. It would seem probable, however, that the Salmontrout limestone as originally defined does not include all the Devonian limestones along the Boundary line, and thus the name is not sufficiently comprehensive to apply to the beds here described.

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[1]Kindle, E. M., Bull. Geol. Soc. Am., Vol. XIX, Oct. 1908, pp. 327-329.

The fossils obtained from these limestones have been described by Dr. Kindle as follows:—

"The Devonian fauna is represented by twenty-two lots of fossils. While the individual lots do not include a great amount of material, they represent a considerable number of localities and it is significant that none of the several lots include any characteristic upper or lower Devonian forms. There is for example no trace of either *Spirifer disjunctus* or *Sp. whitneyi*, which have a very wide distribution in the late upper Devonian throughout North America; nor are there any representatives present of the strongly plicated Spirifers or other peculiar forms of the lower Devonian. The fauna appears to be referable to a middle Devonian or early upper Devonian horizon and there appears to be no doubt that most of the lots representing this fauna are identical with the Devonian fauna which was found by Kindle[1] in the Salmontrout limestone on the Porcupine river. The same fauna has been collected by Brooks and Kindle on the Yukon opposite Woodchopper creek.[2] The presence of *Atrypa* cf. *flabellata* Goldf. and other peculiar undescribed species in both the Boundary collections and those from the Porcupine and Yukon rivers, places this correlation on a secure basis and indicates a wide distribution of the Samontrout limestone within the large triangular area bounded by the Porcupine, the 141st meridian, and the Yukon river.

This Devonian collection includes two lots which may or may not represent a formation distinct from the Salmontrout limestone. They appear to belong in a middle Devonian horizon, but the absence from these lots of any species tying them to the others suggests the propriety of provisionally treating them as possibly belonging to a distinct formation.

In the following list of the Devonian fauna the species are listed under the locality numbers assigned to the various lots during the progress of the survey. These lots are found to be divisible into three groups:—

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[1]"Geologic reconnaissance of the Porcupine valley, Alaska;" Bull. Geol. Soc. Amer., Vol. 19, 1908, pp. 327-329.

[2]"Palæozoic and associated rocks of the Upper Yukon, Alaska": Bull. Geol. Soc. Amer., Vol. 19, 1908, p. 283.

(1) Those referable to the horizon of the Salmontrout limestone on Porcupine river, and comprising lots XIm45; XVIIh,i,18,19; XVIIh, i, 19; XVIIi, 13, 14; XVIIi, 15, 16; XVIIj, 16, 17; XVIIj, k, 16; XVIIp, 4, 5; XIXd22; XIXh19; XIXh, i, j, 22, 23; XIXi20; XIXp10; and XIXq23;

(2) Those which appear to belong to a middle Devonian horizon but which may represent a formation distinct from the Salmontrout limestone, as follows: XVa, b, 35; and XVIIj15; and

(3) In a few cases the fragmentary character of the material or the limited number of species present precludes a definite statement concerning the horizon represented. The following lots have thus been provisionally referred to the Devonian:—XIIl41; XIIp, q, 24, 25; XIIv33; XIIw33; XVIIp, 4, 5; XVIIp 5.

Group 1. Lots referable to the Salmontrout limestone—

Lot XIm45

Lingula sp.
Camarotoechia sp.
Stropheodonta sp.
Gypidula sp.

Lot XVIIp4,5

Favosites sp.
Camarotoechia sp.
Pugnax cf. *pugnus* (Martin).
Atrypa reticularis Linn. var.
Leptaena rhomboidalis (Wilck).
Schizophoria striatula (Schlot.).
Reticularia sp.
Anoplotheca cf. *acutiplicata* (Con.).
Platyceras sp.
Cytherella sp.
Cyphaspis cf. *bellula*

Lot XVIIj16, j17, i16, i15

Atrypa reticularis (Linn.).
Atrypa spinosa Hall.
Schizophoria striatula (Schlot.).
Reticularia? cf. *subundifera* (M. and W.).

Reticularia sp.
Athyris ? n. sp.

Lot XVIIj, k16
Zaphrentis sp.
Favosites sp.
Stropheodonta sp.
Atrypa reticularis (Linn.).
Schizophoria striatula (Schlot.).
Gypidula sp.

Lot XVIIh19, i19
Crinoid stems
Productella sp.
Atrypa reticularis (Linn.).
Reticularia cf. *laevis* (Hall).
Reticularia cf. *subundifera* (M. and W.).
Nucleospira sp.
Fish bone

Lot XVIIi14, i13
Cyathophyllum sp.
Atrypa reticularis (Linn.).
Camarotoechia contracta Hall ?
Stropheodonta arcuata Hall.
Reticularia sp.
Nucleospira n. sp.
Proetus sp.

Lot XVIIh, i, 18, 19
Favosites cf. *basaltica* Goldf.
Favosites cf. *canadensis* (Billings).
Alveolites sp.
Schizophoria striatula (Schlot.).
Chonetes sp.
Atrypa reticularis (Linn.).
Martinia cf. *maia* (Billings).
Nucleospira sp.
Proetus sp.

Lot XIXh19
Zaphrentis sp.
Atrypa reticularis (Linn.).

Stropheodonta sp.
Camarotoechia sp.
Meristella ? sp.
Meristella cf. *laevis* (Vanuxem).
Pugnax pugnus (Martin) var.
Gypidula sp.

Lot XIXi20
Productella cf. *spinulicosta* Hall.
Stropheodonta sp. (identical with *Stropheodonta* sp. in XIXh19.)
Atrypa reticularis (Linn.).
Schizophoria striatula (Schlotheim).
Gypidula sp.

Lot XIXp10
Cyathophyllum ? sp.
Atrypa reticularis.
Leptaena rhomboidalis (Wilck.).
Spirifer sp.

Lot XIXq23
Fenestella sp.
Atrypa reticularis (Linn.).
Atrypa cf. *flabellata* Goldf.
Stropheodonta cf. *arcuata* Hall.
Conocardium cf. *cuneus* Conrad.

Lot XIXi, j, h, 23, 22
Atrypa reticularis (Linn.).
Stropheodonta sp.
Schizophoria striatula (Schlot.).
Cryphaeus ? sp.

Lot XIXd22
Cyathophyllum cf. *quadrigeminum* Goldf.
Crinoid stems.
Atrypa reticularis (Linn.).
Camarotoechia sp.
Gypidula sp.
Conocardium cf. *cuneus* Conrad.
Platychisma ? sp.

Group 2.—Lots which may represent a formation distinct from the Salmontrout limestone.

Lot XVa, b, 35

Cladopora cf. *dichotoma* Hall.
Phillipsastraea verneuilli M Edwards.
Proetus cf. *macrocephalus* Hall.

Lot XVIIj15

Productella ? sp.
Atrypa sp. nov. ?
Martinia cf. *Maia* Bill.
Stropheodonta sp.
Proetus cf. *macrocephalus* Hall.

Group 3.—Lots provisionally assigned to the Devonian.

Lot XVIIp5

Favosites sp.
Camarotoechia sp.
Hercinella ? sp.

Lot XVIIp4, 5

Cyathophyllum cf. *quadrigeminum* Goldf.
Favosites sp.

Lot XII141

Favosites cf. *hemisphericus* Yandell and Shumard.
Cladopora cf. *criptodens* Billings.

Lot XIIv33

Atrypa reticularis (Linn.).

Lot XIIw33

Stropheodonta sp.
Proetus sp.

Lots XIIp,q,24,25

Section of gasteropod shell.
Dalmanites ?

DEVONIAN-ORDOVICIAN SHALE-CHERT GROUP.

Distribution.

The most northerly development of the members of the Devonian-Ordovician shale-chert group that was identified within the Boundary belt here under consideration, occurs along the southern and eastern edges of Jones ridge, immediately to the north of Harrington creek. Thence southward for about 25 miles or to within 6 miles of the crossing of the 141st meridian by Yukon river, these shale-chert beds have a fairly extensive development and comprise quite a percentage of the total rock outcrops.

Lithological Characters.

This series consists dominantly or entirely of shales and cherts which are prevailingly closely and finely interbedded. The cherts in places become really cherty shales or shaly cherts and occur in most places in beds ranging in thickness from 1 to 6 inches. Locally, however, they are more thinly bedded, and occasionally, on the other hand, they are in strata as much as 12 inches thick. They are also generally dark grey to black in colour. The shales are also typically thinly bedded, and in most places are soft and friable and grey to black or bluish black in colour, the darker beds being in places decidedly calcareous in character. Occasional red shales also occur, however, locally intercalated with the darker strata, but these do not appear to be very persistent, or at least the colour is not. Hard grey, quartzitic shales are in addition somewhat extensively developed in places. These quartzitic beds contain locally sufficient iron to produce upon oxidation a bright red to yellow coloration on weathered surfaces, but only rarely are these rocks red on a fresh fracture. These reddish beds decompose readily to form a red or yellowish sand or mud, which is a very noticeable feature of many of the hillsides on which vegetation is lacking.

Along Harrington creek where these shale-chert beds are well exposed they have a red and black and in places even a decided ribboned appearance. The chert bands are generally from one-half to 2 inches in thickness and are finely interbedded with the shales. All the beds of the entire section are black or nearly so, but certain alternate layers weather red in places. The chert beds also in places become shaly or even friable when exposed to the atmosphere, and decrepitate somewhat readily.

In places these shale-chert beds have fairly regular dips and strikes, but being soft and readily pliable and easily distorted they are locally very much deformed. Along Harrington creek and Tatonduk river these beds are much folded, crumpled, contorted, and broken, so much so, that no idea of their general altitude could be there obtained.

Along Harrington creek where these beds include only Devonian members, they appear to have a thickness of about 500 feet or more, but farther south on McCann hill where they include Devonian, Silurian, and Ordovician members, they have a thickness, when measured, of approximately 1400 feet.

Hills on which members of this shale-chert group outcrop, are in many places brightly coloured and characterized by well rounded forms and gentle slopes. The black, greyish, yellowish, and red beds with their oxidation products, also form a striking pictorial feature of the landscape, the red exposures constituting distinctive landmarks easily recognizable for great distances.

Age and Correlation.

In the vicinity of Harrington creek these shale-chert beds contain Devonian fossils and directly overlie middle or lower Devonian limestone beds. They are in turn overlain by Carboniferous shales. A few miles farther south, on McCann hill, these same shale-chert beds are overlain by Carboniferous shales as to the north, but, however, directly overlie Ordovician limestone-dolomite beds, and themselves contain Ordovician fossils. During 1913 Mr. L. D. Burling made collections from several horizons in these Ordovician beds and found them to contain both Devonian and Ordovician fossil horizons at several points between Harrington creek and McCann hill. Thus, toward the south, these shale-chert beds rapidly replace the limestone-dolomite beds in an age sense, and range from the Ordovician to the Devonian.

The writer obtained some plant remains from these beds along the north bank of Tatonduk river near the Boundary line, which were examined by Dr. David White of the United States Geological Survey, who reports concerning one of these, as follows: "The specimen represents the cast of part of the trunk of a stem or tree, a part of the cortical tissue being represented by adhering coal. External characters are wanting and the fragment is too incomplete for specific identification. It appears, however, to represent the basal portion of a small stem of Archaeosigillaria. The fragment offers no features adequate as a basis for an opinion of value as to whether it is Devonian or basal Mississippian. On account of its mere "looks" I am slightly inclined to regard it as upper Devonian."

Shales and cherts similar to certain members of this group are exposed on Calico bluff facing Yukon river, and there underlie Carboniferous beds of the Calico Bluff formation. About 500 feet of these shales and cherts near the base of Calico bluff have been assigned to the upper Devonian[1]. It would seem quite possible, or even probable, however, that these beds also include members much lower in the geological column than upper Devonian, as do the apparently equivalent stratigraphical members along the International Boundary a few miles to the east.

CARBONIFEROUS AND PERMO-CARBONIFEROUS.[2] (?)

General.

Two geological formations or rock groups are developed which throughout the greater part, at least, of the Boundary belt, are lithologically quite distinct and different, but which appear to occupy the same stratigraphic position, and are both definitely of Carboniferous age. These are here for convenience designated as the shale and limestone-chert groups, respectively, and in the vicinity of Ettrain creek toward the southern end of the belt, there appears to be a somewhat rapid transition from one group to the other. These beds are all overlain in places

[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. 286-291.

[2]Some writers now include the Permian of North America in the Carboniferous, see:—

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

by the members of the Nation River formation and associated superjacent beds, which are also considered to be all of Carboniferous age, but may include some Permian members. In addition, there occurs in one locality, a peculiar conglomerate which resembles a glacial till. The age of this conglomerate is somewhat in doubt, but it is provisionally assigned to the Permo-Carboniferous.

Each of these individual groups or formations will now be separately described as regards their distribution. lithological characters, and general age characteristics. Afterwards detailed descriptions concerning the ages and correlations of these different geological groups, as well as lists of fossils found in them, will be included together in a single section dealing with all these rocks. By so doing the ages of these various rock groups which are so closely related, can be more clearly shown than would be possible if the ages were discussed in separate sections combined with other descriptions of the respective formations.

On the geological map accompanying this memoir, the shale group is combined with the Devono-Ordovician shale-chert group; and the Nation River formation and superjacent beds are mapped with the Mesozoic members; but the limestone-chert group, to which the name Racquet group was formerly applied, is given a distinct geological colour.

Shale Group.

The shale group within the mapped Boundary belt here being considered, is developed at a number of points between Jones ridge and Yukon river, and wherever identified overlies the members of the Devono-Ordovician shale-chert group. Possibly the most extensive individual development of these Carboniferous shale beds occurs just to the north of Harrington creek, where they compose the greater part of a low north-easterly trending ridge to the east of the Boundary line and to the south and east of Jones ridge. These beds were also identified on McCann hill and at other points, but become rapidly much less prominent to the south of Harrington creek.

On the geological map to accompany this memoir, these

Carboniferous shale beds have been mapped with the members of the Devono-Ordovician shale-chert group, as except where fossils were obtainable, it was in many places difficult or impossible in the field to distinguish certain members of these rock groups, as both contain beds that are lithologically practically identical.

This shale group consists dominantly of shales, but includes also clays, cherts, calcareous sandstones, and thinly bedded limestones. The shales and clays are prevailingly soft and friable and range in colour from light grey to black, but dark bluish grey beds are possibly the most extensively developed. The cherts are dominantly dark grey to black in colour, but constitute a much smaller portion of this formation than the shale members. They occur prevailingly in beds having a thickness of less than 1 inch, but chert strata were noted which are as much as 3 inches or more in thickness. Calcareous sandstones and arenaceous clays are also developed in places and are typically greyish to brownish in colour. The limestones generally occur in beds less than 12 inches thick and range in colour from light grey to brown. This shale section has thus quite a decidedly striped or ribboned appearance due to the frequently alternating shale, limestone, and sandstone beds.

The members of this shale group north of Harrington creek have an aggregate thickness of at least 800 feet, but to the south this formation becomes rapidly thinner and on the north face of McCann hill is represented by less than 10 feet and possibly not more than 2 feet of shales.

The general section of these beds to the north of Harrington creek, along Tatonduk river, and elsewhere, very closely resembles, lithologically, the Carboniferous portion of the Calico Bluff section on Yukon river a few miles to the west of the Boundary line. However, these Calico Bluff beds are considered by Dr. Girty of the United States Geological Survey, who has examined the fossils from them, to be of Mississippian age, whereas all the fossils that were obtained from the members of the shale group along the International Boundary are considered by Dr. Girty to be of Russian Gschelian or Pennsylvanian age. Since, however, these shale beds rest on Devonian shales and cherts it would seem to be quite possible that Mississippian members are also included in the shale group, although the writer unfortunately failed to obtain any fossil remains from these beds if such occur.

Limestone-Chert Group.

The members of the limestone-chert group, within the Boundary belt here being considered, occur only to the north of Jones ridge and were identified mainly in two localities. The more northerly of these areas occurs between Runt and Bern creeks, where throughout a distance of 7 or 8 miles the limestone-chert rocks are fairly extensively developed, mainly to the east of the Boundary line. The more southerly main development of these beds occurs some 50 miles farther south in the vicinity of Ettrain creek, where for about 5 miles, mainly to the east of the International Boundary, these sediments constitute a considerable portion of the bedrock exposures. Thus the aggregate areal distribution of the members of this group within the mapped Boundary belt between Yukon and Porcupine rivers is relatively small.

This group consists mainly of limestone and cherts, but includes also occasional beds of dark shale, calcareous sandstone, and cherty conglomerate. The limestone beds are generally quite crystalline and range from nearly white through various shades of grey to almost black in colour; on fresh fractures, however, these rocks are typically dark bluish grey to nearly black. The upper limestone beds in places contain chert pebbles which are sufficiently abundant in places to constitute typical cherty conglomerates. The chert pebbles are well rounded and usually about the size of marbles, but some were noted as large as 1½ to 2 inches in diameter. In colour, most of the pebbles are some shade of grey, but occasional black individuals were noted. In places, also, thin beds of chert similar in appearance to the pebbles, occur intercalated with the limestones, and particularly in the vicinity of Ettrain creek, this formation is characteristically composed of closely interbedded limestones and cherts, the limestone beds ranging in most places from 4 to 12 inches in thickness, and the chert beds being dark grey to almost black in colour and ranging in thickness from 2 to 6 inches. Occasional beds of dark shale also occur, but as these weather very readily they are nowhere prominent and were seldom seen. Toward the south, in places, this group also includes occasional intercalated beds of fossiliferous calcareous sandstone. The members of this group have an aggregate thickness in places of at least 1,500 feet.

The members of this limestone-chert group overlie the Devonian limestones, underlie the Nation River beds, and contain both Pennsylvanian and Mississippian fossils. This group includes thus the Gschelian horizon represented by the fossils obtained from the shale group to the south, and is apparently the stratigraphic equivalent of this formation, although as previously mentioned, no Mississippian fossils were actually obtained from the members of the shale group. Thus, although these two rock groups at most points where they have been identified present very distinct and different lithological aspects, they must somewhere merge one into the other. In the vicinity of Ettrain creek, the limestone-chert group includes in places numerous intercalated shale and calcareous sandstone beds and resembles the shale group more than at any other point where it was observed. The transition is, therefore, probably somewhere near this locality.

Nation River Formation and Superjacent Beds.

The members of the Nation River formation and the associated superjacent beds resemble closely in places the overlying Mesozoic sediments, and in numerous localities where fossils could not be found it is uncertain to which of these formations the different beds belong. Consequently on the accompanying geological map these two rock groups have been mapped together. The members of the Nation River formation were, however, definitely identified, palæntologically, at a number of points and are known to be somewhat extensively developed along the Boundary line between Yukon and Porcupine rivers.

The most northerly point at which Nation River beds are known to occur within this Boundary belt is situated about 15 or 16 miles south of the Porcupine where these rocks are exposed throughout a small area. Between Runt and Bern creeks, some 60 miles farther south, Mesozoic beds were identified and Nation River members or the associated overlying sediments probably occur. Between Orange and Ettrain creeks, however, a distance of over 50 miles, the bedrock exposures in most places consist entirely of Mesozoic and the Nation River and superjacent beds, and the Nation River members were identified at a number of points. From the northern edge of McCann hill to Yukon river, also, a distance of 16 or 17 miles, the Nation River beds are quite extensively developed, and for over 5 miles southward from the summit of McCann hill comprise practically all the rock outcrops.

The Nation River formation and superjacent beds consist dominantly of conglomerates, sandstones, and shales, but include also occasional beds of limestone. The pebbles in the conglomerate are composed dominantly of chert, and range in most places from about $\frac{1}{32}$ of an inch to 1 inch in diameter. The sandstones are characteristically greyish to brownish, medium textured, hard, firm rocks which weather prevailingly to a brownish colour. Occasional yellowish or reddish appearing sandstones, however, also occur. The shales are dominantly greyish to yellowish in colour and range in character from friable to hard and somewhat slaty, and from quite fine to coarse and arenaceous, grey arenaceous beds being extensively developed along Yukon river. The limestones are, wherever seen, light grey, semicrystalline to crystalline beds having a very typical limestone appearance; these occur as occasional, generally thin beds intercalated with the more arenaceous and argillaceous sediments.

The lowest member of this terrane is, wherever seen, a heavy massive conglomerate, and on McCann hill this basal member is about 60 feet in thickness. Overlying this basal conglomerate on McCann hill are about 230 feet of brownish to nearly black sandstones of the same composition, dominantly, as the conglomerate, but in a finer state of comminution. These sandstones are followed by a second conglomerate bed 25 to 30 feet thick, which is in turn overlain by sandstones, shales, and occasional intercalated conglomerate beds. These two lower conglomerate beds appear to be quite persistent, and characterize the bottom of the formation along the Boundary, particularly from McCann hill southward. Here also this terrane wherever seen consists throughout dominantly of cherty conglomerates in beds ranging in thickness prevailingly from 6 to 10 feet, which are intercalated or interbedded dominantly with brownish to black coarse sandstones and shales similar in composition apparently to the conglomerates but in a finer state of comminution, the beds having an aggregate thickness of about 4,000 feet. As no limestone beds were noted in this formation from McCann hill southward, it is thought to be altogether probable that only the lower or Nation River members here occur. To the north of McCann hill, however, occasional limestone beds or bands are intercalated with the other sediments of this terrane which has there an aggregate thickness of about 2,400 feet.

From McCann hill southward, the sandstones and shales, in places, contain plant remains, but otherwise the members of this formation, there, were not found to be fossiliferous, and are correlated with the Nation River formation on account of their lithological resemblance to the members of this formation elsewhere, and also on account of the general appearance of the contained plant remains, although none of the specimens that were obtained were definitely determinable. To the north of McCann hill the argillaceous and arenaceous members included in the Nation River formation and the associated superjacent beds also lithologically resemble the Nation River members along Yukon river, and the intercalated limestone beds, in most places, contain invertebrate remains which have been identified by Dr. Girty as belonging to a limestone horizon which outcrops on the Yukon river and there overlies and marks the upper limit of the Nation River formation as originally defined[1].

The Nation River beds of the original locality were described as carrying only somewhat imperfect plant remains,[2] but which by David White were thought to be quite possibly of Carboniferous age. The fossils obtained by the writer from the

[1]Brooks, A. H., and Kindle, E. M., "Palæozoic and associated rocks of the Upper Yukon": Bull. Geol. Soc. Amer., Vol. XIX, 1908, p. 294.

[2]Op. cit., p. 295.

intercalated limestone beds above mentioned are by Dr. Girty stated to be of either Artinskian or Gschelian age. The Artinskian is by some considered to be Permian and by others Pennsylvanian. The Gschelian is definitely Pennsylvanian. One or more of the limestone beds or bands along the Boundary probably corresponds to the limestone horizon that occurs on Yukon river and is there thought to overlie the Nation River formation. Thus, since pre-Mesozoic argillaceous and arenaceous sediments overlie these limestones along the Boundary, these, as well as the calcareous beds, are considered to be probably more recent than the members of the Nation River formation as originally defined.

Conglomerate.

On the extreme western edge of the belt under consideration along the Yukon-Alaska Boundary line, and just north of Tatonduk river, a peculiar conglomerate is developed. This extends over an area only about 1 mile in diameter, within the mapped area, but was seen to have a more extensive development to the west.

This conglomerate is at least 700 or 800 feet in thickness, and consists dominantly of a firm, somewhat dense, finely textured, reddish, argillaceous matrix, in which are embedded angular to subangular pebbles and boulders ranging in size from microscopic to 3 or 4 feet in diameter. The matrix appears to have approximately the composition of a boulder clay, and the greater number of the pebbles and boulders are composed of limestone or dolomite, but some were noted composed of other sediments such as sandstone, conglomerate, and shale.

The prevailing red colour of the matrix is due mainly at least to the considerable amount of iron contained in the matrix which has in places the general appearance of a hematite ore. The conglomerate, where exposed on a small tributary of Tatonduk river, is quite unstratified and has the general appearance of a consolidated and iron-stained boulder clay. The pebbles and boulders are irregularly distributed and are often quite isolated and completely surrounded by the matrix, instead of resting upon one another as in the case of a normal conglomerate.

This conglomerate is thus undoubtedly of terrestrial origin —the term terrestrial being used to imply deposition on the land in contrast to deposition in the sea or on the seashore. Land deposits may, however, be formed in numerous ways, mainly by the action of lakes, rivers, winds, glaciers, and volcanoes, as well as by weathering, creepage, or sliding. Of these, considering the thickness of this conglomerate, its unstratified condition, and the irregular distribution, composition, angularity, and size of the pebbles and boulders, the only two modes of origin which appear to at all satisfy the field observations are glacial action and creepage or sliding.

In general composition, this conglomerate appears to much more resemble a boulder clay than it does slide material, but on the other hand, its prevailing reddish colour, and the fact that this conglomerate has not been previously described as occurring in Yukon or Alaska, so far as the writer is aware, and is thus probably not very extensive, would tend to disprove the glacial theory of origin. Also, no striated pebbles were found; this may, however, be due to the fact that since the pebbles are dominantly composed of soft materials such as limestones and dolomites, the scratches, even if they ever existed, might readily have become obliterated. Further, due to peculiar circumstances, the writer was able to examine this conglomerate in only one very limited area, and could devote only a few hours to the examination, thus striated pebbles may well occur and not have been found. Pebbles having facetted surfaces, much resembling "soled" pebbles, were, however, noted to be somewhat plentiful. Due to its prevailing colour, also, this conglomerate could be seen to extend for several miles to the west of the area examined, showing it to be somewhat extensive for slide material. This, taken in conjunction with the thickness of the conglomerate, rather favours the glacial theory again. Thus until more evidence has been obtained, the origin of this conglomerate must remain an open question.

This conglomerate overlies the Devono-Cambrian limestone-dolomite beds and appears also to overlie Carboniferous shales and the Devono-Ordovician shale-chert group and to stratigraphically correspond to the Nation River formation, but of this the evidence is not conclusive. The conglomerate was thus probably formed about Carboniferous time, and may correspond to the Permo-Carboniferous tillites or conglomerates considered to be of glacial origin, that occur in South Africa, Australia, India, and other parts of the world.[1]

Age and Correlation.

During 1911 the writer collected a number of invertebrate remains from the members of the limestone-chert group which was then named the Racquet group.[2] These fossils have been examined by Dr. George H. Girty of the United States Geological Survey, who reports finding evidence of two faunas in the Carboniferous material forwarded to him, and states: "One is represented by lot IIIl11, while the other is represented by all the remaining collections, though some are so undiagnostic that nothing definite can be said of them. Such, for instance are lots IIIj15sw and IIIm10.

"Lot IIIl11 seems to contain a fairly varied fauna, amongst which the only really diagnostic species is *Spiriferella arctica*. If rightly identified and though not quite typical it seems to me, this fossil would indicate the horizon found on the Yukon near Nation river. This fauna is of Pennsylvanian age and appears to be nearly related to the Gschelian of Russia."

The horizon on Yukon river referred to by Dr. Girty, is the limestone horizon which overlies the Nation River formation. Dr. Girty continues:—

"The large group of collections remaining which, though they show more or less difference of facies, appear to belong together, I can after careful consideration only regard as of upper

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[1]Coleman, A. P., "Glacial periods and their bearing on geological theory": Bull. Geol. Soc. Amer., Vol. XIX, 1908, pp. 349-353.

Hatch, F. H., and Corstorphine, G. S., "The geology of South Africa": London, 1905, pp. 199-210.

Rogers, A. W., "An introduction to the geology of Cape Colony": 1905, pp. 147-179.

[2]Cairnes, D. D., "Geology of a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers": Geol. Surv., Can., Sum. Rep. for 1911, pp. 30-31.

Mississippian age. On the Porcupine they would probably belong with the rocks of the Upper Ramparts (see page 334 of paper by Kindle, Bull. Geol. Soc. Amer. Vol. XIX). Mr. Maddren of this Survey referred to me some excellent collections from this locality (the ones previously mentioned), and they show distinct faunal relationships with yours. On returning to a study of this fauna, however, I am revising the age determination which was originally given as Pennsylvanian, though I do not wish to commit myself to this change until certain stratigraphic relations shall be ascertained by Mr. Maddren. In this connection you should understand that these Alaskan faunas of the Carboniferous are so different from those of the United States, especially from the best known ones of the Mississippi valley, that they are full of pitfalls for the palæontologist."

"The following lists show the species which I have identified in each of the collections:—

"IIq39

Spirifer striatus (Martin) ?

IIq40

Lithostrotion ? sp.
Anisotrypa sp.
Rhipidomella ? sp.
Productus semireticulatus (Martin).
" aff. *pileiformis* McChesney.
" " *Arkansanus*
Camaroteochia ? sp.
Moorefieldella Eurekensis (Walcott) ?
Spiriferella ? sp.
Bellerophon sp.

IIr41

Crinoidal remains
Productus aff. *inflatus* McChesney.
Spirifer striatus (Martin) ?

IIIj15sw

Crinoidal remains
(See IIIt4 centre).

IIIl11

Favosites ? sp.
Fistulipora ? sp.

Lioclema ? sp.
Fenestella sp.
Cystodictya ? sp.
Derbya sp.
Productus aff. *Gruenewaldti*
Spiriferella arctica

IIIm10

Crinoidal material
Derbya ? sp.
Spirifer sp.

IIIp8

Productus aff. *inflatus* McChesney.

IIIt4

Syringoclemis sp.
Batostomella ? sp.
Polypora sp.
Fenestella sp.
Pugnax mutata Hall.
Girtyella ? sp.
Eumetria Verneuiliana Hall.

IIIt4 centre

Crinoidal material
Productus sp. (–P. aff. *Arkansanus* (?)).
Edmondia sp.
Aviculipecten n. sp.
Aviculipecten sp."

The fossils collected in 1912 from the members of the Nation River formation and the superjacent pre-Mesozoic beds as well as from the limestone-chert and shale groups were also examined by Dr. Girty who reports: "These fossils 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, XVIk15, XVIIf42, XVIIn34. To the second group may be referred lots XIIi25, XIVs43, XVc40, XVIj9, XVIk10, on high saddle between XVIl8 and XVIk12. XVIIa38, 39, XVIIa,b33, XVIIe27, XVIIj30, XIXc,d30, 31, 32, XIXe30.

"Of these collections lots XIIi25, XVc40, XVIj9, XVIk10, on high saddle between XVIl8 and XVIk12, and XVIIa38, 39 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."

The following is the list of fossils examined:—

XIi23

Fenestella 3 sp.
Lingulidiscina sp.
Derbya sp.
Chonetes aff. *variolatus* d'Orb.
" aff. *Geinitzianus* Waagen.
Productus aff. *Mammatus* Keys.
" " *Humboldti* d'Orb.
" " *Gruenewaldti* Stuck.
" " *Koninckianus* Vern.
" " *Wallacianus* Derby.
" " *tenuistriatus* Vern.
Tegulifera ? aff. *Uralica* Tscher.
Pugnax Rockymontanus Marcou ?
Rhynchopora aff. *variabilis* Stuck.
" " *Nikitini* Tscher.
Spirifer aff. *rectangulus* Kut.
" " *Nikitini* Tscher.
Aviculipecten 4 sp.
Griffithides sp.

XIIi25

Spirifer aff. *striatus* Martin.

XIVs43

Favosites sp.
Zaphrentis sp.
Crinoidal fragments
Fenestella sev. sp.
Hemitrypa? sp.
Spirifer aff. *marcoui* Waagen.
Martinia? sp.

XVc40

Fenestella sp.
Polypora sp.
Cliothyridina aff. *pectinifera* Sow.

XVIj9

Zaphrentis sp.
Marginifera? sp. aff. *involuta* Tscher.

XVIk10

Fenestella sp.
Pinnatopora sp.
Cystodictya sp.
Hustedia aff. *indica* Waagen.
Mainly from XVIk10.
On high saddle between l8 and k12.
Zaphrentis sp.
Fenestella sp.
Productus aff. *tenuistriatus* Vern.
" " *inflatus* McChes.
Myalina aff. *Keokuk* Hall.

XVIk15

Chonetes aff. *variolatus* d'Orb.
Productus aff. *mammatus* Keys.
Rhynchopora aff. *Nikitini* Tscher.
Spiriferina sp.
Aviculipecten? sp.

XVIl9

Fenestella sp.
Chonetes sp.
Marginifera? aff. *involuta* Tscher.
Reticularia aff. *lineata* Martin.
Spirifer sp.
" aff. *Nikitini* Tscher.
Aviculipecten sp.
" ? sp.

XVIIa38, 39

Chonetes sp.

XVIIa, b33

Batostomella sp.
Productus aff. *tenuistriatus* Vern.
" sp. undet.
" aff. *curvirostria* Schell.
Liorhynchus sp.
Paraparchites sp.

XVIIb39

Zaphrentis sp.

Chaetetes? sp.
Lithostrotion? sp.

XVIIe27

Productus aff. *curvirostris* Schell.
" " *pustulatus* Keys.
" " *cancriniformis* Tscher.
" sp.
Camarophoria sp.

XVIIf42

Polypora sp.
Chonetes sp.
Productus aff. *aagardi* Toula.
" n. sp.
Rhynchopora aff. *Nikitini* Tscher.

XVIIj30

Amplexus sp.
Fenestella sp.
Productus aff. *Gruenewaldti* Stuck.
" " *Juresanensis* Tscher.
" " *tenuistriatus* Vern.
" " *porrectus* Kut.
Marginifera? aff. *involuta* Tscher.
Composita aff. *trinuclea* Hall.
Platyceras sp.

XVIIn34

Chonetes aff. *ostiolatus* Girty.
Productus aff. *aagardi* Toula.
" n. sp.
Rhynchopora aff. *Nikitini* Tscher.

XIXb3

Chonetes aff. *variolatus* d'Orb.
Productus aff. *porrectus* Kut.
" " *Humboldti* d'Orb.
" " *Wallacianus* Derby.
" sp.
Spirifier aff. *cameratus* Martin.
" " *Nikitini* Tscher.

XIXb, c35 to 37

Chonetes aff. *variolatus* d'Orb.
Productus aff. *Humboldti* d'Orb.
" " *Wallacianus* Derby.
Spirifer aff. *Nikitini* Tscher.

XIXc, d30, 31, 32

Michelinia sp.
Zaphrentis 2 sp.
Batostomella sp.
Polypora 3 sp.
Derbya? sp.
Rhipidomella sp.
Chonetes sp.
Productus semireticulatus Martin.
" sp.
" aff. *pustulatus* Keys.
" " *cancriniformis* Tscher.
Marginifera aff. *involuta* Tscher.
Spirifer aff. *fasciger* Keys.
Spirifer aff. *Nikitini* Tscher.
" " *Tastubensis* Tscher.
" " *Condor* d'Orb.
Squamularia aff. *perplexa* McChes.
Spiriferina sp.
Cliothyridina aff. *pectinifera* Sow.
Hustedia aff. *Indica* Waagen.
Aviculipecten sp.
Pleurotomaria sp.
Orthoceras sp.

XIXe30

Favosites sp.
Zaphrentis sp.
Polypora sp.
Batostomella sp.
Lingula aff. *albapinensis* Walcott.
Rhipidomella sp.
Schuchertella aff. *Chemungensis* Conrad.

Chonetes aff. *Geinitzianus* Waagen.
" " *variolatus* d'Orb.
" sp.
Productus aff. *porrectus* Kut.
" " *cancriniformis* Tscher.
" " *fasciatus* Kut.
" " *Juresanensis* Tscher.
Marginifera? aff. *involuta* Tscher.
Spirifer sp.
Squamularia aff. *perplexa* McChes.
Aviculipecten 2 sp.
Pleurotomaria sp.
Paraparchites sp.

Draw near XIXi4
Chonetes aff. *ostiolatus* Girty.
Productus aff. *Humboldti* d'Orb.
Camarotoechia sp.

Of the above collection, with few exceptions where the fossils are poorly preserved and doubtful, those of lot XIi23 and related lots belong to the Nation River formation and associated superjacent beds and those of lot XIIi25 and related lots belong to either the limestone-chert or shale groups—lot XIi23 being considered by Dr. Girty to represent a somewhat higher horizon than lot XIi25.

In a later communication Dr. Girty writes: "It may interest you to know in this connection that I have recently had a visit from Dr. Olaf Holtedahl of Christiania, 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 (i.e., the fauna of the limestone horizon occurring near Nation River but stratigraphically above the Nation River formation) 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."

The Pennsylvanian beds found along the Boundary correspond lithologically and palæontologically with similar sediments mapped and studied by the writer in Upper White River district in 1913.[1] Concerning the fossils collected from these beds in Upper White River district, Dr. Girty reports: "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 represented 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 collections belonging with XIIi25) the second of the faunal facies of the present series of collections may in many respects be compared."

Thus along the Boundary line three fairly definite Carboniferous horizons have been identified. The lowest is represented by the Mississippian fossils obtained from the lower portion of the limestone-chert group. The next more recent horizon is represented by the Gschelian fossils typified by lot XIIi25 obtained from the shale group and the upper portion of the limestone-chert group. The most recent horizon is represented by fossils of lot XIi23 obtained from the Nation River for-

[1]Cairnes, D. D., "Upper White River district": Geol. Surv., Can., Memoir No. 50, 1914, See section on Carboniferous sediments. (In press.)

mation which is of Artinskian or Upper Gschelian age and thus belongs to the upper Pennsylvanian or, possibly the Permian.

Limestones, cherts, and related rocks that lithologically resemble the members of the limestone-chert group are extensively developed on Macmillan river.[1] The members of this group are also probably included in the Braeburn limestones which are extensively developed in Yukon[2] and northern British Columbia,[3] and are dominantly of Carboniferous age, but may include also Devonian members.

MESOZOIC BEDS.[4]

Distribution.

The most northerly point at which the Mesozoic beds were definitely identified occurs about 2½ miles north of Runt creek where these sediments are developed throughout a small area. Some 60 miles farther north, however, the members of the Nation River formation occur as previously mentioned, and it is possible that there also, the Mesozoic rocks may be included to a limited extent with the older but lithologically similar beds. The principal development of the Mesozoic sediments commences at Orange creek and extends southward for a distance of about 55 miles, and throughout this extensive section of the Boundary belt these beds comprise the greater part, at least, of all the various bedrock exposures.

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[1]McConnell, R. G., Ann. Rep., Geol. Surv. Can., Vol. XV, 1902, pp. 31A-34A.

[2]Cairnes, D. D., "Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district": Geol. Surv., Can., Memoir No. 5, 1910, pp. 28, 29.

[3]Cairnes, D. D., "Portions of Atlin district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1912, pp. 53-54.

[4]The writer in 1911 applied the name Orange group to include the Mesozoic as well as the Nation River and superjacent beds which on the accompanying geological sheets are mapped together. These sediments in places all very closely resemble each other, and during 1911 only Mesozoic fossils were obtained from them, so they were provisionally assigned to the Mesozoic. Since fossil remains presumably of Upper Carboniferous age have been found in the lower beds which are now believed to belong to the Nation River formation, it has been considered advisable to discontinue the use of the name Orange group.

Lithological Characters.

These Mesozoic beds consist mainly of shales, sandstones, greywackes, conglomerates, slates, and quartzites which have an aggregate thickness of at least 4000 feet. The shales are dominantly black, brownish or some shade of grey, and vary in character from hard, firm, finely bedded rocks that cleave into broad, thin plates, to soft friable clays, which break into irregular fragments (Plate XVI). The sandstones and greywackes are typically some shade of grey, green, or brown, and range in texture from fine to coarse. They also vary in hardness and density from that of a friable loosely cemented rock to a hard, firm quartzite. Occasional beds of calcareous sandstone also occur, which are in places fossiliferous. In addition, the sandstones locally contain considerable iron and weather readily to form a reddish sand; thus hillsides composed of these rocks present a reddish, well rounded appearance. The conglomerates range in texture from rocks which might be considered coarse sandstones to rocks containing boulders 6 to 10 inches in diameter. The component pebbles in some of these conglomerate beds are composed entirely of chert which ranges in colour from white to black, but is prevailingly some shade of grey. Other beds contain few or no chert pebbles, but instead the component pebbles or boulders are of a heterogeneous character and embrace various types of both sedimentary and igneous rocks. The sedimentary pebbles in these beds are composed mainly of slate, quartzite, and chert, and the igneous pebbles are dominantly fragments either of plutonic rocks possessing a typical granitic habit or of volcanic rocks having an andesitic appearance. Thus all gradations occur from an ordinary coarse greywacke or sandstone to a cherty conglomerate.

In places the shales, sandstones, and greywackes are closely or even finely interbedded, either the shales or the coarser textured more massive rocks predominating. A good section, possibly 500 feet in thickness, of a portion of these Mesozoic rocks, exhibiting this feature, is exposed on the north side of Kandik river about half a mile above the Boundary line. There the beds have a general nearly black, finely textured appearance and consist entirely of interbedded shales and sandstones. The sandstones are prevailingly finely textured, and the shales have the appearance of consolidated mud, and lack any pronounced shaly structure. The sandstone beds range dominantly from 4 inches to 4 feet in thickness and are interbedded with shale beds 2 inches to 2 feet thick.

In places, also, as for example on the hills immediately north of Sitdown creek, there is a decided transition from shales and sandstone to typical slates and quartzites, the slates having a pronounced secondary cleavage. It was at first thought that some of the quartzites might be older than Mesozoic, but they were in places found to grade into quite friable sandstones, and at one point, also, about 4½ miles south of Kandik river, some well preserved Cretaceous fossils were obtained from hard, nearly white, typical massive quartzite members. These metamorphosed rocks are, however, only locally developed, and are of only relatively slight areal importance.

Age and Correlation.

These Mesozoic beds overlie the Upper Carboniferous or possibly Permian sediments which are superjacent to the members of the Nation River formation, and are the most recent consolidated sediments along the portion of the 141st meridian here under consideration. Fossils are, however, of somewhat rare occurrence in these Mesozoic beds, but were nevertheless found at a number of points.

During 1911 the writer collected some invertebrate remains from a calcareous sandstone bed about 2½ miles north of Runt creek, which were examined by Dr. T. W. Stanton of the United States Geological Survey, who reports:—

"The specimens labelled F18, 56, 59, 119, and some others, appear to be casts of a simple species of *Ostrea*. The larger specimen labelled F10 is probably a *Pecten*. The specimens labelled F36, 64, and some others not numbered, are referred to *Astarte* or some related genus. Besides the genera mentioned there are imprints of an undetermined brachiopod and several pelecypods.

"My judgment is that these fossils are not older than Mesozoic and that they may be Cretaceous though there is no definitely distinctive Cretaceous fossil recognized among them and they do not seem to fall into any fauna known to me in that region."

The following summer, fossil remains were collected from several points between Orange and Ettrain creeks, which were also forwarded for examination to Dr. Stanton, who reports:—

"The following report—which I know will be unsatisfactory because the most of the material on which it is based is unsatisfactory—is respectfully submitted.

"D. D. Cairnes' collection from the Alaskan Boundary contains numerous well preserved specimens of the robust form of Aucella which I refer to *Aucella crassicollis* and consider characteristic of the Lower Cretaceous. The few associated forms listed below are not specifically identified and add little to the evidence for age determination.

XIVk25

Nucula sp.
Astarte? sp.
Panopaea? sp.
Undetermined *pelecypod* casts

XVh30, 31, 130

Aucella crassicollis Keyserling.

XIVq31

Aucella crassicollis Keyserling.

XVj30

Aucella crassicollis Keyserling.

XVa31, 32

Aucella crassicollis Keyserling.
Astarte sp."

All the fossils which were collected from these beds thus appear to be of Cretaceous age, but since these rocks rest on Upper Carboniferous or possibly Permian sediments, and since fossils were found at relatively few points it seems quite possible that Jurassic or even Triassic members may also be included.

These Mesozoic sediments correspond somewhat closely, lithologically and stratigraphically, with the Laberge series[1] which is extensively developed in Yukon[2] and northern British Columbia, and particularly resemble these beds in Atlin district,[3] British Columbia, where they are locally much metamorphosed and altered into slates, quartzites, and related rock types. The members of the Laberge series are considered to be mainly at least of Lower Cretaceous or Jurassic age, and are classed provisionally as Jura-Cretaceous.

These Mesozoic rocks along the Boundary also correspond with the Mesozoic beds in Upper White River district[4] where also only Cretaceous fossils were found. However, similar appearing Mesozoic beds occur in the Nabesna-White River district, Alaska,[5] a few miles to the west of Upper White River district, Yukon, and 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.

QUATERNARY—SUPERFICIAL DEPOSITS.

Under "Superficial deposits" are included all Pleistocene and Recent sedimentary deposits and accumulations. These include chiefly gravels, sands, clays, muck, peat, soil, and ground-ice, all of which with the exception of the ground-ice are the result of ordinary eroding and disintegrating processes. These materials floor all the principal valleys of the district and constitute

[1]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.

[2]Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 53-57.

[3]Cairnes, D. D., "Portions of Atlin district, British Columbia, with special reference to quartz mining": Geol. Surv., Can. Memoir No. 37, 1912, pp. 59-63.

[4]Cairnes, D. D., "Upper White River district, Yukon": Geol. Surv., Can., Memoir No. 50. In press. See section on Mesozoic sediments.

[5]Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White River district": U.S. Geol. Surv., Bull. 417, 1910, pp. 27-32.

a thin mantle overlying the consolidated rock formations throughout the greater part of the district, particularly in the less rugged localities. The ground-ice, as in most parts of this entire northern region, remains in most places throughout the entire year, and occurs just below the surface vegetation.

Since no evidence of glaciation has been detected within the belt along the 141st meridian, under consideration in this memoir, the Pleistocene and Recent accumulations are lithologically very similar—so much so, in fact, that in most places considerable care and detailed study are necessary to differentiate them.

On the geological map accompanying this memoir, the colour representing Superficial deposits is employed chiefly to indicate the occurrence of the main heavy valley accumulations where the nature of the underlying bedrock is very uncertain or totally unknown; but does not include the thin irregular mantle of dominantly recent materials which extend over the uplands and through which the bedrock is frequently exposed and is thus fairly well known. This geological colour thus serves a double purpose in not only affording information concerning the position and extent of the Superficial deposits, but also in depicting in somewhat vivid fashion the valley systems of the Boundary belt under consideration.

IGNEOUS ROCKS.

The igneous rocks of this belt are divisible into two main groups. One group is composed of somewhat basic intrusives dominantly diabases, diorites, andesites, and related types; the other group is somewhat more acidic and includes mainly plutonic intrusives of granitic habit, which range in character from granites to gabbros.

The members of the granitic group outcrop in only four or five localities and at each point the exposures are small. The largest area of these rocks occurs along the left limit or west side of the Yukon within about 3 miles of the crossing of this river by the Boundary line. There these rocks appear to constitute a small boss with a diameter of from one-quarter to one-half a mile. The only other exposure of these rocks within this Boundary belt, sufficiently large to be shown on the accompanying map, occurs on the west side of Racquet creek. This exposure much resembles that along the Yukon, but is possibly somewhat smaller in extent. All these granitic rocks where noted cut the members of the Yukon or Tindir groups and are thus only known to be more recent than these rocks. However, since they are lithologically very similar to the Coast Range intrusives[1] which are extensively developed in Yukon and British Columbia, and were intruded in Mesozoic time, it is considered quite possible that these granitic rocks along the Boundary are also of this age.

The members of the more basic group occurring within the Boundary belt for approximately 145 miles south of the Porcupine or to a point between Ettrain and Tindir creeks, include diorites, andesites, and diabases, which occur as dykes and small irregular intrusive masses, but have a very insignificant areal development. In fact, the exposures of these rocks within this portion of the Boundary belt are all too small to be shown on the accompanying geological map, except a dyke which occurs just north of Bern creek and which does not appear to exceed 150 feet in width, and also three small developments in the vicinity of Porcupine river, none of which are more than 1500 feet in their greatest surface dimension.

Commencing about 3 miles north of Tindir creek, however, these intrusives become extensively developed, particularly in association with the sedimentary members of the Tindir group, and thence to Yukon river, a distance of about 45 miles, not only have they invaded Tindir sediments but in addition they have intruded the members of the Yukon group, as well in places as the lower beds of the Devono-Cambrian limestone-dolomite terrane. Throughout this more southerly 45 miles section of the Boundary belt here under consideration, however, all these intrusives that were examined proved to be diabases, although it is quite probable that other related types occur. These in-

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[1]Cairnes, D. D., "Atlin Mining District, British Columbia;" Geol. Surv., Can., Memoir No. 37, 1913, pp. 57-59.

"Upper White River district, Yukon": Geol. Surv., Can., Memoir No. 50. In press. See section on "Granitic intrusives."

trusives constitute here one of the most prominent members of the Tindir group and occur as dykes, sills, and irregular intrusive masses. Since, however, these diabases and related rocks are so extensively developed in association with the members of the Tindir and Yukon groups and only rarely cut the more recent rocks, it seems evident that although they are all lithologically very similar, and range in age from Pre-Cambrian (?) to possibly about Devonian, they must nevertheless be dominantly of pre-Middle Cambrian age. The diabases are prevailingly greyish to dark green, fine to medium textured rocks which possess an ophitic structure, and may or may not be amygdaloidal in character. When amygdaloidal, however, the amygdules are dominantly filled with secondary minerals mainly quartz, calcite, zeolites, or chlorite. On weathered surfaces these intrusives are characteristically reddish to reddish brown, due to the oxidation of the iron-ore minerals which they contain and which in some of these rocks are somewhat abundantly distributed or peppered through the rock mass.

On the accompanying geological map, the colour representing the Tindir group includes the great bulk of the diabase and related intrusives within the Boundary belt, as these rocks in most places occur very intimately associated with the sedimentary members of this formation. A few of the larger or more important areas of these intrusives have, however, been mapped separately and given a distinct geological colour.

GENERAL STRUCTURAL FEATURES.

The general geological structure of the rock formation along the 141st meridian between Porcupine and Yukon river is characterized dominantly by broad gentle folding, the wide bottoms of the synclines being filled with undulating beds.

Commencing at Porcupine river the Tindir beds dip to the south under the overlying Palæozoic sediments and do not again appear for about 40 miles. In between the wings of this broad, rather flat synclinal fold the prevailing Palæozoic beds, although considerably folded and distorted, are dominantly undulating, the same beds occurring repeatedly at the surface, and never apparently dipping far below it. Thence southward for 50 miles the Tindir beds constitute the greater number of the rock exposures and are also prevailingly undulating in structure, the attitude of the beds being nearly flat in many places and the same members being exposed almost continuously for miles at a time. At Orange creek, the Mesozoic as well as the Nation River and superjacent beds appear, and southward for 50 miles comprise practically all the rock exposures. As these beds have a total aggregate thickness of possibly not much if at all exceeding a mile, and outcrop continuously for 50 miles, the general undulatory attitude of the beds is quite apparent in spite of the fact that minor folds are nearly everywhere in evidence. In the vicinity of Ettrain creek the lowest members of the Nation River beds come to the surface and the underlying Palæozoic sediments become exposed. Thence to Yukon river, a distance of about 50 miles, the geological formations compose one wide, gentle, upright anticline followed by a similar synclinal fold, the apex of the anticline being formed of Tindir rocks and the southern limb of the syncline being composed of the older schistose rocks comprising the Yukon group. Thus, although folding, faulting, and general rock contortion are practically everywhere in evidence, the major structures are broad and simple. Between Harrington creek and Tatonduk river, a distance of about 6 miles, there occurs one of the most perfect and striking of the anticlinal folds of secondary magnitude. In the vicinity of Harrington creek the beds all dip to the north and at Tatonduk river the dips are to the south, and on either limb Devonian rocks are exposed, while along the apex, Ordovician and Cambrian sediments outcrop.

The main faults that were observed throughout this belt are dominantly overthrusts and appear to be due to compression which has resulted in the breaking of the harder more competent members, prevailingly near the tops of anticlinal folds. In the vicinity of Porcupine river and elsewhere, numerous breaks were noted as shown on the accompanying geological map, and undoubtedly numerous other minor faults occur, which were not observed due to the rapidity with which the geological work was necessarily performed. Only one major fault was clearly traced for any considerable distance. This occurs just north of Cathedral creek, and there Tindir and overlying lower Palæozoic limestone-dolomite beds have been thrust over members of the limestone-dolomite group for a distance of more than 6 miles.

In the central portions of the various folds, the shales and other softer, more pliable rocks are in places much folded, crumpled, and contorted, these being able to withstand without breaking much more distortion than the harder, firmer, more massive beds, which have, however, dominated and controlled the main structures.

ECONOMIC GEOLOGY.

The mineral resources of this belt include mainly iron-ore, coal, marble, lithographic limestone, and magnesite. Owing to the remoteness of their occurrence, however, none of these are of any present economic importance, although in more accessible localities some of the deposits would be of considerable value.

Iron-containing minerals, chiefly hematite, magnetite, and their oxidation products, comprise a considerable percentage of some of the beds of the Tindir group to the south of Cathedral creek. In places, limited portions of these deposits occurring in beds ranging from 2 to 10 feet in thickness, contain up to 30 per cent or even possibly 40 per cent metallic iron. Also on a small tributary of Tatonduk river flowing into it from the north, certain peculiar reddish conglomerates resembling consolidated boulder clay occur, which contain considerable hematite in places. Limited portions of this conglomerate appear to contain from 5 per cent to 25 per cent metallic iron.

A few local seams also outcrop in the dark shales which are exposed along Tatonduk river in the vicinity of the Boundary line, but none were noted having a thickness exceeding 2 inches.

In addition, lithographic limestone, apparently of good quality, occurs in places in Keele mountains, in beds ranging from 2 to 10 feet in thickness. Marble is extensively developed in Keele and Ogilvie mountains, and some very beautiful varieties and colours occur. Pure white beds were particularly prominent on Keele mountains in places, and other marble beds of various shades of grey, blue, and red were noted.

Exceptionally pure deposits of magnesite occurring in beds ranging from 2 to 10 feet thick, and having an aggregate thickness of 100 feet or more, were noted within a few miles to the north of Orange creek and elsewhere.

CHAPTER IV.

SUMMARY AND CONCLUSIONS.

The belt along the 141st meridian between Porcupine and Yukon rivers, which is here being considered, is quite accessible at the southern end from Yukon river. To the north of the Yukon, however, and between this river and the Porcupine, a distance measured along the Boundary line of 191 miles, most points are reached only with considerable difficulty and by long arduous journeys. It is possible during seasons of high water, to run gasoline boats or small steam craft up the Porcupine to New Rampart House which is situated only a few hundred feet east of the International Boundary, but there is no regular traffic for power boats on this stream. To reach points intermediate between Yukon and Porcupine rivers, particularly when it is desired to take in outfits or supplies, it is easiest to do so by poling up some of the tributaries of these rivers, which cross the Boundary line. To travel north or south across country following in the vicinity of the Boundary itself is very difficult for horses, as muskeg and tundra are so extensive, and besides the meridian in its north-south course is transverse to the main topographic features of the district, which have dominantly westerly trend. Thus numerous hills, mountains, and ridges have to be crossed and quite a number of quite large streams must be forded.

The climatic conditions along this northern belt, part of which lies within the Arctic circle, resemble that of other similarly situated districts, and although the winters are very severe, the summers are pleasant but of very short duration. This shortness of the summer season, combined with the difficultly accessible nature of most portions of the belt and the unusual obstacles to travel throughout this region, caused most of the field work to be performed not only necessarily rapidly, but often under very adverse conditions.

The district is in general only sparsely forested, but nearly everywhere the valleys contain more or less timber which, however, becomes gradually less plentiful toward the north, and along the Porcupine only occasional groves occur in the more protected portions of some of the valleys. Game is, however, plentiful throughout most portions of the belt, so much so in fact, that were parts of this district only somewhat more accessible and better known, few places on the continent would be more attractive to the sport-loving hunter.

Topographically this belt along the 141st meridian lies for the greater part at least within the Yukon plateau province although a small section occupied by Ogilvie mountains probably constitutes an outlying lobe of the Rocky Mountain system. Since, also, the physiographic terranes in the vicinity of this meridian have a general westerly trend, they are crossed by the Boundary line practically at right angles. Thus, the Boundary belt between Yukon and Porcupine rivers is transverse in its general trend to the main topographic features of the region, and consequently includes a considerable diversity of topography.

In certain localities, as in Keele mountains where the prevailing bedrock is limestone or dolomite, the characteristic features of the Yukon plateau are still well preserved and extensive tracts of upland occur at an elevation in most places of between 3,500 and 4,000 feet above sea-level. With the exception of these areas, however, the original plateau surface has been almost or entirely destroyed, and throughout the greater part of the district, the land surface has become thoroughly dissected.

Two ranges or mountain groups are crossed by the Boundary line, the more northerly of which, Keele mountains, commences about 18 miles south of Porcupine river and has a width measured along the Boundary of about 32 miles. These mountains are decidedly an integral of the Yukon Plateau province and their upland surface, which has a general altitude of between 3,500 and 4,000 feet above sea-level, constitutes a particularly striking and well preserved remnant of the former Yukon Plateau upland. These mountains owe their prominence to the character of their component geological beds rather than to any uplift such as would raise them above the surrounding district.

The more southerly mountain group commences about 90 miles south of Keele mountains and is a western extension of the Ogilvie mountains. These mountains where crossed by the Boundary line have a width of about 35 miles and are decidedly rugged in character, the higher summits rising to elevations exceeding 5,000 feet above sea-level. The Ogilvie mountains show no evidence of a planated surface such as is so strikingly developed in Keele mountains, and are considered to probably constitute an outlying portion of the Rocky Mountain system.

With the exception of these two mountain sections, the remaining portions of this Boundary belt are characterized topographically by generally well rounded, irregularly distributed hills the more prominent of which rise to elevations of between 2,000 and 4,300 feet. Occasional flat-topped hills and long straight ridges occur in places, however, the summits of which have notably uniform altitudes and constitute the only remnants in most localities of the old plateau surface. To the south of Orange creek in particular, and within 6 or 7 miles of this stream, several such typical, prominent, flat-topped hills occur, the summits of all of which stand at an elevation of about 3,700 feet above sea-level. The valley bottoms of Yukon and Porcupine rivers where crossed by the International Boundary have elevations respectively of about 850 and 750 feet and the larger intermediate streams where crossed by the Boundary line range from 1,100 to 1,700 feet above the sea.

The streams of the district have all dominantly V-shaped valleys, characterized by interlocking spurs and other features diagnostic of an unglaciated region, no evidence of glaciation having been noted within this belt.

The geological formations within this belt are dominantly of sedimentary origin and range from Recent to Pre-Cambrian in age. Mesozoic sediments have a wide distribution and two main divisions of the Pre-Cambrian appear to be represented. The district is of particular interest, and stratigraphic importance, however, owing to the fact that all the Palæozoic systems from the Cambrian to the Carboniferous are represented, and perhaps nowhere else in the entire Rocky Mountain region of Canada and the United States is a more complete section of the Palæozoic known within so limited an area. Occasional dykes and relatively small intrusive bodies intersect the lower Palæozoic rocks and intrusive greenstones, and in places highly altered igneous rocks of various types have an extensive development in association with the presumably Pre-Cambrian or at least pre-Middle Cambrian terranes.

One of the most important results of this work along the Boundary is the finding of the main great thicknesses of limestones and dolomites which there occur. These beds range in age from Carboniferous down to the Middle and possibly also include the Lower Cambrian, showing that the deep sea reigned, apparently continuously, over extensive portions of the region during this tremendous period of time. Another very interesting conclusion concerns the rapidity with which it has been shown that the lithology changes, and consequently how uncertain and unsatisfactory, lithological evidence has proved to be, thus adding greatly to the difficulties connected with geological mapping in that region. Toward the southern end of the section, where a limestone-dolomite and a shale group are well developed, at one point the limestone-dolomite group persists upward from Middle Cambrian to middle or lower Devonian, and is overlain by the shale group, which there contains upper or middle Devonian fossils. Within a distance of 10 miles the same two formations having changed but slightly lithologically have altered their relations stratigraphically to the extent that there the limestone-dolomite group persists upward from the Middle Cambrian only to the Ordovician, and is overlain by the shale group which contains a fauna ranging in age from Ordovician to Devonian or Carboniferous.

In addition a certain amount of light has been thrown on the age of the older schistose rocks of the region. Heretofore these rocks, which have been generally considered to constitute the oldest geological terrane in each district in which they have been studied, were accordingly variously classed as pre-Devonian, pre-Silurian, or pre-Ordovician, according to the age or supposed age of the oldest overlying sediments. It would now appear that this schistose complex of the Upper Yukon basin is at least pre-Middle Cambrian, and is in all probability of Pre-Cambrian age. This information is of more than ordinary significance, since these rocks are so extensively developed, and since from them has been derived a great portion at least of the placer gold of Yukon and Alaska.

The mineral resources of the district include deposits of iron-containing minerals, coal, marble, lithographic limestone, and magnesite. Iron containing minerals, chiefly hematite, magnetite, and their oxidation products, comprise a considerable percentage of certain beds occurring in the southern part of the district, and portions of some of these deposits contain up to 30 per cent or even possibly 40 per cent of metallic iron. On Tatonduk river, also, a few coal seams not, however, exceeding 2 inches in thickness, were noted in Carboniferous shales. In addition, marble, lithographic limestone, and magnesite are somewhat extensively developed in certain localities. Owing to the remoteness of their occurrence, however, none of these deposits are of present economic importance.

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PLATE II.

Looking northward across the valley of Cathedral creek in the vicinity of the Boundary line, the cutting marking which is seen in the left of the view. The character of the timber is well shown and is typical of the forest growth in the larger valleys of the southern part of the belt. The elevation of the valley of Cathedral creek at the crossing of the 141st meridian, shown in the view, is about 2,100 feet above sea-level.

PLATE II.

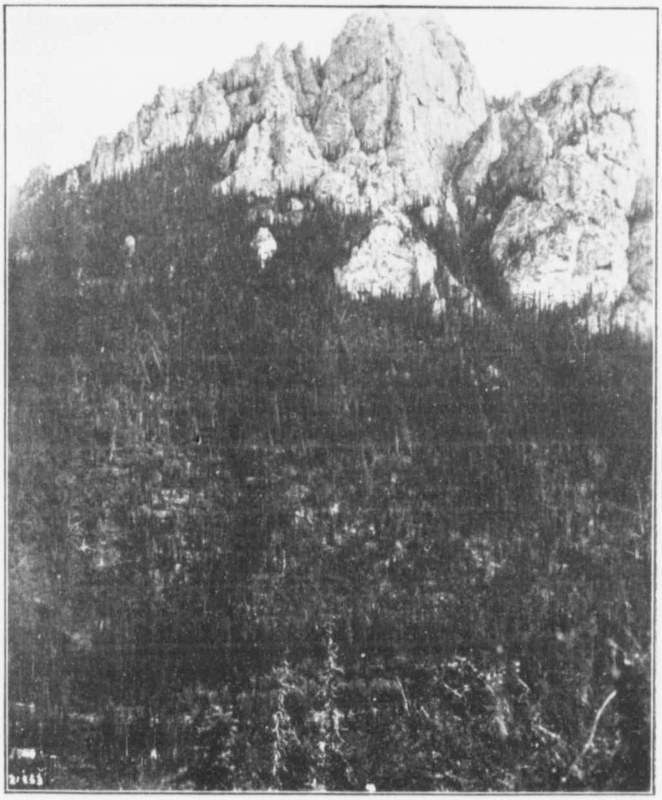

PLATE III.

Looking down Porcupine river from the International Boundary line. The Upper Ramparts of the Porcupine are here well shown. The rocks outcropping in the valley walls along this portion of the river belong to the Tindir group. The view also shows the sparse character of the forest growth in this vicinity.

PLATE III.

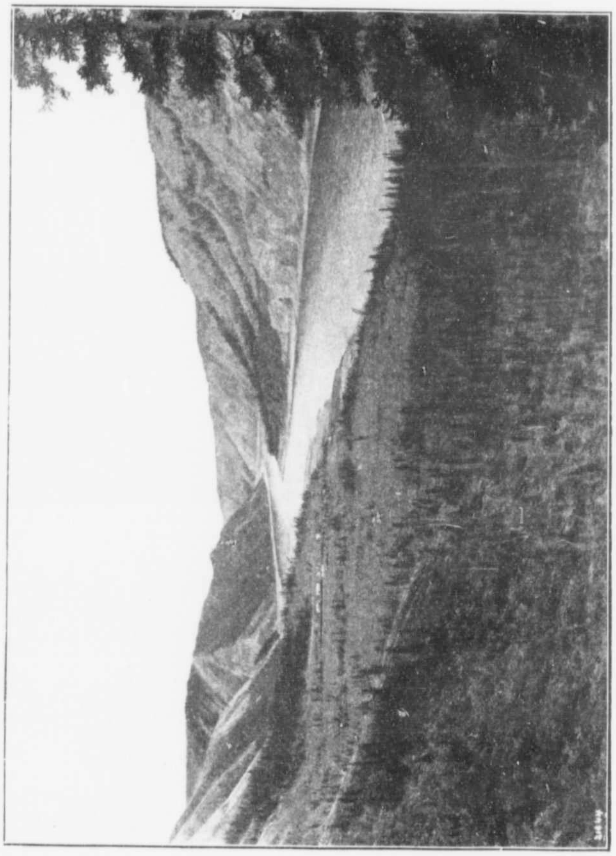

PLATE IV.

A typical view in Keele mountains, illustrating the steep rugged character of the mountain sides and valley walls, as well as the decided topographic unconformities and pronounced shoulders everywhere in evidence at their contacts with the upland plateau surface.

PLATE IV.

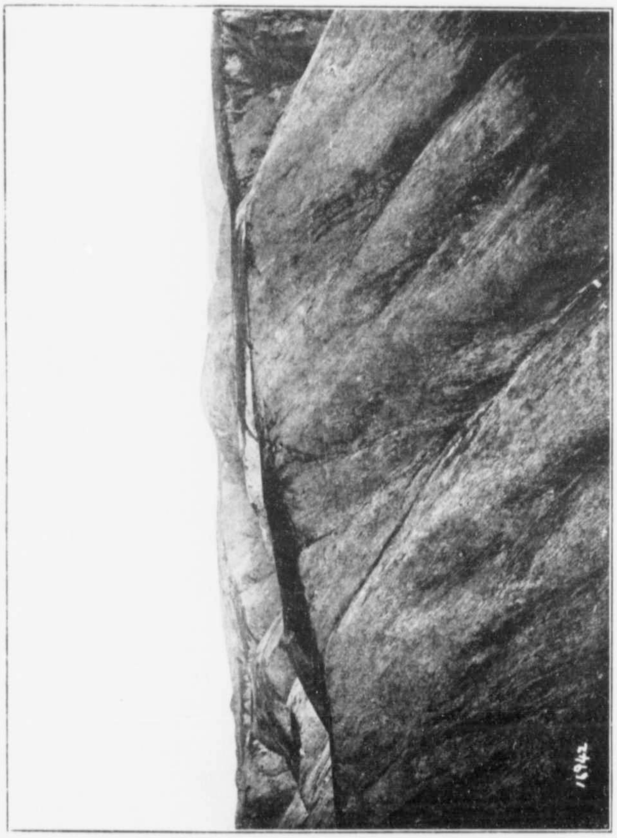

PLATE V.

A typical view of the upland plain-like surface of Keele mountains, which has an altitude exceeding 3,000 feet above sea-level, and is over 1,500 feet above the level of the main intersecting valleys. The bedrock exposed, all consists of the Devono-Cambrian limestones and dolomites.

PLATE V.

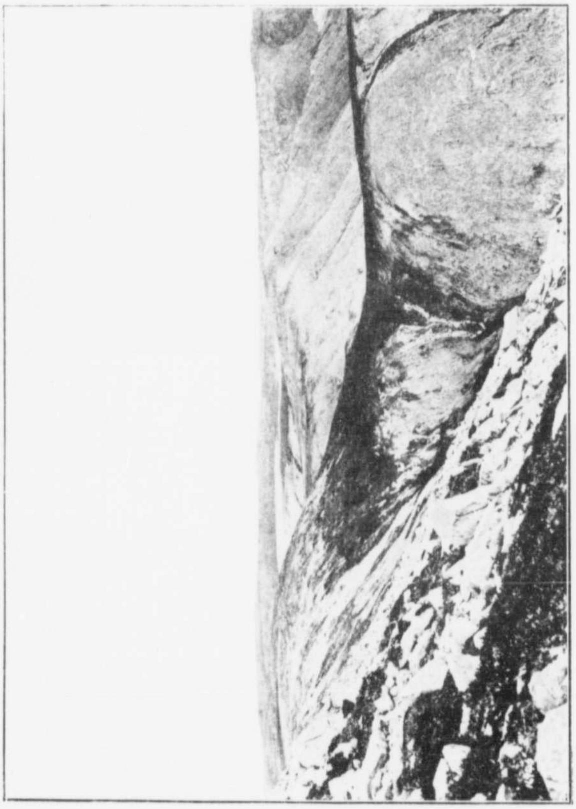

PLATE VI.

A typical view of the upland in Keele mountains, illustrating the equiplanating process which is there in evidence. The flat plain-like portion of the upland which there supports a typical Arctic vegetation, and is underlain by partly frozen accumulations of debris, is distinctly seen to be encroaching on the limestone residual bluff on the right of the picture.

Plate VI.

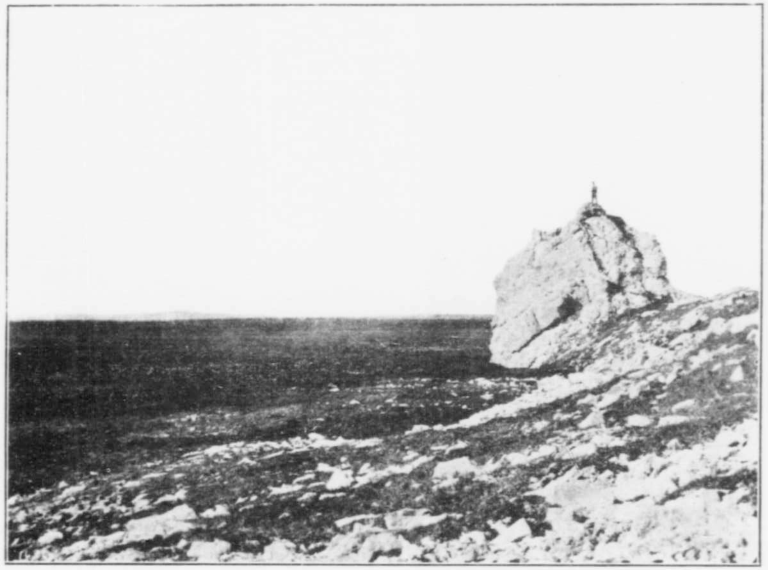

PLATE VII.

A typical view between Keele and Ogilvie mountains, illustrating the completely dissected character of the topography there, where the geological formations consist dominantly of shales, slates, phyllites, and quartzites. The summits are prevailingly composed of quartzite which is harder and more resistant to ordinary subaërial destructive agencies than the other associated rocks.

Plate VII.

PLATE VIII.

View between Keele and Ogilvie mountains showing one of the occasional somewhat straight or flat topped ridges which constitute the principal remaining evidence in that portion of the district, as to the former planated character of the region. The bedrock there dominantly belongs to the Tindir group and consists mainly of slates, phyllites, and quartzites. The sparse character of the forest growth is also illustrated.

Plate VIII.

View between Keele and Ogilvie mountains showing one of the occasional somewhat straight or flat topped ridges which constitute the principal remaining evidence in that portion of the district, as to the former planated character of the region. The bedrock there dominantly belongs to the Tindir group and consists mainly of slates, phyllites, and quartzites. The sparse character of the forest growth is also illustrated.

PLATE VIII.

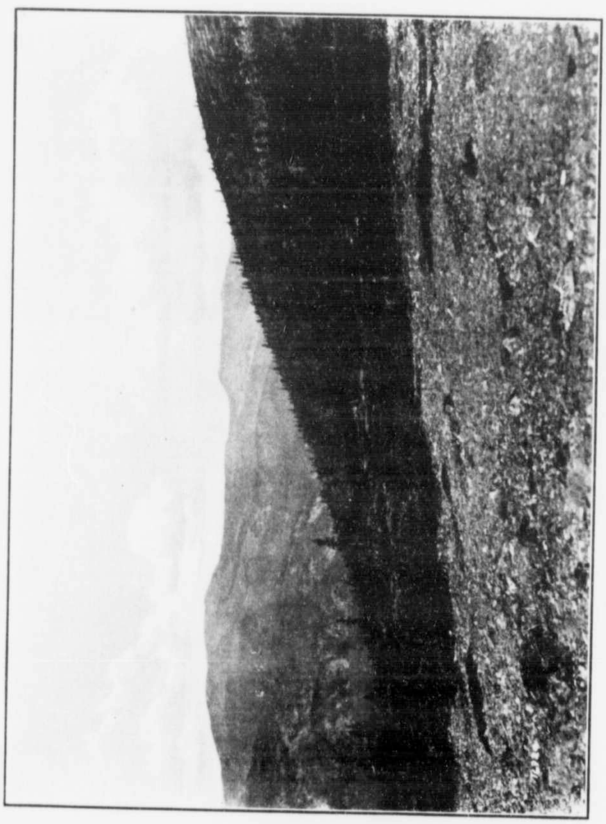

PLATE IX.

The valley of Bern creek in the vicinity of the 141st meridian. The typical V-shaped character of the valley with its interlocking spurs is well illustrated. The nature of the forest growth is also shown.

Plate IX.

PLATE X.

A typical view of the Ogilvie mountains looking northward across the valley of Cathedral creek. Mt. Slipper is shown in the right of the background, the summit being obscured by a cloud. The rugged and irregular character of these mountains is well illustrated, there being no evidence as to their ever having been planated. A close view of a rugged hill of Devono-Cambrian limestone and dolomite is shown in the foreground.

PLATE X.

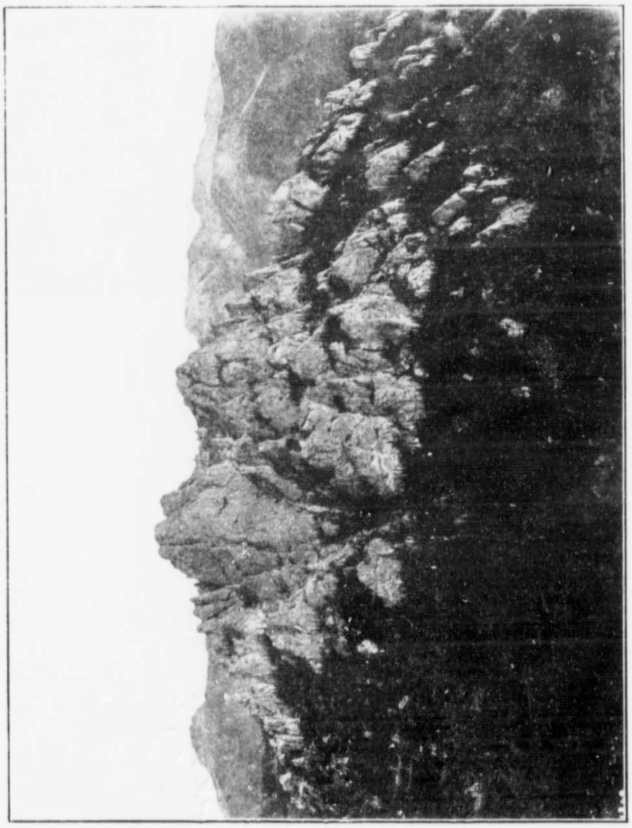

Plate XI.

Showing the southeastern face of Mt. Barlow one of the typical peaks of the Ogilvie mountains. The characteristic steep rugged character of these mountains is here well illustrated. The view also shows the characteristic weathering and general appearance of the Devono-Cambrian limestones and dolomites which compose the greater part of these mountains.

Plate XI.

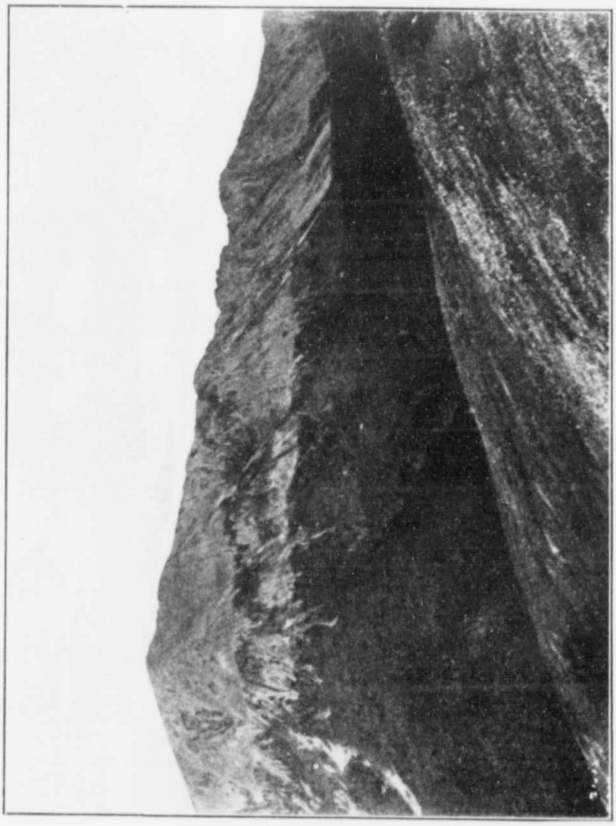

Plate XII.

Looking down Darcy creek toward Porcupine river. The recent, steep-walled, V-shaped character of the valleys of this vicinity is here well shown. Also all the bedrock exposed in this view belongs to the Tindir group. The sparse character of the forest growth is also well illustrated.

PLATE XII.

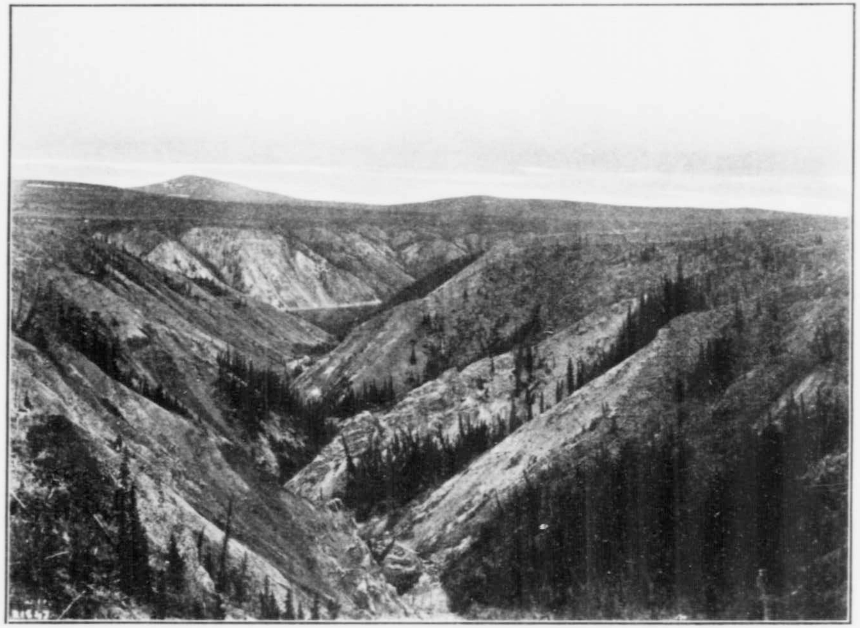

PLATE XIII.

The southwestern face of Mt. Slipper showing the lower Palæozoic limestones and dolomites which cap the mountain, overlying Tindir shales.

Plate XIII.

PLATE XIV.

A typical slate-phyllite ridge-top just north of Runt creek. The characteristic weathering of the readily cleavable slates and phyllites of the Tindir group is here illustrated.

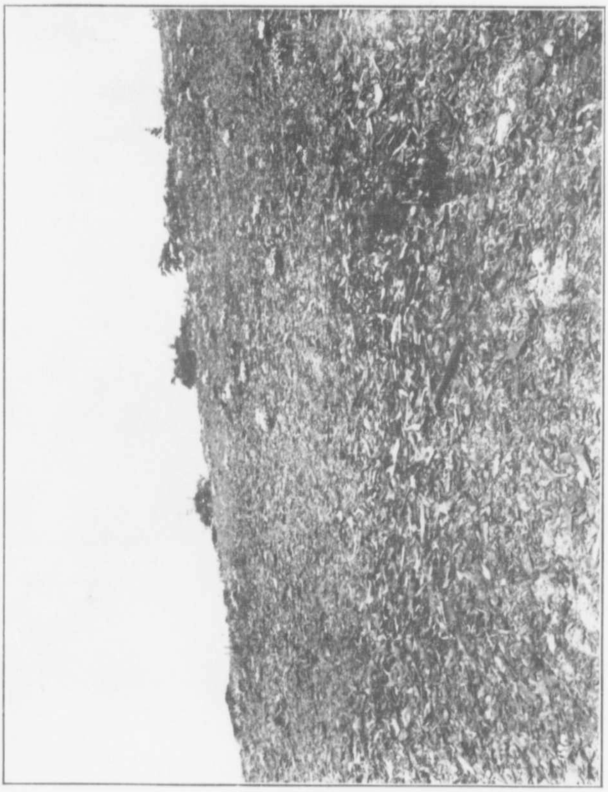

PLATE XIV.

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PLATE XV.

Looking northward across the Ogilvie mountains from a point just north of McCann hill. The typically rough irregular character of these mountains is here well illustrated. The view also shows in the foreground, one of the localities from which Cambrian fossils were obtained. The limestone-dolomite beds forming the broad, sloping summit in the left foreground, are overlain by a few feet of Ordovician shales.

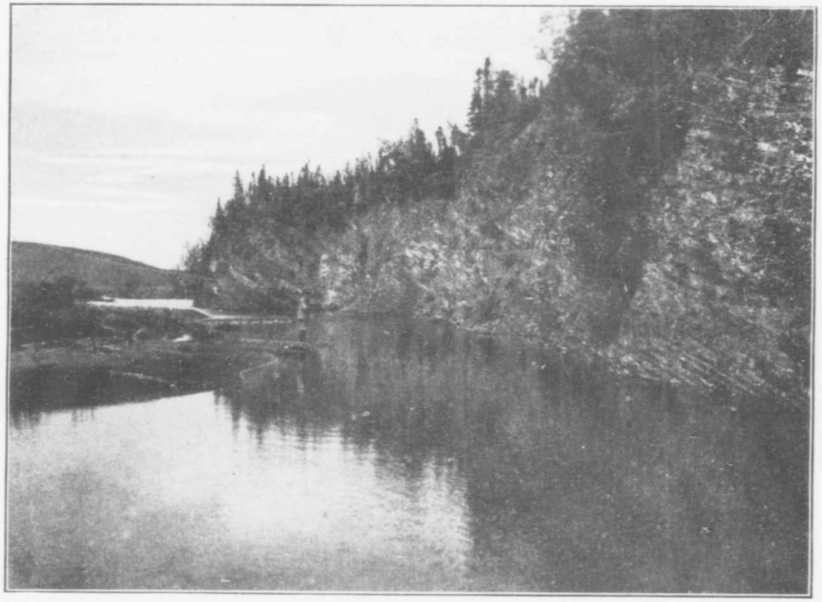
PLATE XV.

Plate XVI.

A typical shale-sandstone exposure consisting of Mesozoic beds in the north bank of Kandik river, a short distance above the Boundary line.

Plate XVI.

PLATE XVI.



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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.

MEMOIR 16. *No. 13, Geological Series.* The clay and shale deposits of Nova Scotia and portions of New Brunswick—by Heinrich Ries, assisted by Joseph Keele.

MEMOIRS—BIOLOGICAL SERIES.

MEMOIR 14. *No. 1, Biological Series.* New species of shells collected by Mr. John Macoun at Barkley sound, Vancouver island, British Columbia—by William H. Dall and Paul Bartsch.

Memoirs and Reports Published During 1912.

REPORTS.

Summary Report for the calendar year 1911. No. 1218.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 13. *No. 14, Geological Series.* Southern Vancouver island—by Charles H. Clapp.

MEMOIR 21. *No. 15, Geological Series.* The geology and ore deposits of Phoenix, Boundary district, British Columbia—by O. E. LeRoy.

MEMOIR 24. *No. 16, Geological Series.* Preliminary report on the clay and shale deposits of the western provinces—by Heinrich Ries and Joseph Keele.

MEMOIR 27. *No. 17, Geological Series.* Report of the Commission appointed to investigate Turtle mountain, Frank, Alberta, 1911.

MEMOIR 28. *No. 18, Geological Series.* The geology of Steeprock lake, Ontario—by Andrew C. Lawson. Notes on fossils from limestone of Steeprock lake, Ontario—by Charles D. Walcott.

Memoirs and Reports Published During 1913.

REPORTS, ETC.

Museum Bulletin No. 1: contains articles Nos. 1 to 12 of the Geological Series of Museum Bulletins, articles Nos. 1 to 3 of the Biological Series of Museum Bulletins, and article No. 1 of the Anthropological Series of Museum Bulletins.

Guide Book No. 1. Excursions in eastern Quebec and the Maritime Provinces, parts 1 and 2.

Guide Book No. 2. Excursions in the Eastern Townships of Quebec and the eastern part of Ontario.

Guide Book No. 3. Excursions in the neighbourhood of Montreal and Ottawa.

Guide Book No. 4. Excursions in southwestern Ontario.

Guide Book No. 5. Excursions in the western peninsula of Ontario and Manitoulin island.

Guide Book No. 8. Toronto to Victoria and return *via* Canadian Pacific and Canadian Northern railways: parts 1, 2, and 3.

Guide Book No. 9. Toronto to Victoria and return *via* Canadian Pacific, Grand Trunk Pacific, and National Transcontinental railways.

Guide Book No. 10. Excursions in Northern British Columbia and Yukon Territory and along the north Pacific coast.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 17. *No. 28, Geological Series.* Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que.—by Morley E. Wilson.

MEMOIR 18. *No. 19, Geological Series.* Bathurst district, New Brunswick—by G. A. Young.

MEMOIR 26. *No. 34, Geological Series.* Geology and mineral deposits of the Tulameen district, B.C.—by C. Camsell.

MEMOIR 29. *No. 32, Geological Series.* Oil and gas prospects of the north-west provinces of Canada—by W. Malcolm.

MEMOIR 31. *No. 20, Geological Series.* Wheaton district, Yukon Territory—by D. D. Cairnes.

MEMOIR 33. *No. 30, Geological Series.* The geology of Gowganda Mining Division—by W. H. Collins.

MEMOIR 35. *No. 29, Geological Series.* Reconnaissance along the National Transcontinental railway in southern Quebec—by John A. Dresser.

MEMOIR 37. *No. 22, Geological Series.* Portions of Atlin district, B.C.—by D. D. Cairnes.

MEMOIR 38. *No. 31, Geological Series.* Geology of the North American Cordillera at the forty-ninth parallel, Parts I and II—by Reginald Aldworth Daly.

Memoirs and Reports Published During 1914.

REPORTS, ETC.

Summary Report for the calendar year 1912. No. 1305.

Museum Bulletins Nos. 2, 3, 4, 5, 7, and 8 contain articles Nos. 13 to 22 of the Geological Series of Museum Bulletins, article No. 2 of the Anthropological Series, and article No. 4 of the Biological Series of Museum Bulletins.

Prospector's Handbook No. 1: Notes on radium-bearing minerals—by Wyatt Malcolm.

MUSEUM GUIDE BOOKS.

The archæological collection from the southern interior of British Columbia—by Harlan I. Smith. No. 1290.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 23. *No. 23, Geological Series.* Geology of the coast and islands between the Strait of Georgia and Queen Charlotte sound, B.C.—by J. Austen Bancroft.

MEMOIR 25.	*No. 21, Geological Series.* Report on the clay and shale deposits of the western provinces (Part III)—by Heinrich Ries and Joseph Keele.
MEMOIR 30.	*No. 40, Geological Series.* The basins of Nelson and Churchill rivers—by William McInnes.
MEMOIR 20.	*No. 41, Geological Series.* Gold fields of Nova Scotia—by W. Malcolm.
MEMOIR 36.	*No. 33, Geological Series.* Geology of the Victoria and Saanich map-areas, Vancouver island, B.C.—by C. H. Clapp.
MEMOIR 52.	*No. 42, Geological Series.* Geological notes to accompany map of Sheep River gas and oil field, Alberta—by D. B. Dowling.
MEMOIR 43.	*No. 36, Geological Series.* St. Hilaire (Beloeil) and Rougemont mountains, Quebec—by J. J. O'Neill.
MEMOIR 44.	*No. 37, Geological Series.* Clay and shale deposits of New Brunswick—by J. Keele.
MEMOIR 22.	*No. 27, Geological Series.* Preliminary report on the serpentines and associated rocks, in southern Quebec—by J. A. Dresser.
MEMOIR 32.	*No. 25, Geological Series.* Portions of Portland Canal and Skeena Mining divisions, Skeena district, B.C.—by R. G. McConnell.
MEMOIR 47.	*No. 39, Geological Series.* Clay and shale deposits of the western provinces, Part III—by Heinrich Ries.
MEMOIR 40.	*No. 24, Geological Series.* The Archæan geology of Rainy lake—by Andrew C. Lawson.
MEMOIR 19.	*No. 26, Geological Series.* Geology of Mother Lode and Sunset mines, Boundary district, B.C.—by O. E. LeRoy.
MEMOIR 39.	*No. 35, Geological Series.* Kewagama Lake map-area, Quebec—by M. E. Wilson.
MEMOIR 51.	*No. 43, Geological Series.* Geology of the Nanaimo map-area—by C. H. Clapp.
MEMOIR 61.	*No. 45, Geological Series.* Moose Mountain district, southern Alberta (second edition)—by D. D. Cairnes.
MEMOIR 41.	*No. 38, Geological Series.* The "Fern Ledges" Carboniferous flora of St. John, New Brunswick—by Marie C. Stopes.
MEMOIR 53.	*No. 44, Geological Series.* Coal fields of Manitoba, Saskatchewan, Alberta, and eastern British Columbia (revised edition)—by D. B. Dowling.
MEMOIR 55.	*No. 46, Geological Series.* Geology of Field Map-area, Alberta and British Columbia—by John A. Allan.

MEMOIRS—ANTHROPOLOGICAL SERIES.

MEMOIR 48.	*No. 2, Anthropological Series.* Some myths and tales of the Ojibwa of southeastern Ontario—collected by Paul Radin.
MEMOIR 45.	*No. 3, Anthropological Series.* The inviting-in feast of the Alaska Eskimo—by E. W. Hawkes.
MEMOIR 49.	*No. 4, Anthropological Series.* Malecite tales—by W. H. Mechling.
MEMOIR 42.	*No. 1, Anthropological Series.* The double-curve motive in northeastern Algonkian art—by Frank G. Speck.

MEMOIRS—BIOLOGICAL SERIES.

MEMOIR 54.	*No. 2, Biological Series.* Annotated list of flowering plants and ferns of Point Pelee, Ont., and neighbouring districts—by C. K. Dodge.

Memoirs and Reports in Press, December 28, 1914.

MEMOIR 58. *No. 48, Geological Series.* Texada island—by R. G. McConnell.
MEMOIR 60. *No. 47, Geological Series.* Arisaig-Antigonish district—by M. Y. Williams.
MEMOIR 50. *No. 51, Geological Series.* Upper White River district, Yukon —by D. D. Cairnes.
MEMOIR 56. *No. , Geological Series.* Geology of Franklin Mining camp, B.C.—by Chas. W. Drysdale.
MEMOIR 62. *No. 5, Anthropological Series.* Abnormal types of speech in Nootka—by E. Sapir.
MEMOIR 63. *No. 6, Anthropological Series.* Noun reduplication in Comox, a Salish language of Vancouver island—by E. Sapir.
MEMOIR 46. *No. 7, Anthropological Series.* Classification of Iroquoian radicals with subjective pronominal prefixes—by C. M. Barbeau.
MEMOIR 59. *No. 55, Geological Series.* Coal fields and coal resources of Canada—by D. B. Dowling.
MEMOIR 67. *No. 49, Geological Series.* The Yukon-Alaska Boundary between Porcupine and Yukon rivers—by D. D. Cairnes.
MEMOIR 57. *No. 50, Geological Series.* Corundum, its occurrence, distribution, exploitation, and uses—by A. E. Barlow.
MEMOIR 64. *No. 52, Geological Series,* Preliminary report on the clay and shale deposits of the province of Quebec—by J. Keele.
MEMOIR 65. *No. 53, Geological Series.* Clay and shale deposits of the western provinces, Part IV—by H. Ries.
MEMOIR 66. *No. 54, Geological Series.* Clay and shale deposits of the western provinces, Part V—by J. Keele.
MEMOIR 70. *No. 8, Anthropological Series.* Family hunting territories and social life of the various Algonkian bands of the Ottawa valley—by F. G. Speck.
MEMOIR 71. *No. 9, Anthropological Series.* Myths and folk-lore of the Timiskaming Algonquin and Timagami Ojibwa—by F. G. Speck.

Summary Report for the calendar year 1913.

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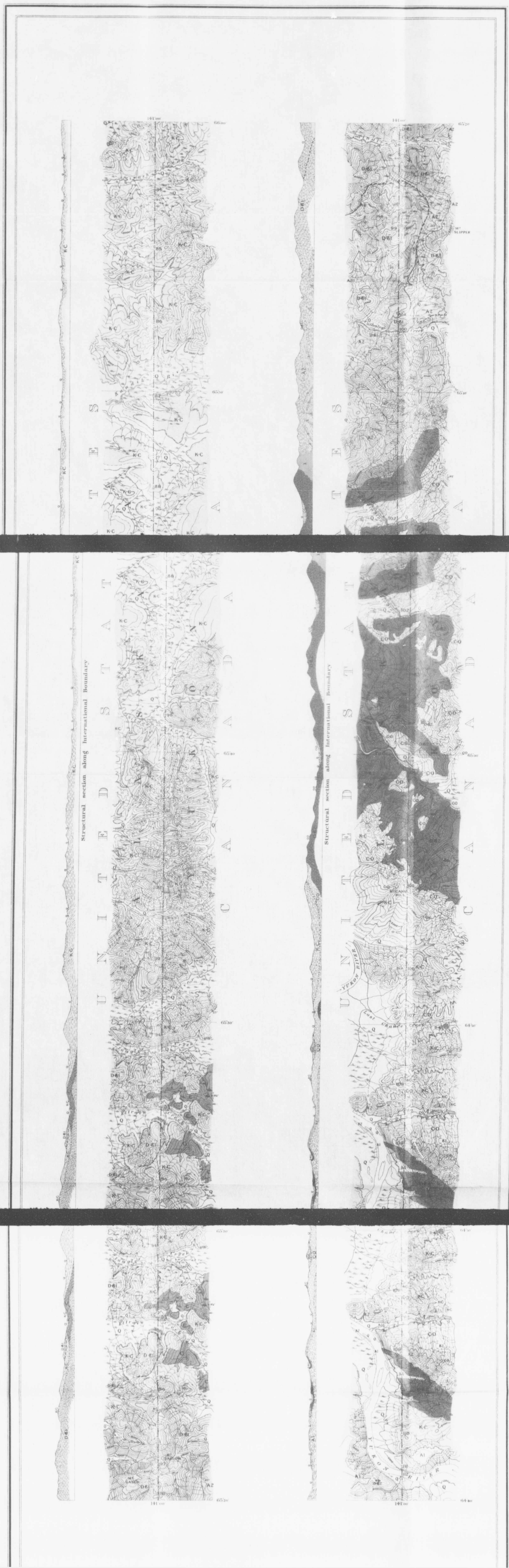
Canada
Department of Mines

HON. L. CODERRE, MINISTER; R. G. MᶜCONNELL, DEPUTY MINISTER

GEOLOGICAL SURVEY



LEGEND

MESOZOIC QUATERNARY
RECENT AND PLEISTOCENE — Q — Superficial deposits (Chiefly gravels, sands, clays, muck, peat, soil and ground-ice)
CRETACEOUS AND UPPER CARBONIFEROUS (MAY INCLUDE SOME PERMIAN) — K-C — (Chiefly shales, sandstones, greywackes, conglomerates, slates and quartzites, with occasional beds of limestone intercalated with lower members)
P — Permo-Carboniferous ? (Reddish conglomerate, resembles consolidated boulder clay)

QUATERNARY

PLEISTOCENE — Superficial deposits (Chiefly gravels, sands, clays, muck, peat, soil and ground-ice)

MESOZOIC

CRETACEOUS AND UPPER CARBONIFEROUS (MAY INCLUDE SOME PERMIAN)

- K-C — (Chiefly shales, sandstones, greywackes, conglomerates, slates and quartzites, with occasional beds of limestone intercalated with lower members)
- P — **Permo Carboniferous ?** (Reddish conglomerate, resembles consolidated boulder clay)

PALÆOZOIC

CARBONIFEROUS

- C — **Pennsylvanian and Mississippian** (Dominantly white to greyish limestones containing considerable chert in places. Also includes some intercalated dark shales and cherty conglomerate beds)
- CO — **Carboniferous to Ordovician** (Finely interbedded, black, grey and reddish shales and cherts. Also includes some thinly bedded limestones) NOTE. The members of CO overlie those of D€2, the lowest beds of CO ranging from upper Devonian to upper Ordovician in age and the uppermost beds of D€2 ranging in age accordingly from lower Devonian to lower Ordovician.

DEVONIAN, SILURIAN, ORDOVICIAN, AND CAMBRIAN

- D€1 — (Chiefly limestones and dolomites with occasional intercalated quartzite beds. Rocks characteristically very siliceous. May include small areas of C.)
- D€2 — **Devonian to Cambrian** (Chiefly limestones and dolomites. Rocks characteristically siliceous.)

PRE-CAMBRIAN ?

LOWER CAMBRIAN OR PRE-CAMBRIAN

- A2 — **Tindir group** (Chiefly quartzites, slates, shales, phyllites, dolomites, conglomerates and greenstones)
- A1 — **Yukon group** (Mainly schistose amphibolites, quartzite schists, and mica schists, with occasional limestone beds)

Igneous Rocks

MESOZOIC? — 2 — (Syenites, grano diorites, diorites and related types having a granitic habit.)

PRE-MIDDLE CAMBRIAN, IN PART DEVONIAN — 1 — (Diabases, diorites, andesites and other basic igneous intrusives.)

Symbols

Geological boundary (observed)

Geological boundary (position assumed)

Fault (observed)

Fault (position assumed)

Dip and strike

LEGEND

Culture

Boundary Survey trail

Boundary and Monuments

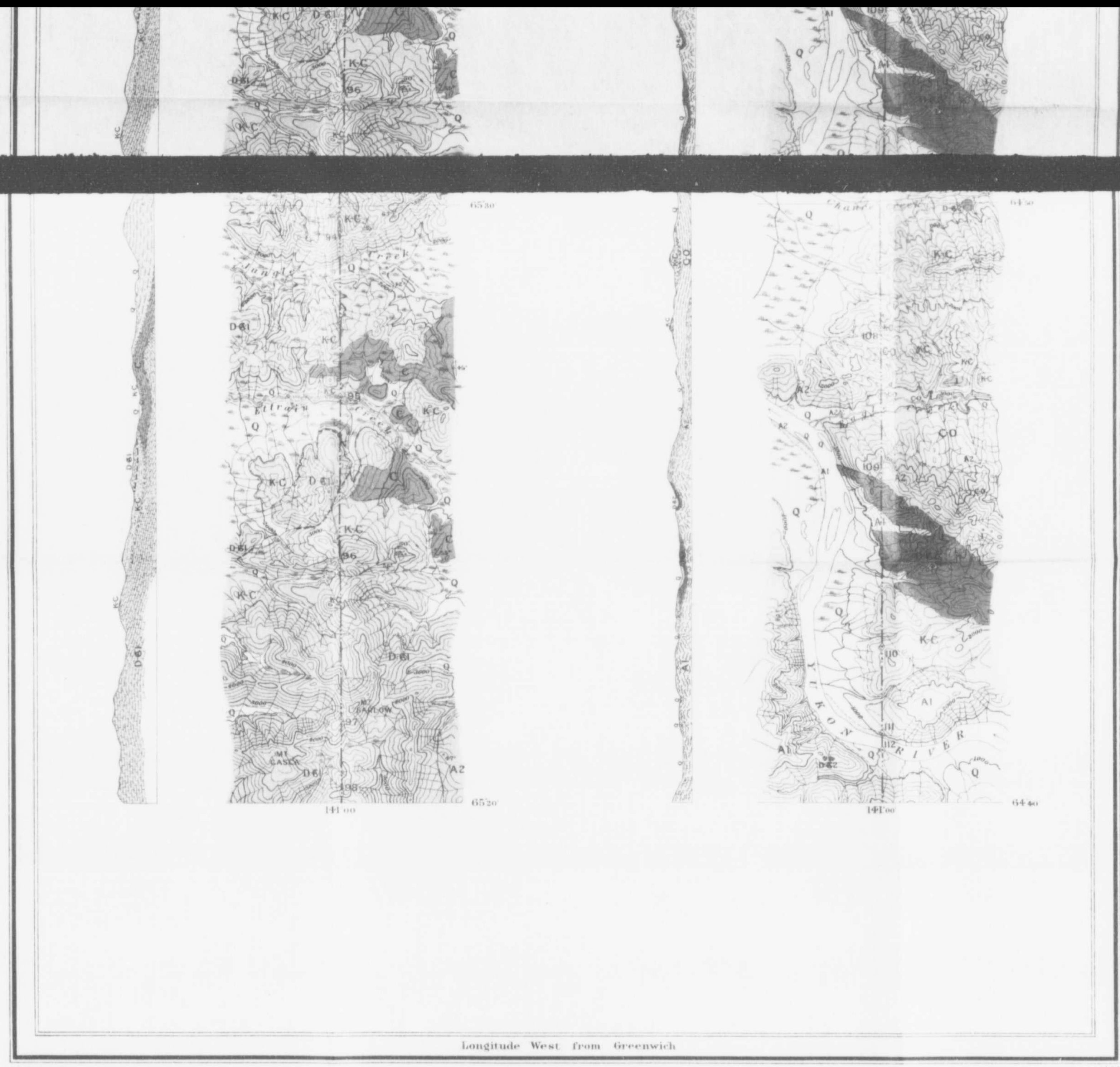
Water

Rivers and streams

Marshes

Relief

Contours (showing land forms) Interval 200 feet.



C.O. Senécal, *Geographer and Chief Draughtsman*
A. Braidwood, *Draughtsman*

MAP 140 A
(Issued 1915)

YUKON-ALASKA INTERNATIONAL BOUNDARY

BETWEEN YUKON AND PORCUPINE RIVERS

(Southern Sheet)

Scale $\frac{1}{125,000}$

Miles

Kilometres

Note. For practical purposes assume
2 MILES TO 1 INCH

TOPOGRAPHY

BASE-MAP REPRODUCED FROM MAPS OF THE INTERNATIONAL BOUNDARY COMMISSION

GEOLOGY

D.D. CAIRNES *1911, 1912*

To accompany Memoir by D.D. Cairnes.

Canada
Department of Mines

HON. L. CODERRE, MINISTER; R.G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

LEGEND

LEGEND

QUATERNARY

RECENT AND PLEISTOCENE — Q — **Superficial deposits** *(Chiefly gravels, sands, clays, muck, peat, soil and ground-ice.)*

MESOZOIC

CRETACEOUS AND UPPER CARBONIFEROUS (MAY INCLUDE SOME PERMIAN) — K-C — *(Chiefly shales, sandstones, greywackes, conglomerates, slates, and quartzites, with occasional beds of limestone intercalated with lower members.)*

PALÆOZOIC

CARBONIFEROUS — C — **Pennsylvanian and Mississippian** *(Dominantly white to greyish limestones containing considerable chert in places. Also includes some intercalated dark shales and cherty conglomerate beds.)*

DEVONIAN, SILURIAN, ORDOVICIAN, AND CAMBRIAN — D-Є1 — *(Chiefly limestones and dolomites with occasional intercalated quartzite beds. Rocks characteristically very siliceous. May include small areas of C)*

PRE-CAMBRIAN?

LOWER CAMBRIAN OR PRE-CAMBRIAN — A2 — **Tindir group** *(Chiefly quartzites, slates, shales, phyllites and dolomites, with some included greenstones)*

Igneous Rocks

MESOZOIC? — 2 — *(Grano-diorites, syenites, and related types)*

PRE-MIDDLE CAMBRIAN, IN PART DEVONIAN — 1 — *(Diorites, diabases, andesites and other basic igneous intrusives)*

Symbols

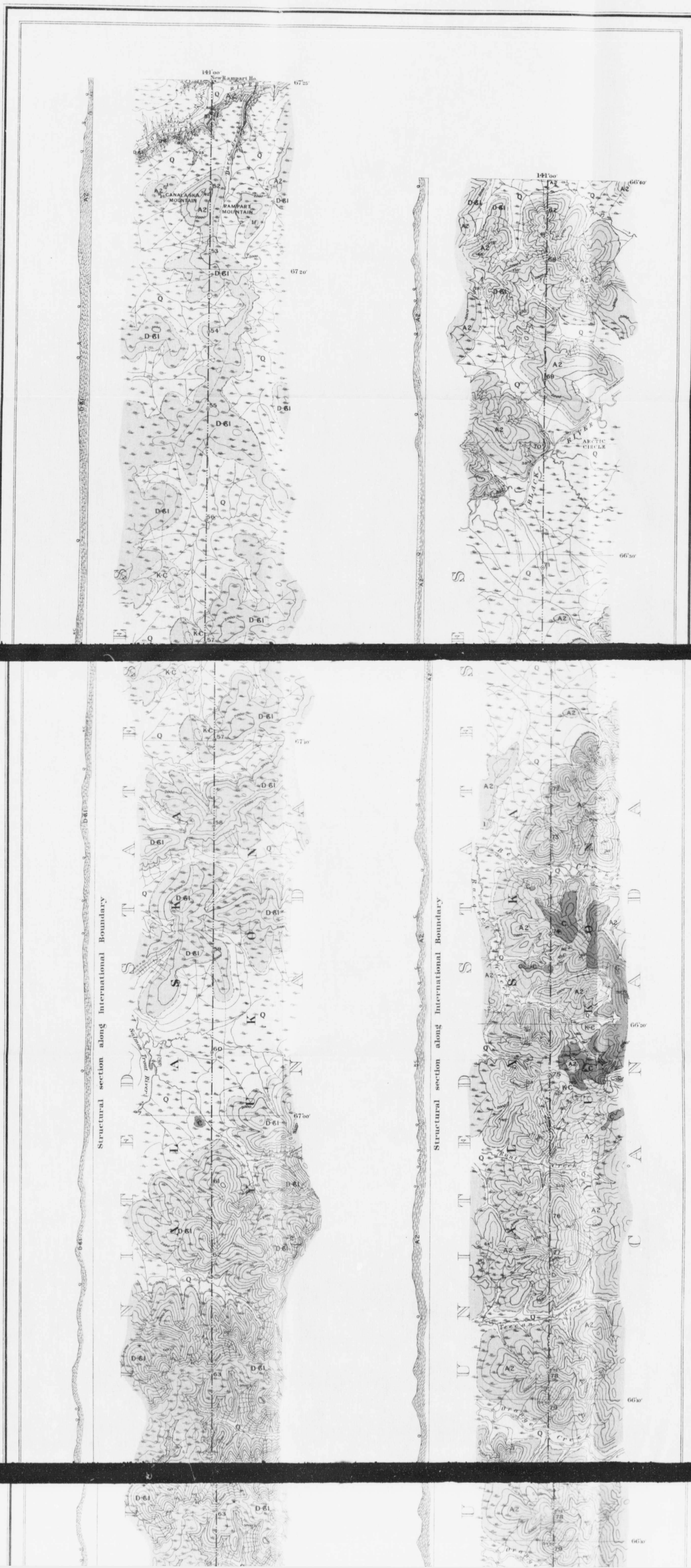
Geological boundary *(observed)*

Geological boundary *(position inferred)*

Fault *(observed)*

Fault *(position inferred)*

Dip and strike



LEGEND

Culture

Boundary Survey trail

Boundary and Monuments

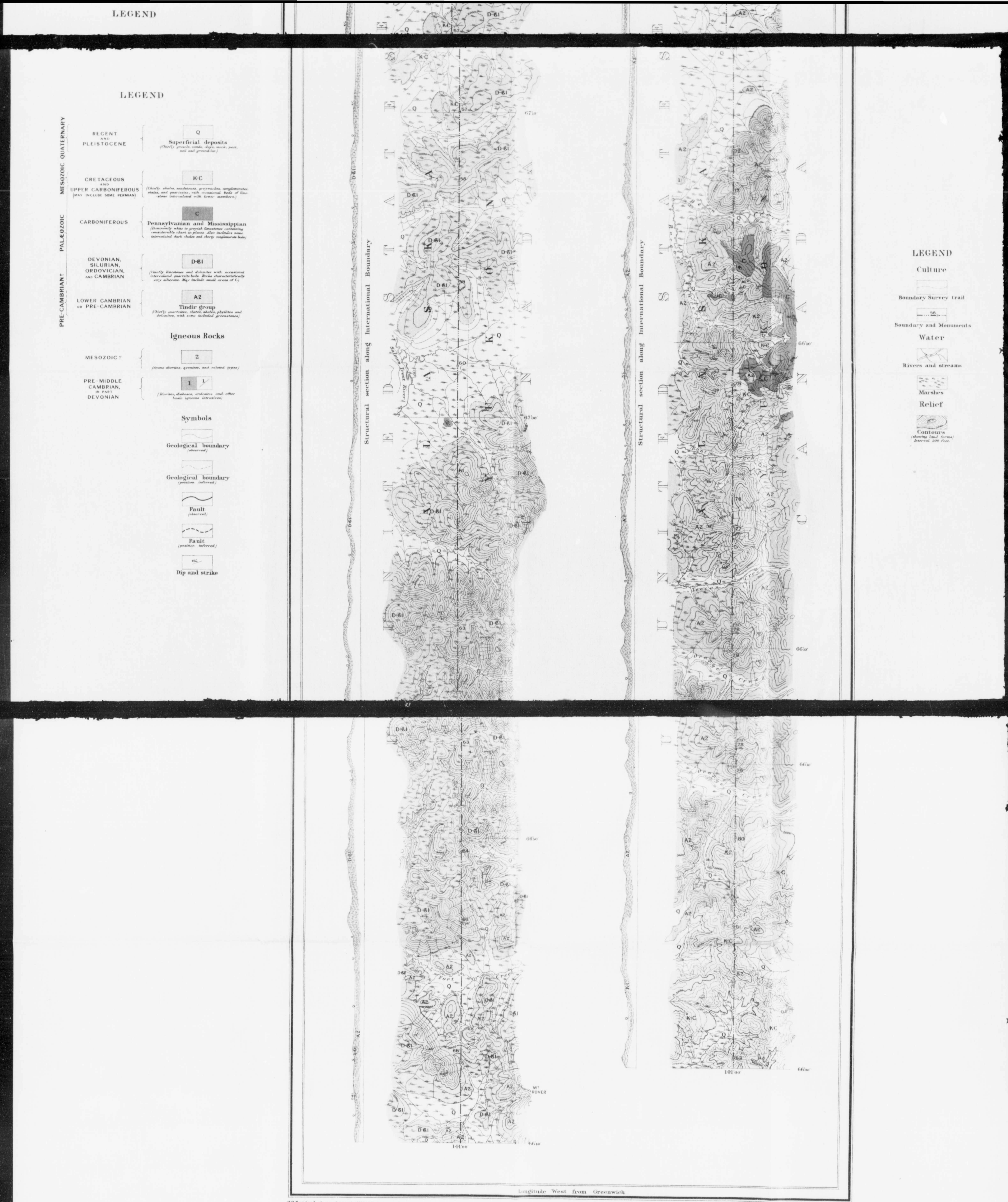
Water

Rivers and streams

Marshes

Relief

Contours *(showing land forms)* *Interval 200 feet.*



C.O. Senécal, *Geographer and Chief Draughtsman*
A. Braidwood, *Draughtsman*

1444

MAP 141 A
(Issued 1915)

YUKON-ALASKA INTERNATIONAL BOUNDARY

BETWEEN YUKON AND PORCUPINE RIVERS

(Northern Sheet)

Scale $\frac{1}{125,000}$

Miles

Kilometres

Note. For practical purposes assume
2 MILES TO 1 INCH

TOPOGRAPHY

BASE-MAP REPRODUCED FROM MAPS OF THE INTERNATIONAL BOUNDARY COMMISSION

GEOLOGY

D.D. CAIRNES *1911, 1912*

To accompany Memoir by D.D. Cairnes.