GOLD PLACERS OF THE ANVIK-ANDREAFSKI REGION.

By G. L. HARRINGTON.

INTRODUCTION.

The Anvik-Andreafski region, as considered in this report, embraces the territory north and west of the lower Yukon River, between Anvik and Andreafski rivers. The area covered by surveys in 1916, extending from longitude 159° 40′ to 163° 20′ W. and from latitude 61° 30′ to 63° 40′ N., is approximately 2,000 square miles.

Topographic and geologic traverses were made on the Yukon from Anvik to Andreafski and up Anvik, Bonasila, Stuyahok, and Andreafski rivers as far as was practicable under the limitations of the short season. The intervening stretches of country that were inaccessible from the boat were not visited. Sixteen days was also spent in the vicinity of Marshall in studying the mineral resources and in topographic and geologic mapping.

The work was in charge of R. H. Sargent, topographic engineer, the writer being attached to the party as geologist. C. F. Bailey and C. E. Anderson acted as recorder and cook, respectively.

The writer wishes to express to each member of the party his appreciation of their cordial aid in the furtherance of the geologic work. To Mr. Sargent especially he feels under great obligations for hearty cooperation both in the field and in office work. Cheerful acknowledgment is made of the indebtedness of the members of the party to Rev. J. W. Chapman and others at Anvik, who assisted in the preparation for field work. To every miner, prospector, and merchant met during the summer thanks are due for hospitality and cooperation.

RELIEF.

GENERAL CHARACTER.

In general the relief of the region is moderate. The highest point attains an altitude of about 2,700 feet, and there are comparatively few small isolated areas lying above 2,000 feet. Along the west and north bank of the Yukon there are in places sharply dissected areas, but as a whole the forms are those of a mature topography, so that the country presents a rolling aspect. Quite as extensive as these uplands are the wide, poorly drained lowlands that occupy the intermontane areas.

UPLANDS.

The uplands are scarcely of sufficient elevation to merit the term mountains, although here and there a point rises well above the general level and furnishes a conspicuous and easily identified landmark. Of this character are Bonasila Dome, Chiniklik, and Pilcher Mountain.

Bonasila Dome lies east of the Stuyahok and south of Bonasila River, and its isolation, together with its peculiar form (a cone on the crest of a gently crowning dome), gives it prominence from whatever point it is seen. This peak is also called Simel Mountain.

The peak known by the guttural native name Chiniklik, frequently corrupted by the whites to Cheneegly, though the highest and most conspicuous peak in the area, is only 4 miles from the Yukon. It lies 8 miles above Russian Mission and 12½ miles below Tuckers Point. This mountain was seen from points along Anvik River, from Andreafski, and from practically all the intermediate stations, except those at the water's edge on the banks of the Yukon. Its conical outline, with shoulders a few hundred feet below the apex, readily identifies it. This peak is visible from many points along the crest of the divide between the Yukon and Andreafski drainage basins and from points far south of the Kuskokwim.

Pilcher Mountain, about 5 miles east of Marshall, rises well above the immediately adjacent hills and is topographically prominent because of the exceptionally well developed altiplanation terraces on all sides but the east.

The softer sedimentary rocks of Mesozoic age are everywhere, except near the Yukon, marked by the gentle slopes and rounded crests that are characteristic of a mature topography. Elsewhere the drainage is that of an area past maturity in the cycle of erosion, but the crests of the hills present a terraced appearance. The origin of these forms has been described by Eakin,[1] who termed the process altiplanation. These terraces are best developed in the areas of igneous rocks at the higher elevations. To a minor degree altiplanation has taken place in some of the more indurated sedimentary rocks, especially in the vicinity of intrusives.

LOWLANDS.

The lowlands may be subdivided into two classes—the lowlands that lie above the flood level of the Yukon and those that are influenced by its highest stages. The first class includes the broad plains that are here characteristic of the tributary valleys of the Yukon. Bedrock crops out along the streams only here and there and not at all for several miles above their mouths. Alluviation has

[1] Eakin, H. M., The Yukon-Koyukuk region, Alaska: U. S. Geol. Survey Bull. 631, p. 78, 1916.

proceeded so far that, except in their headward portions, the streams flow in meandering courses with many oxbow sloughs formed by abandoned meanders. In the area which lies within the influence of the Yukon are to be placed the wide stretches of lowland that extend to the Kuskokwim, east and south of the Yukon. The gradients of the larger tributary have been lowered to such an extent by alluviation that they are controlled by the Yukon at all but the lowest stages. Five miles up the Bonasila was seen débris which undoubtedly came from the Yukon. It is, therefore, conceivable and even probable that the alluvial material, which is now being laid down over the bottom lands in the lower reaches of this and other tributaries, is in large part derived from the overloaded flood waters of the Yukon, which deposit a considerable portion of their burden in the slack water of the embayments furnished by these stream mouths.

DRAINAGE.

To the geologic structure was due the original position and direction of many of the streams, but other factors have affected their later history, and the former courses have been somewhat modified by alluviation and lateral erosion. The valley occupied by Stuyahok, Bonasila, and Anvik rivers affords an excellent example of stream trend initially controlled by the underlying bedrock structure, and the Yukon, above Holy Cross, trends in the same general direction. Structural control is also evident in the vicinity of Marshall and, in part at least, along the north fork of Andreafski River.

The region considered in this report lies wholly within the Yukon drainage basin, but the wide, flat, lake-dotted delta between the Yukon and the Kuskokwim, opposite and below Russian Mission, has so little relief that the watershed between the two rivers is difficult of location. So far as could be ascertained, there are few places, except near the coast, that rise even so high as 100 feet above either of the rivers. At high stages of water much of this lowland is inundated. During the spring of 1916 the small steamer *Tana* left the Yukon through a slough near Pilot station and, entering the Kashunuk River, reached Bering Sea through Hazen Bay. Essentially similar conditions are to be found in the delta of the Innoko. At high water this river may be reached through any one of several mouths, from a point several miles above Anvik to the last slough, about 11 miles below Paimiut. Other tributaries of the Yukon enter that river from the west and north after passing through considerable delta areas, modified by overflow from the Yukon and truncation of their fronts by the larger river. Bonasila, Koserefski, Kuyukutuk, and Chyilnuk rivers and many of the smaller creeks enter the Yukon through sloughs. Lakes are characteristic of the flood

plains of some of these streams throughout their lower reaches and were especially noted in the broad depression occupied by Kuyukutuk and Chvilnuk rivers, which resembles in this regard the region between the Yukon and Kuskokwim.

CLIMATE.

The climate of the Anvik-Andreafski region is intermediate in character between that of the upper Yukon and the coastal region from Norton Sound to Bristol Bay. The proximity of Bering Sea has a stabilizing influence, so that the summer temperatures are not so high, nor as a rule are the winter temperatures so low as those of the upper Yukon, although north winds may occasionally bring about similar conditions in the two areas. From the records the precipitation appears to be greater in this region than at coast points and almost double that of points in the upper Yukon Valley. In any two consecutive seasons there is likely to be considerable difference in the amount of rainfall and in the times when precipitation takes place, but normally the greatest precipitation occurs after the middle of July. In 1916 records were kept from June 15 to September 10, inclusive. In the 40 days from June 15 to July 25 there was some precipitation on 21 days, or 52 per cent. From July 25 to September 10 there was some precipitation on 35 days of the 48, or 73 per cent.

Records of the time of opening and closing of the Yukon at Holy Cross have been kept for a considerable number of years, and there is probably under normal conditions very little difference between the dates at this point and others as far down the Yukon as Andreafski. These dates may be summarized as follows:

Ice began running in spring between April 29 and June 1.
River clear of ice between May 21 and June 3.
Ice began to form in autumn between October 5 and October 16.
River closed between October 19 and November 3.

It was noted that the rains are usually brought by southerly winds and that northerly winds prevail during periods of fair weather. The southerly winds are frequently of such force as to impede navigation seriously, as the steamboats are likely to be driven aground on some of the numerous bars of the river, and the seas caused by the wind make navigation dangerous for any small boat except a dory or one of the skin boats of the natives. The activity of the wind as an erosive agent was observed many times on the sand bars in the river, for as soon as the surface became dry it would drift before the wind and pile up in small irregular hummocks or dunes. Cross sections of dunes thus formed were exposed here and there in the cut banks of the Yukon.

VEGETATION.

Within the area crossed by the expedition of 1916 the conditions affecting vegetal growth are so diverse that a corresponding diversity of plant types is reasonably to be expected. In the vicinity of Anvik the lowlands are well timbered, although an approach to the tundra conditions found below Andreafski is presaged by the lowering of timber line compared with upper river points. In the vicinity of Anvik timber line is about 600 to 800 feet above the river; in favorable localities, such as sheltered, well-drained valleys, it extends somewhat higher. No spruce was seen growing on the Yukon below Andreafski, but scattered stumps of spruce and an occasional straggling birch indicate a former scanty growth of these trees to elevations from 100 to 200 feet above Andreafski River. From the hills back of Andreafski small patches of spruce may be seen scattered through the flat in the cottonwood and willow thickets extending along the Yukon above this point. The best growths of spruce are found along gullies, on slight eminences in the lowlands, or near the banks of streams. Farther back from the smaller streams in the lowlands, where drainage is poor, the growth is usually scattered and stunted. Wherever spruce is found on well-drained hill slopes birch generally occurs also, together with small-leafed poplar or quaking aspen. Extensive growths of these trees are apparently less common than in the Tanana basin. On Anvik and Bonasila rivers the birch bark is used by the natives in making their canoes. Tamarack grows in open groves in the more boggy places along the Anvik and Bonasila and was seen occasionally along the Yukon.

Throughout the lower-lying portions of the area cottonwood and several species of willow constitute the most abundant element of the forests. Some of the bars that have barely emerged from the river are covered with a dense growth of willows a few inches high. Alders are found at considerably higher elevations than any timber trees. They cover the slopes, in places occurring almost at the crests of the hills or ridges, where some protection is afforded by the depressions in the headward portions of the streams.

Grasses are surprisingly plentiful in variety and amount everywhere in the area, so that horse feed could easily be obtained for outfits traveling by pack train. This was especially true along the tributaries of the Yukon. On the Stuyahok there are many beautiful open parks containing luxuriant growths of grass, and at almost every point where a stop was made there was an abundance of forage. On the hilltops and most of the slopes a large part of the vegetal covering consists of mosses and lichens, but there is still a considerable amount of horse feed to be found even here. On the river bars there is usually an abundance of the variety of *Equisetum* called mare's-tail, and occasionally the pea vine is found.

When the party left the field (September 7) there had been no frosts of sufficient severity to destroy the nourishing qualities of the grasses, but the season of 1916 was probably exceptional in this respect, and killing frosts may ordinarily be expected early in September.

Fairly extensive agricultural operations have been carried on for a number of years by the mission at Holy Cross. The native grasses in natural meadows on the flood plain of the Yukon below the mission are cut and cured for forage or are utilized as pasture. A considerable variety of vegetables are grown for private use. Any surplus is sold and finds a ready market along the river. At Anvik some gardening is done, and several varieties of vegetables mature. The season without frost appears to be slightly longer here than farther up the Yukon.

Along the lower course of the Anvik are grass-covered areas almost wholly free from brush or timber. These natural meadows could doubtless be used for pasture or the grass cut for hay. Similar areas were seen on other streams, but there appear to be rather few along the Yukon.

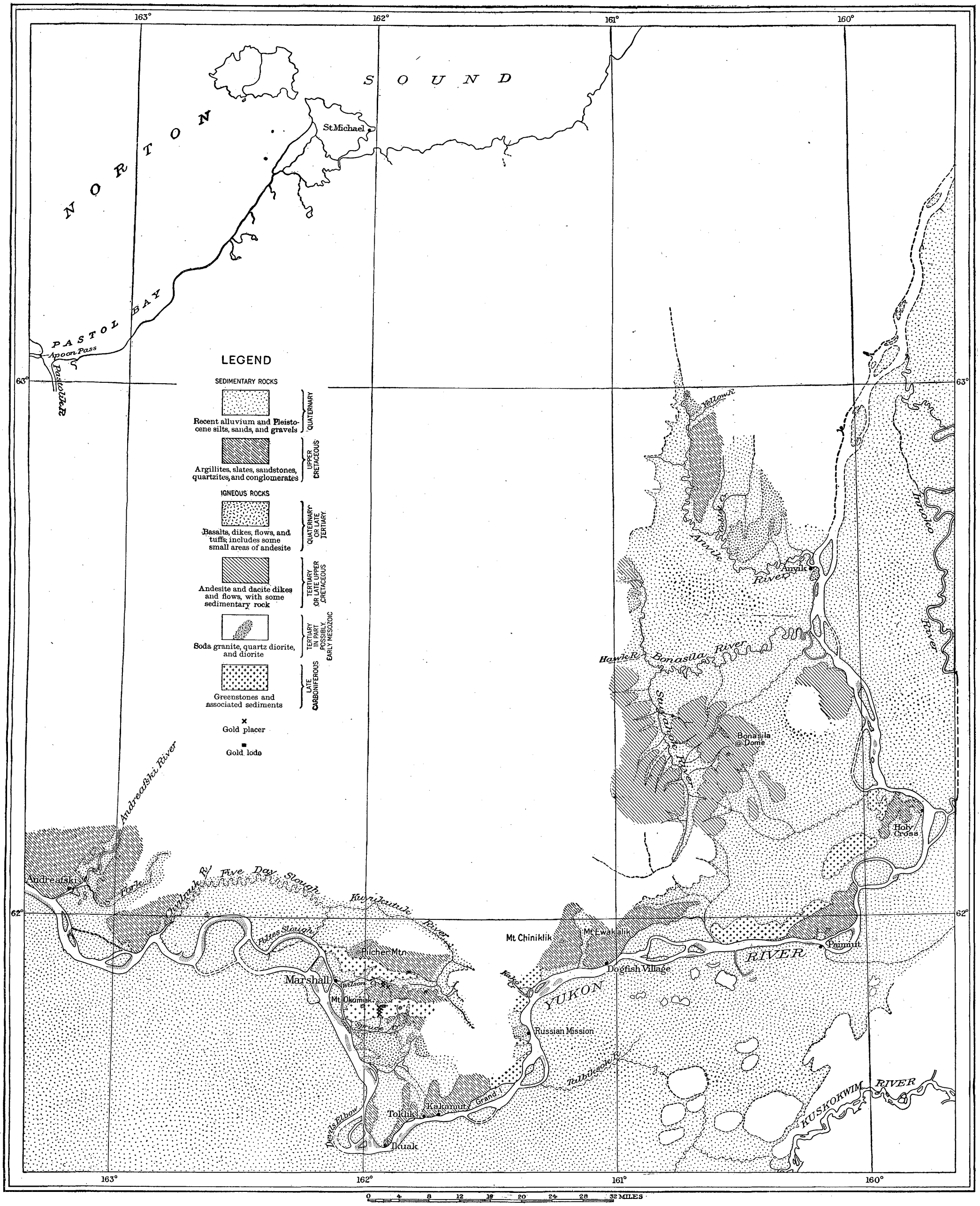
ANIMAL LIFE.

Animal life is abundant in the region, but there is little large game. Though only one small black bear was seen, the tracks were fairly common along the sand bars. Brown bear are reported. Neither caribou nor moose were seen, and it is said that there are none in this part of Alaska. Their former presence in great numbers is recorded by the earlier explorers, and on some of the ridges their trails are still visible. Domesticated reindeer are herded in the southern part of the area, and small bands are pastured near Marshall and Andreafski.

Of smaller animals a few rabbits and an occasional fox were seen. Fox tracks were very frequently observed along the river bars, where the foxes had been stalking aquatic birds. Beaver dams and houses were seen on the Stuyahok, and there was also evidence of the presence of ermine, mink, marten, and muskrats on this and other streams. To judge from their tracks porcupines are fairly common. The red-backed mouse was frequently observed.

Ducks were seen almost constantly on the streams tributary to the Yukon. Geese were abundant on the Stuyahok and lower Bonasila, and in the fall they were seen in flocks of hundreds on the Yukon and Andreafski. Large flocks of ducks were also seen on the Andreafski, as well as smaller flocks of swans and cranes.

On clear-water streams having a good current grayling were taken with a fly, and no difficulty was experienced in getting as many as were desired. Occasionally a trout was caught, but they seemed less



LEGEND

SEDIMENTARY ROCKS

- Recent alluvium and Pleistocene silts, sands, and gravels — QUATERNARY
- Argillites, slates, sandstones, quartzites, and conglomerates — UPPER CRETACEOUS

IGNEOUS ROCKS

- Basalts, dikes, flows, and tuffs; includes some small areas of andesite — QUATERNARY OR LATE TERTIARY
- Andesite and dacite dikes and flows, with some sedimentary rock — TERTIARY OR LATE UPPER CRETACEOUS
- Soda granite, quartz diorite, and diorite — TERTIARY IN PART POSSIBLY EARLY MESOZOIC
- Greenstones and associated sediments — LATE CARBONIFEROUS

× Gold placer

■ Gold lode

GEOLOGIC SKETCH MAP OF ANVIK—ANDREAFSKI REGION.

numerous than the grayling. Fish wheels and fishtraps are used on the Yukon for catching salmon and whitefish. The salmon are smoked and dried or salted down to be eaten during the winter, by dogs as well as men. The whitefish are used largely as summer feed for the dogs. Trout, pike, and pickerel are also said to be taken by the fish wheels or in nets. Considerable quantities of fish of the various kinds are caught in large dip nets, which are handled with consummate skill by the natives. In winter whitefish are caught through holes in the ice, the natives using for bait an artificial minnow made of bone or ivory.

GEOLOGY.

In general the geology of the region is fairly simple, although faulting and a moderate amount of folding have complicated the structure somewhat, so that detailed mapping would be difficult. Difficulties of this kind are increased by the widespread occurrence of Quaternary sediments and residual rock débris, which obscure or completely conceal the distribution of the underlying rock units. The banks of the Yukon, however, present excellent sections and afford opportunity for stratigraphic studies.

A series of greenstone tuffs and flows with some intercalated sedimentary beds of upper Carboniferous age are the oldest rocks found. Their distribution is indicated on the accompanying map (Pl. XVI). Locally, as at Bareface Bluff, these rocks appear to be mainly sedimentary in origin. In the vicinity of Marshall they are much deformed and are almost wholly recrystallized, so that they are now epidote-hornblende schists. Their original composition was probably andesitic or basaltic.

Overlying the greenstones is a thick series of conglomerates, sandstones, and argillitic rocks of Cretaceous age. Locally, metamorphism has produced quartzites, slates, or, as near Marshall, sheared conglomerates. Although the Cretaceous sequence as a whole gives the impression of a succession of rather thin beds, some thick masses of sandstone and grit were seen in which no trace of bedding was apparent. A large proportion of the sandstones are feldspathic, and from the nature of the individual feldspar grains it is inferred that the greenstones were the source of a large amount of the material that makes up the Cretaceous rocks. In the rock on Andreafski River, however, the feldspars are much more acidic than those found in the greenstone and presumably came from soda granite or from dioritic rocks.

No evidence of the Tertiary age of any of the rocks seen was found, but it is possible that some early Tertiary beds may be included in areas mapped as Cretaceous.

Intrusive and extrusive igneous rocks of a number of types are found in this region. Soda granite and dioritic rocks occur in batholiths and dikes, which may belong to two periods of igneous activity—early Mesozoic and Tertiary. Accompanying the later of these intrusions were dacite and andesite dikes, flows, and tuffs, of which the dikes are known to intrude Cretaceous sediments.

At numerous places in the northern part of the area are basalt flows and tuffs, presumably of late Cretaceous or early Tertiary age. They are in part vesicular, in part amygdaloidal, and in part dense and containing little cavity space. At and west of Russian Mission are basalt dikes and flows which are thought to have been extravasated in late Tertiary or Quaternary time.

Sediments of Quaternary age are of widespread occurrence and include deposits of probable marine origin, as well as the products of stream alluviation. The marine sediments appear in the high cut banks of silt, sand, and gravel along the Yukon and its tributaries and are not everywhere readily distinguishable from the later stream deposits. In addition to the various types of sediments, vegetation and the débris due to the weathering of the underlying rock form a mantle that conceals the nature and relations of the older formations.

MINERAL RESOURCES.

HISTORY OF MINING DEVELOPMENT.

Gold has long been known to occur on Anvik River in amounts sufficient to stimulate prospecting, but no rich deposits have yet been found. Its presence on many other streams in the area has also been known to some of the prospectors of the region. Wilson Creek had received some attention, but it was not until July 15, 1913, that gold was discovered on this stream by E. L. Mack and Joe Mills. A stampede followed, and practically all the streams near by were covered with locations, Willow Creek among the number. It was not until June of the following year, however, that gold was discovered on this stream by W. C. Blanker, Ben Blanker, and Robert Barr. Some quartz claims were located near the head of Willow Creek in August, 1914, by Tom Plunkett. Up to the beginning of 1916 the district had produced about $40,000.

To facilitate recording the Wade-Hampton district was established, with the recorder's office at Marshall. It is that part of the second judicial district south of a line drawn along the crest of the divide between Yukon River and Bering Sea, starting at a point between Pastol Bay and the Yukon and extending to the one hundred and sixty-first meridian. The boundary of the district follows the one hundred and sixty-first meridian to a point within 5 miles of the Kuskokwim, runs parallel to the Kuskokwim at a distance of 5 miles

to the sixtieth degree of north latitude, and thence goes due west to Bering Sea and northward to the point of beginning. Islands adjacent to the Bering Sea coast are included within the district.

ECONOMIC FACTORS AFFECTING MINING.

Timber is fairly plentiful for such operations as have been conducted. On Elephant and Disappointment creeks fuel could be procured for a time from the bottoms of the valleys. Extensive operations, using steam power, would necessitate the hauling of wood from the valley of Wilson Creek. Alders are the only trees found on Willow Creek above claim No. 2 below Discovery; consequently all the fuel used for producing power is obtained from the gentle foot slope between Spruce Creek and the hills. This wood costs $5 a cord to cut, and by the time it is laid down at the mine plant ready to use there is an additional charge of $5 to $7 for labor and hauling.

Wages are about the same as at other interior Alaska points. Miners are paid $5 a day and board, and hoistmen, blacksmiths, and cooks receive $7 and board. Two shifts of eight hours are employed by the larger plants; the smaller plants work but one shift. Employment was given to everyone who wished to work when there was a full sluice head of water. Natives are employed around the camp but do no mining. They are paid $2 to $3 a day.

The camp on Willow Creek is easily accessible. About 3 miles from the camp Spruce Creek flows into small lake which empties through a slough into the Yukon, rising and falling with it. Supplies may be brought to the landing on the lake by gasoline boats or in scows, and one of the smaller steamboats also brought a barge load of lumber up to the lake. The freight rate from Marshall to the landing, about 8 miles by boat, is $15 a ton. From the landing the rate is $30 a ton to the lower claims on the creek and $40 a ton to points as far up as claim No. 5 above. The winter rate will probably be much lower. The rate from Seattle to Marshall by way of St. Michael is $45.50 a ton on general merchandise.

In 1916, on account of traffic conditions, there was a scarcity of some commodities at Marshall. The following prices per pound were paid for staples on the creek:

Flour	$0.10	Sugar	$0.13½
Bacon	.37	Butter	.67½
Coffee	.75	Reindeer meat	.25 to .30
Tea	1.00	Beef	.45 to .50
Beans	.12	Potatoes	.07½
Rice	.12½		

Lumber was difficult to obtain until a barge load was brought down from Ruby. This sold at $80 per thousand feet at the lake.

GOLD PLACERS.

WILSON CREEK.

Until the summer of 1916 most of the mining in the Marshall district had been done on Wilson Creek and its tributaries. In the spring of 1916 a small dump was taken out on Elephant Creek, and early in the summer considerable ground was worked at the mouth of Disappointment Creek. At the time of the writer's visit, about the middle of August, there was no one working in the Wilson Creek basin.

Mining had been done by underground methods on claim "No. 5 above" on Elephant Creek, although the ground is comparatively shallow. It is understood that an hydraulic installation is to be made, the water to be obtained from the headwaters of this stream. The ground on claims above and below No. 5 will be stripped and mined by hydraulic methods.

The workings on Wilson and Disappointment creeks have been confined to about two claims at the mouth of the latter, over a maximum width of about 300 feet. The gravels containing gold in quantities sufficient to justify mining appear to have been irregularly distributed, as work was done at several spots separated from one another by unworked ground. Open-cut methods had been employed. The deposits are shallow, apparently not over 10 or 12 feet deep to bedrock. The upper 2 to 3 feet of this material is composed of soil and vegetable matter and, with some of the underlying gravel, was stripped off by ground sluicing. The lower stratum of gravel containing the gold was shoveled into sluice boxes. It is said that holes sunk at the mouth of Disappointment Creek failed to reach bedrock at a depth of 35 feet. They were then abandoned on account of water coming in. No mining has been done in the deeper gravels of the main stream.

The principal mineral found in the concentrates is hematite, probably coming from what is believed to be the weathered outcrop of a pyritized sedimentary bed farther up the creek. In addition to the hematite there is a small amount of magnetite, which occurs in characteristic octahedra.

The bedrock is sedimentary in origin. It was not seen in the creek bed, but slate and conglomerate, together with fine grit, appear along the south bank of Wilson Creek just above Disappointment Creek, and these rocks, together with some dark-gray chert, make up most of the gravels. Some pebbles are derived from dikes that cut the sedimentary rocks and from the igneous rocks at the head of the creek. The gravels are mostly small and well-rounded pebbles, 8 inches being about the average diameter of the largest cobbles seen.

The finer material of the gravels is partly ferruginous, and, although it disintegrates readily in the sluice boxes, on exposure to the air it hardens and cements the larger pebbles into a conglomerate.

WILLOW CREEK.

Willow Creek heads against Disappointment Creek, and the divide rises 700 or 800 feet above the claims on which most of the mining has been done. Mining has been confined to the west fork of the creek and to the claims from No. 2 below to No. 5 above Discovery; the latter claim covers some ground on the western one of the small forks near the head of this stream. Some prospecting has been done on No. 6 above and on other claims below No. 2 below Discovery, but at the time of visit development had not progressed sufficiently to warrant the undertaking of mining operations.

Two small plants were operating on "No. 5 above," shoveling into sluice boxes. Prospecting was being done on Nos. 3 and 4 above Discovery, and it appears probable that some mining will be done on these claims in 1917. Power plants were working on "No. 2 above," the upper half of "No. 1 above," and the upper half of Discovery claim. On Nos. 1 and 2 above Discovery the auriferous gravel is wheeled in barrows to a bucket and then hoisted to the lines of sluice boxes, which have been placed on the side of the hill. A portion of the stripping is done in the same way, but some of the overburden is removed by sluicing.

The plant operating on the upper half of Discovery claim will also work the lower half of "No. 1 above." As these claims lie below the steep-walled portion of the valley, the line of sluice boxes is mounted on trestles to get the necessary grade and dump room for tailings. A novel feature at this property is that both stripping and hoisting are done by a slack-line scraper, a modification of the drag-line scraper used in other Alaska mining districts. The bucket has a capacity of 1½ cubic yards. On account of the large size and angularity of the boulders and the extremely uneven and blocky character of the bedrock, some difficulties have been experienced with this equipment. It appears likely that the bedrock will have to be cleaned by hand, as it is on other properties. The conditions of operation on Willow Creek for a scraper of this type are probably as difficult as will be found anywhere else, and its successful operation here would merit an investigation into the possibilities of its economical use at other Alaskan camps. On Disappointment Creek the rounded and smaller gravels appear to offer more favorable conditions for such an installation than are afforded by any of the placer ground on Willow Creek.

During 1915 the most extensive mining operations on this creek were on the lower half of Discovery claim. Operations were continued in 1916, and one shift of men was employed shoveling into the sluice boxes. The sluice-box arrangement differs from that on other properties, and a greater effort is made to save the fine gold. The upper four boxes, into which the gravel is shoveled, have false bottoms, in which are 2-inch holes spaced 4 to 6 inches on centers. Below these in the line is a box containing Hungarian riffles, with a 6-inch drop to a mud box. The mud box, like the three sluice boxes that follow it, has pole riffles of the usual type. At the other properties on the creek all the sluice boxes carry pole riffles, made either of local spruce poles or, when it is obtainable, of sawed 2 by 2 inch lumber. The sawed riffles are generally faced with 2-inch strap iron.

Mining was done on the upper end of the Bumblebee claim early in the summer, and a small area of ground was worked out. Operations were then shifted to the claim below, and preparations were made for more extensive mining. A sluiceway had been excavated 8 or 10 feet to bedrock, and boxes were being put in on August 27, when the writer left the creek. The contemplated operations include the sluicing of both the overburden and the auriferous gravels from "No. 2 below" through this line of boxes.

On account of the small drainage basin of the creek, the water supply for the claims lying above Discovery is likely to be somewhat scanty unless there are frequent rains. By the time it reaches Discovery claim even this scanty supply has been somewhat lessened. The operators on Discovery claim have diverted the water from the East Fork of Willow Creek and so increased the amount available for this claim and those below it. A ditch from Slope Creek was constructed late in the summer to furnish an additional supply for the mining operations on "No. 2 below."

About even with Discovery claim there is a distinct change in the topography, the front of the range of hills occurring at about this point. Below Discovery claim a wide, coalescing apron slopes gently down to Spruce Creek and the Yukon. Above this break Willow Creek has a V-shaped valley with rather steeply sloping walls; below it the stream has intrenched itself but little in the frontal apron and flows across it at a gradient lower than where it is confined within the valley. There appears to be a suggestion of a beach line between altitudes of 500 and 600 feet, but little evidence has been found at this locality to confirm the suggestion. The widening and somewhat irregular distribution of the auriferous gravels below Discovery claim may be due in part to beach concentration and in part to the changing of the channel of the stream before it had become intrenched in its present course.

The depth to bedrock ranges from about 6 to 16 feet. On "No. 1 above" it is from 12 to 16 feet. The upper half consists of soil and angular rock fragments with comparatively little rounded gravel. This is stripped off before the lower layers are mined. Gold is found both above and below a clay seam lying about 2 feet from bedrock, some of the coarsest gold being found above it. The bedrock is extremely rough and blocky and just above it there are a considerable number of large angular boulders. Part of these are talus boulders from the valley slopes, and part represent frost-heaved material from the greenstone bedrock. On the lower claims there appear to be more rounded gravels, but the bedrock is similar in character to that on the upper portion of the creek.

The gold is somewhat rough, and some of it appears rather porous. Over half of it is too coarse to pass through an 8-mesh screen. Nuggets valued at $5 to $10 are not uncommon in the clean-ups, but those worth over $20 are few. The very fine gold saved constitutes only a very small percentage of the clean-ups. It is believed that the installation of devices for saving the fine gold would be warranted, as some of the fine gold already saved is flaky and light and it is quite possible that a greater proportion of this light gold goes through the boxes than is saved in them. Few assays of the Willow Creek gold are available. One of these is said to have given a value of $18.30 an ounce. The gold passes current at $17 an ounce.

Magnetite is one of the most common minerals associated with the gold in the clean-ups. Ilmenite occurs in small amounts. Although pyrite may be seen occasionally in the greenstone near the head of the creek, little or none is found in the concentrates, oxidation having converted it to hematite.

GOLD LODES.

Since the development of the placers in the vicinity of Marshall the hills have been prospected to find the lodes from which the placer gold has been derived. A number of lode claims have been staked in the Kuyukutuk basin, on the north side of the ridge extending eastward from Pilcher Mountain. Little development work is reported as having been done on these claims, and they were not visited. Free-milling gold is reported from quartz veins near the head of Edgar Creek, and claims have been staked there. A number of quartz veins were seen along the crest of the divide between Wilson and Spruce creeks. Claims have been staked to cover most of these veins, but no evidence was seen of work having been done upon any of them except on the east side of Willow Creek near its head.

The group of claims known as the Arnold lode was staked August 8, 1914, by Tom Plunkett. The development work consists entirely

of open cuts made with a view to determining the size and continuity of the veins, of which a number are exposed. One of the lower veins has been traced along its strike for over 100 feet by a series of trenches 2 to 6 feet deep, through the talus and slide of the hillside. The vein is from 6 inches to a foot in width. It shows free gold in places. Farther up on the slope a cut has been dug about 30 feet into the hill, so that a face 12 or 15 feet in height and 3 to 6 feet in width is exposed. In this face is shown a quartz vein whose width ranges from 4 to 8 inches. The minerals in the vein include calcite, pyrite, galena, molybdenite, and free gold. In places the pyrite is oxidized, and the quartz is stained with iron oxides. There are numerous cavities formed by the removal of pyrite and calcite. In some of these cavities small crystals of glassy quartz may be seen, together with scattered rosettes of calcite crystals. Some of the dirt from the bottom of the open cut was panned. In addition to the vein minerals mentioned above the concentrates from panning included small amounts of wulfenite, the yellow to orange-colored molybdate of lead, and anglesite, the white sulphate of lead. Magnetite and the oxides derived from the alteration of iron pryrite are also present in considerable amounts. Their source is the greenstone country rock, the hanging wall in places showing strong pyritization. Veins near by show a small amount of chalcopyrite accompanied by the characteristic green stain produced by its oxidation.

COAL.

The presence of coal on Anvik River has long been known and is mentioned by Collier.[1] The coal seems to have been used to a slight extent by the natives, who formerly employed it in the manufacture of a black pigment. A small amount has also been used for blacksmith coal at Anvik, but so far as known no other utilization has been attempted.

The following information regarding these deposits was obtained from Mr. F. H. Kruger, a merchant and prospector at Anvik. The coal seams crop out about 45 miles above the mouth of Yellow River, or over 100 miles by water from the Yukon. The air-line distance to the nearest point on the Yukon is probably about 25 or 30 miles. Anvik River cuts diagonally across the sedimentary series, which is made up of sandstone, shale, and coal beds. These beds appear for a distance of about 5 miles along the course of the stream. Both up and down stream from the sedimentary series are rocks of igneous origin. Within the series coal seams appear for nearly a mile along the river. Most of the outcrops are on the east bank. One seam has a thickness of about 10 feet and several are 2 feet thick.

[1] Collier, A. J., The coal resources of the Yukon, Alaska: U. S. Geol. Survey Bull. 218, p. 58, 1903.

Transportation to the Yukon would entail a high expense, as only small poling boats could be used except at high stages, when small scows and power boats might be utilized. Transportation overland would prove feasible only if the local market were sufficient to warrant the construction of a road, after exploration and development work had proved the extent and quality of the coal.

Coal seams of varying thicknesses will doubtless be found elsewhere in the areas of Cretaceous rocks. Many fragments of weathered coal were found in the high gravel bank on the east side of Stuyahok River, about 45 miles from its mouth. It is likely that these fragments have not been carried for any great distance and that careful prospecting would reveal the seams from which they were derived. Like those on the Anvik, these beds when found would probably be of local value only, unless they were of considerable extent and of such a quality as would permit them to compete with other fuels.

At Marshall it was learned that coal occurs on one of the creeks that flows into a slough of the Yukon, about 20 miles above Marshall. No other information concerning this deposit was obtainable.

A narrow band of bituminous shale in the vicinity of the old fort at Andreafski is mentioned by Dall.[1] The Russians attempted to utilize this shale for fuel, but it was too impure to burn well, and the attempt was abandoned. This locality is a few miles down the Yukon from the mouth of Andreafski River, where field work was terminated in 1916, and it was not visited by the writer.

MINERAL SPRINGS.

About 7 miles east of Marshall and half a mile from the Willow Creek landing are what are known locally as the Soda Springs. Analyses show that the mineral content of the waters from these springs is largely iron and lime carbonates. Free carbon dioxide is constantly being liberated and bubbles up intermittently in almost all the pools and springs of this group. Some have built up considerable cones, 4 to 6 feet high and 10 to 20 feet in diameter at the base. The material in these cones consists of lime carbonate and yellow and red iron oxides. At the northern edge of the group is an extensive area covered with granular precipitated oxides of iron, with some lime carbonate, which is rather loose and incoherent, much resembling gas-house cinders. It has been built up sufficiently to afford a solid footing, in contrast with the soft, spongy moss-covered areas adjoining. Very little vegetation grows on the sinter.

Between the main group of springs and the landing are a number of pools of water which in part may represent the overflow from

[1] Dall, W. H., and Harris, G. D., Correlation papers, Neocene: U. S. Geol. Survey Bull. 84, p. 247, 1892.

the springs above and in part may be the basins of springs of a comparatively small flow. The deposits in the vicinity of these pools are chiefly lime carbonate and are conspicuous for their white color and scanty growth of vegetation.

The springs are at the base of the south frontal slope of the range of hills between Spruce and Wilson creeks. A mantle of vegetation and unconsolidated material so completely covers the surface that it is impossible to determine the nature of the underlying bedrock. It appears likely that the springs occur near the contact of the Quaternary lavas and the undifferentiated metamorphic rocks which make up the ridge to the north. Other springs of essentially similar character are reported as occurring about 12 miles to the east, where the topographic situation and geologic conditions are much the same as at this locality.

ANTIMONY.

No deposits of antimony are known within the areas visited, but at Paimiut it was reported that antimony occurs in the group of hills between the Yukon and the Kuskokwim, near the latter.

MINERALIZATION.

Data regarding the mineralization in this region are not sufficiently complete to warrant positive statements regarding the source of the gold, but some inferences concerning it can be drawn. Wherever gold has been found there are also dikes of soda granite or porphyritic dacite, many of them of considerable width, and it is believed that the mineralization was consequent upon their intrusion of both the sedimentary and igneous rocks. The dacite is similar in chemical composition to the soda granite and differs only in possessing a somewhat finer groundmass and a porphyritic texture. It represents offshoots from the larger igneous masses or was derived from the same sodic granite magma. Both the larger granite masses and the dacite dikes appear to have been concerned in the mineralization. The quartz veining that followed was related to the intrusives, and much of the gold occurs in the vein quartz, but impregnation of the wall rock has also taken place. Besides the gold, the sulphides of iron, lead, molybdenum, and copper occur in the veins and mineralized wall rock. These minerals have not been found in the soda granite or dacite but doubtless were due to their intrusion.

SUGGESTIONS FOR PROSPECTING.

As the mineralization was attendant upon the soda granite and the porphyritic dacite, it follows that streams coming from areas where these rocks appear afford the most attractive field for pros-

pecting. Rock exposures are few but may usually be found along the crests of the ridges or here and there along minor streams, but the nature of the gravel along bars will afford an equally reliable indication of the nature of the rocks farther upstream. Vein quartz or pebbles of light-colored granitic or porphyritic igneous rock should be noted. These are not necessarily accompanied by gold, but on the other hand all the gold that has been found in this region occurs under conditions which indicate its relation to these intrusives.

Along the upper courses of the streams the valleys are for the most part comparatively narrow and the depth to bedrock slight, making crosscutting of the channel fairly easy. In the lower reaches, however, the width is greater, in places being several miles, and the valley fill is of unknown depth. Moreover the streams may have shifted their courses since placers were possibly concentrated. It appears, therefore, that the prospecting of these broad deposits would be both difficult and uncertain of profitable results.

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