THE COLD BAY-CHIGNIK DISTRICT.

By W. R. Smith and Arthur A. Baker.

INTRODUCTION.

LOCATION AND AREA.

The area described in this report lies on the southeast side of the Alaska Peninsula west of Kodiak Island and extends from a point 15 miles northeast of Cold Bay for 160 miles southwest along the peninsula to the northeast side of Chignik Bay. This area lies between meridians 155° and 158° west and parallels 56° and 58° north. The northeastern portion of the area includes a part of the Cold Bay district, which has already been described by Capps.[1] Cold Bay lies on the southeast side of the Alaska Peninsula at longitude 155° 30′ west and latitude 57° 45′ north. The mapping by the Geological Survey in 1922 is a continuation of the mapping begun by S. R. Capps and R. K. Lynt in 1921. The geographic boundaries of the area of which a geologic map has now been made are, in the northeastern part, Becharof and Ugashik lakes on the west, the Kejulik Mountains on the north, and the coastal mountains from a point near Mount Katmai to Cold Bay on the east. Between Cold Bay and the southwest end of Wide Bay the mapping has been carried to the shores of Shelikof Strait. Between Wide Bay and Amber Bay the area mapped is about 18 miles wide and lies west of the main crest of the Pacific coastal range and east of a broad expanse of low land bordering Bristol Bay. From Amber Bay to Chignik Bay the mapping has been carried to the coast. The total area mapped geologically in 1922, lying between the head of the Kejulik Valley and the northeast end of Chignik Bay, includes about 2,500 square miles.

PREVIOUS SURVEYS.

The first extensive charting of the coast line of the peninsula was begun in 1827 by Capt. F. P. Lutke, who was sent out by the authorities at St. Petersburg to make a careful survey of the north coast.

[1] Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, p. 77, 1922.

Several years later the south coast was mapped by Ensign Vasilief. Although numerous surveys of parts of the Alaska Peninsula have been made since Alaska passed into the hand of the United States, there remain stretches of many miles of coast line which have not been charted since the work of Lutke and Vasilief and for all existing maps of which their charts are still the basis.

The occurrence of petroleum in sedimentary rocks of the Alaska Peninsula has been known for over half a century, but until the present investigation only a small part of the peninsula had been mapped either geologically or topographically. The earliest references to the occurrence of petroleum were made in 1869 by Davidson [2] and Dall,[3] who reported the presence of a seepage near Katmai Bay, northeast of Cold Bay. A bibliography of publications referring to the occurrence of petroleum in Alaska, compiled by Martin,[4] was published in 1921. The only additional publications that have appeared since then are the report on the Cold Bay district by Capps [5] and that on Iniskin Bay by Moffit.[6]

Previous surveys in the Cold Bay region have been confined largely to hasty reconnaissance trips along the coast and into the more accessible parts of the region. Several expeditions visited Cold Bay to study and report on the thick stratigraphic and structural sections exposed there, and the general geology of the country adjacent to the shores of the bay has been known for many years. During the oil excitement in 1903–4, when the wells were drilled near Cold Bay, G. C. Martin visited the well sites, and a report of his findings has appeared in several publications. In 1921 S. R. Capps made a reconnaissance survey of the country between Wide Bay and Cold Bay, which supplied more accurate information on that area. The territory immediately north of Cold Bay and southwest of Wide Bay had remained virtually unexplored, as they had been visited only by a few trappers and prospectors. Within the last two years many oil claims have been staked in the Kejulik River valley and near Aniakchak Bay.

The country near Mount Peulik has been somewhat better known than that north of Cold Bay and southwest of Wide Bay, but until work was done there by Capps in 1921 no authentic geologic knowledge of it was available. Many prospectors were attracted to the so-called "west field," lying southeast of Mount Peulik, during the oil excitement in 1903–4, but no systematic mapping was undertaken and no accurate information was published. Private examinations have

[2] Davidson, George, Coast Pilot of Alaska, 1869, p. 36.

[3] Dall, W. H., idem, p. 199.

[4] Martin, G. C., Preliminary report on petroleum in Alaska: U. S. Geol. Survey Bull. 719, pp. 75–80, 1921.

[5] Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, pp. 77–116, 1922.

[6] Moffit, F. H., The Iniskin Bay district: Idem, pp. 117–135.

been made at different times with the idea of developing the area if it held sufficient promise of oil production. In 1918 a geologist made an examination for a group of claimants, and in 1921–22 geologists reported on this area for several different oil companies. Surveys other than geologic have been carried on by the United States General Land Office, which had parties in the field in 1920–21 and west of Kujulik Bay in 1921–22, establishing land lines to which claim surveys could be accurately tied. In 1921 a reconnaissance topographic map of the region between Cold Bay and Portage Bay was made by members of the United States Geological Survey. The survey of oil-claim boundaries has been carried on so energetically that the vast network of claims has practically all been surveyed.

A geologic and topographic reconnaissance map of the country bordering Chignik Bay as well as the Herendeen Bay and Unga Island region was made by Atwood and Eakin in 1908, and a report on the work was published the following year,[7] and a fuller report containing geologic and topographic maps in 1911.[8] The coal resources of these districts have been mentioned in several other publications. The region lying between Wide and Chignik bays had not been examined by members of the United States Geological Survey before the summer of 1922. Some of the chief physiographic features, such as Mount Chiginagak and the larger lakes and streams, were named or indicated on the Russian maps, but otherwise the greater part of the interior was unknown. The coast and the south side of the mountain range between Wide Bay and Amber Bay has not been mapped since the acquisition of Alaska by the United States.

PRESENT INVESTIGATION.

In the spring of 1922 two combined geologic and topographic parties were organized, one in charge of R. H. Sargent with W. R. Smith attached as geologist and the other in charge of R. K. Lynt with A. A. Baker as geologist. Each party consisted of 6 men and 10 pack horses. The parties sailed from Seattle June 4 and landed at Portage Bay June 15. Mr. Sargent's party continued westward, and Mr. Lynt's party made a circuit through the country surrounding Mount Peulik and then tied on to previous work at Cold Bay and carried the survey northeastward into the Kejulik Valley.

Mr. Sargent's party made a topographic and geologic reconnaissance survey for about 90 miles parallel to the west side of the coast range southwest of Wide Bay and arrived at Chignik in September. The season's work resulted in a topographic map of an area of about

[7] Atwood, W. W., Mineral resources of southwestern Alaska: U. S. Geol. Survey Bull. 379, pp. 108–152, 1909.

[8] Atwood, W. W., Geology and mineral resources of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, 1922.

3,000 square miles on a scale of 1:180,000 and a geologic examination of an area of about 2,000 square miles. Mr. Lynt's party made a topographic map covering an area of about 1,200 square miles on a scale of 1:180,000, largely by photo-topographic methods, and a reconnaissance geologic map of an area of about 500 square miles. The work of the two parties thus resulted in a topographic map of about 4,200 square miles and a geologic map of about 2,500 square miles. (See Pl. VIII.)

The vicinity of Cold Bay was the scene of much activity during the summer of 1922, as it had been in 1921. Besides the United States Geological Survey parties, several geologists, representing at least three different oil companies, were making examinations of the possible oil-pool locations. One of the companies, which later imported drilling equipment, had several men engaged in work preliminary to drilling, such as choosing a harbor, selecting one of several possible routes for a road, and deciding on a well site. Two different surveyors had parties making boundary surveys of oil claims.

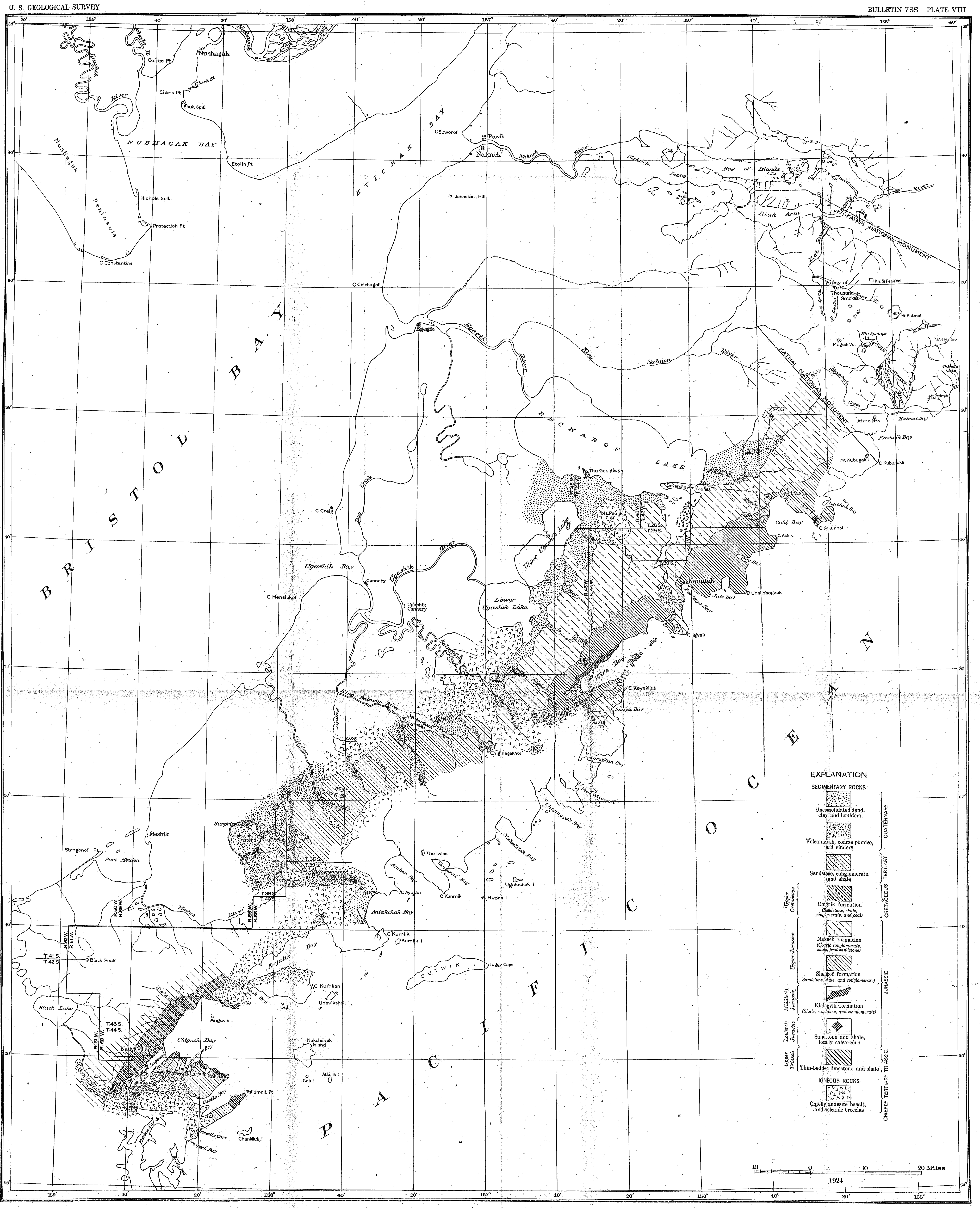
Thanks are due to R. H. Sargent and R. K. Lynt for furnishing base maps in the field and for unfailing assistance in furthering the writers' investigations. To Messrs. Adolf Van Hammel, Charles Weideman, and C. W. Olsen acknowledgment is due for supplying Mr. Sargent's party with several essential articles of food at Aniakchak Bay. Obligation is also acknowledged to the officials of the Northwestern Canneries Co. for the use of a boat at Chignik Bay.

GEOGRAPHY.

TOPOGRAPHY.

The general geographic features of the Alaska Peninsula have been so well described in at least two reports [9] that only a brief summary will be given here. The peninsula is a wedge-shaped land mass extending from northeast to southwest and tapering toward the southwest end. It is about 550 miles long and at its northeast or landward end 100 miles wide. The coast line is very irregular, having many indentations and large bays which in a few places near its southwest end almost cut through the peninsula. The Aleutian Range runs practically the entire length of the peninsula, and between Port Moller and the base of the peninsula it lies much closer to the Pacific side. This asymmetric position of the mountain range gives the south side of the peninsula a very bold, rugged appearance, but the north side is bordered by a wide lowland containing many lakes and swamps.

[9] Atwood, W. W., Geology and mineral resources of parts of Alaska Peninsula: U. S. Geol. Survey Bull. 467, pp. 13–15, 1911. Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, pp. 77–88, 1922.



GEOLOGIC RECONNAISSANCE MAP OF COLD BAY-CHIGNIK DISTRICT, ALASKA PENINSULA

The streams flowing southeastward into Shelikof Strait and the Pacific Ocean are mostly short, turbulent mountain streams with many falls, flowing through steep-sided canyons. This is especially true of those that reach the coast southwest of Wide Bay, where the mountains are rugged and close to the beach. Most of the creeks can be waded at favorable places; the larger ones, those flowing into Wide Bay, have eroded small valleys several miles upstream from their outlets and can be waded without danger except the one at the southwest end of the bay, which is a swift glacial stream. Aniakchak River is about 25 miles long and is the largest stream on the peninsula flowing toward the Pacific Ocean. It rises in Aniakchak Crater and empties into the northeast end of Aniakchak Bay. For the greater part of its course it flows through a valley about 6 miles wide, which has been partly filled with cinders thrown out from the crater. Near its mouth during the summer the river is about 100 feet wide and 4 feet deep. One of the tributaries, Hidden Creek, flows in a subterranean channel for 4 or 5 miles beneath the lava and cinders east of the crater.

The rivers and creeks flowing west and northwest across the lowland into Bristol Bay are sluggish, meandering streams, subject to tidal changes for many miles upstream. They rise along the northwest flank of the main Aleutian Range, where they are typical mountain streams for short distances before they enter broad valleys extending from the lowland through wide gaps in the lower mountain range toward the west. Both the valleys and the lowland contain many lakes, and the outlets of the larger lakes are usually rivers of moderate size. One of the larger bodies of fresh water in the area surveyed is Mother Goose Lake, which lies 10 miles west of Mount Chiginagak and receives the glacial streams flowing from the west side of the mountain. This lake has an area of about 16 square miles and contains eight small islands. The Ugashik Lakes, in the Cold Bay district northwest of Wide Bay, are two of the largest lakes on the peninsula, being surpassed in area only by Becharof and Naknek lakes. Upper Ugashik Lake is 17 miles long and has an area of approximately 85 square miles. Lower Ugashik Lake is irregularly circular in outline and has an area of about 100 square miles. The two lakes are connected by a short, narrow channel. On the banks of their common outlet, Ugashik River, several large salmon canneries have been in operation during the fishing season for a number of years. Becharof Lake is the largest lake on the Alaska Peninsula, as it is more than 40 miles long and has an area of about 450 square miles.

The Cold Bay district lies almost entirely within the limits of the mountainous area. The lower half of the Kejulik River valley and the country north and west of Mount Peulik should be considered as merging into the lowland. In the immediate vicinity of Cold Bay the mountains rise abruptly from the shore line and attain a maximum elevation of about 2,500 feet. Between Cold Bay and the head of Kejulik River the mountainous belt narrows. Extending north and west from the coastal mountains is a broad valley containing a complicated network of meandering streams, large and small lakes and swamps, and here and there low hills standing out prominently in contrast to the low terrane about them. The trunk stream in this drainage network, Kejulik River, a tributary of Becharof Lake, lies nearest the northwestern wall of the valley and is a large sluggish stream whose water has a milky color due to its glacial origin. This stream in its lower reaches is deep enough for horses to swim. The Kejulik River valley is bounded on the northwest by a rugged sawtooth range, the Kejulik Mountains. This range extends northeastward from the northeastern shore of Becharof Lake and joins the coastal range in the vicinity of Mount Katmai. Mount Peulik, a volcanic peak nearly 5,000 feet high, lies across Becharof Lake about in line with the axis of the Kejulik Mountains. From Cold Bay to Portage Bay the coastal range is not so rugged, occupying a belt extending about 10 miles inland, with mountains 2,000 feet or more high. On the cape between Portage and Wide bays the mountains differ in character from those immediately to the northeast and are impassable by pack train, so that a three days' detour is necessary in traveling by land from one bay to the other. Southwest of Wide Bay there are many mountains some of whose peaks attain a height of 4,000 to 5,000 feet. The crest line between Wide and Amber bays is unbroken by any known low passes for 80 miles, so that the inland country behind these mountains is less accessible than the area west of the coast in the Cold Bay district. Along the upper slopes there are many permanent snow fields, and at several places vigorous alpine glaciers descend almost to sea level.

The most conspicuous topographic feature in the region southwest of Wide Bay is Mount Chiginagak, an active volcano at the head of Chiginagak Bay which rises 2,000 feet above its neighboring mountains and reaches an altitude of nearly 7,000 feet. It is regularly conical in shape; the summit is depressed, apparently by an extinct crater whose sides, as viewed from the north, appear in the form of two symmetrical cusplike peaks, which aid in giving the mountain an unusual scenic beauty. The upper 4,000 feet is almost entirely covered with snow fields and glaciers. A thousand feet from the top, on the north side, a white plume of vapors and sulphurous fumes rises from a small fumarole in the center of a snow field. This feature can rarely be seen from the coast, although it is nearer the

Pacific Ocean than most of the active and extinct volcanoes that occur at irregular intervals along the axial line of the Alaska Peninsula.

An extinct volcano that is less conspicuous but of considerably more scientific interest than Mount Chiginagak was discovered at the head of Aniakchak River, about 28 miles west of Aniakchak Bay. The crater is somewhat similar in size and shape to Crater Lake, Oreg., but differs in having a comparatively small body of water on its floor. The rim is almost circular in outline and has a diameter of 6 miles. The mountain summits that form the rim are from 700 to 1,500 feet above the crater floor and are unbroken except in the gorge or "gates" through which Aniakchak River flows. Within the large crater, near the east side, a cinder cone rises 1,000 feet above the general level of the floor and can be seen from the mountain tops northeast of the river. Three smaller cones also occur in the crater. The lake, on the northwest side, has an area of about 2 square miles; it is bluish green in color and does not appear to be deep. The area of the crater, including the cinder cones, is approximately 25 square miles. In places the walls are nearly vertical; where they are not so precipitous they are covered with small glaciers and snow fields. At the places where the walls were examined they were found to be composed chiefly of slightly folded sedimentary rocks. The bottom of the crater is filled with rather coarse black, gray, and red cinders which form ridges around the base of the large cone. The crater can be entered through the gorge on the southwest side of the river. The stream is too turbulent to be waded near the gorge but can be crossed within the crater just below the lake.

This remarkably large crater has been named Aniakchak, after the river whose source is within its walls. Unfortunately, little time was available for the investigation of this interesting crater. It was visited a short time August 26 and a few hours August 30. On the latter date W. R. Smith and Sidney Old went into the crater and attempted to reach the inner cone, but walking over the cinders is slow and difficult, and the summit of the cone was not reached, partly on account of darkness. The party's nearest camp was 6 miles from the "gates."

The mountains along the coast in the vicinity of Aniakchak and Kujulik bays are only 2,500 feet in altitude, but they are very rugged and sculptured by deep gulches.

West of and paralleling the main Aleutian Range a lower range of mountains extends from Lake Ugashik to Aniakchak Crater. This lower range is dissected by streams flowing west into Bering Sea from the slopes of the main range.

CLIMATE.

The Alaska Peninsula has an unusual climate, owing to its geographic position. The most notable features of the climate are the prevalent high winds and fogs, in explanation of which Capps[10] says:

> Any differences in barometric pressure that may exist between the north Pacific Ocean and Bering Sea result in winds that blow across the peninsula either from the northwest or from the southeast, and a complete reversal in the direction of the wind often takes place suddenly. Furthermore, any wind that blows is a sea wind, and the air, having a high moisture content, is chilled on passing over the mountain barrier and forms fog or clouds. Thus windy days are generally cloudy or foggy, and as windy weather is the rule, the mountain tops are generally in clouds. The few clear days that occurred in the summer of 1921 were relatively calm.

The Alaska Peninsula and the islands to the south are considered by Cleveland Abbe, jr.,[11] after studying the meteorologic records up to and including the year 1902, a distinct climatic province. It is characterized by less extremes of climate than many other parts of Alaska. The nearest meteorologic stations to the Cold Bay district and the country to the southwest are at Unga, on Unga Island; at Ugashik, at the mouth of Ugashik River; and at Kodiak, on Kodiak Island. The climatic records are not complete, but they serve to show that the precipitation is much less here than in southeastern Alaska or on the Aleutian Islands and that the extreme annual range of temperature is not so great as in the interior. Ugashik, on the west coast, has an annual rainfall of only 24.41 inches, and a range of temperature of 124°; Unga Island, off the east coast, receives about twice as much rain—48.78 inches—and has a temperature range of only 80° or 90°.

Rains are frequent in the summer, but the actual precipitation is not great, as the rains are usually in the form of a driving mist, with occasional heavy downpours. The summer is usually cool—so cool, in fact, that on rainy days a tent without some sort of a heating device is uncomfortable. There are exceptional days, however, as a temperature of 95° F. was recorded in June, 1922. The nights were uniformly cool, and the temperature dropped below freezing several nights during the later part of August. A few inches of snow fell during the night of August 2 in the vicinity of Mother Goose Lake, and early in September light snow fell upon the higher hills near Cold Bay. From June 14 to September 23, 1922, there were 30 clear days, most of which were calm, in the region between Portage and Chignik bays. The best weather oc-

---

[10] Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, p. 84, 1922.
[11] Brooks, A. H., The geography and geology of Alaska: U. S. Geol. Survey Prof. Paper 45, pp. 140, 150, 1906.

curred during the later part of June and the first two weeks of September.

The winters are severe, because of the cold, heavy winds, which are said to make traveling difficult and even dangerous for days at a time. The snowfall is said to be light, so that during a large part of the winter there is insufficient snow for sledding. This scarcity of snow makes it possible to winter horses without great expense, as the horses can forage for themselves during the day if some sort of night shelter is provided. The horses must be fed during short spells when the snow is deep. In some winters, such as that of 1920–21, the snowfall is so heavy that hay and grain must be fed throughout the bad weather. The snow usually disappears by July 1, except in deep gulches and on the higher mountain slopes. The ground does not freeze to a great depth.

VEGETATION.

The greater part of the Alaska Peninsula southwest of Naknek Lake is completely barren of trees. A rather surprising exception to the general lack of timber was found in several valleys east and southwest of Mother Goose Lake and in the immediate vicinity of Kejulik River. These valleys contain many clumps of cottonwood trees, some of which grow to a height of 35 feet and have a maximum measured diameter of 23 inches. The average height is probably 25 feet and the average diameter about 10 inches. Although the trees are partly protected from the Pacific Ocean winds by the Aleutian Range, which is unbroken in these areas, the tops of the larger trees are gnarled and bent, but the trunks are usually straight and of sufficient length to be useful in the construction of small cabins. The trees are too far from the Cold Bay oil field, however, to aid in solving the serious problem of building material there, and they would be of value only to prospectors or trappers in the valleys in which they grow. The high-bush cranberry grows in association with the cottonwood trees but was not seen elsewhere.

Alder and willow bushes are unevenly distributed in nearly all the valleys and at places on the mountain slopes 500 feet above sea level. In the valley at the southwest end of Wide Bay alder bushes reach a height of 18 feet but are usually stunted and gnarled so that it is difficult to penetrate the thickets. It is interesting to see the alders growing in small canyons with no branches extending above the level of the canyon walls, appearing almost as if they were constantly trimmed back to the level of the tops of the walls, thus showing the powerful effect of the heavy winds upon vegetable growth. At the lower elevations thickets of willow are common and in sheltered places they attain a height of 10 or 12 feet, but in more exposed places they are stunted and twisted by the heavy winds, forming dense waist-high thickets.

The most abundant and conspicuous form of vegetation on the Alaska Peninsula is grass, which grows luxuriantly in all the valleys and lowland areas and also on the mountain slopes to a height of about 1,000 feet above the sea, in places where soil has accumulated sufficiently to permit a footing for vegetation. The grass, chiefly redtop, wild rye, and a smaller amount of bunch grass, grows rapidly and furnishes excellent grazing from the first of June until it is killed by frost in September. There are thousands of acres of this grass growing to a height of 3 or 4 feet, and it would make a fair grade of hay except for the difficulty of curing it properly, owing to the peculiar climatic conditions.

Several varieties of moss clothe the higher slopes and even the summits of the mountains that are not covered with snow or entirely barren of soil. These plants are widely distributed and are seen along the beach and in the lowland areas where the grasses and bushes do not crowd them out. Caribou moss (comprising various species of lichens) is seen occasionally throughout the district and is plentiful on several ridges south of Mother Goose Lake. Wild flowers in amazing variety grow everywhere from the valley floors to the highest altitudes at which vegetation is found. Nearly a hundred species were collected without any effort toward a careful and systematic search.

Several varieties of berries are found in the Cold Bay region, but only moss berries are abundant. In isolated patches blueberries are sufficiently plentiful to offer a welcome addition to the camper's stock of provisions. The dwarf cranberry grows very abundantly on the sand spit in Chignik Bay and forms an important article of food for the natives. Large yellow salmonberries are found at places along Aniakchak and Kujulik bays but are not very palatable.

Vegetation has gained a footing in patches in the valleys filled with cinders in the region around Aniakchak Crater, but there are large areas in these valleys that are entirely lacking in plant life.

The lack of timber immediately raises a question concerning fuel supply. The camper must depend upon the meager supply of alder brush for fuel, and camp sites must be chosen with that in mind rather than for other conveniences. Most of the permanent settlers in the country have erected buildings close to the beach, and the supply of driftwood has heretofore been ample for their needs both for building and for fuel. The buildings away from the coast are all of the type called "barabaras," which are sod houses built around a framework of alder or any other available wood. The town of Kanatak is dependent upon coal shipped in by boat for its fuel supply. During the early stages of the boom the driftwood and the alder brush were sufficient for all needs, but the rapidly growing town demanded a greater supply of fuel. The petroleum residue patches furnish a small local supply of fuel that can be used under boilers. As mentioned elsewhere, the Associated Oil Co. plans to use residue from one of the patches on the Pearl Creek dome for fuel. During the drilling in 1903-4 the residue from the seepage at the head of Oil Creek, near Cold Bay, was used under the boilers and in stoves with satisfactory results. The supply of alder brush and driftwood is sufficient for the needs of the camper or for a small community, but a large community or any commercial enterprise must depend upon coal or oil.

ANIMAL LIFE.

Wild animals are not present in this part of the Alaska Peninsula in large numbers or great variety. The natives and a few white men trap for the fur-bearing animals each winter. The fox is the most abundant of the fur-bearing animals and is the most sought after. Many red fox and some silver-gray fox are taken each winter and are disposed of at the local trading posts by the trappers. Wolverine, mink, marten, and land otter are taken in small numbers. The brown bear is the largest animal on the peninsula and is occasionlly seen by travelers. The bears seem to be more numerous in the more remote parts of the peninsula. The large Arctic hare is probably very numerous, to judge from the number that were seen and the tracks and runs in the willow thickets. Moose, mountain goats, or sheep are not known in this area.

Caribou formerly ranged over the entire peninsula, but they have completely disappeared from many districts and are rarely seen on the peninsula above Mother Goose Lake. Southwest of Mother Goose Lake there is a small area in which about twenty caribou were seen. Farther southwest, near Aniakchak Crater, no caribou and very few tracks were seen. In the vicinity of Chignik Lagoon a few caribou are said to be seen occasionally. Those seen by the Survey party were usually in pairs, but one herd of twelve came within a hundred feet of the pack train. They were rather small and belonged to the mountain type of caribou, which seldom migrate. Their presence in a small area is partly due to the fact that the caribou moss grows more abundantly in this particular area than elsewhere along the route of travel.

Hair seals are captured in the bays and form an important source of oil and food for the natives. The sealskins are used in the manufacture of moccasins, mucklucks, and other articles of clothing. The native's boat or bidarka consists of a framework of bent willows covered with tightly stretched sealskins.

Of the game birds ptarmigan were most plentiful in 1921 and 1922 but are reported to disappear almost entirely for periods of years. They are heavily preyed upon by eagles, foxes, wolverines, and bears. Ducks, geese, and swans breed in great numbers on the lakes, in the low marshy places, and in the lagoons along the coast. Other birds, including sea gulls, sea parrots, shags, and other sea fowl, are very plentiful and find favorable breeding places in the cliffs and on the islands. Small birds are not numerous; several species of snipes were seen on the beach; water wrens, magpies, and one or two other species were seen inland now and then.

A more favorable spawning ground for salmon can scarcely be found anywhere than the many lakes and streams in the lowland bordering Bristol Bay, and an extensive canning industry has been established along the larger rivers. The highly prized Alaska red salmon is the most prolific variety on the Bristol Bay coast. The Pacific streams have a smaller run of red salmon, but several other desirable varieties, including the king salmon, are abundant and supply the three large canneries at Chignik. These are the only canneries on the Pacific coast of the peninsula. In 1922 the Chignik canneries were limited by regulation to a pack of 50,000 cases each. Herring, halibut, and cod are said to be plentiful in the salt water along the coast. Only two kinds of fresh-water fish are known, the trout and grayling. These fish feed on the salmon eggs and the young salmon fry.

COMMERCIAL DEVELOPMENT.

There have been two periods during which outside interests have attempted to develop the Cold Bay district into a commercially producing oil field. The first attempt was in 1903–4, when five or six wells were drilled to depths ranging from 15 to 1,500 feet. Two companies operated in the field at that time, making their headquarters at Cold Bay. Just inside the cape at the southwest entrance to Cold Bay, in a small protected valley, one of the operating companies erected several substantial frame buildings that are still standing and in good condition. A road 7 or 8 miles long was built from the buildings at Cold Bay north along the shore to Trail Creek and up that stream to its headwaters on the upland, where the wells were drilled. Drilling operations were begun in the summer of 1903 and were continued until October, 1904. No commercial quantity of oil was obtained from any of the wells, although a thick residual oil was reported from several strata penetrated by one of the deeper wells.

From October, 1904, until the fall of 1910 no important oil developments occurred. In 1910 all the oil lands were withdrawn from entry, no title having been granted to any claims in this region. The next ten years was marked by a lack of interest in the prospects for oil. In 1920 Congress passed an oil-leasing bill that permitted the staking and drilling of oil lands, and a great revival of interest was manifested immediately, as several prospectors hastened to the Cold Bay district, and before the snow had disappeared most of the promising oil land had been staked. This restaking of oil claims marked the beginning of the second period of commercial development of the district.

Prospecting and surveying was carried on vigorously during 1920–1922, and examinations were made by geologists representing the United States Geological Survey and several oil companies. In August, 1922, two steamers landed drilling equipment at Portage Bay, and soon the town of Kanatak, at the head of Portage Bay, was the center of great activity. During two or three weeks Kanatak changed from a town with a population of 10 or 15 to a typical boom town with a population of nearly 200 and tents, log cabins, and frame buildings numbering 100 or more. Work was immediately begun on a road connecting Kanatak and the site selected for drilling, which is 17½ miles northwest of Kanatak. The Standard Oil Co. of California and the Associated Oil Co. are now operating in the field. The Standard Oil Co. has a standard rig and the necessary equipment to drill to a depth of 4,000 feet. Power is to be furnished by a 75-horsepower gasoline engine. The Associated Oil Co. has two portable Star rigs and intends to use local petroleum residue as fuel.

POPULATION.

The population of this district is normally small but is greatly influenced by commercial activity. During the period of active development work from 1902–1904 a number of people were engaged in road work and drilling. The base camp at Cold Bay was constructed of substantial frame buildings, which were used as a trading post until the fall of 1921. The trading post for many years was the center of activity for the district, being the post office and source of supplies for the trappers and the natives. The winter mail for Bristol Bay and Nome was formerly carried across the peninsula from Cold Bay by dog team. From 1904 until 1920 the permanent white population was limited to one or two at the trading post and a few trappers and prospectors. In 1920 many prospectors went into the region to stake claims and the United States General Land Office established some of the land lines, so that the claims could be definitely described. Most of the early prospectors who staked claims did not stay on the ground, but as interest in the area increased and several oil companies examined the promising structural features many of the prospectors returned to protect their interests. Although the only store in the region was at Cold Bay no activity was manifest there, as it was too far from the prospective oil field. The native village of Kanatak, at the head of Portage Bay, became the center of activity. In 1921 two frame buildings were erected there for stores, and several smaller frame cabins were built. The post office and store were moved from Cold Bay to Kanatak. Building and preparations for building continued on a small scale commensurate with the gradual influx of people until August, 1922, when the drilling equipment for the oil companies arrived. The population increased from 10 or 15 white people to about 200 within two or three weeks, and tents and frame buildings of all descriptions were hastily erected to furnish accommodations for these people. A townsite was laid out, and an attempt was made to regulate the location of buildings so that a future readjustment would not be necessary. In the fall of 1922 people were still arriving at Kanatak on every boat, so that it is impossible to give even an approximately accurate figure for the population. The future population of the town must depend upon the success attained in the drilling, as there is no other activity in the district that could sustain so many people.

Southwest of Kanatak the Alaska Peninsula is very sparsely inhabited in the area covered by this report. Between Wide and Chignik bays there are no permanent inhabitants either along the coast or inland, except at the canneries near the mouth of Ugashik River. At least one white man has lived at Wide Bay for the last 20 years. During the winter several trappers operate inland from the heads of some of the bays along the Pacific coast. These men find employment in the canneries at Chignik during the canning season. Since 1920 there have been several oil prospectors and land-survey parties staking claims or running lines west and southwest of Wide Bay and also west of Aniakchak Bay. Few of these men remain in the country during the winter, as the weather does not permit much out-of-door work. A few people engaged in fox farming occupy some of the smaller islands south of Aniakchak and Chignik bays.

At Chignik three large salmon canneries operate about eight weeks of the summer and employ more than 300 white men during the canning season. These men are brought to the canneries either from Seattle or from San Francisco in the companies' ships, which return to the States at the end of the season with the men and a cargo of canned salmon. The population at Chignik is reduced in the winter to 8 or 10 white people and 25 natives.

There is a small native settlement at Kanatak which has a population that varies during the year. In the winter there are 40 or more natives huddled in their small sod houses (barabaras), but in the summer they scatter, some going to the Bristol Bay side of the peninsula to work in the canneries and others to the small native village at the head of Becharof Lake, where they catch and dry salmon for winter food. Only one family of natives normally resides at Kanatak during the summer. There is a small settlement of natives at Chignik and other small villages still farther southwest. These natives belong to the Aleut tribe, which inhabits the western part of the Alaska Peninsula. It is doubtful if there are any pure-blooded Aleuts at Kanatak and Chignik, as many of them plainly show Russian admixture, and it is probable that all of them have at least a small amount of Russian blood. The natives are all members of the Russian Orthodox Church. Each village has a church, usually a substantial frame building, which presents a great contrast to the barabaras or partly underground huts in which the people live. The natives still speak the Aleutian language, although many of them understand Russian. They are not a thrifty set of people, and their only source of income is hunting, trapping, and fishing, with occasional odd jobs for the white men. Their main article of food is the dried salmon, which they put up in the summer, when fish are very plentiful.

ROUTES AND TRAILS.

The Alaska Peninsula is difficult of access by land but relatively easy by boat. Travel on the peninsula in the summer time is confined to the mountains, as the western lowland is practically impassable to man, except by boat on the large sluggish streams. There are few good harbors, as most of the bays are either open to the sea, offering no protection to boats in storms, or have dangerous unmapped rocks and reefs that make them unsafe for large boats. The bays giving possible access to the prospective oil fields are Wide, Portage, and Cold bays. These bays were uncharted in 1922, but they were examined by representatives of the oil companies, and Portage Bay was chosen as the most favorable. Subsequent charting of Portage Bay and Wide Bay by the United States Coast and Geodetic Survey has shown that Wide Bay is the better harbor, as it is wide and deep and offers a well-protected anchorage for large boats. Portage Bay offers no protection from south or southeast winds, and the bay is shallow, so that large boats can not approach close to the shore. About three-quarters of a mile from the head of the bay is a reef, seen at low tide, that extends from the northeast shore nearly two-thirds of the distance across the bay. This reef gives some protection to small boats, but there is not enough anchor room for large boats between the gently sloping beach and the reef. There are no wharf or docking facilities at Portage Bay or at any other bay along this part of the coast of the Alaska Peninsula except at the three canneries. At Chignik all freight must be handled off Kanatak by small boats or lighters, which are privately owned. If the Pearl Creek dome proves to be commercially productive, better harbor facilities must be provided.

Most of the freight and passengers for the Cold Bay district are routed through Seward or Kodiak. During the summer there are four passenger boats a month from Seattle to Seward and two a month to Kodiak. During the winter the scheduled number of sailings is less. The trip to Seward requires seven or eight days and to Kodiak eight to twelve days, depending upon the route followed. From Seward a mailboat having accommodations for a few passengers and a small amount of freight sails once a month for Alaska Peninsula ports. From Kodiak small boats can be hired to transfer passengers or freight to Portage Bay, the trip requiring about 24 hours. In the spring of both 1921 and 1922 the Seattle steamer made one trip into Portage Bay, and doubtless the steamer would make Portage Bay a regular port of call if the amount of business warranted it and if some quick and reliable means of unloading were furnished. Two large freight steamers were chartered by the oil companies to deliver the drilling equipment at Portage Bay, and both steamers lay at anchor in the bay for several days and unloaded their freight by lighters, being fortunate in having calm weather. Any large steamer anchored in Portage Bay would be compelled to steam out into open water in the event of a storm, as it could not ride out a severe storm in the shallow water of the unprotected, rock-bound bay.

Travel within the district is fairly easy by foot or with a pack train, as many trails have been beaten out by the numerous parties that have moved around in the district during the last two years. There are numerous easy passes across the mountains into the interior lowland. Kanatak has been the headquarters of all the parties working in the district, and the trails radiate from that point. The wagon road under construction from Kanatak to the well sites will make the country around Mount Peulik easily accessible from Kanatak. A good trail for pack horses can be followed from Kanatak to Cold Bay, the last 7 or 8 miles being over the wagon road that was built in 1903 but is no longer suitable for the use of wagons. From the head of Cold Bay there is an easy pass into the Kejulik Valley, but at high tide a bold headland on the west shore of Cold Bay extends into the water and at low tide large boulders make it very dangerous to take pack animals around the point. Just south of the headland is a large creek known as Teresa Creek or Schooner Creek, and near the head of its valley an easy trail may be followed into the Kejulik Valley. The Kejulik Valley may also be entered through one or two low passes from small bays northeast of Cold Bay, but most of these bays are too shallow even for small boats at low tide. Within the Kejulik Valley itself travel is not so easy unless the foothills are followed closely, and even then swampy ground will give some difficulty. A short distance away from the foothills swamps are the rule, and travel with a pack train is extremely difficult. Kejulik River is a glacial stream that is somewhat difficult to cross, as it is cold, swift, and deep. In its lower reaches it is too deep for a horse to wade, but in its upper part many places can be found where a man can wade it. Over a large part of the valley moss grows luxuriantly, making travel both slow and tiresome.

The country northwest of the mountains between Wide and Aniakchak bays had not been traveled by pack train before the summer of 1922. The best route of entrance to the district from the east, so far as known, is either by the Aniakchak River valley or by the valley at the southwest end of Wide Bay. The country could easily be reached by means of small boats going up the rivers from Bristol Bay. The route followed by the Geological Survey party lies between the main range along the coast and the lower range to the northwest. Only slight difficulties for traveling by pack train were encountered, although several detours in the valleys were necessary to avoid swampy areas. The ridges or spurs extending from the main range toward the west are rarely more than 1,000 feet above the valleys at the most favorable points of crossing. Steep slopes could not always be avoided, and as they were often obscured by fog traveling was slow and uncertain. Occasionally short stretches of trail had to be cut through the alders and cottonwoods. A trail leads up the valley of Lee Creek at Wide Bay and across the divide to the Ugashik Lake anticline. This is one of the best routes to the oil field. At Aniakchak the best route for travel by pack train is along the beach, as the area between the beach and the hills to the west is swampy; but at Kujulik Bay the best route is on the benches back of the beach. Near the southwest end of Kujulik Bay a trail leads across the mountains toward the west. At low tide the beach at Chignik Bay, except at a few places, can be traversed. A wagon road has been graded from the coal mines on Thompson Creek, Chignik Bay, to the little bunker on the beach, but it is seldom used. A footpath follows the benches above the beach from the bunker to the sand pit.

Aniakchak and Kujulik bays are uncharted and are avoided by seagoing boats, although Aniakchak Bay is reported to be deep in places and is protected by Sutwik Island from southwest winds.

GEOLOGY.

GENERAL FEATURES.

The field work on which this report is based was undertaken primarily to locate, if possible, areas in which the geologic structure is favorable for the accumulation of oil, and only the principal geologic features are here considered. The recent investigation was a combined reconnaissance topographic and geologic survey, and although every advantage possible under the conditions of rapid traveling was given to the writers, it was not expedient to retard the topographic work greatly in good weather to afford time for making a close investigation of interesting geologic features. In a reconnaissance examination of this sort little time is available for the careful tracing of the contacts between formations.

The sedimentary rocks occurring on the Alaska Peninsula (see Pl. VIII) were deposited during the Mesozoic and Cenozoic eras and range, with many interruptions in their sequence, from the Upper Triassic to the Recent. A complete section of the sedimentary series does not occur at a single locality, and correlation must be made from one part of the peninsula to another by means of the fossil remains of animals and plants. Only a brief description of the formations will be given here, as they have been described in detail in other publications[12] and correlated with exposures in other parts of the Alaska Peninsula and with the beds at the type localities.

[12] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: U. S. Geol. Survey Bull. 250, pp. 50–59, 1905; Notes on the petroleum fields of Alaska: U. S. Geol. Survey Bull. 259, pp. 134–139, 1905. Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Geol. Soc. America Bull., vol. 16, pp. 393–397, 401–402, 1905. Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, 1911. Capps, S. R., The Cold Bay district; U. S. Geol. Survey Bull. 739, pp. 77–116, 1922. Spurr, J. E., A reconnaissance in southwestern Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 31–264, 1900.

Generalized section of the sedimentary rocks in the Cold Bay-Chignik district.

System.	Series.	Formation.	Lithologic character.	Thickness (feet).
Quaternary.	Recent.		Terminal moraines, glacial erratics, mountain outwash, stream gravel, silt, and beach deposits.	
	Pleistocene.			
Tertiary.	Eocene.		Fine conglomerate, sandstone, shale, and thin beds of lignite.	2,000±
Cretaceous.	Upper Cretaceous.	Chignik formation.	Sandstone, conglomerate, shale, and coal seams.	400-780
		Unconformity		
Jurassic.	Upper Jurassic.	Naknek formation.	Conglomerate and arkosic sandstone from 500 to 3,000 feet thick at base, overlain by sandstone, sandy shale, and conglomerate.	5,000±
		Shelikof formation.	Upper 700 to 1,000 feet, black shale with some limestone lenses at top; rests on a thick series of sandstone, with minor amounts of conglomerate and sandy to calcareous shale, carrying Chinitna fauna.	5,000-7,000
		Unconformity		
	Middle (?) Jurassic.	Kialagvik formation.	Sandstone and sandy shale at Wide Bay.	500+
	Lower (?) Jurassic.		Calcareous sandstone, sandy shale, and limestone at Cold and Alinchak bays.	2,300±
Triassic.	Upper Triassic.		Thin-bedded limestone and calcareous shale intruded by basaltic dikes and sills at Cape Kekurnoi.	1,000+

In the southwestern part of the area recently investigated the sedimentary rocks are mainly of Tertiary and Upper Jurassic age. The formations bordering Chignik Bay consist of Upper Jurassic, Upper Cretaceous, and Tertiary sedimentary rocks, overlain and intruded by igneous rocks. In the inland country between the Cold Bay and Chignik districts large areas consist of volcanic rocks and most of the sedimentary beds are of Tertiary age.

The Upper Triassic beds exposed on Cape Kekurnoi are the oldest sedimentary rocks known on the peninsula. The thickness of the exposed beds is estimated to be over 1,000 feet. They are composed of sharply folded, partly metamorphosed limestone and calcareous shale intruded by basaltic dikes and sills. The limestone is thin bedded and is black to bluish gray when freshly broken but becomes light gray upon weathering. The shale is of various colors from red to light brown.

Conformably above the rocks of known Triassic age a series of about 2,300 feet of beds is exposed along the north shore of Cold Bay. These rocks have furnished fossils that are presumably of Lower Jurassic age though not well enough preserved for positive identification. The beds consist chiefly of sandstone, limy shale, and impure limestone. The rocks are somewhat contorted and faulted; their area is small, and they have not been recognized on the Alaska Peninsula except back of Cape Kekurnoi.

Middle (?) Jurassic rocks are represented by a narrow belt of the Kialagvik formation on both sides of the southwest end of Wide Bay. These beds are partly covered by glacial drift, but where they are exposed in contact with the overlying Upper Jurassic rocks there is evidence of an angular unconformity. Fossils have been found in the Kialagvik formation at many localities. A few species from this formation are identical with or closely related to the Tuxedni fauna of Tuxedni Bay, and T. W. Stanton considers the Kialagvik formation of either earliest Tuxedni age or slightly older. The beds consist of about 500 feet of sandstone, sandy shale, and fine conglomerate. The base of the formation is not exposed.

The oil seepages in the Cold Bay district occur in the Upper Jurassic series of rocks, which has been divided into the Shelikof and Naknek formations. The Naknek formation, which is the younger, is exposed throughout the eastern Becharof Lake and Ugashik Lake drainage basins and extends southwestward to the vicinity of Mount Chiginagak, where it is intruded by large masses of igneous rocks and overlain unconformably by the Tertiary rocks. Small areas of the Naknek formation are exposed south of Wide Bay and east of Aniakchak Crater. The Shelikof formation is very thick and forms the coastal mountains between Cold and Portage bays and is present in the mountains west and southwest of Wide Bay.

Along the west shore of Chignik Bay and continuing northwest at least as far as Hook Bay Creek, Upper Cretaceous rocks of the Chignik formation are exposed. The Chignik formation is about 900 feet thick at Chignik Bay. Its extent northwest of Hook Bay Creek is unknown. The beds rest unconformably upon the Naknek formation and are overlain in places by volcanic rocks. The strata are mainly sandstone, shale, and conglomerate, with some valuable coal seams.

Southwest of Mount Chiginagak an area of Tertiary rocks extends to the north side of the upper Aniakchak River valley. The area is about 40 miles long and from 8 to 16 miles wide. Where the rocks were examined, on the north and south sides of the area, they are in contact with large masses of intrusive rocks. The deposits are entirely continental so far as observed, and only plant remains were found in them. They are about 2,000 feet thick and rest unconformably upon a massive gray sandstone, which, although no fossils were seen in it, is presumed to be the upper part of the Naknek formation. The Tertiary beds consist of shale, sandstone, and conglomerate and thin seams of lignite.

The surface rocks in the valleys of streams flowing from the Aleutian Range consist of glacial drift, much of it in the form of small moraines. Most of the drift was deposited by recent glaciers and is composed of unstratified sand, clay, and boulders. Along the north side of Wide Bay a narrow strip extending about 1 mile inland is covered with older drift, which is probably of Pleistocene age. The valley floors of nearly all the streams within a radius of 20 miles from Aniakchak Crater are filled with pumice and black volcanic cinders. In Lava Creek the cinders attain a thickness of over 300 feet and form high, steep terraces above the stream. The hills north and west of the crater are covered to an unknown depth with cinders.

The igneous rocks on the Alaska Peninsula are chiefly of volcanic origin and nearly all of Tertiary age. In the north-central part of the peninsula the older intrusive rocks crop out in a rather broad belt extending southwestward almost continuously from Naknek Lake to the country west of Chignik Bay. Near Mount Chiginagak and also along the southwest side of the Aniakchak River valley the central intrusion is connected with another belt of igneous rocks forming the core of the Aleutian Range southwest of Wide Bay. The greater part of the cape between Portage and Wide bays is made up of an igneous mass extending inland as far as Lake Ruth. The mountains bordering Kujulik and Hook bays are almost entirely composed of rocks of volcanic origin. Dikes and sills are intruded in nearly all the sedimentary formations. The igneous rocks differ in composition and texture from one area to another.

The rocks of the southeast side of the Alaska Peninsula are folded into several more or less well defined roughly parallel anticlines and synclines whose axes extend southwest, in general conformity with the direction of the peninsula. Most of the folds are broad structural features, with dips generally not exceeding 16°. The anticlines are rather persistent but are interrupted at places by igneous intrusions or by major faults.

SEDIMENTARY ROCKS.

TRIASSIC ROCKS.

The Upper Triassic rocks that crop out on Cape Kekurnoi, at the northeast entrance to Cold Bay (see Pl. VIII), are the oldest sedimentary rocks exposed on the Alaska Peninsula. Beds of Triassic age are not known elsewhere on the peninsula, but it is possible that they underlie large areas and might be encountered by deep drilling at Wide Bay. A detailed section of the Upper Triassic rocks has not been made, but in general the lower beds, which are contorted and crumpled, consist of hard, dense thin-bedded limestone and limy shale cut by dikes and sills of basalt. The upper beds become less calcareous and more sandy until finally a dense sandstone is encountered, in the upper part of which are found Jurassic fossils. The transition from limestone to sandstone is very gradual, and there is no evidence of an unconformity; the Triassic formation is therefore considered to end where the sandy phase begins. The upper beds of the series are not so greatly crumpled and dip 10°–20° NW.; the strike is northeast, conforming in general to the strike of the thick overlying Jurassic beds. Calcite stringers are abundant in the limestone.

The limestone beds in the lower part of the formation contain large numbers of the widely distributed Upper Triassic fossil shell *Pseudomonotis subcircularis* Gabb, and a few specimens of a fossil hydrozoan, *Stoliczkaria*, were collected, belonging to a species known only from this locality in North America but found in the Triassic of Europe.

The contact of the Upper Triassic and Lower (?) Jurassic formations has not been followed across the cape, but the areal extent of the former is probably very small, not exceeding 3 or 4 square miles. It is exposed along the beach at Alinchak Bay, the next indentation northeast of Cold Bay, where the succession as reported by Martin[13] consists of basic igneous rock at the bottom, succeeded by contorted cherts that have yielded no fossils, and these in turn overlain by shale and limestone yielding *Pseudomonotis*.

JURASSIC ROCKS.

Most of the sedimentary beds of this region were deposited during Jurassic time. The only known sedimentary beds on the peninsula that are older than Jurassic are the Triassic rocks just described.

The rocks included in this group represent largely shoreward phases of sedimentation. Limestone, which indicates deposition in deep water or clear shallow water, is entirely absent above the Triassic except where it occurs as large concretions in the upper part of the Shelikof formation and as smaller concretions in shaly beds in the Naknek formation. Sandstone is the most abundant and is predominantly arkosic. The coarseness of grain of much of the sandstone is a good indicator of shallow-water deposition, but the evidence supplied by the nature of the bedding is more conclusive. Much of the sandstone is cross-bedded, and in many places it is interbedded with conglomerate. The conglomerate is abundant. Some

[13] Martin, G. C., Preliminary report on petroleum in Alaska: U. S. Geol. Survey Bull. 719, p. 58, 1921.

beds are only a few inches thick; others occur as a series 1,000 feet or more in thickness with a minor amount of arkosic material. The material of which they are composed ranges in coarseness from fine grits to boulders several feet in diameter. These beds of conglomerate, included in formations composed of marine sediments, can represent nothing else than deposition in shallow water under shore conditions, as these large boulders must have been deposited close to their source. Shale is abundant, but less so than the coarser sediments, and even the shale is inclined to be sandy rather than argillaceous. Still other indications of the shoreward phase of sedimentation are the fossil plants that are found in the sandstone and the small lenses and seams of lignitized wood, which indicate the presence of vegetation during the process of sedimentation and therefore shallow-water, near-shore conditions.

LOWER (?) JURASSIC ROCKS.

Sedimentary rocks of Lower (?) Jurassic age crop out on Cape Kekurnoi, where they conformably overlie the Triassic limestones described above. (See Pl. VIII.) These rocks occupy a few square miles in a narrow strip crossing the cape that separates Cold Bay from Alinchak Bay, to the northeast. This strip is the only known area of Lower (?) Jurassic rocks on the Alaska Peninsula. The beds show a gradual transition from the underlying Triassic limestone into the impure limestone and calcareous sandstone and shale that form the basal part of the Lower (?) Jurassic. There appears to be strict conformity between the two formations, and the paucity of fossils makes it difficult to determine the contact. The poorly preserved fossils collected include several ammonites which in form and sculpture suggest Lower Jurassic genera, such as *Arietites*, *Aegoceras*, and *Amaltheus*, but it has not been possible to make positive identifications. The sedimentary beds tentatively included in the Lower Jurassic are 2,300 feet thick. The 1,500 feet at the bottom may be divided into two parts—a lower part consisting mainly of limestone and limy sandstone and shale and an upper part in which there is a narrow zone characterized by conglomerate and sandstone containing abundant bright-red jasper pebbles, brightly colored greenstone particles, and fragments of carbonaceous shale. The 800 feet at the top of the formation is composed of a black to rusty sandy shale with some thin beds of limestone. No fossils were found in this shale, but on the basis of lithology and field relations it is tentatively included in the Lower Jurassic.

MIDDLE (?) JURASSIC ROCKS.

KIALAGVIK FORMATION.

The Kialagvik formation, of Middle (?) Jurassic age, occurs along the sides of the southwest end of Wide Bay and continues a short distance inland along the base of the mountains beyond the head of the bay. (See Pls. VIII and XI.) This formation is of especial interest, because it consists of the oldest rocks exposed along the crest of the Wide Bay anticline and is the only probable representative of Middle Jurassic time on the peninsula. It was named the Kialagvik formation from the native name for Wide Bay, along whose shore has been found the only outcrop of the formation on the Alaska Peninsula. On the northwest side of the bay the formation occurs as a narrow strip about a mile wide extending from a point near the mouth of Lee Creek to a point nearly 3 miles up the broad glacial valley at the southwest end of the bay. The beds exposed in the bluffs along the shore back of the sand spit and farther southwest at the base of the mountains belong to this formation. The rocks on the northwest side of the bay consist of sandstone, sandy shale, and conglomerate, which on Short Creek are intruded by several small dikes and sills. The greater part of the area is covered by glacial drift and by a dense growth of alders and grasses, so that the contact with the overlying Upper Jurassic formation is difficult to follow. In the valleys and on the shore southeast of Lee Creek where the contact was observed there is evidence of an angular unconformity between the two formations. The unconformity is most pronounced at the bluff near the mouth of Lee Creek, where the shale beds of the Kialagvik strike S. 45° E. and the overlying conglomerate and the beds in the hills west of the bay strike southwest. Here the Kialagvik beds can best be examined at low tide. Toward the head of the bay they are nearly horizontal or have very slight dips to the northwest.

The extent of the Kialagvik formation along the southeast shore of the bay was not determined, but it does not crop out at the point of land projecting toward the islands. On this side of the valley the rocks are hidden by vegetation. At the base of the first small glacier, 2½ miles up the valley, only Upper Jurassic rocks were recognized. The beds of the Kialagvik formation dip 6° S. on the southeast side of the bay and consist of perhaps 200 feet of coarse sandstone and a few thin beds of fine conglomerate. From a short distance the rocks appear to be colored light red, but a freshly broken surface of the sandstone is bluish. The greater part of the valley at the head of the bay is probably underlain by the Kialagvik formation.

The formation is abundantly fossiliferous. Some of the fossils have led T. W. Stanton to correlate this formation with the lower part of the type section of the Tuxedni sandstone at Tuxedni Bay, on the west shore of Cook Inlet, or with beds slightly older—a correlation which would indicate that these rocks represent only the lower part of the Middle Jurassic. During at least the greater part of Middle Jurassic time either this portion of the Alaska Peninsula stood above sea level, or else sediments were laid down that were subsequently removed by erosion. It is probable that there was a long period of erosion during the later part of the Middle Jurassic epoch and that the sediments laid down early in the period were partly removed at Wide Bay and entirely removed at Cold Bay.

The fossils that were collected from the Kialagvik formation at Wide Bay have been determined by T. W. Stanton as follows:

11349. No. F 13. South shore at southwest end of Wide Bay:

Rhynchonella sp.
Pinna sp.
Pecten sp.
Inoceramus lucifer Eichwald?
Trigonia sp.
Dactylioceras? sp.
Belemnites sp.

These fossils probably belong to the Kialagvik fauna.

11350. No. F 14. West shore of Wide Bay south of Short Creek. Stratigraphically 150 feet above collection F 31:

Ostrea sp.
Trigonia sp., Glabrae group.
Protocardia sp.
Tancredia? sp.
Pleuromya dalli (White).
Natica sp.
Hammatoceras howelli (White).
Hammatoceras? kialagvikensis (White).
Harpoceras whiteavesi (White).

Kialagvik fauna.

11351. No. F 31. Capps locality 104, Wide Bay:

Pecten sp., smooth form.
Gervillia sp.
Trigonia sp., Glabrae group.
Pleuromya dalli (White).
Natica sp.
Hammatoceras howelli (White).
Harpoceras whiteavesi (White).

Kialagvik fauna.

11352. No. F 15. Wide Bay, 1 mile up creek southwest of Short Creek:

Pecten sp., smooth form.
Lima sp. related to L. gigantea Sowerby.
Inoceramus lucifer Eichwald?
Dactylioceras? sp.

These fossils apparently belong to the Kialagvik fauna.

11353. No. F 16. Wide Bay, 1 mile up Short Creek:

Inoceramus lucifer Eichwald?
Belemnites sp.

Probably Kialagvik fauna.

11357. No. F 30. 1 mile northwest of Lee's cabin at Wide Bay:

Inoceramus lucifer Eichwald?
Inoceramus sp. Larger form with coarse concentric ribs.

Jurassic, probably Kialagvik.

11358. No. F 32. Float found on point at Wide Bay:
Inoceramus lucifer Eichwald?
Stephanoceras? sp.
The fragment of a small ammonite (Stephanoceras?) in this lot is closely related to if not identical with a form in the Tuxedni sandstone and thus apparently gives another tie between the Tuxedni and the Kialagvik.

The species of the Tuxedni fauna described by White have been referred by Pompeckj to the upper Lias—that is, the upper part of the Lower Jurassic. Hyatt said that the nearest relatives of the fauna are in the "lowest parts of the Inferior Oolite, in formations placed by many German and French authors in the upper Lias." On account of the relationship which the fauna shows to the Tuxedni fauna Stanton refers it to the lower part of the Middle Jurassic.

UPPER JURASSIC ROCKS.

SHELIKOF FORMATION.

The lower part of the rocks of Upper Jurassic age in the Cold Bay region is called the Shelikof formation, from the fact that it is the chief outcropping formation on the northwest shore of Shelikof Strait from Katmai Bay to Wide Bay. (See Pl. VIII.) The upper contact of this formation can be traced throughout the district and is marked by a heavy shale member overlain by the coarse basal conglomerate of the Naknek formation. The lower contact was observed by Capps at only two places—at Wide Bay, where the Shelikof formation unconformably overlies sandstones of Middle (?) Jurassic age, and on the northeast shore of Cold Bay, where the Middle (?) Jurassic is entirely absent and the Shelikof rests on Lower (?) Jurassic rocks. Although the lithology of the formation as a whole is not constant, the uppermost member, a massive black shale 700 to 1,000 feet thick, containing numerous limestone lenses and concretions, is observed in every section. This shale member is poorly fossiliferous, but its position, underlying the heavy basal conglomerate of the Naknek formation, leaves no doubt concerning its horizon. Below the massive shale member is 4,000 to 4,700 feet of massive brown to gray sandstone with minor amounts of shale and conglomerate. The shale beds are thicker west of Wide Bay than between Cold and Portage bays, but the sandstone is not so thick, and the total thickness at the extreme southwest end of Wide Bay is less than at Cold Bay. The lower 1,500 feet of the formation along Lee Creek is chiefly shale with some limy and concretionary phases. At the base of the shale a bed of coarse conglomerate lies unconformably upon the Kialagvik formation. A dark massive sandstone, resembling an oil-impregnated sandstone that occurs on upper Trail Creek at Cold Bay, is exposed in the mountains 2 miles west of Wide Bay. The sandstone is about 50 feet thick in the mountains between the main and west branches of Lee Creek.

The sandstone and shale are locally calcareous, and the sandstone is in places little more than a sandy shale. The sandstone is also concretionary in many places, the concretions ranging from small well-rounded bodies a few inches in diameter to large irregular, poorly defined masses. At Wide Bay the lower 1,500 feet of the formation is mostly shale with some limy lenses and concretions. At Cold Bay the lower part of the formation is sandstone with a conglomerate at the base, and below the conglomerate is 800 feet of shale that is tentatively included in the Lower (?) Jurassic as described above. This thick series of shale beds, however, contains no fossils by which its age could be determined, and possibly the shale does not belong in the Lower Jurassic but is the age equivalent of the lower shale at Wide Bay.

The beds on the islands in Wide Bay differ lithologically from other sections of the Shelikof formation and are not fossiliferous. A detailed section of the strata along the southwest shore of the large island opposite Lee Creek is as follows:

Section on island in Wide Bay.

	Feet.
Thin-bedded bluish shale with lenses of limy concretions	50
Coarse arkosic sandstone with seamlets of coal about 1 inch thick and thin beds of shale	100
Massive gray sandstone and thin beds of shale	105
Thin-bedded sandstone alternating with beds of shale	325
Very massive hard brown to light-gray sandstone	585

The islands consist of rocks of the Shelikof formation except several small ones near the northeast entrance of the bay, which consist entirely of igneous rocks. The beds on the islands and the point of land projecting toward the islands on the southwest side of the bay dip 6°–24° SE. and form the southeast flank of the Wide Bay anticline. The prevailing dips on the mainland are to the northwest. Several faults, including one of perhaps 800 feet displacement, occur in the vicinity of Lee Creek. Some of the shale beds contain lenses of limestone nodules which weather to a conspicuous light-yellow color. A freshly broken nodule consisted of dark-blue, nearly pure limestone yielding the characteristic Upper Jurassic ammonite *Cadoceras*.

Cadoceras is found throughout that part of the formation below the uppermost shale member, and as this same fossil is characteristic of the Chinitna shale at its type locality at Chinitna Bay, on Cook Inlet, this part of the Shelikof formation can be definitely correlated with the Chinitna. The type section of the Chinitna formation is not as thick as the Shelikof formation, and there is considerable difference in lithology. The Chinitna attains a maximum thickness of 2,400 feet on Chinitna Bay; the Shelikof is 6,000 to 7,000 feet thick at Wide Bay. The type section on Chinitna Bay is composed predominantly of shale. The uppermost member of the Chinitna formation is a series of dark massive shales 500 to 1,000 feet thick, containing numerous concretions and lenses of impure limestone and a few fossils. The uppermost members of the Chinitna and the Shelikof are comparable, but there the analogy ceases, as the rest of the Shelikof is largely sandstone and the rest of the Chinitna is practically all shale; moreover, as mentioned above, there is a great disparity in thickness. The Shelikof formation and the Chinitna shale are approximately contemporaneous, but the conditions of sedimentation in the two regions were obviously somewhat different.

The Shelikof formation has an economic significance in the Cold Bay district, as it is in this formation that the hopes for a petroleum industry are centered. Considerable black shale is intermixed with the sandstone of the formation, and it is believed that this shale may possibly be the original source of the petroleum. Under proper structural conditions the heavy shale member at the top of the Shelikof would form a good cap rock to prevent the escape of imprisoned gas and oil. Most of the seepages in the Cold Bay district come from the Shelikof formation and are approximately alined along the Bear Creek-Salmon Creek anticline and its prolongation. The seepages near Pearl Creek issue from the overlying Naknek formation, but it is possible that the petroleum has been released from the Shelikof formation by fissures or minor faults.

NAKNEK FORMATION.

The Naknek formation is probably the most extensive surface formation of sedimentary rocks on the Alaska Peninsula. (See Pl. VIII.) The term was originally applied by Spurr [14] to a series of arkose and intercalated sills of lava in the vicinity of Naknek Lake, but the name has since been used to include a great series of sediments, distributed over a wide area on the Alaska Peninsula and the west side of Cook Inlet. The Naknek formation attains a great thickness and is well exposed in the drainage basins of Becharof and Ugashik lakes and also west of Wide Bay in the vicinity of Deer Mountain. It probably extends continuously from Naknek Lake to the north side of Mount Chiginagak, where it is intruded by large masses of igneous rocks that form a group of mountains northeast and west of the volcano. For 40 miles southwest of these moun-

[14] Spurr, J. E., A reconnaissance of southwestern Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 169–171, 1900.

tains only Tertiary rocks were recognized. The Naknek formation is again exposed near the divide of Aniakchak River and Lava Creek. The occurrence of Upper Jurassic rocks between the area visited near Mother Goose Lake and the Pacific coast was indicated by the presence of float rock containing Naknek fossils at the head of one of the westward-flowing streams.

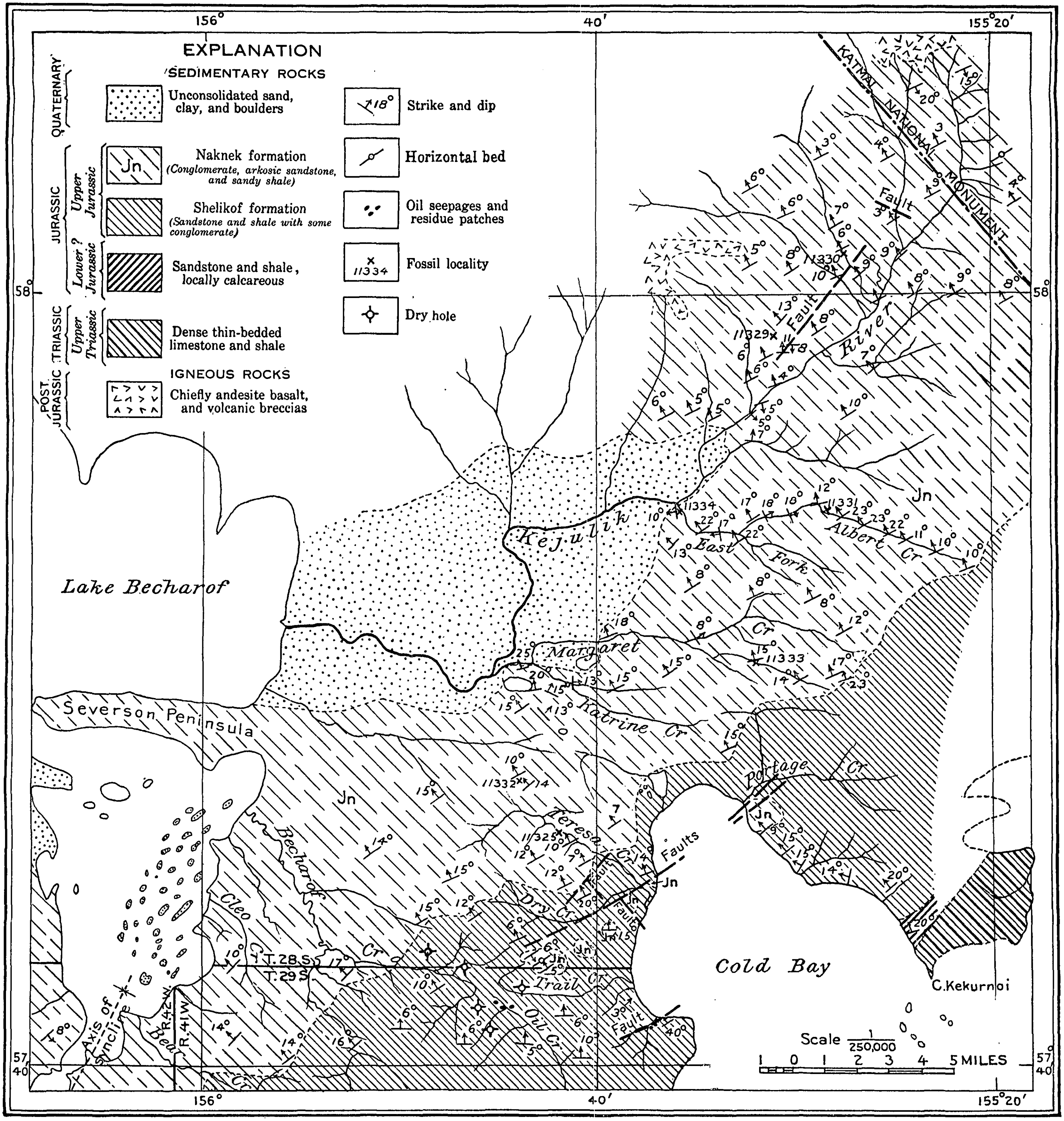
The base of the Naknek formation, wherever observed in this region, is characterized by a coarse conglomerate conformably overlying the upper shale member of the Shelikof formation and making the two formations easily separable on the basis of lithology. The conglomerate is in places separated from the shale by a varying amount of coarse arkosic sandstone. The conglomerate is composed of well-rounded boulders of granitic material in an arkosic matrix. The boulders range in size from small pebbles to large rounded masses of rock 6 or 8 feet in diameter, or even larger. As would be expected in so coarse a sedimentary deposit, there is great lateral variation in character of material and in the thickness of the formation. The conglomerate is interbedded with arkosic sandstone, and laterally it grades into the sandstone either by thinning out or by a gradual change in the coarseness of the material. Northeast of Cold Bay the conglomerate itself is much finer than that between Cold Bay and Portage Bay, as few boulders over a foot in diameter were seen, and the average diameter was not more than 2 or 3 inches. Near the crest of the range southeast of the upper part of the Kejulik Valley the conglomerate at the base of the Naknek formation was estimated to be 40 feet thick and is overlain by 500 feet of coarse arkosic sandstone, which in turn is overlain by several hundred feet of finer-grained sandstone. In the vicinity of Pearl Creek there is a massive conglomerate nearly 900 feet thick underlain by several hundred feet of interbedded sandstone and conglomerate and overlain by arkosic sandstone and massive conglomerate, the whole series being approximately 2,500 feet thick. In tracing the conglomeratic phase of the basal Naknek southwestward from Cold Bay it can be observed to thicken gradually from 500 feet near the head of the Kejulik Valley to the enormous thickness exposed in the vicinity of Pearl Creek and Deer Mountain. There appears to be no break in sedimentation within the formation, so it is probable that more detailed work will show that the thick series of conglomerate and arkose in the Pearl Creek area changes into finer sediments toward the northeast, and that the relatively finer sandstone and shale overlying the conglomerate in the Kejulik Valley were deposited at the same time as the upper part of the coarser sediments.

A conglomerate lying at the base of the Naknek formation has been mapped as a separate formation on the west shore of Cook

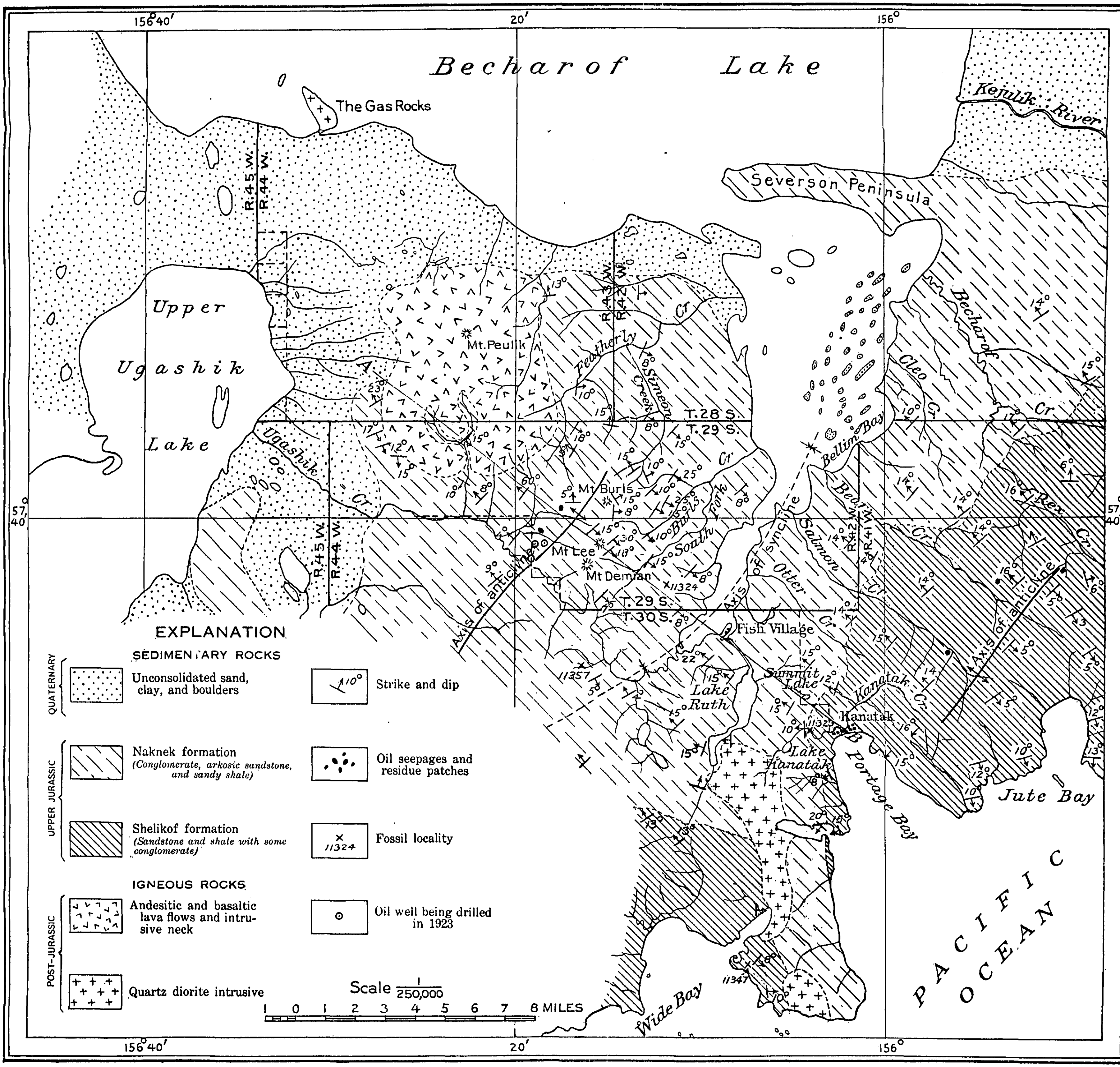
Inlet.[15] This conglomerate is typically exposed on Chisik Island in Tuxedni Bay and has been named the Chisik conglomerate. It occurs below the Naknek formation as there mapped and overlies the Chinitna shale, which is the equivalent of at least a part of the Shelikof formation, and therefore this conglomerate is in the same relative position as the conglomerate exposed in the Cold Bay district. The Chisik conglomerate closely resembles the conglomerate at the base of the Naknek formation at Cold Bay, as it is composed of large well-rounded boulders of granitic material. No fossils could be found in the conglomerate of either area, but the stratigraphic position and lithologic character of the conglomerate at Cold Bay suggest its correlation with the Chisik conglomerate. It would be difficult to map the conglomerate at Cold Bay as a separate unit, however, because of its great lateral variation in thickness and in coarseness. Furthermore, it appears to be an integral part of the Naknek formation, and in the writers' opinion it should be classed as the basal part of the Naknek and so mapped, rather than distinguished by a separate name.

Between Mount Peulik and the south arm of Becharof Lake a thick section of the Naknek formation is exposed. (See fig. 2.) Here the basal 2,500 feet of conglomeratic and arkosic beds are overlain by 1,600 feet of sandstone that is mainly arkosic but does not contain any interbedded conglomerate. Above this sandstone is about 1,500 feet of sandy shale that Capps considered as representing the highest Naknek beds outcropping in the region and is well exposed on the west shore of the southern arm of Becharof Lake. These beds make a total thickness of about 5,600 feet of the Naknek. The rocks exposed around the old crater of Mount Peulik consist largely of sandstone and conglomerate that are similar in character to the conglomeratic phase of the lower part of the Naknek formation, but they contain more sandstone, are about 1,600 feet thick, and are overlain by about 700 feet of sandy shale which immediately underlies the lava flow on the southeast side of the crater. The stratigraphic position of the beds beneath the lava flow is somewhat in doubt, but it is probable that they are to be correlated with the shale beds exposed along the upper arm of Becharof Lake. West of the old crater is exposed a series of sandstone and conglomerate which may be higher in the stratigraphic section than the shale member underlying the lava flow. There is no great thickness of consolidated sedimentary rocks west of the crater between the edge of the lava flow and the unconsolidated Recent deposits near the shore of Ugashik Lake, under which the sedimentary rocks dip.

[15] Martin, G. C., and Katz, F. J., Geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, pp. 68, 69, 1912. Moffit, F. H., The Iniskin Bay district: U. S. Geol. Survey Bull. 739, p. 119, 1922.



GEOLOGIC SKETCH MAP OF KEJULIK VALLEY.



GEOLOGIC SKETCH MAP OF VICINITY OF PEARL CREEK DOME AND MOUNT PEULIK.

A—B, Line of section in Figure 2.

No fossils could be found in these rocks, but lithologically they can not be distinguished from the underlying rocks of known Naknek age, so they are provisionally included in that formation. Extensive faults were not observed around Mount Peulik, but it is probable that considerable movement has taken place, making the determination of the correct stratigraphic position of the strata a problem requiring detailed work.

The rocks of the Naknek formation that crop out in the Kejulik Valley (see Pl. IX) are somewhat different in lithology from those just described, which crop out around Mount Peulik and on the Pearl Creek dome. They are of much finer grain considered as a whole and contain a greater amount of shale. The beds appear to be enormously thick, but the apparent great thickness is thought to be due in part to repetition of the same beds by faults, although only a few minor faults were seen in the valley. An estimate of the thickness made from the dips of the beds across the valley without postulating faults gives a thickness of 11,000 feet.

The basal conglomeratic phase, as described above, thins from a series 2,500 feet thick at Pearl Creek to about 500 feet of coarse arkosic sandstone with 40 feet of conglomerate near the base in the Kejulik Valley section. Overlying this coarser phase and continuing across the Kejulik Valley, as far as the survey was carried, the rocks consist mainly of fine arkosic sandstone with numerous thick beds of dark shale. This variation in the character of the sediments from Pearl Creek to the Kejulik Valley is natural in view of the differences in proximity to the source and the rate of sedimentation that must have prevailed. These rocks were mainly deposited in shallow water, as most of the sandstones are cross-bedded and some of them contain lignitized plant remains. To supply sediments so coarse as those that make up the Naknek formation in the Cold Bay field erosion must have been very rapid, and the material must have been transported by short, swift streams, as this coarse material could not have been moved far from its source. Such conditions, though commonly observed to persist during short periods, rarely continue for so long a period as that represented by the basal part of the Naknek formation.

The fossils that were collected from the Naknek formation in 1922 have been determined by T. W. Stanton as follows:

11323. South side of creek that drains Kanatak Lake:
- Pteria sp.
- Nucula sp.
- Cardium?

Jurassic. Formation not determinable from these fossils; possibly Naknek.

11324. In gulch 2,250 feet S. 60° E. from forks in south fork of Burls Creek:
Aucella sp. related to A. erringtoni (Gabb).
Inoceramus sp.
Astarte sp.
Phylloceras sp.
Belemnites sp.
Jurassic; Naknek.

11325. Three miles up Teresa Creek from shore:
Pecten sp.
Pteria sp.
Aucella sp. related to A. bronni Lahusen.
Nucula sp.
Pleuromya sp.
Jurassic; Naknek.

11332. One mile north of saddle at head of Teresa Creek:
Aucella sp.
Nucula sp.
Astarte? sp.
Patella sp.
Undetermined small slender gastropod.

11333. Basal Naknek on west side of range across from Alinchak Bay:
Aucella sp. related to A. bronni Lahusen.
Nucula sp.
Pleuromya sp.

11334. 1600 feet southwest of junction of East Fork and Kejulik River:
Aucella pallasi Lahusen?
Lima sp.
Pteria sp.
Jurassic; Naknek.

11329. About 1 mile northwest of Kejulik River and 2 miles southwest of point where two large tributaries come into river:
Pecten sp.
Lima sp.
Astarte sp.
Jurassic; Naknek.

11330. Two miles up from Kejulik River along eastern of two tributaries mentioned under 11329:
Pecten sp.
Lima sp.
Lima? sp.
Aucella sp.
Leda? sp.
Astarte sp.
Turbo? sp.
Jurassic; Naknek.

11331. In canyon near head of East Fork of Kejulik River:
Anomia? sp.
Lima sp.
Aucella sp, related to A. erringtoni (Gabb).
Pleuromya sp.
Belemnites sp., large phragmacone.
Jurassic; Naknek.

11363. No. F 37. Shale on bank of Kejulik River, northeast of Becharof Lake:

Amberleya sp. This is a fine specimen, but the range of the species is not known.

11344. No. F 1. Kanatak. From shale just beneath Naknek, 100 feet higher stratigraphically than Capps locality 1-79 (1921).

Pteria sp.
Nucula sp.
Grammatodon sp.
Astarte sp.
Belemnites sp.
Jurassic; nothing distinctive to decide between Chinitna and Naknek.

11345. No. F 7. Across divide at head of Ugashik Creek.

Cidaris? sp., fragmentary imprint.
Pholadomya sp.
Phylloceras sp.
Jurassic; probably Naknek.

11346. No. F 8. Shale just below Naknek conglomerate. West bank at head of north branch of Big Creek, Wide Bay:

Cidaris? sp.
Ostrea sp.
Pteria sp.
Grammatodon sp.
Solemya sp.
Turbo? sp.
Undetermined gastropod.
Apparently belongs to same fauna as 11344, probably Naknek.

11359. No. F 33. Gates of crater, head of Aniakchak River:

Aucella pallasi Keyserling?
Pleuromya sp.
Phylloceras? sp.
Naknek fauna.

11360. No. F 34. Fossil Creek, north of Lake Becharof. Collected by Dr. Laymore:

Aucella pallasi Keyserling?
Naknek fauna.

11348. No. 12. Erma Bay, south of Wide Bay:

Lima sp.
Aucella pallasi Lahusen.
Naknek.

11354. No. F 18. 8 miles southwest of Wide Bay:

Aucella sp. related to A. erringtoni (Gabb).
Fragments of undetermined ammonite and belemnite.
Naknek fauna.

11356. No. F. 26. East bank, near head of Lava Creek:

Aucella sp. related to A. bronni Lahusen.

The highest part of the Naknek formation north of Mount Chiginagak consists of a thick series of dark-yellow to brown sandy shale which lies above the interbedded conglomerate and arkosic sandstone. The shale is somewhat similar in appearance to the shale in Ugashik Mountain and yields the same fossils—several species of *Aucella*.

The uppermost member of the Naknek formation exposed near the headwaters of Aniakchak River and Lava Creek consists of about 200 feet of very massive light-colored sandstone, which is not fossiliferous and does not show any bedding planes. Throughout its thickness it is reticulated with a network of calcite veinlets, which in places are so numerous that the rock appears almost white and can be recognized from a distance. Many small slickenslides occur in the sandstone. It is possibly the uppermost member of the Naknek formation known on the peninsula. The sandstone is overlain unconformably by the Tertiary formation. The rocks lying conformably beneath the sandstone consist of brownish thin-bedded sandy shale that is similar in character to the sandy shale near Mount Chiginagak and Becharof Lake and yields the same species of fossils. The base of this shale is not exposed in the Aniakchak district. The base of the mountains forming the east side of Aniakchak Crater is composed of sedimentary rocks belonging to the Naknek formation. The unconformity between Upper Jurassic and Tertiary rocks can be plainly seen on part of the inner wall of the crater. The extent of the formation southwestward from the crater is not known, but it occurs in the mountains at the head of Hook Bay Creek and inland west of Chignik Bay.

UPPER CRETACEOUS ROCKS.

CHIGNIK FORMATION.

Sedimentary rocks of Upper Cretaceous age are represented only in the extreme southwestern part of the area examined during the summer of 1922. These rocks, occurring along the west shore of Chignik Bay, on Chignik Lagoon, and on the upper part of Hook Bay Creek (see Pl. VIII), were studied and mapped in 1908 and later described by Atwood.[16] The Chignik formation consists of sandstone, shale, conglomerate, and some valuable coal seams. These beds rest unconformably upon the Naknek formation and are overlain by vast quantities of volcanic tuff and basic lava flows in the Hook Bay area north of Chignik Bay proper. The sandstone members of the formation range from fine even-grained sediments to grits, and some of the sandstone has a light-green color when fresh but weathers to black and shades of brown. The conglomerates are conspicuous members in the series, but they are not as thick as those of the lower Naknek, although similar in appearance, consisting of pebbles of granite, greenstone, and quartz as large as 4 inches in diameter. There are lenses of shale and sandstone in some of the

[16] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, pp. 41–48, 109–114, 1911.

conglomerate layers. Concretions and ripple marks are seen at many places in the sandstone beds.

The extent of the Chignik formation northeast of the head of Hook Bay Creek was not determined, but it probably does not extend more than a few miles, for the rocks in that area as seen from a mountain top west of Kujulik Bay appear to be volcanic. The beds on Hook Bay Creek strike N. 15° E. and dip 8°–60° SE. There is evidence of much faulting, although only minor displacements were noted. The beds at this locality consist chiefly of sandstone, with minor amounts of shale, conglomerate, and coal.

The Upper Cretaceous sedimentary rocks yield both plant and shell fossils. Several collections of shells were made at the head of Hook Bay Creek and northwest of the sand spit on Chignik Bay. The Chignik fauna is in part somewhat similar to that of certain beds in the Chico formation of California and in the Nanaimo on Vancouver Island.

TERTIARY ROCKS.

Tertiary rocks occupy an area of at least 600 square miles between Mount Chiginagak and the north side of the Aniakchak River valley. (See Pl. VIII.) This area, which is about 40 miles long and from 8 to 16 miles wide, forms a narrow basin between the main Aleutian Range on the southeast and the lower range on the northwest. These mountains bordering the Tertiary formation consist of intrusive igneous rocks. The Tertiary rocks are possibly of late Eocene or Miocene age. No invertebrate fossils were obtained from them, but several lots of fossil plants, which Arthur Hollick has identified, were collected from the upper part of the formation.

The beds in the area between Mount Chiginagak and Aniakchak River have a total thickness of at least 2,000 feet and are composed of shale, conglomerate, and sandstone, with some thin seams of lignite. East of Mother Goose Lake the lower 800 feet of the formation consists predominantly of bright-colored shale and thin beds of sandstone. These thick beds of shale were seen only at one locality. The base of these beds is not exposed, and their relation to the overlying sandstone and conglomerate was not determined. The upper 200 feet of the shale does not yield fossils; the lower beds exposed were not closely examined. The carbonaceous shale and thin lignite beds of the formation at other localities were entirely lacking in these shale beds. A section of the overlying beds is as follows:

Section of upper Tertiary beds between Mount Chiginagak and Aniakchak River.

	Feet.
Uppermost beds of bituminous shale yielding fossil plants; thin beds of sandstone and conglomerate	300±
Coarse dark to light gray sandstone and fine conglomerate	105
Light-yellowish shale with thin seams of lignite near the top	75
Coarse thin-bedded sandstone containing pebbles near the base	80
Yellow shale with 6-inch seams of lignite	65
Alternating beds of sandstone and shale	80
Chiefly shale with thin beds of pebbly sandstone	580
Coarse massive sandstone	50
Dark thin-bedded shale	40
	1,370

The beds are not persistent and the stratigraphic sequence could not be recognized from one locality to another, except the beds containing fossil plants, which occur over a large part of the area. Northeast of Aniakchak River the greater part of the section below the fossiliferous shale consists of thick beds of fine to very coarse conglomerate. The pebbles are as much as 3 inches in diameter and are usually worn very smooth. They consist of rocks of volcanic origin; occasionally a bright pebble of jasper is seen, and locally quartz pebbles are numerous. The pebbles are cemented by a matrix of hard coarse greenish sandstone which forms about half of the rock material. The following section was measured near the contact of a large intrusion:

Section of upper Tertiary beds 10 miles southwest of Mother Goose Lake.

	Feet.
Coarse pebbly sandstone and conglomerate	30
Light-colored sandstone, fine conglomerate, and minor amounts of shale	65
Coarse massive sandstone and fine conglomerate	40
Sandy shale and thin beds of limy shale	55
Pebbly arkosic sandstone and conglomerate	75
Sandy blue and yellow shale	40
Arkosic pebbly sandstone and conglomerate; some thin beds of fine-grained sandstone	70
Unexposed	75
Sandy limestone	20
	470

This section represents the highest Tertiary beds that were examined and is higher than the preceding section.

The strike of the beds in the entire area is predominantly southwest and the dip from a few degrees to 40° NW. There are local changes in strike, and in a few places the dips are reversed, but in general the whole area has been tilted upward and forms a monocline on the west flank of the Aleutian Range. The formation is not greatly faulted, although a fault of considerable displacement was noted southwest of Mount Chiginagak. Many small intrusions of andesite and granodiorite in the form of dikes, sills, and a small laccolith occur in the formation. A few miles northwest of the lower Aniakchak River valley the Tertiary rocks are overlain by vast quantities of volcanic tuff and breccia. In the lowland at the head of Aniakchak Bay there are several exposures of pebbly sandstone beneath the volcanic rocks. The age of these rocks was not determined, but they are probably Tertiary. Thin beds of coal are reported from the cape between Aniakchak and Kujulik bays and indicate either Tertiary or Cretaceous rocks.

The rocks west of Amber Bay are of sedimentary origin, but they were not examined, and their age is unknown. The upper beds are probably Tertiary. The strike of these rocks is N. 60° E. and the dip 18°–22° W.

QUATERNARY DEPOSITS.

The Alaska Peninsula has been the scene of active glaciation, but the glacial deposits that now remain there are not very abundant. There are two types of valleys, which may be classed as glacial and postglacial. The postglacial valleys are relatively small and V-shaped, but all the larger mountain valleys are of the typical U-shape due to scouring out by glacial erosion. Many of the present streams head in small glacial cirques, and some of the cirques contain small lakes of clear water. The only glacial moraines observed in the Cold Bay district were between Mount Peulik and Becharof Lake. The topography of that part of the district is the typical morainal topography, with low mounds like so many piles of débris and numerous small lakes hidden away among the hills. The moraines wherever visited are composed entirely of volcanic material of the same character as the lavas that were poured out from Mount Peulik. It is believed that these moraines represent the deposits from a slowly retreating small alpine glacier that descended from the volcanic peak.

The Kejulik Valley contains no terminal moraines in the area visited. The valley itself, during glacial time, contained a trunk glacier fed by numerous small glaciers that entered from nearly all the tributary valleys on the northwest side and from some of those on the southeast side. Some erratic boulders of basaltic rock are seen on the low hills and elsewhere in the main valley, regardless of the topography. Most of the tributaries of Kejulik River, entering from the northwest side, flow through wide, deep, U-shaped valleys showing the scouring effect of the ice that previously almost filled them. At present there are small tongues of ice at the heads of most of these valleys, and the water of Kejulik River has the milky color characteristic of streams of glacial origin.

Glacial drift, some of which is probably of Pleistocene age, occurs at a few localities in the region southwest of the Cold Bay district. Small patches of glacial material occupy the intervalley areas in the slightly elevated irregular plain between the west shore of Wide Bay and the mountains. These deposits are not conspicuous and are probably not thick, although in many places they obscure the underlying consolidated rocks. The greater part of the drift is unassorted and has the heterogeneity of material and size characteristic of glacial till. It is composed of clay, sand, gravel, and large boulders. Many of the boulders are striated and are smooth and flattened on one side. In the higher mountains there is evidence of vigorous glacial activity during Pleistocene time. The broad, steep-sided valleys extending inland from the heads of the bays are undoubtedly the result of ice scouring. Cirques, U-shaped valleys, and rounded surfaces of bare rock are common physiographic features that indicate extensive glaciation in the region. The greater part of the morainal material was either carried directly to the sea or has been washed away by recent streams. Many of the valleys and the lowland in the northwestern part of the peninsula probably contain more or less glacial material of Pleistocene age which has been worked over and redeposited in recent time.

In the high mountains of the Aleutian Range between Wide and Aniakchak bays numerous small glaciers, some of which are several miles long, exist at the present time. Morainal deposits at the heads of the valleys, especially southwest of Wide Bay and around the base of Mount Chiginagak, are formed by these glaciers. Most of the streams that carry the finer material from the glaciers build deltas of mud and clay in the lakes or bays.

Recent deposits of alluvium, glacial drift, beach sand, delta sand, and pumice form the surface material of many of the valley bottoms and stretches of sea and lake shores. The alluvium consists of unconsolidated clay and gravel which have resulted from the erosional work of streams, waves, and wind. Sand dunes and old sea beaches occur at the heads of many of the bays. Between Aniakchak Bay and the hills to the west nine crescent-shaped beaches can be distinctly seen in the form of low ridges, conforming in direction to the present shore line. The nature of the geologic work did not permit accurate mapping of the alluvium, but the larger areas have been indicated on the map. (See Pl. VIII.)

On the northwest slopes of Mount Peulik the streams have cut deep, narrow valleys into a thick series of unconsolidated gravel, composed of subangular basaltic pebbles and boulders which range from a fraction of an inch to several feet in diameter. In some places the streams have cut 30 or 40 feet into the gravel. This gravel is believed to be outwash from the mountain, the streams being greatly augmented by the great banks of snow that accumulate on the mountain side each year. Still higher on the mountain boulders of basaltic rock 10 or 12 feet in diameter are scattered promiscuously on the surface; these were transported to their present position by melting snow and the action of gravity.

Large quantities of pumice and fine volcanic ash have been thrown out of Aniakchak Crater over the surrounding country in Recent time. Much of the ash has been washed from the mountains and concentrated in the valleys. (See Pl. VIII.) The thickness of these deposits ranges from an inch of fine material 25 miles from the crater to at least 200 feet at the head of Lava Creek, 5 miles from the base of the crater. The physiographic features of the area within a radius of 10 miles indicate the enormous amount of material that was ejected from the crater. The bottoms of the Aniakchak and Meshik river valleys have been completely filled with ash and cinders. At the present time the valley floors form a broad, nearly level plain with a few isolated sharp-peaked mountains surrounded by the ash deposit. Since the eruption the streams have been continually transporting pumice and the fine ash to the sea. Small pieces of pumice can be seen moving rapidly along the bottom of Aniakchak River. Some of the transported material forms bars in the bay, but much of it has been thrown back on the beach and has made a remarkable series of sea beaches.

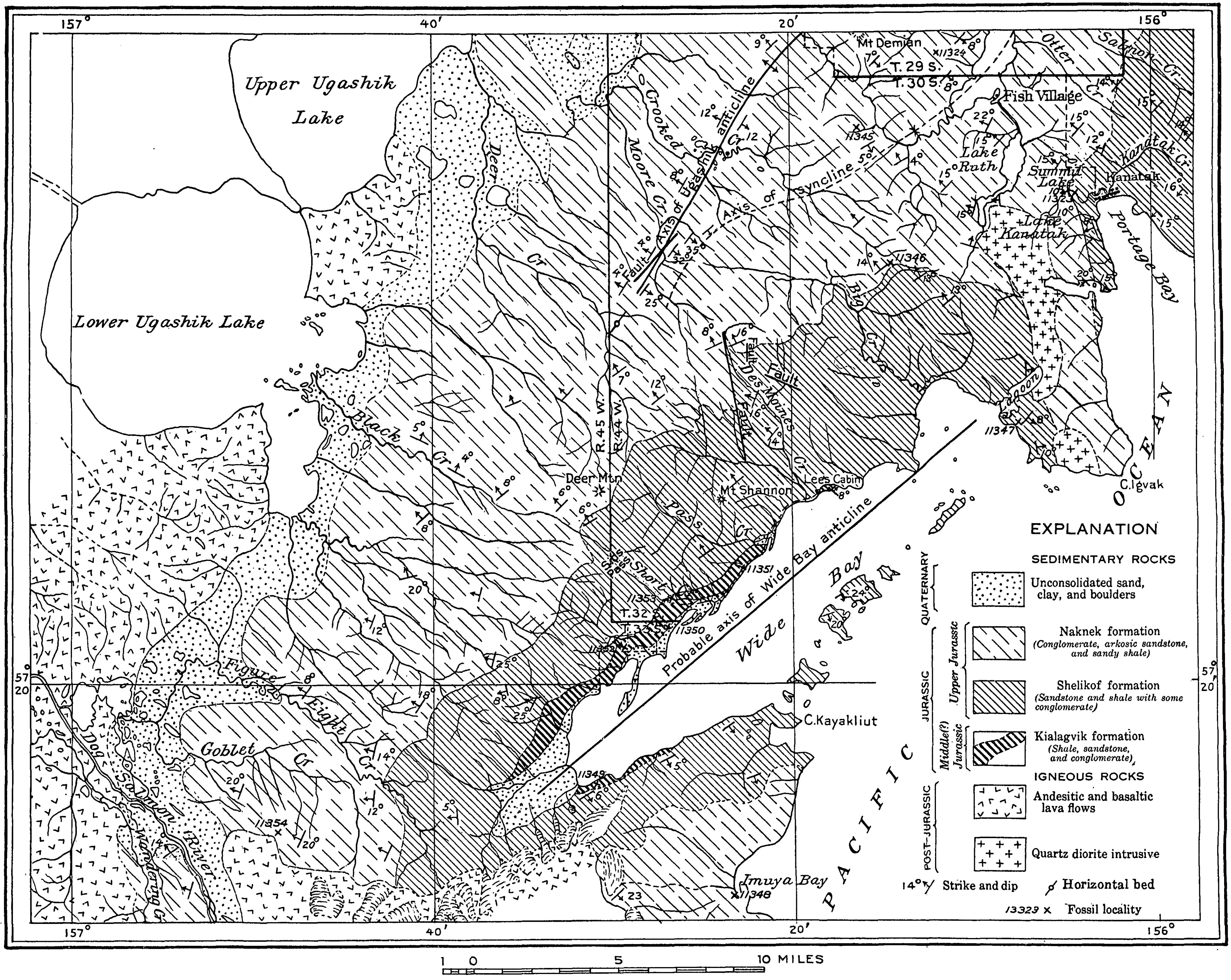
IGNEOUS ROCKS.

A variety of igneous rocks are seen in the Cold Bay region, but most of them are the result of volcanic activity. A quartz diorite stock forms the rugged hills on the promontory between Portage Bay and Wide Bay. (See Pls. VIII, X, and XI.) A few dikes that are not shown on the maps cut the Triassic limestones and the beds of the Shelikof formation. Mount Peulik, the most striking topographic feature in the region, is a recently extinct volcano standing on the rim of an older crater. Lavas from these craters have spread over a moderate area in all directions. North of Mount Peulik, on the south shore of the main body of Becharof Lake, is a volcanic neck surrounded by a greatly dissected cinder cone. North of Cold Bay are the Kejulik Mountains, with their lava-capped ridges and jagged peaks of igneous rocks.

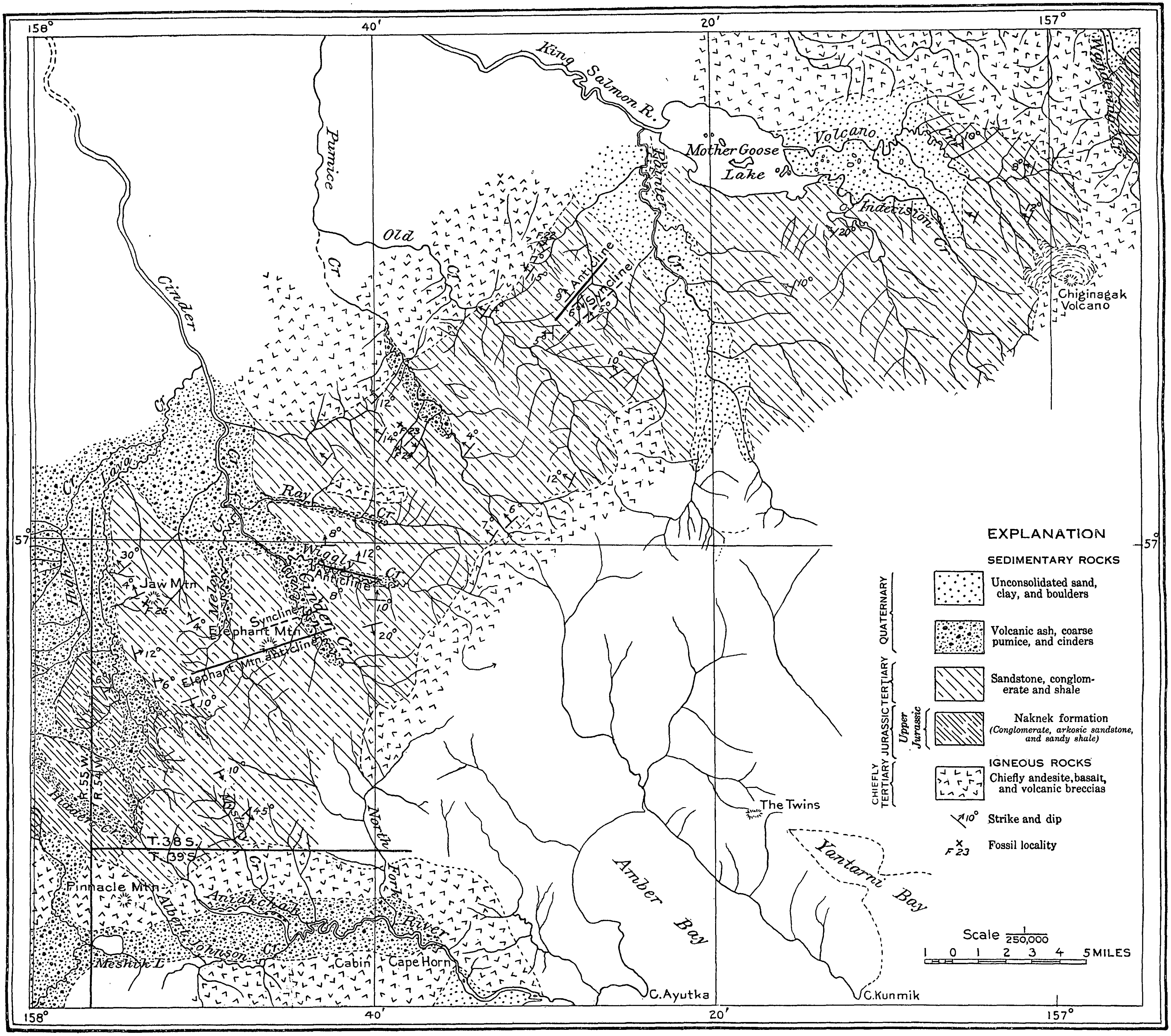
Cape Igvak, between Portage Bay and Wide Bay, with its high, rugged mountains, is composed of plutonic igneous rock. The intrusive body is about 10 miles long and 2 miles wide, elongated in a nearly north-south direction. On the seaward sides, except at the outer extremity of Cape Igvak, the intrusion is bordered by a narrow fringe of sedimentary rocks, which have been altered by the heat and hydrothermal action attending the intrusion. The sedimentary beds are cut by the intrusion but not flexed. Good exposures of the contact between the intrusive rock and the sediments can be seen at several places, but easily accessible points are in the cirque above Kanatak Lake, near the head of the lagoon on the west side of Portage Bay, and at the head of the lagoon indenting the cape at the northeast end of Wide Bay. The most striking feature that impresses the observer from a distance is the rich brown color of the hills adjacent to the intrusion, which is in marked contrast to the more somber color of the hills elsewhere in the region. Upon closer examination the sediments are found to be richly impregnated with pyrite, which, when exposed to the agents of weathering, becomes oxidized and imparts the familiar iron-oxide coloring. Abundant tourmaline is found near the contact as a black fibrous aggregate in thin sheets or in masses several inches in diameter in the igneous rock. Small veins composed almost wholly of magnetite cut the igneous rock at Kanatak Lake. The igneous rock is a quartz diorite and is a medium to coarse grained light-colored rock in which abundant black glistening flakes of biotite and crystals of hornblende can be seen on fresh surfaces. Microscopically the rock was found to contain biotite, hornblende, quartz, and andesine plagioclase, with subordinate amounts of augite, orthoclase, magnetite, and apatite.

The age of this intrusive mass can not be closely determined, but as it cuts the youngest sedimentary beds which are included in the Upper Jurassic Naknek formation it is post-Jurassic. As the sedimentary beds are not flexed at the contact of the igneous rock, there must have been a heavy load of overlying sediments at the time of the intrusion. This assumption is further borne out by the coarsely crystalline nature of the igneous rock itself, which indicates slow cooling at considerable depth. Subsequent to the intrusion a long time must have elapsed to permit the removal of the overlying sediments, for at present the igneous rock is well exposed, forming high, rugged mountains. Glacial cirques are cut into the quartz diorite at the heads of the valleys in several places where the streams and ice have cut through the bordering sedimentary beds.

The intrusive mass trends a little northwest and is thus nearly transverse to the structural trend of the sedimentary rocks. At Portage Bay the Bear Creek-Salmon Creek anticline plunges toward Cape Igvak, and at Wide Bay the Wide Bay anticline also plunges toward the cape, forming a low point or saddle between the two parts of the anticline, and the intrusive body of quartz diorite cuts across the saddle. From the description of the geologic struc-



GEOLOGIC SKETCH MAP OF WIDE BAY AND VICINITY.



GEOLOGIC SKETCH MAP SHOWING ELEPHANT MOUNTAIN ANTICLINE AND VICINITY.

ture in the Cold Bay region (p. 195) it is seen that nowhere else have the axes of the anticlines been folded to form a saddle, and it may be significant that the intrusive mass is associated with the only known fold of this kind. The interpretation of the relation depends to a large extent upon the time relations of the period of folding and the period of deformation. The geologic record is far from complete, and the most that can be certainly stated with present knowledge is that both the intrusion and the folding occurred after the deposition of the Upper Jurassic sediments, which are cut by the intrusive mass and are involved in the folds. However, from the field relations it seems probable that the period of folding preceded the period of intrusion, and the location of the intrusive mass in the saddle is believed to have no genetic relation with the saddle.

A dike at Portage Bay cuts both the Shelikof and Naknek formations and is described as diorite porphyry heavily impregnated with pyrite. This dike is undoubtedly an offshoot from the intrusive mass described above. Basaltic dikes cut the Shelikof formation and the Upper Triassic limestones at Cold Bay. Some of the basalts may be lava flows interbedded with the Triassic limestone.

There are nearly thirty active or recently active volcanoes[17] on the Alaska Peninsula and the Aleutian Islands, and probably many more than that have been long extinct and subsequently dissected. The Cold Bay district presents no exception to the history of volcanic activity so characteristic of the rest of the peninsula. It contains no volcanoes that are active now, but former activity has left a clear record in the district. The most recently active volcano is Mount Peulik (see Pl. X), which is the most prominent topographic feature on this part of the peninsula, rising to a height of 4,800 feet, and it has so recently become extinct that it still retains its conical shape. The present volcano stands on the rim of an older crater which is drained by Hot Springs Creek, through a deep, narrow gorge cut in its rim. In the center of the crater rises a large purplish cone-shaped hill, which represents either the core of the ancient volcano or a more recent subsidiary cone. The walls of the crater are composed of upturned shale, conglomerate, and sandstone, overlain by basaltic lava flows. Except for the Hot Springs Creek gorge the rim of the crater is intact and rises to a height of 2,000 feet, inclosing a great circular basin 2 miles across, in the middle of which the dull-purple cone rises as high as the rim. Basaltic lava flows have been poured out in all directions from the craters of both the ancient volcano and the present Mount Peulik.

[17] Waring, G. A., Mineral springs of Alaska: U. S. Geol. Survey Water-Supply Paper 418, pl. 1, 1917.

North of Mount Peulik three low hills rise out of Lake Becharof and are connected to the shore by a narrow strip of land which is very low and swampy. These hills are prominent, not because of their great height but because they rise directly out of the water and because they contrast strongly with the low rolling topography adjacent to the shores of the lake. They are the remnants of a volcanic cone which has been dissected by erosion. The middle hill of the three is composed of diorite porphyry and represents the core of the ancient volcano. The hill on the south side of the volcanic neck is composed of cemented ash and cinders, roughly stratified and dipping away from the core. The smaller hill, north of the other two, was not visited, as its existence was not known until the group was seen from the southwest, but it is doubtless also made up of cemented cinders and ash representing another flank of the cinder cone.

The Kejulik Mountains trend northeast and are about 15 miles northwest of Cold Bay. Near their junction with the coastal mountains is Mount Mageik, the active volcano nearest to Cold Bay. Great volumes of steam ascending about 3,500 feet in the air are frequently emitted by this volcano. From favorable places near the head of Cold Bay can be seen other volcanoes giving off quantities of steam, but these are all farther northeast along the peninsula, in the vicinity of Mount Katmai. The Kejulik Mountains have a very rugged appearance, showing numerous jagged peaks of igneous rock and lava-capped ridges. No distinct craters can be observed from the valley, but the extent of the lavas that can be seen on many of the ridges suggests that lava must have been poured out from several openings. The Kejulik Mountains, if extended southwestward, would include Mount Peulik, and the dissected volcano lying north of Mount Peulik and other volcanic areas on the peninsula southwest of Mount Peulik would line up with this same general trend. A line of weakness appears to exist along the peninsula in this region, localizing the volcanic activity, and there must be a genetic relation between the different volcanic areas.

An extensive area of granite was reported to occur on the west shore of the south arm of Becharof Lake near the mouth of Featherly Creek. An outcrop of arkose was found 2 or 3 miles from the mouth of Featherly Creek in the creek bed, and it is believed that this arkose was mistaken for a granite, as it was classed as an arkose with some hesitation in the field. Microscopic determination, however, leaves no doubt as to its sedimentary origin. The topography and structure of the area adjacent to Becharof Lake do not suggest the presence of granitic rocks. The south arm of the lake lies in a syncline, and normally the younger rocks should be exposed near the axis of a syncline, rather than the basement rocks upon which they were deposited. If the granite had been intruded subsequent to the deposition of the Jurassic sediments, later erosion that would have uncovered it would have cut away the soft sandstone and shale much faster than the granite, which would have been left as rugged peaks and elevated masses. Such forms do not occur in the Featherly Creek region, where the lower part of Featherly Creek flows through a low, slightly rolling country, such as would be produced by the physiographic development of the region in the absence of any intrusive masses.

The igneous rocks in the area southwest of Wide Bay, as in most other parts of the Alaska Peninsula, are chiefly of volcanic origin and are composed of andesitic and basaltic flows, tuff, and volcanic breccia. Dikes, sills, and laccolithic intrusions are also of frequent occurrence throughout the region.

The most conspicuous mass of igneous rocks mapped in the region extends from the southwest end of Lower Ugashik Lake to Aniakchak Crater, in the central part of the peninsula. The lower chain of mountains west of the main Aleutian Range is composed entirely of this central igneous mass. In the lowlands that border the Bering Sea and extend westward from these igneous mountains is a small isolated group of mountains west of Ugashik Lakes. This group was not visited, but from its physiographic expression and its position in respect to the known igneous rocks it is probably part of the same mass. Specimens collected from various parts of the large igneous mass have been determined to be andesite. Segregations of red jasper in the form of stringers and small irregular veins occur abundantly in these rocks, and crystal aggregates of stilbite were found scattered over the surface of some of the mountains. The entire mass of andesite is of a light-red or pink color, which, together with the rugged crests of the mountains, distinguishes the igneous rocks from the dark-gray sedimentary rocks of the region. From a distance the igneous rocks in several localities appear to be rudely stratified, with a strike and dip accordant with those of the contiguous sedimentary rocks.

The core of the main range along the Pacific coast between Wide and Chignik bays consists of large masses of andesite, quartz diorite, and basalt. The eastern boundaries of these igneous masses were not mapped, but volcanic rocks of various types are reported to occur along the coast from Wide Bay to Chiginagak Bay. At the head of the valley southwest of Wide Bay is a large mountain composed almost entirely of dark columnar basalt, into which a small glacier has cut deeply, forming a steep wall in which the basalt columns are well exposed. They stand vertically, are about 1 foot in diameter, and reach 20 feet or more in length.

The sides of Mount Chiginagak appear to be partly covered with recent lava flows, which are reported to extend to sea level at the head of Chiginagak Bay. The base of the volcano on the west side is formed by sedimentary rocks. A narrow strip of quartz diorite about 2 miles wide extends from the northwest side of Mount Chiginagak and merges into the central igneous area. On the south is a belt of sedimentary rocks, probably Upper Jurassic, which extends toward the coast. These rocks are intruded northwest of Amber Bay by a large mass of igneous rocks. Only the western border of this area was examined, but many mountains with the sharp crests characteristic of igneous rocks were seen toward the east. The specimens examined from this area range in character from basalt to diorite.

The largest area of igneous rocks in the region is found west of Aniakchak and Kujulik bays, where at least 200 square miles is covered to an unknown depth by andesitic flows and coarse volcanic breccia or agglomerate. This area extends about 16 miles up Aniakchak River and laterally from a point 2 miles north of the river southwestward to the northern entrance of Chignik Bay. The area narrows toward the southwest end of Kujulik Bay but includes parts of the peninsulas between Amber, Aniakchak, Kujulik, and Hook bays. The physical character and texture of the rocks vary somewhat throughout the area, but they are all varieties of hornblende andesite and pyroxene andesite. The greater part of this igneous breccia is in the form of angular fragments cemented together by a matrix of similar composition but in part differing in color from the fragments. Volcanic tuff and breccia of this type occur in many parts of the Alaska Peninsula. As described by Atwood,[18]

> The fragments included in this tuff range up to 20 feet in diameter; commonly their dimensions vary from 3 to 6 feet. Individual blocks display the darker shades of red, green, and gray. Some of the blocks are distinctly black and all of them show a scoriaceous texture. The tuff is poorly stratified but appears to have been in part, at least, laid down in water.

This description fits the rocks in the region west of Aniakchak and Kujulik bays except where they are less noticeably scoriaceous and more massive. Quartz occurs at places in the form of thin stringers through the tuff. At one locality west of the central shore line of Kujulik Bay a quartz vein about 3 feet wide was noted. Silicified tree trunks 2½ feet in diameter are embedded in the igneous material north of the long spit on the shore of Kujulik Bay. Smaller fragments of silicified wood were found on the mountains west of the bay, where the volcanic rocks are at least 1,000 feet thick. A high pinnacled mountain about 5 miles southeast of Aniakchak Crater does not consist of the brecciated material but is composed of massive

[18] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, p. 70, 1911.

hornblende andesite. This mountain is probably older than the flows.

Nearly all the igneous masses southwest of Wide Bay are either intruded through the Tertiary rocks or have flowed out over their surface. Similar igneous rocks in other parts of the peninsula have been considered chiefly of late Eocene or Miocene age. At several localities, especially at the head of the valley southwest of Wide Bay, the intrusive masses are found only in Upper Jurassic sedimentary rocks and may possibly be older than Tertiary, but their similarity to known Tertiary intrusive rocks and, in one place, their connection with such rocks make it probable that they are of the same age. Volcanic activity has undoubtedly been continuous on the Alaska Peninsula since early Tertiary time.

STRUCTURE.

GENERAL FEATURES.

The structure in the Cold Bay district is simple and is characterized by large features that can be easily followed in the mountainous part of the district. The sedimentary beds have a northeast strike and a dominant northwest dip, but this general attitude is interrupted by at least two and probably three lines of folds and faults that are approximately parallel to one another and to the coast. One line of folding extends through Wide Bay and Portage Bay to Rex Creek, a tributary of Dry Bay, and is continued northeastward through Cold Bay and an unknown distance northeast of Cold Bay by a fault. The second line of folding is a well-developed anticline lying 8 to 15 miles inland and extending southwestward from Mount Burls. Between these two anticlinal folds lies a synclinal trough extending northeastward through the southern arm of Becharof Lake and possibly into the Kejulik Valley. (See Pl. IX.) These folds have been fully described by Capps,[19] but a brief description of the folds will be given here in order that the reader may have a general knowledge of the structure of the region and its relation to adjacent regions.

The line of folding and faulting nearest the coast has been divided into three parts called the Wide Bay anticline, the Bear Creek-Salmon Creek anticline, and the Dry Creek fault. The Wide Bay anticline (see Pl. XI) is described in detail on pages 201-202.

At Portage Bay the extension of the Wide Bay line of folding is seen as a plunging anticline that rises on the east side of the bay and spreads out within a short distance to form the Bear Creek-Salmon Creek anticline. This anticline, which is conspicuous and well developed, extends from Portage Bay across the headwaters of Bear

[19] Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, pp. 109-116, 1922.

Creek and Salmon Creek and gradually flattens out near Rex Creek, a tributary of Dry Bay. The southeast flank of the anticline dips only 3° to 5°, but the northwest flank dips about 16°. The sediments exposed over the fold consist of sandy shale of lower Shelikof age near the crest and progressively younger beds on the flanks, the Naknek formation cropping out far down on the northwest flank. The Shelikof is the only known oil-bearing formation in this region, and it is deeply cut by erosion on the crest of the anticline. The lower 1,000 feet of the Shelikof formation at Wide Bay is made up predominantly of shale. Little is known of the distribution of the formations below the Shelikof, as it was deposited on an eroded surface. At Cold Bay the Shelikof is underlain by Lower (?) Jurassic sediments, so far as known, and at Wide Bay it is underlain by the Kialagvik formation, of Middle (?) Jurassic age. The areal extent of these formations and the possibility that either one of them contains oil are not definitely known, but no oil has yet been found in the formations underlying the Shelikof in the Cold Bay district. The Bear Creek-Salmon Creek anticline flattens out northeast of Rex Creek and is succeeded near the head of Trail Creek by the Dry Creek fault. This fault cuts across the head of Cold Bay, and two parallel faults appear on the northeast side of the bay. The south side of the fault has moved down relative to the north side, and several outliers of Naknek rocks have been formed. The maximum displacement is believed to occur on the west side of Cold Bay near the mouth of Teresa Creek and is estimated by Capps to be 2,500 feet. The fault continues an unknown distance northeast of Cold Bay.

The next structural feature northwest of the main line of deformation just described is the Becharof Lake syncline. (See fig. 2, p. 202.) This is a broad, open fold extending southwestward from the south arm of Becharof Lake and possibly northeastward into the Kejulik Valley. The syncline is asymmetric, having dips averaging 15° on its southeast flank and only 8° on its northwest flank. On the west shore of the south arm of Becharof Lake, in the trough of the syncline, a series of shale beds that contain numerous fossiliferous limy concretions and are estimated to be over 1,000 feet thick may represent the highest Naknek beds known in the region. The relation between this shale and the sandstone and conglomerate that crop out around Mount Peulik is not known, but if the relation is not complicated by concealed faulting, the sandstone and conglomerate with some shale exposed around Mount Peulik must be the youngest sediments that crop out in the Cold Bay region and may be either the highest Naknek or some undetermined younger formation.

The Ugashik Creek anticline lies northwest of the Becharof Lake syncline and extends southwestward from Mount Burls. This anticline shows its maximum development between Mount Lee and Mount Demian on the east and the old crater of Mount Peulik on the west, where the strata are arched into a dome that is locally called the Pearl Creek dome. Southwestward from the Pearl Creek dome the anticlinal fold flattens, and in the vicinity of Deer Creek it disappears entirely. The dome is slightly asymmetric, and the axial plane is inclined to the southeast, in the same direction as the other folds in the region. The southeast flank has a maximum dip of about 30°, but dips as high as 69° have been recorded on the northwest flank. The rocks exposed over the dome belong to the Naknek formation. Between the crest of the dome and Mount Peulik about 4,000 feet of Naknek sediments are represented. Between the crest of the dome and the axis of the Becharof Lake syncline, to the southeast, about 5,000 feet of Naknek sediments are well exposed. (See fig. 2.)

Owing to the great lateral variation in the sediments it was not possible to determine the exact position in the Naknek formation of the rocks exposed on the crest of the dome, but they seem to belong in the lower part of the formation, an inference which means that the Shelikof formation is probably covered at the crest of the dome by only 200 or 300 feet of Naknek sediments.

The Pearl Creek dome, which is now being exploited, offers more promise of containing commercial quantities of petroleum than any other structural feature in the Cold Bay field. The main features that make this dome the most advantageous place to drill are the well-developed closed structure, which is so favorable to the retention of petroleum, and the presence of the unexposed Shelikof formation, comprising a thick series of sandstone and interbedded shale that constitute potential oil-bearing beds, overlain by 1,000 feet of shale that forms an impervious cap rock.

A less important feature of the structure of the region is the upturning of the strata around the old crater of Mount Peulik. This phenomenon is most apparent from points within the crater itself, where erosion has cut stream valleys around the periphery of the inner cone, exposing the sediments that were cut through by the volcanic neck. Around the southern half of the crater the strata dip from 8° to 18° away from the volcano; around the northern half the sedimentary rocks are not exposed. This upturning is believed to be very local, as the dip of the sedimentary beds where they crop out beyond the lava flows does not show any definite relation to the volcano. It is probable that the volcano broke through near the crest of an anticline and that many of the apparently inconsistent dips are the combined result of a change in direction of dip at the crest of the anticline and the secondary local upturning of the sedimentary beds around Mount Peulik.

The general structure of the sedimentary rocks southwest of the Cold Bay district is monoclinal, with a prevailing southwest strike and dips of 4°–42° NW. A narrow asymmetric fold is superimposed upon the monocline 10 miles southwest of the lower end of King Salmon Lake. This fold is local and can be followed only a few miles across a high ridge, although it may continue for a short distance in the valley north of the ridge. The strike of this small anticline is N. 40° E. The southeast flank is about half a mile wide and dips 4°–6° SE. The northwest flank extends about 2 miles from the axis and dips 8°–15° NW. The upper strata exposed along the anticline belong to the Tertiary formation, which is at least 2,000 feet thick at this locality. The underlying beds are probably Upper Jurassic. Unless a detailed study reveals more favorable structural and stratigraphic features or indications of oil that were overlooked in a hastily made reconnaissance, the possibility of obtaining oil within moderate drilling depth on this anticline is small.

The crest of a broad anticline extends northeastward across the divide from the north side of the upper valley of Lava Creek to the headwaters of Cinder Creek. (See Pl. XII.) This structural feature, which has been named the Elephant Mountain anticline, is probably part of the main anticlinal fold of the Aleutian Range. A description of it is given on page 204.

AREA NORTH OF MOUNT PEULIK.

The investigation around the north side of Mount Peulik in 1922 (see Pl. X) did not supply much information additional to that obtained by Capps in 1921, as the greater part of the area is masked by lava flows, glacial débris, or mountain outwash, making it impossible to determine the character and attitude of the sedimentary beds. Immediately north of Mount Burls the Ugashik Creek anticline flattens out abruptly and merges into the northwest limb of the Becharof Lake syncline. Observations on Featherly Creek showed that the syncline extends that far, although somewhat flattened, owing to the disappearance of the anticline. The maximum dip observed on the northwest flank of the syncline north of the end of the Ugashik Creek anticline is 10°. One erratic dip of due north was seen in the bank of the creek that marks the eastern contact of the lava with the sediments and flows northward into the main part of Becharof Lake. No other consolidated sedimentary rocks were seen north of Mount Peulik in an area of about 75 square miles, which is covered by lava flows and glacial débris. West of Mount

Peulik the consolidated sediments are covered by an unknown thickness of mountain outwash composed of basaltic boulders. Outcrops of consolidated sedimentary rocks reappear beneath the lavas due west of the old crater of Mount Peulik. The outcrops are very small, and only one was found to have the dominant northwestward dip. Southwest of the crater several outcrops show a northeast strike but dip to the southeast. These local observations suggest an anticlinal fold with a northeasterly trend and with flanks dipping 23° NW. and 15° SE. Such an anticline, if it really exists, may have been formed by the intrusion of the igneous core of the older volcano, with which it is so closely connected. The force of this intrusion complicated the system of folding by bowing up the strata immediately around the contact, and then the outpouring of lava effectively concealed the sedimentary rocks. On the east side of Mount Peulik, near the edge of the lava flow, the sedimentary beds dip southeast, forming the limb of the Becharof Lake syncline, but southwest of Mount Peulik the sedimentary beds in one outcrop dip northwest. If the dominant dip in the region is northwesterly, as it seems to be, the sedimentary beds of the northwest limb of the Becharof Lake syncline would naturally be expected to flatten out and then to dip to the northwest, in conformity with the major structural trend, thus forming an anticline. The northeastward extent of such an anticline can not be determined, but it may extend out into Becharof Lake and across Severson Peninsula, where the rocks are said to have a northerly dip. The other anticlinal folds in the Cold Bay district have gently dipping southeastern flanks and more steeply dipping northwest flanks, and the scanty evidence would indicate that the supposed Mount Peulik anticline is no exception. A close examination of Severson Peninsula would be necessary to verify the existence of this anticline. Even if it exists it is not likely to prove of economic importance.

KEJULIK VALLEY.

The sedimentary beds in the Kejulik Valley (see Pl. IX) have not been folded into definite anticlines and synclines, like the beds in the areas farther southwest just described. The dominant structural feature is a northwestward-dipping monocline showing minor variations in the amount of dip. The highest dip recorded is 25°, and from this dip the angle decreases with minor variations until the beds become horizontal, and still farther northwest the strata are turned up the other way, giving low dips to the southeast, away from the Kejulik Mountains. The consistent and uniform dips and well-developed folds that occur southwest of Cold Bay and Becharof Lake do not persist into the Kejulik Valley. It is possible that the Becharof Lake syncline is a persistent structural feature extending along the east side of the south arm of Becharof Lake and thence into the Kejulik Valley. If so the monocline which occupies nearly the entire valley represents the south limb of the syncline.

The area of monoclinal dip may be divided into four zones—two of steeper dips and two of relatively low dips. Steep dips occur at the extreme southeast edge of the valley, in the high hills immediately north of the head of Cold Bay. A dip of 23° was recorded at the contact of the Shelikof and Naknek formations at the crest of one of these hills. The first zone of steep dips is about 2½ miles wide, from the hills at the head of Portage Creek to a line extending from the forks of Margaret Creek to the head of Albert Creek. Within this zone the dips gradually decrease from 23° on the southeast side to 8° at the northwest. This low dip is arbitrarily assumed to mark the beginning of the first zone of flatter dip, which is a little over a mile wide. About 2½ miles from the head of Albert Creek the dip increases rather abruptly from 10° to 22°, thus marking the end of the zone of low dips. The steep dip of 22° does not persist and gradually decreases to 8° or 9° within 5 miles, so that the second zone of relatively steep dips ends at a line drawn N. 65° E. from the junction of the East Fork with Kejulik River. Northwest of this line the dips are all low, averaging about 7° in a zone about 4 miles wide. Kejulik River flows through this zone. This northwestern limit of the valley and of the monocline is marked by an upturning of the strata against the Kejulik Mountains. This upturning is particularly noticeable at the head of the valley. This resulting trough may represent the extension of the Becharof Lake syncline, or it may be genetically related to the forces that caused the intrusion of the igneous rock into the Kejulik Mountains. Future investigation may determine the exact relation of the sediments to the igneous rock, but so much low land with no rock outcrops intervenes between Becharof Lake and the upper part of the Kejulik Valley that it has not been possible to trace the rock structure between the two areas. The gradual regional flattening of the dip from the southeast toward the Kejulik Mountains would suggest that the reversal of the dip is a structural feature which is not primarily related to the mountains but which may have been slightly modified by the intrusion of the igneous rocks. The syncline may represent the extension of the Becharof Lake syncline, and the upturning of the strata against the mountains may represent one limb of an anticline along which the igneous rocks were intruded and which might be extended to join the anticline supposed to underlie Mount Peulik. This hypothesis is supported by observations made farther northeast on the peninsula by Spurr,[20] who says:

[20] Spurr, J. E., A reconnaissance in southwestern Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 146, 233, 1900.

On each side of the chain of volcanoes which form the axis of the range the stratified rocks dip away very gently and are slightly undulating. * * * The line of volcanoes is along a belt where the lava has broken up through the sedimentary Jurassic rocks, tilting these very gently on both sides away from the mass.

The zones of low dip and of relatively steep dip do not form large, pronounced structural features but simply show minor variations of the monoclinal dip. The strike of the rocks would carry these zones across the coastal mountains into an area not covered by this report, and within the valley the evidence for some of the zones is based upon only a few outcrops. Owing to scattered erratic dips and the grading of one zone into another, the placing of the border lines of each zone is somewhat arbitrary, but it is believed that the descriptions given essentially represent the conditions existing in the valley.

WIDE BAY ANTICLINE.

The Wide Bay anticline (see Pl. XI) is a fold of large dimensions, but unfortunately the greater part of its crest lies beneath the waters of the bay, and the details of the anticline can not be studied. This anticline is a continuation of the Bear Creek-Salmon Creek anticline. which extends northwestward from Portage Bay. On the cape between Portage and Wide bays the line of folding is interrupted by a large igneous intrusion. From the northeast end of Wide Bay the anticline extends to the head of the valley at the southwest end of the bay. The southeast flank is represented by the group of islands and point of land partly inclosing the bay. The northwest flank is from 5 to 8 miles wide and is formed by the westward-dipping beds in the mountains on the mainland. The anticline is terminated at the head of the valley southwest of the bay by large masses of igneous rocks. Some of the igneous rocks, especially the basalt, may be only surface flows, but a large intrusion of quartz diorite near this locality is probably deep seated. Farther southwest the rocks were not examined, but it is quite likely that the anticline reappears, inasmuch as the crest of the Aleutian Range is structurally a great anticline or anticlinorium. However, the mountainous country between Wide and Amber bays is very rugged and difficult of access.

The lowest beds exposed on the Wide Bay anticline are part of the Kialagvik formation, of Middle (?) Jurassic age. These beds are exposed from the banks and bluff close to the beach southwest of Lee Creek to and beyond the head of the bay. The thickness of this formation and the character and age of the underlying beds are not known. The Shelikof formation, of Upper Jurassic age, overlies the Kialagvik formation unconformably. The unconformity shows that erosion and deformation of the Middle (?) Jurassic rocks occurred before the Upper Jurassic sediments were deposited.

If folding took place before Upper Jurassic time it may have been slight and local, but it would have significance in the accumulation of oil, provided oil is present beneath the Wide Bay anticline. The beds of the Kialagvik formation for half a mile northeast along the beach from the mouth of Lee Creek can be seen at low tide striking out in the bay at an angle of nearly 90° to the axis of the Wide Bay anticline. This unconformity does not appear so well marked elsewhere, but other discordant dips were noted. Only at the extreme southwest end of the bay do the Middle (?) Jurassic beds conform in strike and dip to the overlying Shelikof formation. At other localities the lower beds are either horizontal or are discordant with the Upper Jurassic beds. The apparent irregularities of the lower beds, which in places strike transverse to the axis of the Wide Bay anticline, may be of such magnitude as to form suitable reservoirs for oil, but care should be taken in selecting a well site.

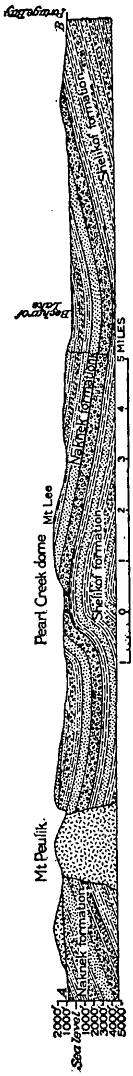


FIGURE 2.—Structure section from Mount Peulik to Portage Bay, along line *A–B*, Plate X.

The exact location of the axis of the Wide Bay anticline can not be determined, as its crest is covered by the bay or the alluvium in the valley. However, the axis is probably closer to the shore of the mainland than to the islands. At several places along the northwest side of the bay the beds are nearly horizontal. The beds in the islands dip 6°–24° SE. and are probably well down on the southeast flank of the anticline.

UGASHIK CREEK ANTICLINE.

The most promising fold for the accumulation of oil in commercial quantities in this region is the Ugashik Creek anticline. (See Pl. X and fig. 2.) This anticline extends from Burlis Mountain, near the source of Featherly Creek, southwestward about 16 miles to Deer Creek. It lies within the northeastern part of the drainage basin of Upper Ugashik Lake and is from 8 to 12 miles inland from Portage and Wide bays. The northeast end of the anticline, which is now being drilled for oil, is a well-developed dome, referred to above as the Pearl Creek dome, on which there are several seepages and two patches of oil residue. Special attention was given during the recent investigation to the southwest end of the anticline. Where the fold crosses Crooked Creek both limbs dip 12°, but the dips become gradually less toward the southwest, until at

Deer Creek the anticline dies out into a monocline with only northwest dips.

The axes of the Becharof Lake syncline and the Ugashik Creek anticline, which are about 5 miles apart between upper Becharof Lake and the Pearl Creek dome, converge in the vicinity of Moore Creek until they are only 3,000 feet apart. Where the synclinal axis approaches the anticline a thrust fault of considerable displacement occurs along the crest of the anticline and parallel to the axis of the syncline. The beds on the northwest flank of the anticline at Moore Creek are undisturbed and dip 4° NW. The overthrust beds, which are composed of conglomerate and arkosic sandstone, dip 19°–35° SE. The angle of the fault plane is about 45°, which would project the fault down the southeast flank, leaving the crest of the anticline undisturbed at a moderate depth. However, the area in which oil could accumulate on the southeast flank is very small, whereas the dips on the northwest flank are gentle but extend at least to Ugashik Lake. The fault was traced about 2 miles. Southwest of Moore Creek the syncline swings to the south, toward Deer Mountain. The anticline continues as far as Deer Creek, but it is more in the nature of a terrace than a well-developed fold.

Rocks of the Naknek formation extend over the entire area of the Ugashik Creek anticline except near the northeast end, where igneous rocks occupy a small area in the vicinity of Mount Peulik. Toward the southwest end of the anticline the surface rocks are composed of conglomerate, arkosic sandstone, and thin beds of shale, part of which represent the conglomerate at the base of the Naknek formation. The basal conglomerate of the Naknek is exceedingly variable in thickness. At Cold Bay it is only 70 feet thick, but along Lee Creek at Wide Bay the member is represented by at least 3,000 feet of conglomerate and arkosic and pebbly sandstone. In the valley of Deer Creek near Deer Mountain 2,000 feet of rather massive conglomerate is exposed. Where the anticline crosses Ugashik Mountain the beds dip southwest, forming part of the Pearl Creek dome. These beds are not exposed on the anticline southwest of the mountain, although the altitude is no greater than at Ugashik Creek. Hence deeper drilling would propably be necessary on the anticline to the southwest than on the dome.

The wells that are now being drilled at the most favorable sites on the dome should demonstrate whether the southwestern part of the Ugashik Creek anticline is worthy of a test by drilling. By means of a well log and a detailed stratigraphic study of the strata in Ugashik Mountain and along the anticline farther southwest, with the thickening of the Naknek conglomerate in mind, it should be possible to make fairly accurate estimates of the depth to the oil horizon at different localities.

ELEPHANT MOUNTAIN ANTICLINE.

The Elephant Mountain anticline (see Pl. XII) is the only large anticline in the region southwest of Wide Bay. It lies close to the divide between the Pacific Ocean and Bering Sea drainage and extends from the north bank of upper Lava Creek northeastward across Elephant Mountain to the headwaters of Cinder Creek. The country beyond Lava Creek in the direction of the anticline is very rugged, and some of the mountains are composed of igneous rocks. Several intrusive dikes and sills occur along the crest and on the limbs of the anticline. The extreme outer flanks of the anticline on Lava Creek and the middle part of Aniakchak River dip 18° to 45° and are 12 miles apart. Both flanks can be seen from Pinnacle Mountain. Along the axis of the main anticline the dips are gentle and the beds are folded into several small anticlines and synclines whose axes roughly parallel the main line of folding. These superposed folds are difficult to follow across the rugged country. The axis of one of the small anticlines is nearly parallel with the valley of Wiggly Creek, and the flanks of this anticline are narrow, with dips of 2° to 6°.

The main line of folding is probably part of the principal anticline of the Aleutian Range. This structural feature, although broken in several places, extends through the greater part of the Alaska Peninsula. In the area between Lava Creek and Aniakchak Crater the anticline rises and flattens out. The oldest rocks exposed on the crest of the anticline are part of the Naknek formation. These beds crop out in a small area on the north side of Lava Creek valley and in several mountains toward the southwest, including the south side of the crater rim. The surface rocks over the greater part of the Elephant Mountain anticline are Tertiary.

FAULTS.

The deformation in the Cold Bay district has not been marked by severe faulting. The only recorded fault of any notable size is the one described by Capps, which crosses the head of Cold Bay. This fault has a maximum displacement of 2,500 feet on the west shore of Cold Bay, but the throw seems to decrease both southwest and northeast from that point. The southwestward extent of the fault is not known, but it extends at least to the head of Dry Creek; northeast of Cold Bay the fault has not been followed. A few small faults were also mapped southwest of Cold Bay, but all of them are of local extent. North of Cold Bay, in the Kejulik Valley, a few small fault planes were seen near the point of upturning of the sediments against the Kejulik Mountains, but nowhere is there much if any displacement along these faults. In other places in the valley erratic dips were seen that may represent local faulting, but no fault planes were seen in conjunction with them. North of Mount Peulik the sedimentary rocks do not crop out and if faults are present they can not be seen on the surface.

MINERAL RESOURCES.

PETROLEUM.

The presence of petroleum in the sedimentary rocks of the Alaska Peninsula is disclosed by seepages that have been reported at several places from time to time. The earliest reference to petroleum on the peninsula was made by Davidson[21] and Dall[22] in 1869, when they reported a seepage "near Katmai Bay." Subsequently seepages were seen in the Cold Bay region and have been reported around Aniakchak Bay and Chignik. Most of the seepages reported have been in the region that has become popularly known as the Cold Bay field, where patches of residue and seepages have been seen at several places.

The petroleum seepages in the Cold Bay field have been described by Capps,[23] and the following descriptions are taken substantially from his report. The seepages are in two groups lying along the two lines of anticlinal folding. Several seepages have been reported along the Bear Creek-Salmon Creek anticline and near the extension of its axis at the head of Oil Creek. Two seepages occur on the Pearl Creek dome, a part of the Ugashik Creek anticline. (See fig. 2.) The largest seepage is found at the head of Oil Creek, in the East field, where oil, gas, and water emerge as a strong spring and the evaporation of the more volatile constituents of the oil has left a large area of a viscous black residue 1 to 6 feet thick. The flow of this seepage was estimated by Capps at about half a barrel of oil a day. On Oil Creek below the residue patch there are several seepages that yield a small flow of oil. Other seepages are reported from the South Fork of Rex Creek, and one each from upper Bear Creek and Salmon Creek. All these seepages are on the Bear Creek-Salmon Creek anticline, but they emerge from sandstone of the Shelikof formation well down on the flank of the fold.

Two residue patches occur on the Pearl Creek dome. One near the mouth of Barabara Creek on its north side is similar in size and

[21] Davidson, George, Coast Pilot of Alaska, 1869, p. 36.
[22] Dall, W. H., idem, p. 199.
[23] Capps, S. R., The Cold Bay district: U. S. Geol. Survey Bull. 739, pp. 107–109, 1922.

character to the patch on Oil Creek. The actual point of emergence of the oil could not be seen, but water running along a drainage line through the residue was covered with thick dark-brown oil. The other residue patch, which is somewhat smaller, lies in the valley of Pearl Creek about a mile northeast of the large patch. No oil was seen emerging from the rock, but a thick brown oil oozes from the residue and flows down the creek. The rocks underlying these two residue patches belong in the lower part of the Naknek formation. Other small seepages have been reported to occur in the valley of Pearl Creek.

No seepages have been reported to occur in the region around Mount Peulik, except at the Pearl Creek dome, and none were seen during the summer of 1922. In the Kejulik Valley also no oil seepages were seen, although some have been reported and a gas seepage was seen near the head of the East Fork of Kejulik River. The gas emerges at two places several hundred feet apart, both at the foot of a bluff on the edge of a narrow valley. The gas flows in a nearly continuous stream of bubbles and has built up a low mound around the orifice. Evidently considerable water is emitted with the gas, as the mound is composed of a soft mud surrounded by an otherwise dry valley floor and a small stream of water flows away from the seepage. The rocks forming the bluffs along the edge of the valley and underlying the valley belong in the lower part of the Naknek formation.

The Kejulik Valley has been frequently mentioned as an area possibly underlain by oil reservoirs. It is generally understood at the present time that the geologic structure most favorable for petroleum accumulation is that of an anticline or dome. Petroleum accumulations have also been formed, however, as the result of different physical features of the rocks themselves, and any petroleum accumulations that may exist in the sediments underlying the Kejulik Valley are most probably due to such features. A change in porosity due to a change in the coarseness of the sediments deposited, a variation in porosity due to a variation in the amount of cementing material, and the presence of lenticular bodies of sandstone are all features that may be of prime importance in their influence upon the localization and accumulation of petroleum. The change in porosity and the presence of lenses of sandstone are likely to be of more importance in sediments deposited in shallow water and near the shore, such as most of the sediments in the Cold Bay district. Sediments laid down near the shore are usually of coarser grain than those deposited farther out, but they may grade laterally into the finer-grained sediments without any distinct break, and where they do there is a gradual change in the effective porosity of the rock and in its effect upon permeating liquids and gases. Petroleum might migrate through a loose, porous reservoir sand, but if that sand becomes dense and fine grained the petroleum can no longer migrate through it and will accumulate in the coarser part of the bed if it is inclosed in impervious sediments. The sediments in the Cold Bay district are known to differ greatly in different parts of the district, but it is impossible to predict just where the porosity has changed sufficiently to cause accumulation, and hence it is impossible to predict the location of reservoirs formed in this way.

The variation in the amount of cementing material may also be an important factor in determining the location and extent of an oil reservoir. A sandstone may be tightly cemented so that it contains little effective pore space, or a sandstone composed of grains of the same size may be very loosely cemented, thus having a high effective porosity. The first sandstone would not make a good reservoir, but the second one might make an excellent reservoir.

There are local variations in the degree of cementation within a sandstone bed, and this feature is of particular interest in considering the possibilities of oil accumulation on a monocline. The reason for the differential cementing is not well understood, but it unquestionably exists. In a tightly cemented sandstone the existing pore space may consist of voids so small that the rock is relatively impervious to migrating petroleum, owing to the high frictional and capillary resistance. In many places the tightly cemented parts of a sandstone are in the form of thin seams paralleling the bedding planes, but in other places they are arranged irregularly. A tightly cemented part may occur in such a position as to effect an accumulation of petroleum in the more porous sandstone lying along the dip below it, giving rise to what is known in the oil men's vernacular as a "spotty sand." The determination of the location of such areas is even more difficult than that of the lateral variation in the lithology of sandstone beds, so that this feature is of no assistance in predicting the oil possibilities of the Kejulik Valley.

The third feature that was mentioned above as having a possible influence on the accumulation of oil is the presence of lenticular bodies of sandstone. Such bodies are frequently deposited under shallow-water conditions, where shore currents and river currents may both be active in forming bars and deltas. The sand lenses may be thick bodies having a lateral extent of several miles, and if they are included within a shale member of the formation that contains organic matter in sufficient abundance to supply petroleum to the sandstone lenses, large accumulations may be formed. Several fields in the United States have produced petroleum from lenticular sands.

All three of the features above set forth are difficult of determination in advance of drilling, but all three may have a decided influence upon the accumulation of petroleum upon a monocline. The

76813°—24——14

rocks that crop out in the Kejulik Valley are largely of the Naknek formation and overlie the Shelikof formation, which is the oil-bearing formation in the other parts of the Cold Bay district. Although no oil seepages were seen in the valley it is reasonable to assume that the Shelikof formation, underlying an area 10 or 12 miles from the nearest known seepage, contains petroleum, which under the proper structural and physical conditions would form accumulations. In the Kejulik Valley there is no known structural feature of the types that are usually considered favorable for petroleum accumulations, but various conditions of sedimentation may have produced the same result. The dip of the strata carries the Shelikof formation to a considerable depth below the Naknek formation within a short distance, so that it is only close to the southeast side of the valley that the Shelikof formation lies near enough to the surface to be reached by the drill.

The flattening of dip of a monocline forms the structural feature known as a terrace. In the Pennsylvania, Ohio-Indiana, Oklahoma-Kansas, and many other fields petroleum has been obtained from terraces, but as commonly used the term "terrace" includes any minor flattening of the dip of a monocline, so that the presence of a terrace does not necessarily mean the presence of structure favorable to the accumulation of oil. Such an accumulation on a terrace involves many factors that make its prediction difficult. The effect of change in porosity and lenticular sands is the same as on a monocline. (See p. 207.) The degree of change of dip is the critical factor, as the oil accumulates at and immediately below the point where the inclination of the strata has changed sufficiently to prevent further migration. The change of dip necessary to offer such a barrier is dependent upon the character of the sand, the initial inclination of the monocline, the force behind the movement of the petroleum, and nearly all the other factors that influence migration. In general the closer the flattened beds approach to the horizontal or to a reversed dip the greater the barrier they offer to the further migration of petroleum. In sediments having a low dip a flattening of only a few degrees may furnish an effective barrier, whereas if the same sediments are steeply inclined they might have to flatten a great many degrees to make the change in dip effective as a barrier. In the Kejulik Valley the zone of flattened dips extending across the headwaters of Albert Creek has dips 12° to 15° flatter than the zone of steeper dips northwest of it. However, as the less steeply inclined sediments dip 8° to 10°, it is believed that the relative decrease in the amount of dip is insufficient to prevent the further migration of the petroleum. In conjunction with the other factors that influence the accumulation of petroleum on a monocline the decrease in dip may have an importance that can not now be seen or predicted. The fact that the dip may within a short distance carry the oil-bearing formations to a depth beyond reach of the drill must be emphasized. It is only near the southeastern edge of the valley that the Shelikof sandstones lie near enough to the surface to be reached by the drill, according to the common commercial practice, in which the limit of depth is 3,500 feet.

A few observations west of Mount Peulik suggest the existence of an anticline (see Pl. X), but its size and extent and even its existence can only be conjectured. Further, the igneous material involved in the formation of Mount Peulik is believed to have been ejected through a channel extending down through the crest of the anticline, and the heat and pressure exerted by this material may have severely metamorphosed the sediments and driven away any oil they may have contained. It is apparent that the area around Mount Peulik can not be recommended as probably containing available oil accumulations.

Oil seepages were reported to occur near the head of Moore Creek, but they were not found by members of Mr. Sargent's party. Along the fault at Moore Creek there are several springs giving off sulphur dioxide gas, which has a very characteristic odor and forms a white scum on the water. After the scum has been in contact with the air for some time it becomes black. The black substance has the appearance of an oil residue, but its physical properties differ, and it can easily be distinguished from oil residue by its peculiar odor and low viscosity. Several pools of water with an iridescent scum of iron oxide, which might be mistaken for oil, were seen in the small valleys in this general locality.

Oil seepages were not seen on the Elephant Mountain anticline, and none have been reported to occur along this fold, although there have been many reports of seepage west of Aniakchak Bay and on the cape between Aniakchak and Amber bays. Some of these supposed seepages were found to be films of iron oxide on pools of water and red iron stains on rocks. The seepages reported on the cape were not examined. The claims that have been staked in the Aniakchak district do not extend inland as far as the crest of the anticline, although some of the claims may include part of the southwest flank, where the dips are locally 45° SE. The lowest beds exposed on the anticline, those in the upper part of the Naknek formation, are probably thousands of feet above the supposed oil-bearing beds in the Cold Bay district. However, owing to the variable thickness of the strata, especially the conglomerate beds 60 miles to the northwest, it is impossible to estimate the depth to any particular horizon below the surface on the Elephant Mountain anticline. It is not improbable that there are oil-bearing rocks in the Upper Jurassic series that are not known. The oil in the Cold Bay district is supposed to be derived from the Shelikof formation, but the exact horizon is unknown. A stratigraphic study of the region southwest of Aniakchak Crater, where Jurassic rocks are thought to be exposed, may furnish information regarding the succession beneath the Elephant Mountain anticline. Although at places on the anticline the structural conditions are favorable for the accumulation of oil, until indications are found or some of the reports of seepages in this general region are verified there is no reason to believe that this anticline contains commercial pools of oil. From present knowledge of the stratigraphy the possibility of such pools within drilling depth is relatively slight.

Oil seepages have been reported from the country west of Aniakchak Bay and east of the high mountains in the central part of the peninsula, and many claims have been staked there. It was learned in the field that most of the claims had been staked by one man. By far the greater number of claims are located in an area of igneous rocks, or in the valley of Aniakchak River, which is covered by the ejecta from the crater at the head of the valley. The consolidated rocks beneath the cinders are probably also of igneous origin, as the mountains on both sides of the lower part of the valley and several small outcrops within the valley consist of igneous rocks. Most of the rocks consist of volcanic tuff and breccia which have flowed out over the sedimentary rocks. The thickness of this volcanic material is not known but is thought to be several thousand feet. The thickness undoubtedly varies from place to place owing to the irregularities of the surface over which the material flowed. The volcanic center or vent was not located. A few small isolated blocks of sedimentary rocks, dipping very steeply beneath the igneous material, occur close to the beach at Aniakchak Bay.

Pools of stagnant water covered with an iridescent film of iron oxide were found in the area of igneous rocks near the localities where oil seepages were reported to occur. Oil seepages were also reported on the cape between Amber and Aniakchak bays. These seepages were not found, but sedimentary rocks of unknown age occupy part of the cape. If oil seepages occur in the general district they are more likely to be found in the vicinity of Amber Bay than in the area west of Aniakchak Bay.

Neither the Kejulik Valley nor the region north and west of Mount Peulik contains sufficiently well developed structural features of the types that are usually considered favorable for the accumulation of petroleum to be recommended as good places to drill wells. The sedimentary rocks of the Kejulik Valley have been folded to form a terrace, a structural form that has proved to be productive here and there in oil fields in the States, but in this valley the decrease in dip is not believed to be sufficient to form a reservoir unless it is accompanied by other features, such as certain conditions of sedimentation and cementation that can not be predicted. If "spotty" sands are present in this area, no one drill hole would prove the nonexistence of an oil reservoir. Further, the oil-bearing Shelikof formation, except for a narrow belt at the southeast margin of the valley, is too deeply buried below the Naknek formation to be reached by the drill. In view of the expense of drilling in a new region and the number of holes that would be necessary to test the field thoroughly, the prospects of obtaining oil are not good enough to warrant drilling. The geologic structure in the region north and west of Mount Peulik is not as well known as the structure in the Kejulik Valley, as the bedrock is concealed by gravel and volcanic material, but some observations and the regional relations suggest the presence of an anticline extending northeastward through Mount Peulik, parallel to the trend of the other folds. The sedimentary rocks that crop out around the old crater of Mount Peulik are on the crest of this supposed anticline and are believed to be possibly high in the Naknek formation. The oil-bearing Shelikof sandstones may therefore be buried under several thousand feet of younger sediments, and even if the formation contains oil on this anticline it may lie beyond reach of the drill.

The future of the Cold Bay district depends very largely upon the result of the drilling on the Pearl Creek dome, as that is the most promising structural feature in the region, and the success or failure of the work there will probably govern the amount of later exploratory work.

The country southwest of Wide Bay, especially the Aniakchak district, is covered by large areas of igneous rocks, in which oil does not occur. The sedimentary rocks are mostly Tertiary and of a character that makes the possibility of the occurrence of oil in commercial quantities in them very slight. The anticlines are not as pronounced as those in the Cold Bay district, and those that were observed are small or possess unfavorable features.

COAL.

The distribution and economic possibilities of the coal in the Chignik Bay region are set forth by Atwood,[24] who gives detailed sections and describes the developments up to and including 1908. Since 1912 little coal has been mined, although some development work has been done, especially at a mine on Thompson Creek, where mine buildings were erected and a small bunker built on the beach. No coal, however, has been sold from this mine. The following

[24] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, pp. 104–105, 109–116, 1911.

description of the coal near Chignik is compiled by G. C. Martin from the account by Atwood, with slight modification.

GEOLOGIC AND AREAL OCCURRENCE.

The bituminous coal in the Chignik Bay region is of Upper Cretaceous age and belongs to the Chignik formation. The coal measures consist of sandstone, shale, and conglomerate that occur in the middle portion of the formation and are underlain and overlain by thin beds of sandstone and shale. The Upper Cretaceous (Chignik formation) in this region rests unconformably upon the Upper Jurassic (Naknek formation), but it is overlain conformably by rocks of Eocene age. This section is shown along Chignik River and along the shores of Chignik Lagoon.

The known extent of bituminous coal in this field does not exceed 15 square miles, but from the distribution of the coal outcrops and the general geologic structure in the field it is probable that coal underlies an area of 40 to 50 square miles.

A few thin lignite seams occur in the Tertiary rocks on the southwest side of Chignik Bay. The areal extent of these lignite seams is probably between 10 and 20 square miles, but the quality of this material is not such as to make it of economic value.

The developed coals are at Chignik River, Whalers Creek, Thompson River, and northwest of Hook Bay. Some detailed sections of these coals are given in the following paragraphs.

COAL BEDS.

Chignik River.—The coal bed that has been worked outcrops on the river bluff 3 miles above the head of Chignik Lagoon and has been traced inland for a little more than half a mile. At this locality it strikes N. 2° E. and dips 24° E. A section of the bed measured in the drift is as follows:

Section of Chignik River coal bed.

	Ft.	in.
Dry bone, with thin coal streaks		3
Coal		6
Coal and dirt		8
Coal	1	
Bony coal	1	5
Coal	1	4
	5	2

The roof, which is of shale with thin layers of coal overlain by sandstone, is very even. The floor, however, is not so regular, and the roll or swelling in it reduces the thickness of the bed at the end of the drift from 5 feet to 9 inches. It is possible that the roll, which is known to be rather long, may be narrow, and that a short tunnel driven through it would discover the full thickness of the coal bed on the other side.

The coal is solid and bright and comes out in good-sized pieces. When used under a boiler it has to be stoked very frequently to keep it burning freely. It is a fairly satisfactory steaming coal when it is properly handled, but it makes a large amount of ash, and the fires have to be cleaned often. An analysis of this coal is given on page 218.

The Chignik River mine was formerly worked throughout the year by two men without machinery, the coal being undercut by hand and shot down. Coal outcrops appear at several other places on the north bank of Chignik River east of the mine, but the beds do not seem to be of as good grade as that at the mine and have not been worked.

Whalers Creek.—Whalers Creek is a small stream entering Chignik Lagoon from the north a short distance below the mouth of Chignik River. Coal is exposed for 600 feet along the northernmost of the three main branches of the creek, the exposure being along the strike of the coal measures, which outcrop at the coal mine on Chignik River. The strike of the coal is N. 5° E. and the dip is 22° E. The section of the coal is as follows:

Section of Whalers Creek coal bed.

	Ft.	in.
Shaly sandstone roof.		
1. Coaly shale		10
2. Shale		8
3. Coal	1	
4. Coaly shale		4
5. Sandy shale		7
6. Coal with slate partings	5	
7. Coaly shale		6
8. Sandstone	1	6
9. Coal	1	10
10. Shaly coal		1½
11. Coal	3	4
Sandy shale floor.		

The slope, which has been driven 130 feet on the coal, follows the lower part of the bed and includes the strata numbered 8 to 11 in the above section. The coal bed (Nos. 9 to 11) was sampled in the usual way and analyzed, with the result given on page 218 (laboratory No. 6955).

The coal is bright, black, and blocky, very much like that mined at Chignik River, but at this locality the section of the coal is better in that the partings are thin. A nearly vertical fault, about 500 feet downstream from the mine opening, probably cuts off the coal bed.

On the upstream side, about 40 feet from the opening, a vertical fault throws the coal down 6 feet, and 115 feet upstream from the mine another fault, which cuts off the coal, has been reported.

Although faults have disturbed the coal somewhat, there appears, nevertheless, to be a very considerable body of good coal available. The location of this coal favors shipment on small boats down Chignik Lagoon or by rail. A railway might be built across Chignik River a short distance above the mouth and thence across a lowland area to the head of Kuiukta Bay, where excellent harbor facilities are reported. The distance from Whalers Creek to the head of Kuiukta Bay by the proposed railway route is about 5 miles.

Coal has been reported to outcrop at several places high on the mountain slopes northeast of the outcrops of coal in Whalers Creek. The localities pointed out in the field by prospectors are along the general strike of the coal measures and presumably contain the same beds that are exposed elsewhere in the field.

Thompson Valley.—Thompson Valley lies northwest of the northern portion of Chignik Bay and is a broad, open, flat-bottomed valley, heading among the high mountains at least 10 miles from the beach. Coal is exposed on the northeastern slope 1¾ miles from the beach and 300 feet above the valley floor. The strike of the beds is N. 61° E. and the dip is 21° NW. Two workable coal beds are exposed for at least a mile, and their extent is probably much greater. Where the tributary streams to Thompson Valley cross these coals there are falls or cascades in their courses. The detailed measurements of these beds are given below:

Sections of coal beds in Thompson Valley.

Lower bed.

	Ft.	in.
Sandy shale roof.		
1. Coal	1	8
2. Shale parting		2
3. Coal	2	6
4. Coaly shale		4
5. Coal		5
6. Bone		1
7. Coal		2
Sandstone floor.		

Upper bed.

	Ft.	in.
Cross-bedded sandstone roof.		
1. Clay		2
2. Coal		4
3. Coaly shale		4
4. Shale		8
5. Coaly shale		4
6. Coal	1	
7. Clay parting		1

	Ft.	in.
8. Coal	2	6
9. Coaly shale		8
10. Coal	4	
11. Bone		8
12. Coal		5
13. Shale		5
14. Bony coal		8

The analysis of a sample taken from the beds numbered 6, 8, and 10 in the foregoing section of the upper coal is given on page 218 (laboratory No. 6956).

A large body of good coal is available at this locality. The conditions for mining are favorable, and the space at the base of the bluff is ample for mine buildings and mine bunkers. The chief difficulty in the way of exploiting this coal is in making arrangements for shipping. The beach at the mouth of Thompson Valley is exposed to the severe storms from the Pacific Ocean. A railway from the valley to Chignik Lagoon could be easily built, for the route would be over a lowland area and not more than 9 miles in length. The conditions in Chignik Lagoon, however, are not favorable for loading large ocean-going vessels. Hence it would probably be necessary to continue the railway along the northwest shore of the lagoon and then by the same route as that from Whalers Creek to the head of Kuiukta Bay, as already described.

Hook Bay.—Hook Bay is in the northern part of the field examined. The coal in this vicinity occurs near the headwaters of the right-hand branch of the stream entering Hook Bay from the west and in the foothills of the main mountain range. The general strike of the beds is N. 11° E. and the dip 34° E. The section of the coal is as follows:

Section of Hook Bay coal bed.

	Ft.	in.
Firm sandstone roof.		
1. Coal	1	3
2. Clay		8
3. Coal		4
4. Clay		7
5. Coal	1	6½
6. Clay parting		2
7. Bony coal		5
8. Coal	1	5½
9. Bone		1
Shale floor.		

Above this bed is an 8-foot bed of sandstone overlain by a thin layer of coal. Below the main bed of coal lies a 4-foot layer of shaly sandstone, underlain by a 3-foot bed of coal, in the middle of which is a 6-inch parting of shale. The exposures in the tunnel show the coal to be uniform in thickness and quality.

In sampling this bed a cut was made across Nos. 5 to 8, inclusive, in the above section. The analysis is given on page 218 (laboratory No. 6952).

The strike, so far as the beds could be examined, is uniform and appears to continue without notable break for at least half a mile to the northeast. The tunnel opening is 50 feet above the stream bottom, where there is space for mine buildings. At present there is a wagon road from Hook Bay to the coal croppings, along a stream bottom where the general gradient and space would be favorable to railway construction. Hook Bay is an excellent small harbor and is bordered by favorable sites for wharves and bunkers. The distance from the harbor to the coal is about 8 miles. Four claims were staked in this field, and development work was being done in 1908 under the auspices of the Alaska Peninsula Mining & Trading Co.

CHARACTER OF THE COAL.

The coal from the Chignik River mine is bright black and of medium hardness. It was worked out in lumps as much as 10 or 12 inches in diameter. The seam, as exposed late in the season of 1908, showed some crushing at the front wall and at the end of the tunnel. The section in the mine shows sufficient shale partings and bony streaks to indicate the general bedded structure of the coal, which corresponds to the general dip of the formations in that part of the field. The coal, when taken from the mine, was dumped upon a barge near the entrance of the tunnel and was unloaded from the barge and dumped into the coal bins at the cannery, where it was used. In the processes of handling the coal usually became broken into fragments, the largest 3 or 4 inches in diameter. This coal does not appear to slack badly. The best exposures in Whalers Creek are in a prospecting tunnel, where the coal seam is firm and the bedded structure pronounced, the structure being emphasized by certain shale partings. The coal is a dull black on the weathered surfaces but is bright in fresh exposures. The Thompson Valley exposures are only a little beneath the surface and not beyond the zone of weathering. This coal, however, is in a heavy firm bed, more resistant than the shale and sandstone associated with it, as is indicated by the rapids or falls where streams cross the coal seam.

In the short tunnel in the coal northwest from the head of Hook Bay the coal is in seams 18 inches or less in thickness, separated by thin beds of shale. These shale partings indicate the general bedded condition of the sediments and correspond with the general dip of the strata. The upper portion of the seam is bright and black and of medium hardness and appears to be a high grade of bituminous coal. The lower portion of the seam has more bony streaks but would average a fair grade of bituminous coal.

The following table gives the results of the analyses of some of the coals from the Chignik field. The samples were obtained at the following localities:

6952. Coal bed on west side of main stream, 7 miles northwest of Hook Bay, east side of Chignik Bay, Alaska Peninsula.
6956. Chignik Bay, Thompson Valley, three-fourths of a mile above mouth of stream.
6955. Chignik Lagoon, Whalers Creek, three-fourths of a mile above mouth.
6953. Chignik River, north side, 2 miles below Chignik Lake.

Analyses of Chignik coals.

[Analyses by F. M. Stanton, U. S. Geological Survey.]

Samples as received.

Laboratory. No.	Locality.	Proximate analyses.				Ultimate analyses.						Calorific value.	
		Loss on air drying.	Total moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	Near Hook Bay	4.00	5.07	27.24	42.42	25.27	2.26	4.53	55.76	0.59	8.38	5,618	10,112
6956	Thompson Valley	6.50	10.77	30.37	43.99	14.87	.70	4.98	55.27	.61	23.57	5,356	9,641
6955	Whalers Creek	2.50	5.02	34.28	45.45	15.25	1.75	4.87	62.04	.56	15.53	6,245	11,241
6953	Chignik River	5.20	7.06	31.48	39.68	21.78	1.30	4.83	55.14	.61	16.34	5,470	9,846

Air-dried samples (calculated from table above).

Laboratory No.	Locality.	Proximate analyses.			Ultimate analyses.						Calorific value.	
		Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	Near Hook Bay	1.11	28.38	44.19	26.32	2.35	4.26	58.08	0.61	8.38	5,852	10,533
6956	Thompson Valley	4.57	32.48	47.05	15.90	.75	4.56	59.11	.65	19.03	5,728	10,310
6955	Whalers Creek	2.58	35.16	46.62	15.64	1.79	4.71	63.63	.57	13.66	6,405	11,529
6953	Chignik River	1.96	33.21	41.86	22.97	1.37	4.48	58.17	.64	12.37	5,770	10,386

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A certain number of copies are delivered to the Director of the Survey, from whom they can be obtained for a limited period free of charge (except certain maps) on application.

2. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at the prices indicated. No copies are available of those marked with an asterisk (*); they may be consulted at many public libraries.

3. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

The maps whose price is stated are sold by the Geological Survey and not by the Superintendent of Documents. On an order for maps amounting to $5 or more at the retail price a discount of 40 per cent is allowed.

GENERAL.

REPORTS.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18-31. 15 cents.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4-9. 25 cents.

The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19-39. 30 cents.

The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30-53. 45 cents.

The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21-62. 50 cents.

The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20-46. 40 cents.

Alaska coal and its utilization. Bulletin 442-J, reprinted 1914. 10 cents.

The mining industry in 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 21-42. 40 cents.

The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19-44. 50 cents.

The mining industry in 1912, by A. H. Brooks. In Bulletin 542, 1913, pp. 18-51. 25 cents.

The Alaskan mining industry in 1913, by A. H. Brooks. In Bulletin 592, 1914, pp. 45-74. 60 cents.

The Alaskan mining industry in 1914, by A. H. Brooks. In Bulletin 622, 1915, pp. 15-68. 30 cents.

The Alaskan mining industry in 1915, by A. H. Brooks. In Bulletin 642, 1916, pp. 17-72. 35 cents.

The Alaskan mining industry in 1916, by A. H. Brooks. In Bulletin 662, 1917, pp. 11-62. 75 cents.
*The Alaskan mining industry in 1917, by G. C. Martin. In Bulletin 692, 1918, pp. 11-42.
*The Alaskan mining industry in 1918, by G. C. Martin. In Bulletin 712, 1919, pp. 11-52.
The Alaskan mining industry in 1919, by A. H. Brooks and G. C. Martin. Bulletin 714-A, reprinted 1921. 25 cents.
The Alaskan mining industry in 1920, by A. H. Brooks. In Bulletin 722, 1921, pp. 7-67. 25 cents.
The Alaskan mining industry in 1921, by A. H. Brooks. Bulletin 739-A, 1922, pp. 1-44. 10 cents.
The Alaskan mining industry in 1922, by A. H. Brooks and S. R. Capps. In Bulletin 755, 1924, pp. 3-49. Free on application.
Alaska's minerals and production, 1923, by Alfred H. Brooks. In Bulletin 773, 1925, pp. ———. Free on application.
Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10-17. 25 cents.
Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45-88. 50 cents.
Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43-93. 40 cents.
The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18-44. 60 cents.
The future of gold-placer mining in Alaska, by A. H. Brooks. In Bulletin 622, 1915, pp. 69-79. 30 cents.
Tin resources of Alaska, by F. L. Hess. In Bulletin 520, 1912, pp. 89-92. 50 cents.
Alaska coal and its utilization, by A. H. Brooks. Bulletin 442-J, reprinted 1914 10 cents.
The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63-66. 50 cents.
The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101-132. 40 cents.
*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. (Abstract in Bulletin 259, 1905, pp. 32-46, 15 cents.)
Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54-77. 45 cents.
*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp.
Tin mining in Alaska, by H. M. Eakin. In Bulletin 622, 1915, pp. 81-94. 30 cents.
Antimony deposits of Alaska, by A. H. Brooks. Bulletin 649, 1916, 67 pp. 15 cents.
*The use of the panoramic camera in topographic surveying, by J. W. Bagley. Bulletin 657, 1917, 88 pp.
The mineral springs of Alaska, by G. A. Waring. Water-Supply Paper 418, 1917, 114 pp. 25 cents.
Alaska's mineral supplies, by A. H. Brooks. Bulletin 666-P, 14 pp. 5 cents.
The future of Alaska mining, by A. H. Brooks. Bulletin 714-A, reprinted 1921. 25 cents.
Preliminary report on petroleum in Alaska, by G. C. Martin. Bulletin 719, 1921, 83 pp. 50 cents.

In preparation.

The Mesozoic stratigraphy of Alaska, by George C. Martin.
The Upper Cretaceous flora of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds, by George C. Martin.

TOPOGRAPHIC MAPS.

Map of Alaska (A); scale, 1:5,000,000; 1920, by A. H. Brooks. 10 cents retail or 6 cents wholesale.

*Map of Alaska (B); scale, 1:1,500,000; 1915, by A. H. Brooks and R. H. Sargent.

Map of Alaska (C); scale, 1:12,000,000; 1916. 1 cent retail or five for 3 cents wholesale.

Map of Alaska showing distribution of mineral deposits; scale, 1:5,000,000; by A. H. Brooks. 20 cents retail or 12 cents wholesale. New editions included in Bulletins 642 (35 cents), 662 (75 cents), and 714–A (25 cents).

Index map of Alaska, including list of publications; scale, 1:5,000,000; by A. H. Brooks. Free on application.

Relief map of Alaska (D); scale, 1:2,500,000; 1923, by A. H. Brooks and R. H. Sargent. 50 cents retail or 30 cents wholesale.

Map of Alaska (E); scale, 1:2,500,000; 1923, by A. H. Brooks and R. H. Sargent. 25 cents retail or 15 cents wholesale.

SOUTHEASTERN ALASKA.

REPORTS.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68. 15 cents.

The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30–53. 25 cents.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54–60. 25 cents.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 47–72. 30 cents.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1917, pp. 73–81. 30 cents.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82–88. 30 cents.

Lode mining in southeastern Alaska, 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.

The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp. 60 cents.

The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.

Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133–143. 40 cents.

Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146. 40 cents.

Report of water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157. 40 cents.

Geology of the Berners Bay region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp. 20 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 480, 1911, pp. 94–102. 40 cents.

The Eagle River region, southeastern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp. 25 cents.

The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp. 5 cents.

The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin, with a preface by G. K. Gilbert. Professional Paper 69, 1912, 135 pp. 60 cents.

A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109-117. 60 cents.

Lode mining in the Ketchikan district, by P. S. Smith. In Bulletin 592, 1914, pp. 75-94. 60 cents.

The geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright. Professional Paper 87, 1915, 110 pp. 40 cents.

Mining in the Juneau region, by H. M. Eakin. In Bulletin 622, 1915, pp. 95-102. 30 cents.

Notes on the geology of Gravina Island, Alaska, by P. S. Smith. Professional Paper 95-H, 1916, 9 pp. 30 cents.

Mining in southeastern Alaska, by Theodore Chapin. In Bulletin 642, 1916, pp. 73-104. 35 cents.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 642, 1916, pp. 105-127. 35 cents.

Mining developments in the Ketchikan and Wrangell districts, by Theodore Chapin. In Bulletin 662, 1917, pp. 63-75. 75 cents.

Lode mining in the Juneau gold belt, by H. M. Eakin. In Bulletin 662, 1917, pp. 71-92. 75 cents.

Gold-placer mining in the Porcupine district, by H. M. Eakin. In Bulletin 662, 1917, pp. 93-100. 75 cents.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 662, 1917, pp. 101-154. 75 cents.

*Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 692, 1919, pp. 43-83.

*The structure and stratigraphy of Gravina and Revillagigedo islands, Alaska, by Theodore Chapin. Professional Paper 120-D, 1918, 18 pp.

*Mining developments in the Ketchikan mining district, by Theodore Chapin. In Bulletin 692, 1919, pp. 85-89.

*The geology and mineral resources of the west coast of Chichagof Island, by R. M. Overbeck. In Bulletin 692, 1919, pp. 91-136.

The Porcupine district, by H. M. Eakin. Bulletin 699, 1919, 29 pp. 20 cents.

*Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 712, 1920, pp. 53-90.

*Lode mining in the Juneau and Ketchikan districts, by J. B. Mertie, jr. In Bulletin 714, 1921, pp. 105-128.

*Notes on the Unuk-Salmon River region, by J. B. Mertie, jr. In Bulletin 714, 1921, pp. 129-142.

*Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 714, 1921, pp. 143-187.

Marble deposits of southeastern Alaska, by E. F. Burchard. Bulletin 682, 1920, 118 pp. 30 cents.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 722, 1922, pp. 75-115. 25 cents.

Ore deposits of the Salmon River district, Portland Canal region, Alaska, by L. G. Westgate. In Bulletin 722, 1922, pp. 117-140. 25 cents.

Mineral deposits of the Wrangell district, by A. F. Buddington. In Bulletin 739, 1923, pp. 51-75. 25 cents.

Mineral resources of southeastern Alaska, by A. F. Buddington. In Bulletin 773, 1925, pp. ———. Free on application.

In preparation.

Geology and ore deposits of the Juneau district, by H. M. Eakin.
The Ketchikan district, by Theodore Chapin.

TOPOGRAPHIC MAPS.

Juneau gold belt, Alaska; scale, 1:250,000; compiled. In Bulletin 287, 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; by W. J. Peters. 10 cents retail or 6 cents wholesale.

Berners Bay special (No. 581B); scale, 1:62,500; by R. B. Oliver. 10 cents retail or 6 cents wholesale. Also contained in Bulletin 446, 20 cents.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 40 cents.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 40 cents.

Eagle River region (No. 581C); scale, 1:62,500; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502, 25 cents. Not issued separately.

Juneau and vicinity (No. 581D); scale, 1:24,000; contour interval, 50 feet; by D. C. Witherspoon. 20 cents.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

REPORTS.

Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp. 50 cents.

Geology and mineral resources of Controller Bay region, Alaska, by G. C. Martin. Bulletin 335, 1908, 141 pp. 70 cents.

Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.

Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp. 40 cents.

Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 78–96. 50 cents.

Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.

Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.

Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163. 40 cents.

Mining and prospecting on Prince William Sound in 1909, by U. S. Grant. In Bulletin 442, 1910, pp. 164–165. 40 cents.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp. 45 cents.

Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp. 40 cents.

Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp. 35 cents.

The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp. 30 cents.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80. 25 cents.

Mining in Chitina Valley, by F. H. Moffit. In Bulletin 542, 1913, pp. 81–85. 25 cents.

Mineral deposits of the Ellamar district, by S. R. Capps and B. L. Johnson. In Bulletin 542, 1913, pp. 86–124. 25 cents.

The mineral deposits of the Yakataga region, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–154. 60 cents.

The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236. 60 cents.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 592, 1914, pp. 237–244. 60 cents.

The geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp. 70 cents.

Mineral deposits of the Kotsina-Kuskulana district, with notes on mining in Chitina Valley, by F. H. Moffit. In Bulletin 622, 1915, pp. 103–117. 30 cents.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 622, 1915, pp. 131–139. 30 cents.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson. In Bulletin 622, 1915, pp. 140–188. 30 cents.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletin 605, 1915, 125 pp. 25 cents.

*A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 372, 173 pp.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 642, 1916, pp. 137–145. 35 cents.

Mining in the lower Copper River basin, by F. H. Moffit. In Bulletin 662, 1917, pp. 155–182. 75 cents.

*Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914, by B. L. Johnson. In Professional Paper 98, 1916, pp. 35–36.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 183–192. 75 cents.

Copper deposits of the Latouche and Knight Island districts, Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 193–220. 75 cents.

The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp. 25 cents.

The upper Chitina Valley, by F. H. Moffit, with a description of the igneous rocks, by R. M. Overbeck. Bulletin 675, 1918, 82 pp. 25 cents.

*Platinum-bearing auriferous gravels of Chistochina River, by Theodore Chapin. In Bulletin 692, 1919, pp. 137–141.

*Mining on Prince William Sound, by B. L. Johnson. In Bulletin 692, 1919, pp. 143–151.

*The Jack Bay district and vicinity, by B. L. Johnson. In Bulletin 692, 1919, pp. 153–173.

*Mining in central and northern Kenai Peninsula in 1917, by B. L. Johnson. In Bulletin 692, 1919, pp. 175–176.

*Nickel deposits in the lower Copper River valley, by R. M. Overbeck. In Bulletin 712, 1919, pp. 91–98.

*Mining in Chitina Valley, by F. H. Moffit. In Bulletin 714, 1921, pp. 189–196.

The Kotsina-Kuskulana district, Alaska, by F. H. Moffit. Bulletin 745, 1923, 149 pp. 40 cents.

The metalliferous deposits of Chitina Valley, by Fred H. Moffit. In Bulletin 755, 1924, pp. 57–72. Free on application.
The occurrence of copper on Prince William Sound, by Fred H. Moffit. In Bulletin 773, 1925, pp. ———. Free on application.

In preparation.

Geology of the Chitina quadrangle, by Fred H. Moffit

TOPOGRAPHIC MAPS.

Central Copper River region; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41, 50 cents. Not issued separately.
Headwater regions of Copper, Nabesna, and Chisana rivers; scale, 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In Professional Paper 41, 50 cents. Not issued separately.
Controller Bay region (No. 601A); scale, 1:62,500; by E. G. Hamilton and W. R. Hill. 35 cents retail or 21 cents wholesale. Also published in Bulletin 335, 70 cents.
Chitina quadrangle (No. 601); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents retail or 30 cents wholesale. Also published in Bulletin 576, 30 cents.
Nizina district (No. 601B); scale, 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448, 40 cents. Not issued separately.
Headwater regions of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498, 35 cents. Not issued separately.
Prince William Sound; scale, 1:500,000; compiled. In Bulletin 526, 30 cents. Not issued separately.
Port Valdez district (No. 602B); scale, 1:62,500; by J. W. Bagley. 20 cents retail or 12 cents wholesale.
The Bering River coal fields; scale, 1:62,500; by G. C. Martin. 25 cents retail or 15 cents wholesale.
The Ellamar district (No. 602D); scale, 1:62,500; by R. H. Sargent and C. E. Giffin. Published in Bulletin 605, 25 cents. Not issued separately.
Nelchina-Susitna region; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, and others. In Bulletin 668, 25 cents. Not issued separately.
Upper Chitina Valley; scale, 1:250,000; by International Boundary Commission, F. H. Moffit, D. C. Witherspoon, and T. G. Gerdine. In Bulletin 675, 25 cents. Not issued separately.
The Kotsina-Kuskulana district (No. 601C); scale, 1:62,500; by D. C. Witherspoon. 10 cents. Also published in Bulletin 745, 40 cents.

In preparation.

Prince William Sound region; scale, 1:180,000; by J. W. Bagley.

COOK INLET AND SUSITNA REGION.

REPORTS.

Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201–202. 40 cents.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp. 25 cents.
*The Mount McKinley region, Alaska, by A. H. Brooks, with description of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp. 35 cents.
Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp. 30 cents.
The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp. 20 cents.
Mineral resources of the upper Matanuska and Nelchina valleys, by G. C. Martin and J. B. Mertie, jr. In Bulletin 592, 1914, pp. 273–300. 60 cents.
Mining in the Valdez Creek placer district, by F. H. Moffit. In Bulletin 592, 1914, pp. 307–308. 60 cents.
The geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp. 70 cents.
The Willow Creek district, by S. R. Capps. Bulletin 607, 1915, 86 pp. 25 cents.
The Broad Pass region, by F. H. Moffit and J. E. Pogue. Bulletin 608, 1915, 80 pp. 25 cents.
The Turnagain-Knik region, by S. R. Capps. In Bulletin 642, 1916, pp. 147–194. 35 cents.
Gold mining in the Willow Creek district, by S. R. Capps. In Bulletin 642, 1916, pp. 195–200. 35 cents.
The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp. 25 cents.
*Mineral resources of the upper Chulitna region, by S. R. Capps. In Bulletin 692, 1919, pp. 207–232.
*Gold-lode mining in the Willow Creek district, by S. R. Capps. In Bulletin 692, 1919, pp. 177–186.
*Mineral resources of the western Talkeetna Mountains, by S. R. Capps. In Bulletin 692, 1919, pp. 187–205.
*Platinum-bearing gold placers of Kahiltna Valley, by J. B. Mertie, jr. In Bulletin 692, 1919, pp. 233–264.
*Chromite deposits of Alaska, by J. B. Mertie, jr. In Bulletin 692, 1919, pp. 265–267.
*Geologic problems at the Matanuska coal mines, by G. C. Martin. In Bulletin 692, 1919, pp. 269–282.
*Preliminary report on chromite of Kenai Peninsula, by A. C. Gill. In Bulletin 712, 1920, pp. 99–129.
*Mining in the Matanuska coal field and the Willow Creek district, by Theodore Chapin. In Bulletin 712, 1920, pp. 131–176.
*Mining developments in the Matanuska coal fields, by Theodore Chapin. In Bulletin 714, 1921, pp. 197–199.
*Lode developments in the Willow Creek district, by Theodore Chapin. In Bulletin 714, 1921, pp. 201–206.
Geology in the vicinity of Tuxedni Bay, Cook Inlet, by F. H. Moffit. In Bulletin 722, 1922, pp. 141–147. 25 cents.
The Iniskin Bay district, by F. H. Moffit. In Bulletin 739, 1922, pp. 117–132. 25 cents.
Petroleum seepage near Anchorage, by A. H. Brooks. In Bulletin 739, 1922, pp. 133–147. 25 cents.
Chromite of Kenai Peninsula, Alaska, by A. C. Gill. Bulletin 742, 1922, 52 pp. 15 cents.
Geology and mineral resources of the region traversed by the Alaska Railroad, by S. R. Capps. In Bulletin 755, 1924, pp. 73–150. Free on application.
An early Tertiary deposit in the Yentna district, by S. R. Capps. In Bulletin 773, 1925, pp. ———. Free on application.
Mineral resources of the Kamishak Bay region, by K. F. Mather. In Bulletin 773, 1925, pp. ———. Free on application.
Aniakchak Crater, Alaska Peninsula, by W. R. Smith. In Professional Paper 132, 1925, pp. ———. Free on application.

In preparation.

The Alaska Railroad route, by S. R. Capps.
Geology of the Iniskin-Chinitna Peninsula, by F. H. Moffit.

TOPOGRAPHIC MAPS.

Kenai Peninsula, southern portion; scale, 1:500,000; compiled. In Bulletin 526, 30 cents. Not issued separately.

Matanuska and Talkeetna region; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. In Bulletin 327, 25 cents. Not issued separately.

Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. In Bulletin 500, 30 cents. Not issued separately.

Yentna district; scale, 1:250,000; by R. W. Porter. Revised edition. In Bulletin 534, 20 cents. Not issued separately.

*Mount McKinley region; scale, 1:625,000; by D. L. Reaburn. In Professional Paper 70. Not issued separately.

Kenai Peninsula; scale, 1:250,000; by R. H. Sargent, J. W. Bagley, and others. In Bulletin 587, 70 cents. Not issued separately.

Moose Pass and vicinity (No. 602C); scale, 1:62,500; by J. W. Bagley. In Bulletin 587, 70 cents. Not issued separately.

The Willow Creek district; scale, 1:62,500; by C. E. Giffin. In Bulletin 607, 25 cents. Not issued separately.

The Broad Pass region; scale, 1:250,000; by J. W. Bagley. In Bulletin 608, 25 cents. Not issued separately.

Lower Matanuska Valley (No. 602A); scale, 1:62,500; by R. H. Sargent. 10 cents.

Nelchina-Susitna region; scale, 1:250,000; by J. W. Bagley. In Bulletin 668, 25 cents. Not issued separately.

Iniskin-Chinitna Peninsula, Cook Inlet region; scale, 1:62,500; by C. P. McKinley, D. C. Witherspoon, and Gerald Fitz Gerald (preliminary edition). Free on application.

The Alaska Railroad route: Seward to Matanuska coal field; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

The Alaska Railroad route: Matanuska coal field to Yanert Fork; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

The Alaska Railroad route: Yanert Fork to Fairbanks; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

Iniskin Bay-Snug Harbor district, Cook Inlet region, Alaska; scale, 1:250,000; by C. P. McKinley and Gerald Fitz Gerald (preliminary edition). Free on application.

SOUTHWESTERN ALASKA.

REPORTS.

A reconnaissance in southwestern Alaska, by J. E. Spurr. In Twentieth Annual Report, pt. 7, 1900, pp. 31–264. $1.80.

Gold mines on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.

*Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp. 35 cents.

Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, 1913, pp. 125–136. 25 cents.

The Lake Clark-central Kuskokwim region, by P. S. Smith. Bulletin 655, 1918, 162 pp. 30 cents.

*Beach placers of Kodiak Island, Alaska, by A. G. Maddren. In Bulletin 692, 1919, pp. 299–319.

*Sulphur on Unalaska and Akun islands and near Stepovak Bay, Alaska, by A. G. Maddren. In Bulletin 692, 1919, pp. 283–298.

The Cold Bay district, by S. R. Capps. In Bulletin 739, 1922, pp. 77–116. 25 cents.

The Cold Bay-Chignik district, by W. R. Smith and A. A. Baker. In Bulletin 755, 1924, pp. 151–218. Free on application.

The Cold Bay-Katmai district, by Walter R. Smith. In Bulletin 773, 1925, pp. ———. Free on application.

The outlook for petroleum near Chignik, by G. C. Martin. In Bulletin 773, 1925, pp. ———. Free on application.

TOPOGRAPHIC MAPS.

*Herendeen Bay and Unga Island region; scale 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

*Chignik Bay region; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

Iliamna region; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485, 35 cents. Not issued separately.

Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, pt. 7, $1.80. Not issued separately.

Lake Clark-central Kuskokwim region; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655, 30 cents. Not issued separately.

Cold Bay-Chignik region, Alaska Peninsula; scale, 1:250,000; by R. K. Lynt and R. H. Sargent (preliminary edition). Free on application.

YUKON AND KUSKOKWIM BASINS.

REPORTS.

The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bulletin 375, 1909, 52 pp. 30 cents.

Water-supply investigations in Yukon-Tanana region, Alaska, 1907–8 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp. 20 cents.

The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp. 40 cents.

Mineral resources of the Nabesna-White River district, Alaska, by F. H. Moffit and Adolph Knopf, with a section on the Quaternary by S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245. 40 cents.

Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246–250. 40 cents.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, pp. 153–172. 40 cents.

Gold-placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, pp. 236–270. 40 cents.

Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.

Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240–245. 50 cents.

Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.

The Bonnifield region, Alaska, by S. R. Capps. Bulletin 501, 1912, 162 pp. 20 cents.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp. 20 cents.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp. 55 cents.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp. 25 cents.

A geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle. Bulletin 538, 1913, 82 pp. 20 cents.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. In Bulletin 542, 1913, pp. 203–222. 25 cents.

The Iditarod-Ruby region, Alaska, by H. M. Eakin. Bulletin 578, 1914, 45 pp. 35 cents.

Placer mining in the Ruby district, by H. M. Eakin. In Bulletin 592, 1914, pp. 363–369. 60 cents.

Placer mining in the Yukon-Tanana region, by Theodore Chapin. In Bulletin 592, 1914, pp. 357–362. 60 cents.

Lode developments near Fairbanks, by Theodore Chapin. In Bulletin 592, 1914, pp. 321–355. 60 cents.

Mineral resources of the Yukon-Koyukuk region, by H. M. Eakin. In Bulletin 592, 1914, pp. 371–384. 60 cents.

Surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp. 45 cents.

Mining in the Fairbanks district, by H. M. Eakin. In Bulletin 622, 1915, pp. 229–238. 30 cents.

Mining in the Hot Springs district, by H. M. Eakin. In Bulletin 622, 1915, pp. 239–245. 30 cents.

Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren. In Bulletin 622, 1915, pp. 272–291. 30 cents.

Gold placers of the lower Kuskokwim, by A. G. Maddren. In Bulletin 622, 1915, pp. 292–360. 30 cents.

An ancient volcanic eruption in the upper Yukon basin, by S. R. Capps. Professional Paper 95–D, 1915, pp. 59–64. 20 cents.

Mineral resources of the Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington. In Bulletin 642, 1916, pp. 228–266. 35 cents.

The Chisana-White River district, Alaska, by S. R. Capps. Bulletin 630, 1916, 130 pp. 20 cents.

The Yukon-Koyukuk region, Alaska, by H. M. Eakin. Bulletin 631, 1916, 88 pp. 20 cents.

The gold placers of the Tolovana district, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 221–277. 75 cents.

Gold placers near the Nenana coal field, by A. G. Maddren. In Bulletin 662, 1917, pp. 363–402. 75 cents.

Lode mining in the Fairbanks district, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 403–424. 75 cents.
Lode deposits near the Nenana coal field, by R. M. Overbeck. In Bulletin 662, 1917, pp. 351–362. 75 cents.
The Lake Clark-central Kuskokwim region, Alaska, by P. S. Smith. Bulletin 655, 1918, 162 pp. 30 cents.
The Cosna-Nowitna region, Alaska, by H. M. Eakin. Bulletin 667, 1918, 54 pp. 25 cents.
The Anvik-Andreafski region, Alaska, by G. L. Harrington. Bulletin 683, 1918, 70 pp. 30 cents.
The Kantishna district, by S. R. Capps. Bulletin 687, 1919, 116 pp. 25 cents.
The Nenana coal field, Alaska, by G. C. Martin. Bulletin 664, 1919, 54 pp. $1.10.
*Mining in the Fairbanks district, by Theodore Chapin. In Bulletin 692, 1919, pp. 321–327.
*A molybdenite lode on Healy River, by Theodore Chapin. In Bulletin 692, 1919, p. 329.
*Mining in the Hot Springs district, by Theodore Chapin. In Bulletin 692, 1919, pp. 331–335.
*Tin deposits of the Ruby district, by Theodore Chapin. In Bulletin 692, 1919, p. 337.
*The gold and platinum placers of the Tolstoi district, by G. L. Harrington. In Bulletin 692, 1919, pp. 338–351.
*Placer mining in the Tolovana district, by R. M. Overbeck. In Bulletin 712, 1919, pp. 177–184.
*Mineral resources of the Goodnews Bay region, by G. L. Harrington. In Bulletin 714, 1921, pp. 207–228.
Gold lodes in the upper Kuskokwim region, by G. C. Martin. In Bulletin 722, 1922, pp. 149–161. 25 cents.
Supposed oil seepage in Nenana coal field, by G. C. Martin. In Bulletin 739, 1922, pp. 137–147. 25 cents.
The occurrence of metalliferous deposits in the Yukon and Kuskokwim regions, Alaska, by J. B. Mertie, jr. Bulletin 739–D, 1922, 17 pp. 5 cents.
The Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington. Bulletin 754, 1924, 129 pp. Free on application.
Geology and gold placers of the Chandalar district, by J. B. Mertie, jr. In Bulletin 773, 1925, pp. ———. Free on application.

In preparation.

Geology of Fairbanks and Rampart quadrangles, by J. B. Mertie, jr.

TOPOGRAPHIC MAPS.

Circle quadrangle (No. 641); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents retail or 30 cents wholesale. Also in Bulletin 538, 20 cents.
Fairbanks quadrangle (No. 642); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents retail or 30 cents wholesale. Also in Bulletin 337, 25 cents, and Bulletin 525, 55 cents.
Fortymile quadrangle (No. 640); scale, 1:250,000; by E. C. Barnard. 10 cents retail or 6 cents wholesale. Also in Bulletin 375, 30 cents.
Rampart quadrangle (No. 643); scale, 1:250,000; by D. C. Witherspoon and R. B. Oliver. 20 cents retail or 12 cents wholesale. Also in Bulletin 337, 25 cents, and part in Bulletin 535, 20 cents.
Fairbanks special (No. 642A); scale, 1:62,500; by T. G. Gerdine and R. H. Sargent, 20 cents retail or 12 cents wholesale. Also in Bulletin 525, 55 cents.

Bonnifield region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and C. E. Giffin. In Bulletin 501, 20 cents. Not issued separately.

Iditarod-Ruby region; scale, 1:250,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578, 35 cents. Not issued separately.

Middle Kuskokwim and lower Yukon region; scale, 1:500,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578, 35 cents. Not issued separately.

Chisana-White River region; scale, 1:250,000; by C. E. Giffin and D. C. Witherspoon. In Bulletin 630, 20 cents. Not issued separately.

Yukon-Koyukuk region; scale, 1:500,000; by H. M. Eakin. In Bulletin 631, 20 cents. Not issued separately.

Cosna-Nowitna region; scale, 1:250,000; by H. M. Eakin, C. E. Giffin, and R. B. Oliver. In Bulletin 667, 25 cents. Not issued separately.

Lake Clark-central Kuskokwim region; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655, 30 cents. Not issued separately.

Anvik-Andreafski region; scale, 1:250,000; by R. H. Sargent. In Bulletin 683, 30 cents. Not issued separately.

Marshall district; scale, 1:125,000; by R. H. Sargent. In Bulletin 683, 30 cents. Not issued separately.

Upper Tanana Valley region; scale, 1:125,000; by D. C. Witherspoon and J. W. Bagley (preliminary edition). Free on application.

Lower Kuskokwim region; scale, 1:500,000; by A. G. Maddren and R. H. Sargent (preliminary edition). Free on application.

Ruby district; scale, 1:250,000; by C. E. Giffin and R. H. Sargent. In Bulletin 754, free on application. Not issued separately.

Innoko-Iditarod region; scale, 1:250,000; by R. H. Sargent and C. G. Anderson. In Bulletin 754, free on application. Not issued separately.

SEWARD PENINSULA.

REPORTS.

The Fairhaven gold placers of Seward Peninsula, Alaska, by F. H. Moffit. Bulletin 247, 1905, 85 pp. 40 cents.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141. 25 cents.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp. 70 cents.

Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp. 15 cents.

Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

Mining in the Fairhaven district, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith. Bulletin 433, 1910, 227 pp. 40 cents.

Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371. 40 cents.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp. 30 cents.

Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344. 50 cents.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp. 60 cents.

Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology by P. S. Smith and a description of methods of placer mining by A. H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp. 45 cents.

Placer mining on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 385–396. 60 cents.

Lode developments on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 397–407. 60 cents.

Iron-ore deposits near Nome, by H. M. Eakin. In Bulletin 622, 1915, pp. 361–365. 30 cents.

Placer mining in Seward Peninsula, by H. M. Eakin. In Bulletin 622, 1915, pp. 366–373. 30 cents.

Lode mining and prospecting on Seward Peninsula, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 425–449. 75 cents.

Placer mining on Seward Peninsula, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 451–458. 75 cents.

*Tin mining in Seward Peninsula, by G. L. Harrington. In Bulletin 692, 1919, pp. 353–361.

*Graphite mining in Seward Peninsula, by G. L. Harrington. In Bulletin 692, 1919, pp. 363–367.

*The gold and platinum placers of the Kiwalik-Koyuk region, by G. L. Harrington. In Bulletin 692, 1919, pp. 368–400.

*Mining in northwestern Alaska, by S. H. Cathcart. In Bulletin 712, 1919, pp. 185–198.

*Mining on Seward Peninsula, by G. L. Harrington. In Bulletin 714, 1921, pp. 229–237.

Metalliferous lodes of southern Seward Peninsula, by S. H. Cathcart. In Bulletin 722, 1922, pp. 163–261. 25 cents.

The geology of the York tin deposits, Alaska, by Edward Steidtmann and S. H. Cathcart. Bulletin 733, 1922, 125 pp. 30 cents.

TOPOGRAPHIC MAPS.

Seward Peninsula; scale, 1:500,000; compiled from work of D. C. Witherspoon, T. G. Gerdine, and others, of the Geological Survey, and all available sources. In Water-Supply Paper 314, 45 cents. Not issued separately.

Seward Peninsula, northeastern portion, reconnaissance map (No. 655); scale, 1:250,000; by D. C. Witherspoon and C. E. Hill. 50 cents retail or 30 cents wholesale. Also in Bulletin 247, 40 cents.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; by T. G. Gerdine and D. C. Witherspoon. 50 cents retail or 30 cents wholesale. Also in Bulletin 328, 70 cents.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1:250,000; by E. C. Barnard, T. G. Gerdine, and others. 50 cents retail or 30 cents wholesale. Also in Bulletin 328, 70 cents.

Seward Peninsula, southeastern portion, reconnaissance map (Nos. 655–656); scale, 1:250,000; by E. C. Barnard, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449, 30 cents. Not issued separately.

Nulato-Norton Bay region; scale, 1:500,000; by P. S. Smith, H. M. Eakin, and others. In Bulletin 449, 30 cents. Not issued separately.

Grand Central quadrangle (No. 646A); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533, 60 cents.

Nome quadrangle (No. 646B); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533, 60 cents.

Casadepaga quadrangle (No. 646C); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433, 40 cents.

Solomon quadrangle (No. 646D); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433, 40 cents.

NORTHERN ALASKA.

REPORTS.

A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville rivers and the Arctic coast to Cape Lisburne in 1901, by F. C. Schrader, with notes by W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

Geology and coal resources of the Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.

The Noatak-Kobuk region, Alaska, by P. S. Smith. Bulletin 536, 1913, 16 pp. 40 cents.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp. 25 cents.

The Canning River region of northern Alaska, by E. de K. Leffingwell. Professional Paper 109, 1919, 251 pp. 75 cents.

A reconnaissance of the Point Barrow region, Alaska, by Sidney Paige and others. Bulletin 772. Free on application.

TOPOGRAPHIC MAPS.

Koyukuk River to mouth of Colville River, including John River; scale, 1:1,250,000; by W. J. Peters. In Professional Paper 20, 40 cents. Not issued separately.

Koyukuk and Chandalar region, reconnaissance map; scale, 1:500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532, 25 cents. Not issued separately.

Noatak-Kobuk region; scale, 1:500,000; by C. E. Giffin, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 536, 40 cents. Not issued separately.

Canning River region; scale, 1:250,000; by E. de K. Leffingwell. In Professional Paper 109, 75 cents. Not issued separately.

North Arctic coast; scale, 1:1,000,000; by E. de K. Leffingwell. In Professional Paper 109, 75 cents. Not issued separately.

Martin Point to Thetis Island; scale, 1:125,000; by E. de K. Leffingwell. In Professional Paper 109, 75 cents. Not issued separately.

Northwestern part of Naval Petroleum Reserve No. 4, Alaska; scale, 1:500,000; by E. C. Guerin, G[illegible]Fitz Gerald, and J. E. Whitaker (preliminary edition). Free on application[illegible]veyed for Department of the Navy.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
40 CENTS PER COPY
△