MINERAL RESOURCES OF THE YUKON-KOYUKUK REGION.

By Henry M. Eakin.

INTRODUCTION.

The region in central Alaska lying between Yukon and Koyukuk rivers westward from the Yukon Flats has in general been little frequented by prospectors. Owing to the consequent lack of economic interest those parts of the region not immediately accessible from the rivers have long remained geologically unexplored.

The northwestern part of the region, along Koyukuk River, was visited by Schrader [1] in 1899, and the northeastern part, along Dall and Kanuti rivers, by Mendenhall [2] in 1901 and, along Dall River, by Maddren in 1909.[3] The areas along the Yukon have been touched upon by Dall,[4] Russell,[5] Spurr,[6] Collier,[7] Maddren,[8] the writer,[9] and others incident to general investigations along the Yukon or to the surveys of adjacent regions.

During the summer of 1913 a survey party in charge of the writer made a rapid reconnaissance through the more inaccessible and geologically unknown parts of the region. The journey embraced two stages, the first from Yukon River near Fort Hamlin northwestward to Hughes, on Koyukuk River; the second from Hughes southwestward to the Yukon near Ruby. It is the purpose of this paper to set forth a brief summary of the geography, geology, and mineral resources of the region as indicated by the investigations of the writer and of his predecessors in the same general field. A more comprehensive report is in preparation.

[1] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 441-486, 1900.

[2] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: U. S. Geol. Survey Prof. Paper 10, 1902.

[3] Maddren, A. G., The Koyukuk-Chandlar region, Alaska: U. S. Geol. Survey Bull. 532, 1913.

[4] Dall, W. H., Exploration in Russian America: Am. Jour. Sci., 2d ser., vol. 45, 1868, pp. 97-98; Correlation papers—Neocene: U. S. Geol. Survey Bull. 84, p. 247, 1892.

[5] Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889.

[6] Spurr, J. E., Geology of the Yukon gold district, Alaska, with a chapter on the history and present condition of the district by H. B. *Goodrich*: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 87-392, 1898.

[7] Collier, A. J., The coal resources of the Yukon, Alaska: U. S. Geol. Survey Bull. 218, 1903.

[8] Maddren, A. G., Placers of the Gold Hill district: U. S. Geol. Survey Bull. 379, 1909, pp. 234-237; The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers: U. S. Geol. Survey Bull. 410, 1910, pp. 80-83.

[9] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 17, 34, 1913.

GEOGRAPHY.

The Yukon-Koyukuk region embraces an area of about 12,000 square miles in central Alaska, lying between Yukon and Koyukuk rivers westward from the Yukon Flats. Roughly speaking it extends from longitude 149° to 157° W. and from latitude 65° N. to the Arctic Circle, although considerable areas within these boundaries are not included between the rivers.

The relief of most of the region is low, but locally elevations rise to 5,000 or 6,000 feet. The main river valleys as a rule have extensive lowland plains. These plains are set in among areas of rolling, maturely dissected upland of moderate elevation that cover most of the region. The higher elevations are restricted to one relatively large mountainous area and several smaller ones. The larger area, occupied in part by the Ray Mountains, includes about 2,000 square miles in the northeastern part of the region and contains the headwaters of Ray and Tozitna rivers and of a southern tributary of Kanuti River. The highest known point in the area is about 6,000 feet above sea level. Numerous peaks rise above an altitude of 5,000 feet and considerable areas stand almost as high. Much of the area has an extremely rugged topography, which is largely a result of glaciation in late geologic time.

The smaller mountainous areas lie between Melozitna River and the Yukon, about the northerly headwaters of Indian River, and from the Melozitna Canyon northwestward for about 25 miles. The elevations within these areas nowhere greatly exceed 4,000 feet, but their features have a bold mountainous aspect owing to the general low relief of the adjacent country. There is evidence of alpine glaciation in places along the Melozitna-Yukon divide and a few miles northwest of the Melozitna Canyon. The glaciers here were much less extensive than those in the Ray Mountains, the longest not exceeding 2 miles in length.

The region is drained entirely by the tributaries of Yukon and Koyukuk rivers. The arrangement and relative size of the streams are shown on the map (Pl. XVI).

The climate of the region is semiarid and is characterized by the great seasonal variations in temperature common throughout central Alaska. The open season, available for sluicing and navigation, usually extends from early in May to the end of September. The growing season available for agriculture usually lasts about 3 or 3½ months. The ground below a slight depth is permanently frozen, in places to known depths of 130 feet or more.

The timber line in the region is about 2,000 feet above sea level. Locally, in protected valleys, trees grow at slightly higher elevations. In the mountainous areas timber grows only in the valleys and on the lower slopes. In the Ray Mountains the valleys are devoid of timber for a distance of 5 or 10 miles from their heads. There are large areas in the Melozitna basin below timber line that apparently have never been forested.

The principal species growing in the region are the spruce and birch. A few scattered tamarack grow in places and willows and alders thrive along watercourses and about timber line.

Except in favored situations along the banks of streams and at the heads of valleys the trees are small, generally measuring less than 1 foot in diameter. In favored spots trees 2 feet or more in diameter can be found, but the areas that support such growth are very small.

Forest fires have swept over large tracts in recent years, and in places repeated burnings have cleared the land completely. Probably half the area between Yukon and Koyukuk rivers was burned over in 1913. However, there is sufficient timber remaining in almost any part of the region below timber line for the ordinary uses of prospectors.

Game is generally abundant in all parts of the region not recently burned. Moose, caribou, and bear were encountered in considerable numbers by the Survey party. Small game and fish were to be had almost anywhere.

Steamboats ply on Yukon and Koyukuk rivers during the open season and furnish a ready means of reaching the border of the region. The larger tributaries of these rivers are generally navigable for poling boats for considerable distances, but much of the region is inaccessible in this manner. Melozitna River has a canyon near its mouth said to be impassable for craft of any sort. Above the canyon this stream is ideal for poling boats and furnishes a possible route through a large territory. Very little boating is done except on Tozitna and Kanuti rivers. Inland travel is mostly done in winter, when dogs and sleds can be used.

The population of the region is chiefly localized in settlements on the banks of Yukon and Koyukuk rivers. The white settlements include Rampart (population about 50), Tanana (300), and Ruby (1,000), on Yukon River, and Hughes (population 75), on Koyukuk River. Minor settlements along the rivers, including telegraph stations, road houses, and the like, have a total population of about 50 individuals. About a score of prospectors spend more or less time in the interior of the region.

The native population numbers about 300. They live in camps and villages on the banks of Yukon and Koyukuk rivers, usually near the mouths of important tributary streams. The two largest settlements are probably those near Rampart and Tanana.

The industries pursued by the inhabitants of the region are numerous, but all are related more or less directly to mining, transportation, and the Government military and signal service. An agricultural experiment station is maintained at Rampart under Government auspices, and a great variety of products have been grown there successfully.

Government mail service extends to all river settlements throughout the year, and the principal Yukon River settlements are in touch with the United States military telegraph lines.

GEOLOGY.

GENERAL FEATURES.

The sketch map (Pl. XVI) presents graphically a summary of the salient geologic features of the Yukon-Koyukuk region. It will be noted that a broad zone lying along the Yukon upstream from Ruby is occupied predominantly by metamorphic rocks, probably of Paleozoic age. Westward from Melozitna River to the Koyukuk the rocks are composed almost entirely of Mesozoic sediments. Between the metamorphic rocks on the east and the Mesozoic sedimentary rocks on the west is an area in which the rocks are predominantly igneous, being for the most part granitic intrusions and their metamorphic equivalents. Tertiary sedimentary rocks occupy small areas on the Yukon, on Ray River, and possibly in other parts of the region. Quaternary deposits are widespread and cover large areas of the older rocks. The most extensive of these is the alluvium of the lowland plains. At higher elevations are gravel and silt terrace deposits. Locally in the mountainous areas are considerable bodies of material deposited by valley glaciers. Much of the material now included in the terrace and alluvial deposits may be glacial outwash.

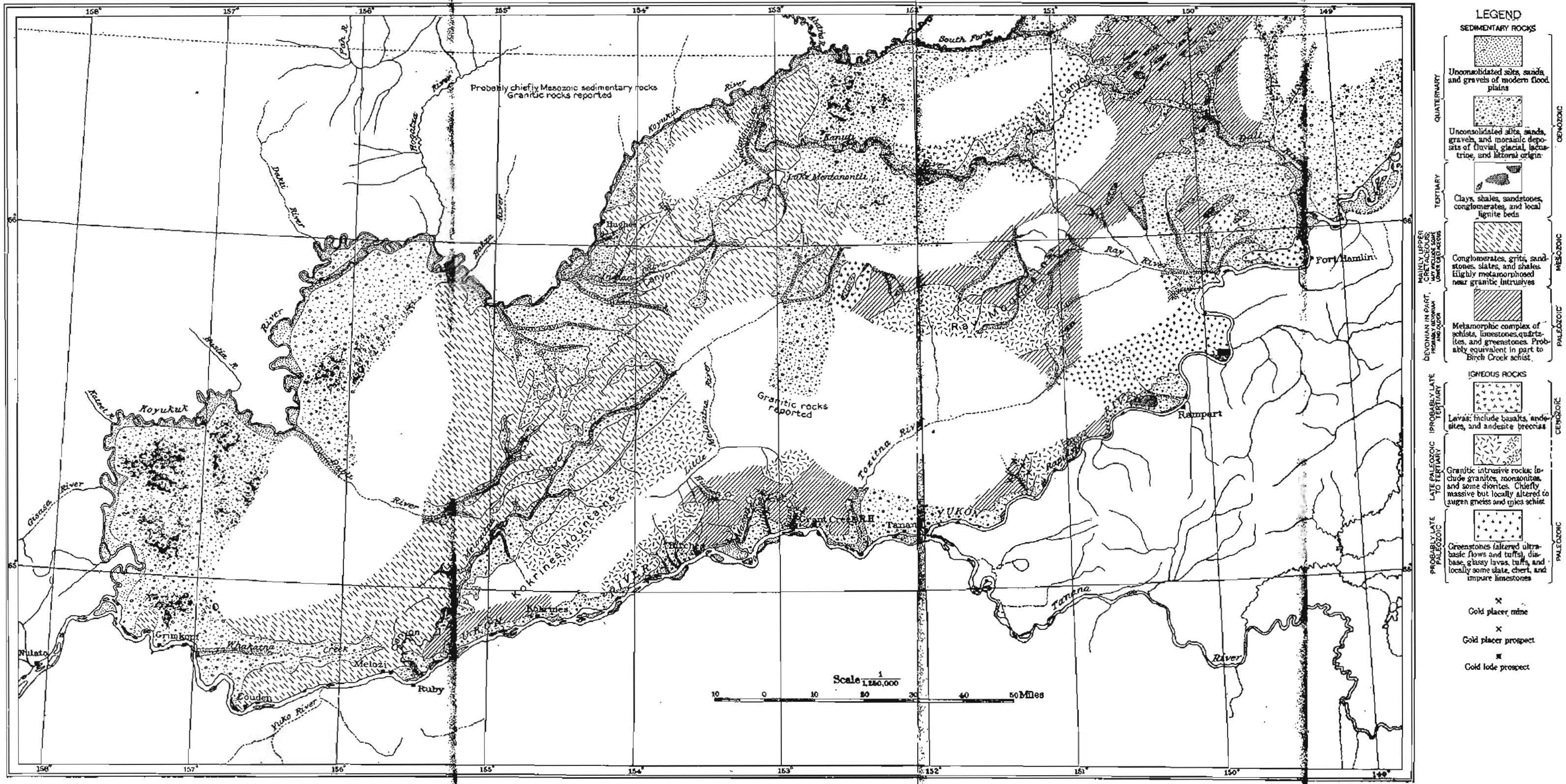
METAMORPHIC ROCKS.

The metamorphic rocks of the eastern part of the region are divisible into two general groups—a schist group, derived chiefly from original sedimentary rocks, and a greenstone group, in which altered basic igneous rocks predominate.

The schist group outcrops at intervals along the Yukon from Kokrines nearly to Rampart and probably covers considerable areas in the adjacent territory north of the river. It also occupies a large area on the headwaters of Tozitna and Ray rivers that continues northeastward to the headwaters of Dall and Kanuti rivers.

The predominant rock types of the schist group are quartzite schists and quartz-mica schists. Associated with these rocks are limestones, augen gneisses, and greenstones, whose mechanical alteration is comparable with that of the predominant schist types. They are also cut locally by unsheared intrusive rocks.

The schist group is undoubtedly in large part the equivalent of the schist series on the headwaters of Dall and Kanuti rivers described



GEOLOGIC SKETCH MAP OF THE YUKON-KOYUKUK REGION.

by Mendenhall [1] and considered by him to be of probable Devonian and Silurian age. The same physical characteristics have been noted in the rocks of the Ruby district to the southwest, where Devonian fossils were collected by the writer in 1912, and in the metamorphic rocks at the head of Little Minook Creek and on Quail Creek of the Rampart district, that have furnished Silurian and Devonian fossils. It seems probable that the group is composed chiefly of Silurian and Devonian terranes, though other Paleozoic periods may be represented.

The greenstone group forms the chief visible bedrock along the Yukon from a little below Rampart to Fort Hamlin and occupies a large area on both sides of the river. These rocks continue westward from the Yukon about 20 miles to the headwaters of Tozitna River. From this locality the western boundary swings to the northeastward and crosses the Yukon a little above Fort Hamlin. A published description [2] of this group as it occurs in the vicinity of Rampart is as follows:

> The greenstones proper are altered basic igneous rocks, principally diabasic flows and tuffs. Associated with them in the vicinity of Rampart are minor beds of slate, chert, and limestone, besides other igneous types. Among the latter are rhyolitic lavas and flow breccias and dense aphanitic laminated rocks that apparently include glassy lavas and fine-grained tuffs. The rhyolitic rocks occupy considerable areas to the exclusion of other types, their white or buff color contrasting strongly with that of the greenstones. At the head of Squaw Creek the sedimentary rocks are absent and reddish andesitic flows are interbedded with the greenstones. Throughout the area of the greenstones basic igneous dikes are common, but in the Squaw Creek locality they are especially abundant. In stratigraphic position the greenstones are apparently above the limestones and schists. The nature of their relation to the underlying rocks is not clear, but they seem to record a continuance of the same activities with a marked increase in volcanism. The lowermost greenstones are interbedded with marine sediments and were probably submarine flows. The absence of such sediments among the higher members suggests that either the accumulation of the lower beds or uplift brought the area above sea level and afterward igneous activities alone were recorded. The rate of accumulation of an igneous series is capable of such wide variation that it is obviously unsafe to designate any age as that witnessing the formation of all the greenstones. It seems likely that the formation of the lower members closely followed the Devonian sedimentation. They may represent only late Devonian activities or possibly some late Devonian and more or less of the succeeding age.

The greenstone group probably holds the same stratigraphic relation to the schists of the Yukon-Koyukuk region that it does to the limestone-schist group of the Rampart district, so that the discussion given of the age of the greenstones near Rampart is applicable to the group as a whole in the entire area of its occurrence.

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[1] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers: U. S. Geol. Survey Prof. Paper 10, p. 32, 1902.

[2] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 18-19, 1913.

Mendenhall reports the occurrence of somewhat similar rocks in an area near the head of Kanuti River, which he describes, under the name Kanuti series, as a group of greenstones and fine-grained pyroclastics intruded by dioritic and gabbroic rocks and associated with compact and vesicular basalts and detrital volcanic rocks. The Kanuti "series" differs from the group under discussion in being made up predominantly of intrusive rocks and in having a greater range in the degrees of alteration to which its different members have been subjected. The two groups correspond in being of volcanic origin and it seems likely that they were formed at about the same time.

No other extensive areas of similar rocks are known in the Yukon-Koyukuk region, but their presence in parts of the region not yet visited is suggested by the occurrence of greenstone bowlders in the wash of Tozitna and Melozitna rivers.

MESOZOIC SEDIMENTARY ROCKS.

DISTRIBUTION.

Mesozoic sedimentary rocks comprise the visible bedrock of the entire region between Melozitna and Koyukuk rivers, excepting in the local areas occupied by granitic intrusions and the belts of indeterminate contact rocks surrounding them. Their eastern boundary follows the main course of the Melozitna for much of its length, but locally they extend for a short distance east of the river. North and west they extend beyond the field investigated.

STRATIGRAPHY.

These rocks comprise a sedimentary series of great thickness and of great diversity in the lithologic character of its members, which exhibit no available evidence of any notable stratigraphic break. A great number of formations, 50 to 300 feet thick, can be distinguished. The aggregate of the different recognizable members indicates that the thickness of the whole series is extraordinarily great. A complex structure, together with the limitations of a reconnaissance survey, prevented accurate measurements, but it seems clearly indicated that the series includes many thousand feet of beds.

The base of the series, where recognized, is a massive conglomerate of coarse texture. Locally, as near camp 41, it contains bowlders, of which the largest are 5 feet in longest dimension. The usual texture is not so coarse, the bowlders as a rule being about a foot in diameter. There is commonly a great discordance in size among the materials of the basal conglomerate, which suggests a marine origin. It probably was formed on a shore line that advanced by destroying pronounced sea cliffs.

The basal conglomerate is overlain conformably by finer beds—grits, sandstones, and shales. These beds may represent offshore deposits that were laid down contemporaneously with another part of the basal conglomerate a short distance away. Still higher in the series is an alternation of fine conglomerates and sandstones with more or less shale (now generally altered to the form of pencil shales and slates). The materials of the higher beds show better assortment as to size than the basal beds and in places have the bedded arrangement characteristic of stream deposits. Evidently the series was laid down in an area that was subject to intermittent subsidence. Now a marked subsidence gave marine conditions and again a period of stability permitted streams to build deltas and extend their flood-plain deposits out over areas that had just previously received marine sediments.

LITHOLOGIC CHARACTER.

The basal conglomerate is made up of bowlders of granite, gneiss, and a great variety of metamorphic rocks, such as occur generally in the region east of Melozitna River and probably form the floor on which the series rests.

The finer beds of the series include clays, shales, sandstones, grits, and fine conglomerates, the shales and sandstones predominating. The shales are generally dark-colored gritless sorts that have developed a slaty or pencil shale cleavage. Some are arenaceous and one important shale member has gravel scattered through it, singly or in thin lenses and strata. The sandstones are chiefly feldspathic and some approach a true arkose in composition. For the most part they contain a variety of materials, including quartz and feldspar grains, femic minerals, and fragments of chert, quartzite, and dense igneous rocks. These beds are the kind that would be formed by a greater comminution of the materials that enter into the basal conglomerate and point to continued sedimentation from the same sources.

STRUCTURE.

The series is massively bedded for the most part, but locally a close horizontal lamination is evident in the sandstone members and a strong cross-bedding in the fine conglomerates. The whole series has suffered extensive deformation. In general, a close irregular folding is indicated. Pronounced faults have developed in places, especially along Melozitna River at the eastern margin of the area. Locally, about the granitic intrusive areas, the beds are highly contorted and the original structures are entirely obscured. Pronounced secondary structures, including flow structures, schistosity, and slaty cleavage, have developed in these localities.

METAMORPHISM.

The granitic areas are surrounded by broad zones that are occupied by a peculiar assemblage of rocks whose origin and relationships are not entirely clear. In part they have the essential characteristics of basic lavas. Some are clearly altered Mesozoic sedimentary rocks and others contain much material derived from the magma that gave rise to the granitic rock in admixture with other material that came from the rocks which the magma invaded—probably from the Mesozoic rocks. This assemblage may be in part the rocks of an older group of strata than the typical unaltered Mesozoic beds (that are generally without igneous members), which have been exposed by erosion in local anticlines produced by the intrusion of the granites. Or it may be that the granitic intrusions coincided in position with locally developed volcanic members in the Mesozoic succession. However, as many of the rocks more or less characteristic of the whole assemblage are known to have been derived from the Mesozoic sedimentary rocks, and as locally the evidence of extensive igneous metamorphism is conclusive, it seems to the writer that these rocks are best interpreted as having developed from the Mesozoic sedimentary rocks through the metamorphic influences that attended their invasion by the granitic magma.

The metamorphism attending the granitic intrusions is illustrated in the present condition of a fine even-grained quartz conglomerate bed that abuts against the granite area west of the head of Pocahontas Creek. Near the contact the conglomerate is reduced to a solid mass of quartz in which structure and the original form of pebbles have been effaced. This condition holds for over a hundred feet. Beyond this the pebble forms may be more or less clearly distinguished. A pronounced induration and silicification extends for more than a mile from the contact. Flow structure is developed in places and the addition of magmatic material is seen near the contact. The impure sedimentary beds associated with the conglomerate are profoundly altered for a mile or more from their contact with the granites, and for the most part have taken on an igneous appearance generally characteristic of the rocks of this group. As the rocks of the whole assemblage are considered to be analogous to the metamorphosed beds associated with the conglomerate, they are grouped together in mapping under the head of contact rocks, and no attempt is made to distinguish between various members of the group that may differ considerably as to the details of their genesis.

The contact rocks are for the most part dark or greenish in color, entirely dense or porphyritic, with a dense groundmass, and are very hard and resistant to weathering. In the least altered phases of the typical arkose of the sedimentary series there is a partial isolation of the coarser quartz and feldspar grains by the development of a glassy or finely crystalline matrix. In more altered phases the matrix is developed in relatively greater volume, the quartz and feldspar grains are more completely isolated, and the quartz grains show marked corrosion. A gradation exists in which the quartz grains approach complete resorption and the recrystallized or glassy matrix is developed in progressively greater quantities. In still more advanced phases of alteration the more acidic of the feldspars are more or less resorbed and secondary basic feldspars are developed. The porphyritic appearance of these rocks is due in part to the resistance of basic feldspars original in the arkose, in part to the development of secondary feldspars, and in part to masses of epidote and chlorite that have replaced some of the original grains, the principal mass of the rock having been reduced to a glassy or finely crystalline condition. Near the granitic areas the magma probably contributed much of the material of the contact rocks. Here femic minerals are abundant and there are phases that differ from the typical granites only in the relative abundance of their common constituents. Apparently there are gradations of the contact rocks into the granites on the one hand and into the sedimentary rocks on the other. The more siliceous sandstones have been altered to quartzite and the shales have been indurated or vitrified and partly recrystallized.

AGE AND CORRELATION.

No fossils have been found in the sedimentary series in the Yukon-Koyukuk region. The character of the series at a distance from the problematic contact rocks and its distribution indicate close relationships with the Shaktolik group of the Nulato-Norton Bay region, of known Upper Cretaceous age, and with the Bergman group of the upper Koyukuk basin which has been correlated with the Shaktolik group. It is quite probable that these beds furnish a continuation of contemporaneous strata northeastward from the Shaktolik area through the Yukon-Koyukuk region into the upper Koyukuk basin, which strengthens the correlation between the Bergman and Shaktolik groups.

Lower Cretaceous fossils were collected by Schrader [1] from a pinkish limestone, which is associated with igneous amygdaloidal and andesitic tuffs on the west bank of the Koyukuk a few miles below Hughes. No rocks of this character were noted by the writer south of the Koyukuk, unless possibly they are included among the apparently igneous members of the so-called contact rocks. There is no evidence of a stratigraphic break between the contact rocks and the normal rocks of the Shaktolik and Bergman type, such as generally exists

[1] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, p. 477, 1900.

between the Lower Cretaceous and Upper Cretaceous series in Alaska. Unless the series are conformable in this part of Alaska the presence of Lower Cretaceous strata in the region south of the Koyukuk is improbable. If they are present conformably below the Upper Cretaceous, much more extended and detailed work will be required to distinguish them and outline their areal distribution.

TERTIARY ROCKS.

Small isolated areas of Tertiary sedimentary rocks occur on Dall and Ray rivers and at a number of localities along Yukon River. The beds include clays, shales, sandstones, conglomerates, and thin lignitic seams, and are apparently of fluviatile origin, the coal beds representing vegetal accumulations in the lateral basins of aggrading Tertiary streams. There is a close accordance in their composition and physical condition in all the areas and they are probably of the same age. Fossils that were collected from the area near Rampart have been determined as younger than the Kenai flora of Cook Inlet.

QUATERNARY DEPOSITS.

Quaternary deposits mantle a large part of the Yukon-Koyukuk region. They include moraines and glacial outwash deposits, lacustrine silts and beach gravels, and the alluvial deposits of lowland plains and modern flood plains.

The glacial deposits are found chiefly in the valleys that head in the Ray Mountains. These valleys show many well-developed transverse moraines, some of which are more than 20 miles below the heads of the valleys in which they lie. Beyond the lowermost moraine the valleys are commonly walled by outwash deposits in which the postglacial streams have entrenched themselves. In the reaches that traverse the outwash deposits the valleys are broadly V-shaped—a form that is in marked contrast with the glaciated headward parts of the same valleys.

A few small moraines occur in the glaciated part of the Yukon-Melozi divide and at a locality a few miles northwest of Melozitna Canyon, but the material involved in them is insignificant in amount. Lacustrine silts are extensively developed in many parts of the region. They fill an erosional depression at the lower end of the Yukon Flats that represents a northeastward continuation of the valley of Ray River. The present topography of the lower parts of the basins of Ray and Dall rivers is carved largely in silt deposits. Similar deposits also fill the abandoned valley through which Indian River formerly flowed to the northeast and are exposed at places in the bluffs along the Yukon and Koyukuk rivers and many of their tributaries. The general distribution of the lacustrine silts is what would be expected if they had once prevailed over the entire region up to an elevation at least several hundred feet above that of the major streams and had since been partly removed by erosion.

Gravel terraces and probable wave-cut terraces and wave-flattened ridges have been noted in many parts of the region, particularly in the basins of Ray, Dall, and Melozitna rivers and along the Yukon in the vicinity of the Ramparts. In the basins of Ray and Dall rivers and along the Yukon these features have their chief development at an elevation of about 1,500 feet above sea level. Farther down the Yukon and in Melozi River basin they are probably most strongly developed at less elevation.

Lowland plains occupy large areas bordering on Yukon and Koyukuk rivers and in the basins of many of their tributaries. They have resulted from the aggradation of the valleys of an antecedent drainage system whose arrangement was considerably different from the present. The materials of the lowland plains have probably been brought to place chiefly by streams, but in places glacial deposits and lacustrine silts are included. The flood plains of the present streams are nowhere much wider than the meander belts of the streams that traverse them. They are even narrower where the streams have recently entrenched themselves and in places are absent, as in the Ramparts of the Yukon and the canyons of Melozitna, Kanuti, and Indian rivers.

IGNEOUS ROCKS.

The igneous rocks of the region are of three general types: The greenstones, the altered, and the unaltered granitic intrusions. This order expresses the apparent age relations of the different types, beginning with the oldest, and will be followed in further discussion. The greenstones have already been described in connection with the Paleozoic metamorphic rocks. Another rock type of doubtful origin, having the essential characteristics of basic lavas, has been discussed on a preceding page in connection with the contact rocks that surround the late intrusions in the Mesozoic area west of Melozitna River.

ALTERED GRANITIC INTRUSIVES.

Altered granitic intrusives occur in many places in the eastern half of the region that is occupied chiefly by Paleozoic metamorphic rocks. Their present forms include gneisses, augen gneisses, and sericite schists. They occupy large individual areas for the most part, but there are many long and relatively narrow areas that may represent granitic dikes or sills intruded into the Paleozoic rocks before their principal alteration took place. Schists and augen gneisses are characteristically developed at the margin of the great granitic areas of the Ray Mountains and in the prominent mountain range along the Yukon southwest from the vicinity of Tozitna River. Gneissoid rocks penetrate the other granitic bodies, and in many places a complex relationship exists between the sheared and unsheared types that could be shown only on a map of much larger scale and after extensive detailed study. The gneisses are plainly derived from igneous rocks. The origin of the schists is less easily determined. There is a gradation between gneiss and schist in places that indicates their equivalency, though there are schists of like character in many parts of the field which may be igneous derivatives but whose origin is still uncertain.

The more highly altered granitic derivatives have about the same degree of metamorphism as the Paleozoic sedimentary rocks. The exact age of the metamorphism of the Paleozoic rocks is unknown, but it was probably in late Paleozoic time. The oldest of the granitic derivatives may have been intruded in Paleozoic time. If the degree of alteration is a criterion of age there must have been a succession of intrusions during later ages, for there is a gradation of the altered granites from schistose forms through the whole range of gneissic development.

UNALTERED GRANITIC ROCKS.

Unaltered granitic rocks occur in all parts of the region, cutting both Paleozoic and Mesozoic terranes. They are developed chiefly as huge batholiths and thick lenses. The largest areas comprise one in the Ray Mountains and one between the Melozitna and Tozitna rivers. It is not unlikely that these areas will be found to merge when their extents are fully known. Elsewhere in the region the granitic bodies have thick lenticular forms. But few thin dikes or sills were noted.

The unsheared granites of the western part of the region cut strata of probable Upper Cretaceous age. Those near the Ramparts of the Yukon are closely analogous to granitic intrusives of the Yukon-Tanana region, which in places cut Upper Cretaceous rocks. However, the basal conglomerate of the sedimentary series along the Melozitna contains bowlders of unsheared granites. Evidently the unsheared granites include rocks both older and younger than Upper Cretaceous and it is not unlikely that they represent a considerably greater range in age than the bare limits of this period. In connection with the granitic derivatives the unsheared granites suggest a period of intermittent intrusion, extending from some Paleozoic age possibly into the Tertiary.

MINERAL RESOURCES.

PROSPECTS.

Placer gold is apparently widely distributed in the Yukon-Koyukuk region, but the deposits have thus far shown little economic importance. Gold prospects have been found on a number of northern tributaries of the Yukon from Morelock Creek westward to Melozitna

River. A little desultory mining has been done on Morelock and Grant creeks, but the production from this whole section of the region has been negligible. Active placer mining on a small scale has been in progress since 1911 on Indian River in the northern part of the region. A little gold has also been recovered from the south bank of the Koyukuk at a place called Red Mountain a few miles above Hughes. Gold is said to occur also on some of the southern tributaries of the Koyukuk below Indian River.

There are no gold lode mines in the region and but a single prospect. This prospect is on the north side of the Yukon near the bank, about 20 miles below Tanana, and has the distinction of being the first attempt to open a lode mine in the interior of Alaska. It was opened about 1890, but was abandoned soon afterward.

A silver-lead prospect has been opened on the west side of the Yukon near Morelock Creek. This prospect is described by prospectors as a close stockwork about 10 feet wide. Large pieces of nearly pure galena from this locality were shown the writer at Rampart in 1912, and it was stated that the ore contained considerable silver and a little gold. No quantitative analysis of the ore is known to have been made and the economic value of the deposit is uncertain.

INDIAN RIVER GOLD PLACERS.

The gold placers of Indian River are all on the main northern headwater stream from 3 to 5 miles below its source. More or less mining has been done on 13 different claims, but the profitable placers are restricted to five or six claims. A little gold has been recovered also from Black Creek, a southern tributary of Indian River above the workings.

The gold-bearing deposits of Indian River are almost entirely in the immediate bed of the stream. At one place the pay streak is under the east bank of the stream for a short distance, but the deposit is on a level with the stream and does not indicate a true bench deposit.

The auriferous gravels are 2 to 6 feet deep and have an average width of about 50 feet. The bedrock throughout the area of profitable placer ground is granite and the deposit is made up chiefly of granite sands and residual bowlders from local sources. The bowlders are a product of concentric weathering in the granite rather than of water wear. They have been concentrated in the stream bed by the flow of waste from the hillsides under frost action and the removal of the finer materials by the stream. The bowlders make up most of the deposits and are a hindrance to economic mining.

Gold was first discovered on Indian River in 1909 by a native. He gave information of his discovery to J. C. Felix, a white prospector, who visited the locality in 1910 and struck pay dirt late in the summer. The summer of 1911 witnessed the first actual mining in the district, when four claims were worked by 10 men and nearly $10,000 worth of dust was produced.

In 1912 seven claims were worked by about 20 men, with a reported production of $24,500.

In 1913 work was being done on 13 different claims by about 35 men. Little besides prospecting was accomplished, however, until late in the summer, as the stream was almost dry on account of the prolonged drought. Up to July 24 only $8,700 had been produced. Work later in the summer was more successful and a total production of $31,952 was reported for the season.