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THE WILLOW CREEK-KASHWITNA DISTRICT ALASKA

BY

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THE WILLOW CREEK-KASHWITNA DISTRICT

By S. R. Capps and Ralph Tuck

INTRODUCTION

LOCATION AND AREA

The Talkeetna Mountains are a roughly circular mass of mountains in south-central Alaska, north of the Chugach Mountains, which border the Pacific Ocean, and south of the Alaska Range. The Talkeetna Mountains form part of the divide between the two master streams of south-central Alaska—the Copper River on the east and the Susitna River on the west—although the greater part of the drainage flows to the Susitna.

The district described in this report is a triangular area covering about 300 square miles in the southwestern part of the Talkeetna Mountains. The Kashwitna River forms the northern boundary, the Susitna Valley flats the western, and the Willow Creek gold district, which is in the extreme southwestern part of the Talkeetna Mountains, the southern.

As the area examined is not a distinct geographic unit, its boundaries being arbitrarily chosen and set only by the limitation of time spent in the field, a description of its geography applies to practically the entire western and southern portions of the Talkeetna Mountains, of which it is a part.

PREVIOUS INVESTIGATIONS

Since 1898 a large number of geologists from the Geological Survey have visited areas bordering on the district here considered, and their reports have long been in print. Each of these investigators had the advantage of having in hand the findings of his predecessors, and later reports have now been issued covering much of this region.[1]

[1] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska: U. S. Geol. Survey 20th Ann. Rept., pt. 7, pp. 1–31, 1900.

Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska: Idem, pp. 265–340.

Martin, G. C., A reconnaissance of the Matanuska coal fields, Alaska, in 1905: U. S. Geol. Survey Bull. 289, pp. 1–32, 1906.

Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139–152, 1911.

Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley: U. S. Geol. Survey Bull. 500, pp. 1–95, 1912.

Capps, S. R., The Willow Creek district: U. S. Geol. Survey Bull. 607, 1915.

Chapin, Theodore, The Nelchina-Susitna region: U. S. Geol. Survey Bull. 668, 1918.

Capps, S. R., Mineral resources of the western Talkeetna Mountains: U. S. Geol. Survey Bull. 692, pp. 187–205, 1919.

Ray, J. C., The Willow Creek gold-lode district: U. S. Geol. Survey Bull. 849–C, 1933.

Two of these reports are, however, still authoritative for the nearby Willow Creek district. The report by Capps,[2] published as the result of field work done in 1913, is the most complete report that treats of the general geology of the district. A more recent and more complete description of gold lodes of that district was prepared by Ray [3] as the result of his studies in 1931. Prospectors and trappers have also contributed information on unsurveyed areas.

PRESENT INVESTIGATION

The field work of the present investigation was done by S. R. Capps and Ralph Tuck during the summer of 1933. With 2 camp hands and 6 horses for the moving of camp equipment, the party left the Lucky Shot mine, in the Willow Creek district, July 12 and immediately started work on the adjacent area to the north. The basins of Purches, Peters, and Little Willow Creek and a part of the Kashwitna River Basin were examined. The field work was completed September 12 on the arrival of the party at Caswell station on the Alaska Railroad.

The field work was financed from a special appropriation made to the Alaska Railroad in 1931 for the development of the mineral resources in the area traversed by the railroad and was carried on under the direction and with the cooperation of the United States Geological Survey. Specifically, the purpose of the expedition was to determine the distribution, amount, and character of the mineralization in the area, particularly in regard to a possible extension of the adjacent Willow Creek mineral belt. The Willow Creek district through 1933 had produced more than $5,500,000 in gold, and there is assurance that it will continue to be productive, as many of the veins are rich and apparently continue to considerable depth. Furthermore, some prospecting in the area that was to be examined had seemed to suggest that gold lodes of value might be found there, and it was hoped that the investigations would permit determining some of the more favorable areas for prospecting. It was already known that the country rock in the entire area is granodiorite similar to that in the Willow Creek district, but more detailed information on structural conditions was desired. Earlier geologic studies in this region had suggested that the granitic rocks of the Talkeetna Mountains might represent two distinct periods of intrusion. If that proved to be true it might be found that the gold mineralization was related to one or the other of those periods, and that would give a clue as to the areas in which prospecting was most likely to be successful.

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[2] Capps, S. R., The Willow Creek district: U. S. Geol. Survey Bull. 607, 1915.
[3] Ray, J. C., The Willow Creek gold-lode district: U. S. Geol. Survey Bull. 849–C, 1933.

The writers are greatly indebted to C. H. Hart and A. H. Crocker, camp hands, for their faithful and hearty cooperation; to W. E. Dunkle, of the Willow Creek mines, for numerous favors; and to General Manager O. F. Ohlson and other employees of the Alaska Railroad for their willingness to cooperate in every possible way.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

As the term " Talkeetna Mountains " indicates, the area is a mountainous mass. The mountainous area is bounded on the west by the broad Susitna Valley, which at this point is about 40 miles wide and through which the Susitna River flows in its southward course to Cook Inlet. East of the Susitna River broad gravel-covered flats extend for 6 to 8 miles with but slight relief and with an almost imperceptible rise toward the Talkeetna Mountains. Small lakes and marshes are numerous in these flats.

East of the flats the relief increases, the lowlands giving place to long, narrow north-south ridges between which there are many small lakes and long interconnected marshes that make cross-country travel tedious and difficult. Still farther east the main Talkeetna Mountain mass rises from this ridge country in slopes that are smoothly rounded up to elevations of more than 3,000 feet. These regular slopes are characteristic along the west front of the range and are in part the result of glacial erosion, but in places they may represent an older preglacial surface that has been dissected by glacial deepening of the tributary valleys. Toward the center of the range, at the headwaters of Peters, Purches, and Little Willow Creeks and in the upper part of the Kashwitna Basin, the ridges lose completely this rounded character and instead become predominantly knifelike, with numerous pinnacles. The projection of the smooth, rounded slopes of the front of the range would pass 1,000 feet or so above the highest existing peaks, thus suggesting the amount that glacial and stream erosion has lowered these mountains since they were uplifted. In the center of the range the mountains reach elevations of 6,000 to 8,000 feet and are characterized by steep talus-covered slopes, sharp ridges, sheer cliffs, and pinnacles.

The region here discussed is drained by the Kashwitna River (see pl. 1), which heads near the center of the range, and by Little Willow, Purches, and Peters Creeks, which extend back into the range for only a few miles. The Kashwitna River, a tributary of the Susitna River, is some 60 miles in length, flows in a general westerly course, and has its source in a number of small glaciers. Within the mountains the valley of the Kashwitna is a typical glaciated valley, U-shaped in cross section, with smooth, steep walls, which at many places show glacial flutings. Practically all the tributary streams emerge from hanging valleys at elevations 500 to 1,200 feet higher than the Kashwitna, so that on reaching the Kashwitna Valley they descend in falls or cascades. Many of the tributary streams, particularly those near the head, rise in small glaciers. For its upper 30 miles the Kashwitna River is a rapidly flowing silt-laden stream, below which for 10 miles it is sluggish, with beautifully developed meanders extending from wall to wall of the valley. Below this meandering portion it flows rapidly again for a number of miles, to enter the broad flats of the Susitna, where it has a moderate gradient to its junction with the Susitna River.

Purches and Peters Creeks, tributaries of Willow Creek, and Little Willow Creek are alike in character in that for the upper 10 miles each flows in a broad glaciated valley which becomes narrower downstream. In the upper basins of these creeks the tributaries emerge from hanging valleys like those of the Kashwitna River. Peters and Purches Creeks have small glaciers as their sources. Their basins are striking because of their asymetric development, for the north valley walls are smooth and almost unbroken by tributary streams, that of Purches Creek in particular being straight and unbroken for an east-west distance of about 12 miles, whereas the south walls of both valleys are dissected by numerous tributaries, all of which head in cirque basins far back in the ridge. This conspicuous lack of symmetry is due in part to the structure of the underlying rocks and in part to a southward shifting of the divides as the result of unequal glacial erosion.

CLIMATE

The climate is similar to that of other mountainous localities between the coastal ranges and the Alaska Range. From the first of October to the first of May snow may be expected, particularly in the higher country, where snow flurries may occur even during the summer. Most of the streams are free of ice about the middle of May and freeze up during October. The winter temperature is prevailingly around zero. In June, July, August, and a part of September snow is found only on slopes sheltered from the sun or at the higher elevations. A large part of the annual precipitation falls during the later part of July and in August and September.

Climatic records for the area are not available, as there are no settlements. The nearest place at which records have been kept is the town of Matanuska, at the head of Knik Arm, a few miles south of the Talkeetna Mountains. The records at Matanuska from 1922 to 1929 show an annual precipitation of 11.25 to 18.31 inches, which includes a snowfall of 22.1 to 55 inches. The mean annual temperature as shown by these records is from 33.4° to 37.6°. The Talkeetna

Mountains, because of their higher elevation, undoubtedly have a greater precipitation and a lower mean annual temperature than Matanuska.

VEGETATION

A large part of the area lies above timber line (see fig. 4), which in most places has an elevation of 1,800 to 2,000 feet, although in the larger valleys clumps of timber are often found 200 to 400 feet higher. Below timber line spruce and birch are abundant in the better-drained areas, and cottonwoods are numerous in many places along the streams. The maximum diameter attained by the spruce and birch trees is from 2 to 3 feet, but cottonwoods 4 to 5 feet in diameter are common. The swamps and poorly drained areas below timber line do not support a growth of timber with the exception of stunted black spruce. The spruce, which is in most demand locally, both for fuel and for building material, has in the last few years been attacked by beetles that have already killed large numbers of the trees. It is estimated that in this area at least 60 percent of the spruce is already dead or dying. In a few years green spruce will be hard to obtain, and travel will be made difficult by windfalls resulting from the rotting of the roots of the dead trees. The danger of forest fires will also be increased. The beetles are not confining themselves to one particular area but are threatening to devastate the entire Susitna Valley of spruce.

Above the zone of timber alders and willows grow up to an elevation of 3,000 feet and furnish fuel for camp purposes. Above 3,000 feet only grasses, mosses, and heatherlike plants grow. The most common grass, a variety known as "redtop", grows luxuriantly at all but the higher elevations and furnishes stock feed from the first of June to the middle of September.

SETTLEMENTS AND ROUTES OF TRAVEL

No permanent settlements exist in the area examined, with the exception of the stations of Willow (mile 185.7 from Seward), Kashwitna (mile 193.9), and Caswell (mile 202.3), on the Alaska Railroad. At these points the railroad keeps small crews for track maintenance, and a few cabins are occupied occasionally by prospectors or trappers. A few trappers' cabins are also scattered throughout the area and are occupied in season. Several fur farms have been started in the vicinity of the railroad, and at Willow there is a roadhouse for the convenience of transients going to and from the Willow Creek mining district.

The region here described lies immediately north of the Willow Creek district, and the southern part of it, particularly the basins of Purches and Peters Creeks, can be most easily approached from that direction. The Willow Creek district is connected by a good road with the Alaska Railroad at Wasilla and by a newer but poorer road with Willow station on the railroad. The drainage basins of

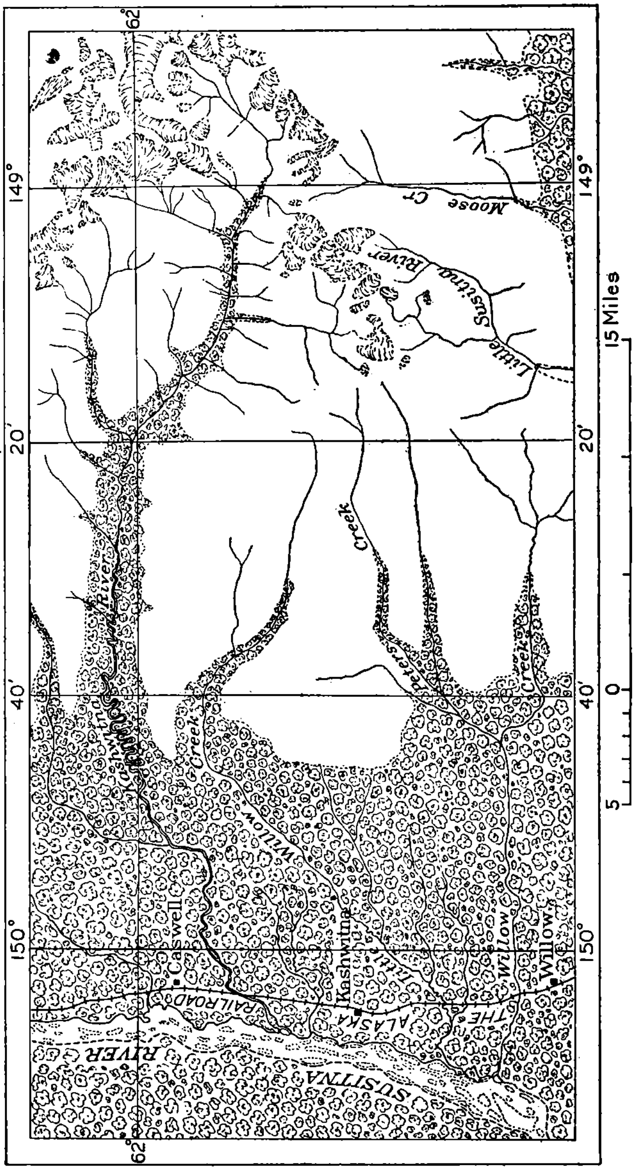
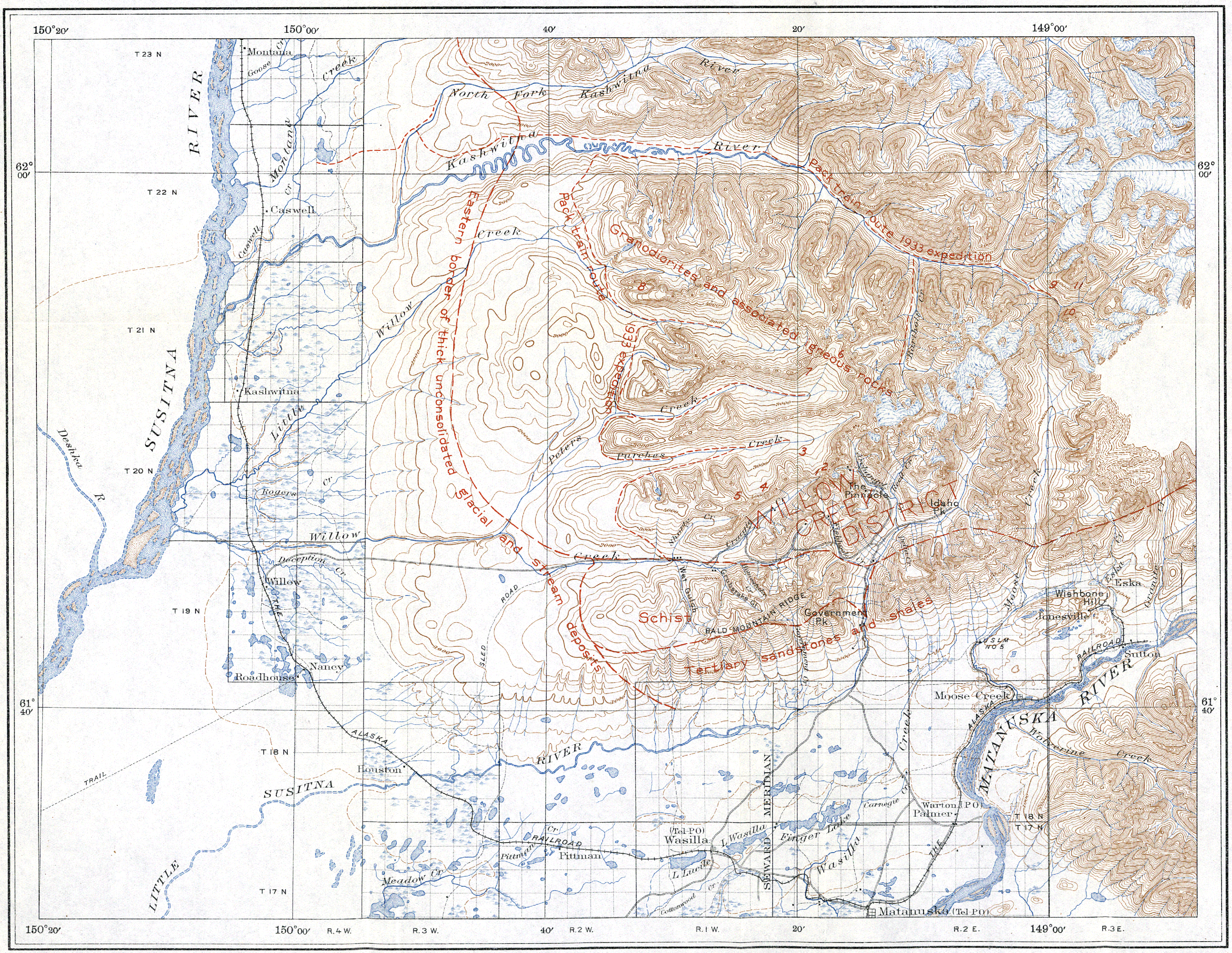


FIGURE 4.—Sketch map showing the distribution of timber in the Willow Creek-Kashwitna district.

the Kashwitna River and of Little Willow Creek can be reached from the railroad stations of Willow, Kashwitna, and Caswell. (See pl. 1.) The Kashwitna Basin is most easily reached from Caswell. From this point there are 4 miles of wagon road leading northeastward to a



Base from U. S. Geological Survey maps

5 Locality referred to in text

MAP OF THE SOUTHWESTERN PART OF THE TALKEETNA MOUNTAINS, ALASKA

Scale $\frac{1}{250000}$

5 0 5 10 15 Miles

1935

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lake locally known as "Caswell Lake", where there is a fur farm. From this lake a passable pack trail runs eastward to the North Fork of the Kashwitna River. This trail leads up the North Fork, but faint trails also continue directly eastward along the north side of the Kashwitna almost to its headwaters. Pack horses can be taken along this route from Caswell up the Kashwitna River for a distance of about 40 miles, although some care must be exercised in crossing swamps, particularly those in the Susitna Valley. From the station of Kashwitna there is a winter trail leading back to the mountains, but no summer trail is known to the writers. No doubt a passable route could be selected, but the marshy nature of the ground in the lowland of the Susitna Valley presents difficulties to summer travel. Short trails also exist on the south side of the Kashwitna River, and one leads up Bartholf Creek.

The knifelike character of the ridges and the abundance of coarse talus slopes makes north-south travel with pack horses impossible in the higher mountains. However, a roundabout route, such as that taken by the Geological Survey party of 1933 (see pl. 1), can be followed without great difficulty.

Each of the streams here discussed flows in a wide-floored glacial valley with a moderate gradient. No unusual difficulties would be encountered in building a road from the Alaska Railroad to any part of the district in which mining developments warranted the expenditure.

GEOLOGY

GENERAL FEATURES

It has long been known that most of the southwestern part of the Talkeetna Mountains is composed of and is a part of the Talkeetna Mountain granodiorite batholith. Early reconnaissances by Paige and Knopf [4] and by Capps [5] showed the presence of granodiorite and related rocks along the west face of the range, and from examination of float from the streams they inferred that the interior mass of the mountains was also predominantly granodiorite. The present detailed investigation confirmed these inferences. Conclusive evidence of more than one intrusive mass is lacking, and although several types of intrusive rocks are present, they all probably represent one general magmatic period.

No other consolidated deposits were found in the area, as the field work did not extend into the Susitna Valley beyond the west face of the range. However, as Tertiary (Eocene?) lignite is present at numerous localities throughout the Susitna Valley, and as several

[4] Paige, Sidney, and Knopf, Adolph, op. cit., pp. 19–20.
[5] Capps, S. R., op. cit., pp. 196–197.

coal seams have been reported from localities bordering the western margin of the field visited, it seems probable that Tertiary sediments overlap the western margin of the granodiorite batholith, as they do the southern margin, both in the Willow Creek district and farther east in the Matanuska Valley.

The only other formations in the area are Quaternary glacial deposits and Recent stream and talus deposits, which are confined chiefly to the present valleys and valley walls.

IGNEOUS ROCKS

CHARACTER AND DISTRIBUTION

The igneous rocks that underlie almost the entire region consist predominantly of quartz monzonite, granodiorite, and quartz diorite, although granite and gabbro occur in places. As the distinctions between these rocks are often discernible only through microscopic examination, the general term "granodiorite" can correctly be applied to the batholith in general, and for the purpose of simplicity it is so used in this report. Almost all these intrusive rocks are of medium to coarse grain, so that most of the common mineral constituents can be identified by inspection with the unaided eye. The chief constituents are quartz, orthoclase, microcline, plagioclase feldspars ranging from albite to andesine, hornblende, biotite, and muscovite. Accessory minerals such as zircon, apatite, titanite, magnetite, and pyrite are common. Secondary minerals such as epidote, zoisite, chlorite, and sericite are usually present and have been formed by the alteration of the common primary mineral constituents.

Although the average composition of the igneous rocks is probably that of a granodiorite, there are many variations from this normal facies. Along the west face of the mountains more acidic varieties predominate, and there the rocks have an average composition approaching that of a quartz monzonite with only a small percentage of iron-bearing minerals such as hornblende and biotite. On the south side of the lower part of Purches Creek a pegmatitic variety occurs in many places. The pegmatites occur as dikes and are composed of quartz, orthoclase, and plagioclase with scattered sheets of muscovite half to three-quarters of an inch across, black tourmaline crystals from 1 to 3 inches in length, and the variety of garnet called "andradite." Parts of these pegmatites look like quartz veins, but they rarely contain metallic minerals; in this area even valuable nonmetallic minerals have not yet been found in them. As a general rule the rocks of the eastern part of the area, or toward the center of the mountains and including the heads of Purches and Peters Creeks and the Kashwitna River Basin, are slightly more basic in composition, with quartz diorite, diorite, and in places gabbro predominating. Rocks composed predominantly of hornblende, called " hornblendite ", occur near the head of the Kashwitna River, but they commonly display a gneissic structure, and it may be that the hornblende has been developed through metamorphism. The mineralized areas usually occur in the quartz diorite instead of in the more acidic types of intrusive rock, but this may be only a coincidence. Granite and alaskite also occur on the north side of the upper Kashwitna Basin and appear to be slightly younger than the more basic rocks.

STRUCTURE

Flow structure, induced while the igneous rock was not completely consolidated, is a common feature in the more basic varieties of the intrusive rock. In this structure the hornblende crystals and in places the biotite crystals also are alined in one direction, giving to the rock a slightly banded appearance. Other less common structural features are segregated bodies of hornblende and biotite that form small parallel lenses.

In addition to these primary structural features formed before the complete consolidation of the intrusive rock, secondary features have been produced as a result of stresses after consolidation. Well-developed granodioritic gneiss, or banded granodiorite, occurs at several localities, principally on the Kashwitna River about 10 miles from its source. The banding of this gneiss is vertical and strikes N. 15° E., although the general trend of this belt is N. 45° E. Associated with the gneiss are some fine-grained basic rocks that contain chlorite and are locally somewhat gneissic. It appears probable that these gneisses have resulted from regional deformation.

Other later structural features imposed upon the granodiorite are faults and well-developed joint systems. Inasmuch as the igneous rocks are essentially homogeneous, faulting can usually be recognized only by actual detection of the fault plane. Several faults were observed, and on Purches Creek many of them had a strike to the northwest and most of them a dip to the northeast. Many of the postmineral faults in the Willow Creek district have similar attitudes. Minor faults are common in the dioritic varieties of the intrusive rock, and many of the talus slopes show numerous large blocks with polished and slightly striated faces.

Jointing or fracturing in the granodiorite is common, from one to three sets of joints having been developed almost everywhere. There is no uniformity in the attitude of these joints over the entire region, but in somewhat local areas the jointing is uniform. On both Purches and Peters Creeks joints with an east-west strike and a north dip have been developed; these have played an important part in determining the courses of the streams. Many of the other topographic forms, particularly the peaks, exhibit the influence of joint control in their formation.

AGE AND CORRELATION

No new evidence as to the age of the igneous rocks in this region was obtained in this investigation, for granitic rocks occupy the entire area and have not been found in contact with other rocks of known age. In nearby areas some of the granitic rocks of the Talkeetna Mountains have been regarded as of Middle Jurassic age, and for some time it was believed that the entire batholith was of that age. Recent studies in neighboring regions both to the north and west have shown, however, that apparently similar granitic intrusives there cut sediments of Upper Cretaceous age, and this suggests the possibility that at least part of the granitic rocks of the Talkeetna Mountains may be younger than they were formerly considered to be.

Within the district here discussed careful attention was given to the problem of determining whether all the granitic rocks there represented only one general period of intrusion, or more than one, and the conclusion was reached that although a succession of injections took place, they were probably all part of one general period of intrusion and merely represent successive pulses of the magma. Evidence for a succession of pulses was seen on the south side of Purches Creek, on a small tributary that heads against the divide with Shorty Creek, where the granodiorites that form the larger part of the west face of the mountains ramify into quartz diorites. Here it is clear that the quartz diorites are somewhat the older. Near the headwaters of the Kashwitna River quartz diorites grade into more basic and gneissic rocks. Still farther east an alaskite mass intrudes these basic gneissic rocks. It is evident that the more basic variety—the quartz diorite—was followed by a more acidic variety—the quartz monzonite—and that these were intruded first by pegmatite dikes and later by a few basic dikes. The time that elapsed between these various injections is not known, but for the present they are believed to represent successive phases of a single general period of intrusion.

TERTIARY DEPOSITS

No Tertiary sediments are present in the area that was examined, as the field work was confined entirely to the mountainous area. Tertiary sandstones, conglomerates, and shales with interbedded seams of lignitic coal are known to occur at many places on the western and southern flanks of the mountains, overlying the granodiorite. It seems probable that much of the lowland south and west of the Talkeetna Mountains was formerly covered by Tertiary coal-bearing deposits. These beds were locally tilted and folded, and later stream erosion and glaciation removed the coal formation in places. Still later the remaining beds were covered with glacial deposits and glacial outwash, such as clay, boulders, sand, gravel, and silt. The present exposures in the Susitna Valley are largely due to postglacial stream erosion, which in places has stripped away the mantle of unconsolidated sediments. A similar condition is present on the south margin of the Talkeetna Mountains, in the Matanuska Valley.

GLACIATION

The most impressive recent geologic event that has left its imprint upon the topographic features was wide-spread glaciation. During the glacial period over four-fifths of the area examined was covered by ice, and only the higher ridges and peaks protruded as islands above the surface of the ice fields. Glacially scoured and polished surfaces, U-shaped valleys, hanging valleys, truncated spurs, cirques, and morainal deposits all give eloquent testimony of the severity of glacial erosion and the tremendous change that it imposed upon the topography. Small glaciers still survive at the heads of many of the streams, but all at the present time show indications of slow retreat.

During the height of glaciation in this area, glaciers from the small stream valleys coalesced with those in the major valleys, and all flowed to the west to unite with the Susitna Valley glacier. The west front of the Talkeetna Mountains shows unmistakable evidence of having been glaciated up to an elevation of 4,000 feet, so that in places the ice of the Susitna Valley glacier had at least that thickness.

The Kashwitna Valley is an almost perfect example of a glacially modified valley. It has a strongly U-shaped cross section and steep walls. All its tributaries within the mountains occupy hanging valleys, the mouths of which lie 500 to 1,200 feet above the Kashwitna Valley, so that the tributary streams enter the main valley in falls and cascades. Projections of the profiles of the tributary streams into the main valley suggest that the Kashwitna Valley was cut down from 400 to 1,000 feet by the ice. The major part of the overdeepening is probably due to glacial action, although it is possible that some of this difference in elevation between the tributaries and the main valley is due to preglacial stream erosion during which the major stream cut a deeper valley owing to its greater volume of water.

QUATERNARY DEPOSITS

Unconsolidated Quaternary deposits, although widespread in the Susitna Valley, are not widely present in the Talkeetna Mountains, being found only in the present stream valleys. In the mountainous area the valley glaciers swept the rock surfaces clean, but after the retreat of the glaciers some glacial debris, consisting of boulder moraines, was left behind, and in the lower valleys fluvioglacial deposits of sand and gravel were laid down. In almost all the cirque basins tributary to the main valleys, as well as at the heads of the main valleys themselves, small moraines composed entirely of boulders represent the dying phase of glaciation. Glacial material is unevenly scattered on the broad, flat tops of the western front of the range up to elevations of over 3,000 feet, but in no place is there any great accumulation of it.

The time since the ice retreated has been so short geologically that the present streams have reworked only a very small amount of rock debris, and this occurs along the present stream channels as silt, sand, and gravel. Talus slides cover a large part of the slopes of the steeper mountains, particularly in the headward basins of the streams. Conditions have been favorable for the formation of talus slopes, as glaciation left the valley walls steep, the granodiorites are highly fractured and jointed, and the range of temperature is great. The rocks forming the talus slopes range from fine material a few inches in diameter to blocks 30 feet or more across. Some of the talus slides are relatively stable, the component boulders being covered with moss, but others are lying precariously on steep slopes and give evidence of continual slow movement.

From the face of the mountains westward to the Susitna River the valley floor is covered by thick deposits of glacial moraine and glaciofluvial sand, silt, and gravel and to a lesser extent by the recent stream sediments.

Purches and Peters Creeks, in addition to having typically glaciated valleys, show one other feature that may at least in part be attributed to glaciation. Both of these streams have asymmetric drainage, almost all the tributary streams coming from the south and comparatively few from the north. These valleys lie along prominent east-west joints that may have been the original factor in determining the course of the streams. Most of these east-west joints also have a northerly dip, which may in part explain the asymmetry of the valleys. The original lack of symmetry has been accentuated by glaciation, however, for all the tributary streams have cirques at their heads. On northern slopes, protected from the direct rays of the sun, melting would be much less rapid than on southern slopes. Consequently glaciers would be longer-lived and their erosion more intense on northern than on southern slopes. Furthermore, in a mountainous region that is slowly entering a glacial period, glaciation would start sooner on northern slopes than on those facing the south. Much of the alpine glacial topography characteristic of this region is the result of cirque growth or headward ice erosion that took place long after the main glacier in the Susitna Valley had retreated. This headward ice erosion resulted in the retreat toward the south of the divides between westward-flowing streams and produced an asymmetric drainage system.

ECONOMIC GEOLOGY

GENERAL FEATURES

The chief object of the field work upon which this report is based was to ascertain the mineral possibilities of the area. The Willow Creek district, directly adjacent to the south, has been an active gold-lode camp for more than 25 years and has produced more than $5,500,000 in gold during that period. The mineralized belt, as outlined by the producing mines, has a length of 10 miles and a width of about 5 miles, but so far no structural feature has been discovered that would limit the gold lodes to the small area of present production. The Willow Creek lodes are particularly attractive to the lode miner because of the fact that the ore is free-milling and the proportion of sulphides small. As a result of the large proportion of gold that can be recovered by amalgamation, after crushing to a moderate degree of fineness, and the small proportion that remains locked in the sulphides, the miner can recover the greater part of his gold directly as amalgam, and such concentrates or tailings as need cyanidation require only a moderate consumption of chemicals. The principal sulphides of the ore are arsenopyrite and pyrite, with only minor amounts of other metallic minerals. A detailed description of the ore deposits of the Willow Creek district has recently been published.[6] The veins so far exploited are scattered irregularly throughout that district without any definite relation to structure that has so far been discovered. They strike in various directions and dip at angles that range from almost horizontal to almost vertical. Their surface outcrops are inconspicuous, for the quartz is usually shattered, and upon weathering the vein outcrops form depressions rather than prominences. The veins range in thickness from a few inches to a maximum of 15 feet or more, though the average stoping width in the larger mines is from 2 to 4 feet. In such veins $15 to $20 ore is considered about the lowest grade that can

[6] Ray, J. C., The Willow Creek gold-lode district, Alaska: U. S. Geol. Survey Bull. 849–C, pp. 165–229, 1933.

be mined profitably, and the major portion of the production from the camp has come from ore that carried $30 to $50 to the ton. Prospecting in the valleys north of the productive belt has been sporadic, and nearby areas in the Peters and Kashwitna Basins have received little attention from the prospector. It was therefore expected that a study of those basins might lead to some conclusion concerning their lode possibilities, and it was for that purpose that the present investigation was undertaken.

Although a few men have prospected in this area, the total amount of work that has been done there is small. Near the head of Purches Creek several claims have been located, but there has been no commercial gold production. It is reported that a gold quartz vein was located a number of years ago on the north side of Peters Creek and some development work was contemplated, but no further details concerning that discovery are known, and its location is uncertain. North of the area examined some prospecting and development work has been done on the North Fork of the Kashwitna, but within the area here considered no other lode locations are known. Although other parts of the area have been visited by prospectors, so far as could be learned their visits have been infrequent and have resulted in little detailed prospecting.

PROSPECTING CONDITIONS

Although only trails exist in this region, all the valleys can be reached with pack horses without any great difficulty. If developments should warrant it, passable roads could be constructed with a relatively small expenditure. June, July, August, and a part of September may be considered the open period for prospecting, but in August conditions are most favorable, for on northern slopes and in other sheltered localities snow covers the ground until late summer and in many years does not disappear entirely even then, at the higher elevations. The best exposures are usually at the heads of the tributary and main streams, well above the timber and brush line, where the cirque walls expose fresh rocks. The numerous talus slopes below the steep cliffs are also favorable places in which to search for mineral-bearing float. In many of the upper basins there are sufficient willows and alders to furnish fuel for camp purposes, but in others it would be necessary either to bring in fuel or to make camp at lower elevations, farther from the favorable prospecting areas.

In the event of mining developments, native spruce of sufficient size to furnish mining timbers and rough lumber can be had anywhere within a distance of 8 miles (see fig. 4), and water power for small mills is nearly everywhere available.

PLACER DEPOSITS

Commercial placer deposits are not known to exist in the region. Glaciation was so extensive and intense that most placer deposits that may have existed in preglacial time were destroyed by ice erosion. Since the final withdrawal of the glaciers the amount of erosion of bedrock by streams has in general been too small to yield postglacial placer concentrations of commercial importance. About the only chance that commercial placer deposits might have survived is that certain spots may have escaped intense glaciation. It is also possible that there may be small areas where the recent streams have reworked a considerable amount of glacial gravel and so effected a reconcentration of gold. In mountains so severely glaciated as these, however, the survival of preglacial placer deposits is hardly to be expected, and postglacial erosion has in few places advanced far enough to concentrate placers of commercial value.

LODE PROSPECTING

The area at the head of Purches Creek has been spasmodically prospected for many years, as it lies immediately north of such productive gold-bearing areas as the basins of Craigie, Fishhook, and Archangel Creeks, all of which are in the Willow Creek district. As a result of this prospecting some gold-bearing veins have been located, but the only production has been a small amount from the property of the Marion Twin Mining Co.

This property, which is one of the company's several holdings, is on the east side of the divide between Craigie and Purches Creeks (pl. 1, no. 1). At the time of the writer's visit, July 22, the chief exposures were almost completely covered with snow. One opening showed a quartz vein 2 to 10 inches wide and dipping 45° SW., which contained considerable free gold and a few flakes of galena and chalcopyrite. The vein is well defined and has distinct walls, and the quartz appears to have been deposited in a strong fissure in the country rock, which at this locality is a quartz diorite. Postmineral faulting in the plane of the vein has resulted in a crushing of the vein material and in frequent changes in its thickness. It is reported that in 1929 and 1930 a few tons of rich ore was mined here, a part of which was shipped to the smelter and the remainder milled at the company's mill on the Little Susitna River.

The Little Willie group of claims, held by E. Holland, is at the head of Purches Creek, high on the divide between Purches and Fairangle Creeks (pl. 1, no. 2). The principal vein dips 25° N. 20° E. and is composed of 2 to 8 inches of quartz. In some places the vein has well-defined walls; elsewhere it breaks into small quartz stringers a few inches wide. Specimens of the vein material from the surface show free gold with small amounts of chalcopyrite and bornite. Several small inclines have been put down on the vein, and in them the sulphides are more numerous and free gold is less common, indicating that much of the free gold present in the surface material is a result of the oxidation of the sulphide minerals. The vein has been traced for a distance of several hundred feet. Northwest of the workings it is faulted and its continuation has not been found. Another vein showing chalcopyrite and bornite occurs in a pegmatite dike,[7] but it was covered with snow at the time of the writer's visit. On the same slope there is a quartz float that contains disseminated flakes of molybdenite, which also has been found in some of the veins but nowhere in quantities of commercial importance.

Several claims have been located by Harvey Smith on the south side of Purches Creek about 1 mile from its head (pl. 1, no. 3). The prospect is at an elevation of 3,500 feet, or about 500 feet above the main creek. A small tunnel and a number of pits expose a shear zone that is from 2 to 3 feet wide and dips 25° S. 80° W. It lies in quartz diorite and consists of sheared diorite, gouge, and quartz. The quartz is reported to contain some gold.

At the head of the largest south tributary of Purches Creek there is a quartz vein exposed on the divide with Craigie Creek (pl. 1, no. 4). The vein dips 30° S. 20° W., is 1 foot wide and well defined, and can be traced for several hundred feet. It is composed of "bull" quartz that contains a small amount of chalcopyrite. A characteristic sample of the vein material assayed 0.16 ounce of gold and 0.60 ounce of silver to the ton. A piece of quartz float found on the east side of the same basin assayed 0.02 ounce of gold and 0.20 ounce of silver to the ton. At another locality in the next tributary of Purches Creek to the west (pl. 1, no. 5), a piece of crushed quartz float with disseminated pyrite assayed 0.01 ounce of gold and 0.20 ounce of silver to the ton. On lower Purches Creek, near the west face of the Talkeetna Mountains, there are numerous pegmatite dikes, but no minerals of value were found in them.

On upper Peters Creek some of the quartz float contains small amounts of chalcopyrite and bornite, especially in the basin of the largest north tributary. At one locality (pl. 1, no. 6) a characteristic piece of quartz float assayed a trace of gold and 0.40 ounce of silver to the ton. In the same basin (pl. 1, no. 7) quartz float assayed 0.02 ounce of gold and 0.60 ounce of silver to the ton. The country rock of quartz diorite is highly sheared and suggests the possible presence of structural conditions suitable to mineralization. On the west face of the mountains north of Little Willow Creek

[7] Ray, J. C., op. cit., p. 184.

(pl. 1, no. 8) small stringers of bornite and chalcocite occur in quartz monzonite. These stringers are very irregular, and none more than an inch in width and 1 to 4 feet long were observed.

In the upper part of the Kashwitna Basin quartz float and numerous veins contain small amounts of pyrite and such copper minerals as chalcopyrite and less commonly bornite and chalcocite. In many of the veins the quartz is glassy and closely akin to the quartz found in pegmatites; usually quartz of this type is valueless. On the north side of the Kashwitna River (pl. 1, no. 9) a strong vertical quartz vein strikes S. 42° E. It ranges from 1 to 2 feet in width and can be traced for 400 feet. The country rock is a hornblende diorite, but in a few places a fine-grained acidic dike rock forms one wall. The vein contains a small amount of disseminated pyrite, and a characteristic sample of the vein material assayed 0.01 ounce of gold and 0.20 ounce of silver to the ton. At another locality (pl. 1, no. 10), on the south side and about 400 feet above the river, a quartz vein parallels the structure of a quartz diorite gneiss. The vein and gneiss dip 60° E. The vein has sharp walls, is 6 inches to 2 feet wide, and can be traced up the hillside for 250 feet, to a place where it is obscured by talus. The vein material is fractured by minor postmineral faults and contains a small percentage of disseminated pyrite. A characteristic sample of the quartz assayed 0.04 ounce of gold and 0.10 ounce of silver to the ton. On the north side of the river (pl. 1, no. 11) there are small irregular veinlets of quartz containing seams of chalcopyrite, and a characteristic sample assayed 0.02 ounce of gold and 5.00 ounces of silver to the ton.

FUTURE PROSPECTING

The presence of mineralized quartz veins at the heads of Purches and Peters Creeks and the Kashwitna River, even though those so far found show only a small gold content, suggests the possibility of a northeastward extension of the Willow Creek belt of mineralization, and the area between the head of Peters Creek and the Kashwitna River should be prospected more thoroughly. The present study indicates that the areas of quartz diorite are more strongly mineralized than those of granodiorite, and although this distinction may be difficult to make in the field, it may be regarded as meaning that the rocks that contain many dark-colored minerals are more favorable for prospecting than those with only a few dark-colored minerals. In general the area of quartz diorite trends northeastward from the upper part of the Purches Creek Basin. It may be that there are two separate intrusive masses that form the Talkeetna Mountain batholith, one of which may be barren of metals, or it may be that the apparent association of the mineralized veins with quartz diorite is only a local phenomenon and of no special significance.

Throughout most of this district there are numerous small veins composed of a glassy quartz closely akin to pegmatite, and in these veins copper minerals such as chalcopyrite and bornite commonly occur. Such veins are closely related to the country rock, and in places they grade into it almost imperceptibly. It is probable that veins of this type contain no gold of commercial importance. Similar conditions exist in the Willow Creek district.[8]

Mineralized quartz float is generally most abundant in those areas where the rocks are sheared and slickensided—a fact which suggests the influence of structure on mineralization and emphasizes the desirability, in prospecting, of a careful examination of those areas in which there is evidence of shearing.

The veins that carry the highest metal content usually contain minor amounts of sulphides, and the vein material has been fractured by post-mineral movements. As a consequence the veins weather rapidly, are usually obscured by rock debris, and may even appear as small depressions and so remain unrecognized. Although this tendency of the veins to occupy depressions on the surface makes them difficult to examine, it may aid in their discovery, as in many places veins and shear zones can be traced by these small depressions.

All assays of mineralized quartz taken from several localities in this region yielded at least a trace of gold. It was noticed, however, that silver and copper increase in amount progressively northward from the Willow Creek district—a fact which suggests that there may have been a tendency for the mineralizing solutions to become more basic in that direction, with a greater proportion of sulphides and less free gold.

Ray,[8] in his study of the Willow Creek district, found three distinct types of veins, and the richest gold ore occurs only in the youngest type. In the area here considered the other two types of veins have been found. Evidence as to the presence of the youngest type is inconclusive and can be proved only by further and more detailed prospecting. Although not enough work has been done to justify any final and definite conclusions, it is possible that mineralization similar to that in the productive Willow Creek district extended to the northeast and north, and that gold-bearing veins may be found in the area between the heads of Purches Creek and the Kashwitna River, although it is doubtful if the veins will be of as high grade as those in the Willow Creek district.

In Alaska little attention has been paid to the search for nonmetallic minerals which in more accessible regions have commer-

[8] Ray, J. C., op. cit., p. 189.

cial importance. Pegmatite is a type of rock that in many localities throughout the world contains valuable nonmetallic as well as metallic minerals. It is composed mainly of very large feldspar crystals and glassy quartz masses and usually occurs as irregular veins or dikes in granodioritic masses. Commercial minerals obtained from pegmatite are feldspar and mica, precious and semiprecious stones such as beryl, topaz, and some varieties of tourmaline and garnet, and metallic minerals containing tin and tungsten. Although no definite indications have yet been found that the granodiorites of the Talkeetna Mountains contain pegmatites of value, the fact remains that there is an extensive area in which these rocks occur and in which some varieties of pegmatites have been found. The Alaska prospector should keep in mind the possibility of finding workable deposits of some of these nonmetallic minerals.