GEOLOGY AND ORE DEPOSITS

OF THE

YUKON TERRITORY

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INTRODUCTION.

In this thesis the writer has attempted to give as complete a compilation of the geology of Yukon Territory, as the literature permits. The geology of Yukon Territory is lacking in sedimentary formations and those sedimentary formations present have a rather remarkable scarcity of identifiable fossil remains. The work of W.E. Cockfield and E. Lees during the field season of 1929 promises to straighten out at least some of the difficulties. What information the writer has of these discoveries has been stated in the following pages.

A discussion of the placer deposits of Yukon is considered too extensive a subject to be dealt with in this thesis and have thus purposely been omitted.

Where possible and without going into too much detail the writer has attempted to correlate the geology of Yukon with that of the Interior of British Columbia.

A complete bibliography dealing with the literature published on the geology of Yukon will be found at the end of this thesis.
Fig 1. Physiographic Provinces of the Yukon
PHYSIOGRAPHY.

Yukon territory is essentially composed of three physiographic provinces which are continuous with similar divisions in British Columbia, to the southeast, and Alaska, to the west. These physiographic provinces named from southwest to northeast are: the Coastal system, the Interior system and the Rocky Mountain system. These three provinces form the Cordillera of North America.

The Cordillera extends from Mexico northward to the Arctic Ocean, paralleling, to an amazing degree, the Pacific coast line of North America. In British Columbia the general trend of the Cordillera is northwest, in Alaska the trend is westerly, while in Yukon which is in between, the course of the Cordillera is intermediate between the two, generally northwesterly. Lying to the north, northeast, and east of the Rocky Mountain system are various plains or lowland tracts.—The Arctic Slope region, the Mackenzie lowlands, and areas of broken wooded plains, possibly belonging to the great plains. (See Fig 1.)

A. The Coastal System.

The Coastal system, from the vicinity of the 50th to near the 60th parallel, embraces only the

Figure II

Nomenclature of the Mountains of Western Canada.
Coast range. The islands to the west were considered by Dawson as a separate range and are now called the insular range by the Dominion Geographic Board. (See Fig. 2) The simplicity of the Coastal system is interrupted near the head of Lynn canal, whence northward and northwestward this province embraces a number of ranges or mountain groups including the Coast range, the St. Elias range, the Aleutian range and the Alaskan range, which are in places separated by wide valleys.

The Coast range consists, in a general way, of an irregular complex of peaks and ridges, that possess but little symmetry other than a rough alignment parallel to a northwesterly-trending axis. The range has everywhere a precipitous and jagged aspect, and consists largely of knife-like crests, rugged or even needle-like summits, and sharply incised valleys. The summits in southern British Columbia, rise to uniform altitudes of from 8,000 to 9,000 feet above sea-level, but toward the north gradually decrease in elevation, until in Yukon they stand at only 5,000 to 6,000 feet; though the change in elevation is apparently great, it


(2) Dominion Geographic Board of Canada 1918.
is so gradual as not to break the general uniformity of summit-level which, however, bears no relation to structural features.

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

The Coast range has been considered by a number of geologists to represent a peneplanated or at least mature to old surface of erosion. Other geologists, however, maintain that this terrane shows no evidence of having ever been peneplanated.

The St. Elias range as the name is applied by Brooks, with its broader significance, includes the Chugach, Kenai, and Skolai mountains which are Orographically a western extension of the St. Elias range as this term is usually intended. Thus defined, the St. Elias range extends northwesterly from Cross sound,

(1) Dawson G.M. "Report on Kamloops map sheet, B.C."

(2) Brooks, A.H. "The geography and geology of Alaska." U.S.G.S. Prof. paper #45 1906.
bends westerly near the mouth of the Copper river, and near the head of Prince William sound, in longitude 147, turns sharply southwest and merges into the highlands of Kenai peninsula. The St. Elias range varies in width from 50 miles near Cross sound, to nearly 100 miles at Mount St. Elias, and then narrows down to less than 20 miles to the southwest in the Kenai peninsula. This "range is a rugged mountain mass parallel with and close to the Pacific coast from Cross sound as far as the entrance to Cook inlet, with one spur, the Skolai mountains, stretching to the southwest. On the seaward side, the range presents an abrupt escarpment, often rising directly from the water, while its northern slopes almost everywhere, fall off abruptly to the Central Plateau." (Yukon Plateau.) Peaks in this range rise to great elevations, for example Mt. St. Elias and Mt. Logan which attain an elevation above the sea of 18,024 and 19,500 feet respectively.

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

shed comprised of Wrangell and Skolai mountains, is known as Skolai pass, which lies between the heads of Nizina and White rivers.

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

These mountains are, also, exceedingly rugged and occupy an intermediate position between Skolai and Chugach mountains in the south and east, and Nutzotin mountains on the northeast. Mount Wrangell, with an elevation of 14,005 feet, is centrally located in the group of mountains to which it gives its name, and although possibly the most imposing among them, it is not the highest. These mountains reach their culminating point in Mount Sanford which is 16,200 feet above sea-level; and at least five other peaks rise to elevations exceeding 12,000 feet. The higher portions of the Skolai-Wrangell ranges constitute a vast snow field from which scores of valley glaciers descend, and form
the headwater sources of practically all the more important streams of the region.

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

B. Rocky Mountain System.

The Rocky Mountain system extends northward from the western United States through Canada to near the Arctic, where, 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 the Yukon river on the west and the Mackenzie river on the east. After bending to the south-
west 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 (1) has been applied.

The Rocky mountains increase in ruggedness northward from the 49th parallel to Mt. Brown and Mt. Murchison where they attain their maximum heights; from thence northward they decrease in ruggedness and elevation until where the Peace river crosses they resemble only rolling hills. Their elevation varies from a maximum of 13,000 feet at Mt Robson to an elevation of 6,000 feet where the Peace river crosses. They have an approximate width of 200 miles in the southern portion but their width decreases northwards. The Rocky mountains rise steeply from the Great Plains on their eastern border, and on the west they are bounded by the Rocky Mountain trench—— the master valley of the Cordilleras.

The Mackenzie mountains, which include the greater part of the Rocky Mountain system in Yukon, are (2) described by Keele (2) as a complex of irregular mountain masses which are the result of deformation and uplift of sedimentary rocks and include summits rising to

(2) Keele Joseph"A reconnaissance across the Mackenzie Mts. on the Pelly, Ross, and Gravel rivers, Yukon and N.W. Territories." G.S.C. 1910 PP. 16-18
heights of 7,000 to 8,000 feet above sea-level. They have a maximum width of about 300 miles. The Ogilvie mountains appear to constitute a northwesterly lobe of the Mackenzie mountains. The Mackenzie mountains are bordered on the west by a northward continuation of the Interior system (the Yukon Plateau) and on the east by the Mackenzie river and the Franklin mountains. The Mackenzie mountains are less rugged than the Rocky mountains and of greater lateral extent.

Throughout Yukon the axis of the ranges comprising the Rocky mountain system, have an echelon character, the different ranges not persisting any great distance, but instead giving place in either direction to other parallel ranges.

North of the Yukon river and just south of the Porcupine river Cairns describes the Keele mountains as having undoubtedly had the same physiographic history as the surrounding portion of the Yukon plateau and they are considered to constitute a portion of this terrane. The Keele mountains are characterized by 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. When viewed from the upland, 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. 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.

The Ogilvie Mountains are unusual in the fact that they are composed essentially of soft sedimentary rocks — mainly limestone. The valleys and lowlands are composed of slates and schists which generally are more resistant than limestones. In Yukon the extremes of temperature have more effect than the usual forms of erosion. The slates and schists permit ready access of water, and frost action is prevalent to a high degree, thus the slates and schists split along the cleavage planes and readily break off. The fine-grained limestone, on the other hand, does not permit the entrance
of water to any great extent therefore frost-action on
the limestones is not as great on the slates and schists.
Thus the limestone forms the tops of the mountain ranges
in this vicinity.

C. The Interior System.

The Interior system of Yukon, the Yukon Plateau,
is a continuation of the interior plateau region of
central British Columbia. It is cut off from the in-
terior of British Columbia by the Cassiar range which
occurs in the vicinity of latitude 58°.

The Yukon plateau, comprises the major portion
of the Yukon territory and is drained almost wholly by
the Yukon river. It extends from about latitude 58° in
northern British Columbia, through Yukon and Alaska to
the Bering sea, and has a width of from 200 - 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 pro-
vince in Yukon, the main drainage courses have incised
channels varying from 3,000 to 4,000 feet in depth, thus
producing a very irregular topography consisting essent-
ially of rolling uplands separated from each other by
wide deep valley trenches. The summits of the unreduced
hills and ridges, lying between the waterways, constit-
ute remnants of what was once, apparently, a gently roll-
ing plain sloping toward the northwest. The plateau seen from a summit having an elevation corresponding to that of its surface and where one of the major river trenches does not cut the line of sight displays an even sky-line sweeping off to the horizon, and broken only here and there by isolated, residuary masses rising above the general level. This upland, however, bears no relation to rock structure, erosion having bevelled the upturned edges of the hard rock as well as the soft strata, with the result that its surface is entirely discordant to the structure of the highly contorted, metamorphic rocks that outcrop over it so extensively.

Along the northern portion of the Coast range, the general summit-level merges into that of the Yukon plateau, in a manner suggesting the synchronous planation of these two provinces, but during the various vertical movements that have affected these terranes, the uplift has been greatest along the axis of the Coast range and least along that of the Yukon plateau, which terrane is thus given the contour of a huge flowing trough whose median line is in a general way, marked by the present position of the Yukon river from near its headwaters in northern British Columbia to Bering.

No distinct line of demarcation indicates the boundary between the plateau and mountain provinces; these, instead, grade into each other, so that a transition belt occurs, generally from 1 to 4 miles wide, in which many of the points cannot definitely be said to belong to either terrane.

The plateau topography is characterized by two striking features, the numerous, irregularly-distributed, wide, deep, steep-walled valleys, and the elevated and in places slightly undulating, intervalley, upland areas. Over considerable portions, the plateau surface has been almost if not quite destroyed by later erosion, and in such places the topography consists of irregularly-distributed, rounded hills, many of them gently-contoured and with summits that are in many cases remarkably uniform in elevation.

Towards the south and west the surface of the Yukon plateau gradually rises and becomes more and more dissected, and the topography consequently assumes an increasingly rugged aspect until the Coast range is reached.

The topography of the Yukon plateau may be divided into two groups: the Uplands and the Valleys.

The Uplands.

Over large portions of the Yukon Plateau region, the plateau characteristics are still well preserved, and numerous fragments of almost flat, or gently rolling upland still remain in spite of sub-aerial erosive agencies which tend to destroy the old surface. Over considerable portions of the plateau region, little trace of the former upland remains and the topography consists of isolated, generally rounded, hills, many of the summits of which rise to an elevation of the plateau surface. In places erosion has succeeded in removing the plateau surface entirely, and only low, irregular hills remain which show no concordance of summit level.

The plateau surface to be observed to the best advantage must be viewed from interstream points, situated some distance back from the edges of the master valleys; from such positions the even, gently rolling character of the plateau is strikingly apparent. The surface bears no relation to rock structure, the various rocks underlying the plateau are all truncated, regardless of their structure, hardness, composition or other qualities.

The plateau-surface thus represents a plain of erosion that has probably been produced mainly by ordinary erosive agencies rather than by glaciation,
since if it has been produced by glaciation its surface would be everywhere strewn with foreign glacial materials, which is, generally, not the case. In places there is evidence such as the occurrence of striae and erratics, that ice has moved over the local plateau surface, but the greater part of the upland is covered with local material produced by ordinary erosive and weathering agencies.

This plateau surface thus appears to form part of a region that during a long period of crustal stability was almost completely base-levelled and was reduced to a condition of old age. The residual mountains that now constitute monadnocks rising above the plateau level, represent the only considerable elevations that remained to break the monotony of the former landscape. Base-levelling processes, which tended to reduce the entire plateau region to sea-level were interrupted, before the reduction of these remaining hills, by an uplift which affected a great portion, at least, of British Columbia and Yukon.

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 at one time this region
must have formed a portion of a plain, the edge of which was at or nearly at sea-level. This base-levelling process was followed by a widespread uplift and the nearly flat or gently undulating lowland became an upland tract. This uplift rejuvenated the streams which immediately commenced trenching their valleys in the upland surface and a new physiographic cycle was inaugurated. There is some difference of opinion as to the exact date of this planation and subsequent uplift, but the bulk of the evidence goes to show that this region was planated during either the Eocene or Pre-Pliocene Post-Eocene time, and that the planated tract was uplifted to nearly its present position during late Miocene, Pliocene, or nearly Pleistocene (1) time.

The amount of uplift is somewhat indefinite. The Lewes and Yukon rivers have grades much in excess of rivers traversing a district in its old age. Further it seems very improbable that the area, prior to uplift, was drained by a longer water system than the present circuitous one; in fact, investigations have tended to show that the district was drained into (2) the Pacific by a much shorter system. The vertical extent of the uplift was probably in the neighbourhood

(1) Cairns D.D. "Wheaton district, Yukon Territory." G.S.C. Mem. #31, 1912 pp 83-84
of 4500 feet.

Sometime subsequent to the uplift, and the development of the present valley systems, a climatic change caused glaciers to form in the higher regions, and great tongues of ice moved from the gathering grounds down the main valleys of the plateau and the uplands of the plateau surface were only slightly affected.

(2) Cockfield is of the opinion that glaciation as an ice-sheet did not effect the Yukon plateau. He believes that the Coast range and the Mackenzie mountains acted as accumulating centres for the ice which eventually descended upon the plateau in tongues following the main river valleys and to a small extent covering some of the upland portions of the plateau-surface. These ice-tongues deposited morainal material in the valleys and on some of the upland surfaces; and in some cases formed dams in the streams due to the rapid retreat of the ice, thus also forming lakes.

It has been calculated that when the Cordilleran ice-sheet was present in North America the snow line was lowered 3,000 feet. In Yukon the snow level is 7,500 feet and a lowering of 3,000 feet would place the snow line at 4,500 feet. The general level of the plateau is approximately 5,000 feet, thus the snow line

(2) Cockfield W.E. Personal Communication.
during the time of the Cordilleran ice-sheet would be well below the general level of the plateau. The accepted reason for the absence of glaciation in Yukon is the lack of precipitation. The Yukon plateau is a dry belt, which is readily realized by the volume of water in the drainage systems. The Yukon river drainage basin is as large as that of the St. Lawrence river system but the volume of water is only one seventh. Thus if, during Cordilleran ice-sheet time, the moisture laden winds came from the Pacific in a southwesterly direction, as believed, the St. Elias range and the Coast range would prove an efficient barrier to precipitation over the Yukon Plateau region.

At no time, apparently, did snow gather on the plateau in sufficient quantities to form considerable masses of ice, but for the most part, it seems to have been blown by the winds into the valleys and depressions. It is believed that, during Pleistocene and Recent times, the plateau surface, although only modified slightly by moving ice, has been considerably affected by accumulations of snow.

The effects of neve snow are to convert shallow V-shaped valleys into flat U-shaped depressions, to efface their drainage lines without materially changing their grades, and in this manner to produce general smoothness of surface. Since the snow-drifts have no
sliding motion, there is no transportation of material by them; however, because of excessive frost action, and continued alternations of freezing and thawing, the rocks at the peripheries of the quiescent snow, are finely comminuted and the material is removed by innumerable rills to neighbouring depressions. These effects of the work of quiescent neve, called nivation, have resulted in grading, to a considerable extent, the already gently rolling surface of the plateau region, and account for the great amount of fine material that fills all the minor depressions in the upland surface. The presence of the snow also helped to preserve the smooth outlines of the topography, by protecting the surfaces from stream action.

A review of the above shows that the following causes mainly account for the contrasting topographies of the Coast range and Yukon plateau:-

1. The Coast range was uplifted more than the plateau tract and was consequently subjected to a greater degree to erosive agencies; and as the mountains of the Coast range are composed mainly of homogeneous grano-diorite the forms produced by erosion are noticeably irregular since no bedding planes or lines of hard and soft layers exist to be emphasized by degradation.

2. The rocks of the Coast range are generally harder and more resistant to ordinary sub-aerial agencies than are the rocks to the east, and the more nearly the rocks of the plateau approach those of the mountains in physical properties the less apparent, and the more gradual is the change from plateau to mountain provinces.

3. The Coast range is sufficiently high to still hold great amounts of glacial ice which is actively employed accentuating the features of the mountains and giving them a typical fretted appearance. In the case of the Yukon plateau, on the other hand, the ice, except for small masses in occasional cirques, has long since vanished from the region, and instead of the features there continuing to become more pronounced, they are being rounded and smoothed over by nivation. Thus once a difference of elevation between these two provinces was established, their features became continually more and more contrasted. This appears to account mainly for the striking difference in the physiography of the terranes, although apparently synchronously planated and uplifted.

The Valleys.

After having considered the gently undulatory character of the upland, the observer will be impressed

by the pronounced topographic unconformities that present themselves at the contacts of this surface with the high, steeply-inclined walls of the various valleys that intersect it.

The last great uplift, probably in Pliocene time, which affected this district, give the streams of the region renewed life and energy, and they immediately began vigorously trenching their channels in the uplifted surface. Throughout the area deep incisions were rapidly made, which, in Pleistocene time, were invaded by glaciers from the mountains to the west and south. Although the ice produced but little effect upon the upland surface, it had a profound influence upon the valleys.

When a broad ice-sheet covers a district it has the effect of moderating the topographic features and reducing the relief, by eroding material from the higher elevations and depositing it in the depression. However, where the ice occupies only the valleys, much greater and different results are seen. Here the interstream areas maintain their even character, unaffected by the ice, while the valleys are widened and deepened; and the maximum effects of glaciation are produced in areas where the topography indicates that

it has been previously prepared to receive the ice, by having deep valleys already made, in which the ice can most advantageously operate. The V-shaped valleys are then transformed into wide, deep, steep-walled, U-shaped depressions, and hanging valleys, cirques, roches moutonnes, and other well known glacial forms are produced.

In addition to being mainly destructive, the glaciers also acted in a constructive capacity, and contributed vast amounts of morainal and other materials which deeply covered the floors of the master-depressions. Since the retreat of the ice but little erosion has occurred, and considerable portions of these valleys are still almost as the ice left them, and the larger the valleys the more material they have received.

The broad, flat-bottomed, steep-walled valleys are found only in southern Yukon and in the vicinity of the mountain ranges, which as noted before, acted as collecting regions for the ice. Northward, wide, flat, gently sloping valley walls with interlocking spurs are more common. These are the unglaciated valleys of the plateau province. The glaciated valleys are usually dotted with numerous lakes and muskegs but the non-glaciated valleys have a complete drainage system.

The small streams that traverse the upland flow over this surface in wide, flaring depressions, with gentle gradients, but on coming to the edge of this
elevated platform they plunge suddenly, by successive falls, through gorge-shaped incisions, to join the master streams below. Thus the tributary streams have hanging valleys, and the smaller the tributary, the less eroding power of the stream, either of ice or water, which it contained, and the more its valley was left hanging above that of the master stream.

Perfectly developed and well preserved cirques occur plentifully, and exist prevailingly along the edges of the master-valleys. A notable feature in connection with these forms is that they are invariably found along the sides of the larger valleys, or at what may be considered the heads of the almost insignificant sub-tributaries. The cirques that originally existed at the heads of the larger tributaries have, in all cases noted, been successful in gnawing headward to meet others moving in an opposite direction, and cols or (1) passes have resulted.

Glaciation has generally extended practically to the top of the cirque-walls, but above and back of this only nivation has been operative. The snowbanks are always the forerunners of glaciers, and when they accumulate on favourable hillsides the comminuted material produced is removed, not as in the case of drifts

on the upland surface to fill minor depressions nearly, and so to moderate the topographic relief, but instead innumerable rills carry the finely broken material to larger waterways which distribute it widely. As this continues, the drifts enlarge their containing nooks, and nourishing catchment basins for glacial ice are soon produced, and in this way many cirques are formed. The boundary between the quiescent neve snow and the glacier is marked in cirques by the well known bergschrund, or semicircular, irregular crack that occurs approximately conforming to the contour of the cirque, but standing some distance from its walls. Matthes has calculated that the neve must be 125 feet thick and on a 12 per cent grade before motion commences. 

From the immediately preceding statement it would seem, since the general level of the valley floors is roughly 1,500 feet below the plateau level, that all the valleys of the Yukon plateau should have been glaciated. This is stated in view of the fact that the snow of the uplands was considered as blown into the depressions, therefore the valleys should have been filled with roughly 1,500 feet of snow and the valley walls having a grade of greater than 12 per cent would produce motion. There appears to be only one reason why this

neve did not form and this is that there was not sufficient snow, or there was not 125 feet of more in the valleys. As explained before, the Yukon plateau is a dry belt between two mountain systems and the absence of glaciation in the northern portion of the plateau shows that this area was, as now, a dry belt. The mountain system on the west protected the interior regions from precipitation but formed the gathering ground for the valley glaciers which sent out their tongues of ice onto the plateau region.

It is the belief of the writer that too much erosive power is attributed to glaciation, in the lower levels especially. Glaciation, in the writer's opinion, is more of a moulding, somewhat scourging, process in which the sharp lines of non-glacial erosion are effaced. It is probable, too, that the erosive power of glaciation in the higher levels may be due to frost action and the extremes of temperature. These conclusions are engendered by the writer's limited experience with glaciation and will be cheerfully recalled in favour of evidence to the contrary.

In a number of places in the valleys terraces are found, which are often quite persistent and exist up to 700 or 800 feet above the valley bottoms. These are peculiar in that, although from a distance, preferably from the other side of the valley in which they
occur, they may be quite evident and even somewhat striking on account of their persistency, still when a person is actually on the spot where they occur, it is often difficult to tell exactly where they lie, since only slight amounts of terrace-tops or platforms (1) remain.

Generally several of these terraces can be seen clinging to the valley-walls, and in a few places four of five may exist, one above the other. Of these, the majority extend but a short distance. These terraces have been described by a number of writers; and everywhere the origin of these terraces is in doubt. Dawson and Spurr consider that subsequent to the uplift of the Yukon plateau, and after the valleys had become deeply trenched, a submergence occurred in late Pliocene or Pleistocene time. The valleys are thus thought to have become partly filled with gravels, sands, silts etc. After a brief period, elevation commenced, and as the streams cut down through the debris terraces were left clinging to the valley walls--- the amounts

Nordenskjold O.The American Geol. Vol.XXIII.PP.290-98
of the subsidence and uplift being indicated by the terraces.

The postulation of a submergence and subsequent uplift appears to Cairnes to be quite uncalled for, to explain the origin of these terraces. Quoting Cairnes:

"It is true that a certain amount of uplift has occurred in recent times and may be still in progress, as indicated by recent rock terraces along the Yukon river above Dawson and elsewhere, but these appear to have had an origin quite distinct from the gravel, sand and silt terraces which characterize many of the valleys of northern British Columbia and Yukon. In whatever manner the terraces were formed, they must have originated since the glacial period, otherwise the valley glaciers would have entirely obliterated them. It is further evident that no great amounts of material have been deposited in many of the valleys since glacial time, as in depressions such as along the White Pass and Yukon railway between Corcross and Whitehorse, and around Annie lake, the valley floor is pot-holed and minutely rough, and possesses still the characteristic appearance of a surface that has been overlain by ice."

Brooks and others have supposed the terraces to be due to changes in the erosive powers of the stream, and in places this appears to be true, but in the por-

tion of Yukon territory where the terraces reach high up on the valley walls, this theory calls for the former existence of vast amounts of material over the present valley floors, which cannot be true in some localities.

It has been supposed that the terraces are remnants of lateral moraines formed along the edges of the valley glaciers, and consist thus partly of ground-up debris accumulated by the ice itself, and partly of materials that rolled down the sidehills from above, and gathered along the upper surface of the ice. As the ice retreated, and stood at successively lower elevations, other accumulations would tend to form, and those left above would remain in the form of terraces clinging to the valley walls. The most persistent and prominent of the terraces would thus mark elevations at which the ice maintained constant elevations for exceptionally long periods.

In certain valleys where the terraces have been but poorly preserved it is difficult to disprove this theory. However, in some cases, quite extensive flat-topped terrace accumulations remain in the mouths of the tributaries, and extend out flush with the edge of the walls of the master-valley. If the terraces originated due to ice action, the ice would also have invaded the mouths of the tributaries, and the entire lower
portions of such would not now contain flat-topped accumulations.

It thus seems evident, as suggested by Norden-skjold and other, that these terraces are dominately, at least, lake terraces, and represent successive elevations at which the water stood in post-glacial time. This calls for a damming of the drainage system somewhere along the Yukon river. As the terraces indicate that the period of submergence was only brief, the damming was probably due to accumulations of ice or other glacial materials.

The great masses of ice which occupied the master-depressions planated the valley sides, reducing all projecting spurs, ridges, etc, and bringing them into alignment to form quite regular walls. Since the close of the glacial epoch, the numerous small tributary streams from the upland have been cutting channels in these walls and enlarging the pre-glacial incisions in them. The result is that, cut in these steeply-inclined valley slopes are numerous V-shaped, trench-like forms, and between these are facetted forms carved in the valley-walls. These forms are quite pronounced along the glaciated valleys and represent forms produced by a combination of glacial and post-glacial activities.

The structural control of drainage courses and
the effect of rock structure upon topography in Yukon
are questions which have not been dealt with at length
by geologists and others writing of the region. Cairnes
states that the present course of Yukon river marks the
axis of the Yukon plateau, towards which there is a
gradual slope both from the east, and that this was
caused by differential uplift. Cockfield and Bell are
of the opinion that a number of the larger valleys in
Whitehorse district likewise had their position deter-
mined to a great extent by structural factors. They
also noted a rather striking rectangular effect in the
drainage of the McClintock basin, which suggest struc-
tural control of drainage.

Reinecke noted the relation of drainage to
structure in the Interior plateau of British Columbia.
There, he found the general trend of the drainage to be
north, northwest and northeast and also noted a marked
rectilinearity in drainage pattern. Reinecke is of the
opinion that the drainage is controlled by fractures
trending north northwest and northeast. Schofield finds
that the fracture system of British Columbia has three
main directions north, northwest and northeast.

Although there is little information on the fracture system of the Yukon territory, from a study of the drainage pattern there appears to be a definite design. Most of the streams have a general north, northwest or northeast trend and some rectilinearity is noted. It thus seems probable and possible that the fracture system of British Columbia may be extended into Yukon.

As has been shown, glaciation has modified the valleys of the streams and has left deposits of morainal material upon the valley floors; but glaciation has also modified the drainage. On the wide, flat valley-bottoms of the glaciated valleys innumerable pot-hole lakes are found. These lakes are due partly to the scouring action of the ice but mainly to the disruption of the original drainage by damming with glacial debris, leaving a disconnected drainage system.

Through the glacial debris the rivers wend a rather sinuous course and some lakes are formed by the cutting off of ox-bows. In quite a number of cases, the drainage has been reverted by the damming of the ancient valley with morainal material and, as in the case of Miles canyon near Whitehorse, with recent flows.

An inspection of the map suggests certain rather obvious changes that may have taken place. Lewes river may have flowed through the lower part of the valley of Watson river instead of around by lake Bennett. Wheaton
river may have followed its same course above Big Bend and here turned to the left instead of to the right, flowing northward through the valley now occupied by Annie lake. Cockfield and Bell are of the opinion that changes such as these were due perhaps, to one or both of two factors: 1. deposition of glacial materials in the former valleys and 2. diastrophic movements.

Cairnes suggests that the Lewes river formerly flowed through the Ogilvie valley, which is a continuation of that occupied by lake Laberge, and which channel has been filled with morainic and other drift material during the glacial period, forcing the river to seek its present course.

The evidence in Upper White River district would seem to indicate that Upper White river in pre-Glacial time followed a course similar to that of the present stream as far as the International Boundary, but below that point, this river swung to the north and continued down through Lake Tchawsahonon valley to the Beaver. The Genere river, on the other hand, apparently held practically its present course to the White River valley, and thence persisted as now, through the Nutzotin mountains, was joined by Koldem river and

(1) Cockfield W.E. and Bell, A.H. "Whitehorse district, Yukon." G.S.C. Mem 150 P.5 1926.
other streams and was united with the Upper White river which had been joined by the waters of the Upper Tanana. These combined streams then may have flowed either down the Tanana and thence to the Yukon, or may have continued down the present valley of the White to the Donjek river a decided change occurs. The valley of the White above this point is wide and contains on either side heavy banks and terraces of glacio-fluvial accumulations. Below the Donjek these are suddenly replaced by high abrupt rock cliffs, and the valley instead of having an old appearance, exhibits considerable evidence of being a youthful depression. Thus in all probability a former river drained through the present valley of the White to the mouth of the Donjek, but thence followed some other route to the pre-Glacial channel of the Yukon river. The Upper White, according to this system of drainage, came very close to the Generc and, due possibly to glacial accumulations, was eventually turned into it over the present position of the Upper canyon.

(1) Cockfield is of the opinion that from where the Pelly river swings sharply to the south to join the Yukon river it has left its old valley. This ancient valley is approximately ten miles wide and extends to join the Stewart river. There is a difference of elevation in the ancient valley of about 300 feet.

(1) Cockfield W.E. Personal Communication 1930.
He also stated that the Yukon river enters a totally different valley north of its junction with the Pelly river. South of this junction the Yukon river flows in a wide, flat valley with rounded hills while north of this junction it flows in a narrow steep-walled valley. He attributes these changes to accumulation of glacial debris.

Further detailed investigation will be necessary before the drainage changes will be understood, and the former drainage system is established.
A great variety of rocks, both sedimentary and igneous and ranging in age from Pre-Cambrian to Recent, are found throughout the Yukon territory.

The oldest rocks are metamorphic and are dominantly schistose in character. They are considered to be, mainly, of sedimentary origin. These metamorphic schistose rocks consist dominantly of schistose amphibolites, quartzite schists, mica schists, and occasional beds of limestone and are known as the Yukon group. Occasional dykes and small intrusive bodies pierce the Palaeozoic 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 evidence obtained regarding these rocks, indicates rather conclusively that they are all of Pre-Cambrian age.

Overlying the metamorphic schistose rocks is a group of rocks composed mainly of dolomites, quartzites shales, slates, phyllites, and associated greenstones. These are known as the Tindir group and are considered as younger than the Yukon group of Pre-Cambrian age.

The Tindir group is overlain, unconformably, by a thick series of limestone-dolomite beds which range in age from Cambrian to Carboniferous. Shales, cherts, sandstones, cherty conglomerates and thinly bedded limestones are found ranging in age from Ordovician to Carboniferous. These beds are in turn overlain by 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 compose the Nation River formation.

Apparently conformably, overlying the Nation River formation is a thick series of Mesozoic sediments including mainly shales, sandstones, greywackes, conglomerates, slates and quartzites. Fossils have been found in these rocks indicating a Cretaceous age.

Investigations, so far, have failed to show any large basins of Tertiary sedimentation as occur in the Interior plateau region of British Columbia. A few small basins of sedimentary Tertiary are known to occur in the central portion of the Yukon plateau. More recent than these consolidated rock formations are the superficial deposits of silts and glacial debris of Recent and Pleistocene times. These Recent and Pleistocene deposits form a mantle obscuring the older formations throughout a large portion of Yukon.
The igneous rocks throughout the region consist of intrusive and extrusive phases. The intrusive rocks are represented by the Coast Range intrusives, which consist mainly of grano-dioritic rocks. They form the Coast Range batholith and occur as outlying stocks in the plateau region. These rocks are considered of Jurassic or younger in age.

Older than the Coast Range intrusives is a series of igneous rocks composed of diorites, andesites, andesitic tuffs, pyroxenites, amphibolites, and manganites. Of their age nothing is known except that they are older than the Coast Range.

The extrusive phase of the igneous rocks is represented by a series of flows, tuffs and breccias. Younger than the Coast Range intrusives is a wide-spread series of andesites and andesitic tuffs and breccias. Some of these are considered contemporaneous with and some younger than the Jura-Cretaceous sediments. More recent than these andesitic flows are late Tertiary or Pleistocene basalts occurring mainly in the form of flows. These later flows were, in places, accompanied by extensive accumulations of basalt tuffs. About this time a number of dykes and small stocks of granite and syenite-porphyry were also intruded, but it is not known whether before or after the basalts. The most recently
consolidated rocks consist of a series of rhyolites, trachytes, and latites, which pierced the older rocks and poured over the country in places, generally in sheets 50 feet or less in thickness. These outpourings were accompanied by great quantities of tuffs and breccias.
The oldest rocks known to occur in Yukon are the Yukon group, and consist mainly of mica schists, quartz-mica schists, and schistose amphibolites, which are considered to be of Pre-Cambrian age. These rocks are so highly metamorphosed that they afford very little information concerning this early period in the geological history of the area. They show that great thickness of arenaceous and argillaceous sediments were deposited in a probable Pre-Cambrian sea which occupied this region at this time. They also show that these sediments have been invaded by various igneous rocks, and that all have since become so metamorphosed as to be dominantly schistose or gneissoid in character.

The Yukon group probably represents the northward extension of the Pre-Cambrian rocks of central British Columbia and with the Tindir group of relatively unaltered sediments may possibly represent a continuation of the Pre-Cambrian sea-way from southern British Columbia to the Arctic ocean as suggested by Schofield. The Tindir formation may also comply with Schofield’s Beltian of the Cranbrook region of British Columbia.

During Lower Palaeozoic times great thickness-

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es of argillaceous and arenaceous matter, followed by calcareous materials, were deposited in a sea-way. Vulcanism was also active. The Lower Palaeozoic terminated in Yukon with a wide-spread, dynamic revolution which caused extensive deformation and metamorphism, and was accompanied by considerable volcanic activity. It is probable that some of the intrusives may have been injected at this time.

Where the records are still legible, they show that at the close of the Silurian disturbance a considerable area was above the sea and a long erosion interval ensued. Some time before the Middle Devonian a great part of Yukon sank beneath the sea, and at about that time vulcanism became active at a number of points.

This sea-invasion, which commenced in Devonian time, continued well into the Carboniferous period. The normal course of sedimentation was, however, repeatedly interrupted by volcanic activity, as a result of which andesitic and basaltic lavas were extruded. It seems probable that certain members of these volcanics may be contemporaneous with the Carboniferous sediments.

Marine occupation with its accompanying sedimentation continued from Carboniferous until well into Cretaceous time, and during the Mesozoic epoch, aren-
ceous and argillaceous sediments were deposited which have now become altered into shales, argillites, sandstone, greywackes, and conglomerates.

Throughout the western portions of British Columbia and southern Yukon, a widespread crustal movement occurred in Jurassic times and possibly earlier, to later, which was accompanied by the intrusion of vast amounts of igneous materials including a great part, at least, of the rocks composing the Coast Range batholith. At the close of the Jurassic disturbance a considerable area was above the sea, and what was probably a short period of erosion ensued.

Cretaceous rocks are known to contain pebbles of granitic rocks, which are similar, lithologically, to the Coast Range intrusives, and to be cut by lithologically similar granitic rocks. It is evident, therefore, that granitic intrusions apparently derived from the same magma, have invaded this same general belt at different and, in some places, widely separated periods ranging from sometime in, or previous to, the Jurassic until at least the close of the Cretaceous.

The Mesozoic era, and particularly the latter part of it, was also characterized by volcanic activity as a result of which the Mesozoic and Carboniferous sediments became intensively invaded by andesites, diabases, basalts, and related rocks. As mentioned pre-
viously these rocks were considered to be interbedded with the Carboniferous sediments, and it was thus considered possible that these older volcanics represent a long intermittent period of vulcanism extending from Carboniferous until late Cretaceous times. Cockfield, however, is of the opinion that these Carboniferous rocks belong high up in the Mesozoic era.

The Mesozoic period of sedimentation was terminated, at or about the close of Cretaceous time; by a widespread deformation, at the close of which a considerable portion of Yukon was above the sea. Degradation became active, and no evidence has, so far, been obtained to show that from then to present time, any portion of this region has been subjected to marine conditions.

During early Tertiary time fresh-water sediments were deposited throughout considerable portions of Yukon. The beds were for the greater part at least, deposited in shallow basins and in places contain seams of lignite. Previous to the deposition of the early Tertiary beds, and after the deposition of the Cretaceous sediments, an extensive and far-reaching period of deformation ensued corresponding apparently to the Laramide revolution elsewhere.


(2) Cockfield W.E. Personal Communication. 1930.
After the deposition of the Tertiary beds, a gradual uplift occurred which though of orographic character, was in places accompanied by volcanic activity and by a considerable disturbance of the Eocene sediments. This movement affected apparently all of the Yukon plateau as well as the Coast range. (1)

Much discussion has ensued about the actual time of this period of crustal stability but it would seem from evidence given by Cairnes that the planation of the Plateau region was contemporaneous with the deposition of the Eocene beds. Some discussion has ensued both for and against the synchronous planation of the Yukon plateau and the Coast range by the above writers. (2) Cairnes is of the opinion that they were synchronously eroded but believes that considerable relief remained. (2) Cairnes believes the Coast range and the Yukon plateau were synchronously uplifted but that the Coast


range being near the edge was uplifted more than the Central tract which was near the axes.

The Tertiary period, particularly after Eocene time, was also one of persistent volcanic activity. It is probable that these flat-lying lavas were poured over the surface from vents and are considered to have flowed out over a region of considerable topographic diversity. These flows are later than the dissection that followed the uplift of the plains and are indeed Recent.

Later than the above lavas and in pre-Glacial time volcanic activity was present in Yukon. These volcanics occur both as intrusives and extrusives and apparently all originated from local vents.


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PRE-CAMBRIAN ROCKS.

The Pre-Cambrian rocks of the Yukon region are grouped, in this thesis, under the term Yukon group. They are exposed over a large area of the Plateau region and are considered to be possibly underlying the whole of the Yukon plateau.

The rocks of this group are dominantly schistose in structure and consist mainly of quartzite schists, schistose amphibolites chlorite schist, granite-gneiss, and mica schists but also include thin bands of crystalline limestone. All these members are much folded, faulted and distorted, and are so metamorphosed that in places it is difficult to 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 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 rocks are sheared and metamorphosed quartzites and related sediments.

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.

The mica schists are grey, medium-grained, and with a pronounced development of mica on the planes of schistosity. They consist of quartz and mica, with subordinate feldspar and chlorite. The proportion of quartz to mica varies widely in different specimens; ranging from types in which mica is abundantly developed to others in which the mica is rather sparse, and which approach quartzites in composition. The quartz-grains are usually intergrown. The mica is in parallel bands that occasionally show intense plication, even in a band specimen, sweeping in a series of curves through
the specimen.

The clorite schists are bright green to grey rocks with pronounced foliation, and a glistening appearance on a freshly broken surface. They consist of varying amounts of chlorite, biotite, and hornblende, with laths of feldspar, and minor amounts of magnetite.

The granite-gneiss is grey to pink, with characteristic gneissoid texture, and in some localities with an abundant development of crystals of feldspar forming an augen gneiss. It consists essentially of quartz, orthoclase, plagioclase, biotite or hornblende or both, and micropegmatite. The quartz and feldspar in some cases show granulation, but in most cases the quartz grains are intergrown, with a saturated texture. Mica when present is arranged in parallel bands. In some specimens the individual leaves of mica show bending or crushing against an individual of quartz or feldspar.

The limestones vary from white to brown, and are more or less impure, being usually quite siliceous. Practically all traces of the original bedding has been obscured. These crystalline limestones appear in places to represent infolded portions of more recent beds but in other places, however, the limestone is intercalated somewhat regularly, and has every appearance of being,
and probably is contemporaneous with the schistose
(1)
members.

The age and correlation of these metamorphic
schistose rocks had afforded geologists, working in
(2)
Yukon, a great deal of trouble. Cairnes apparently
has their horizon definitely determined. He found Pre-
Middle Cambrian sediments to be overlying the schistose
rocks. The next difficulty is the correlation of pro-
bably similar rocks of other areas with this known area.
The other exposures of metamorphic rocks are correlated
by lithology which is a rather uncertain method. In
many places there still remains a great amount of un-
certainty regarding their age and origin. Still it
seems fairly certain that there does exist a Pre-Cam-
brian (?) metamorphic complex underlying all the sed-
imentary rocks of known age throughout Yukon.

(1) Cairnes D.D. "Yukon-Alaska International Boundary
between Porcupine and Yukon rivers."
(2) Idem
(3) Cairnes D.D. "Yukon-Alaska boundary between Porcu-
pine and Yukon rivers."
G.S.C. Mem 67. P. 44.
PALAEOZOIC ROCKS.

CAMBRIAN

Pre-Middle Cambrian.

Rocks of this age have been described as being composed dominantly of sedimentary rocks, but includes also, in most places, some basic volcanics which are in a general way designated as greenstones. The sedimentary rocks include, mainly, quartzites, dolomites, shales, slates phyllites, and also occasional beds of conglomerate and magnesite. In different localities the formation varies greatly in its general lithological aspect due to the predominance of certain members.

These rocks are all grouped together as Pre-Middle Cambrian in age, however, since these beds are unfossiliferous the grouping and correlation depends upon lithological characteristics, which are by no means infallible.

These Pre-Middle Cambrian rocks have been described from only one locality, namely, along the 141st. meridian between Porcupine and Yukon rivers.

The quartzite are dominantly white to light grey in colour, giving them a resemblance to limestone. They are almost universally finely textured and thinly bedded. Microscopically these rocks consist dominantly of interlocking and intergrown quartz and feldspar

grains, with which is always associated a certain amount of sericite and carbonate, that occurs as a binder or matrix filling the comparatively slight amount of interstitial space throughout the rock mass.

The dolomites much resemble the fine-grained, greyish quartzites in appearance and are similar to them in hardness. They are dominantly light gray to yellowish in colour, and are nearly everywhere thinly bedded. The dolomites also contain intercolated seams of chert and quartzites.

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.

Although the rocks are highly folded and faulted, metamorphism is not pronounced in the different members of the group; they have nowhere a schistose or gneissoid structure and seldom possess a slaty cleavage. They are thus very different in this respect to 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 Palaeozoic rocks, the diabase is probably also of Pre-Middle Cambrian age.
No fossils were found in this group of rocks, but the beds underlie Devono-Cambrian limestones in which Middle Cambrian fossils were found. Below this Middle Cambrian horizon several hundred feet of lithologically similar, but unfossiliferous limestones and dolomites, which in all probability represent the Lower Cambrian, occur and underlying these beds unconformably occur the Tindir rocks described above. Cairnes is of the opinion that the Tindir rocks are entirely Pre-Cambrian or that this group includes both Lower Cambrian and Pre-Cambrian members.

It is considered that these rocks may belong to the Belt Terrane of British Columbia. It also appears that the Pre-Cambrian is extensively developed in portions of Yukon, and that these rocks are divisible into an upper but slightly metamorphosed division, the Tindir rocks, and a lower highly metamorphosed division, the Yukon group.

Cambrian - Silurian.

Rocks of this age are described by Cairnes, and are only known, so far, to occur in this one locality. He finds that these rocks are restricted to the

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(2) Daly R.A. G.S.C. Mem. #38, PP. 179-191 1912.
    Schofield S.J. "Reconnaissance in East Kootenay, B.C."
higher mountainous tracts of Keele and Ogilvie mountains.

The rocks consist of white to light grey limestones and dolomites. They are dominantly crystalline and in places beds of particularly good marble occur. In texture these limestone-dolomite rocks vary from firm dense, dolomites to coarsely crystalline almost pure limestones. They also appear somewhat massive. The dolomites are considered to have been derived from the limestone.

In a few places, greyish, yellowish, to nearly black shales are intercalated with these limestone-dolomite beds. They are, however, of minor importance. Cairnes found it practically impossible and impracticable to separate the Silurian, Ordovician and Cambrian beds. They are all much folded and faulted.

These limestone-dolomite rocks are overlain by Devonian limestones, which are, in turn, overlain by Carboniferous limestones, cherts and related rocks. The fossils obtained from the limestones gave ages from Cambrian to Silurian, and the Cambrian, Ordovician, and Silurian horizons were recognizable. Devonian.

Limestones of this age have been described by (1) Cairnes from the Keele and Ogilvie mountains where they are intimately associated with the Cambro-Silurian group
of limestones and dolomites.

Shale-chert rocks ranging in age from Ordovician to Devonian have been described by Cairnes and Cockfield from many localities in Yukon region.

The limestone beds resemble very closely those of the Cambro-Silurian and fossils, alone, serve as the distinguishing feature. They are more homogenous and darker in appearance, the colour being typically dark, bluish grey. They are also somewhat crystalline.

Their age is definitely fixed by fossil remains and the rocks have been correlated lithologically with known areas of Devonian limestone in Alaska.

The shale-chert series consists dominantly of shales and cherts which are prevalingly closely and finely interbedded. They vary from cherty shales to shaly cherts. The cherts are generally dark grey to black in colour and the shales are grey to black or bluish black in colour, the darker beds being decidedly calcareous in character.

Devonian fossils have been found in these shale-chert beds and they directly overlie middle or lower Cambrian limestone beds. They are, in turn, overlain by Carboniferous shales. Shale-chert beds, probably similar to these beds, have been described from various

places in Yukon but Cairnes affords the most accurate
data, to date, as regards their age. They have been,
by Cairnes, referred to the Cache Creek series of
British Columbia.
Carboniferous.

Rocks ascribed to the Carboniferous period
have an extensive development in Yukon. However,
there has been considerable difficulty in determining
their age.

Cairnes affords us the first clear intimation
of their age, in his work along the 141st. meridian.
Here he describes two geological formations, one the
shale group, and the other the limestone chert group.
The shale group is, apparently, only known in the vic-
inity of the 141st. meridian.

This shale group consists dominantly of shales,
but includes also clays, cherts, calcareous sandstones,
and thinly bedded limestones. The whole group is domin-
antly dark in colour.

Since these shale beds rest upon Devonian
shales and cherts it would seem quite possible that
Mississippian members are also included in the shale
group, unfortunately fossil remains were not found.

The limestone-chert group consists mainly of limestone and chert, but includes also occasional beds of dark shale, calcareous sandstone and cherty conglomerate. The limestone beds are quite crystalline and range from white to grey to almost black in colour.

These beds contain both Pennsylvanian and Mississippian fossils. They overlie the Devonian limestones and are overlain by Pennsylvanian beds.

Another group of rocks the Nation River formation, was described by Cairnes from this same area. These consist dominantly of conglomerates, sandstones, and shales but include also occasional beds of limestone. The pebbles of the conglomerate consist dominantly of chert and are small (1 inch) in size. The sandstones are characteristically greyish to brownish, medium textured, hard, firm rocks. 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. The limestones are light grey, semi-crystalline to crystalline beds and occur generally as thin beds intercalated with the more arenaceous and argillaceous sediments.

Imperfect plant remains were found, thus placing the beds as of possible Carboniferous age.

A conglomerate consisting of a firm, somewhat dense, finely textured, reddish, argillaceous matrix,
in which are embedded angular to sub-angular 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 appearance of hematite ore. The conglomerate 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 undoubtedly of terrestrial origin. In general composition, this conglomerate resembles boulder clay more than it does slide material, but on the other hand, its prevailing reddish colour, and the fact that this conglomerate has not been described from other portions of Alaska or Yukon, and is thus probably not very extensive would tend to disprove the glacial theory of origin. Although striated pebbles
were not found Cairnes thinks they might occur. Pebbles having facetted surfaces, much resembling "soled" pebbles were noted to be somewhat plentiful. The conglomerate is considered to be too extensive for slide material. This taken in conjunction with the thickness of the conglomerate Cairnes thinks rather favours the glacial theory.

This conglomerate over-lies the Devono-Cambrian limestone-dolomite beds and appears to overlie Carboniferous shales and Devono-Ordovician shale-chert group and to stratigraphically correspond to the Nation River formation. 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.

Along the boundary line Cairnes found three fairly definitely identifiable Carboniferous horizons. The lowest is represented by Mississipian fossils from the lower portion of the limestone-chert group. The next more recent horizon is represented by Pennsylvanian fossils obtained from the shale group and the upper portion of the limestone-chert group. The most recent horizon is represented by fossils from the Nation River.

formation which is of Upper Pennsylvanian or possibly Permian age.

Limestones, cherts, and related rocks that lithologically resemble the members of the limestone-chert group are described by McConnell. Cairnes is of the opinion that the members of this group are also probably included in the Braeburn limestones which are extensively developed in Yukon and northern British Columbia and are dominantly of Carboniferous age, but may include also Devonian members. Cockfield, after the field season of 1929, is of the opinion that he has sufficient fossil evidence, which was hitherto lacking, to place the Braeburn limestones high up in the Mesozoic succession.

The writer feels that the Braeburn limestones should be described here rather than be placed in an indefinite period of the Mesozoic era. These limestones are generally sub-crystalline, in places approaching marble, but in others quite flaggy and argillaceous or

(5) Cockfield W.E. Personal Communication 1930.
even siliceous. They are commonly white to light bluish in colour. Cairnes states that "this limestone appears to be the same as that of the Upper Cache Creek series, found to the south in the Conrad Mining district, and therefore of Carboniferous age. The evidence afforded by the fossils collected has been of an indefinite character, and the inference that the two formations are of the same age has been made mainly on lithological grounds."

As previously stated Cockfield feels certain that recent fossil evidence will place these limestones in the upper Mesozoic era. If this happens it will help greatly in unravelling the volcanic complex.

Limestones similar to the Braeburn limestones have been described by Cockfield from the Whitehorse District and as regards their age he states:—"The evidence as to the age of the limestones is very unsatisfactory. It is however, quite possible that limestones belonging to more than one geologic period have been included. --- The most definite evidence to date is the finding of the genus fusilina by G.M. Dawson, which would demonstrate that part at least of the limestone is Carboniferous. Some evidence has been presented to show that Devonian and Triassic faunas may also be represented, but as yet

no progress has been made in subdividing the limestone into different formations. The evidence as a whole is too meagre to permit of stating that Devonian and Triassic are represented."

Cockfield describes cherty quartzites, black slates, biotite slates and limestone from Windy Arm and Tagish lake. These beds extend toward Atlin and are followed by generally crystalline limestone, from which fragments of fossils are obtained. Without further statement he refers the limestone to the Upper Carboniferous or Triassic thus placing the quartzites, slates and the other band of limestone as Pre-Upper Carboniferous.

Rocks ranging in age from Ordovician to Carboniferous have been described from the Dezadeash Lake area. They consist of dark, coarsely-bedded argillites seldom strongly cleaved, but in some instances considerable mica has developed and they pass into a schist. These rocks also contain greyish quartzite and some conglomerate but no limestone was found. They dip at steep angles from 50-85°. No fossils were found. The only evidence as to their age is that they overlie Pre-Cambrian (?) schists and are cut by granitic intrusives.


Since the age of the granitic intrusives is assumed as Jurassic, Cockfield places these sediments as ranging from Ordovician to Carboniferous in age.
MESOZOIC ROCKS.

The most wide-spread sedimentary horizon of the Mesozoic era is represented by sediments ranging in age from Jurassic to Cretaceous. This horizon appears to be more wide spread in Southern Yukon than in the northern portion.

Igneous rocks of the Mesozoic era are very extensively wide-spread throughout Yukon and will be described in some detail under the heading "Igneous Rocks."

Triassic.

Limestone occurring in patches and bands in andesitic rocks has been described by Cockfield. These bands are seldom more than 500 feet wide and the bedding is in most places obscure, and difficult or impossible to detect. The limestone is grey and compact, and largely, if not, wholly recrystalline. From the poor fossils collected there would appear to be two bands of limestone, one of Carboniferous (?) age and the other of Triassic (?) age. These cannot be separated but it is probable that Mesozoic limestone may be present.

Cockfield also describes a series of conglomerates and argillites from this same area. The conglomerates are massively bedded with cobbles and boulders of

granite, andesite and schistose rocks in a tuffaceous matrix. A few exposures of dark grey to black argillites were found. The argillites have been jointed and sheared so that the bedding is indistinguishable. Fossils obtained from the argillites correlated the beds as belonging to probable Upper Triassic.

The Laberge beds have been determined in Whitehorse district as of probable Lower Jurassic age to Middle Jurassic age. It seems apparent that argillites above do not belong to the Laberge beds, but constitute an underlying formation. "Occasional fossils that were believed to be Triassic forms have been heretofore found in southern Yukon, in all cases in limestone, but their poor state of preservation prevented a definite age determination. It would now appear to be fairly definitely established that marine Triassic is much more widespread in southern Yukon than was formerly believed to be the case. It is also possible that some marine Triassic has been included with the Laberge beds in other sections.

Jurassic.

Sedimentary rocks have been assigned to the Jurassic period by Cockfield in the Whitehorse District. Here Cockfield finds these rocks extensively developed.

in the eastern half of the district. They occur as long, somewhat narrow belts with a trend a little east of north and south of west, parallel to the Coast range. 

(1) Cairnes has determined their thickness as between 5,000 and 6,000 feet. These rocks consist dominantly of volcanic clastics, tuffs, breccias, and conglomerates. Interbedded with the tuffs are considerable thicknesses of marine shales and argillites in which tuffaceous material is an important constituent. In a few places thin beds of dark, impure limestone are interbedded with the bedded tuffs.

This group of rocks Cockfield has called the Laberge series and includes in the series the Tantalus conglomerate. Cairnes, in his report on the Conrad and Whitehorse mining districts, groups these two formations under the name Tutshi series.

(2) In Wheaton district where the best exposures of typically marine sediments occur, a three fold division of the Laberge beds was recognized and if the Tantalus conglomerate be included, a four-fold division was determined. The lower beds of the Laberge series consist of arkoses, tuffs with shales and conglomerates. The middle members are composed of shales, sandstones and arkoses; and the upper beds consist chiefly of


sandstone. Overlying these divisions is the Tantalus conglomerate which is composed of conglomerate, shale, sandstone, and coal.

Cairnes notes that these divisions are only approximate and that the thickness of each varies. In the lower beds the arkoses are generally light to dark grey or pale greenish, but occasional red beds are found. They have a dense texture and are firm, compact rocks, which occur in heavy, massive beds, so that the stratification is in many cases only distinguishable from a distance. Associated with the arkoses are tuffs which so resemble them that it is generally difficult to tell them apart.

More than half the lower beds of the Laberge series consists chiefly of these arkoses and tuffs but the upper portion contain a considerable development of conglomerate and shale. The conglomerate occurs in thick, massive beds and consists of material varying widely in size. The pebbles and boulders range in size from that of sand grains to 6-8 inches, or more in diameter and are mainly either andesitic fragments derived from the "Older Volcanics" or pebbles identical in composition with the Coast Range granodiorites. The shales range from light grey to almost black, and usually form successive 20 or 50 feet thick and each of a uniform colour.
The middle beds consist chiefly of shales similar to those described above, but characteristically iron-stained and generally presenting a red appearance. When broken, however, they are seen to be grey to black, hard, dense rocks. These rocks occur in layers, with associated arkoses and sandstones, but the shales predominate.

The upper beds consist almost entirely of medium-textured, somewhat friable sandstones prevailing-ly greyish, yellowish, of light brown, and occur in heavy, massive beds. These differ greatly from the hard, dense, compact rocks noted in the middle beds.

In the Wheaton district the more truly clastic members of the group occur in a belt following the margin of the Coast range, and the members composed largely of volcanic material apparently increase in importance to the north and east.

In the Whitehorse district the tuffs of the Laberge series are of two main types; 1. fine-grained bedded and 2. medium-grained, massive. These two varieties occur interbedded, but in places there is a thickness of several hundred feet of one variety without any admixture of the other. The bedded tuff occurs in somewhat greater abundance than the non-bedded.

The non-bedded tuff is not easily distinguished from an igneous rock such as diabase or basalt. It is an important member of the Laberge series. This rock has been described as a sandstone, arkose, or greywacke. It is fine to medium-grained and varies in colour from light to dark grey and from grey to green. In some cases it contains mica, and to the unaided eye appears to have the composition of a granite or diorite. It is interbedded with fossil-bearing shales or argillites and with more or less finely laminated tuffs.

In the Whitehorse district the Laberge series appears to overlie the Palaeozoic limestone with angular unconformity. The contact of the tuffs with the Coast Tange intrusives is of an extremely undulating nature and the fact that large apophyses are connected with the main body of the intrusive prove beyond doubt that the tuff is intruded by the granodiorite. Dykes of granitic rocks, probably connected with the larger intrusive bodies, cut the bedded tuffs and the greenstones with which the latter are associated.

Fossils were found in the shale beds of the Laberge series in Whitehorse district. Here it has been stated "that on the whole fossils are of somewhat rare occurrence."

The fossils from this district indicate the presence of strata ranging in age from Middle Lias to Inferior Oolite, that is of strata of various stages, exclusive of the oldest, of the Lower Jurassic and earliest Middle Jurassic.

Fossils have been collected from the Laberge beds in Wheaton, Atlin, Whitehorse and Tantalus areas. In the collections from the Tantalus area, the specimens (1) were regarded as Jurassic or Cretaceous, but these species are now regarded as Jurassic forms. Fossils collected in the Atlin district were reported on by Stanton as follows: "These may possibly be Triassic, but I think it more probable that they are early Jurassic. They are certainly not as late as the Cretaceous." (2)

In the Wheaton and Whitehorse districts Cairnes reports numerous specimens which were regarded as possible young individuals of Prioncyclus woolgari. Cockfield and Bell (3) are of the opinion that: "In view of the more positive evidence afforded by other collections of fossils, it seems highly probable that the tentative identification of Prioncyclus woolgari by Whiteaves should be disregarded. Thus it appears to be very well established that the Laberge beds range in age from

(1) Cairnes D.D. "Lewes and Nordenskiold Rivers Coal District." G.S.C. Mem 5, PP. 34-35
middle Lower Jurassic to lower Middle Jurassic. These rocks have formerly been correlated as of Cretaceous age.

The Tantalus conglomerates have been included as a subdivision of the Laberge beds in this thesis. The conglomerates are rather wide spread in Southern Yukon and are of economic interest since they are horizon markers for the coal seams of Yukon.

These conglomerates consist chiefly of massive beds of conglomerate, but also contain sandstones, shales, and coal seams. Their thickness as measured by Cairnes in the Wheaton district is in the neighbourhood of 1,800 feet. The conglomerates differ from all others of Yukon in that they are composed almost entirely of pebbles of quartz, chert and slate, the pebbles being generally cemented by a siliceous matrix. The component pebbles are remarkably uniform in size, rarely exceeding three inches in diameter and for the most part being between 1 and 2 inches in diameter. The associated sandstone consists of the same materials as the conglomerates, but in a finer state of division. The shales occur chiefly in the vicinity of the coal seams and are generally finely textured rocks with a slaty cleavage.

The Tantalus conglomerate overlies, to all appearance, conformably, the Laberge series. Fossil
(69)

(1) plants from the coal seams place the age of the conglomerate as Cretaceous.
(2) Fossil plants collected by Cairnes from the Wheaton district placed the age of the conglomerate as Jurassic. In view of the fact that the beds were lithologically similar to the Kootenay beds and contained coal seams and that some forms of the fossil plants had been reported from the Kootenay formation, Cairnes classed these beds as probably belonging to the Cretaceous. Cockfield and Bell, however, consider that; "The plant evidence given above seems to corroborate the animal evidence obtained from the Laberge beds, and there can be little doubt that the Laberge beds and Tantalus conglomerate are both of Jurassic age, and it would appear that the earlier determinations of fossils are to be regarded as extremely doubtful in the light of the more exact evidence now presented."

Cretaceous.

Rocks of this age have been described from the Upper White River district, they consist to a great extent of dark or banded shales and argillites with which are interbedded a large proportion of greywacke

and smaller amounts of conglomerate and sandstone, the entire series being notably more siliceous than the underlying Carboniferous beds.

Similar rocks were found by Cairnes along the Yukon-Alaska boundary. The lithological descriptions are similar.

These sedimentary formations were found to lie conformably upon the Permo-Carboniferous (?) beds and in places it was difficult to determine between them. Fossils, although rare, were found and they place the age of the beds as Lower Cretaceous.

Formerly the Laberge series and the Tantalus conglomerate were considered of Cretaceous age but the Laberge series is definitely of Jurassic age as shown. The Tantalus conglomerate Cockfield thinks may be younger than Jurassic but it rests conformably upon the Laberge series and fossil evidence, so far, appears to indicate a Jurassic age.


(2) Cockfield W.E. Personal Communication 1930.
TERTIARY

Tertiary sedimentary rocks have been described from a few areas namely the Upper White river, Sixty-mile river, Kluane and Klondyke districts. They have also been described from the Porcupine, Peel and Frances rivers.

These beds comprise mainly loosely or only partly consolidated sandstones, shales clays and conglomerates. The sandstones are prevalingly greyish to yellowish and brown in colour, and the shales and clays are dominantly some light shade of grey, green or blue, but some quite black strata occur. The shale is a dense, compact rock containing abundant fossil wood, though no other fossils could be found. The sandstone is a soft, friable, coarse sandstone or arkose, consisting of quartz and decomposed feldspar with abundant ferruginous matter. These sandstones contain a few scattered pebbles of quartz, quartzite, or schist, and towards the upper portion of the beds the pebbles become more numerous, the rock grading into a conglomerate. Where these beds have been intruded by volcanic rocks they have become indurated probably due to the infiltration of siliceous materials from the volcanics.

All the beds are soft and decrepitate readily to form sand and clay beds. These rocks are prevalingly
flat lying, and in most places have been only slightly disturbed by earth movements. They have been extensively invaded by more recent volcanics including members of both the rhyolite-latite group and the newer volcanics, which pierce or overlie them wherever they are exposed. Their occurrence in scattered patches on the upland suggests that they participated in the movements of the Yukon Plateau prior to its planation.

(1) Prindle is of the opinion that the lower beds of these sediments are usually fine-grained but become coarser towards the top and the upper beds are almost always conglomeratic. The lignite does not appear to be confined to any particular horizon in these beds.

Though the absence of fossils in these beds makes their age difficult to determine, their structural relations show they participated in the movement of Yukon plateau prior to its uplift and subsequent planation. (2) Spurr believes that the uplift and planation of the Yukon plateau was probably contemporaneous with the deposition of Miocene strata in lower valley of Yukon river, and that the beds are Pre-Miocene. These rocks are probably continuous with the Tertiary rocks described

by McConnell from the Klondike region as the Kenai series and possibly equivalent to certain beds in the Fortymile district which, from fossil evidence, have been referred to that age.

These correlations place the rocks as Upper Eocene. Since, also, the Kenai beds contain seams of lignite, it is customary to include in that formation all Tertiary beds containing coal. It would thus seem possible that rocks more recent than Eocene have been in places included in the Kenai series.

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

QUATERNARY and RECENT.

These deposits are very extensive in Yukon and in places quite thick. They are generally confined to the valleys and lowlands; as a rule they are lacking on the upland surfaces. These deposits are of glacial, fluvial, and lacustrine origin and consist of sand, gravel, soil, silt, clay, boulder clay and a subordinate amount of volcanic ash.
IGNEOUS ROCKS.

Pyroxenite and Peridotite.

Under this heading all Pre-Mesozoic igneous rocks will be described except those already described in connection with the Yukon group. These Pre-Mesozoic igneous rocks are comparatively wide spread and vary greatly in composition, with possibly basic rocks predominating.

(1) Cairnes describes a series of igneous rocks along the Yukon-Alaska boundary as to include diorites, andesites and diabases. These occur as dykes, sills and small intrusive masses. They appear to be extensively developed in association with the sedimentary members of the Tindir group (Pre-Middle Cambrian). These rocks, however, have not only invaded the Tindir sediments but in addition they have intruded the members of the Yukon group, as well in places as the lower beds of the Devonian-Carboniferous limestone-dolomites. All the intrusives examined in this region proved to be diabases although Cairnes states that other related rock types may be present. Cairnes places their age as ranging from Carboniferous to Pre-Cambrian but thinks they are dominantly Pre-Middle Cambrian.

These 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 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.

(1) Cockfield describes a series of igneous rocks from the Upper Beaver River area. These rocks are both intrusive and extrusive, but occur chiefly as sills. Two types of igneous rocks are found in this locality, one an augite andesite, the other an augite diorite. The augite andesite, is a dark green, fine to aphanitic textured rock which under the microscope shows advanced alteration to secondary minerals. This rock occurs both as an intrusive and as an extrusive. The augite diorite varies from coarse to fine texture but is of granitic habit. This rock contains augite and andesine. The augite andesite and augite diorite are considered of post Ordovician-Devonian age since they are found

intrusive into Pre-Ordovician-Devonian rocks. Although Cockfield found no evidence, he thinks that the andesite and diorite are of the same age.

Pyroxenite and peridotite rocks are described from the Whitehorse and the Wheaton districts. Associated with these basic igneous rocks are veins filled with serpentine and, in some cases, coarsely crystalline amphibole. Talc and magnesite were also found associated with these veins. The serpentine is dark olive-green with a waxy lustre and a pale brown coating of weathered products. Some serpentine veins have central veins of chrysotile asbestos. Fibrous serpentine and talc occur in narrow fissures throughout the rock and on surfaces which appear slickensided.

The pyroxenite and peridotite rock as a whole is very massive. Fresh surfaces in some cases appear coarse-grained granular, and in others no granular texture is visible. The rock is medium to dark grey or black, with, in places, a greenish tinge. The weathered surface is coarsely pitted and has a bright reddish-brown colour due to the presence of iron oxide.

Under the microscope the texture of the basic rocks was seen to be hypidiomorphic granular and rather coarse-grained. The rock contains over 80 per cent and

up to 95 per cent olivine. Chromite is prominent as an accessory, probably making up 2 per cent of the rock. Serpentine is an important alteration product.

The contact of these rocks with other formations was not seen. Cockfield is of the opinion that the peridotites may be intrusive. He correlates them with the "Gold Series". Cairnes was unable to obtain in the Wheaton district any definite information concerning the age of these rocks except that they cut members of the Mt Stevens group (Yukon Group), but from their lithologic similarity to the rocks in other parts of Yukon and in northern British Columbia, he considers them to be probably of about Devonian age.

Older Volcanics.

The rocks of the Older Volcanics group are chiefly andesites, diabases, and basalts. Smaller quantities of deep-seated, basic rocks such as diorite, gabbro and amphibolite have been included. Areas of the Older Volcanics are rather widespread throughout Yukon and have presented somewhat of a problem as regards their age.

These rocks are typically compact, finely textured, and dark green, but red, brown, and blue types also occur. They are prevalently porphyritic, with feldspar crystals in an aphanitic ground-mass. In some

cases phenocrysts of hornblende and biotite may be discerned with the naked eye. Iron in the form of magnetite or pyrite is commonly present, and in many cases has oxidized, giving reddish or brownish colour to the rocks. Tuffs and breccias occur in many places.

Under the microscope these rocks are seen to possess a variety of compositions and of structures. Plagioclase is always present and generally occurs in two generations. It ranges from oligoclase to bytownite in composition, but by far the more common plagioclases or andesine or labradorite. The acid plagioclase is present chiefly in the groundmass of the rocks. Orthoclase occurs in a few cases as phenocrysts, and also in the groundmass. The ferro-magnesium minerals include hornblende, biotite, pyroxene, and olivine. Both the common green hornblende and brown basaltic hornblende occur, but the former is by far the more common. Biotite is also common and in some cases is the only ferromagnesium mineral present. Biotite and hornblende occur together, and exist in both generations. Pyroxene, usually diopside, is present, but seldom in phenocrysts of sufficient size to be detected with the naked eye. Olivine has been noted in some of the augite andesites. Pyrite and magnetite are abundant, in many cases in specks large enough to be detected with the naked eye.
The alteration of these rocks in some cases is well advanced, and in many cases masks the original character. Calcite, chlorite, epidote and zoizite are abundant as secondary constituents.

The structure of the rocks is usually phophryritic, and the phenocrysts, as described, consist of plagioclase and the ferromagnesium minerals. Phenocrysts are as a rule fairly abundant. The groundmass is either holocrystalline or partly glassy.

The rocks of deep-seated character that have been included under the term "Older Volcanics" are on the whole greenish in colour, massive and from fine- to medium-grained. These rocks vary in composition but are generally high in ferromagnesium minerals. Zoizite and serpentine are common as alteration products.

In his earlier work Cairnes separated the "Older Volcanics" into two groups, the Perkins group and the Chieftain Hill volcanics. This subdivision was later abandoned and both were included in one group and correlated with the Older Volcanics of White River district. Portions of the Older Volcanics are definitely intrusive into the Laberge beds, and may,

therefore, be considered as younger. The similarity between the tuffs of the Laberge beds and those of the Older Volcanics has been pointed out by Cairnes, who believed that the period of vulcanism represented by the Older Volcanics was in some measure contemporaneous with the deposition of the Laberge beds. Gwillim is of the opinion that these rocks may be closely connected with the origin of the sandstones. He also noted that "the change from the fragmental rocks to the porphyrites and andesites is gradual."

The older Volcanics are, probably, all older than the granitic intrusives. Although some of the flows are more recent than the Laberge series with which they come in contact, Cockfield is of the opinion that they are to a large extent contemporaneous with the Laberge series and are probably of Lower and Middle Jurassic age; and that the tuffs, which are so plentiful in the Laberge series, are to be attributed to the same period of vulcanism. Granitic Intrusives.

The granitic intrusives form one of the major geological formations of Yukon, both in areal extent, and in importance as possible ore-bringers. These rocks

are exposed mostly in southern Yukon where the Coast Range mountains trend northwesterly across the southern portion of this province. Considerable granitic outliers have been described but it is the general opinion that these isolated outcrops are connected with the main body of the intrusive. Thus it is the consensus of opinion that the Coast Range intrusives probably underlie at least, the southern portion of the Yukon province.

The rocks grouped under the head of Coast Range intrusives present many different types, but they have in general a granitic habit. They are generally grey in colour, and fresh and unaltered in appearance. In some cases, however, pink feldspar is present in sufficient quantity to give a pinkish cast to the rocks, but on the whole this is exceptional. The typical rock of the Coast Range intrusives is medium to coarse-grained, with the essential constituents visible to the naked eye. Locally, phenocrysts of feldspar, many exceeding one to two inches, are developed, and the rocks may be said to have a porphyritic texture. Quartz, orthoclase, plagioclase, and ferromagnesium minerals, in nearly every case hornblende and biotite, can readily be detected by the unaided eye.

When examined under the microscope, the majority of the sections are seen to contain quartz, ortho-
clase, microcline, plagioclase, hornblende, biotite
and, only in some cases augite. The amount of quartz
varies greatly, but is mostly between 10 and 25 per cent
feldspars from 60 to 75 per cent, and the remainder is
hornblende and biotite, or augite. Orthoclase and mic-
roline are as a rule about equal in amount to the plag-
ioclase. Plagioclase is most commonly oligoclase or
andesine. The hornblende and augite, in many places,
are intergrown. Biotite is present as a rule.

The typical rock would, therefore, seem to
have a composition midway between granite and quartz-
diorite. To this the name granodiorite has been applied;
also it may be termed a quartz-monzonite.

With an increase of the orthoclase and decrease
of the plagioclase, typical granites have been noted,
and the decrease of orthoclase and increase of plagio-
clase and augite give rise to diorites. An attempt was
made, in the Aishihik Lake district, to determine whether
there was a progressive change in composition across the
batholith or along its strike, but the conclusion was
reached that the variation from the normal type around
any single locality was greater than the variation ex-
hibited by the normal type either across the batholith
or along its strike. No regular change in the normal

type of intrusive was detected, but it must be remembered that the batholith in this region is narrow, and possibly no striking change is to be expected.

(1) Cairnes describes these rocks as "under the microscope decidedly granodiorite," while he describes somewhat similar rocks from the Upper White river as commonly diorites but "in addition, granodiorites, quartz granodiorites, granitites, gabbros, and even hornblendites were examined."

Where the batholith is in contact with the schistose rocks of the Yukon group, as occurs in many instances, it cannot be determined what part of the metamorphism of these rocks is due to the intrusion of the batholith, and what part is due to other causes. Along many of the contacts garnet is found in the schists, pointing to a certain degree of contact metamorphism. Where the limestones of the schistose group are in contact with the granites the degree of contact metamorphism is high; garnet, epidote, and other silicate minerals are abundant and in some cases make up the bulk of the intruded rock, but the zone where these minerals are found is quite narrow. In no instance have silicate minerals been noted more than a quarter of a mile from the granitic contacts.

Cockfield found that the western contact of the batholith where observed, in the Desadeash district, was steep but the contact minerals show it to be gently sloping.

Pegmatite dykes which are usually contact phenomena have not been reported from the eastern contact but although not common do occur along the western contact. These pegmatite dykes generally contain large crystals of tourmaline.

Cockfield has revealed some interesting facts as regards the Coast Range intrusives. Here he notes that; "the presence, on the tops of many of the higher hills, of bodies of the intruded rocks, leads to the belief that these are possibly remnants of the roof of the batholith. In Wheaton district several long, relatively narrow curtains of Pre-Jurassic rocks occur in the batholith, are cut by the valleys to depths of 3,000 feet or more, and at the level of the valley bottoms are almost as wide as at their highest points. In the same district, small, irregularly shaped patches of the older rocks outcrop at widely different elevations. These cannot be parts of the roof of the batholith but are inclusions. The method of batholithic

invasion which best answers the known facts appears
to be that of overhead stoping -- the batholith advanc-
ing by the breaking away from the roof of fragments or
blocks which sank in the magma that rose to replace
them. The batholith also appears, in general, to have
intruded the overlying rocks in the form of great
tongues and dykes, from which branched off smaller por-
tions. However, there is not the minute interfingering
of the batholith and the older rocks that occurs in
connection with the Pro-Cambrian batholiths. There is
little in the way of addition of granitic material to
the intruded rocks, except in the form of distinct
bodies such as dykes and sills. That a certain amount
seems evident, for at the contacts of some of the dark-
er rocks the granite becomes darker as the contact is
approached, but this is operative for a few feet only.

"It is almost certain that a cover was main-
tained over the magma until it cooled. Further, it
would appear that the roof of the batholith was highly
irregular. This is perhaps, best illustrated on the
hills north of Champagne, where the summit are of
granite and, therefore, not at the roof of the batholith;
passing northward the schist contact a year at a
distance of 2 miles and at an elevation of at least
2,000 feet lower, still farther northward, schists are
exposed in the bottom of the Mendenhall valley; and on
the higher hills to the north of this valley granite once more appears. If it be assumed that these granite bodies are connected beneath the schist cover, the original roof of the batholith must, indeed, have been highly irregular. Moreover, a study of the areal geology of Atlin to Whitehorse shows that there are numerous outlying bodies of granodiorite that are identical in appearance and composition with the intrusives of the batholith itself, and no evidence has as yet been presented to show that these are of a different age. They can, perhaps, best be regarded as peaks of the granitic body, which have, as yet, been barely deroofed."

It appears to the writer that if the Pre-batholithic rocks occur as "curtains" as stated by Cockfield and if the granitic intrusives have assumed the form of huge tongues on intrusion, these might account for the apparent regularities described from Cockfield above. It seems quite possible that these "curtains" could easily be two or more miles in width or that there could be a distance of two, or possibly more, miles between the tongues of the intrusive.

Cockfield in his report on the same district, has shown that the mineral deposits give some indication of the shape of the body of intrusive rocks. He finds that there are two types of mineralization, namely contact metamorphic and hydrothermal. Contact metamor-
Photic deposits are believed to have been formed under conditions of high temperature and pressure, and consequently soon after the intrusion of the batholith. The hydrothermal deposits of Yukon, belong to deposits formed under conditions of moderate temperature and pressure. As these occur not only in the surrounding rocks, but in the granodiorite itself, it follows that these were formed at a later date than the contact metamorphic deposits, after the upper part of the granodiorite had solidified and cooled.

Moreover, as the mineral deposits of this region occur in a belt following the eastern margin of the batholith, and as the deposits have been found to be genetically connected with the batholith, it follows that the rocks to the east of the main boundary ("where most of the hydrothermal deposits occur") are really the roof of the batholith. This is further borne out by the facts that numerous outlying bodies of granodiorite occur to the east of the main margin of the intrusives and no evidence has yet been found in this region that these outlying bodies differ in age from the main intrusives. It follows that on the whole the eastern margin of the batholith in this region slopes gently eastward with recurrent upward projections whose summits have been laid bare to the east of the main margin. This conclusion
does not agree with that of Schofield, namely a steeply-dipping and smooth-flowing eastern contact, with a narrow contact metamorphic zone.

"The deposits of the contact metamorphic type occur for the most part at considerable distances from the main margin of the Latholith and are found at the borders of outlying bodies of granodiorite. Deposits of this type, with one possible exception, are confined either to limestone, schist or granodiorite. At one locality, Boeker creek, a deposit of this type occurs in a schist inclusion, and deposits of hydrothermal origin occur in the granodiorite at approximately the same elevation. As the hydrothermal deposits are low temperature types, compared with the contact metamorphic, and as the differences in this case cannot be explained by zoning as ordinarily understood, it, therefore, appears that the time at which the deposits were formed becomes the deciding factor; that deposits formed soon after the intrusion of the batholith were of the contact metamorphic type; and that near them may be found deposits of the upper vein zone formed in the dying stages of vulcanism from the same intrusion."

The age of the Coast Range intrusives has been,

and still is, the source of many discussions. When Calmes first worked in the Wheaton district he was of the opinion that the intrusives antedated the Mesozoic LaBerge beds, but his later work in Atlin and Wheaton districts corrected this when he recognized the fact that the granite cut the uppermost of the LaBerge beds and even the Tantalus conglomerate. A prominent feature of the LaBerge beds is conglomerates which contain pebbles and boulders of granitic rocks identical in character with the Coast Range intrusives. From this data Cairnes concluded that the Coast Range intrusives, although lithologically very similar, were intruded at different times; that parts of the batholith were intruded and deroofed to supply material for the LaBerge beds, and that this period of sedimentation was followed by further intrusion.

Nothing, however, has been put forward to show that these pebbles and boulders were actually derived from the Coast Range batholith, except their lithological similarity to the intrusives now found. For purposes of age determinations, this evidence is largely valueless. It is, therefore, more reasonable to consider the Coast Range intrusives with respect only to the rocks they cut.

The later determination of the age of the Laberge beds as Lower and early Middle Jurassic limits to some extent the age of the intrusives. They are not earlier than the lower part of the Middle Jurassic. With regard to the upper limit of their age the evidence is less certain. It has not been definitely established that the Upper Jurassic is not represented by some part of the Laberge series, and the age of the Tantalus conglomerate remains in doubt. Cairnes is of the opinion that the Tantalus conglomerates are older than the intrusives. He correlated the Tantalus conglomerate with the Kootenay formation of Lower Cretaceous age found in northwestern British Columbia. But Knowlton, after examining one collection of fossil plants from the Tantalus, pronounced them to be Jurassic. Thus the evidence obtained to date in Yukon indicates that the granite is more recent than the lower part of the middle Jurassic and older than certain Tertiary rocks. Beyond this the age is not fixed.

Newer Volcanics.

This includes an important group of volcanic rocks comprising mainly andesites, basalts, andesite tuff and breccia and scoria. These rocks are wide spread over Yukon and have been reported on from many localities.

These rocks present, characteristically, a bright

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(2) Cockfield F.E. G.S.C. Sum. Rp. 1927 F. 6A.
fresh appearance and are contrasted in this respect with the dominantly dull appearing older volcanics previously described. Black, and various shades green and grey, predominate, but reds, ranging from a dull brick-red or even purple to bright vermilion or even lavender, are by no means rare. Black scoria is abundant in the Whitehorse district. The tuffs and breccias, which are prevalingly lighter in appearance than the lavas with which they are interbedded, are generally ash coloured or some shade of grey, or yellow.

These extrusive lavas are for the greater part porphyritic rocks of medium coarseness, containing phenocrysts of plagioclase, hornblende, pyroxene, biotite and olivine. The plagioclase feldspars range from oligoclase to bytownite, but are usually andesine, labradorite, or bytownite. Both common green hornblende and basaltic hornblende occur. The pyroxene is mostly diopside or hypersthene. The chief alteration products are calcite, epidote and chlorite.

These lavas in the Upper White River district cut and overlie the Tertiary sediments and are thus at least Cenozoic in age. These rocks have been studied in a number of localities in Yukon, and wherever definite determinations could be made they have been assigned to

the late Tertiary or early Pleistocene. They have been found to cut the Older Volcanics and the Coast Range intrusives, and are in turn intersected by the Acid Volcanics. Mendenhall, who studied similar flows in Alaska, says, "These flows, therefore, instead of preceding the deformation of the early Tertiary plain, are later than the dissection which followed its uplift, and are to be regarded as very recent indeed." In Whitehorse district it is certain that at least some of the flows have been poured out since the valleys were cut approximately to their present depths. This is apparent in the case of Miles canyon, where Lozr's river has cut through a basalt flow in the valley to a depth of probably less than 100 feet.

Acid Volcanics.

Grouped under this heading is a series of rhyolites, quartz-porphyries, granite-porphyries, latites and related rocks with accompanying tuffs. These rocks represent the most recently consolidated rocks in Yukon and are of wide occurrence throughout the district. They occur chiefly as dykes and small masses.

The members of this group consist of light coloured porphyritic rocks ranging from nearly white, light grey or yellowish, to pale lavender or darker green-

ish grey shades. The groundmass is invariably cryptocrystalline and the phenocrysts include mainly feldspars, hornblende, and biotite. These rocks have been described as rhyolites, latites, quartz-porphyries, granite-porphyries andesites, basalts, and other varieties have been noted. They are thought to have been extruded upon the surface through fissures and necks, but the fissures were not open over great distances as these lavas only occur locally.

(1) Cockfield is of the opinion that the andesitic and basaltic flows are older than the more acid varieties. Cairnes, in the Wheaton district, observed volcanic necks, surface flows, and tuffaceous accumulations in their characteristic forms and concluded that these rocks were of comparatively late origin, and assigned them to the late Tertiary or Pleistocene. In the Mayo hill district, Stockwell and Cockfield in the Aishihik Lake district consider that these rhyolites and quartz-porphyries are connected with the granitic rocks. These Acid Volcanics cut the Newer Volcanics wherever they come in contact with them and are thus younger than the Newer Volcanics. In the Upper White River district Cairnes

(3) Stockwell G.S.C. Sum. Rp. 1925 P.A.
shows that these rocks have flowed over the present land surface since it has become uplifted and eroded to nearly its present form, the topographic features having since been modified only by glaciation. They are thus of late Tertiary or Pleistocene age.
The economic aspect of geology in Yukon is not very favourable. In the first place prospecting is exceedingly difficult due to the thickness of the drift and the overburden. In the second place, Yukon is rather remotely situated and thus the cost of production is greatly increased by the transportation charges. Although the climate of the region is not as severe as considered by most people it is severe enough to prevent operations for approximately seven months, however, the long days in the summer months readily permit surface work without the use of artificial lights.

The mineral deposits consist of practically only two types, namely, contact metamorphic deposits and fissure vein-replacement deposits. The latter is divisible into three divisions and will be dealt with in detail later.

The contact metamorphic deposits contain chiefly copper values with traces of gold in some places. They occur as irregular masses without any definite trend. They occur in two conditions; first in altered limestone close to or in direct contact with the Coast Range intrusives, and secondly, they occur in the schistose rocks at the contact with the same intrusives.
Cockfield states, "There can be no doubt about the close genetic connection between the ore-bodies and the intrusion of the Coast Range batholith, this connection being apparent even on most casual examination." The minerals are chalcopyrite, bornite, tetrohedrite, chalcocite and their oxidation products, malachite, azurite, chrysocolla, cuprite and malachite. The cuprite is occasionally associated with native copper. Pyrrhotite and pyrite are not abundant but magnetite and hematite occur in large masses. The ores have either a gangue of magnetite and hematite or a gangue of silicate minerals.

The gold-silver veins are typically high temperature deposits in the intruded rocks and in the granite itself. The gold occurs in the free state and is intimately associated with the sulfides, pyrite and pyrrhotite. These deposits are of considerable importance as the sources of the placer gold of Yukon but not at present of any great economic value.

The silver-lead veins represent the mining wealth of Yukon. These veins are subdivided into three groups on a mineralogical basis.

In the first group galena and friebergite are the chief ore minerals and manganiferous siderite is the chief gangue mineral. Quartz and pyrite are present in small quantities. Cerussite, limonite and manganite are

oxidation products; chalcopyrite, malachite and azurite are present in small amounts. These veins are high in silver values with no gold values. They represent the best mineralization type of vein in Yukon.

The second group of veins have a gangue of quartz or ankerite, calcite in a few places, and siderite either subordinate or absent. The ankerite usually contains manganese. Galena, friebergite and zinc-blende are the ore minerals; pyrite, limonite, cerussite, chalcopyrite, malachite and azurite are also present. In these veins the silver content is important although small values for gold are obtained. This group of veins and the group described immediately above belong to the transverse veins which will be described later.

The quartz-arsenopyrite veins represent the third group. Quartz is the chief gangue mineral but ankerite, calcite and sericite are present. Arsenopyrite is characteristic and pyrite, galena, zinc-blende and pyrrhotite occur also. Native gold has been found in these veins, but like the silver values, is low. Cerussite and limonite occur as oxidation products. Deposits of this type belong to the longitudinal class, as described below, and are not as yet of any importance.

(1) Cockfield and Stockwell have described the lead-

silver veins in some detail in the Mayo district. Here they found that the ore deposits are practically all fissure veins, that is, they represent vein material deposited in fault fissures. The faults are all normal faults with a horizontal displacement of 500 feet or more. The longitudinal and transverse faults occur and are determined mainly by their mineralization. The transverse faulting, that cutting across the bedding, is attributed to the bending of the beds from an east-west direction to a southerly direction and they trend N. 5 W to N. 15 E. The longitudinal faults, those paralleling the strike of the beds, may be due to the stresses developed at the time of the intrusion of the granitic masses and trend N. 30 -40 E.

The earlier mineralization, in the longitudinal faults, consists of quartz, arsenopyrite and pyrite. These longitudinal fissures remained planes of weakness, after filling, and were affected by subsequent movement. The transverse fissures acted as circulation channels for the mineralizers and considerable amounts of minerals were deposited in them. Thus, the principal ore shoots are found in the transverse fissures. The chief minerals of these fissures are galena, siderite (manganiferous) freibergite and sphalerite.

Both the gentlemen previously mentioned noted a rule: "Where the transverse fault taps a longitudinal
fault and passes upward out of a hard stratum, such as quartzite or greenstone, into schist, an ore-shoot is usually found in the vein beneath the schist as if the latter had acted as an impervious barrier to the ore-bearing solutions and had forced deposition at that point. "Stockwell states, "This is probably due to the fact that the fissure through the harder rocks remained open to the ore-bearing solutions, whereas in the schist the fault was more or less sealed by a clayey impervious gouge, forming a dam which forced deposition below it." Evidence is offered by Cockfield to prove the latter. The transverse fissures are short and are not likely to continue with depth but there is always the possibility of finding ore-bodies in them. The schist however is not barren of ore in all cases.

The mineralogy of the veins is interesting as it affords some light on the occurrence of the silver.

<table>
<thead>
<tr>
<th>Native elements</th>
<th>silver, gold.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfides</td>
<td>argentite, galena, sphalerite, covellite, chalcopyrite, pyrite and arsenopyrite.</td>
</tr>
<tr>
<td>Sulpho-salts</td>
<td>pyrargyrite, freibergite, polybasite, jamesonite.</td>
</tr>
<tr>
<td>Oxides</td>
<td>quartz, limonite, manganite.</td>
</tr>
<tr>
<td>Carbonates</td>
<td>siderite, calcite, cerussite, malachite, azurite.</td>
</tr>
<tr>
<td>Sulphates</td>
<td>barite.</td>
</tr>
</tbody>
</table>

Argentite --- this mineral is uncommon but is found in small masses enclosed in cerussite and as crystals with galena.

Galena --- this is the most important mineral and is found in nearly every deposit. It is commonly coarsely crystalline and is not intimately intergrown with the other ore or gangue minerals. The coarse galena has a rather gneissoid appearance. The fine-grained steel galena is rare but carries average values in silver.

Sphalerite --- occurs in most of the deposits. It is generally yellowish brown and resinous in appearance.

Covellite --- is very rare.

Chalcopyrite --- is not common and where found is, as a rule, intimately associated with galena.

Pyrite --- is fairly abundant and occurs both with arsenopyrite and galena.

Arsenopyrite --- occurs with quartz and pyrite in the veins of the older series.

Fyorgyrite --- is rare. It occurs with feibergite and galena and was noted in only a few deposits where it is of local occurrence and not disseminated.

Freibergite --- is common and is one of the chief silver minerals. Where freibergite is present even in small quantities the silver value of the ore is increased. This mineral is associated with siderite, galena and sphalerite.

Polybasite --- is of rare occurrence. It is believed to be secondary.

Jamesonite --- also rare. It may belong to the quartz-arsenopyrite stage of mineralization.

Quartz --- this mineral is common as a gangue mineral in veins of the earlier stage of mineralization. It is not coarsely crystalline.
Limonite and Manganite. --- these are oxidation products. The latter is believed to have been derived from the siderite.

Siderite or Mangan-siderite. this is the most abundant gangue mineral. The colour varies from dark brown to light brown in depth. It is as a whole finely crystalline, but many coarsely crystalline masses were found. This mineral is always accompanied by freibergite, galena and sphalerite.

Calcite --- is not common and is mostly associated with siderite.

Cerussite --- is confined to the surface and is not common. It occurs as white earthy masses.

Malachite and Azurite -- occur as oxidation products.

Borite --- is of rare occurrence and is a gangue mineral.

The majority of the veins represent a simple filling of fault fissures. Replacement of the wall rock operated only to a slight extent. The ore minerals are in most cases fastened to the polished walls and do not project into them. It is believed that the small openings of the faults increased as mineralization took place. It is possible that the crystallizing force of the minerals may have assisted the widening of the fissures. Some replacement is noted in the Sadie-Treadwell vein of Kena Hill.

Cockfield found that the acid dyke rocks, in the Keno Hill area, carry small amounts of galena, pyrite and tetrahedrite. These are not considered as the source of the mineralizing solutions but it is believed that the solutions and the acid dykes have been derived from a larger body of magma. Granitic rocks occur in the vicinity of nearly all the ore deposits and it is possible that these outliers represent peaks of a batholith that underlies the area. The age of the granite is not definitely fixed but the ore deposits are younger than the granite, and beyond this their age cannot be fixed more definitely.

Secondary enrichment is practically unknown in glaciated areas but occurs at the St. Eugene, Premier and Dolly Varden mines of British Columbia. In the workings at Keno Hill area, the frost extended down to the 350 foot level so any secondary enrichment found in this region is considered to antedote glaciation. The frost is believed to have originated in the Pleistocene Period. The geological evidence and mineralogical composition of the main ore-bodies point to a primary origin and Cockfield is of the opinion that secondary enrichment played a relatively minor role in the formation of these deposits.

The silver-antimony veins have a quartz gangue. They carry low values in silver and their origin is considered the same as the veins above.

All these lead-silver and silver-antimony vein deposits are believed to have been formed at moderate depths by hot ascending solutions. It is also considered that the mineralizing solutions had their origin in the same magma that gave rise to the acid dykes and sills, and that the changes in ore with depth will depend upon changes in primary deposition.

Cockfield notes, "It may also be pointed out that the majority of the ore-bodies occur in connection with outlying bodies of granite rather than with the main mass of the batholith, although there are many exceptions. It may also be laid down as a general rule that the main mass of the batholith away from its borders is not likely to have been the seat of ore deposition, except possible where there are inclusions of the older intruded rocks."

These mineral deposits are in many ways similar to the ore deposits of British Columbia. The contact metamorphic deposits are identical. The lead-silver veins resemble those of the Slocan district and those of the Interior Plateau region of British Columbia. The

striking feature of the latter is the fact that the silver values like those of Yukon are intimately associated with tetrahedrite and freibergite. It is found both in Yukon and in British Columbia that if tetrahedrite or freibergite are both absent from a deposit the silver values are low. In Yukon the silver has proved to be uniformly distributed through the galena when free from gangue. The average silver value for the area is 200 ounces per ton. It is known that silver may exist in galena in the form of sub-microscopic particles or in solution only up to 0.2 per cent. Under the microscope the galena from Keno Hill area shows crystals of argentite and freibergite intergrown with the galena.

Saline incrustations occur at many points (1) along the Dezadeash River valley and also along Aishihik river. This material is white and occurs around the edges of lakes and small ponds, being left as a residue after the evaporation of the water. These saline encrustations also occur at many points as a thin deposit on top of the soil. In some of these cases there is apparently an abundance of stagnant water early in the spring, and the encrustations are left as the water evaporates. They contain hydrated sulphates of lime and soda, with a small quantity of magnesium sulphate,

and insoluble argillaceous and organic matter. They are slightly ferrugenous and contain small quantities of chlorides and phosphates. The potassium content is 0.2 to 0.3 per cent $K_2O$.

Coal

The coal-bearing formations of Yukon are all of either Tertiary or Jura-Cretaceous age. The mineral fuels in the Tertiary beds are classified as lignites, while those of Jura-Cretaceous age range from high-grade lignite to anthracite.

The Tertiary coal beds are not of very great areal extent, but have a wide distribution. In places these beds apparently constitute remnants of once larger areas now infolded with older terranes, but in most cases they represent deposits laid down in separate basins of deposition. The fossil plant remains show that most of them are of fresh-water origin. These beds are correlated with the Kenai series which is generally referred to the upper Eocene. These rocks are in most places little disturbed, although locally they have suffered considerable deformation. The rocks of the Kenai series consist of light coloured conglomerates and sandstones and light and dark shales and clays. Volcanic material is also associated with these sediments in some places.

The coal of Tertiary age is classified as lignite.
and Cockfield states that; "These deposits have no present economic importance, for other deposits of a much better grade at Tantalus are capable of supplying requirements for many years to come."

The Tertiary coals have been mined at only three points; 1. Cliff Creek; 2. Coal creek (tributary of Yukon river;) 3. Coal creek (tributary of Rock creek.) The known areas of Tertiary coal beds cover a total of 1,450 square miles with this much area again as a favourable coal horizon. The estimated tonnage of the known coal areas is 4,690,000,000 metric tons.

The period of Tertiary coal deposition of Yukon probably corresponds with the period of Tertiary coal deposition known in British Columbia to the south.

The coal seams of Jura-Cretaceous age are closely associated with the Tantalus conglomerate beds. Two horizons have been recognized — an upper horizon occurring near the top of the Tantalus conglomerate, to which belong the seams at the Tantalus mine; and a lower horizon some distance below the conglomerate which contains the seams at the Five Finger mine.

These coal bearing beds have been much more disturbed than those of Tertiary age. These Jura-Cretaceous beds are considered as remnants of former extensive

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areas which were originally all connected but have been reduced by erosion to their present proportion.

In considering the distribution of the coal (1) Cairnes is of the opinion that, in a general way, it is chiefly to be found in the areas covered by the Tantalus conglomerate. Further he declares, it would be quite possible for coal seams of the lower horizon to be found where the overlying conglomerate was not to be seen, being either covered by other formations or deposits, or having been eroded away. In only one locality namely, at the Five Fingers mine have coal seams of any economic value been found where the Tantalus conglomerates are not in evidence. In any case, Cairnes states, the Coal Measures of the upper horizon contain much the more valuable coal seams. In all geological and prospecting work these conglomerates form a very valuable horizon marker, which is very readily identified, and, when found, the approximate positions of both coal horizons can be determined at once.

The thickness of the coal seams of the Tantalus beds varies from eighteen inches up to eight feet. The coal on the whole is classed as low carbon bituminous although individual outcrops vary from lignite to anthracite.

The only coal mine working these coals is the Tantalus mine. Here the coal outcrops in three seams on the river banks and is, therefore, well situated for economical working. The three seams have been opened up, but only the lower two have been worked to any extent. The seams are somewhat variable in width but have averaged 7'6'', 6'6'' and three feet of coal in the bottom, middle and top seams respectively. The lower two seams have in places not more than four feet of rock between them, and the middle and top seams are generally seven feet apart. The seams dip from 24 to 40° and are somewhat dirty but the coal could easily be washed and stored.

An average analysis of the seams shows the following results:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.75</td>
<td>0.82</td>
</tr>
<tr>
<td>Volatile combustible matter</td>
<td>23.61</td>
<td>25.12</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>55.21</td>
<td>66.03</td>
</tr>
<tr>
<td>Ash</td>
<td>20.43</td>
<td>8.03</td>
</tr>
<tr>
<td></td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Firm coherent coke per cent 75.64 - 74.06

The demand for coal in this region is small and it is used mainly for fueling some of the river boats. Accessible wood, near the rivers, used for fueling the steamers is rapidly decreasing and either coal or oil will be required as fuel in the future.
(11)

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