Professional Paper No. 2

Series { A, Economic Geology, 19
B, Descriptive Geology, 21

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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A RECONNAISSANCE OF THE NORTHWESTERN PORTION OF SEWARD PENINSULA, ALASKA

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

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ILLUSTRATTONS.

A RECONNAISSANCE OF THE NORTHWESTERN PORTION OF SEWARD PENINSULA, ALASKA.

By ARTHUR J. COLLIER.

INTRODUCTION.

In response to an urgent demand by the public, the Geological Survey, in 1900, undertook a topographic and geologic reconnaissance of the southern half of the Seward Peninsula.[a] The area mapped embraced the more important gold fields of the peninsula. The topographic map made in 1900 included the drainage of Bering Sea from Cape Darby to Port Clarence, the southern drainage of Grantley Harbor and Imuruk Basin, and the northern drainage of Norton Sound. A geologic reconnaissance was also made of the York mining district and of part of the Kuzitrin drainage.

In view of the northern extension of these gold fields it was deemed desirable that the northern part of the peninsula should be investigated, and a party was organized for this purpose in 1901. This party, to which the writer was detailed as geologist, was placed under the leadership of Mr. T. G. Gerdine, topographer; Mr. D. C. Witherspoon acted as assistant topographer, and Ed. Brown, Robert Baskins, Samuel Conrad, J. G. De Forest, and E. Goodall were engaged as camp hands. Twelve horses were provided for the transportation of the camp outfit in the field. It was thought that a party thus organized and equipped would be able to cover a larger area than any one party of the previous season, when canoes and men were used for transportation. This expectation was realized, although a backward and unusually stormy season made the work difficult and prevented the accomplishment of the entire plan,[b] which contemplated the completion of the survey of the peninsula.

[a] See Preliminary Report on the Cape Nome Gold Region. Alaska, by F. C. Schrader and Alfred H. Brooks; U. S. Geol. Survey, 1900. Also Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, by Alfred H. Brooks, George B. Richardson, Arthur J. Collier, and Walter C. Mendenhall; U. S. Geol. Survey, 1901.

[b] The average temperature as observed in 1901 was 44° in July, 43¼° in August, and 40° in September. The mean temperature at Port Clarence, as obtained from observations covering four years, is 51° for Jnly, 49° for August, 41° for September. The number of rainy days in July, August, and September, 1901, as observed by the United States Geological Survey party, was 36. The mean number of rainy days at Port Clarence for these months is 29. Cf. "Climatic notes" in Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900.

The party assembled in Seattle and on May 30 embarked on the steamship *Senator,* bound for Nome and Port Clarence. On June 9 the Aleutian Islands were passed, and about midnight of that day floe ice was encountered in Bering Sea. Several attempts were made to navigate through the ice, but it was found impossible, and for six days the ship lay to in the vicinity of St. Paul Island surrounded by the ice pack.

The ship finally dropped anchor at Nome on June 16. It was the first of the fleet of large steamers to arrive, and it was almost immediately surrounded by a multitude of small boats from the shore, crowded with men who had spent the long winter in the Arctic region and were anxious to greet the new arrivals from the outside world. The winter of 1900–01 had been an unusually severe one, and had begun to break only a few days before our arrival. There were still snow drifts in the streets of Nome and blocks of ice along the shore, while the hills back of the town were yet white with snow. As Port Clarence was still frozen in, the steamer could not make a landing there, and as it was impossible to travel overland with horses, owing to the ice in the creek beds and to the absence of grass or other forage, it was decided to land the outfit at Nome, which was accomplished on June 20.

Five days later the party started from Nome for Port Clarence; two men went by land with the horses and the remainder in a whaleboat with most of the supplies. Stormy weather delayed the boat, so that the entire party was not assembed in Teller until July 12. At this point work was begun. The signals erected the year before by the Coast and Geodetic Survey were repaired and used as a base for the control of the topographic work. The party left Teller on July 14 and moved westward along the coast toward Cape York. Progress was slow, owing to rainy and foggy weather, which greatly interfered with the work of both the topographers and the geologist, and to the necessity of carrying a supply of grain for the horses, the grass being very poor. A week later the larger section of the party had to be sent back from the forks of the Don River for more horse feed. The remainder spent the time in exploring and mapping the southern face of the York Mountains and the head of the Don River.

On July 24 Mr. Gerdine, Mr. Witherspoon, and the writer, with two men arid a light camp outfit carried on three horses, left the main party, which was instructed to move northward by double-tripping with the heavier part of the supplies, and proceeded around the north side of the York Mountains to the head of the Anikovik River in the York mining district. From this point Mr. Gerdine went northward to the main camp near the forks of the Mint River, while Mr. Witherspoon and the writer spent several days in mapping the western border of the York Mountains. During the season of 1900 Mr. Alfred H. Brooks had spent a few days in this region,

GEOLOGICAL RECONNAISSANCE MAP AND SECTION OF THE NORTHWESTERN PORTION OF SEWARD PENINSULA ALASKA

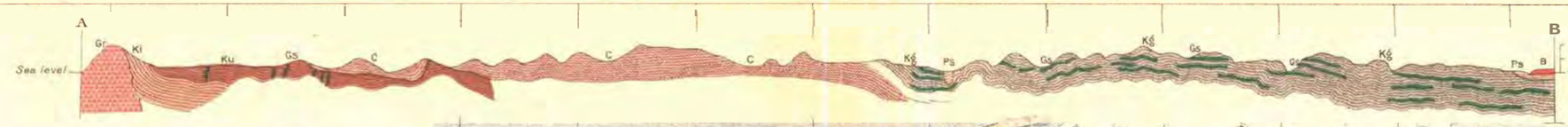
Geology by Arthur J. Collier

Scale

4 3 2 1 0 4 8 12 16 20 miles

Contour interval 200 feet

Datum is mean sea level



LEGEND

SEDIMENTARY

PLEISTOCENE

Silts, sands, and gravels

UPPER PALEOZOIC

Kuguruk Group
Shists, limestones and intruded greenstones

LOWER SILURIAN

Port Clarence limestone

OLDER THAN SILURIAN

Kuzitrin series

Kigluaik series

IGNEOUS

Basalts and lavas

Intrusive granite

Intrusive greenstone

T. G. Gerdine, Topographer in charge
Triangulation by United States Coast and Geodetic Survey and R. H. Robertson
Shore line of Port Clarence, Grantley Harbor and Imuruk Basin by United States Coast and Geodetic Survey
Topography by T. G. Gerdine, D. C. Witherspoon, and A. H. Brooks
Surveyed in 1901.

JULIUS BIEN & CO. LITH. N.Y.

OUTLINE MAP OF SEWAKD PENINSULA

SHOWING AREA OF LARGER SCALE MAPS

Scale

60 0 60 MILES

and had discovered stream tin in the placers on the Anikovik River.[a] The geologic work at York was, therefore, largely directed to an effort to locate the source of the tin.

In the York region generally fuel, consisting of small green willows, often not over half an inch in diameter, was found to be very scarce. As the weather was often rainy and foggy, the conditions of camp life were far from pleasant.

The entire party were reunited on the Nuluk River on August 3. Messrs. Witherspoon and Goodall, with two horses, were then detailed to traverse the north coast of the peninsula, while Messrs. Gerdine, De Forest, and the writer, with three horses, made a trip to the head of the river. During this time the remainder of the party moved the heavier part of the supplies to the base of Ear Mountain. On August 16 the party was again reunited in a camp on a tributary of the Kugruk River near the base of Ear Mountain. Here it was detained several days by severe, stormy weather, and the provisions having run short, they were replenished from the stores of some prospectors on Tuttle Creek who were leaving the district. Grass for the horses was abundant and of good quality, and the unfavorable weather gave them a much needed rest. On August 20 the heavy fog which had hung over Ear Mountain lifted, and the day was spent on its summit. This mountain rises abruptly 2,000 feet above the plateau on which it stands. Near its summit are two large pinnacles of granite which from a distance resemble the ears of some great animal whose head is hidden behind the hill. The mountain was first located and named "Ears" on a chart made by Captain Beechey in 1826. The Eskimos know it by the name "Enigarok," which translated into English is said to mean ears, so that it is probable that this same name has been applied to this mountain since it was first known to man. Ear Mountain occupies a commanding position, and from its summit, below the low-hanging clouds, sights were taken to the Siberian coast, Diomede Island, Cape Mountain, Mukacharni Mountain, Midnight Mountain, Devil Mountain, and Shishmaref Inlet, besides numerous minor points.

From Ear Mountain the party moved as rapidly as possible southeastward, crossing the headwaters of the several rivers and creeks which together make up the American River, as the left fork of the Agiapuk River is called, and also crossing the Mary River about 10 miles above its mouth. The weather during this trip was more favorable than it had been earlier in the season. On the morning of August 22, however, while in camp on Igloo Creek, an inch of snow fell, and several days were lost because of bad weather. When approaching Marys Igloo, which lies in a bend of the Kuzitrin River, well down in the Kuzitrin Flats, a short cut was made across the tundra. In places it was so marshy that the horses would have been lost but for the solid ice which was found to underlie the moss at a depth of about 2½

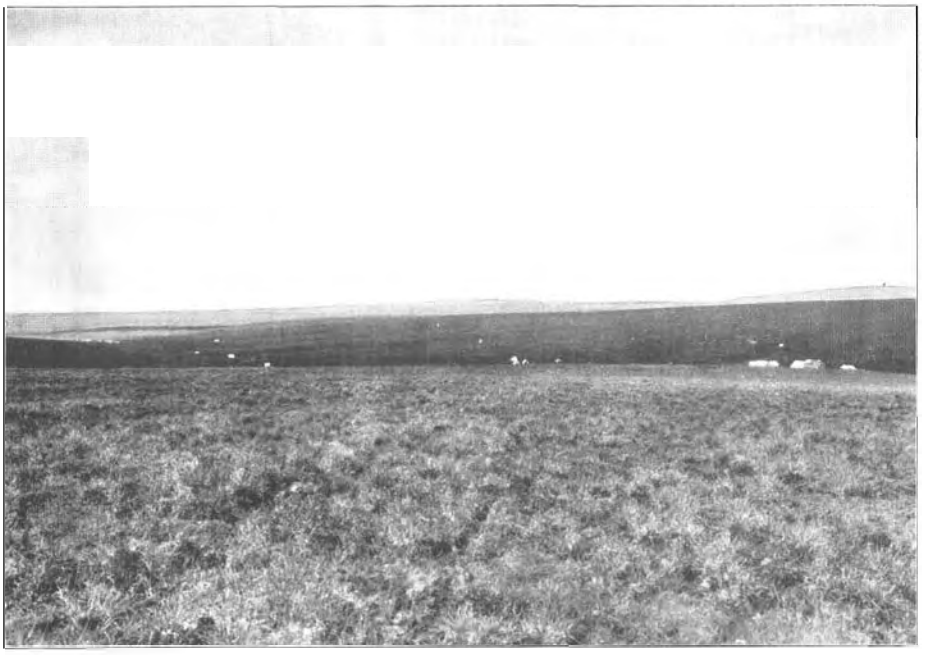
[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 136.

feet. Marys Igloo was reached on September 3. This place, the former winter home of a well-known Eskimo woman, is at the head of steamboat navigation on the Kuzitrin River, and has within a year or two become a settlement of some importance. Here the stock of provisions was replenished from supplies shipped to this point from Nome and kept in storage by Mr. A. D. Nash, who was doing a general freighting business on the Kuzitrin River. The horses here rapidly recuperated from the privations of the long trip, as forage was abundant. At Marys Igloo the party was again divided, Mr. Witherspoon with two men going westward to map the lower basin of the Agiapuk and to return to Nome by way of Teller and the beach, while the remainder of the party made a hasty trip northward.

Mr. Witherspoon's party successfully crossed the Agiapuk River at a point where its broad alluvial basin narrowed down between low bluffs, examined the mines on Allene Creek, and arrived at Nome about September 23, having accomplished its task.

The remainder of the party proceeded up the Kuzitrin River to Lanes Landing, where there is a small settlement, and thence took the wagon road to Quartz Creek. Near this point a halt of two days was made to examine the placers in the vicinity and to occupy Coffee Dome, a low mountain which is one of the prominent landmarks of the Kugruk district. Thence the party proceeded northward to the junction of Windy Creek with the Kugruk River and up the Kugruk River to the mouth of Taylor Creek, making a side trip to the summit of Baldy Mountain. On September 14 camp was made about 3 miles from Midnight Mountain on Schlitz Creek, tributary to Shishmaref Inlet. Here, during a halt of two days, the writer, with Mr. De Forest, visited the hot springs, about 7 miles to the north; and Mr. Gerdine occupied Midnight Mountain, which commands a view of the whole northern coast of the peninsula from Ear Mountain to Goodhope Bay. On September 17 the party proceeded southward by a long march to the North Fork of the Kugruk, crossing Taylor and Harris creeks. Here a halt of one day was made while the writer visited the mines on Boulder Creek, about 8 miles to the south. On September 19 the camp outfit was sent by way of Baldy Mountain and Dahl Creek to Lanes Landing. The plan was for Mr. Gerdine and the writer to secure some kind of transportation down the Noxapaga and Kuzitrin rivers, and thus to complete the mapping of those rivers, and then to rejoin the party at Lanes Landing. After a delay of three days at Noxapaga, during which time hasty trips were made to Garfield Creek and to the edge of some lava beds on the Kuzitrin, transportation was secured down the river through the courtesy of Mr. A. D. Nash, and during the journey the numerous bends were mapped. On September 23, at 11 p. m., Lanes Landing was reached, over 100 miles by river having been traversed to gain an air-line distance of about 25 miles. Here the rest

A. TELLER, FROM POINT OF SAND SPIT.



B. VALLEY OF QUARTZ CREEK CUT IN HIGH GRAVEL BENCH

of our party was found; and, since the season was nearly spent and the hard frosts occurring nearly every night were rapidly destroying the grass, it was decided to return to the coast. After a halt of one day to readjust the loads and to dispose of all surplus weight, the start southward was made on September 25. The route lay by way of the Kruzgamepa River, Salmon Lake, and the Nome-Snake divide to Nome. This journey took five days, three of which mere pleasant, but during two days rain and snow fell in torrents, and was accompanied by strong winds.

Nome was reached on September 30. There Mr. Witherspoon and the parties of Peters and Mendenhall, which had arrived from the north a few days before, were found. On October 6 all these parties embarked on the steamship *St. Paul* for Seattle, which was reached October 17 after a pleasant voyage.

A distance of about 700 miles was traversed by the party between July 14 and September 26. Data had been secured for topographic. geologic, and economic reconnaissance maps covering an area of nearly 5,000 square miles. Triangulation was carried eastward from Port Clarence to Mount Bendeleben, which proved the accuracy of the work done by Messrs. Rarnard, Hefty, and Reaburn of the United States Geological Survey during the previous tield season.

GEOGRAPHY.

General outline.—Seward Peninsula is an irregular land mass, comprising approximately 20,000 square miles, and extending from the western coast of Alaska westward to within 60 miles of the Asiatic coast, from which it is separated by Bering Strait. It separates Bering Sea from the Arctic Ocean, and is itself cut off from the mass of the continent on the south by Norton Bay, a deep indentation of Bering Sea, and on the north by Kotzehue Sound, an inlet from the Arctic Ocean. A mountain axis, represented in the Kigluaik and Bendeleben ranges, divides the peninsula naturally into a southern and a northern part. This axis has an area of depression, partly occupied by the sea, on its northern side. The southern part of the peninsula was investigated by the United State.: Geological Survey in the season of 1900, and is the subject of a report entitled Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900. The present report deals with the northwestern part of the peninsula, comprising an area of approximately 5,000 square miles lying west of the one hundred and sixty-fourth meridian and north of Port Clarence and Imuruk Bay.

Shore line.—Along the southern edge of this area the series'of bays and sounds known as Port Clarence, Grantley Harbor, Tuksuk Channel, and Imuruk Basin form an inland extension of the sea. In its eastern half the southern shore line is characterized by broad, low, coastal plains, often fringed with lagoons shut in by wave-built beaches, but where it is open to Bering Sea, from the entrance

to Port Clarence northwestward to Cape Prince of Wales, the coast line is marked by sea cliffs and generally more abrupt relief. Where coastal plains or lagoons exist they are of limited extent. In the vicinity of Cape York the sea cliffs, rising in some instances to an elevation of 600 feet, extend for a distance of about 15 miles, making navigation dangerous for small boats, since no landings can be made. On the southern side of Cape Mountain the cliffs rise 100 feet or more, while above them Cape Mountain attains an elevation of 2,500 feet. Northeastward from Cape Prince of Wales the coast line is marked by barrier beaches which protect the mainland from the force of the waves. Back of this barrier there are large lagoons. Prom Cape Prince of Wales eastward the outer coast line forms a series of broad, concave curves, a tangent to which would fall into an almost straight line extending from Cape Prince of Wales to an unnamed cape 20 miles west of Cape Espenberg, the most northerly point on the peninsula. Along this stretch where the inner or mainland coast line, as represented by the shores of the lagoons, is very irregular, there are evidences that the land has recently been elevated.

Harbors.—The coast line of Seward Peninsula affords but few sheltered anchorages. Port Clarence is a deep indentation of the coast line, which is in part cut off from the open sea by a long sand spit. It is connected with Grantley Harbor, an almost landlocked bay, by a channel 12 or 14 feet deep. The town of Teller is located on a sand spit which separates the two bodies of water.

Imuruk Basin is an arm of the sea which is connected by a narrow inlet, named Tuksuk Channel, with Grantley Harbor. This channel is used by river steamers which are bound for the Kugruk gold field. Imuruk Basin is bounded on the south by the rugged Kigluaik Range, and is a very treacherous body of water. The north side of the basin is shallow, but on the south side it has considerable depth.

At the entrance to Shishmaref Inlet, Kotzebue in 1816 reported 8 fathoms of water, and C. W. Mashburn, deputy recorder of the district, reports that small coasting vessels can find sufficient depth of water and good harbor facilities behind Sarichef Island. Shishmaref post-office and the recording office of Goodhope district are located on this island. Prom this point supplies can be easily transported in row boats or small steamers to within a few miles of the mines about the head of the Kugruk and Serpentine rivers. The inlet is practically filled with mud flats, through which the stream channels have very sinuous courses, making navigation difficult.

Goodhope Bay and Kotzebue Sound are large inlets containing much shallow water. They afford safe anchorage and good harbor facilities, protected from all winds except the northwest. At the eastern end of Kotzebue Sound a safe

anchorage, protected from practically all winds, is found near Chamisso Island. The town of Deering, the principal supply point of the mines of this region, is located on Kotzebue Sound at the mouth of the Imnuchuk River.

Drainage.—The watershed of the northwestern part of the Seward Peninsula lies close to the Arctic coast, and the major part of the drainage is carried southward through rivers which flow into Port Clarence and its connecting bodies of water, or into Bering Sea.

The Kuzitrin and Agiapuk are the largest rivers within the region under discussion. Their northern tributaries head within a few miles of the inlets from the Arctic Ocean on the north, and they flow southward and, approaching the highest mountain mass of the peninsula, find outlet to the sea through Imuruk Basin. Their valleys are broad and gravel floored.

A number of small rivers, none over 20 miles in length, empty into Bering Sea and Port Clarence. These are the California, Don, Lost Rapid, Kanauguk, and Anikovik. These rivers generally occupy comparatively narrow valleys, cut in the upland that borders the coast.

A number of large rivers which cross the coastal plain in tortuous channels flow into the lagoons which characterize the coast of the Arctic Ocean. The more important are the Mint, the Pinguk, the Nuluk, and the Kugruk.[a] A number of small streams empty into Shishmaref Inlet, the largest of which is called the Serpentine Biver, so named from the tortuous character of its lower course. Little is known of the drainage of the peninsula between Shishmaref Inlet and Goodhope Bay. This region was only seen from a distance by our party, and but little could be determined in regard to its detail. The Goodhope, Kugruk, Kiwalik, and Buckland rivers, flowing into Goodhope Bay, are good-sized streams. They lie beyond the area covered by the topographers in surveys, and their courses indicated on the maps are only approximately correct. All of the rivers noted are navigable to some extent for small boats. Extensive freighting is done with large flat-bottomed boats along the Kuzitrin and Noxapaga for about 100 miles of their courses. The Kuzitrin is ascended hy steamers to Marys Igloo. Some of the rivers flowing into the northern lagoons and into Shishmaref Inlet are reported to be navigable for small steamers near their mouths.

Relief.—The highest mountains of the peninsula. rising to an elevation of 4,700 feet, are the Kigluaik, lying immediately south of Imuruk Basin. This system is extended to the east and southeast by the Bendeleben and Darby mountains, of lesser altitude. North of these mountains the topography is characterized by hroad lowland plains which surround a central upland mass. The lowlands occur both

[a] There are three rivers of this name in Seward Peninsula. They flow into the Arctic Ocean, Goodhope Bay, and the Kuzitrin River.

as coastal plains and as inland basins, and are built up from gravels derived from the upland portion.

The central upland portion is characterized by broad benches and flat-topped hills, representing remnants of uplifted and dissected plains. The maximum elevation in the northern portion of the peninsula is found in Brooks Mountain at 2,900 feet.

These features will be further discussed under physiography. Some small mountain masses and isolated buttes, with relief of from 500 to 1,500 feet, are scattered over the upland plateaus with no definite system of arrangement. In most instances these represent harder members of the bed rock, which have resisted erosion. The York Mountains, covering an area of about 100 square miles, are a rugged mountain mass, attaining at their highest point, in Brooks Mountain, an elevation of 2,900 feet; while the buttes are represented by Mukacharni, Cape Mountain, Cone Hill, Ear Mountain, Midnight Mountain, and others, all of which will be considered in more detail in other parts of this report.

Between the drainage basins of the Agiapuk and Kugruk rivers a series of high hills and ridges bearing in a north-south direction culminates in Kugruk Mountain, which has an elevation of 2,767 feet.

GENERAL GEOLOGY.

OUTLINE.

The areal distribution of the various formations and their stratigraphic relations are indicated on the accompanying geologic map and section (Pl. III). As the inap embraces an area of nearly 4,000 square miles, and as only seventy days were spent in the field work, and most of these were stormy, the conclusions reached must be regarded as only tentative and the boundaries indicated as only approximate. The scarcity of outcrops in some parts of the region added to the difficulties of the work. The classification of the stratigraphic succession in general is the same as that adopted by Mr. Brooks[a] in 1900. It has been possible, however, because of the additional stratigraphic and paleontologic evidence obtained, to subdivide the terranes which were grouped together by Brooks under the name Nome series. The following table shows the stratigraphic equivalents of the various subdivisions made by Brooks, Mendenhall,[b] and the writer:

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[a] Reconnaissances in Cape Nome and Norton Bay Regions, Alaska, in 1900, pp. 27-31.
[b] Idem, pp. 27-31, 199-207.

Correlation of geologic formations in Seward Peninsula.

Collier, northwest portion, 1901.		Brooks, southern portion, 1900.		Mendenhall, eastern portion, 1900.	
Pleistocene.	Sands and gravels.	Pleistocene.	Sands and gravels.	Pleistocene.	Muds, sands, and gravels.
				Tertiary?	Unaltered sediments.
Upper Silurian.	Kugruk group.	Mesozoic and Paleozoic.	Nome series.	Mesozoic and older.	Metamorphic series.
Lower Silurian.	Port Clarence limestone.				
Older than Silurian.	Kuzitrin series.	Paleozoic and older.	Kuzitrin series.		
	Kigluaik series.		Kigluaik series.		

The above table shows that four subdivisions have been made of the sedimentary bed rocks of the northern portion of the Seward Peninsula. The Kigluaik series is the oldest, and is made up of white crystalline limestones and mica-schists. Succeeding this, apparently conformably, is the Kuzitrin series, made up of arenaceous and argillaceous sediments. These two series are identical with those described by Brooks. The Kuzitrin series is overlain by the Nome series, probably unconformably, as suggested by Brooks. The Nome series has been here subdivided into two conformable groups, the lower named the Port Clarence

limestone and the upper called the Kugruk group. The Port Clarence limestone, which is blue and almost unaltered, was found to contain Lower Silurian fossils. The Kugruk group is made up of limestones and calcareous beds, with some argillites, which are locally considerably altered. The unconsolidated sediments which have been assigned to the Pleistocene include sands, gravels. and alluvium, and need no special mention here.

Three classes of igneous rocks have been recognized in the region and indicated on the map. The oldest are intrusives of various types, which are usually schistose, and these have been grouped together under the field term greenstone. The granites form a second group, and probably represent Mesozoic intrusions. These two classes were recognized by Brooks, but the third, which comprises Pleistocene lavas, was not represented in the region mapped in 1901.

In the northern part of the peninsula the earliest crustal movements produced a series of folds whose axes run approximately north 'and south. This deformation probably took place in Paleozoic times, and was accompanied by extensive intrusions of greenstone. A later period of disturbance, probably during the Mesozoic, produced folds whose axes are transverse to the earlier system. This was accompanied by the intrusion of some large masses of granite.

STRATIGRAPHIC SUCCESSION.

KIOLUAIK SERIES.

The Kigluaik series was named and described in the report cited, and the investigations made by the writer have not added much information concerning it. Its type section is in the Kigluaik Mountains, where it consist's of white crystalline limestones with some interbedded mica-schists. This series occupies a considerable belt in the southeastern part of the area under consideration, where it, together with the associated granite, forms the main mass of the Bendeleben Mountains. On the eastern flank of Cape Mountain, near Cape Prince of Wales, it is again exposed by the erosion of an anticlinal fold. This occurrence was not examined by the writer, but was described by Mr. Brooks as a belt of crystalline limestone, often beautifully banded and containing intercalated beds of mica-schist, and intruded by a large granite batholith. This limestone is the oldest rock in the York region, and it and the granite of Cape Mountain have the same relation as the limestones and granites in the Kigluaik Mountains. It was: therefore tentatively correlated by Mr. Brooks with the Kigluaik series.

KUZITRIN SERIES.

The type rock of this series is a graphitic quartzite, or quartz-schist, sometimes passing into a graphitic flag, or even a slate. The Kuzitrin series forms a well-

defined stratigraphic unit, which is recognized and named in the previous report. The relation of these rocks to the underlying Kigluaik series was not definitely established, but such evidence as there is indicates that they are conformable. On the south side of the Kigluaik Mountains they were found standing at a high angle and forming a belt 1 to 2 miles wide flanking the mountains. At this place the thickness of the series was estimated at approximately 2,000 feet.

Two considerable belts and a number of small areas of these rocks have been identified in the northern part of the peninsula. The southern belt, extending eastward from Port Clarence to the Kugruk River, forms a part of the northern limit of the great anticlinal uplift of the Kigluaik and Bendeleben mountains. On the accompanying map it is interrupted by the Pleistocene deposits, and by unmapped areas which have not been colored.

The slates which are found covering a large area in the vicinity of York are less highly metamorphosed than those in the above localities, but on stratigraphic and lithologic grounds they were tentatively correlated with the Kuzitrin series.[a] All the evidence collected during the season of 1901 tends to confirm that opinion.

The Kuzitrin series is exposed in three other smaller areas, where it is associated with granitic intrusions, and probably occurs in dome-shaped uplifts accompanied by more or less faulting. These areas were not examined in detail, and it seems possible that beds belonging to the underlying Kigluaik series may be exposed in the central portions of the domes. In the Kuzitrin series of the York region there are a number of intrusive masses of greenstone, believed to be altered gabbros, apparently occurring as dikes and sills. Similar rocks, though of a more diabasic character, were found in the Bluestone region southeast of Port Clarence, and in general it can be said that greenstone intrusives are not uncommon in the Kuzitrin series.

It will be shown below that the succeeding beds, which are Lower Ordivician, probablv bear an unconformable relation to the Kuzitrin series. This would make the Kigluaik and the Kuzitrin series Cambrian or pre-Cambrian.

NOME SERIES.

Introduction. — In the report of 1900 a great thickness of limestones, graphitic and calcareous schists, with some intrusive greenstones and chloritic schists of undetermined origin, were grouped together under the name Nome series.[b] The stratigraphic relation of the Nomc series to the underlying Kuzitrin series has not been definitely established, though from the evidence collected in 1900 on the south

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 29.
[b] Ibid.

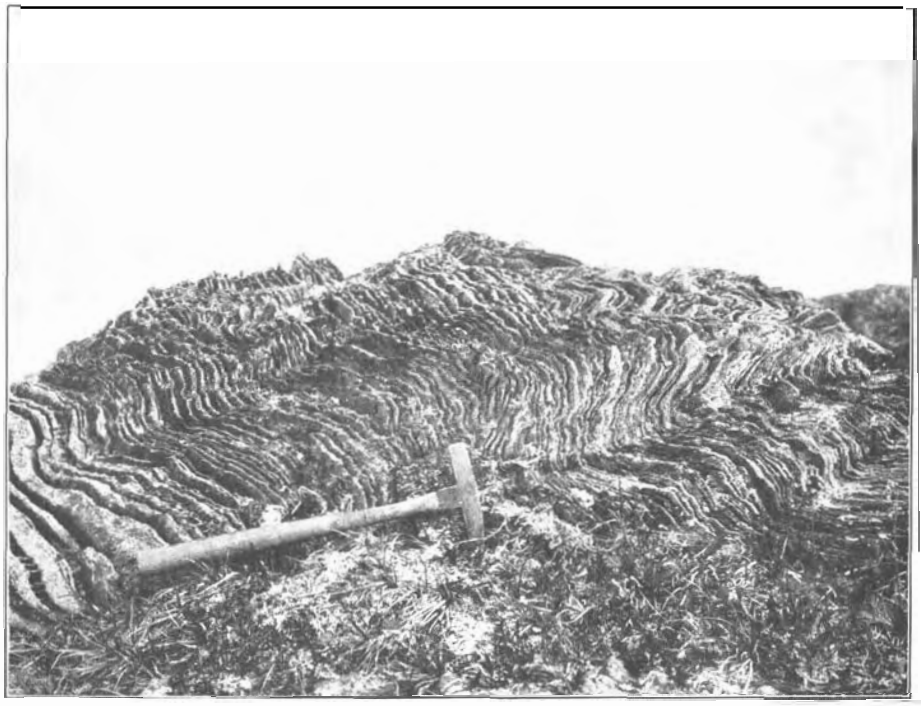
slope of the Kigluaik Mountains, near the head of the Kruzgamepa, it appears to be one of unconformity. In the York region, as will be shown, a similar relation of the two series seems to obtain. Where originally described, in the southern part of the peninsula, the basal member of the Nome series is a flaggy limestone or calcareous schist, probably less than 1,000 feet in thickness. Above this terrane a few hundred feet of graphitic limestones and phyllites were found, succeeded by heavily bedded limestones aggregating 1,000 or 2,000 feet in thickness. The upper part of the Nome series, of which no measure of thickness was obtained, is made up of thin-bedded limestones, calcareous schists, and mica-schists. A few fragmentary fossils were found in the lower part of the series, which were determined as Ordovician. It was recognized by Brooks[a] and his associates that the Nome series included terranes of widely different ages, but the character of the field work did not permit of any subdivisions at that time. Attention was called to the large number of greenstones occurring in the series, and also to the comparatively local character of its metamorphism. The investigation of the last season has enabled the writer to subdivide the Nome series into the Port Clarence limestone and the Kugruk group.

Port *Clarence limestone.*—North of Port Clarence the basal member of the Nome series was found to be a gray, earthy limestone, which over large areas exhibits but little evidence of metamorphism. This limestone occupies a large area, including the York Mountains, near the western extremity of the peninsula. Within this belt are a few small areas of Kuzitrin rocks which have been exposed by dome-like uplifts.

A short distance north of Grantley Harbor some quartz-schists which belong to the Knzitrin series are found outcropping near the exposures of the Port Clarence limestone. The quartz-schists have steep dips, and are considerably indurated, while the Port Clarence limestone consists of blue limestone which has been but little altered. There can be but little doubt that the relation of the two terranes is one of unconformity, the limestone being the younger.

Along the western margin of the Port Clarence limestone belt the contact relations with the Kuzitrin series also point toward unconformity. The contact, which was traced for several miles, there follows the western face of the York Mountains; and while the evidence was not decisive, it all pointed toward a structural break between the two formations. The arenaceous rocks of the Kuzitrin series along this line of contact are indurated and have a highly developed cleavage, while the Port Clarence limestone, which forms the mass of the mountains to the east, is little altered and has low dips. The relations are more or less obscured by the large intrusion of greenstone which occurs near the contact of

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 31,



;I. CRUMPLED LIMESTONE, BROOKS MOUNTAIN.

B PORT CLARENCE LIMESTONE, NULUK RIVER

the two series. All this evidence leads to the conclusion that the deposition of the arenaceous beds of the Kuzitrin series was followed by crustal movements by which the beds were indurated and a well-marked cleavage was developed. After this period of disturbance the Port Clarence limestone was deposited unconformably on the older series.

The York Mountains are largely made up of the Port Clarence limestones, which, as stated above, are usually but little altered. They are plainly bedded, and have been folded in a broad way only. This formation comprises a thickness of at least 2,000 feet of almost pure limestone. The basal beds are flaggy and slightly schistose, but the strata become more massive in ascending the series. They contain invertebrate fossils and impressions of fucoid stems.

The Port Clarence limestone was positively identified over an area 35 by 45 miles. Within this area dips vary from horizontal to 45°, and the axes of the folds follow no well-defined system. During the hasty reconnaissance no dominant structural features mere recognized. Reference has already been made to some small areas of older rocks which occur within this belt, and with which are associated granite dikes. As has been stated, these rocks are regarded by the writer as belonging to the Kuzitrin series. If this view is correct, they represent either residual hills in York slates which antedate the deposition of the Port Clarence limestones, or they have been brought up by faulting or folding since its deposition.

On the south and west the Port Clarence limestone, as has already been shown, is well defined by contact with the underlying strata; to the north it is bounded by the Pleistocene gravel. To the northeast, where it passes under the Kugruk group, the limits of the formation are obscured by what seems to be local metamorphism. For this reason it has not been thought best to represent this boundary on the geologic map by a sharp line of demarcation. This part of the map has been left uncolored, but the following description shows the character and general relations of the bed rock.

Along the Nuluk River the Port Clarence limestone dips to the north and passes under calcareous schists, probably belonging to the Kugruk group, which outcrop along the creek near the southern margin of the coastal gravel. Near the contact at this place the Port Clarence limestones are flaggy and show rather intense folding. In following the divide northward from the head of the Nuluk River toward Ear Mountain the line between the Port Clarence limestone and the schistose limestone was very noticeable, but tho age of tho schistose limestone was not determinable. Eastward from the head of the Nuluk River the Port Clarence limestone was found to extend to the low divide between the headwaters of the Agiapuk and American rivers. At this place these limestones dip northeastward at a high angle.

About 10 miles east of this locality, and along the east side of the American River Basin, the bed rock was found to consist of highly altered limestones and graphite-schists and mica-schists, dipping toward the west. These rocks were of the type common in the Nome series of the southern half of the peninsula. The stratigraphic evidence is not sufficient to justify any conclusions in regard to their relations with the Port Clarence limestone.

Between the head of the Nuluk River and Ear Mountain very few exposures of bed rock were seen. The region is to a large extent covered by gravel and tundra. Some depressions were seen on the broad ridge, which indicate limestone sinks beneath the gravel.

Ear Mountain consists of rocks which probably belong with the Kuzitrin series. The relation of these rocks to the schistose limestones found to the southeast of Ear Mountain was not determined. These latter limestones are highly crystalline and often schistose, but are practically homogeneous and represent a great thickness of strata. The bedding is often obscured by jointing and cleavage. The dips, where they can be determined, are high. Above these highly altered limestones there is a bed of graphitic schist, above which the bed rock consists of alternating beds of schist and limestone common in the Nome series, in which the limestones predominates. If these highly altered limestones which lie to the south and east of Ear Mountain are correlated with the Port Clarence limestone, then the graphitic, micaceous, and calca eous schists and limestones overlying it belong to the Kugruk group.

The age of the Port Clarence limestone was definitely determined by the fossils from several localities. These were submitted to Mr. Charles Schuchert, of the National Museum, who reports as follows:

"Loc. **26.** July **20.** Two miles southwest of forks of the Don River. *Porambonites*, probably *P. intercedens* Pander; *Columnaria* with large corallites, and Bythotrypa? sp. undet.

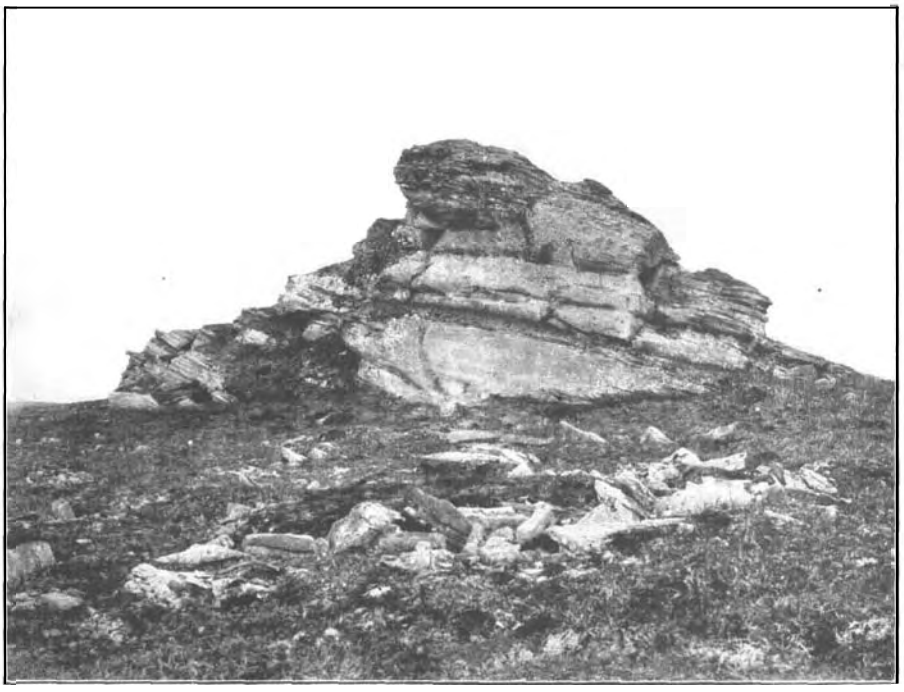
"Loc. 28. July **21.** Mountain 4 miles north of Rapid River. *Illænus* near **I.** *tauricornis* but much smaller; *Illænus* sp. undet.; and a lithistid sponge on the order of *Calathium.*

"Loc. **45.** July **23–24.** Don River **4** miles north of Tozier Creek. *Maclurina*, probably *M. manitobensis* Whiteaves; *Columnaria* with small corralites; *Halysites catenularia* Linne; *Syringopora* sp. undet.; *Streptelasma?;* and an undetermined *Lophospira.*

"Loc. 77. August 9. Bluff above Nuluk River, latitude 65° 41′, longitude 166° **20'.** *Orthis*, probably *O. parva* of European Russia.

"Loc. 78. August **10.** Boot of talus slope, Nuluk River. A large section of an undetermined gasteropod.

"Loc. 76. August 10. Bowlder from gravel of Nuluk River. Fragments of a large trilobite. Undeterminable.



A. SCHISTOSE LIMESTONE, KUGRUK GROUP, HEAD OF PORTAGE CREEK.

B. SCHISTOSE LIMESTONE, KUGRUK GROUP, BUDD CREEK

"Loc. 185. Pebble from sand spit 1 mile north from Teller. *Girvanella* and *Raphistoma?*

"The above localities represent the middle of the Lower Silurian system. This is the first proof of the occurrence of rocks of this age in Alaska. Localities 26, 28, and 77 are particularly interesting, as species found there were first described from European Russia about St. Petersburg. This fauna has not before been ascertained to occur in America, nor has *Porambonites* been noted in any American Arctic region.

"Locality 45 is also very interesting and perplexing—perplexing in that the association of *Halysites* with *Syringopora* would under ordinary circumstances be accepted as proof for Upper Silurian age. However, since both are here associated with such unmistakable Lower Silurian forms as *Maclurina manitobensis* and *Columnaria*, the latter outweighs the evidence of the corals. On the other hand *Halysites* is often found in the Lower Silurian, and while I know of no *Syringopora* in this system, yet I learn from Mr. Ulrich that this genus has been noticed by him twice in association with Lower Silurian species."

To recapitulate briefly, the Port Clarence limestone is typically a gray, slightly indurated rock of Lower Silurian age. The formation has a thickness of probably 8,000 feet, and it occupies a considerable area in the western part of the Seward Peninsula. It probably overlies the Kuzitrin rocks unconiformably. Usually it is only gently folded, but near its northeastern boundary it has been considerably disturbed and somewhat metamorphosed.

Kugruk group.—Much of the region mapped during last season is occupied by interstratified limestones, mica-schists, and graphitic schists, which have been classed together under the name Kugruk group. This group constitutes the upper member of the Nome series, and in lithologic character has a close resemblance to the rocks in the portion of that series which is found in the southern part of the peninsula, between the coast and the Kigluaik Mountains. Like them, the Kugruk rocks include many schists and intrusive masses of schistose greenstone. Reference to the map will show that the Kugruk group covers a large area extending eastward from the American River. The rocks of this group differ from the older Port Clarence limestone in that they do not include any great thickness of pure limestone strata, such as are found in the older formations. The limestones included in the group frequently grade off into calcareous and micaceous schists—a characteristic which was not observed in the Port Clarence limestone. As has been shown, the contact with the older formation is obscure, and did not yield definite evidence of the stratigraphic relations of the two terranes. The dominant structures are a series of open folds whose axes stretch in a north-south direction. The dips of the strata are variable; they are usually low, but sometimes reach 80°.

The Kugruk group yielded fossils at only one locality. Some imperfect fossils were obtained from the summit of Baldy Mountain, on which Mr. Schuchert makes the following report:

"Looality 163 indicates a second formation younger than any of the above-described lots. The rock has undergone considerable alteration, so that the fossils are mostly undeterminable. However, the presence of a coral like *Cladopora* or *Striatopora* indicates either Upper Silurian or Devonian. No coral of this nature is known to me in the Lower Silurian."

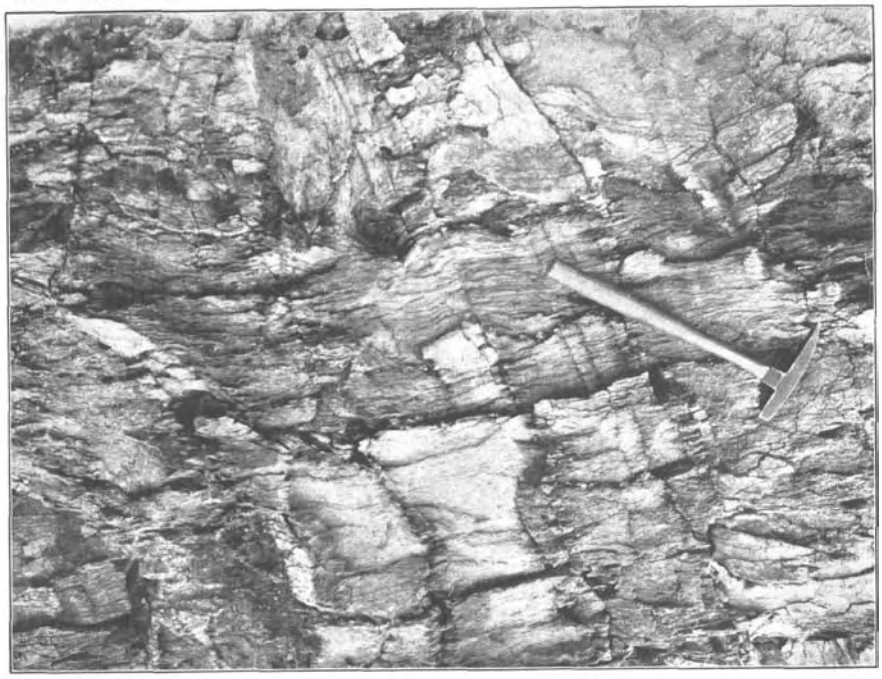
This evidence, as far as it goes, shows that the group is in part of Upper Silurian or of Devonian age. As the Kugruk group includes all of that portion of the Nome series as originally defined which lies above the Port Clarence limestone, it may be in part Mesozoic, for in the earlier report evidence is presented which goes to show that the upper beds of the Nome series are in part Mesozoic.[a] No additional facts bearing on this point were observed during last season's work.

The rocks which make up the Kugruk group are, as a rule, more altered than the Port Clarence limestone, which is believed to be the older formation. This anomaly is rather difficult to explain, but can perhaps be assigned to the progressive increase in degree of metamorphism which is found in passing from west to east in this province. In the York Mountains the strata are usually only gently folded and little indurated, while to the east of the American River, where the Kugruk beds are developed, the dips are often steep and the rocks considerably altered. As a concomitant to the more disturbed condition in the eastern province the greenstone intrusives are more abundant and have themselves produced more or less metamorphism. These facts bear out the statement made in the previous report,[b] that in the Seward Peninsula the forces which produced metamorphism acted very locally.

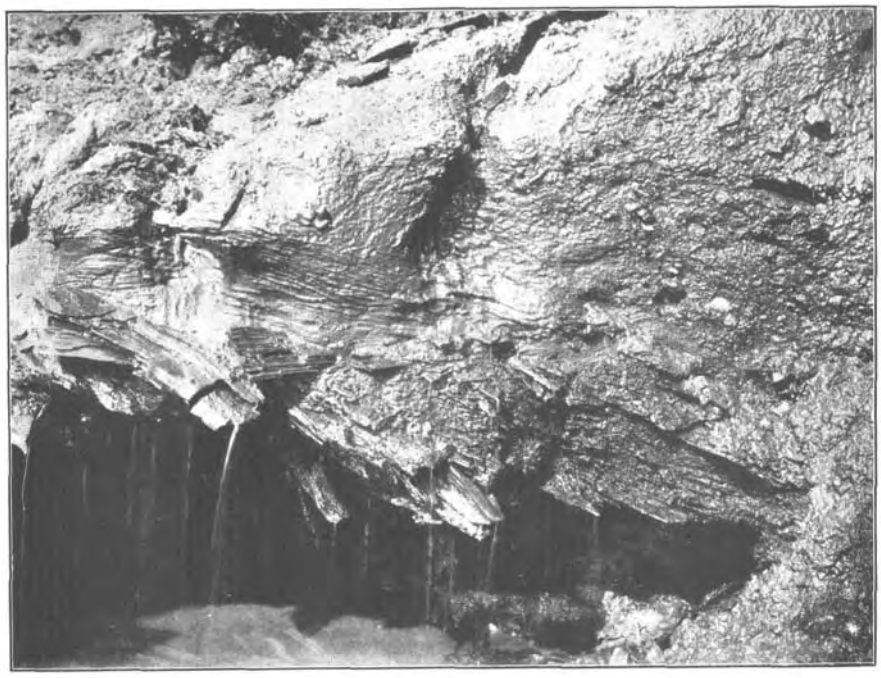
As the limited field work done in the region did not permit of working out the structure of the Kugruk rocks in detail, it has been thought best to add the following more or less detailed but fragmentary descriptions.

On the east side of the American River, Budd and Igloo creeks cut across the strike of a series of limestones interbedded with graphitic and calcareous schists, with some small sills of greenstone. The dips measured vary from horizontal to 70°. The topography is determined by the bed-rock structure, the principal features being a series of north-south ridges parallel to the prevailing strikes. Between the drainage basins of the American and Kugruk rivers these strike ridges form a sharp divide. Kugruk Mountain, at the northern end of this divide, is composed of a great thickness of highly metamorphosed quartz-mica-schist, probably an altered sediment. It is surrounded by crystalline limestones, which on the west side dip toward the west, away from the axis of the ridge. In this mountain the bedding is wholly obscured by the secondary foliation or schistosity. The limestones at the east base of the mountain were seen only from a distance, so that

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 31.
[b] Idem, pp. 34–L6.



A. BEDDING AND CLEAVAGE IN KUGRUK LIMESTONE, SOUTH OF IGLOO CREEK.



B. FROZEN SILTS CONTAINING SPRUCE LOGS ON QUARTZ CREEK

their attitude with regard to dip and strike is not known. Their position flanking the ridge on both the east and the west side suggests the belief that the Kugruk ridge is an anticline. The schist of Kugruk Mountain, as well as the surrounding limestone, is cut by small dikes of rhyolite.

Southward from Igloo Creek, toward the Kuzitrin River, a low north-south ridge of limestone, between outcrops of schist, has sharply folded bedding planes standing nearly vertical, with a well-marked. nearly horizontal cleavage. On the broad ridge between the forks of the Mary River there are several low, rocky buttes of pure white crystalline limestone, in which the bedding is not distinguishable from a complex system of jointing. This ridge is covered generally with waterworn gravels, and few outcrops were seen. South of this limestone the dark slates and quartzites of the Kuzitrin series form a broad belt between it and the Imuruk flats. In a hill toward the west, about 5 miles away, the white limestone could be seen overlying the dark slate. the line of contact between the two dipping northward at an angle of 10°. These limestones lying above the Kuzitrin slates are probably an altered form of the Port Clarence limestone. However, in this locality they can not be distinguished lithologically from the Kugruk limestone.

Along the Kuzitrin River above Marys Igloo the Kuzitrin slates and schists strike to the northeast and dip to the northwest. Above these schists, in the vicinity of Quartz and Coffee creeks, some very highly altered mica-schists were found in fragments strewn over the surface. No outcrops were seen, and their relation to the Kuzitrin formation could not be determined. This region is so deeply gravel covered that little can be learned of its bed-rock structure.

The canyon of the Kugruk River follows in a general way the strike of the bed rock, which consists of highly altered mica-schists and limestones, interbedded with some large masses of greenstone. The greenstone is schistose, having dip and strike parallel to the foliation of the mica-schists and the bedding of the limestones. The angles of dip are often high, but vary from 10° to 80°. The strike is generally north and south, parallel to the direction of the river. Dips both to the east and to the west were noted. The tributaries from both east and west sides of the river carry gravel containing limestone and schist pebbles. Near the head of the river dark graphitic schist, consisting mainly of secondary quartz, feldspar, and calcite, forms Midnight Mountain, and these are regarded as a part of the Kugruk group.

In the preceding account of the Kugruk group it has been shown that the whole region from the east side of the American River to the edge of the area mapped is characterized by bed rock showing a rather high degree of metamorphism, which is made up of thick beds of limestone interbedded with schists of various composi-

tion, including mica-, graphitic, and quartz-chlorite-schists. These beds have been folded into anticlines and synclines with north-south axes.

In general the limestone and schist of the Kugruk group east of the American River are more highly altered than the Port Clarence limestone, and consist of beds which are variable in their lithologic character, while the Port Clarence limestone is nearly pure. The Port Clarence limestone is known to be of Lower Silurian age, while Upper Silurian or Devonian fossils have been found in the rocks of the Kugruk group.

SURFICIAL DEPOSITS.

GENERAL DESCRIPTION.

Unconsolidated material, consisting of gravels, sands, and silts, constitutes the most widely distributed terrane of the region. These deposits are as a rule plainly stratified, and while the individual exposures show no plication they have been subjected to a certain amount of deformation, as will be shown in the discussion of the physiography. A bed of black silt, varying from a few inches to 20 feet in thickness, in many places forms the topmost layer of the unconsolidated terrane. Remains of both mammoth and horse have been found in this silt, showing it to be of Pleistocene age. As this Pleistocene silt bed and the underlying sands and gravels make up a conformable series, they are probably all of Pleistocene age, and have been so represented on the accompanying map.

On the geologic map only the more extensive Pleistocene deposits are shown. These are of two types, represented by the coastal plain and the inland basins. The largest areas of Pleistocene are found in the Arctic coastal plain, the Port Clarence coastal plain, and the inland basins of several of the rivers tributary to Port Clarence.

In general the deposits in these large areas are similar; they consist largely of silts and sands, and near the margins often contain considerable gravel. The sand dunes and beach deposits can also properly be grouped with the coastal plain Pleistocene.

A third class of surficial deposits consists of the material forming the flood plains and benches of the rivers and creeks. These fluvial deposits grade on one hand into the coarse gravels of the smaller tributaries, and on the other into the finer material which characterizes the Pleistocene beds of the inland basins and coastal plains.

A fourth class of deposits includes all those on high benches and terraces which are not assignable to the action of existing streams. In addition to distinctly waterworn material, there are extensive deposits of bowlders, pebbles, and clay,

which mantle many of the plateau surfaces, and are in part produced by weathering, but in many instances include some waterworn material.

COASTAL PLAIN DEPOSITS.

Arctic *coastal plain.*—This is a broad lowland bordering the Arctic coast from Cape Prince of Wales to Cape Espenberg. Along its southern margin it is composed of gravels derived from the adjacent bed rock. Near the coast the material becomes finer, and is made up of beach sand, sand dunes forming an important part of the deposits. A series of lagoons fringes the coast, which is separated from the Arctic Ocean by barrier beaches. Sand dunes are being built on these barrier beaches, which are encroaching on the lagoons from the seaward side, and the rivers and streams are filling up the lagoons from the landward side. The southern edge of the gravel deposits is serrate, since the gravels extend up the rivers and creeks and merge with the fluvial deposits of the flood plains. Their southern limit can be drawn approximately on topographic evidence, since the gravels are seldom found above the 200-foot contour.

The width of the coastal plain varies from about 5 miles near Cape Prince of Wales to 30 miles at Shishmaref Inlet. The depth of the Pleistocene deposits is not great along the southern edge, but it probably increases toward the coast. On the Mint, Nuluk, and Kugruk rivers isolated outcrops of the underlying bed rock were seen in the river banks several miles north of the southern edge of the gravels. Between the Pinguk and Nuluk rivers an island-like mass of bed rock is wholly surrounded by these deposits. South of Ear Mountain the Pleistocene extends over the divide between the Kugruk and Arctic rivers, almost cutting off the Ear Mountain area of bed rock from the hard formations adjacent on the south. In the silts which overlie the gravels and quite generally form the upper layer of these deposits mammoth bones are common. Mr. Charles A. Ruddy, who spent a part of the season of 1901 on Tuttle Creek, a tributary of the Kugruk, reports that they are abundant along that river. One large tusk in the silt, 15 feet below the surface, was partly exposed by the river cutting its bank. Mammoth teeth were seen by the writer on the Nuluk River, and they are reported to occur on other streams of the coastal plain region.

Port Clarence coastal *plain.*—This second coastal plain embraces a small lowland lying north of Port Clarence. It has a maximum width of about 5 miles, and extends from the mouth of the Rapid River to Grantley Harbor, a distance of about 24 miles. Along its southern edge the plain has a gravel escarpment about 20 feet high. The gravel is composed principally of pebbles derived from the Port Clarence limestones. The plain rises gradually toward the north, and along the base of the hills the gravel covering is only a few feet in thickness,

and rests on the upturned and truncated edges of Port Clarence limestones. Below the gravel escarpment, at the southern edge, the present beach has been Formed. The beach is composed of sand and gravel derived from the escarpment. A large lagoon cuts it off from the mainland. This beach and lagoon have been formed since the elevation of the coastal plain.

INLAND BASINS.

There are three extensive lowland basins in the province under consideration, which will he called the Agiapuk, Imuruk, and Kuzitrin lowlands. Except for the fact that they are inclosed by uplands, they resemble the coastal plains. They occupy broad basins, probably produced in part by deformation, and represent either lakes or estuaries which have been filled with gravel and silt deposits. The Agiapuk lowland is connected along the flood plain of the Agiapuk River with the lowland of the Imuruk Basin. A short canyon cut in bed rock intervenes between the Imuruk Basin and the Kuzitrin lowland. All three of these basins probably have the same history. They were formed at nearly the same time and their silt and gravel deposits are of Pleistocene age.

Agiapuk lowland.—This lowland, having an area of about **60** square miles, is located in the valley of the Agiapuk River, **25** miles above its mouth. It is dotted over with many lakes, and from the surrounding hills it has the appearance of a filled lake or estuary. As they approach the plain the tributaries of the Agiapuk River have broad valleys and flood plains. A mining shaft has been sunk on Allene Creek, one of the tributaries from the south, and is said to have failed to reach bed rock at a depth of **65** feet. Below a surface layer of gravel, blue clay containing bark and other driftwood was found. Mammoth bones are reported to be common within this basin.

Imuruk lowland.—This is a broad tundra-covered plain which surrounds Imuruk Basin and extends up the Kuzitrin and Kruzgamepa rivers, and has an area of about **200** square miles. The tundra is underlain by frozen silts of varying thickness, below which gravel and sand are exposed along the rivers. Along the northern edge of this plain, near the Mary River, there are some gravel mesas, about **50** to **100** feet high, which are regarded as remnants of an upper gravel plain that has been eroded away by the meandering of the river.

Kuzitrin lowland.—This is an area of lowland covering approximately **200** square miles on the north side of the Bendeleben Mountains and drained by the Kuzitrin River. The lowland is tundra covered, and underlain by silts, sand, and gravels, probably of no great depth. It is dotted over with many small lakes, probably formed by oxbows of the meandering creeks and rivers. Around the lowland area on the west, north, and east sides there is a higher gravel plain, from **50** to **150** feet above the lowland. A well-marked escarpment usually

separates this upper plain from the lowland. On the lowland surface, away from the margins, there are occasional gravel buttes, 50 feet or more in height, which at a distance resemble haystacks. These are regarded as remnants of the upper plain which have been left by erosion. At the edge of the upper plain transition phases between the plateau and the isolated buttes were noted in a few instances.

On Quartz Creek the gravels of the upper plain are overlain by frozen silts, in which bones of mammoth and horse have been found associated with the trunks of large spruce trees. A spruce log, said by the miners to be 5 feet in diameter and 80 feet long, was uncovered at this place.

Near the mouth of Turner Creek an isolated butte, known as Coal Hill, is composed largely of black peat containing many pieces of bark and branches of spruce trees. At the present time there is no spruce timber within the drainage of the Kuzitrin River. In Coal Hill there are seams of white sand interbedded with the peat, suggesting driftwood origin. However, the abundance of small twigs and some spruce cones would seem to indicate that the material has not drifted far. Associated with a spruce log which was found in the frozen silt on Quartz Creek, and which was followed by a tunnel for a distance of 80 feet, a part of the jaw and some teeth of a horse were found by Mr. A. H. Jose, who gave them to the writer to be placed in the National Museum. The specimens were submitted to Mr. F. A. Lucas, who reports in regard to them as follows:

"It is difficult—almost impossible—to identify horses from their teeth alone, but the teeth collected by you resemble those of *Equus complicatus*, which occurs throughout a large portion of the United States east of the Rocky Mountains. The extension of this species to Alaska would seem to give it an extraordinary range; still, this would not be greater than that of the bison in modern times and the elephant and mastodon in the Pleistocene. In the absence of more material this identification should be considered as provisional."

Teeth and tusks of the mammoth (*Elephas primigenius*), together with bones of other animals, are reported by the miners to be common in the placers along Quartz Creek.

MAMMOTH REMAINS.

Elephant remains have been found in the silts of the Arctic coastal plain, in the Agiapuk Valley, and in the Kuzitrin Valley. In the Kuzitrin Valley they were associated with spruce logs and horse remains. Similar bones have been known from other parts of Alaska for many years, the most noted locality being at Elephant Point, on the south shore of Kotzebue Sound, about 50 miles northeast of the Kuzitrin Basin. At this point the remains of the horse, elephant, and bison were associated with those of the reindeer and musk ox.[a] This association of

a Dall, Bull. U. S. Geol. Survey No. 84, 1892, p. 264.

animals known to require such diverse climates would seem to indicate very unusual climatic and physical conditions.

Dr. Dawson[a] states that mammoth remains are found only in the nonglaciated portions of Alaska and the Yukon district of Canada. He also finds evidence that during the time of the mammoth there was a land connection between Alaska and the coast of Siberia. Whatever may have been the relation of the mammoth to the Glacial epoch, it seems certain, on account of the association of the remains with the evidence of forest growth, that a milder climate prevailed during at least a part of the mammoth period, and while these extensive gravel deposits were accumulating.

ALLWIAL SANDS AND GRAVELS.

Sand and gravel deposits, usually too small to be represented on the geologic map, occur to a greater or less extent in all the valleys. They are the product of stream action, and occur not only in the beds and flood plains of streams, but also as benches and terranes along the sides of the valleys above the present stream beds. The coarse gold of the placer mines is usually found in gravel deposits of this kind, which are described in more detail in the section on "Economic geology."

ELEVATED SURFICIAL DEPOSITS.

Extensive gravel deposits at great elevations in places far removed from present stream beds have been noticed less frequently than in the southern part of the peninsula. In the neighborhood of Nome deposits of this kind have been extensively explored by prospectors, since they often carry placer gold. No search for them in' the northern portions of the peninsula has yet been made by prospectors. Rounded pebbles and washed gravel at high elevations were noted in a few instances, the most striking cases being on the ridge between the forks of the Mary River, at 700 feet elevation, and in the divide between the waters of the Arctic and Kugruk rivers, south of Ear Mountain, at about 400 feet elevation.

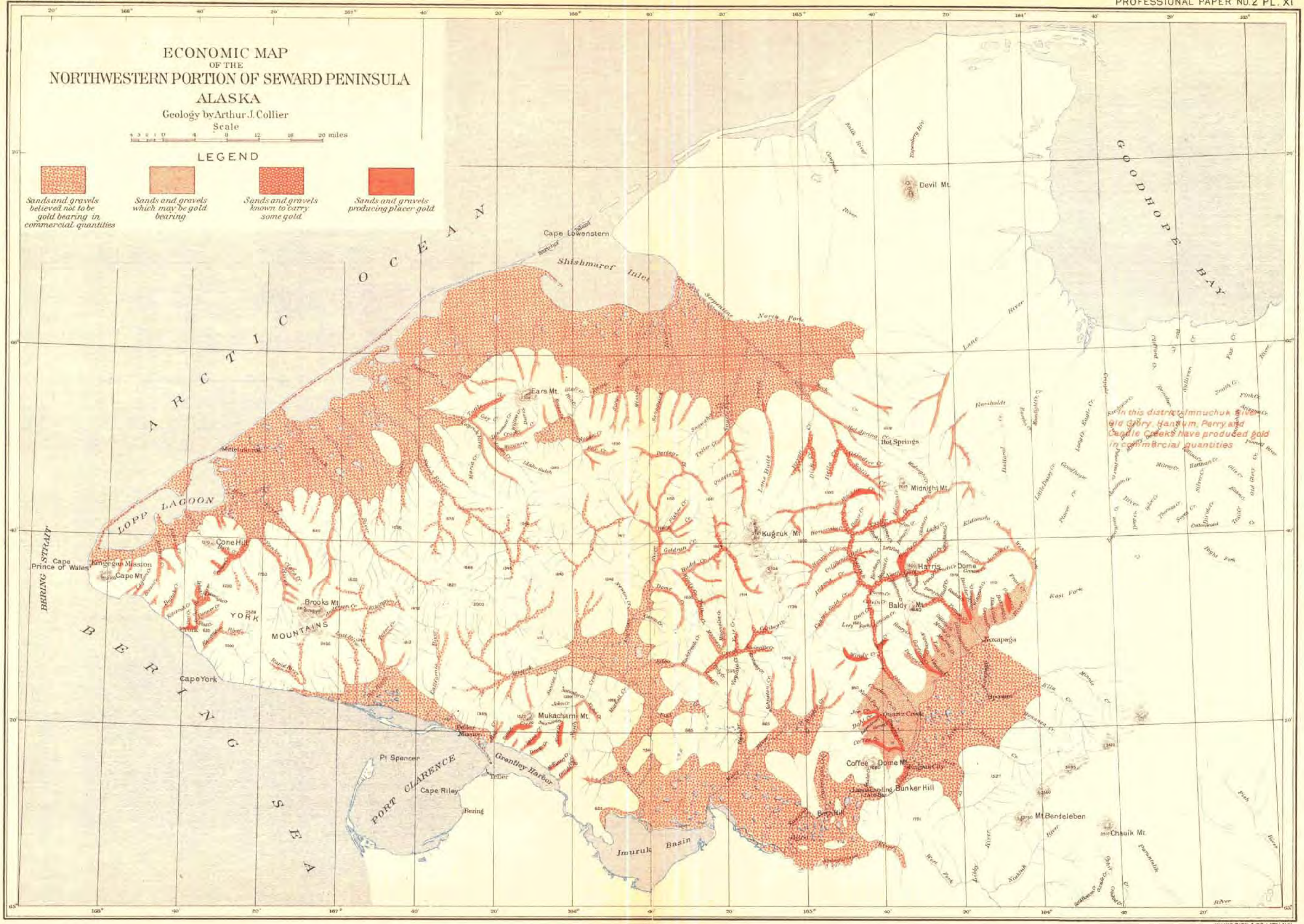
Extensive plateaus have been developed over this region by erosion in a previous physiographic cycle.[b] These plateau surfaces are covered with semiangular gravels derived from the adjacent bed rock or with residual clay containing weathered fragments of the bed rock. Where the clay is found a tundra growth of moss often occurs, covering the surface.

GLACIATION.

No evidence was found of general glaciation over the region explored. The surficial deposits over the upland portions, consisting of residual soil and gravels

[a] Notes on the occurrences of mammoth remains in the Yukon district of Canada and Alaska: Quart. Jour. Geol. Soc. London, Vol. L, pp. 1–9.

[b] See Physiography, pp. 34–39.



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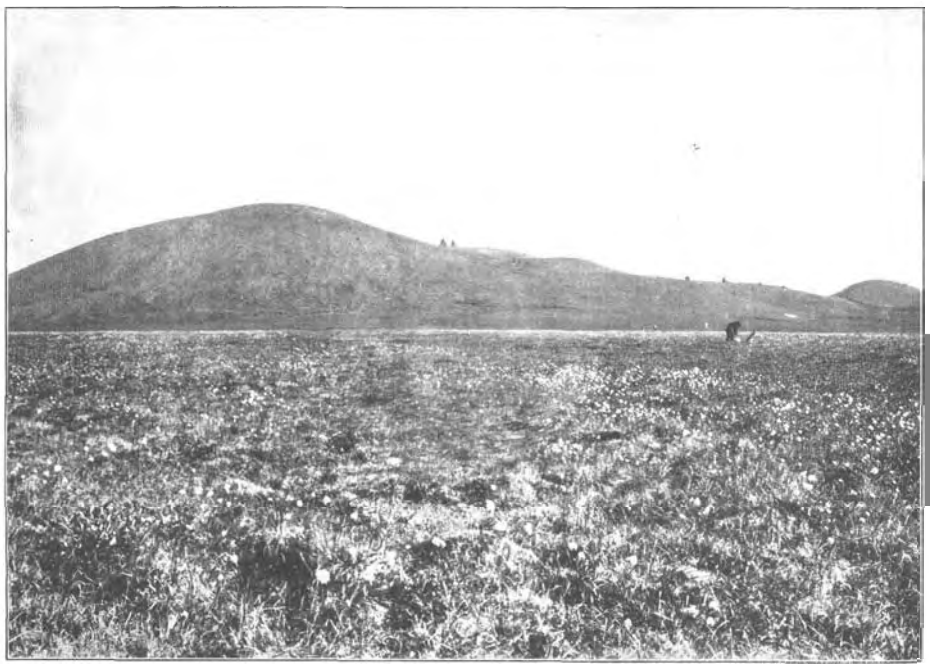
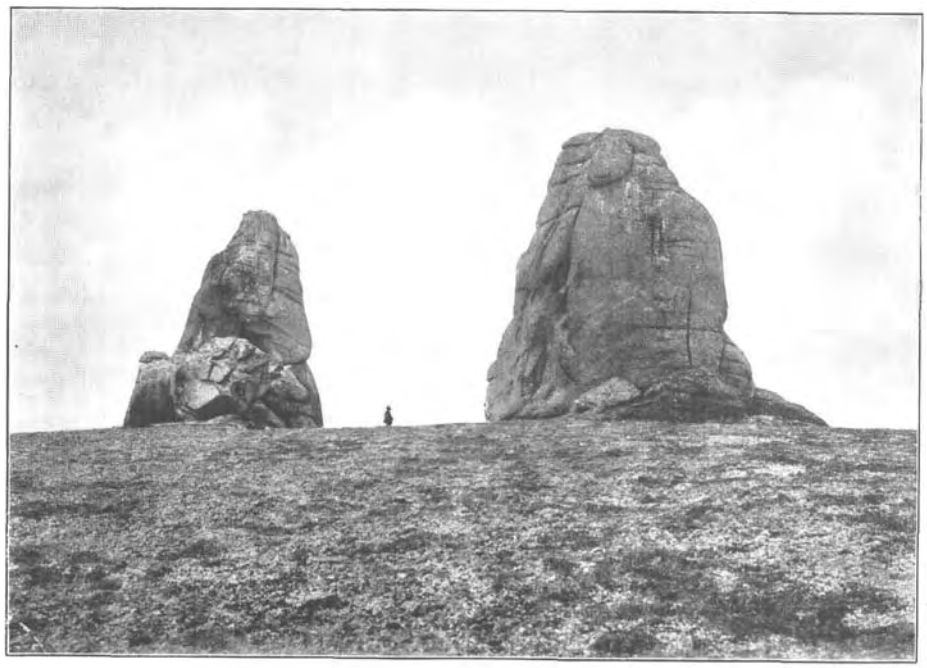


A EAR MOUNTAIN, FPOM BENCH AT 1,000 FEET ELEVATION.



B THE EARS, GRANITE PINNACLES ON EAR MOUNTAIN.

derived from the adjacent bed rock, are regarded as evidence of nonglaciation. Erratic bowlders, such as were found in the southern portion of the peninsula and were attributed to floating ice, have not been found in the northern portion.[a]

The topography of the Bendeleben Mountains, the York Mountains, and Cape Mountain was noted by Brook? as indicating local glaciation. Similar indications of local glaciation were observed on Ear Mountain. During the season of 1901 no detailed examination was made of the Bendeleben Mountains. The explorations made last season show that the glaciers of the York Mountains were of very limited extent, as were also those of Cape and Ear mountains. The glacial deposits in no instances extend beyond the limits of the mountain valleys. Although small glaciers have undoubtedly existed in connection with these mountain masses, their deposits are of such limited extent that they can be neglected in this report.

IGNEOUS ROCKS.

INTRODUCTION.

All the types of igneous rocks described by Brooks[b] from the southern part of the peninsula were found in the northern portion of the region studied by him. In addition to these, recent basalts, occurring both as necks and surface flows, were found in a few localities, indicated on the geologic map.

GREENSTONES.

The greenstones and greenstone-schists include a number of more or less altered intrusives, occurring both as sills and stocks. In the Kuzitrin slates near their contact with the Port Clarence limestones there are many intrusions, both in the form of dikes and sills, of greenstones which seem to be altered gabbros. Similar rocks were found intruded in the Kuzitrin slates at Cape Douglas. In the schists and limestones of the Kugruk group east of the American River there are many small bodies of greenstone, which are often highly schistose and composed chiefly of secondary minerals. In general they have been derived from basic igneous rocks, either diabase or gabbro, though in some cases the minerals present indicate that they were derived from more acid rooks. These greenstone-schists reach their greatest development along the Kugruk River, where they often contain phenocrysts of hornblende, and are designated "porphyry" by the miners of the region.

GRANITIC AND RHYOLITIC INTRUSIVES.

In Cape Mountain, Brooks Mountain, and Ear Mountain, and near the hot springs north of Midnight Mountain, granites and fine-grained porphyries occur

a Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 46.
b Idem, p. 31.

as large intrusive masses and small dikes. The granite frequently forms needles and pinnacles on account of weathering along a double system of joints. Ear Mountain derives its name from two of these granite needles which have a semblance to the ears of some animal. Similar "ears" are found scattered over Ear Mountain and over the granite area near the hot springs. Small dikes of quartz-porphyry, probably connected with these granite intrusions, were found in the slates outside of the larger mass of granite.

The granite of Cape Mountain was described by Brooks as being coarsely crystalline, usually porphyritic, and as consisting essentially of quartz, microcline, and biotite. It has had considerable metamorphic effect on the adjacent limestones.

The granite in Brooks Mountain has not been examined microscopically. A small dike from this locality showed quartz and orthoclase phenocrysts in a groundmass composed of quartz and feldspar. In this mountain the limestones which lie adjacent to this intrusive are considerably altered.

The granites of Ear Mountain consist essentially of quartz, orthoclase, and biotite. A smaller body of pegmatite-granite is made up of quartz and orthoclase and plagioclase feldspars, while a small dike from the same region consists essentially of quartz and orthoclase phenocrysts in a groundmass of quartz and feldspar, with muscovite, largely secondary, and a secondary growth of feldspar surrounding the larger orthoclase phenocrysts. In the Ear Mountain granites a platy structure, brought out by the weathering, gives the rock a stratified appearance.

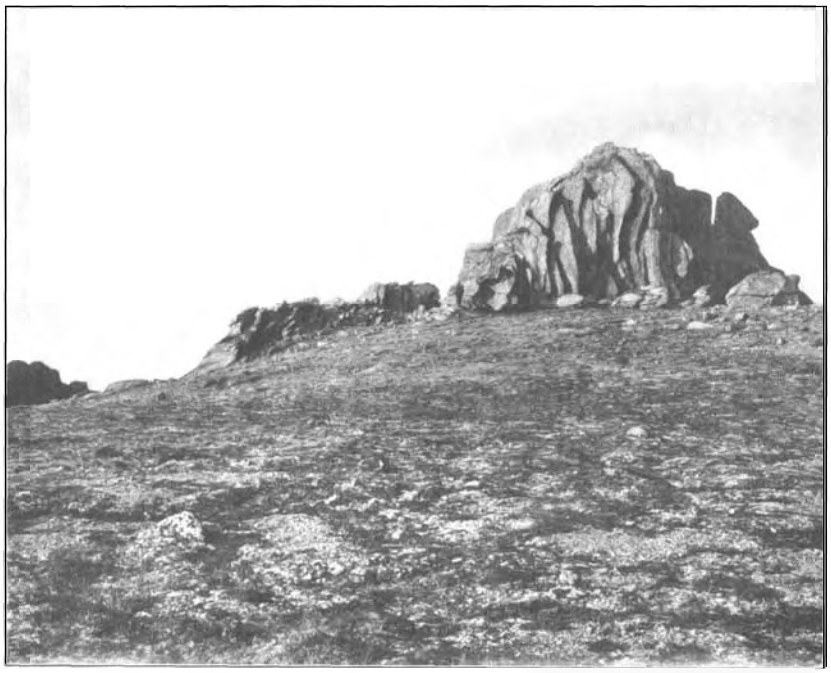
The granites of the hot springs region were not examined microscopically, but are similar in general type to those of Ear Mountain.

In Kugruk Mountain and in the limestone west of that mountain there are small dikes of rhyolite, which under the microscope show phenocrysts of quartz and feldspar. In the dikes which cut the schists the feldspar phenocrysts are replaced by chlorite, while in the dikes which occur in limestone the feldspar is replaced by calcite. These dikes are not associated with any granite mass which reaches the surface, and are the only cases of the kind seen in the area explored.

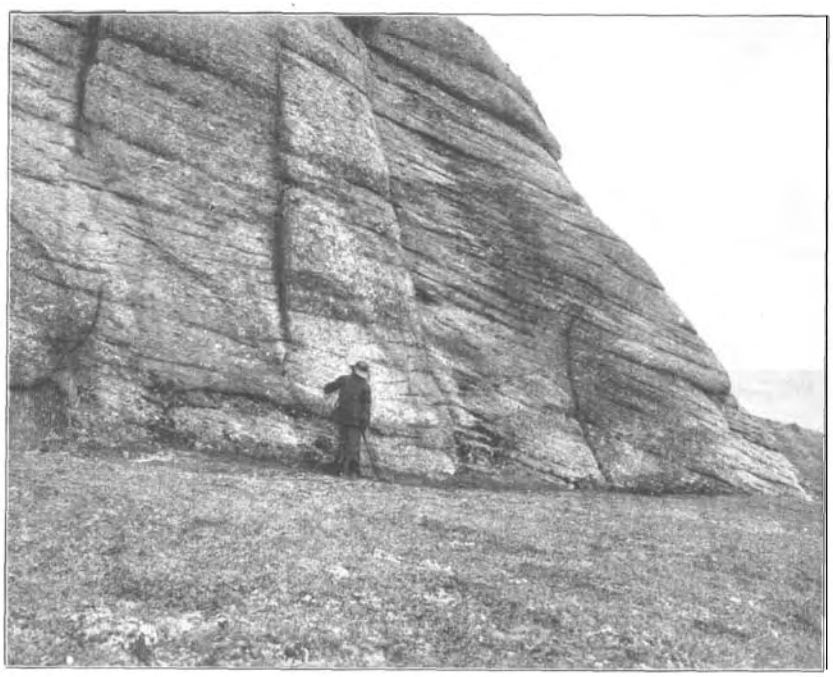
From the above description it will be seen that the acid intrusives have a wide distribution in the region, though they form no considerable masses such as occur in the Kigluaik and Bendeleben mountains farther routh. The age of these intrusives has not been established, but they were probably injected during the last period of disturbance, which is believed to have been in Mesozoic time.

BASALTS.

Basalts occur as small flows and volcanic necks at a number of localities. Mukacharni Mountain and the two small buttes to the east of this mountain, a



A. PLATY STRUCTURE IN GRANITE NEAR HOT SPRINGS



B. PLATY STRUCTURE IN GRANITE, EAR MOUNTAIN.

small area on the east side of the California River, all north of Grantley Harbor, and a small hill about 2 miles east of the forks of the Don River are composed of unaltered basalts. These basalts are both compact and vesicular, and vary in color from gray to black. The vesicles are unfilled, and are often confused in weathered specimens with the cavities from which olivine phenocrysts have weathered. Under the microscope the rock is seen to consist of many olivine phenocrysts in a groundmass consisting of plagioclase feldspar, probably labradorite, and a more or less opaque aggregate in which augite and magnetite can sometimes be recognized, the former in short prisms.

Mukacharni Mountain and the two buttes to the east of it and the small hill to the cast of Tozier Creek are volcanic necks cutting the schists and slates. The basalt areas west of Mukacharni Mountain and east of the California River are remnants of surface flows or sills, which have probably been erupted at the same time as the necks. The amount of erosion since these eruptions indicates that they took place in pre-Pleistocene time.

Between the Buzitrin and the Noxapaga rivers extensive lava beds are reported by prospectors. These lava beds are reported to extend across the divide between the headwaters of the Kuzitrin and Koyuk rivers and down the Koyuk Valley. Similar lavas were described in the Koyuk Valley by Mendenhall.[a] In the Noxapaga River many fragments of basalt were found in the gravels on river bars.

At a point on the Noxapaga River 2 miles above Noxapaga these lavas extend across the river, and their relation to the other rock was seen in a bluff above the river. Here the Pleistocene gravels filling the Noxapaga Valley rest on the upturned edges of the schists. The basalts lie upon these gravels, and near the contact the gravels are cemented by indurated clay. In the upper part of this gravel a few pebbles derived from basalt were found, mixed with quartz pebbles derived from the schist. This lava flow probably occurred in Pleistocene time, while the upper gravel plain of the Kuzitrin Basin was being formed. In the Koyuk Valley Mendenhall found evidence that the basalt is of Pleistocene or late Pliocene time.[b] The evidence obtained in the Kuzitrin Basin indicates a similar age for the basalts found there.

Tbese basalts show phases from gray to black. They are more often vesicular than compact, the vesicles unfilled. Under the microscope they show large olivine phenocrysts and smaller phenocrysts of feldspar, probably labradorite, set in an almost opaque groundmass.

DYNAMIC HISTORY.

The dynamic history of the province is complex, and, in spite of the two seasons of field work, still presents many unsolved problems. In the southern part

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 206.
[b] Idem, p. 207.

of the peninsula[a] four distinct periods of dynamic activity were recognized, and some evidence was obtained of a fifth, which antedated all the others. The facts which suggested this oldest period of disturbance were those which indicate a deformation of the Kuzitrin series previous to the deposition of the Nome series. This unconformity was, however, not definitely established by independent evidence.

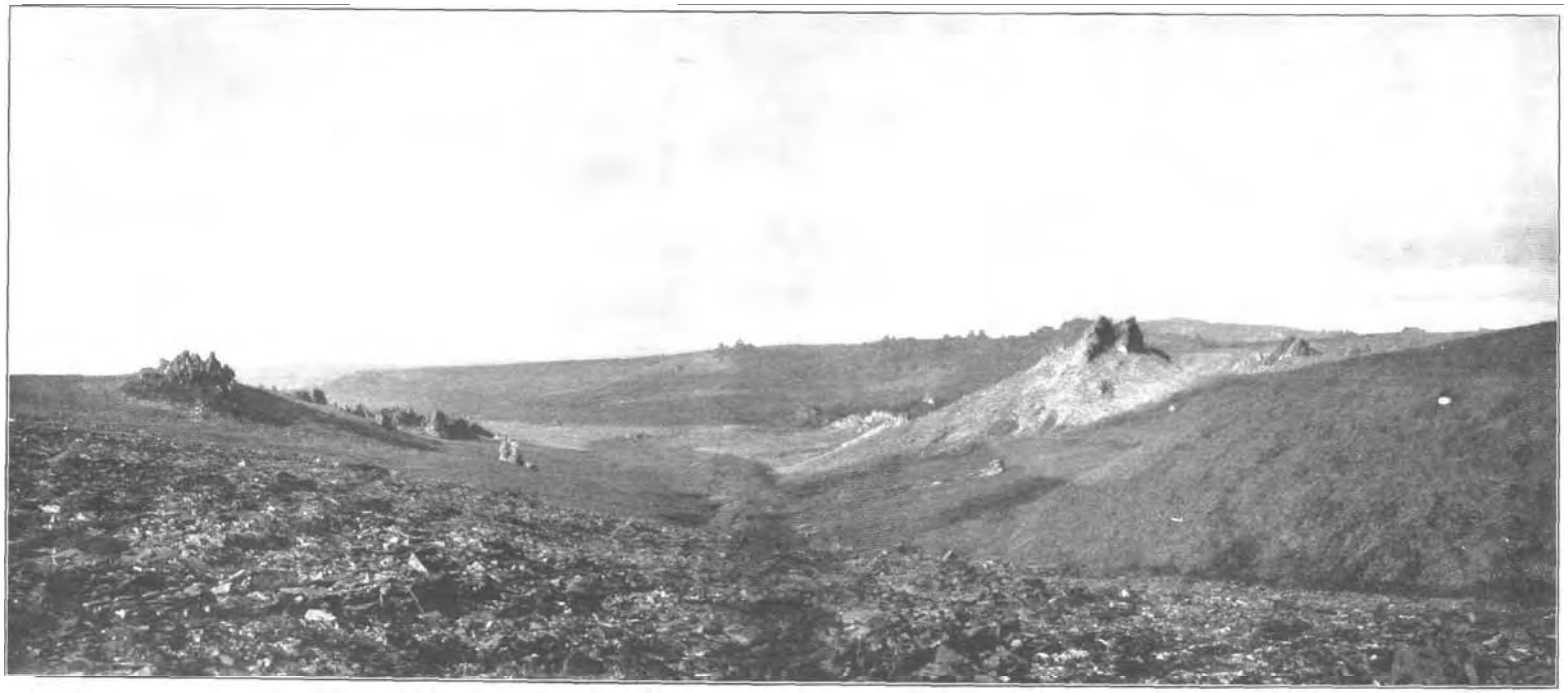
The record of the oldest of the four periods of revolution which were definitely recognized in the southern belt is found in the broad, often dome-like, folds which affected all the rocks up to and including the Nome series. The crustal movement resulting in this doming was accompanied by large injections of greenstones, and it probably occurred in pre-Silurian time. The next disturbance was one which rendered these greenstones schistose, and locally produced considerable shearing and jointing. Its effects are exhibited by local deformation and metamorphism in the Nome series, and its date was probably Mesozoic. The third crustal movement was more widespread in its effect, and was accompanied by the intrusion of large granite masses along the axes of the Kigluaik, Bendeleben, and Darby mountains. The age of this dynamic revolution can be definitely assigned to the late Mesozoic or pre-Tertiary. The evidence of a still later epoch of crustal movement was found in the sheared and jointed character of some of these granite masses.

The investigations of the past season in a general way corroborate this statement of the dynamic history of the province. More definite evidence of the unconformable relation of the basal member of the Nome series to the Kuzitrin series was obtained (see p. 17). The Kuzitrin series, as has been shown, suffered some metamorphism previous to the deposition of the Port Clarence limestone, which is the lower member of the Nome series. As the Port Clarence limestone is of Lower Silurian age, this crustal movement can be definitely assigned to the pre-Silurian.

The first well-established epoch of dynamic activity in the Nome region proper was the period of the intrusion of the greenstones, and this is also recognized in the northern province. The writer is, however, unable to present any evidence of the presence of dome structures similar to those which were described by Brooks[a] and assigned to this period.

The next epoch of disturbance which was recognized in the southern part of the province was the post-Nome revolution. In the northern region this epoch has also been recognized, but was proved to be rather local in its effect. In the York Mountains the beds belonging to the older member of the Nome series were found to be but little affected by this movement, while in the eastern part of the province the upper member of the same series is sharply folded and con-

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 39.
[b] Idem, p. 31.



GRANITE OUTCROPS NEAR HOT SPRINGS

siderably metamorphosed. This is in accordance with the fact, pointed out by Brooks,[a] that the disturbances were of a local character. As in the southern belt, both the sediments and the igneous rocks were rendered schistose by this movement. This disturbance was provisionally assigned to the Mesozoic, and is shown by the work of the past season to be at least post-Devonian.

The third period recognized by Brooks has been the last one of extensive deformation. Deformation and alteration were accompanied by the intrusion of the granites of the Kigluaik and Bendeleben mountains. In the southern province this disturbance is shown by structural lines which run parallel to the axes of the mountains and have a general east-west trend. In the northern belt no large intrusions of granite occur, but there are structural lines running east and west, which may have been produced by this crustal movement, as noted more especially in the York Mountains. The evidence, briefly summarized, is as follows: In the York Mountains, where the bed rock is chiefly the Port Clarence limestone, broad, open folds were observed whose axes run nearly east and west. These are transverse to the lines of more intense disturbance in the eastern part of the belt. As is shown by the character of the rocks in the eastern belt, the western belt must have remained practically undisturbed during the early Mesozoic evolution which has been described. These in the York Mountains must therefore be of a later date than the north-south structures, and are here provisionally correlated with the epoch during which, in the southern part of the peninsula, the Kigluaik and Bendeleben mountains were uplifted.

No evidence of the fourth dynamic evolution described by Brooks was obtained by the writer, though it may exist. The extrusion of the lavas which have been assigned to the Pleistocene is the latest evidence of dynamic activity.

We have thus four definite periods of crustal movements, with accompanying injections, in the northern province. The first, which was probably regional, occurred in pre-Silurian times. The second was a period of intrusion, and can be provisionally assigned to the close of the Paleozoic, or the beginning of the Mesozoic. The third was a period of folding, which was rather local in its effect. The last was an epoch of extensive lavas, which, though rather widespread, was not great in the amount of material which was ejected.[b]

Since the injection of the granites and the uplift of the Kigluaik Mountains, which is assigned to the Mesozoic era, the northern portion of the peninsula has been base-leveled and uplifted and in the uplift has suffered more or less deformation. These features are described in some detail under the heading "Physiography."

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[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 35.

[b] Mr. Henry S. Washington has recently described some effusive rocks from adjacent portions of the Siberian coast. See Am. Jour. Sci., 4th series, Vol. XIII, pp. 175–184.

PHYSIOGRAPHY.

INTRODUCTION.

A general statement with regard to shore line, drainage, and relief of the region under discussion has been given in the chapter on geography. A general discussion of the physiography of the Seward Peninsula, by Alfred H. Brooks, is also to be found in Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, 1900, pages 48–64 and pages 163–198. Mr. Brooks[a] has called attention to the fact that the Seward Peninsula may be divided, by a line from Cape Espenberg to Rocky Point, into two regions, of which the eastern has been depressed and the western uplifted. The region under discussion is a part of this uplifted portion. In the northern part of the peninsula many new facts bearing on physiographic development were collected. However, owing to the hasty nature of the work and the small scale of the map, and in view also of the fact that further exploration in an adjacent region is contemplated at an early date, the writer will only attempt to describe in a preliminary way some of the more important topographic features, and to suggest their possible history.

The northern portion of the Seward Peninsula is characterized by broad lowland plains surrounding a central upland. These lowlands are built up of silts, sands, and gravels derived from the upland, and deposited in shallow waters, probably both marine and lacustrine, which surrounded it. The lowlands to the southeast occupy inland basins extending parallel with the axes of the Bendeleben and Kigluaik mountains, which rise abruptly from their southern edge.

The relief of the upland is considerable, but its summits are flattened at elevations varying from 1,600 to 8,900 feet in different parts of the region. Between the summit level and the lowland plain there is a series of broad benches surrounding the central mass, two of which are particularly prominent. The different plateau benches and plains represent distinct epochs of erosion, and in the case of the lower gravels have been quite generally deposited since its formation. The existence of these features is regarded as indicating repeated uplifts, which affected the whole region.

In the case of the latest uplift there is unmistakable evidence that the movement was of a differential nature. Similar differential movements have probably occurred in connection with older uplifts, but definite evidence of them is wanting. Although the general movement has been one of uplift there is also evidence of local depressions of minor importance during the latest period. The four epochs of erosion indicated will be discussed further under the headings Nuluk Plateau, Kugruk Plateau, York Plateau, and Lowland plains.

[a] Op. cit., p. 56.

NULUK PLATEAU.

This is the highest as well as the oldest erosion feature of the region. It is reprtsented by the flattened tops of the most elevated portions of the central upland. Remnants of this plateau were found on Ear Mountain at 2,300 feet, on Kugruk Mountain at 2,700 feet, and on Midnight Mountain at 2,000 feet. It is most extensively represented, however, in the mountain mass surrounding the headwaters of the Nuluk River, from which it takes its name. From this point it extends westward continuously to the York Mountains, while to the east and north it is represented by a few broad, flat-topped mountains, which must he regarded as remnants of a more extensive plain. This plateau has an elevation of from 1,300 to 1,800 feet. Seen from a distance its profile is continuous with the general sky line of the York Mountains. It is largely dissected, and is now represented by the flat tops of the ridges, along which the greater inequalities in elevation are probably due to differential uplift. It is impossible 'from the evidence in hand to determine positively the nature of the erosion by which this plain was produced. In the vicinity of the Nuluk River the surface is rounded from north to south, while it rises gradually to the westward. Since its formation it has been subjected more or less both to subaerial wasting and to deformation.

KUGRUK PLATEAU.

A second epoch of erosion is represented by a well-marked plateau surface extending from the eastern limits of the area mapped westward across the Kugruk River and continuing in a system of benches and table-topped hills to Cape Prince of Wales, the westernmost point of the American continent. Its relation to the Nuluk Plateau is best seen a few miles east of the Nuluk River, where a prominent bench, at 1,000 feet elevation, extends for several miles and encircles one of the mountains on which the Nuluk plain is well marked at 1,600 feet. Southward from this point this 1,000-foot plain is extensively developed over several hills. The interval between the Kugruk and Nuluk plateaus varies in different parts of the region. At Midnight and Baldy mountains in the east it is about 400 feet, while at the west side of the York Mountains it is upward of 1,000 feet. In the eastern part the Kugruk River and its tributaries have cut deep canyons in a well-marked plateau surface, which is continuous to the eastern limit of the area mapped. While these canyons are deeply cut, they are somewhat rounded and terraced, and are of an older type than those of the York region to be described later. West of the divide between the Kugruk and Agiapuk rivers, this plateau has suffered more dissection, but extensive tables and benches persist, showing its continuity northwestward to Ear Mountain. At this place it forms a platform at an elevation of 1,000 feet, from which the

mountain rises abruptly. Westward, along the north face of the York Mountains, it is represented by well-marked benches and the flat tops of a few isolated buttes. In the region west of the York Mountains the isolated buttes are flat-topped at 1,000 to 1,200 feet, and Cape Mountain has a well-marked bench at 1,200 feet. South of the Agiapuk River this platform, on which Mukacharni Mountain stands, is correlated with this plateau. In the eastern area, where this plateau is best developed, it is dotted over with scattering residuary buttes and mountains, of which Midnight, Baldy, and Harris mountains are types. The system of buttes and ridges extending southward from Kugruk Mountain rises above it, as do also Ear Mountain, Cape Mountain, and the York Mountains. It is impossible to state with certainty the nature of the erosion by which this feature was produced. In the vicinity of the Kugruk River the plateau surface is characterized by rounded hills and ridges, which often vary considerably in elevation, and rise gradually toward the bases of residual hills and mountains. The erosion of the Kugruk surface was probably subaerial, and it is proper to call the plateau a peneplain.

Since its formation this peneplain has suffered some deformation, the details of which are only imperfectly known. Southeast of Midnight Mountain, at latitude 64° 40′, the plateau has an elevation of 1,600 feet, while to the northward it appears to slope gradually down to the level of the Arctic coastal plain in a distance of 20 miles. To the southward it slopes toward the Kuzitrin Basin and has suffered erosion, so that it is only preserved in a few remnants. Coffee Dome, with an elevation of 1,000 feet, is such a remnant of the old plateau surface. In 1900 the writer, with Mr. Brooks, observed a broad bench with washed gravel on the west end of the Bendeleben Mountains. A further examination of the benches in this vicinity was made the past season. It seems probable that they are to be correlated with the Kugruk Plateau. These benches stand at an elevation of from 1,000 to 1,200 feet. This feature seems to indicate the formation by warping of a trough parallel with the Bendeleben Mountains since the development of the Kugruk Plateau surface.

YORK PLATEAU.

The third important erosion epoch is represented by the York Plateau. It is well developed about the mass of the York Mountains, though its equivalents may be traced with a fair degree of certainty along the northern flank of the Kugruk upland to the Serpentine River, and along the southern flank to the Kuzitrin River. The breadth of this bench, where it has been observed, varies from 100 yards to 15 miles. It slopes from the mountains toward the sea both to north and south. Its general altitude varies from 100 to 700 feet above the sea. Notable variations which occur along a line parallel to the southern shore are undoubtedly traceable to warping.

The interval between the York and Kugruk plateaus is usually about 700 feet.

Between the York Mountains and Cape Prince of Wales the York Plateau is represented by a well-marked plateau surface at an elevation of from 500 to 700 feet. This was described by Brooks in 1900. It is a striking feature and has been noted by a number of early explorers. The top of the plateau is smooth and perfectly hard, affording excellent footing.[a] To the northward it slopes rather gradually to the level of the Arctic coastal plain, while at its southern margin it terminates rather abruptly in a steep slope or escarpment toward Bering Sea.

Eastward around the north side of the York Mountains the York Plateau is apparently continuous with an imperfect plain surface developed over the hilltops at an elevation of 300 to 500 feet above sea level. Around the north side of the York Mountains this plain extends into the mountains in a system of broad benches along the rivers which emerge from them. On the Nuluk River this feature is developed in a broad valley floor about 400 feet above the present stream bed. At this place the plain extends through the upland in a broad pass between the waters of the Nuluk and Agiapuk rivers at about 500 feet elevation.

Surrounding Ear Mountain there is an extensive upland composed of rounded ridges which attain an elevation of 500 to 600 feet, and which seem to be continuous with the York Plateau as developed farther west. From these levels there is a gradual rise of the land toward Ear Mountain, at whose base is a well-marked platform having an elevation of 1,000 feet, from which the mountain rises abruptly for 1,300 feet.

From Ear Mountain to the Serpentine River this bench was not traced, and the topographic map affords no evidence of its existence. However, on Spring Creek, a tributary of the Serpentine River, henrhes at about 600 feet were observed, which may be tentatively correlated with this plateau.

South of the York Mountains a broad marine bench from 1 to 3 miles wide is cut on the Port Clarence limestones, of which the mountains are composed. This has been elevated from 100 to 600 feet above the sea and is bounded on the south side by a steep escarpment to the Port Clarence coastal plain or by a cliff to the sea. On the north it is bounded by the abrupt slopes of the York Mountains. The surface of this bench is an almost perfect plain swept bare of gravel or other detrital material, but is covered in many places with yellow clay derived from the solution of the limestone. A study of the topographic map shows with certainty that this bench is a continuation of the York Plateau above described.

Between the California and the Agiapuk there is a broad plateau surface having an elevation of about 500 feet. This plain extends up the Agiapuk River as a broad bench and is continuous over the divide with the benches along the

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 132.

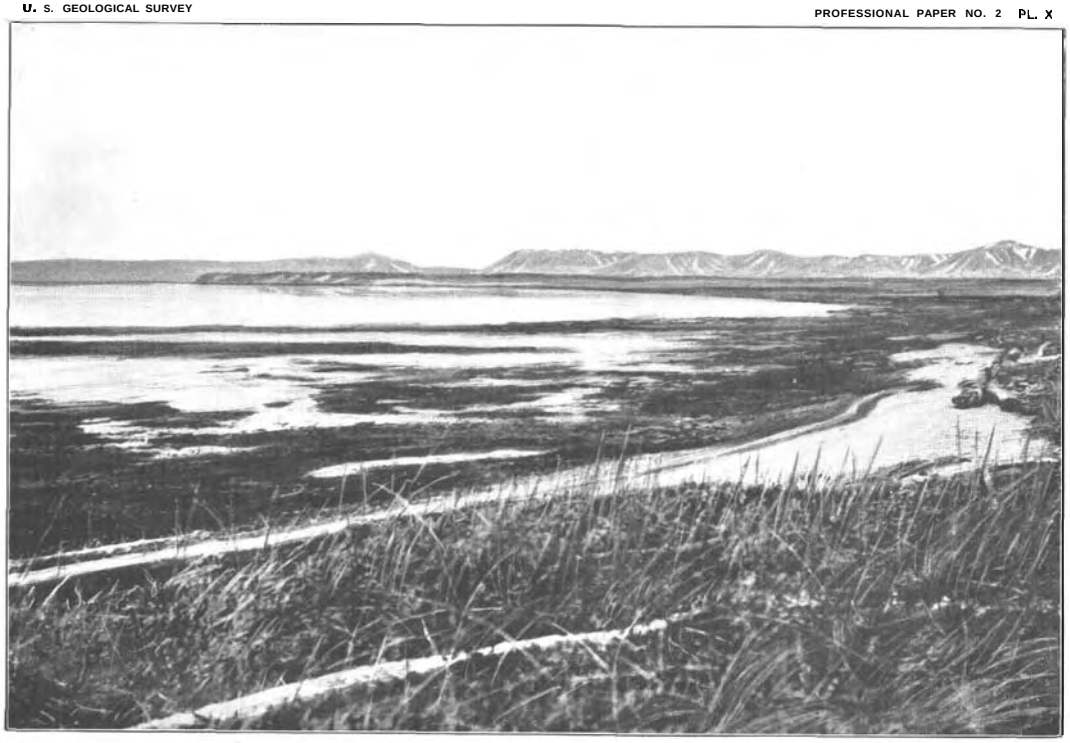
Nuluk River, which, as has been shown, are connected around the northern side of the York Mountains with the York Plateau. Eastward from the great bend of the Ayiapuk River this plateau has not been traced with certainty. The plateau between Grantley Harhor and Imuruk Basin, in which Tuksuk Channel is cut to a depth of about 200 feet, and the plateaus and benches along the Kuzitrin River between the Imuruk and Kuzitrin basins are tentatively correlated with it.

The York Plateau, since its elevation, has been dissected to a base-level by the larger streams which cut across it. The smaller of these streams flow in sharply cut new V-shaped canyons, while the larger streams flow in comparatively broad valleys. An example of the larger valley is shown in the Anikovik Xiver, which has a width of several miles (see topographic map), while its smaller tributaries, such as Deer Creek and Ruhner Creek, are still in sharply cut canyons. In the northern and eastern extensions of the York Plateau the valleys are broader and generally appear to he older. The sharply cut V-shaped valleys are only seen near the foothills of the mountains. Along the northern margin of the plateau the gravels of the Arctic coastal plain extend up the valleys, making it often difficult to draw the boundary between the lowland region and the upland.

In the eastern extension of the York Plateau, south of the York Mountains, the smaller streams flow in very abrupt canyons, with almost perpendicular walls, which interrupt the continuity of the plain, and are discovered only when the traveler stands on their immediate edge. However, Rapid River, the largest stream which crosses this bench, has a broad valley quite similar to that of the Anikovik River. The California River and Tuksuk Channel both occupy sharply cut canyons in plateaus which have been correlated with the York Plateau.

On that portion of the York Plateau which has been called the Cape York bench the plain surface appears to be perfectly developed, but elsewhere there are a number of residual hills, usually at places where the slates are intruded by stocks or sills of igneous rock. Cape Mountain, the largest of these hills, is of this type. It rises in a sharp peak 2,000 feet above the plateau level. It is composed of harder rocks of an older series than the slates to the eastward, raised up and intruded by a large mass of granite. Conical Hill, rising, about 1,000 feet above the plain, is composed of slates similar to those of the surrounding plateau region. Other smaller buttes have been found, when examined, to be composed, in part at least, of greenstone, which seems to be an altered gabbro. On the northeastern extension of this plain there are a few residual hills near the southern margin which were not examined in detail.

Concerning the manner in which the York Plateau was produced it may be said that the Cape York bench, which is an almost perfect plain, was undoubtedly



A SOUTH SIDE OF YORK MOUNTAIN AND BEACH.

B. CAPE MOUNTAIN FROM YORK

produced principally by marine erosion. It was cut in the southern side of the York Mountains by wave action. The main portion of the York Plateau has been regarded by Brooks[a] as of similar origin. Some slight irregularities on the surface of this plateau, which are apparent on more detailed topographic examination of the region, would seem to throw some doubt on this statement. It seems probable that this is in part of subaerial origin. In the northeastern extension of the plateau these irregularities increase, and it seems probable that the plain here was to a greater extent produced by subaerial agencies.

In its elevation to the present level, this plateau has suffered marked deformation, and the proof of differential movement which is afforded has been sufficient to throw doubt upon correlations in the case of widely separated plain surfaces within the region. Rut it has also confirmed the opinion that many of the inland basins of the region owe their origin to such warping. The deformation is most strikingly shown in the marine bench south of the York Mountains, above referred to as the Cape York bench. This bench, which must have been horizontal at the time of its formation. has an elevation of 200 feet at Don River, while 12 miles to the westward the same plain has an elevation of 600 feet. Near the Kanauguk River the York Plateau has an elevation of 800 feet, while at the east base of Cape Mountain the elevation is below 500 feet. The plateau between the California and Agiapuk rivers has an elevation of 500 feet. This plain is located about 10 miles east of the depressed portion of the York Plateau, near the Don River. The benches and plateaus about Imuruk Basin, which have also been correlated with this plateau, have elevations of from 200 to 300 feet.

If these correlations are correct, the York Plateau along its southern edge shows the following variations in level, due to warping: Near Cape Prince of Wales its elevation is 500 feet; 8 miles eastward, near the Kanauguk River, its elevation is 700 feet; 20 miles eastward, at the Don River, it stands at 200 feet; 10 miles eastward, at the California River, it stands at 500, and 20 miles farther east, at Tuksuk Channel, it stands at 200 feet. It has been noted that the plateau surface seems to slope to sea level and merge with the coastal plain. It is impossible to tell, in the present state of information, to what extent this may be due to deformation. The great accumulation of gravel in this region was probably largely derived from the region of the York Plateau, and the fluviatile agencies have here acted more strongly and for a longer time, making the valleys wider and rounding off the upland between them.

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 59.

LOWLAND PLAINS.

The last epoch of erosion is represented by the extensive lowland plains which surround the upland mass. They comprise coastal and valley plains, and in general are covered by unconsolidated Pleistocene deposits. In each case these deposits are probably underlain by even rock floors, representing a period of erosion which preceded subsidence and deposition. It is suggested that in the southeastern part, previous to this deposition, wide valleys were converted into basins by warping. The lowland areas have been already partly described under the heading "Surficial deposits." They are the Arctic and Port Clarence coastal plains and the lowland surrounding Imuruk Basin and occupying the broad valleys of the Agiapuk and Kuzitrin rivers, tributary to that basin.

The Arctic coastal plain extends from Cape Prince of Wales to Cape Espenberg. At Cape Prince of Wales it is not over 5 miles wide, but about Shishmaref Inlet it extends inland for 30 miles to the base of gently sloping hills which rise up to the Kugruk Plateau. To the eastward it appears to cover a large part of the peninsula between Shishmaref Inlet and Goodhope Bay. At its southern margin it is probably nowhere above 200 feet in elevation. The rivers and creeks which flow across it usually have intrenched their channels into the frozen deposits of the plain, sometimes exposing a face of gravel 20 feet high. In being elevated to its present position, this tract is not known to have suffered warping. All irregularities seen by the writer may be attributed to irregular deposition.

The Port Clarence coastal plain is a small gravel-covered plain north of Port Clarence. It has a maximum width of 5 miles, but is usually much narrower. The gravels thin out toward the foothills, where in river sections they are seen to rest on the truncated edges of the limestone bed rock. Westward this plain extends in a narrow strip toward Cape York, where it is interrupted. The plain on which the village of York is bailt is regarded as belonging to the same erosion period as this plain. During the uplift this plain has suffered some slight deformation. At the mouth of the Don River the plain is scarcely above sea level, while at the Teller Mission its elevation is about 20 feet. North of the entrance to Grantley Harbor it appears to dip down and pass below sea level.

VALLEY LOWLANDS.

These are the low-lying plains which surround the Imuruk Basin and occupy the Agiapuk and Kuzitrin valleys.[a] They have a general similarity, and are probably to be accounted for by similar causes. The Imuruk lowland is partly occu ie by the waters of Imuruk Bay. North of the bay the lowland has a width of about 6 miles, but extends farther northward in embayments in the surrounding hills. It is

[a] Reconnaissances in Cape Nome and Norton Bay Regions, Alaska, in 1900, pp. 51 and 62.

apparently connected along the valley of the Agiapuk River with the broad valley lowland about the forks of that river. It extends up the Kuzitrin River, but is not now connected with the extensive lowland basin of that river, a short canyon intervening. Along the northern margin of the Imuruk lowland an older plain similar to the present lowland and standing 20 to 50 feet above it is indicated by some low mesas and buttes. These may, as suggested, represent a general upper plain, or they may be merely portions of the same plain raised by local deformation and so subjected to erosion. The writer is inclined to accept the latter view, although present information is too meager for definite conclusions.

On the north side of Imuruk Bay the coastal plain slopes gradually into the water, and the shallowness of the central portion of the bay suggests that its floor is formed by a depressed portion of the same plain which lies above the water in the surrounding country. In short, it is believed that all of these lowlands are of the same date and that their present relations have been brought about by warping. In the eastern end of the Imuruk lowland there are a number of island-like buttes of bed rock surrounded by the gravels of the lowland. Birch Hill is a typical example of this kind. Its flat top rises above the lowland to an elevation of about 200 feet, and a similar level is reached by several broad hilltops in this region. At the west end of the Imuruk lowland, Imuruk Basin finds outlet to Grantley Harbor through the Tuksuk, a tidal channel which occupies a narrow canyon cut to a depth of 200 feet in an upper bed-rock plain or bench. This upper bench is probably the floor of a higher valley through which the Imuruk waters found their way to the sea before the present levels were established. These upper bed-rock benches about the Imuruk lowland have been correlated with the York Plateau.

Of the Agiapuk lowland little is known by the writer except what may be learned from the topographic map. In general appearance, from the surrounding hills, it resembles the Imuruk Basin with which it connects. Embayments from this lowland extend far up the tributary streams and merge with their flood plains.

The Kuzitrin lowland covers an area approximately 10 by 20 miles, its longer axis parallel with the Bendeleben Range. The portion of this plain lying along the Kuzitrin and Noxapaga rivers is subject to inundation at the time of flood. North of the Kuzitrin River a gravel terrace of about 20 feet in height marks a higher portion of the lowland. The principal settlement of this region, known as Checkers, was formerly located at the junction of the Kugruk and Kuzitrin rivers. Owing to the high water, this location was abandoned and a new town, called Kugruk, was built on the terrace near the Kugruk River, about a mile above its mouth.

Around the western, northern, and eastern sides of the lowland there are broad gravel benches about 100 feet above the present lowland level. Out on the lowland

in many places there are small isolated gravel buttes and hills which are remnants of the same higher plain that is shown in the benches.[a] Whether this upper plain represents a higher water level over the whole basin or is simply a part of the old plain raised up differentially, can not be determined from the evidence in hand.

The basins in which these lowlands occur, it is believed, were first formed as broad erosion valleys during the epoch represented by the York Plateau. In the process of uplift, deformation occurred, forming inland basins in which the lowlands were built up of silts and gravels and the uplifted portions of the valley floor were dissected and are now represented by the 200-foot bench along the Tuksuk and the flat-topped hills around the Kuzitrin Canyon. Since the formation of the lowland plain, a slight subsidence has allowed the sea to invade the Imuruk Basin and slight deformation has raised up portions of the lowland gravels, subjecting them to erosion and forming the gravel mesas and benches above described.

DRAINAGE.

In the upland portions of the region, the rivers flow in deep-cut valleys, while in the lowland portions they meander in shallow valleys trenched to near sea level. In general in the upland portions no readjustment of drainage can be recognized. The present stream courses are inherited from previous physiographic conditions. The few minor changes of drainage which have been noted can here be neglected.

The Agiapuk River, at the place of its emergence upon the York Plateau from the Nuluk upland, presents the most interesting case of deflected drainage observed. Its deflection eastward toward the Agiapuk lowland, through which it flows to Imuruk Basin, is believed by the writer to be due to the warping of the plateau surface while it was yet a lowland. Whether it has ever had an outlet directly southward to Port Clarence can not be certainly determined. If it did have such an outlet, it was perhaps obstructed by the lava flows which occurred in the vicinity, probably near the time of the uplift and warping.

The California River. having a steeper gradient and a shorter course to sea level, has cut a steep canyon in this plateau surface and will probably ultimately capture the upper part of this river and restore it to its former course to the sea.

SUMMARY.

From the above facts and discussion the following conclusions are drawn. There have been four extensive periods of erosion in this region, separated by periods of elevation. These periods of erosion are evidenced by systems of plateaus, benches, and plains named as follows in the order of their formation: The Nuluk Plateau, the Kugruk Plateau, the York Plateau, and the Lowland

[a] See also "Surficial deposits," p. 24 et seq., and economic description of Quartz Creek and Bowlder Creek, pp. 62, 66.

plains. All of these features have been produced since Mesozoic time, for rocks intruded during that period have been planed off along with the others of the region. Each plateau and bench is taken to represent a distinct uplift of the land, and in the process of uplift warping has occurred. In the first period of uplift the warping was considerable, but its amount can not he determined; during the second uplift the warping was insignificant; while during the third extensive deformation occurred. producing basins in which silts and gravels were deposited, forming the valley lowlands. In the latest uplift a small amount of warping occurred, in connection with which a slight local depression permitted the sea to invade the Imuruk Basin. The present drainage adjustment in the region is inherited from the physiographic conditions represented in the earlier erosion periods. The most noticeable case of diversion of drainage is shown by the Agiapuk River, the change in its course being directly traceable to the warping of the York Plateau.

ECONOMIC GEOLOGY.

INTRODUCTION.

The mineral values of the northern part of the Seward Peninsula, like those of the southern part, lie in its placer gold deposits. No quartz deposits of economic importance have been discovered. In the York region considerable placer tin has been found, but up to the present time has not been developed on an economic scale. The region under consideration lies north of the better developed and better known gold fields of Nome. In spite of the fact that many of the creeks in which gold has been found in paying quantities were not discovered until late in the season of 1901, and although the season was very unfavorable for placer mining, this northern district produced about $100,000. Of this gold $20,000 came from Candle Creek,[a] which lies in the region south of Goodhope Bay and east of the area explored by our party. Dr. Cabel Whitehead, of the United States mint, has estimated the product of the placers of the region south of Goodhope Bay at $60,000. The greater part of the area covered in the explorations made the last season is not gold bearing. Of the remainder, a few small, scattered areas have produced some gold on a commercial scale, while colors of gold and undeveloped prospects have been found widely distributed.

DISTRIBUTION AND SOURCE OF PLACER GOLD.

An examination of the economic map (Pl. II) shows that the regions of actual gold production are in creeks and rivers which are tributary to Port Clarence,

[a] A portion of this region is discussed in a report entitled Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by Walter C. Mendenhall: Prof. Paper U. S. Geol. Survey No. 10.

especially the Kugruk, Kuzitrin, and Agiapuk rivers. A little gold has also been found at York.

The source of the gold is undoubtedly in the bed rock, not far distant from the placers where it is found. Though no large reins of commercial importance have been found, there are many small veins and stringers, which are often more or less mineralized, and from these the gold has been derived.

Such mineralization as the rocks of the region exhibit can only occur in areas of deformation where the rocks have been jointed and fractured. In the region under discussion the rocks of the Kuzitrin series and of the Kugruk group present conditions favorable for mineralization, and a comparison of the geologic and economic maps will show that gold-producing areas are in a general way identical with the area occupied by these two groups.

The bed rock of most of the auriferous creeks is made up of the Kugruk beds, but there are some gold-bearing creeks whose courses cut the Kuzitrin series. The inference is that the erosion of the Kugruk rocks contributed most of the gold which is now found in the placers. In any event it can be definitely stated that the Port Clarence limestone is not gold bearing, and it will be a useless waste of time for prospectors to search for placers in the region occupied by these rocks. The placers which have thus far been developed are confined entirely to the stream beds of the smaller creeks, though the larger rivers carry fine gold, which may some time be worked to a profit. There is also a possibility that gold values may be found in some of the gravel terraces, which might be worked by hydraulic methods.

DESCRIPTIONS OF LOCALITIES.

INTRODUCTION.

Since the region promises to be of some importance in placer mining, and since much of it has been prospected, it has been thought best to add the following detailed descriptions of those creeks which were visited by the party. The writer will also include some accounts of adjacent regions, about which reliable information was obtained. It is hoped that these notes, incomplete as they are, will throw some light on the economic possibilities of this region. The placer tin deposits of York will also be briefly considered. The regions described coincide in a general way with the various recording districts, but since the boundaries of the districts are often indefinitely located and are subject to frequent change, no attempt has been made to follow them closely.

CRANTLEY HARBOR REGION.

Under this heading an area will be considered which is tributary to and north of Grantley Harbor. In 1900, colors of gold were found in several creeks

which flow into the harbor from the north, but no mining proper was done." The Bluestone region, which was described in the report cited, and lies to the south of Grantley Harbor, in 1900 produced considerable gold, but during 1901 hardly realized the expectations. The Bluestone Basin lies outside of the region considered in this report.

More or less successful mining has been done on Sunset and Igloo creeks, flowing into Grantley Harbor, and Allene Creek, flowing into the Agiapuk. When the writer visited Sunset Creek on July 14, sluice boxes had just been set up on one claim. Assessment work, represented by drain ditches, crosscuts, etc., had been done at several places, but little could be learned regarding the probable value of the creek for mining purposes. Sunset Creek is about 5 miles in length. In its upper part it occupies a rather deep canyon, while in the lower 2 miles of its course it is only slightly incised in the rolling, moss-covered lowland which borders Grantley Harbor. The bed rock, where it has been seen, consists of fine-grained chloritic mica-schists and very highly altered greenstones, composed almost wholly of secondary minerals, but probably representing basic intrusions in the schists. The schists contain many small veins of quartz. About 4 miles from the coast the creek forks, the larger branch rising on the east side of Mukacharni Mountain, while the west fork rises west of that mountain. This mountain is composed of unaltered basalt, which extends practically to the forks of the creek. At the head of the west fork calcareous schists and limestones, which probably overlie the mica-schists, were found. The relation of these mica-schists and limestones to the Port Clarence limestones, which are well represented a few miles west, was not determined, although all the evidence obtained seems to indicate that they underlie them. If this is true, these rocks should be correlated with the Kuzitrin slates. At the forks of the creek, where sluicing had just begun at the time of the writer's visit, there mas still a great deal of snow in the creek bed and the ground was still frozen to within a few inches of the surface. No exposure of bed rock at this place was seen. It was reported, however, by the miners, that prospect holes made the year before showed 4 feet of gravel carrying pay above a yellow clay bed rock.

Allene Creek heads a few miles southeast of Mukacharni Mountain, about 5 miles from Port Clarence, and flows northward to the Agiapuk River. The creek was visited by Mr. Witherspoon late in September. At the time of his visit one claim only was in operation. All the other claims were shut down for the season, although some mining had been done on several of the claims. The pay dirt was confined to the creek bed and rested on a clay foundation, below which the true bed rock had not been reached. About 3 miles down the creek a prospect hole is reported to have been sunk 65 feet without reaching bed rock. This shaft showed

[a] Reconnaissances in the Cape Nome and Norton Bay Regions. Alaska, in 1900, p. 126.

gravel at the top, below which there was blue clay containing bark and driftwood. The gold in Allene Creek is bright and flaky, not much waterworn. One small nugget was found during the season. The bed rock, consisting of mica-schist and greenstone, which was seen on the north shore of Grantley Harbor, probably extends northward at this place into the Agiapuk drainage, passing underneath the basalts of Mukacharni Mountain.

Sluicing was also done during the season on Igloo Creek, which enters Grantley Harbor a few miles east of Sunset Creek.

Bay Creek marks the eastern boundary of the Port Clarence limestones, which extend to the westward practically all the way to the Kanauguk River. None of the streams which enter Bering Sea from this limestone area are known to the writer to yield placer gold. On the north side of the Agiapuk the Port Clarence limestones, resembling those near Teller Mission, are well developed over a large area, and are probably not gold bearing. The gold-bearing gravels north of Grantley Harbor then will probably be found to be confined to the high land between Grantley Harbor and the Agiapuk, west of Bay Creek. The Agiapuk Valley itself is filled with Pleistocene clays and gravels, probably old lake-bed' deposits, in which placer gold is probably not sufficiently concentrated to be of economic importance. The whole of this area is easily accessible from Grantley Harbor, and is entirely within a radius of 20 miles from Teller. On account of its location, mining can probably be done here at small expense.

Sunset Creek at its forks, 4 miles from the coast, carries sufficient water for sluicing, probably during the whole season. This is probably also true of Allene and Igloo creeks. If hydraulic mining should be attempted, water would probably have to be brought from the California River or the Agiapuk, which would require a long ditch.

PORT CLARENCE AND YORK MOUNTAIN REGION.

Under this heading a region will be discussed which lies adjacent to and drains into Bering Sea, and embraces the southern drainage of the York Mountains and the streams tributary to Port Clarence from the north. With the exception of a few small areas the region as a whole is underlain by the Port Clarence limestone, which has never been found to be gold bearing. The more important streams which have received attention at the hands of prospectors are Mission Creek, and the California, Don, Lost, and Rapid rivers, besides a number of smaller streams whose names were not learned. Of these, as far as known, one of the forks of the Don River alone yielded colors of gold.

About 5 miles from its mouth the Don River forks, the eastern fork being known as Tozier Creek. This creek flows along the western base of a mountain composed of dark slates of the Kuzitrin series. These slates are cut by dikes

of granite, and are often considerably mineralized. They appear in the bed of the creek and in a number of tributaries from the east side. The main creek at this point and several of the tributaries have been extensively staked, and it is probable that colors of gold have been found here, although no development work has been done and no miners were seen. Prospectors seen along the Don River above Tozier Creek reported a failure to find in the gravels either colors of gold or black sand. This is probably also true of all the rivers and creeks named above, with the possible exception of Tozier Creek.

YORK REGION.

That part of the Seward Peninsula lying west of the York Mountains, and including all streams flowing southward into Bering Sea and northward into the Arctic Ocean, is comprised in the York mining district, and was described by Brooks in 1900[a] under the heading "York region." The writer visited the region during July, 1901, but was able to add little of economic importance to the information already in hand. The following description of the topography is quoted from Brooks's report:

"The York region extends westward from the York Mountains to the extremity of Seward Peninsula, an area of about 120 square miles. Its general topography has already been described. It is a plateau about 600 feet in height, bounded on the east by the York Mountains, which rise rather abruptly from the plateau level to elevations of 2,600 feet. Cape Mountain, a sharp pinnacle of like elevation, marks its western margin. A shelving shingle beach, usually not more than 100 or 200 yards wide, lies between the escarpment of the plateau and the ocean. To the north the plateau seems to slope more gently toward Lopp Lagoon. A number of isolated hills rise above the plateau level, which usually have flat tops or are benched at elevations of 1,000 feet. The southward drainage of the region is by a number of streams which have trenched sharply into the plateau surface; those flowing to the north have broader valleys with more gently rising slopes. The smaller tributaries of the main drainage system flow in small but typical canyons. The remarkable evenness and level character of the plateau is very striking; by avoiding the large waterways and making detours around the smaller canyons, a horse and wagon can be driven anywhere on the plateau surface as on a good roadway.

"This plateau surface is probably due to denudation by wave action during a period when the land stood at a lower elevation than it does now. Since its elevation some minor stream adjustments have taken place. . . . A drainage channel once existed which carried the drainage at the head of Kigezruk and Baituk creeks into Anakovik River by way of Deer Creek Valley. The causes of this change in drainage are difficult to discover."

The larger part of the plateau is made up of jointed slates, which have been correlated with the Kuzitrin series. To the west, near Cape Mountain, is a belt

[a] Reconnaissances in the Cape Nome and Norton Bag Regions, Alaska, in 1900, p. 132.

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of white limestone, which probably belongs to the Kigluaik series. Cape Mountain is itself made up of an intrusive granite stock, which is much jointed. The Kuzitrin rocks are overlain to the east by the Port Clarence limestone, which makes up York Mountain. Near the west end of the two series there are some large intrusive masses of greenstone.

The bed rock of the Anikovik River consists of slates in which the original bedding is lost, and jointing and cleavage lead to the breaking up of the rock into pencils and rhombohedra1 forms.[a] These slates contain a number of massive greenstone bodies, which are clearly diabasic in their origin. There are also interbedded some smaller schistose, greenstone sills, whose origin could not be determined. The mineralized portions of these slates were found to carry some gold, which is disseminated in quartz belts. Slates of this type were found extending northward along Grouse Creek and the Mint River to within a few miles of the lagoon, where they pass under the heavy gravel deposits which border the Arctic Ocean.

Buck Creek heads in Conical Hill, a sharp peak rising about 1,000 feet above the general level of the York Plateau, and is composed of slates which do not differ essentially from the slates of the surrounding country. A number of quartz veins, much decomposed and stained with iron, were seen in the slates at its base on the head of Buck Creek. An assay of a sample of this quartz, however, showed no trace of gold.

The Yankee River, a large tributary of the Mint River, heads near Brooks Mountain, the highest of the York group. This mountain is composed, in part at least, of slates similar to those at York, and in part of highly altered crystallized limestones, cut by granite and porphyry dikes. The mountain is almost wholly surrounded by Port Clarence limestones, which form hills on both sides of Mint River Valley several miles below the head of the river. The river occupies a broad, gravel-filled valley, in which there are no exposures of bed rock until, near the junction with the Mint River, the Kuzitrin slates are again exposed. The western branch of the Pinguk River, known as the York River, also heads in the slates of Brooks Mountain, and has cut down to the slates through nearly all its length until it enters the gravel-covered area near the Arctic Ocean.

Gold.—The discoveries of more promising deposits in other parts of the peninsula had drawn away many of the prospectors whom Brooks found at York in 1900, and the backwardness of the season had delayed mining operations. In the whole district sluicing was in progress on only one claim. The entire district during the summer of 1901 probably produced less than $200 in gold. Several creeks flowing into the Arctic Ocean, which were not visited by Brooks in 1900, were found to carry colors of gold, but no sluicing was done.

[a] See also Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 133.

Grouse Creek, a tributary of the Mint River, is the most important stream flowing northward in the district. This creek is trenched in the plateau surface to a depth of from 100 to 300 feet, but for a great part of its course flows over gravel bars which occupy its bed, and at the present time the creek is broadening rather than deepening its valley. The eastern tributaries of Grouse Creek generally head in the York Mountains, and are largely filled with gravels composed of limestone, with some greenstone, the latter derived from the intrusives in slates near the base of the mountains. The western tributaries of Grouse Creek flow wholly within the slates, and offer more inducement to the prospector. Colors of gold have been found in Buck and Gold creeks, and prospectors were doing assessment work on the former at the time of our visit. A drain ditch 100 feet long had been cut near the mouth of the creek, and other developments were being made on some of the tributaries. In this ditch good prospects had been found. The gold was in rounded grains identical in character to the gold of the Anikovik River and Buhner Creek, which flow southward in the region. Well-rounded fragments of magnetite were found associated with the gold.

Tin.—During his examination of the York region Brooks's attention was called to stream tin[a] (cassiterite), which the miners had found in their sluice boxes but had not identified. This mineral was associated with garnets, magnetite, gold, and other heavy minerals in the sluice boxes. The source of the tin placer he was not able to determine, but believed that it was in the bed rock of the immediate vicinity of the placers. At the time of the writer's visit to this district mining operations had scarcely begun. There were, however, a number of prospectors who had only learned a few days before, from a bulletin sent in by Mr. Brooks, that the heavy mineral found in the sluice boxes was of possible economic value. Considerable prospecting for tin was done after this time, the details of which are not definitely known. It is reported that stream tin has been found by prospectors in nearly all the streams northeast from York for a distance of about 20 miles. The streams mentioned as carrying placer tin are the Anikovik River and all of its tributaries, the Kanauguk River, Baituk Creek, Kinzuk Creek, and Lagoon Creek, flowing into Bering Sea, and Grouse, Buck, Yankee, Mint, and York creeks, flowing into the Arctic Ocean. The York River, the western branch of the Pinguk, is said to be very rich in placer tin.[b] Gravel deposits, yielding from an ounce to a pound of tin to the pan, are reported to have been found. Pebbles of magnetite, worn smooth and having a luster resembling that of the tin, occur associated with and are often not easily distinguished from the darker forms of the cassiterite. This iron, being quite generally distributed through the placers

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 136; and An occurrence of stream tin in the York region, Alaska: Mineral Resources U. S. 1900, pp. 267–270.

[b] For this information the writer is indebted to T. B. Fish, of York.

of the region, may have been in some instances mistaken for cassiterite by the prospectors.

Tin veins, where found in other parts of the world, are usually associated with intrusions of granite or other acid igneous rocks. However, in Cornwall they are sometimes found in the slates adjacent to the granite. Wherever found the wall rocks are altered by mineralizing solutions, and are often impregnated with cassiterite. Where such veins occur in granite the important ore bodies are often found to consist of this altered wall rock, the feldspar of the granite being replaced by cassiterite."

No acid eruptive rocks have jet been found within' the drainage area of the Anikovik River. There are large intrusive masses of greenstone, which are probably gabbros, at the head of this river and also on some of its eastern tributaries. Sills of schistose greenstone, whose origin is obscure, but which are probably altered basic intrusives, occur distributed through the slates of the York region. The stream tin may be associated in the bed rock with these basic intrusives, though such an occurrence would be unusual. Tin-bearing veins of a type similar to ordinary silver and copper-bearing veins may occur in the slates of the York district, and so account for the distribution of the placer tin.

The region about York in which the Anikovik River and other tin-bearing streams are located has, in recent geologic time, been reduced to a plain, possibly in part by wave action and in part by subærial erosion.[b] At this time a considerable thickness of rock strata was undoubtedly removed by erosive agencies, and the heavier constituents of these rock masses must have been more or less concentrated upon the plain surface. Subsequent to this base-leveling the York plain has been elevated to a plateau, which has been dissected by the creeks and rivers of the region. That the elevation of this plateau is an occurrence of comparatively recent geologic time is shown by the fact that the smaller creeks flow in sharply cut V-shaped canyons, and have scarcely begun to broaden their valleys. As these valleys and canyons are developed, the heavier materials of the surface are naturally reconcentrated in them. If during the base-leveling period the heavier concentrates of the erosive agencies were transported to any extent from their original sources, and if they are again concentrated in subsequent creek beds, they may be found removed some distance from their original sources. It is possible that the rocks from which they came may in some instances have been wholly removed, leaving no evidence in the present bed rock to show what they may have been.

Waterworn pebbles and bowlders of gabbroic greenstone of the type which forms large masses about the head of the Anikovik River are common in the

a Genesis of ore-deposits, by F. Posepny: Am. Inst. Min. Eng., 1902, p. 139.
b Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 132.

beds of the Anikovik River and Grouse Creek. These bowlders are frequent along Buhner Creek, where the tin was first found. No rock of this character has been found in the bed rock within the Buhner Creek Basin, or indeed within 5 miles of Buhner Creek. There is no evidence that these bowlders were transported to their present place otherwise than by being rolled along with currents of water. The possibility of their being floated on shore ice at some time of submergence must be considered. The wide distribution of the stream tin in this region, together with the fact that pebbles and bowlders of known origin have been widely distributed independently of the present drainage, suggest at least that the original source of the stream tin may be some distance from the present deposits, and is not necessarily to be found within the present drainage of the streams where it occurs.' Acid igneous intrusions, such as cassiterite veins, are usually associated with, are found in Cape Mountain and Brooks Mountain. The slates of Brooks Mountain have suffered great metamorphism. The York River, which is reported to be very rich in tin, heads in this mountain and carries granite pebbles and bowlders, which suggests that the tin had its origin near the granite contact. The wide distribution of this mineral in the creeks of the York district justifies the belief that the veins from which it is derived will yet be discovered.

ARCTIC REGION.

The Arctic recording district includes the drainage of the Arctic Ocean between the Mint River and Shishmaref Inlet. The old recording office of the district, which was located a few miles west of Ear Mountain, at the junction of Tuttle Creek with the Kugruk River, has been abandoned. The general area included in the Arctic district will, however, be described in this report under the heading "Arctic region." It includes a number of rivers and creeks which flow northwestward into the lagoons bordering the Arctic Ocean. The three largest of these rivers are designated on the map by the native names, Pinguk, Nuluk, and Kugruk.[a] All of these rivers have received attention from prospectors, and during the early part of the season of 1901, at the time of our visit, a mining camp was located on Tuttle Creek, one of the tributaries of the Kugruk. So far as is known to the writer, however, no discoveries of valuable placer deposits were made. Adjacent to the shore is a belt of low-lying coastal plain which is dotted over with small lakes and underlain by thick layers of gravel, but in which no bed rock is exposed. Back of this coastal plain there is a gently rolling plateau standing 400 to 500 feet above the sea, and more or less dissected by streams and river valleys. This upland plain is the continuation of the York Plateau. It is terminated to the south by more abrupt slopes rising to higher hills.

[a] There are two other rivers of this name in the northern part of the Seward Peninsula.

Pinguk River.—This river flows into a lagoon about 30 miles northeast of Cape Prince of Wales, and has a serpentine course over the gravel of the coastal plain in its lower stretch. About 10 miles from the sea the river forks, the western fork being called the York River, the eastern being known as the McKillop River. The York River heads at the eastern end of Brooks Mountain, and flows northeastward to its junction with the McKillop River. In crossing the plateau above mentioned it occupies a valley from 200 to 300 feet deep. Along this valley slate bed rock is exposed through part of the distance, at least, and the stream gravels contain pebbles of slate derived from the Kuzitrin series as well as limestone derived from the Port Clarence limestones. It is reported that stream tin has been found in this river, with but little, if any, gold. No development work had been done on this river at the time of the writer's visit early in August.

McKillop River rises in the limestone hills which form the eastern extension of the York Mountains. Its valley is cut almost wholly in limestones of the Port Clarence formation, and it is not known to have yielded colors of gold.

Nuluk River.—This river enters the lagoon 40 miles northeast of Cape Prince of Wales. It heads in the high mountains made up of the Port Clarence limestone about 35 miles south of the Arctic Ocean. For 15 miles from its head the river occupies a canyon, varying from 100 to 1,000 feet in depth, cut in these Silurian limestones. Fossils of the same age as those north of Port Clarence were found about the head of the river. Northward along its course the character of the bed rock changes, and calcareous mica-schists are found. The Silurian limestones dip toward the schists, and near the contact with them are very highly folded. These schists are believed to overlie the limestones.

The coastal plain gravel extends inland farther along the Nuluk River than it does on the other rivers of this region. No colors of gold are known to have been found in the gravels of the Nuluk River or of its tributaries. The unaltered limestones through which it flows do not contain mineralized veins, and are not promising as sources of placer gold.

Kugruk River.[a]—This river enters the lagoon about 45 miles northeast of Cape Prince of Wales, and lies almost wholly within the coastal plain gravels and the York Plateau. Its source is about 25 miles from the sea, but it has a number of tributaries from the northeast side, which give it a comparatively large drainage area.

The bed rock about the river's head is limestone and calcareous schist, with some intrusive greenstones. The river and its tributaries have cut valleys from 200 to 400 feet deep in this bed rock. These limestones are probably in part Silurian,

[a] It should be noted that there are two other riven of this name in the region.

but they are more highly crystalline than the Port Clarence limestone, and their exact relation to that formation was not determined.

The bed rock along the Kugruk River seems promising for placer gold. Many claims were found staked along it and its tributaries, although very few prospectors were seen in the region. It is not known to the writer that gold has been found along the river.

Tuttle Creek is a northern tributary of the Kugruk River, about 10 miles from the mouth. The creek heads on the north side of Ear Mountain, and has cut a rather narrow valley in the plateau which surrounds the mountain. During the summer of 1901 Tuttle Creek was the scene of a small excitement caused by reports brought out the year before. About 50 men visited the creek during the course of the summer. Colors of gold and small nuggets are reported to have been found in the gravels, but the creek was practically abandoned before the end of the season. Through much of its length the creek meanders over gravel flats with no bed-rock exposures, but about 5 miles from its head dark quartzite or slate bed rock outcrops. This quartzite extends to the head of the creek at Ear Mountain, contains large intrusions of granite, and is more or less metamorphosed by them. The stratigraphic relations of these slates could not be definitely determined. In lithologic character they resemble Kuzitrin rocks, and are regarded by the writer as belonging to that formation.

Other streams.—Between the Kugruk River and Shishmaref Inlet there are several small streams, none of which were visited by members of the Geological Survey party. It is not known that any of these have yielded colors of gold.

Quartz veins.—The dark slates in which the granite of Ear Mountain is intruded are often cut by small veins of quartz more or less mineralized. A specimen taken from a slide in the bank of Crosby Creek, about 3 miles south of Ear Mountain, consisted of glassy quartz and large crystals of pyrite. It was assayed by Dr. E. T. Allen, of the United States Geological Survey, and showed a trace of gold.

SHISHMAREF REGION.

The Arctic drainage of the region lying east of the Arctic district will be considered under this heading. The name is taken from Shishmaref Inlet, which is the deepest embayment on the northern coast line of the peninsula. The region all lies in the Goodhope recording district, which also embraces a considerable area to the east, outside of the region surveyed by our party.

This district includes the drainage of Shishmaref Inlet and the western drainage of Goodhope Bay, together with the peninsula lying between them on which Devil Mountain is situated. As far as known to the writer no gold has been found in this district east of Shishmaref Inlet.

With the exception of Devil Mountain, the region between Shishmaref and Goodhope Bay is low and flat. It was not explored by members of the Geological Survey party, and little is definitely known of it. The surface, as viewed from Ear Mountain and Midnight Mountain, appears to be an erosion plain slightly elevated above sea level, above which rise a few low dome-shaped buttes. The topography of these buttes suggests that the bed rock is composed of schist and limestone. Devil Mountain rises about 600 feet above the general level, and is a ridge with a northwest trend, and has on its summit a number of jagged crags. Kotzebue, who named the mountain, compared its irregular crest to a ruined castle. These rocks are probably outcrops of granite similar to that of Ear Mountain.

The rivers flowing into Shishniaref Inlet have received considerable attention from prospectors. A recording office and Shishmaref post-office are located on Sarichef Island, at the northeastern entrance to Shishmaref Inlet. The writer was informed by Charles W. Mashburn, the deputy recorder of the district, that there is a good harbor for small coasting vessels at this place, and that the Serpentine, the largest river of the district, is navigable for small steamers for at least 20 miles inland. Kotzebue reported 8 fathoms of water at this entrance. Shishmaref Inlet is bordered by a wide coastal plain, made up of gravel, from the margin of which a dissected erosion plain slopes upward to an elevation of 500 to 1,000 feet. Ear Mountain, Kugruk Mountain, Midnight Mountain, and Devil Mountain, rising above this plateau, mark the limits of the Shishmaref drainage. The Serpentine and Arctic rivers are the two most important streams of the basin.

Arctic River.—The Arctic River rises south of Ear Mountain, has a length of about 25 miles, and flows into the west side of Shishmaref Inlet. Southeast of Ear Mountain the course of this river is in a broad basin containing a number of small lakes. Below this basin the river has cut a well-defined canyon. Viewed from the surrounding hills the basin appears to be an old lake bed. A broad, flat divide, which has what appears to be an abandoned river channel across it, separates this basin from the drainage of the Kugruk River of the Arctic region.

The bed rock is highly crystalline limestone and calcareous schists, with occasional highly altered greenstones. Veins and stringers of quartz are frequent. These limestones and calcareous schists were found within a short distance of the slates of Ear Mountain. If, as seems probable, they overlie these slates, they are to be correlated in part with the Port Clarence limestones. Their highly altered condition, however, in the absence of definite stratigraphic evidence, makes this correlation doubtful, and they have therefore been mapped with the more indefinite Kugruk group of schists and limestones.[a]

[a] See description of the Nome series, pp. 21–24.

Many of the tributaries of Arctic River have been staked, and colors of gold are reported to have been found. At the time of the writer's visit, in August, all of the prospectors had left the river.

Serpentine River.--This is the largest river of the district. Heading near Midnight Mountain, about 35 miles from Shishmaref Inlet, it flows into that inlet by a very sinuous course, from which character it receives its name. The river was first explored and named by Charles McLennan, who, with dog team and Eskimo assistants, made a trip into the region from Shishmaref Inlet in May, 1900. McLennan was probably the first white man to reach the hot springs on Spring Creek, a tributary of this river. He staked a number of claims along this creek, and prepared a map of the region, a copy of which was received in Washington in March, 1901. In September, 1901, the writer found a small settlement at the hot springs, but no trace of the claim stakes set up by McLennan the year before remained. A small garden had been made on some of the ground near one of the springs, and vegetables, consisting of lettuce and radishes, had been grown without difficulty.

The bed rock of the Serpentine River Basin above the coastal gravel belt consists of dark graphitic and feldspathic mica-schists, which form Midnight Mountain, and of crystalline limestones and mica-schists of the Kugruk group. The relations of the dark schists to the limestones were not determined, though they are regarded as belonging to the Kugruk series. In the vicinity of the hot springs these dark schists have been intruded by extensive granite masses, forming a large area of granite. This granite outcrops in needles and pinnacles, produced by weathering along a double set of joints.

Colors of gold are reported to have been found on a number of the tributaries of the middle fork of this river, and in September a number of miners were preparing to winter' in the neighborhood, the principal settlement being at the hot springs. In the season of 1901 development work preparatory to mining was reported on Schlitz, Bella, and Bryan creeks. No gold in commercial quantities has yet been taken from any of these creeks, and owing to the limited amount of time at his disposal the writer was unable to visit them.

Two routes of travel are used by prospectors entering this region overland. The first is from Teller to the junction of the Agiapuk and American rivers, thence up the American River and Portage Creek to the divide, and around the north end of Kugruk Mountain. The second is from Nome or Teller by way of the Kugruk River and Macklin Creek. This creek heads within a short distance of the head of the Serpentine River. The first of these routes is used for travel with dog teams in the winter; the second is more generally traveled in summer.

Along Spring Creek for a distance of about half a mile there are hot sul-

phur springs. Two of these, the upper and lower ones, were visited by the writer. The upper spring is on the banks of the creek, probably above any except the highest floods. The spring is in the center of a broad mound, 10 feet in diameter and perhaps 2 feet high, built up from material precipitated from the spring water. The temperature of the water is about 212°. The lower springs are below the high-water mark of the creek. The amount of water is not over 1 miners' inch. For some distance around the spring the ground is warm, making it an ideal place for wintering in that climate.

AOIAPUK REGION.

The Agiapuk, flowing into Imuruk Basin from the north, drains an area of from 800 to 1,000 square miles in the center of Seward Peninsula. The river forks about 20 miles north from Imuruk Basin, the eastern and larger branch being called the American River by the prospectors, while the western branch retains the name Agiapuk. Below the forks the Agiapuk River makes many meanders on a broad flood plain, from which the upland rises by gentle slopes to flat-topped hills with elevations of 600 to 800 feet.

The western branch occupies a broad depression which for about 20 miles extends parallel with Grantley Harbor and Port Clarence, from which it is separated by an upland of about 1,000 feet elevation. Near its western end this depression has an altitude of about 500 feet, and is about 5 miles wide. The California River drains a part of this depression through a new, deep-cut canyon. The depression is limited on the north by flat-topped mountains, which rise to elevations of 1,000 to 1,800 feet. The main part of the Agiapuk River emerges from a comparatively narrow valley in these mountains into this depressed area.

The Agiapuk Valley below the forks is filled with flood-plain gravels. These gravels extend up the river, and fill the depression above described. It is reported that a shaft has been sunk near the mouth of Allene Creek to a depth of 60 feet through gravel and clay containing driftwood, etc. These gravels probably occupy a depression which has been at some time either a lake or arm of the sea and filled with sediments. Where the upper end of the depression is cut by the California River bed rock is exposed in some places. Schists and limestones with later basalts are exposed in the upland lying between the Agiapuk and Grantley Harbor. These have already been described in connection with the Grantley Harbor region.

North of the Agiapuk the bed rock, as far .as known, consists of Silurian limestones of the Port Clarence formation. These limestones are comparatively unaltered and are generally not mineralized to any extent.

It has already been shown that some of the streams flowing into Grantley Harbor from the north carry gold. No promising prospects of gold are known

to have been found in the tributaries which enter the Agiapuk from the north side. The unaltered and unmineralized character of the bed rock is not favorable for the occurrence of gold.

American Riser.—The American River is the eastern and larger fork of the Agiapuk. It joins the Agiapuk River in a broad, gravel-filled basin, and for 20 miles up is characterized by a wide flood plain and a meandering course. It receives a number of large tributaries from the east, which also have wide flood plains developed in their lower parts. The important tributaries are Portage Creek, Budd Creek, and Igloo Creek, while smaller tributaries are Burke, Gold Run, Dome, and Camp creeks. All of these tributaries have received some attention from prospectors. The river is easily navigable for small boats for several miles above the mouth of Portage Creek, and the region can also be easily reached by pack train from Teller.

During our brief stay in this region in the latter part of August no mining was being carried on, and but few prospectors were seen, although gold had been discovered in the region in September of the previous year, and a number of the streams[a] are known to be gold-bearing to some extent. Some assessment work, consisting of prospect holes and crosscut ditches, had been done earlier in the summer.

Above Portage Creek the American River has an east-west course for about 20 miles. This part of the river was not examined by the writer, and no discoveries of gold are known to have been made. The bed rock at the head of the river consists of the limestones of the Port Clarence formation. These limestones are little altered and are not mineralized to any extent, and are probably not productive of placer gold. At the mouth of Portage Creek, where this river was examined, the bed rock consists of calcareous mica-schists and limestones, which are more promising as a source of placer gold. The bed rock between these points is not known, although the topography suggests the extension of the Port Clarence limestones for some distance down the stream.

Portage Creek heads about 15 miles southwest of Shishmaref Inlet, and flows eastward for several miles in a canyon cut, in the pleateau which slopes down to that inlet. It then turns southward and flows in a comparatively deep valley for 10 miles, to its junction with the American River. Through the last 5 miles before entering the American River a broad flood plain is developed, within which the creek has a very sinuous course.

Along Portage Creek limestones and calcareous mica-schists, with occasional beds of graphitic schist, constitute the bed rock. Prospect holes and one crosscut ditch 100 feet long were seen, but no active mining was in progress.

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 125.

Budd Creek enters the American River from the east, about 6 miles below Portage Creek. It is 15 to 20 miles in length. About 3 miles from its mouth it receives a large tributary, Windy Creek, from the south .side. About 10 miles above its mouth it forks, the two parts coming from the north and south, their direction being determined by the strike of the bed rocks.

The bed rock on Budd Creek is composed of crystalline limestones, calcareous mica-schists, and graphitic schists, usually striking in a north-south direction, and having dips varying from 0° to 70°. Kugruk Mountain, a few miles east of the forks of Budd Creek, is made up of quartz-mica-schist, which has been thrown up into an anticline. Below the forks the creek sinks, leaving its bed dry except in times of high water. After flowing underground for about 2 miles, the creek rises again in a number of springs. This sink occurs where a massive bed of limestone, dipping downstream at a small angle, cuts across the creek.

Windy Creek is tributary to Budd Creek from the south about 5 miles from its mouth. This creek is about 5 miles long and flows nearly north, parallel to the strike of the bed rock, which consists of more or less flaggy beds of limestone, between which there is a strata of graphitic schist that outcrops along nearly the whole length of the creek. Near the head of the creek its bed contains many bowlders of greenstone, which are derived from sills intruded in the limestone near its head. The valley of Windy Creek is broad and gravel filled. Along the sides of the valley, back from the creek bed, the gravel extends up the slopes, forming some well-marked gravel benches., A cut bank of the creek shows 6 feet of muck overlying 6 feet of gravel. Prospecting has not reached bed rock.

Along the upper parts of Budd Creek many claims have been staked, and assessment work, consisting of prospect pits and crosscut ditches, has been done in a number of places. Windy Creek is staked by one company 'for about 3 miles of its length. No prospectors were seen on Budd Creek or its tributaries, and no active mining has been done. This creek carries sufficient water for sluicing, except at the places where it sinks in passing over limestone. The same is true of Windy Creek, the large southern tributary.

Igloo Creek, also calied on some maps Lewis Creek, enters the American River a few miles above its junction with the Agiapuk. This creek, like Budd Creek, flows west across the strike of the. bed rock, which, as on Budd Creek, consists of limestones, calcareous and graphitic schists, with some intruded sills of greenstone, which are highly altered. Like Budd Creek, Igloo Creek sinks for about a mile of its course, probably in crossing the same bed of limestone that causes the sink on Budd Creek. In its lower course Igloo Creek meanders over a broad flood plain, from which the hills rise by very gentle slopes to the flat-topped upland.

Practically all of Igloo Creek and its tributaries have been staked, but little evidence of prospecting or assessment work and no active mining was being done. Colors of gold have been found on the creek, but the exact localities are not known to the writer. Igloo Creek, except where it sinks in passing over limestone beds, carries a large amount of water, which is ample for mining the creek bed on a large scale at all seasons.

The Mary River has a length of about 20 miles, flows into the upper end of Imuruk Basin, and is included in the Agiapuk mining district. About 5 miles from its mouth the river forks, the two branches being of about equal size. The lower part of the course of the Mary River is within the flats which border Imuruk Basin. Above these flats the valleys of the two branches of the Mary River are wide, and within them the rivers meander over broad flood plains. Between the forks of the river there is a broad, flat-topped ridge, with an elevation of 700 feet, and partly covered with washed gravel.

At the edge of the Imuruk lowlands, where the Mary River enters them, there are gravel bluffs and isolated gravel buttes. These bluffs and buttes are remnants of a higher gravel plain.

On the ridge between the forks of the Mary River there are two low, rocky buttes, which, on account of the general low relief of the region, stand out as landmarks. These buttes are composed of white crystalline limestone, whose bedding is obscured by jointing and cleavage. Except for these buttes the bed rock, as indicated by fragments found on the surface, consists of calcareous mica schists, whose horizon was not determined. The Kuzitrin slates form a broad belt of dark schistose quartzites between the Mary River and the Kuzitrin at Marys Igloo. About the heads of the two branches of the Mary River the hed rock consists of calcareous and graphitic schists similar to those on Igloo and Budd creeks, tributaries of the American River. Little bed rock is exposed on the Mary River.

Gold is not known to have been found on this river, and but little or no prospecting has been done. The bed rock is of a highly altered character and promising for placer gold, but the great thickness of gravel along the stream and the uncertain depth to the bed rock render it doubtful if gold will be found in paying quantities.

KUZITRIN BASIN.

The basin of the Kuzitrin River lies in the southeastern part of the region under discussion. This river has a southwesterly course and flows into the upper end of Imuruk Basin. It drains the northern slopes of the Bendeleben Mountains, and receives a number of large tributaries from the north, of which the Kugruk is the largest. The Kruzgamepa, which joins the Kuzitrin about 20 miles from tide water, flows through the broad depression between the Kigluaik and

Bendeleben mountains, and receives the drainage of the southern slopes of the Hendeleben Mountains.

The drainage basin of the Kuzitrin River has produced placer gold in a number of widely scattered localities, and its placers have been more or less exploited since the winter of 1899.[a] It was originally divided into two recording districts, the one known as the Kugruk district including the drainage of the Kugruk River below the mouth of that river, while the other, known as the Kuzitrin district, includes all the drainage of the Kuzitrin above the mouth of the Kugruk. From the head of Imuruk Basin to Marys Igloo, a distance of about 20 miles, the Kuzitrin River has no well-defined channel, but flows through a succession of small lakes or sloughs with many low islands between. This part of the river is called Kaviruk by the natives, and is, in fact, the delta portion of th'e Kuzitrin and Kruzgamepa rivers. Small steamers ascend the river to Marys Igloo, where is the first rapid and the limit of tidal influence. From Marys Igloo to the mouth of the Kugruk the river occupies a broad canyon cut in the upland. Through this canyon the river has long stretches of comparatively quiet water with small rapids between. The total fall in this distance does not exceed 100 feet. Above the mouth of the Kugruk a low, gravel-filled basin extends to the northeastward for a distance of 20 miles, with its longer axis parallel to the Bendeleben Mountains. In this basin the Kuzitrin River and its tributaries meander extensively. The southern tributaries of the Kuzitrin, before entering the lowland, emerge from deeply cut valleys in the Bendeleben Mountains, while the northern tributaries occupy canyons cut in a high plateau to the northward. The largest northern tributaries are the Kugruk and Noxapaga rivers.

The production of the whole drainage basin of the Kuzitrin River did not exceed $35,000 during the season of 1901. This amount is considerably less than the estimated product for 1900. The decrease in the production is due to the exhaustion, during the previous season, of certain shallow deposits of rich pay dirt and to the unusual shortness of the season of 1901, which did not permit the completion of systematic development work.

Along the Kuzitrin River below the mouth of the Kugruk the bed rock, wherever exposed, consists of the black slates and schists of the Kuzitrin series and the biotite-schists and granites of the Kigluaik series. No gold has been obtained in this part of the district.

Quartz Creek was visited by Brooks in 1900 and is described in detail in the report of that season's work.[b] The creek occupies a narrow valley, cut to a depth of 50 to 100 feet in a high gravel plain west of the Kugruk River.

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, pp 119–125.
[b] Idem, p. 121.

Dahl Creek is an important tributary from the south, about 6 miles above the mouth of Quartz Creek. The village of Quartz Creek is located at this point. During the summer of 1900 gold was found in the creek bed nearly throughout its whole length. At the time of the writer's visit to the creek, in September, 1901, nearly all the workings, except those near the mouth of Dahl Creek, had been abandoned or suspended for the season. Every claim on Dahl Creek for a distance of 1 mile from its mouth was being worked. The excavations along the creek show great irregularity in the deposition of the gravel below the creek bed. Streaks of reddish gravel, showing cross bedding interbedded with layers of clay and muck, often containing vegetable matter, make up the sections exposed. These irregular gravel streaks are often found to be pay streaks. In the bottoms of the pits a thicker layer of gray, gravelly hardpan was found *to* carry good values in coarse gold. On claim No. 2 on the left bank of Dahl Creek the section from the surface down was as follows:

Section on Dahl Creek.

	Feet.
Muck	6
Reddish gravel, showing cross bedding	4
Gray hardpan gravel.	

The gray gravel consists almost wholly of white quartz pebbles, cemented together with a whitish clay. This layer carried gold to a depth of 6 feet, as far as it had been tested. The bed rock had not been reached in any of these mines, although excavations have been made to a depth of about 9 feet below the creek bed.

An upper pay streak has been found near the mouth of Dahl Creek, about 50 feet above the level of the creek and 100 yards back, where a man with a rocker was working at the time of our visit. An excavation, about 50 by 100 feet and 2 to 3 feet deep, showed a gray, gravelly hardpan, similar to that in the bed of Dahl Creek. The gravel lying immediately above this hardpan was rich enough in gold to pay for rocking.

A thick layer of frozen muck generally overlies the gravel along the creek. In this layer mammoth and horse bones have been found together with the trunks of large trees.

No bed rock is exposed within the workings on either Quartz or Dahl Creek. On the hill east of Dahl Creek fragments of a highly altered mica-schist were found, which probably were not far from their bed-rock sonrce. The high ground between Dahl and Coffee creeks has no exposures of bed rock, although fragments of mica-schist are often found on the surface, and it is not probable that the gravel in which Quartz Creek is cut mantles over this hill.

Coffee Creek enters the Kugruk River immediately below the mouth of Quartz Creek. It resembles Quartz Creek in general character. In its lower course it

flows in a sharply out canyon across the same high gravel plain. About 5 miles up, however, at the point where the wagon road from Lanes Landing to Quartz Creek crosses, the bed rock, consisting of a highly altered mica-schist, is probably near the surface. Some successful mining is said to have been done along this creek during the summer of 1901. This work had been suspended, however, at the time of the writer's visit in September.

Quartz Creek and Coffee Creek seem to carry considerable gold disseminated through a large amount of gravel. The deposits of gravel which can be worked successfully by the methods of mining now in use are probably of limited extent, so that more refined and economical methods will have to be ultimately adopted. Water for hydraulic purposes can probably be brought in a ditch from the head of Windy Creek, a distance not exceeding 10 miles. Brooks called attention to the probable occurrence of gold in gravels of the bench in which these creeks have incised their courses. These may possibly be worked by hydraulic methods. During ordinary seasons these creeks all carry sufficient water for mining by the methods now in use.

The Kugruk River is a large northern tributary of the Kuzitrin. It has a length, neglecting meanders and minor bends, of about 60 miles. Throughout the greater part of its course it occupies a canyon cut in a high plateau-like upland, which varies in elevation from 1,200 to 1,800 feet.

About 10 miles above its mouth the Kugruk River emerges upon the Kuzitrin lowland from its canyon. The course of this canyon is approximately north and south for 30 miles, and follows in a general way the strike of the bed rock. Below the mouth of Coarse Gold Creek the canyon is sharply out, and no gravel benches or extensive gravel bars were observed in the creek bed. Above Coarse Gold Creek the valley broadens. At this place there are broad benches, about 20 feet above the river bed, cut on the upturned edges of the schists, and covered with several feet of gravel. Similar gravel benches occur occasionally as far as the mouth of Taylor Creek, above which point the creek bed was not examined in detail. At the mouth of Macklin Creek the Kugruk River turns sharply, and above this place it flows in an east-west direction from its source at the east base of Kugruk Mountain.

The bed rock along the Kugruk River is generally highly metamorphosed, consisting of mica-schists and calcareous schists, with large intrusions of greenstone. The greenstone is schistose, but has a porphyritic texture, the phenocrysts being hornblende, while the groundmass is made up essentially of epidote, hornblende, quartz, and chlorite, mostly secondary minerals.

Colors of gold are reported to have been found pretty generally distributed in the gravels along the Kugruk. Good prospects of placer gold and some mining are reported on Windy, Neva, North Fork, Coarse Gold, Henry, Taylor, and Macklin

creeks, tributaries of the Kugruk River. Many smaller tributaries have been staked to some extent, but of them the writer has no personal knowledge.

Windy Creek is a large tributary of the Kugruk River from the west. Its source is near that of Igloo Creek, which is tributary to the Agiapuk. Windy Creek flows across the strike of the bed rock in a deep canyon, cut in the Kugruk Plateau. The gravels seen at the mouth of this creek consist of greenstone, limestone, and mica-schist. The bed rock along the creek is reported to be a series of limestones and mica-schists.

Sluicing is reported to have been carried on for about two weeks on No. 14 on this creek, and developments made on a number of claims preparatory for work next season. Windy Creek carries sufficient water for ordinary mining purposes.

Neva Creek is a short tributary of the Kugruk River from the east side, about one-fourth of a mile above the mouth of Windy Creek. The bed rock at its mouth is gray mica-schist, highly metamorphosed. Sluicing was done in shallow gravels near the mouth of the creek during the summer. At the time of the writer's visit the camp was deserted, although the sluice boxes and canvas hose were still in position.

North Fork is a large tributary of the Kugruk River from the east, about 10 miles above Windy Creek. Harris Creek flows into North Fork about 4 miles from its mouth. The original discoveries of gold in the Kugruk region were made on Harris Creek, but during the season of 1900 it produced little gold. The writer was unable to visit the workings on this creek, but received the following information in regard to it from a prospector. Mining was in progress during September, 1901, on claims Nos. 4 to 10, inclusive. The creek cuts across the strike of the series of limestones and schist.. At claim No. 11 the creek enters a limestone belt and sinks. Throughout nearly all the workings water for sluicing is insufficient on account of this sink. In all, 14 men were engaged in rocking and sluicing on Harris Creek during September. In these claims the bed rock consists of red and yellow clay, on which the pay gravel lies to a depth of from 3 inches to 4 or 5 feet. Above the sink Harris Creek carries an amount of water amply sufficient for mining purposes. North Fork and its tributaries generally have been staked and prospected to some extent. No mining has been done except on Harris Creek.

Coarse Gold Creek is a large tributary of the Kugruk River from the west side, about a mile above North Fork. It heads in the high divide between the Kugruk and Agiapuk drainages, and flows eastward, cutting across the strike of the schists and limestones. At the mouth of the creek the bed rock consists of highly altered mica-schists. Colors of gold have been found in the creek, but no mining has been done.

Henry Creek is tributary to the Kugruk River from the west, about 10 miles

above the mouth of the North Fork. It heads in the high divide south of Kugruk Mountain, and flows eastward in a deep canyon cut in the upland and across the strike of the schist and limestone bed rock. Good prospects of gold have been found on this creek, but no mining has been done. On the Kugruk River, immediately below the mouth of Henry Creek, a mining ditch has been dug and sluice boxes set up to work the gravels near the river. The mine was not in operation in September.

The Kugruk River forks about 35 miles from its mouth, the branches being of about equal size. The eastern fork is called Taylor Creek, while the western retains the name Kugruk River. Taylor Creek rises to the southeast of Midnight Mountain, and flows west to its junction with the Kugruk River. It occupies a valley about 800 feet deep, cut in the plateau on which Midnight Mountain stands. The bed rook at the mouth of Taylor Creek is a dark schist similar to that of Midnight Mountain, while immediately south of that mountain, at a point about 6 miles from the mouth of Taylor Creek, there are exposures of very much altered limestone. The creek probably cuts across the strike of a series of beds of schist and limestone. Colors of gold are known to have been found on this creek and some of its tributaries, but no mining has been attempted.

Macklin Creek is a tributary of the Kugruk River from the east side, about 6 miles above the mouth of Taylor Creek. It heads near the base of Midnight Mountain and flows westward about 6 miles to its junction with the Kugruk River. For several miies Macklin Creek flows parallel to Schlitz Creek, tributary to the Serpentine River, and a low pass between the two creeks suggests an old waterway. The creek occupies a rather broad valley cut in the upland. The bed rock, where it has been seen, consists of dark feldspathic, graphitic mica-schist, similar to that of Midnight Mountain. Promising prospects of gold were discovered on Macklin Creek in the summer of 1900. There are 29 claims on the creek, and considerable development work preparatory to mining was done during the summer of 1901, but by the middle of September no sluicing had been done. The thick vegetable growth of the hillsides also covers the creek bed, making a great deal of stripping necessary before mining can be begun. The pay gravel contains many angular fragments of graphitic schist. In the pay streak as high as 75 cents to the pan has been obtained, though the average is much less. Some sluicing was done on the creek after the time of the writer's visit. Though the exact results obtained are not known, they are reported to have been satisfactory and to justify a continuation of the work next year. Macklin Creek at the point where the present mines are located carries sufficient water for sluicing in all ordinary seasons.

About 15 miles northeast of the mouth of the Kugruk the Kuzitrin River forks, the northern fork being called the Noxapaga, while the eastern branch retains the

name Kuzitrin. The Kuzitrin River receives four large tributaries from the south, which head in the mountains of the Bendeleben group, and the main volume of water comes from these mountains.

The Noxapaga River has a very sinuous course across the valley lowland. About 8 miles north of its junction with the Kuzitrin the Noxapaga flows near the northern edge of the valley lowland. At this point it receives a large tributary from the north, known as Turner Creek, where Noxapaga, the recording office of the district, is located. Two miles above Turner Creek the Noxapaga occupies a rather broad canyon cut to a depth of *50* feet or more in a gravel-covered plain above the valley floor. About 8 miles above Noxapaga the river forks, the branches being known as the East and West forks. Their upper waters lie in valleys incised in the higher plateau. Gold has been obtained from Garfield Creek, Boulder Creek, and Goose Creek in this region.

Garfield Creek enters the Kuzitrin River from the north side, about *5* miles below the mouth of the Noxapaga. For about *5* miles it has a very sinuous course through the lowland basin. Above this part of its course it occupies a valley cut in the upland for a distance of about 5 miles. Gold was discovered on the creek in 1900, during which season it produced considerable gold from a shallow pay streak above a white clay foundation which was confined to the creek bed. The mining conditions during 1900 are described in a previous report.[a] In September, 1901, the workings on Garfield Creek had been abandoned. The exact amount produced during the season of 1901 is not known, but was not great. The owners of claims along the creek were preparing to prospect them with steam thawers during the winter, with a view to locating a deeper pay streak near the bed rook. Garfield Creek carries sufficient water for sluicing during ordinary seasons.

Turner Creek is a good-sized tributary which enters the Noxapaga where that river approaches the northern edge of the valley lowland. Its general course is about S. 20° E. In the lower 3 miles of its course it meanders in a broad valley cut in the upper gravel plain which borders the lowland. Above this point the valley becomes narrower as the inclosing upland becomes higher, and at the creek's head the valley is deeply and sharply incised in the upper plateau surface. Three miles above its mouth Boulder Creek. about 5 miles in length, enters Turner Creek from the east.

No bed rock is exposed on Turner Creek for 4 miles above its mouth. Above the mouth of Boulder Creek there are occasional outcroppings of limestones and calcareous mica-schists, the strike of which, as far as could be determined, is nearly parallel to the course of the creeks. About *5* miles above

[a] Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska, in 1900, p. 122.

the mouth of Boulder Creek Turner Creek receives a number of tributaries, which together form a fan-shaped basin in the plateau surface. The larger forks of the creek head near Baldy Mountain. No mining has been done along Turner Creek, although good prospects of gold are reported to have been found and the whole creek is staked.

Boulder Creek occupies a straight, rather broad valley, which is deeply cut in the higher upland about the creek's head, but has less depth in the lower country, where Boulder empties into Turner Creek. The bed rock is calcareous schists and limestones, with some beds of graphitic schists, whose relations to the other schists were not determined. The rocks are deeply covered with moss, muck, and gravel, so that they are exposed only in mining excavations: Gold in paying quantities was discovered on Boulder Creek early in the summer of 1901. Twenty claims have been staked on the creek, all of which are reported to show colors of gold. Sluicing was begun on the creek about August 8, and some gold had been taken out with the rockers previous to that time. At the time of the writer's visit mining was in progress on claims between 3 and 7, and development work, consisting of stripping off the moss and muck, had been done on several others. On a claim about 1½ miles from the mouth of the creek both sluicing and rocking were in progress. About 2½ feet of moss and muck had been removed, exposing gravel consisting of angular fragments of graphitic schist and limestone. The gravel is reported to carry pay at this place to a depth of 4 or 5 feet, below which it has not been tested, owing to the frozen ground. A width of 56 feet of pay gravel has been uncovered. Good prospects are reported to have been found in test pits 100 feet or more from the creek bed, indicating a greater width for the pay streak. About three-fourths of a mile above this mine a prospect hole through the gravel to a depth of 11 feet failed to reach solid bed rock. The gravel there consisted mainly of limestone pebhles. Although the surface covering of moss and muck had been removed, the pay gravel below it was still frozen in September. A layer of pay dirt a few inches thick thawed each day, and was shoveled into sluice boxes and rockers. The whole area that has been worked on the creek if put together would not exceed 100 feet square. The gold is comparatively coarse, as nuggets from 25 cents up are not uncommon. These are usually rounded and dark colored. The largest nugget so far taken weighed over two ounces and was valued at $36. It was a well-rounded piece of gold, stained with iron. Mr. A. D. Nash, who controlled the freighting on the Noxapaga River and handled most of the gold from the creek, estimated that the creek produced $7,000 during the season of 1901.

At the time of the writer's visit, in September, Boulder Creek carried a volume of water sufficient to run several sluice boxes. It will probably carry

sufficient water for sluicing in all ordinary seasons. Should hydraulic methods be adopted on this creek, water can probably be brought from Turner Creek in a ditch not over 5 miles in length.

Near the Noxapaga, at the mouth of Turner Creek, a low, round hill, about 50 feet high, rises above the level of the lowland. This low butte is similar in form to many others scattered over the lowland, and is the remnant of an upper gravel plain which has in part been removed by erosion. The edge of the upper plain is usually marked by a sharply cut escarpment, from which partly isolated points often project, showing the phases of transition between the isolated butte and the continuous gravel plain. The butte near Noxapaga consists mainly of a dark deposit of impure peat mixed with layers of white sand. The peat contains trunks, bark, and limbs of spruce trees. The smaller branches are flattened by pressure of overlying gravels. The layers of white sand resemble sea-beach deposits, and suggest a driftwood origin for the peat. There is no spruce timber at present growing within the drainage of the Kuzitrin and Noxapaga rivers. At the time of this deposition, however, the climate here was undoubtedly milder, as is evidenced by the remains of the elephant and horse found in gravels of this period. At the base of the coal butte there is a large mineral spring from which carbonic acid escapes. The water is cold and resembles in taste that of soda springs, but no sample was taken for analysis. There is no connection between the spring and the coal butte, and their proximity is accidental. The peat has been tried with some success as fuel for steam thamers, and the butte is staked as a coal mine. It may prove of some importance in the development of the mines of the vicinity.

A number of creeks enter the Noxapaga River from the north, parallel to Turner and Bowlder creeks. These have been staked generally, and to some extent prospected. So far as is known to the writer, no mining has been done on any of them, with the exception of Goose Creek, a small tributary of the Noxapaga, 4 miles above Turner Creek. One man is reported to have mined continuously through the season on this creek. The writer was not able to visit the mines, and is indebted for his information in regard to the region to Mr. Lars Gunderson, recorder of the district. There is only one claim of importance on the creek. This claim was worked continuously, but the amount of gold obtained is not known. The bed rock is mica-schist and limestone.

East of Goose Creek the region between the Noxapaga and Kuzitrin rivers is reported to be covered with lava. This lava flow extends down to the Noxapaga River, and is found on the north side of the river at a point about midway between Noxapaga and Goose Creek. At this point the lava overlies the Pleistocene gravels, which here overlie mica-schists exposed in the river banks.

Southern tributaries of the Kuzitrin.—The creeks flowing into the Kuzitrin from the south side have not produced gold in commercial quantities; however, the writer was informed by a prospector that on Birch Creek some sluicing has been done. The pay gravel consisted mainly of decomposed granite, and the bed rock was also granite. The gold is probably derived from the rocks of the Kigluaik series. The mountains of the Bendeleben group are less rugged than the Kigluaik Mountains, and there has been little, if any, glacial erosion in them. If gold occurs in these rocks it is more likely to be concentrated in the gravels of the Bendeleben Range than in those of the Kigluaik Mountains.

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