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CHARLES D. WALCOTT, DIRECTOR

THE

MINERAL RESOURCES

OF THE

MOUNT WRANGELL DISTRICT, ALASKA

BY

WALTER C. MENDENHALL AND FRANK C. SCHRADER

WASHINGTON

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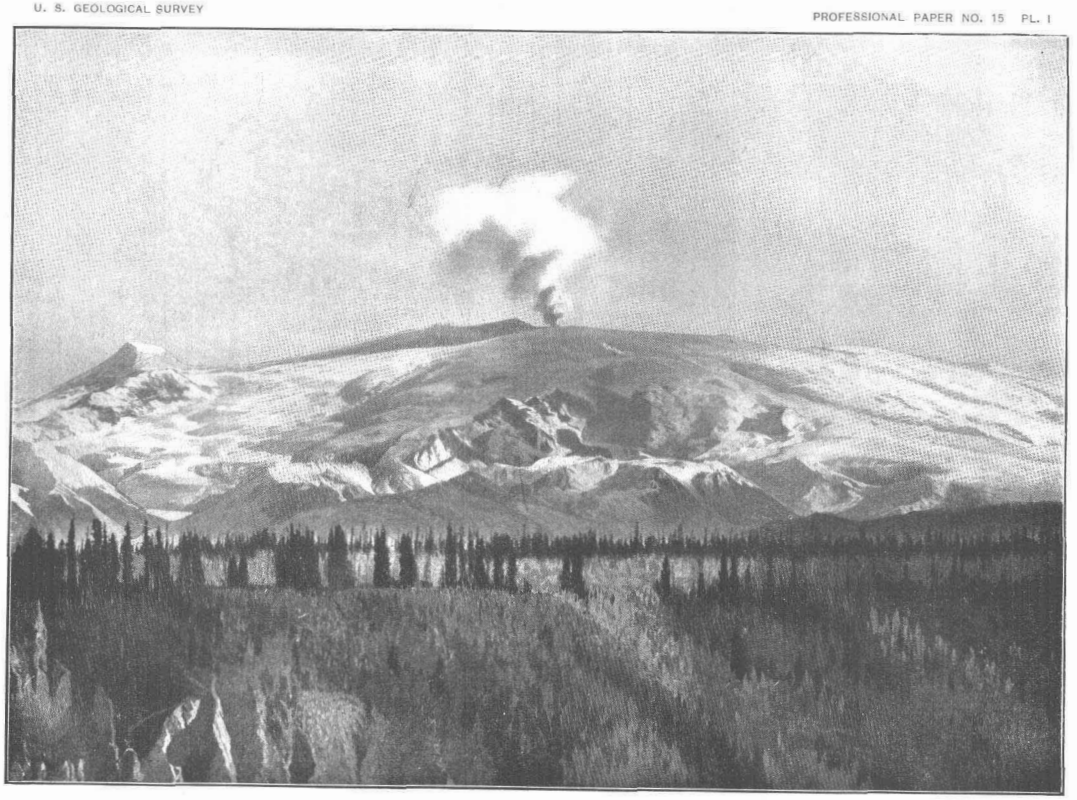
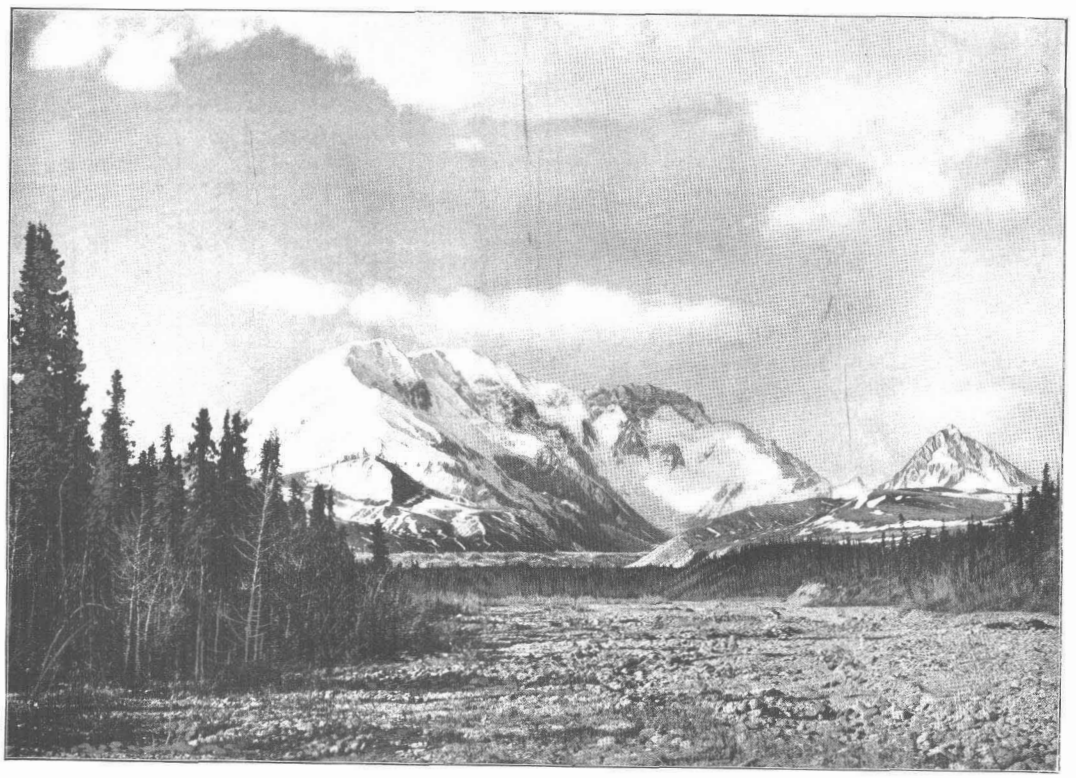


A. MOUNT WRANGELL.

View taken from the Government trail above Tonsina Bridge, 45 miles from the summit of the mountain.



B. NADINA RIVER BARS.

Mount Drum in background.

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THE MINERAL RESOURCES OF THE MOUNT WRANGELL DISTRICT, ALASKA.

By WALTER C. MENDENHALL and FRANK C. SCHRADER.

INTRODUCTION.

The Tenth Census, taken in 1880, gives the number of white inhabitants of the Territory of Alaska as 430. In the decade from 1880 to 1890 this number had increased to 4,298, and in the following decade, that between 1890 and 1900, a further increase to 30,493 is recorded. The Director of the Mint in his report for 1891 gives the value of the yield of the Territory in precious metals as $772,197. By 1900 these figures were increased to $8,265,772. These statistics of the growth in population and in mineral output of Alaska serve as an index to the general increase in the importance and commercial value of the Territory as an integral part of the domain of the United States.

The larger part of this growth began with the discovery, late in the autumn of 1896, of the placer deposits of Klondike River in Canadian Yukon territory. Soon after this discovery there was a great influx of prospectors, miners, and business men to all parts of Alaska, but particularly to the regions tributary to the Yukon, and with this increase in population came a proportional increase in transportation facilities and business interests.

An important part of the general movement toward Alaska during this period was directed toward Copper River, the immigration there first reaching considerable proportions in the spring of 1898. Previous to this date something had been learned of the geography and less of the geology of the Copper River Valley through a number of explorations, usually made under the auspices of the War Department. Lieutenant Abercrombie[a] reached Miles Glacier in 1884 in an attempt to ascend the river, and Lieutenant Allen[b] in 1885 explored the main valley of the Copper and the Chitina and carried his explorations across the

[a] A supplementary expedition into the Yukon Valley, 1884, by Lieut. W. R. Abercrombie.

[b] A military reconnaissance of the Copper River Valley, 1885, by Lieut. Henry T. Allen.

divide to the Tanana by way of Mentasta Pass. Lieutenant Schwatka and Dr. Hayes[a] in 1891 contributed a definite knowledge of Skolai Pass and its approaches and added some geographic and geologic facts concerning the upper course of the Nizina. Except for these surveys nothing of consequence was done within the Copper River Basin previous to 1898, and the Prince William Sound district had been inhabited only by natives and those whites who were engaged in the salmon fisheries or had established trading stations for carrying on fur traffic with the natives.

The 1898 movement assumed large proportions before it ceased. It has been estimated[b] that at least 4,000 people were landed at Valdes during the late winter and spring of that season, none of whom realized that between the coast and the Copper River Valley there stood a barrier of forbidding mountains nearly 100 miles in width and 6,000 feet high. Nevertheless, about 3,000 of these people reached the Copper Valley by crossing the Coast Range over the Valdes Glacier. They had but vague rumors of the mineral wealth of the interior to guide them; a large proportion of them were entirely without experience in mining or pioneer work of any sort, and the amount of work they accomplished bore no adequate relation to the number of people engaged or the energies expended in the explorations. The ebb of the tide of immigration began with the early summer and continued throughout the season, so that by the end of the year probably not more than 300 of the original 4,000 remained in the country. The majority of these were at Copper Center and a few other points in the interior, though some settled in Valdes. The next spring those who had not been utterly discouraged by the hardships of 1898 and by scurvy, which assumed the proportions of an epidemic before the close of the winter, continued the investigations which had been begun by a few of the best equipped and most experienced in 1898. The result was that during the summer of 1899 the first real work was done in the Chistochina gold field (Hazelet and Meals visited the Chistochina in 1898), and the Nikolai copper mine on the Chitina was located. In spite of the undoubted value of these finds the country recovered but slowly from the reaction that followed the stampede.

In the first place the interior was difficult of access; the Copper could be ascended only in small boats and with considerable difficulty, while the original route over the glacier was very trying and could be traveled to advantage only during the few months of early spring. A better route had to be found before movement between the coast and the interior could take place freely. After the discovery of Thompson Pass and the route now used by way of this pass

[a] An expedition through the Yukon district, by Charles Willard Hayes: Nat. Geog. Mag., vol. 4, pp. 117–162.

[b] A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898, by Frank Charles Schrader: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 368.

to the Copper Valley, the development of the interior was advanced to an extent but faintly comprehended outside of the Territory, by the construction of the military trail under the direction of Major Abercrombie, in 1899, 1900, and 1901. This roadway once built, access to the southern edge of the Copper Basin became comparatively easy, and additional trails were established to the various parts of the Chitina and Copper valleys, all of which connected with the military route across the Chugach Range.

Concurrently with the construction of the military trail, map work was carried on by officers of the United States Army, so that some of the geographic details of that part of the Chugach Range lying between Valdes Bay and the Klutina and Copper rivers became well known. Meanwhile the pioneers of 1898 who had declined to be discouraged by the disasters of that year and had obtained the control of gold and copper properties which they regarded as valuable had been persistent in endeavoring to enlist the interest of capitalists residing in the States. In some cases sales had been made of some of the better-known properties, so that each spring more extensive outfits, representing greater interests, entered the country for the purpose of carrying on prospecting or development work.

During this period the United States Geological Survey assisted in making known the resources of the country and added to its accessibility and to the sum of accurate knowledge concerning it through studies whose results were published in maps and reports. In 1898 Mr. Schrader was attached to the expedition commanded by Captain Abercrombie, and the report[a] which was based upon his work contained comprehensive maps of the route then pursued to the interior by way of the Valdes Glacier, and of the route which probably in the future will be followed by a railroad, that by way of the Tasnuna and Lowe rivers from the Copper to Valdes. In 1900 Messrs. Schrader, Spencer, Gerdine, and Witherspoon, all of the United States Geological Survey, spent the summer in the Copper River region, and as a result of their work during that season the Kotsina and Chitina valleys and all their various routes of approach were accurately mapped, and the first comprehensive account of the geology and the mineral resources of the district from the hands of competent experts was published.[b]

At the same time the Signal Corps of the United States Army took up the work of telegraph construction. A line was begun at Valdes in 1900 and during the summer of 1902 was completed by way of the Copper Valley and Mentasta Pass to Eagle, on the Yukon, connecting there with the line to Dawson, thus

[a] Op. cit.

[b] The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, by Frank Charles Schrader and Arthur Coe Spencer; special publication, U. S. Geol. Survey, 1901.

completing telegraphic communication with the interior of Alaska and the outside world.

Recognizing the prospective importance of the district and the interests involved there, the United States Geological Survey in 1902 expended one-half of its Alaskan appropriation in dispatching to the region two well-equipped parties, whose object was to extend the work commenced in 1900 by Messrs. Schrader and Spencer and their associates, until a practically complete map of the Copper Basin and the economically important contiguous regions should be thus made. It was the further object of those intrusted with the work to examine such of the mineral deposits of the district as had not been examined in 1900 and to prepare for public distribution a statement on those deposits. It is in the fulfillment of this design that the present report has been prepared. In order to place it in the hands of those interested at an early date, it has been hastened to completion as rapidly as possible, and is issued in advance of the contoured maps which will accompany a later report on the general geology of the district, but the topographic material has been brought together in the accompanying hachured map (Pl. III), which is confidently presented as the most complete and accurate representation of the physical features of the district centering in Mount Wrangell that is now available.

Since it is improbable that the Survey will do further geologic work in this field until its development reaches such a point that examinations of a detailed character will be justified, we have deemed it wise to assemble here all the available data relative to the economic deposits of the region. Hence we have supplemented our own observations by drawing freely on the published reports of coworkers, where areas were treated in those reports which it has not been possible to visit this season. In this way it has been feasible to assemble in one paper such definite information as is now available concerning the mineral resources of the Mount Wrangell district as a whole.

In the discussion which follows the subject-matter has been arranged under mineral headings, and the various localities in which each mineral is known are described in turn. Only such geologic notes are added in the description of each region as seem necessary to bring out the association and relations of the mineral deposits.

Finally we desire to acknowledge the universal courtesy and hospitality extended to us generally in our field work. To attempt to mention each one to whom we are indebted, would be to publish a roster of the operators of the various camps, the officers of the Army in the district, and the business and professional men of Valdes, so we must content ourselves with this general public acknowledgment.

COPPER.

SOUTHERN AREA.

LOCATION.

This area (see Pl. IV) lies in the foothills that form the southern flanks of the Wrangell Mountains. It is drained by the Cheshnina, the Kotsina, and the Chitina and its tributaries. Since it is largely in the drainage basin of the latter stream it is frequently referred to as the Chitina copper belt.

ROUTES AND TRAILS.

The field is so well known that it is not considered necessary to do more than mention briefly the routes usually followed in reaching it. For the movement of freight and supplies the early spring, from February until late April, is utilized, the frozen condition of the streams and the abundance of snow at this season greatly facilitating transportation. The military trail is followed from Valdes to Tonsina Bridge, and the Tonsina is descended over the ice; or this route may be followed only to the head of Lowe River, whence Marshall Pass is crossed and the Tasnuna descended to the Copper. After reaching the Copper the routes diverge to different parts of the field, but in general the rivers are the highways. Heavy loads can be hauled over them, and supplies may thus be landed in the various camps at a minimum cost.

During the summer season travel is less easy. The streams are then open, swift, and frequently difficult to ford, and, during the early part of the season particularly, the trails through the marshy areas are often mere sloughs. As during the winter season, the military route is utilized as far as Tonsina Bridge. From this point a trail leads down the north bank of the Tonsina to a road house on the Copper, where there are always small boats to ferry the traveler across. From the crossing of the Copper there are two routes to Strelna Creek. The southern one is very direct, but crosses the Kotsina within 7 or 8 miles of its mouth, at a ford which is considered unsafe during the midsummer high-water season. The other, known as the Kotsina trail, ascends the Kotsina nearly to its head and crosses to upper Strelna Creek by way of Pass Creek and the upper course of Rock Creek. These two routes converge at the Strelna and continue eastward as the McClellan trail to the Nizina in the vicinity of the Nikolai mine.

Another route, sometimes followed, leaves the military trail in Kimball Pass, and crosses the Copper at Taral. Ascending the mountains back of Taral, it continues eastward by way of Hanagita Valley to the Chitina near the mouth of Tana River. Any portion of the valley of the Chitina or its tributaries may be reached from one or the other of these routes.

GEOLOGIC SKETCH.

That part of the areal geology of the Chitina region which bears upon the known distribution of minerals that are of economic value may be summarized in about the following terms, the summary being based on the detailed surveys of Messrs. Schrader and Spencer, to whose report reference may be made for further information as to the general geology.[a]

Nikolai greenstone.—One of the oldest formations of the region and economically the most important, is a series of bedded greenstones that attain a thickness of at least 4,000 feet. They stretch across the region lying between the Chitina and the snow-capped mountains to the north in an interrupted and irregular belt, with a general northwest-southeast trend, and exhibit their greatest areal extent, as well as their greatest thickness, in the region of the upper Kotsina, where they cover a belt 10 or 12 miles wide in a direction at right angles to their strike. These greenstones represent a series of superposed flows of basic lava, which have been more or less altered mineralogically, but in which the pseudo-bedding, due to the distinction between individual sheets, is clearly discernible, and lends itself to the determination of attitude (structure) as readily as does the stratification in water-laid beds. The structural changes that have affected them are precisely similar to those which are usually shown in sedimentary formations in disturbed areas, and are identical with those which involve the overlying heavy-bedded limestone.

The precise age of the greenstone is not known, but as it underlies conformably limestones that are believed to be Permian, and as sedimentary formations below this horizon in the Carboniferous farther north contain interbedded igneous material, it is assigned with some degree of confidence to the Carboniferous. In 1900 Messrs. Schrader and Spencer gave the greenstones a somewhat lower position in the time scale, because the overlying limestone was regarded, in the light of the evidence then available, as Carboniferous.

The formation is particularly important commercially, because it is regarded as the reservoir from which the copper has been locally concentrated into deposits of economic value.

Chitistone limestone.—The massive limestone conformably overlying the greenstone, and practically coextensive with it in outcrop, is a conspicuous stratum throughout the entire region north of the Chitina. It varies in thickness from 200 or 300 feet near the western end of the area to a maximum of about 2,000 feet in the neighborhood of the Nizina River. The contrast in color between its white cliffs and the darker rocks of the underlying greenstones makes it possible to

[a] The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, by Frank Charles Schrader and Arthur Coe Spencer; Special publication U. S. Geological Survey, 1901, p. 32 et seq.

follow with great definiteness throughout the region the contact between the two. This contact is important, because it seems to be the place near which valuable copper bodies have been concentrated. These sometimes lie above the contact in the limestone itself, but are more usually found below it, in the upper part of the greenstone, and occasionally in fissure veins that cut directly across the boundary between the two beds. In general the contact follows a tortuous line from a point on the Cheshnina River several miles below the glacier to the unexplored upper portion of the Chitina, crossing in its course the Kotsina, the Kuskulana, the Lakina, the Nizina, the Chitistone, and probably the head of Young Creek. The line is frequently broken, as the contact is buried under the unconformable Kennicott conglomerates and shales, or under the much later lavas from Mounts Wrangell and Blackburn.

The age assigned to the limestone is based on its relation to the overlying Triassic beds and on the finding of fossils north of Skolai Pass by Messrs. Hayes and Brooks in similar beds, which probably belong to the same horizon. These fossils are regarded as Permian.

Triassic shales and limestones.—Conformably overlying the massive Chitistone limestone is a series of thin-bedded limestones and black shales, often locally exhibiting intense folding. The thin limestone beds are abundant near the base of the section, but toward the top they die out and the series becomes essentially shaly. Great variations in thickness are observed in different parts of the field, due not to differences in the amount of material originally deposited, but to later erosion, previous to the deposition of the Kennicott. In some localities the conglomerates of this terrane lie directly upon the the Chitistone limestone, the thinner Triassic limestones and shales having been removed entirely; in other places 3,000 feet of Triassic beds remain. Their age was determined by Mr. T. W. Stanton from fossils collected by Messrs. Schrader and Spencer.

At the close of the period of deposition whose record we find in the Triassic shales and limestones, these beds and the older ones of the region were subjected to stresses that folded and in some instances faulted them, following which they were subjected to a long period of erosion, resulting in the removal of many thousands of feet of rock material.

Kennicott formation.—At the close of this epoch of erosion a great series of conglomerates, sandstones, limestones, and shales were deposited on the exposed edges of the older beds. The rocks of this period have been proved by their contained fossils to be of Jura-Cretaceous age. They now exist in patches following in general the trend of the older rocks, but burying in many places the outcrops of the important economic horizons below.

Intrusive rocks.—All of the formations that have been described are affected

more or less throughout the area by intrusives of various types, including gabbroic and dioritic masses (often covering considerable areas), and porphyritic intrusives, which are especially abundant in the Triassic shales. The latter intrusives may bear some genetic relation to the Chititu gold.

COPPER OCCURRENCES.

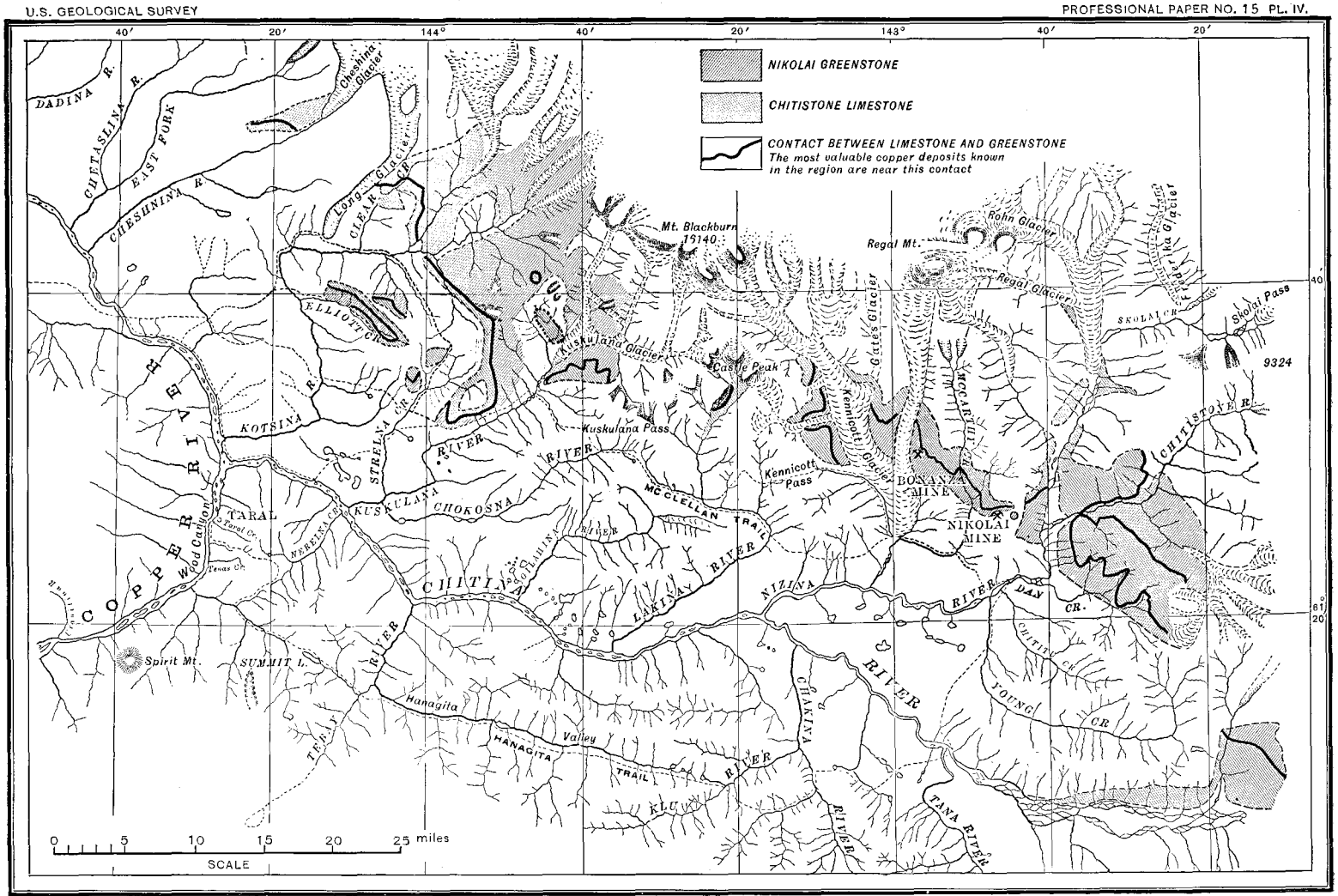
GENERAL STATEMENT.

The copper deposits everywhere within the Chitina district are closely associated with the body of altered igneous rocks which has been described as the Nikolai greenstone. It is believed that the copper was originally disseminated in minute quantities throughout this formation and that the valuable deposits now recognized are concentrations, in various forms, from this original widely disseminated condition. These concentrations have been made at different horizons, but the richer ore bodies seem generally to have formed near the contact with the overlying limestone, usually in the upper part of the greenstone, but in one or two notable instances in the limestone itself, a short distance above the contact. This contact is easily followed and has been recognized by prospectors as marking an important economic horizon throughout the district. Its position, so far as it is at present known, is indicated on the accompanying map (Pl. IV).

Owing to the limited amount of development in the region and the general character of the work done in the study of the copper deposits, it is not now possible to classify genetically the various occurrences or to give in detail the mineral association or the chemical processes that have accompanied the deposition of the various forms of copper ore. Such work must be left largely to the closer studies which may follow the mining developments of the future. For convenience of discussion, however, the ore bodies may be divided, on the basis of their form, into two general classes, the vein deposits and the "bunch" deposits. Such a division is believed to indicate in a measure the economic value of the ore bodies, those of greatest prospective worth falling in the first class.

The term "vein deposits" is so defined as to include all tabular ore masses. This type is best represented by the Bonanza and Nikolai mines, in the eastern part of the area, and by the Goodyear and Henry Prather prospects, on Elliott Creek. With these are classed the ore bodies along bedding planes in the limestone, where they occur, as they do sometimes, in association with fissures, and the deposits along joint and fault planes and in shear zones in the Kotsina Basin. The ores may be found only in shoots within the planes that have controlled their form, but are characteristically of indefinite extent in one or two directions.

The "bunch" deposits, on the other hand, are irregularly bounded masses of



MAP OF THE SOUTHERN COPPER AREA, SHOWING THE KNOWN DISTRIBUTION OF LIMESTONE AND GREENSTONE, AND POSITION OF CONTACT BETWEEN THEM

ore from a few inches to a few feet in diameter, which usually are not obviously related to fractures or fissures or joint planes, but in form are much like basic segregations in igneous rocks, that is, they generally have indefinite limits, grading from masses of practically pure ore at the center, through leaner and leaner phases, into the entirely unmineralized inclosing country rock. These "bunches" are so numerous in certain parts of the field within the upper part of the greenstone that prospectors who have opened a number of them 400 or 500 feet below the base of the limestone have been led to conclude that a "ledge" of ore parallels the contact at this horizon. In some places tiny fissures filled with the sulphides were traced upward into "bunches" of this character, so that it is probable that they represent replacements of the greenstone (they have not been observed in the limestone) that have grown outward in all directions from such a fissure, but although they may originate in fissures and in exceptional cases may grade into deposits of the tabular vein type, they normally constitute a class entirely distinct in form and in value.

The copper of the Chitina district occurs native and as the sulphides—chalcocite (or glance), bornite, and chalcopyrite—which are superficially altered into oxides and carbonates.

Native copper is reported by Schrader and Spencer in the country rock bordering certain well-marked veins which carry metallic sulphides. On the upper Kotsina it is found in small quantities near the base of the greenstone, in compact quartz veins, and is reported to occur as a filling of the amygdaloidal cavities in the greenstone. The source of the big nugget of Nugget Gulch (p. 27) has not been discovered, and the manner of its occurrence is not known.

The best known deposit of chalcocite is on the Bonanza claim, where the vein in limestone carries practically nothing but this rich sulphide. It occurs occasionally associated with bornite in the "bunch" deposits of the Kotsina and Elliott Creek, and in quartz stringers on the Kotsina, but is of importance only at the one locality.

Bornite is the usual ore of the district. The ore of the Nikolai vein, the greater part of the Elliott Creek ores, and the innumerable bunches near the top of the greenstone are chiefly this sulphide. It is sometimes associated with quartz and calcite, particularly in fissure veins, and frequently small quantities of chalcopyrite are found with it, but it constitutes the greater part of the majority of the deposits, often with little or no trace of other copper minerals present.

Chalcopyrite is found in bands 3 or 4 inches thick in the bornite of the Nikolai mine. It occurs sparingly associated with bornite and calcite on Elliott Creek, and has been brought from the upper Cheshnina in small, practically pure masses. It is not generally important in the surface phases of the deposits,

which alone it is now possible to examine, but may be expected to become more important with increasing depth.

The carbonates, malachite and azurite, occur almost universally as surface stains upon the other copper minerals, and sometimes malachite appears in thin sections in veinlets in the ore masses, or as a coating, inclosing a kernel of bornite. Copper oxide, probably cuprite, is found in small quantities in the earthy condition as a surface product.

DESCRIPTION OF PROPERTIES.

CHESHNINA RIVER.

On the south side of the Wrangell Mountains the western limit of the Nikolai greenstone and the Chitistone limestone, the copper-bearing formations of the district, is exposed in the upper basin of the Cheshnina River. Beyond this point the only older rocks that are revealed by the cutting of the streams beneath the lava covering are schists and massive intrusives.

On the Cheshnina some prospecting was done by Mr. A. W. Tibbitts and associates during the season of 1902, and fair indications are reported both of ores and native copper, although developments are not sufficiently extensive to determine the magnitude of the deposits. The ores that were shown to the writers consist of solid masses of chalcopyrite, or of the same mineral associated with epidote and quartz, from Bear Creek, and of bornite in quartz from Mount Chitty. A selected sample of the bornite proved upon assay to carry $\frac{1}{10}$ ounce of gold and 4.52 ounces of silver per metric ton of 2,204.6 pounds. The chalcopyrite has a trace of gold and 1.8 ounce of silver per metric ton. Nuggets of native copper are found also in the stream wash.

KOTSINA RIVER.

Schrader and Spencer[a] report having seen bornite ore from the heads of Clear (Chitty) and Barrett creeks, where the greenstone outcrops, and the same writers report upon the Warner prospect[b] at the mouth of Rock Creek and the Hoffman prospect on Copper Creek. These two prospects were revisited in 1902, and in addition several other localities on the upper Kotsina were examined. It is to be regretted that practically no development work has been carried on in this section since 1900, so that nearly all the properties are mere prospects as yet, and must be judged accordingly. The Kotsina properties which it was possible to examine are described below in the order of their occurrence from the head of the stream down.

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[a] Geology and Mineral Resources of a Portion of the Copper River District, Alaska, p. 84.

[b] Ibid., p. 84.

KEYSTONE CLAIM.

Two short forks, both glacial streams, unite to form the main Kotsina. The southern one of these drains two glaciers. Just below the foot of the northernmost of these glaciers, in a sharp little post-Glacial gorge, is the Keystone claim. Here, in the wall of the canyon, in the greenstone, 4,000 or 5,000 feet stratigraphically below the limestone contact, are some compact quartz stringers and lenses, varying in width from a mere thread to 5 or 6 inches. They strike east and west and are approximately vertical.

Epidote as a gangue mineral in the veins is associated with the quartz, which it sometimes equals in amount. Native copper occurs as grains inclosed in the epidote and in single quartz crystals, but is more abundant in later irregular crevices running through both minerals of the gangue. A small amount of chalcocite is present also, and in one prominent example fills a narrow fissure which intersects masses of epidote and quartz and is evidently later than either, so that the order in which the vein materials were deposited seems to be: Epidote, quartz and copper, copper and chalcocite. In the greenstone of the wall rock the principal change seems to have been a uralitization of the augite.

The occurrence is thus interesting genetically, although of no economic importance.

COPPER KING CLAIM.

This prospect is situated on the north side of the Kotsina Valley, about one-fourth mile west of the Keystone claim and 700 or 800 feet above the river level. It consists of an altered belt of greenstone, in part amygdaloidal, extending several feet east from a well-defined north-south vertical crevice, along which there has probably been some movement. The greenstone within this altered zone has been rendered quartzose, the quartz occurring as stringers and as a filling of the amygdules. The septa between the latter are sometimes changed to granular epidote and chlorite.

Native copper occurs here and there in the mass in grains and flakes, sometimes intimately associated with chalcocite. The latter mineral occurs with the native copper and in tiny crevices, which seem to be later than the general alteration and *silicification*.

ELEANOR, DAVY, AND ASSOCIATED CLAIMS.

The sharp ridge south of the upper Kotsina, separating Peacock and Roaring Gulch creeks, is capped near its southern end by a picturesque remnant of the Chitistone limestone, while the underlying greenstone outcrops along all of the lower slopes. A number of claims have been staked on the Peacock Creek side of this divide, about 2,500 feet above the Kotsina Valley, in that belt in the greenstone, a few hundred feet below the limestone contact, which seems every-

where to carry "bunches" of copper ore. No development work has been done here, but the exposures on the faces of the greenstone cliffs show small, irregular ore bodies from a few inches to 2 or 3 feet in diameter. They usually have cores of nearly pure bornite or chalcocite, but marginally these copper minerals become mingled with the surrounding greenstone, as though the replacement of the greenstone had been less complete near the limits of the mass.

In one or two instances narrow fissures from one-half inch to 1½ inches wide, filled with copper sulphides, were noted, extending downward from ore pockets, but in the majority of cases no such connection between pocket and veinlet is to be seen.

The sulphides carry small quantities of silver, one assay showing 3.3 ounces per ton.

SKYSCRAPER CLAIM.

A shallow open cut has been made on this claim just across the crest of the ridge west of the Eleanor, Davy, etc., and in it ores of the same general character and mode of occurrence are revealed.

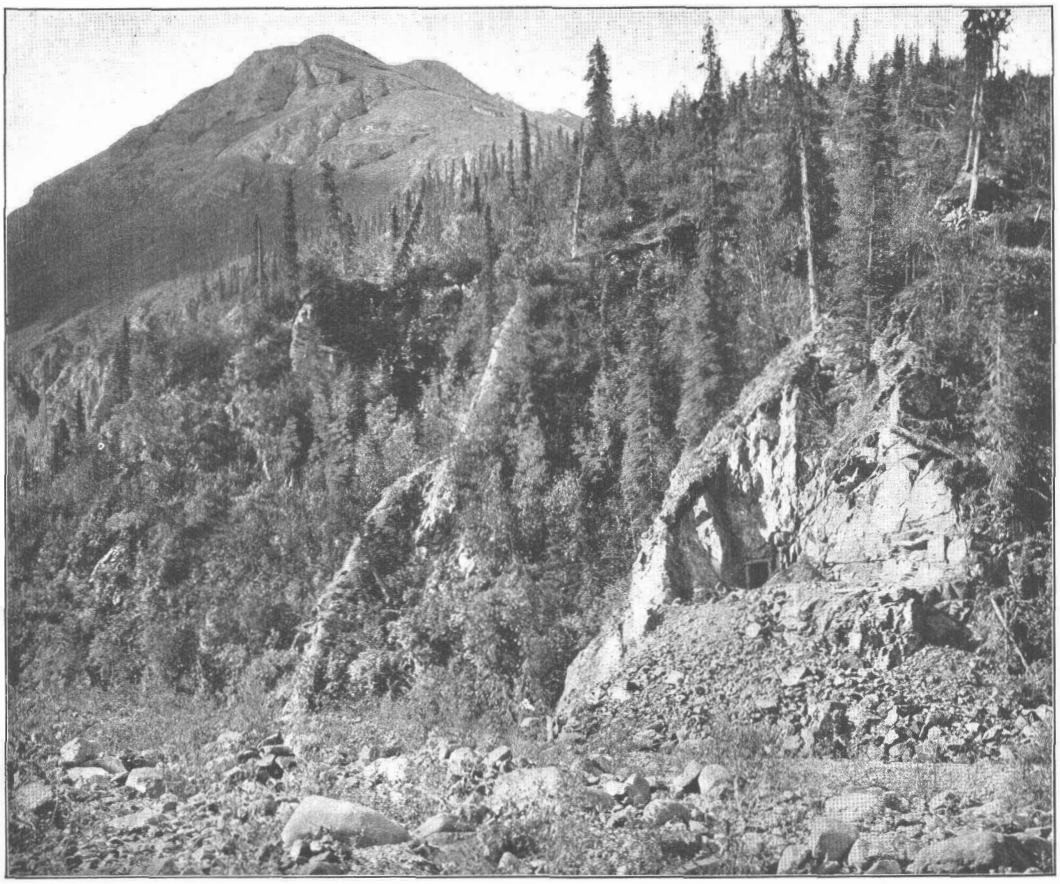
WARNER PROSPECT.

This property (see Pl. V, *A*) is on the west bank of Rock Creek near water level and about one-fourth mile from the Kotsina River. It was visited and described by Schrader and Spencer in 1900, but development work was continued for some time after their visit, and the character of the deposit is therefore somewhat more clearly revealed at present.

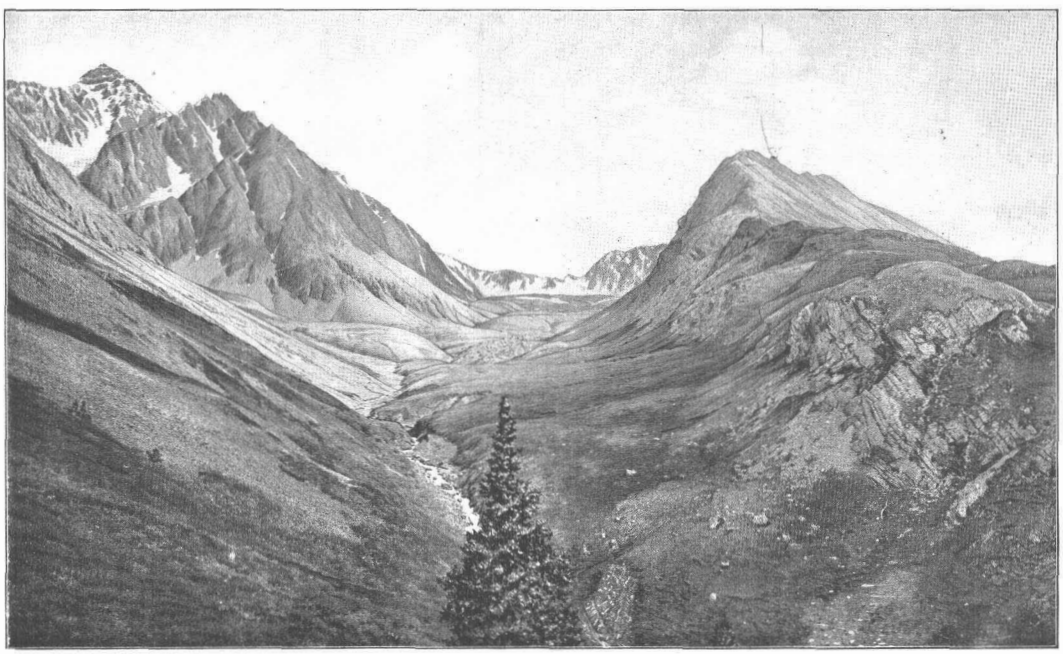
The face of the greenstone bluff adjoining Rock Creek has been stripped over an area about 25 by 40 feet, and a tunnel, running S. 40° W., has been driven for a distance of 18 feet along a zone of slight movement in the greenstone. This zone is from 1 inch to 1 foot wide and is marked by crushed country rock, considerable calcite filling (the bodies of calcite usually being lenticular in form), and a relatively small amount of quartz in stringers, closely associated with the occasional small ore bodies.

On the face of the bluff above the tunnel, the main lead, fairly well defined, is marked as in the tunnel by a succession of calcite lenses, measuring up to 1 foot or more in cross section. The main lead is paralleled at a distance of 3 or 4 feet by a second plane of movement, along which occur quartz stringers from one-fourth to one-half inch in width, with which are associated limited quantities of copper sulphides. The adjacent and intersecting joint planes in the greenstone all show evidence of some mineralization by copper-bearing solutions.

Bornite, the principal copper mineral present, is accompanied by a little chalcopyrite. The ore occurs in small irregular bodies along the crushed zone, masses 8 inches to 1 foot in thickness having been encountered while driving the tunnel. The deposit, however, does not appear to be continuous.



A. WARNER COPPER PROSPECT AND TUNNEL, NEAR MOUTH OF ROCK CREEK.



B. VALLEY OF LIME CREEK, A TRIBUTARY OF ROCK CREEK.

G. & B. AND UNITED VERDE CLAIMS.

Rock Creek is joined, about 1¼ miles above its mouth, by its principal eastern tributary, Lime Creek, which flows nearly west along the contact between the greenstone and the overlying limestone. On the north side of the valley of Lime Creek (Pl. V, *B*), one-half mile above its mouth and a few hundred feet stratigraphically below the top of the greenstone, is the G. & B. claim.

Early in July, 1902, work had been started on an open cut, but, had not been carried far enough to give a definite idea of the extent of the ore body tapped. From the partial exposures, however, it appears highly probable that the ores of bornite and chalcopyrite belong to the "bunch" type and not to the fissure-vein type, although small amounts of quartz are present, both in the ores and in the surrounding greenstone. The ore body appears to represent a replacement of an area within the greenstone, the replacement being in places sufficiently thorough to give blocks 1 or 2 feet in diameter, which contain at least 50 per cent of copper minerals. Some material taken from the dump yielded 10.64 per cent of copper and 0.75 ounce of silver per ton.

A few hundred feet above the G. & B. is the United Verde claim. Here, on a cliff of greenstone, is exposed a small body of bornite ore. Perhaps its outcrop covers 4 or 5 square feet of surface. Just below the exposure is a narrow quartz stringer, but there is no surface connection between them. Other smaller isolated ore bodies occur here and there in the greenstone. None of them, however, are in vein form.

KLUVESNA CREEK.

Native copper and bornite ores are reported along lower Kluvesna Creek, where the limestone-greenstone contact outcrops. A number of claims have been staked in this section, and sufficient work has been done on them to hold title, but lack of time prevented a visit to any of the holdings.

COPPER CREEK.

On a western tributary of Copper Creek, about 3½ miles from the mouth and 1,500 or 1,600 feet above the Kotsina River, on a spur in limestone 125 feet above the nearest exposure of greenstone, is a shallow open cut, with a shaft 6 or 8 feet deep at one end. The shaft has been dug in a poorly defined shoot in a shattered zone in the limestone. Mr. Schrader visited the property in 1900, since which time there has been no development, and the following is quoted from his description:[a]

"The excavations have disclosed three poorly defined zones of mineralized material, each from 1 to 3 feet in thickness, and apparently made up of altered

[a] Geology and Mineral Resources of a Portion of the Copper River District, Alaska, p. 85.

limestone rather than of ordinary vein materials. There is no well-defined vein, but a general north-south trend is observed, and there is a cleavage in the rocks having a steep dip toward the east. The deposit is made up of chalcopyrite and bornite somewhat stained with malachite and iron oxide. The ore appears to be a replacement of the limestone which forms the country rock."

ELLIOTT CREEK.

LOCATION AND ACCESSIBILITY.

Elliott Creek heads near the sources of Rock and Strelna creeks, and flows for a distance of 10 miles a few degrees north of west in a narrow but picturesque valley. It then turns southwest through a succession of canyons and joins the Kotsina 15 or 16 miles above its mouth.

Practically all of the tributaries of Elliott Creek enter it from the north. None of them is more than 2 miles long. In consequence the drainage basin is narrow, and, walled in, as it were, on the north and south by abrupt mountains, its existence is scarcely suspected until one surmounts one of the bounding ridges.

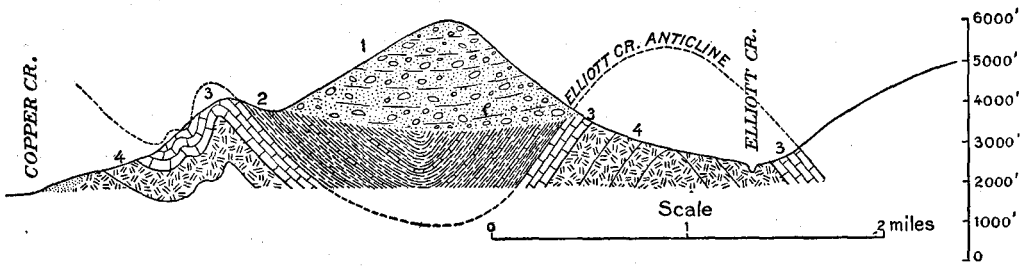


FIG. 1.—Profile and section from Copper Creek to Elliott Creek. 1, Kennicott conglomerate; 2, Triassic shale and limestone; 3, Chitistone limestone; 4, Nikolai greenstone.

Elliott Creek Valley was first entered by Messrs. Elliott and Hubbard from Copper Creek, in 1899, and the same route into the valley was used during the following year. But during 1901 and 1902 the necessity for crossing the steep and high divide separating it from Copper Creek was obviated by the construction of an excellent trail along the north slope of Elliott Creek Valley to a point 3 miles above its mouth, where the Kotsina is fordable at any except the highest stages of water. West of the ford the new trail joins the well-established upper Kotsina trail leading to Valdes by way of Tonsina Bridge and the military trail. Elliott Creek may also be reached from the head of the west fork of the Strelna and from upper Rock Creek.

GEOLOGY.

A section from lower Copper Creek to Elliott Creek (fig. 1) shows a succession of folds in the conformable greenstone, limestone, and Triassic beds, with a great body of Kennicott conglomerates overlying the eroded edges of these older rocks and forming the crest of the ridge separating Elliott Creek from

the other streams to the north. On the Copper Creek side of this ridge a syncline and its succeeding anticline may be seen in the pre-Kennicott beds, before the structures are obscured by the overlying conglomerates, and on the Elliott Creek side the limestone and greenstone emerge from beneath these younger formations in an unsymmetrical anticline near whose axis Elliott Creek flows. As one consequence of this anticlinal relation, the head of Elliott Creek is encircled by a scarp of white limestone, separating the gray Kennicott conglomerates above from the dark Nikolai greenstone below. This scarp continues westward along the north slope of Elliott Creek Valley, rising higher and higher relative to the stream, until it passes from view in the direction of Kotsina River. Whether its disappearance is due to the introduction of complex structures or to a simple overlap of the Kennicott beds was not determined.

The south slope of the valley of Elliott Creek is not broken by the limestone scarp which is so conspicuous a feature of the opposite wall except near the source of the creek, for, while the axis of the narrow anticline and the course of the stream coincide there, they diverge downstream, until Elliott Creek is found

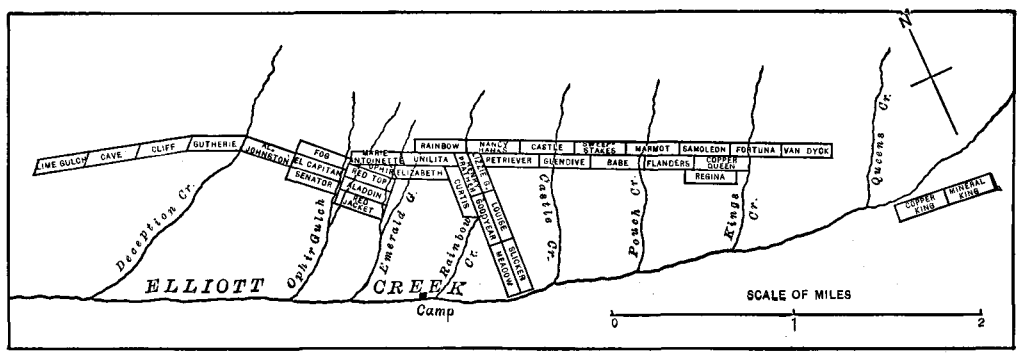


FIG. 2.—Map of the Elliott Creek copper claims.

flowing well to the south of the ridge of the anticline, and the limestone bed on the south side of the valley gradually disappears from view near creek level, beneath the overlying formation.

RELATION OF ORE DEPOSITS TO GEOLOGIC STRUCTURE.

As all of the Elliott Creek deposits on which work has been done are in that belt in the greenstone which extends downward a few hundred feet from the contact with the limestone, the position of these deposits relative to the stream is dependent absolutely upon the structure. As a consequence, they all occur in a zone which extends along the north side of Elliott Creek, well up the valley slope, encircles the head of the valley, and disappears below water level on the south side of the stream, a short distance below its source (see fig. 2). This position in a belt encircling the valley means that the deposits are well situated for economical exploitation, should their richness justify their development.

DESCRIPTION OF PROSPECTS.

Mineral King.—The Mineral King claim is near the head of Elliott Creek, 12 miles from its mouth, on the south side of the valley, and about 215 feet above creek level. About 300 feet vertically, and about the same distance stratigraphically above it, the massive limestone strikes east and west and dips 45° S.

The development on this claim in early July, 1902, consisted of an open cut about 20 feet long and 6 feet deep toward the back, in which a mineralized zone is laid bare. Several tons of ore had been taken from the cut and were piled up on the side next the valley. The prospect is developed along a rather indefinite belt in the amygdaloidal greenstone, which trends N. 60° W. and is nearly vertical. The rock in this belt is somewhat crushed, but whether this effect is due to mechanical strains or to changes in volume, accompanying the mineralization, is not evident. The ore impregnations coincide roughly with this crushed zone, and, like it, are without sharp boundaries. There seems to be no definite vein filling, the greenstone within the mineralized belt differing from the normal rock without, only in its partial replacement by the sulphides, chalcocite, and bornite. The extent of the mineralization along this belt in the greenstone seems to be limited, since at a point 25 feet west along the strike it is no longer evident, so that the deposit probably represents an ore shoot. The ore body which it is intended to exploit is about 4 feet wide in the cut, and a sample taken at intervals of 4 or 5 inches across this zone yielded, when assayed, 10.85 per cent copper. Surface staining by carbonates is extensive in the vicinity.

Copper King.—This prospect is about 800 feet southwest of the Mineral King, and, like it, is on the south side of Elliott Creek, in the greenstone lying about 300 feet stratigraphically below the base of the limestone.

The development work here consists of a cut about 15 feet long, penetrating 6 or 8 feet into the greenstone. The prospectors have what they call two "ledges"—i. e., separated by perhaps 15 feet of greenstone are irregular mineralized masses, showing considerable bornite and smaller quantities of chalcopyrite. There is no trace of vein matter and no evidence of definite fissuring, the ore bodies being more or less thoroughly impregnated portions of the greenstone mass, without sharp boundaries or definite limits. The greater diameters of the visible ore bodies appear to lie in planes which are parallel to the limestone-greenstone contact and to the pseudo-bedding in the greenstone. The copper-bearing solutions followed of course the easiest channels. These were often the bedding planes, the surfaces of the old basalt flows, but were sometimes irregular cracks, due to cooling or folding or later chemical alteration of the lavas. These channels were thus essentially irregular, as compared with true fissure veins, and

the ore masses which derive their form in part from them are likewise very irregular.

Copper Queen.—This prospect is on the west slope of King Creek, about 1 mile below the Copper King claim. No development work had been done upon it at the time of our visit. The surface showing consisted of a small outcrop of greenstone impregnated with chalcopyrite.

Marmot.—This is situated on the west side of Pouch Creek, within 25 feet of the base of the limestone. It was undeveloped at the time of our visit, but appears from the scanty outcrop to be the same character of deposit as the Mineral King and Copper King, except that chalcopyrite instead of bornite is the principal ore.

Louise.—This claim is on the east side of Rainbow Creek, nearly half a mile above its junction with Elliott Creek and about 3 miles from the head of the valley. The open cut, which represents the development work done in the midsummer of 1902, is on a steep hillside 75 or 100 feet above the bed of Rainbow Creek and stratigraphically several hundred feet below the base of the limestone. Here, in the shallow cut, a slickensided face of greenstone, forming a well-defined and (so far as exposed) regular foot wall, is to be seen. This face strikes S. 10° W. and dips 70° W. The cut does not expose an equally definite hanging wall, but adjacent to the foot wall is a crushed zone which has a maximum width of 15 or 16 feet. Within this zone the greenstone is generally irregularly fractured, but at the present surface there exists in the center of this crushed mass a "horse" of solid greenstone about 7 or 8 feet wide. It is probable that the slickensided foot wall is a fault plane, but since no displacement was observed in the limestone above, its throw can not be great. The mineralization within this belt consists of an impregnation of chalcopyrite and bornite, the latter mineral being more abundant. The impregnation follows the fractures and partakes of their irregularity; the exposed surfaces of the greenstone fragments generally showing more or less ore.

A commercial sample taken across the 16-foot face is reported by the owners to have yielded 20 to 25 per cent copper. Although without more development work it is not possible to predict the future of this claim, its situation along a definite zone of crushing, which provides an easy channel for mineralizing solutions, gives a basis for the hope that it may contain fairly continuous ore bodies.

Goodyear.—Across Rainbow Creek from the Louise claim, and a few feet below it, an open cut reveals a well-defined fissure vein 4 to 5 feet wide, striking N. 12° E. and dipping 45° SW. The vein can be traced 50 or 75 feet up the slope directly toward the limestone contact before it is buried under the talus.

The gangue minerals are quartz and calcite, entirely distinct from the perfectly definite walls of greenstone. This gangue carries heavy bodies of bornite and a smaller quantity of chalcopyrite. While the heavy ore bodies are confined to the vein, the shattered hanging wall and the more massive foot wall are impregnated with copper sulphides for some distance above and below.

In the upper part of the open cut, which represents the assessment work done on this claim at the time of our visit, a slight horizontal fault has displaced the vein laterally, so that the hanging wall above the displacement is continuous with the foot wall below it. This illustrates well the tendency of the greenstone mass to accommodate itself to stresses by faults of slight throw.

Henry Prather.—About 25 feet above the Goodyear claim, and practically parallel with it, is another similar deposit which has been exposed in an open cut. Here a fissure about 4 or 5 feet wide is filled with a quartz-calcite gangue carrying rich bornite ore with some associated chalcopyrite. This filling, while very definite in the cut, pinches out about 20 feet higher up the slope, then reappears as a lens. There has probably been slight faulting along the fissure, the condition of the greenstone forming its hanging wall indicating movement, and probably the latest portion of this faulting postdates the vein filling, as is so evidently the case in the Goodyear claim just below.

Elizabeth.—High up in Emerald Gulch, but several hundred feet below the limestone, is a striking outcrop, on which no work had been done in early July, but which resembles, so far as it is exposed, the type of deposit exhibited in the Goodyear and Henry Prather cuts.

Encircling the hill for a distance of 30 or 40 feet is a succession of small outcrops showing copper indications through a vertical interval of from 2 to 6 feet. The exposures show a definite gangue entirely different from the greenstone mass, and in this gangue are bodies carrying a large percentage (estimated to be from 40 to 75 per cent) of bornite and chalcopyrite, and measuring 2 to 3 feet in greatest diameter. Presumably a vein of some importance gives rise to these fragmental exposures. Other small outcrops of ore-bearing rock in the vicinity are insufficiently exposed for any sort of determination. A small specimen of selected ore assayed 1.87 ounces of silver per metric ton, and 21.69 per cent of copper.

Fog.—On the crest of the ridge separating Ophir Gulch and Deception Creek the Fog claim has been staked. The outcrop shows a heavy calcite lens in the greenstone, associated with which is a small amount of chalcopyrite. This weathers and gives the rusty and green stains of iron and copper.

Albert Johnson.—This is a natural exposure of greenstone in Deception Creek showing green carbonate stains and exhibiting some bornite along crevices. The exposures here are of the Mineral King type.

DEPOSITS IN THE CHITINA DRAINAGE BASIN.

The writers were unable to visit the copper belt south and east of the Kotsina during the summer of 1902, so that descriptions of the occurrences there are quoted from the report of Messrs. Schrader and Spencer, who saw these deposits in 1900. Since that time assessment work has been done on the important properties each season, but, except in the statements as to amount of development, these earlier descriptions are adequate.

Strelna Creek deposits.—A considerable amount of prospecting has been done within the region drained by Strelna Creek, several mineral-bearing veins have been recognized, and some good prospects have been located. The ores comprise bornite, chalcopyrite, and native copper.

"About 2 miles above the fork the north branch of this stream is crossed by the contact of the massive limestone and the greenstone, along which there is a mineralized zone some 40 feet or more in width. This zone is impregnated to a greater or less extent throughout with sulphides of iron and copper, but the 8 or 10 feet of limestone next to the contact is considerably altered and contains a larger amount of the sulphides than the neighboring rock. The greenstone is mineralized only a short distance from the contact.

"There are many evidences that movement has taken place in this vicinity, since the rocks are folded and crushed and the planes of shearing show slickenside surfaces. In one case a considerable fault was observed dislocating the base of the limestone. This mineralized zone is an example of the contact as a favorable position for the deposition of ores.

"*Kuskulana River.*—At the time of the writers' visit there had been no effective prospecting along the tributaries of the Kuskulana, but in traversing the region good float was noticed in many places, and in one instance a well-marked vein was found. In the bed of the stream that has been named Nugget Creek, a large mass of copper was discovered partly buried in the gravel. This was afterward uncovered by prospectors and reported to be about 8 feet in length, with other dimensions from 3 to 5 feet. Along the southeastern side of the glacier fragments of copper ore were also observed at several places, and there can be but little doubt that good discoveries will be reported from the Kuskulana drainage.

"*Bonanza mine.*—The Bonanza mine is located upon a high ridge between Kennicott Glacier and McCarthy Creek, at the contact of the greenstone and the limestone [see Pl. VI, *B*]. It is 6 miles or more above the foot of the glacier and about 8 miles west of the Nikolai mine. Here, upon the western slope of the ridge, is exposed the largest and richest body of ore thus far reported from the Chitina region. The vein occupies a true fissure, which cuts across the contact of the greenstone and limestone, though for some distance below the contact the vein is barren. The mass of the ore occurs in the limestone, from the contact to a height of perhaps 150 feet along the slope, and is exposed for a horizontal distance of nearly 400 feet. In width the vein is irregular, varying from 2 to 7 feet. Its course is N. 40° E. There is no quartz or other vein mineral associ-

ated with the ore, though between the walls of the vein there is sometimes a considerable amount of crushed limestone. The ore is practically pure chalcocite or copper glance, and is stained upon the surface by copper carbonates. Solid masses of the ore from 2 to 4 feet across and 15 feet or more in length are exposed in several places, their depth being not apparent. Besides the ore within the fissure there are also bedded ore bodies running off into the limestone along the planes of stratification. The relations of the ore are such as to indicate that it was formed as a replacement of the limestone.

"The amount of ore in sight, with practically no development, amounts to several hundred tons. An assay of a sample collected gave over 70 per cent of copper and 14 ounces of silver, besides a trace of gold.

"The claim is situated about 1,500 feet above timber line, at an elevation somewhat above 4,500 feet, but the nature of the topography is such that a good trail could be built to it without great difficulty.

"Besides the Bonanza claim several other locations have been made along the outcrop of the contact, on the Kennicott side of the ridge, and, in one case, on McCarthy Creek. The ore in all of these claims is, however, bornite or chalcopyrite instead of chalcocite."[a]

Old Independent vein.—The Old Independent vein lies just southeast of the Bonanza property on the McCarthy Creek side of the divide and is exposed at an elevation of about 5,000 feet. It is a fairly persistent fissure vein, from 6 to 8 inches wide, in the amygdaloidal Nikolai greenstone, and trends about N. 20° E., obliquely to the contact between the greenstone and the overlying limestone. The greenstone at this locality is cut by a system of jointing which trends northeast, forming an acute angle with the vein both in strike and dip. The jointing dips northwest by west at an angle of 80°.

The ore consists essentially of bornite, but has some chalcopyrite associated. Crystalline calcite and quartz are present in places as gangue, but a considerable portion of the ore is relatively pure.

The walls of the vein for the most part are well defined, but at a point on the east side of the head of the gulch in which it is exposed the ore was observed to fade gradually into the foot wall of the country rock. An assay, presumably of a selected specimen, is reported to have yielded 34 per cent copper and $6 in gold per ton. This vein was discovered by Messrs. Warner and Gates early in September, 1899.

"*Nikolai mine.*—The Nikolai mine is located on the creek of the same name, tributary to McCarthy Creek from the east [see Pl. VI, *A*]. The occurrence has probably been known to the natives for a long time, and was revealed to Mr. Edward Gates by an Indian named Jack, who, though he had never visited the locality, was able to find it with the aid of a map drawn by Nikolai, late chief of the Taral Indians.

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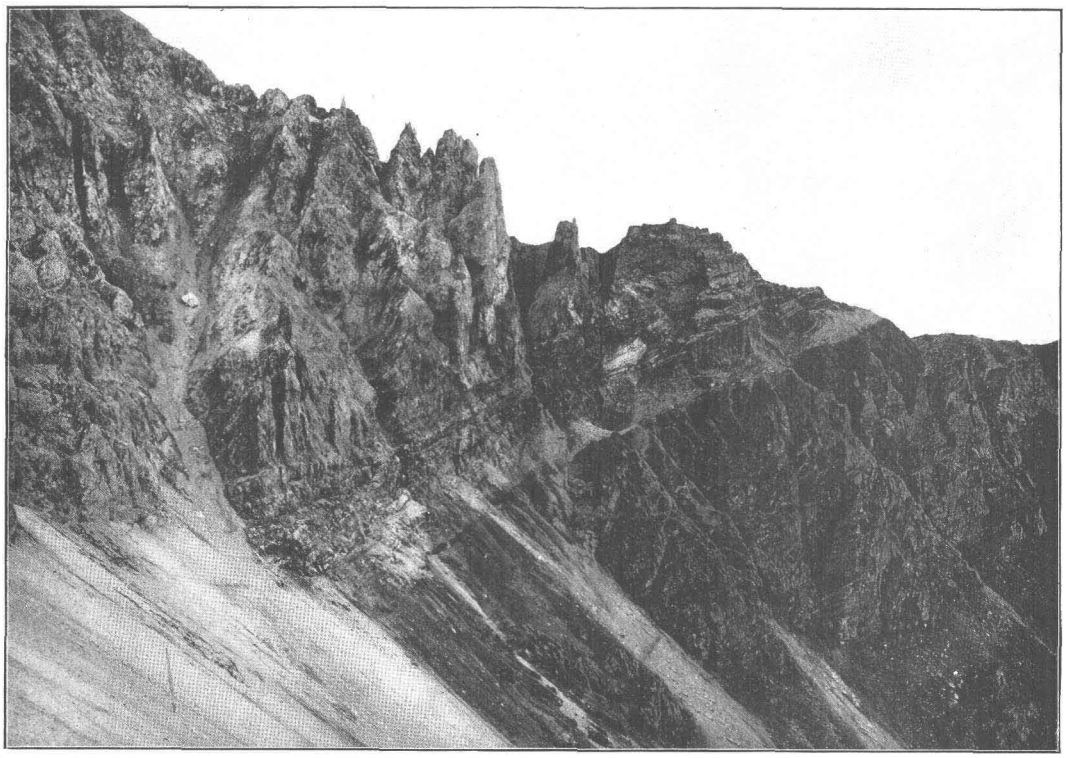
[a] The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, by F. C. Schrader and A. C. Spencer; special publication U. S. Geol. Survey, 1901, pp. 85–86.

A. VIEW OF NIKOLAI MINE ACROSS UPPER NIKOLAI CREEK.

Photograph by Miles Brothers.



B. VIEW OF BONANZA MINE FROM HORSESHOE TRAIL.

The contact between the Chitistone limestone above and the Nikolai greenstone below extends diagonally across the view from the lower left to the upper right-hand corner. (Photograph by Miles Brothers.)

"The Nikolai mine is situated 1,000 feet or more above timber line, at an elevation of 4,200 feet. The country rock in the lower part of the creek is Triassic shale intruded by porphyry, but a great fault brings up the Nikolai greenstone, which forms the bed rock from the vicinity of the main forks of the creek to a point above the mine. On the south side of the gulch, opposite the mine, the greenstone is opposed by the unconformable beds of the Kennicott formation, but to the north the Chitistone massive limestone is seen dipping steeply into the mountains, and this is followed by the Triassic shales, covering a large area between McCarthy Creek and Nizina River.

"The vein occurs in the greenstone at a horizon not more than 50 feet below the bottom of the limestone, which outcrops in the creek bed a few hundred feet above the shaft. It is a true fissure vein, with well-marked walls, and there has been displacement or faulting along it to the amount of perhaps 50 feet, with the upthrow on the northwest. The course of the fissure varies from N. 50° E. to N. 55° E., and the vein dips about 65° SE. It may be traced for several thousand feet, though it shows no ore on the surface except near the place of discovery. The main fissure is paralleled at a distance of 90 and 140 feet, respectively, by two fissures which, though less prominent, also contain copper minerals, and the rock between is cut by many stringers of ore. In the vicinity of the shaft the main vein has a width of from 8 to 12 feet, and is divided about equally by a horse of greenstone 3 or 4 feet across, in which the shaft has been sunk. The ore on either side of the horse is practically pure bornite, with only a small amount of quartz associated in an irregular way. Locally, as shown near the creek bed, there is a band of chalcopyrite lying next to the hanging wall. The development in the latter part of August, 1900, consisted of a shaft 30 feet in depth and an open cut along the vein for perhaps 50 feet. Throughout this distance ore having a thickness of from 2 to 4 feet had been exposed, and in the bottom of the shaft the horse had been penetrated and bornite ore was found on the foot-wall side. The development has been sufficient to show the presence of a large shoot of ore which can be mined from the present shaft or from a short adit which could be driven to cut the vein at a depth of perhaps 100 feet, but whether the ore is generally distributed or whether there are other large ore bodies along its course is yet to be determined.

"A good trail, a mile or more in length, had been constructed from the camp at timber line to the mine. During the summer of 1900 about a dozen men were engaged in the exploitation of the Nikolai mine.

"*Other occurrences.*—Rich deposits of native copper are reported to occur at the headwaters of Chitina River, and since the geological structure of the region adjacent on the west indicates the probable continuation of the greenstone belt into this region, it seems likely that workable amounts of copper will be found there. The region lies directly between the exposures of greenstone on the Nizina and those which carry native copper at the head of White River across the intervening range.

"The natives also report the occurrence of copper in the mountains between Hanagita Valley and Chitina River, though the localities can not be determined from their descriptions.

"In the lower part of the Chitina Valley several locations have been made, and though these were not visited the rocks of the region were seen and found to consist

of gabbros and diorites, probably intrusive in limestones and amygdaloidal greenstones. These ores are made up almost entirely of chalcopyrite."[a]

The workers in the Chititu gold placer region report that in the sluice boxes there they catch great quantities of small copper nuggets. It is not believed that the copper-bearing rocks, the greenstone and the overlying limestone, outcrop in the basin of this stream, and while the Triassic shales, which are there thought to be gold-bearing, may also carry copper, brought up from a source in the greenstone below, it is at least as probable that in the general glaciation to which the region has been subjected this placer copper has been brought in by ice streams across the divide lying to the east from a region where the limestones and greenstones outcrop.

NORTHERN AREA.

GENERAL STATEMENT.

The northern copper area bears about the same relation to the north slope of the Wrangell Mountains that the southern area does to the south slope—that is, it forms an ill-defined belt extending approximately east and west through the foothills of the range. Four large streams rise in glaciers that flow down from the Wrangell Mountains and cross this belt; they are the Copper, the Nabesna, the Chisana, and the White rivers. The copper occurrences in each of these valleys will be considered separately, but the routes by which the northern district, as a whole, is traversed will be discussed together and at somewhat greater length than in the case of the better known area south of the mountains. The most important routes described appear on the accompanying map (Pl. III).

ROUTES AND TRAILS.

The easiest and most practicable way of getting into this northern area for prospecting and mining is to sled up Copper River on the ice with horses before the spring thaw sets in. Much more freight can be moved by this means, per man and per horse, than by any other method at present known, a good, strong animal readily drawing two or more tons on the ice, which on the upper Copper is usually smooth. This route was followed by the Survey party in placing its season's supplies at Batzulnetas last spring (1902). Below Batzulnetas the sledding period was ended by copious overflows and some local breaking up of the ice about April 20, and above Batzulnetas about April 25. These dates, however, are reported to be somewhat earlier than that on which the break-up usually occurs. According to Mr. D. C. Witherspoon, who spent the spring in the

[a] The Geology and Mineral Resources of a Portion of the Copper River District, pp. 86–88.

region of Batzulnetas, the season is about two weeks later on the upper Copper than at Copper Center.

Good grass grows early in the season and will support stock by the 1st of June at Batzulnetas, at the foot of Lake Suslota, and at the foot of Lake Billy, all of which places are old Indian camp grounds. Nowhere else on the upper Copper can grass be depended upon to support stock before the latter part of June.

From Batzulnetas there are two principal routes leading southeastward to the Nabesna. Of these, the northern is the usual route to the upper Tanana and White River countries. It follows a topographic depression which extends from the Copper to the White along the south base of the Mentasta and Nutzotin mountains. From Batzulnetas it takes a southeasterly course over a low open divide into Jack Creek Valley, which it crosses at nearly right angles, then crossing a second low divide, descends Platinum Creek and strikes the Nabesna at the north base of the Nutzotin Mountains, nearly opposite the mouth of Cooper Creek, at about 25 miles below the foot of Nabesna Glacier. If it is desired to reach the Nabesna a little higher up, this can be done by turning off to the right before getting to Jack Creek and following a trail which leads down this creek to the Nabesna. The winter route is up Batzulnetas Creek to a bend about 3 miles below Lake Tanada. Here it turns off to the northeast and descends Jack Creek.

The southern trail or upper Nabesna route, leaving the Copper River about 5 miles above Batzulnetas, leads by way of Lake Tanada southeastward 30 miles, where it crosses a low, flat divide to the Jacksina, the west fork of the Nabesna. Thence, continuing southeastward, across the Jacksina, it soon bears a little north of east and, after crossing two divides, descends Monte Cristo Creek to the Nabesna, which it strikes about 3 miles below the foot of the glacier. To reach the east side of the Nabesna River, a crossing is usually found above the mouth of Monte Cristo Creek, where the bulk of the water coming from either side of the glacier is divided into two main forks, which in turn are split up by bars into numerous small channels, as is the case opposite the lower end of Orange Hill and the mouth of California Gulch. Since the bars and channels are constantly shifting, no definite crossing can be indicated.

The west bank of the Nabesna is passable for pack train from below Platinum Creek to near Bend Gulch, 8 or 10 miles above the foot of the glacier. The east bank is passable for pack train from above Niconda Creek to the open Tanana Valley beyond the north base of the Nutzotin Mountains.

From a point on the Nabesna nearly opposite the mouth of Platinum Creek about 1½ miles above the mouth of Cooper Creek, a trail leads up Cooper Creek, over Cooper Pass and down Notch Creek to the Chisana. From here, horses can

be taken up Cross Creek nearly to the foot of Cross Glacier, or up the river to the foot of Chisana Glacier, and through a considerable portion of the country between Cross Creek and Euchre Mountain. From the mouth of Cross Creek they can be used down the river through the so-called Chisana Canyon and Nutzotin Mountains to the open country of the Tanana Valley.

From a few miles below the foot of Chisana Glacier the trail continues southeastward, apparently by several different routes, to the White River. Of these, the most direct seems to strike the White about 15 miles below Skolai Pass and 6 miles below Russell Glacier. None of the latter routes, however, were traveled by the Survey party during the season of 1902.

Another route feasible for pack horses from the Nabesna to the Chisana and White River is in the open country along the north base of the Nutzotin Mountains. This is probably the most direct route for reaching the Attul and the middle White River country in the region of the mouth of the Donjek. It was followed by the Survey party from the Chisana to the Nabesna during the past season. The region, however, contains considerable underbrush and in some places is swampy.

COPPER OCCURRENCES.

UPPER COPPER RIVER REGION.

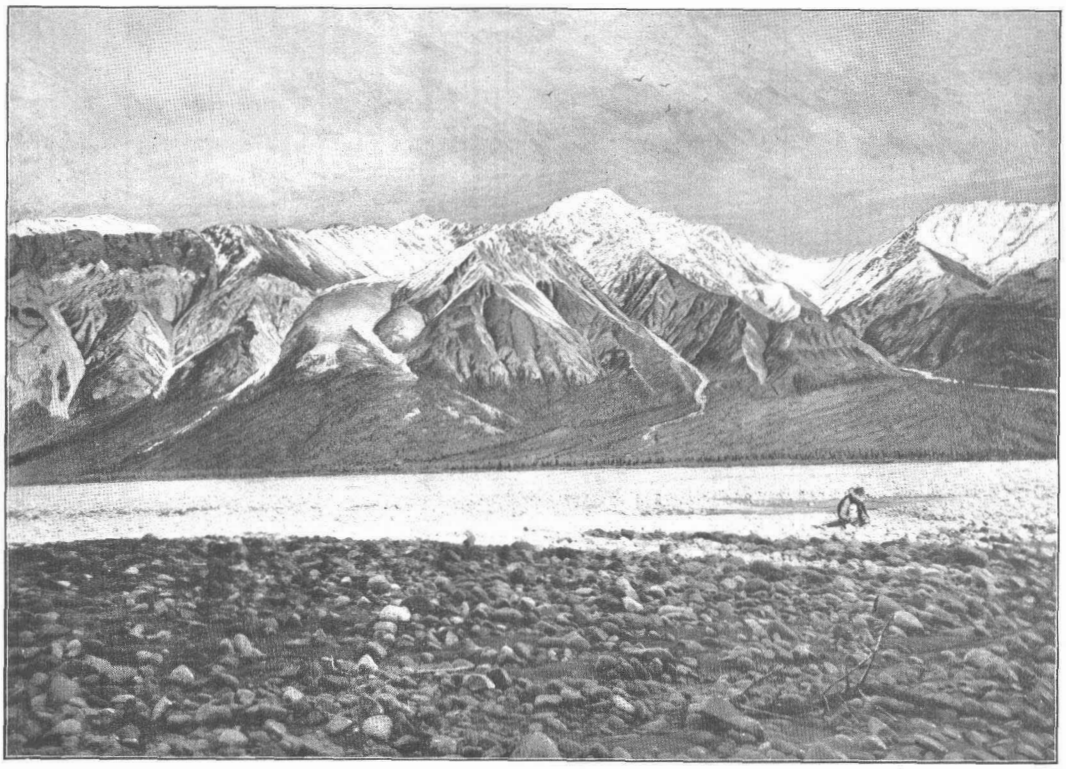
Were it not for the fact that much of economic value has been expected from that part of the upper Copper River Valley lying on the north slope of the Wrangell Mountains, it would not be referred to in this report.

From the meager and indefinite accounts that could be obtained of the region, it had been somewhat widely supposed that the copper-bearing rocks and consequently copper ores would be found to occur here as on the Chitina side of the mountains. The past season's work (1902), however, has shown that the Wrangell portion of the upper Copper River Valley consists of a waste of andesitic and basaltic lavas. These lavas, which in general lie nearly horizontal or dip gently northward, consist of innumerable sheets or flows superposed one upon the other. They are varicolored and all apparently much younger than the copper-bearing Nikolai greenstone, of which no exposures were seen, nor do the moraine gravels brought down by the glaciers denote the occurrence of this rock in any considerable quantity in the unvisited portions of the mountains above snow line. In the mouth of a side gulch at the eastern foot of Drop Glacier a single light-gray crystalline limestone cobble was seen, but its character was not such as to indicate the occurrence of the parent rock in place near by.

It should be noted, however, that in the moraine gravels at the foot of Drop Glacier fragments of lava were found exhibiting distinctly the stain of

A. MONTE CRISTO DIORITE INTRUDED BY DIABASE.

Looking northeast down Monte Cristo Creek.



B. NABESNA LIMESTONE INTRUDED BY DIABASIC SERIES ON NABESNA RIVER.

Looking east.

malachite or green copper carbonate. But since the occurrence of the deposit was noted only on the plane surfaces of the rock, which apparently represent joint or fissure faces, one is led to infer that the copper is foreign to the andesite on which the stain is found and that it was probably deposited here by copper-bearing solutions or vapors which followed fissures and fractures in their ascent from the region of the older rocks below. On the eastern branch of the Copper, whose extreme headwaters were not visited, considerable prospecting was done in 1898 or 1899, but, so far as can be learned, no indications of either copper or gold were found.

UPPER TANANA OR NABESNA AND CHISANA REGION.

GEOLOGIC SKETCH.

At about 30 and 60 miles, respectively, east of the source of Copper River the Nabesna and Chisana, large streams like the Copper, head in glaciers on the north slope of the Wrangell and Skolai mountains, and, flowing thence northward through the Nutzotin Range, which is about 20 miles wide, finally unite in the open country of the Tanana flats to form the Tanana River (see map, Pl. III). We shall have to deal only with the upper or mountainous portion of their drainage basins.

This portion of the Nabesna Valley, measured from the foot of the Nabesna Glacier to the north base of the Nutzotin Mountains, is about 40 miles long. It is 2 or 3 miles wide, is floored generally with river gravels, and has an elevation of about 3,500 feet above the sea. From either edge the mountain masses rise more or less steeply to heights of from 5,000 to 8,000 feet.

It has been shown that on the headwaters of the Copper River the rocks are essentially andesitic and basaltic lavas. These continue 25 or 30 miles eastward to near the Nabesna. Here, however, they begin to diminish in force, and through the agency of faulting and erosion older rocks are exposed. These are first encountered in the lower slopes of the Wrangell Mountains, where the western tributaries of the Nabesna have sunk their channels down into them, while to the east of the Nabesna they occur in some of the highest peaks (see Pl. VII, *B*). These older rocks consist of several classes, of which the principal are the Monte Cristo diorite, the Nabesna limestone, a diabasic series, and the Mesozoic series of the Nutzotin Mountains.

The rocks on the west side of the Nabesna, down as far as Jack Creek, at the northern edge of the Wrangell Mountains, are almost exclusively igneous, while on the east side of the valley the mountains are made up largely of sedimentaries, variously disturbed and intruded by igneous masses.

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MONTE CRISTO DIORITE.

This rock, so named from its character and exposure on Monte Cristo[a] Creek (fig. 3, and Pl. VIII, *A*), a western tributary of the Nabesna, is a medium to coarse-grained granitoid belonging to the diorite family. In its less altered state the rock varies in color from dark green to dark gray, but when weathered its surface is stained a reddish brown or bright orange, due to the oxide of iron derived from the iron pyrite it contains.

This diorite is exposed for about 4 miles along the middle course of Monte Cristo Creek, and at California Gulch and Orange Hill, on the east side of the Nabesna near the glacier, as well as on Niconda and Bond creeks. Occasionally it forms the walls of the valley or gulch in which it outcrops. Usually, however, it is found only on the lower slopes and is overlain by effusive rocks. It consists essentially of plagioclase and hornblende, with some augite, biotite, and quartz in varying amount. Iron pyrite is present in considerable quantity and there is some magnetite.

In the Monte Cristo exposure the rock is greatly crushed and altered and is intruded by a basaltic diabase (Pl. VII, *A*) and apparently by a mica-diorite. The weathered portion is also freely traversed by seams of clay or talcose material and contains pyritiferous honeycombed quartz.

It should be noted that there seems to be a zone of mineralization extending from Monte Cristo Creek across the Nabesna, embracing the California Gulch and Orange Hill region, and continuing thence a little south of east into the mountains, where, at an elevation of *5,000 to 6,000 feet, considerable sulphide of* iron occurs in the diabase.

Though the Monte Cristo diorite is not extensively exposed, from its position in the geologic section and its relations to the other rocks it is supposed to be among the oldest rocks in the field, and is probably pre-Permian.

NABESNA LIMESTONE.

Character and occurrence.—The term Nabesna limestone is here provisionally used to denote a series of limestones occurring on the upper Nabesna and Chisana rivers, whose exposures, so far as observed, are almost entirely restricted to the Wrangell Mountains. The series is more or less freely associated with diabasic intrusives and apparently also with older effusives. It is probably a part of the limestone included by Brooks under the head of Nutzotin series farther eastward.[b] In general, the limestone is heavy bedded, much of it is white and

[a] Monte Cristo is the name given to this creek by the parties who have prospected and now hold claims on it. Its Indian name is Na-un-da.

[b] A Reconnaissance from Pyramid Harbor to Eagle City, Alaska, by Alfred Hulse Brooks: Twenty-first Ann. Rept., U. S. Geol. Survey, pt. 2, p. 359.

crystalline, but darker gray or bluish layers, which are apparently dolomitic, are also present. West of the Nabesna it is exposed along the face of the mountains, between Jacksina[a] and Jack creeks, and between the upper part of Jack Creek and the head of Platinum Creek. East of the Nabesna, beginning about opposite Pear Gulch and proceeding northward, exposures occur successively at various points, usually high up in the mountains (Pl. VII, *B*). Near the head of Camp Creek the trend veers eastward in the direction of Cooper Pass.

On the Chisana side of the divide exposures occur on Notch Creek, above the forks, and the rock is again very prominent on the upper part of Cross Creek for a distance of several miles below Cross Glacier. Outcrops also occur along the edge of the Chisana flats, between Euchre Mountain and the mouth of Cross Creek, or the head of Chisana Canyon. In many instances the rock has been folded, faulted, and much broken by orographic uplift, and metamorphosed to various degrees by igneous effusives and intrusives. A good example of the intrusive contact is shown in the mountains east of the Nabesna, a few miles north of Bond Creek, where the limestone is penetrated by large tongues of typical diabase belonging to the diabasic series next to be described.

Age.—No determinative fossils have been found in the limestones on the Nabesna and Chisana, but from forms occurring in similar limestones in the pass between Jack Creek and the head of Platinum Creek the Nabesna is regarded as Permian and may be identical with the Chitistone limestone on the south side of the Wrangell Mountains.

DIABASIC SERIES.

Character and occurrence.—Diabasic series is the term here provisionally employed to designate a group of volcanic rocks older than the basaltic and andesitic lavas which represent the relatively recent eruptions of the Wrangell Mountains. Though in a general way these older rocks appear massive, in favorable localities they are seen to consist of successive heavy sheets or flows which future investigation will probably resolve into more than one series. The flows in general dip gently north and are cut by a joint system dipping steeply southwest.

In character and occurrence the rocks in the lower part of the series resemble the Nikolai greenstone of the Chitina country, being vesicular and amygdaloidal and considerably altered mineralogically, while those in the upper part consist largely of typical fresh dense diabase, whose essential constituents are plagioclase and augite. There is also present considerable magnetite, much of which seems to be primary.

[a] The Indian name of this creek is Di-bat-i-chit-in-da.

The series is exposed in the base of the mountains along the Jacksina and the Nabesna and at the base of the plateau between these two streams, where the rocks are largely of the greenstone type. It becomes very prominent in the mountains between the Nabesna and the Chisana, where it extends northward to beyond Cooper Pass. It is present on the Chisana between Euchre Mountain and the head of the canyon and apparently also south of Euchre Mountain along Chisana Glacier.

This diabasic series is of economic importance, since it seems to be the source of the copper and iron found in this northern field, and has locally metamorphosed the sedimentary rocks into which its members are intruded.

Relations and age.—Between the Nabesna and the Chisana the series is closely associated with the Nabesna limestone, into which some of its later members are intruded. Exposures of this intrusive contact of the diabase into the Nabesna limestone occur in the mountains a few miles north of Bond Creek (Pl. VII, *B*). Farther north, in the region of Cooper Creek, the diabases seem also to be intrusive into the Mesozoic series of the Nutzotin Mountains, to be next described.

We have seen that, in the Chitina district, the Chitistone limestone overlies the Nikolai greenstone, with which its contact is depositional. On the north side of the mountains, however, between the limestone and its associated diabasic series, no such relations have yet been proved. It is probable, however, that the lower part of what is here included in the diabasic series is older than the Nabesna limestone, into which the younger members of the series have been intruded. In this case the series must range in age from pre-Permian to Mesozoic.

MESOZOIC SERIES.

Occurrence and character.—In the foregoing pages the rocks on the north slope of the Wrangell and Skolai mountains have been described as extending northward about 20 miles from the foot of the Nabesna Glacier to a northwest-southeast line which crosses the region of the Nabesna and Chisana valleys roughly by way of Jack, Cooper,[a] and Notch creeks, and a little north of Cooper Pass. Along this line there is a marked topographic and geologic change, where the above-described rocks give way to a new series of slates, shales, thin-bedded dark limestones, greywackes and conglomerates, forming the Nutzotin Mountains. These mountains, where cut through by the Nabesna and Chisana rivers, are about 20 miles wide.

Relations.—The relations of the Nutzotin Range and its rocks to the north slope of the Wrangell and Skolai mountains suggests that a fault occurs here. The younger rocks forming the Nutzotin Range trend in the main northwest-

[a] The Indian name of this creek is The-con-da.

ward, and dip prevailingly to the southwest, apparently unconformably overlying the Nabesna limestone series. This relation is probably best shown in the region between Bond and Cooper creeks, at an elevation of 6,000 to 8,000 feet.

The series is intruded by diabase and by granitic, dioritic, and gabbroic masses, sometimes of considerable size. Of these latter, the principal areas, so far as known, occur west of the Nabesna, one at the north base of the mountains, another north of Jack Creek, and a third farther westward, between Bear Creek and the head of Little Tokio, trending in a northeast-southwest direction.

Age.—A few fossils collected in the region between the Nabesna and the Chisana indicate that this Mesozoic series ranges from Triassic to Lower Cretaceous. It can probably be correlated with the Triassic and Kennicott of the Chitina region.

OCCURRENCE OF COPPER.

Copper was long ago reported on the upper Tanana, chiefly on the Nabesna and Chisana rivers, whence stories of fabulously rich deposits have come from time to time, but thus far, though considerable prospecting has been done, nothing of economic value has been found. Brooks, who regards this belt as the westward continuation of that of Kletsan Creek, refers to the region as the Tanana-Nabesna belt of copper deposits,[a] and says that "in this belt the evidence of the presence of copper is the same association of rocks as on Kletsan Creek" (page 40), "and the presence of copper colors in the streams."

Rohn[b] states that in the pass between the Tanana (Chisana) and the Nabesna rivers, fragments of volcanic rock were found, thoroughly impregnated with native copper, and that pebbles of diabase and volcanic tuff found in the moraine of the Chisana Glacier often showed considerable copper stain.

ON THE UPPER NABESNA.

Green and variegated blotches of malachite or copper carbonate are sometimes conspicuous on the surface of the altered Monte Cristo diorite and also occur sporadically along some of the lines of fracture of this rock in California Gulch, Orange Hill, and Monte Cristo Creek. The malachite is secondary and was probably derived from a little copper pyrite contained in the weathered rock. So far as observed, however, it gives no promise of economic value. As no copper pyrite was found in the unweathered portion of the rock, it is suggested that the copper carbonate, whether it has come from pyrites or not, may originally have been derived by leaching from the intrusive and in some instances overlying diabase,

[a] Op. cit., p. 381.

[b] A reconnaissance of the Chitina River and Scolai Mountains, Alaska, by Oscar Rohn: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 438.

since, in the California Gulch and Orange Hill region, where apparently the contact of the diabase with the Nabesna limestone occurs near by in the mountain slope to the east, a pyrrhotite-chalcopyrite ore is known to occur.

In California Gulch and the region of Orange Hill many claims have been staked, but apparently in most instances rather for their gold than for their

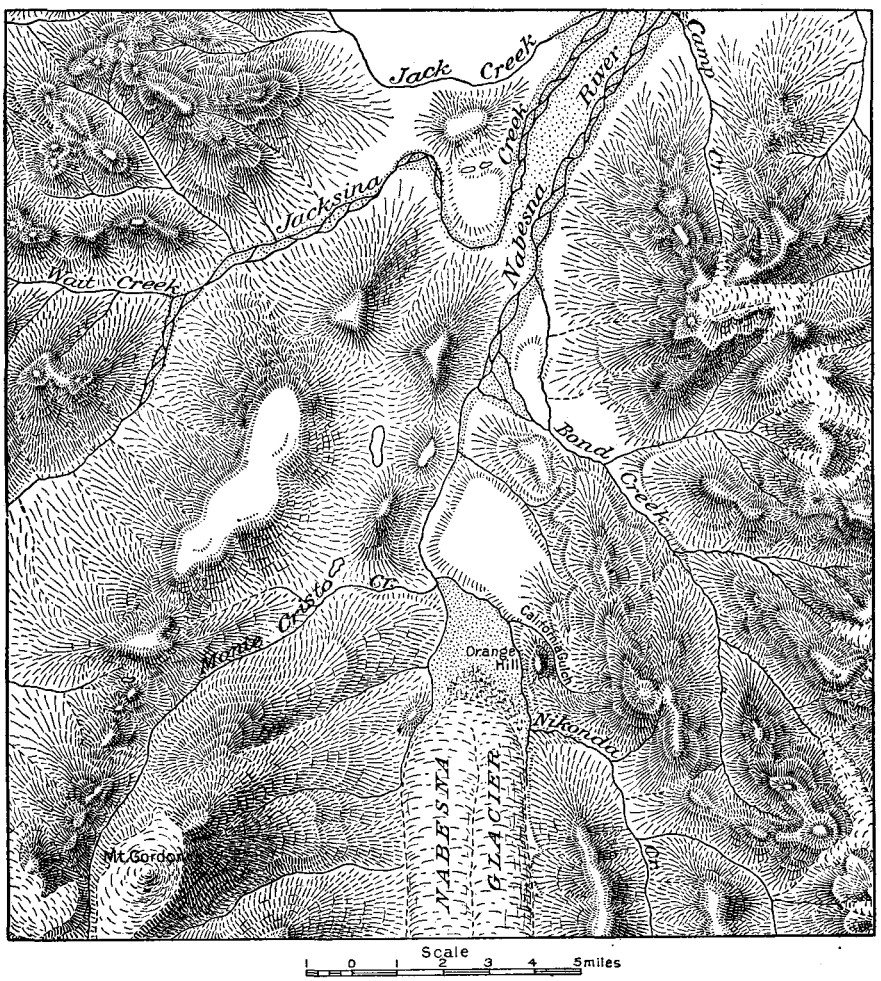


FIG. 3.—Map of the region adjacent to the upper Nabesna.

copper values. In the gulches draining the basal slopes of the mountains to the east of this region pieces of low-grade ore, consisting essentially of magnetic pyrites or pyrrhotite and a little chalcopyrite, were found in such sizes as to indicate that the vein or ore bodies from which they were derived must be at least 6 inches in thickness. However, an assay of this ore collected by the writer yielded only six-tenths of 1 per cent of copper, an amount manifestly of no economic value.

A little above this locality, along a zone extending from about 4,500 to 5,500 feet in elevation, the Nabesna limestone is irregularly exposed, and though the actual contact was not seen, the limestone pretty surely rests upon and is probably intruded by members of the diabasic series. It is in assocation with this contact that the above ore is supposed to occur. This seems especially likely since the ore is highly magnetic, and the diabase is known to contain much magnetite. From the association of magnetite and pyrite it is also suggested that the ore may represent a magmatic segregation in the diabase along the contact, as is probably true of the deposit of magnetite 2 feet or more in thickness found north of Bond Creek.

On Camp Creek.—At the head of Camp Creek, in association with the Nabesna limestone, are found several phases of the greenstone diabase, some of which appear most favorable indeed for the occurrence of copper, but no copper was seen there except some malachite stain on coarsely crystalline limestone débris in the moraine gravels. Much of the rock in the moraine and some that was seen in place is of the variegated or purple amygdaloidal type, apparently identical with that in which the native copper occurs in the Chitina country.

On the north side of the head of Camp Creek, about one-half mile from the stream, Mr. Alfred B. Iles, a mining engineer who has made somewhat extensive investigations in the country, reports the occurrence of a small vein of copper ore.

The vein is said to occur in a greenstone near its contact with sedimentaries. Because of unfavorable conditions it was not traced for any considerable distance. It was found, however, to be from 6 inches to 2 feet thick, and to consist, in part at least, of chalcocite or copper glance, with little or no gangue. A small piece of the ore is reported to have yielded an assay of 61 per cent copper.

Although this prospect can not of itself be considered of economic value, it is probably the best that has yet been found by white men on the north slopes of the Wrangell and Scolai mountains within the drainage basins of the upper Nabesna, Chisana, and White rivers. Near the prospect—in the "wash" of an adjacent gulch—fragments and pebbles of diabase, more or less freely spotted with bornite, are reported.

On Cooper Creek.—Several miles west of Cooper Pass, in the gulches on the south side of Cooper Creek, gravels of a coarse-grained igneous rock, apparently belonging to the diabasic series, were observed to contain a little chalcopyrite, and the relations of the diabase in this region to the Nabesna limestone seem favorable for the occurrence of copper ore.

ON THE CHISANA.

Tanana natives, residing at the time of our visit mostly on the lower part of Cross Creek, had in their possession collections of native copper nuggets, ranging

in size from a shot or pea to several inches in diameter. The collections contained perhaps 100 nuggets, averaging about one-half inch in diameter, this being the most common size. The largest piece seen weighs 35 to 40 pounds, and, as is true of most of the larger nuggets, is irregular in form and partially coated with malachite. Many of the pieces have adhering to them a little quartz and calcite gangue or fragments of reddish vesicular lava, whose presence seems to denote the occurrence of the nuggets in the usual way, in association with the contact of the igneous rock and the limestone.

The source of this native copper seems to be a small western tributary of the Chisana, which it joins about 6 miles above the foot of the glacier. The native name for the gulch is Tinast or Chitty.

This Tinast Gulch occurrence of copper seems to be the only one between the Nabesna and the Chisana of which the natives have any knowledge, and as some of them are very intelligent and are familiar with the region it seems safe to infer that if any other deposits occur they are few and small. The natives had no samples of copper ore in their possession, nor did they seem to know of any occurring in the region. It should be mentioned, however, that prospectors claim to have found native copper in the Nutzotin Mountains, on the first western tributary of the Chisana below Cross Creek. While the geologic conditions here are not unfavorable, it seems strange that the Indians who dwell near by know nothing of the occurrence.

ON WHITE RIVER.

Upper White River.—The region of Kletsan Creek, on the upper White River, has been known for many years as one from which copper nuggets are brought by the natives. It was visited by Hayes in 1891 and by Brooks in 1899. The latter author describes the deposits and the conditions under which they occur in some detail. The following account is taken from his descriptions:[a]

"Kletsan Creek, from which this deposit takes its name, is an unimportant tributary of the upper White River, which joins that stream about 5 miles above the international boundary [see fig. 4]. This stream rises in a glacier which occupies the north slope of Mount Natazhat, a peak of the northern portion of the St. Elias Range. * * *

"The geology of the region, so far as studied, is not very complex. Close to where the brook leaves its rocky floor there is exposed a belt of white crystalline limestone containing numerous fossils, which show it to be Upper Carboniferous. [These fossils have since been determined as Permian.] Above the limestone is a series of carbonaceous schists and shales, which sometimes approach an impure coal in character. Both the limestones and the shales are cut by dioritic and diabasic

[a] A reconnaissance from Pyramid Harbor to Eagle City, Alaska, including a description of the copper deposits of the Upper White and Tanana rivers, by Alfred Hulse Brooks. Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 379-381.

rocks, which are exposed along the creek in large areas. The diorites seem to be the older intrusions, and are in turn cut by diabases. As far as determined from the talus and stream gravels, the mountains themselves are made up of effusive rocks, which overlie the sediments and intrusives uncomformably. * * *

"The placer copper deposits (all native) are contained in stream benches that owe their existence to rock barriers through which the streams have now cut their courses. The placer copper, as far as observed, is confined to a section extending about half a mile upstream from a point where the creek leaves its rocky canyon. The copper is irregularly distributed on bed rock in the crevices and also among the large bowlders. The nuggets found by the Indians who accompanied me seldom exceeded a few ounces in weight, though one was found which weighed 5 or 6 pounds; and another which I saw, from the same region, weighed 8 or 10 pounds. * * *

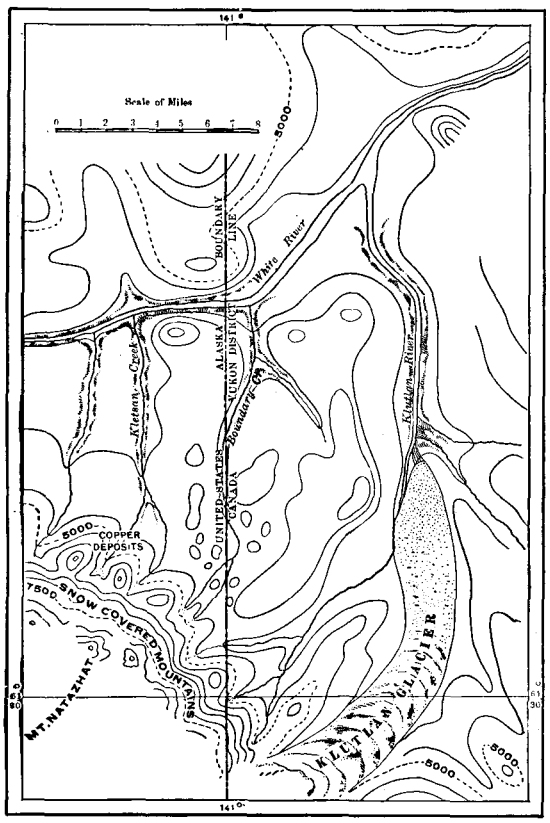


FIG. 4.—Sketch map showing location of Kletsan Creek copper deposits.

"A search was made for evidence as to the source of this native copper. An examination of the greenstones showed them to be traversed by an irregular system of joints, and calcite veins were observed which followed these joints. * * * Some of these veins [which occur close to the contact with the limestones] carry native copper. Calcite veins were also found in the white crystalline limestone near the contact with the greenstones. * * * No other copper minerals, except secondary malachite, were found. * * * To the east, the Kletsan copper belt was traced only to the vicinity of the international boundary [a distance of about 6 miles]. Its eastern extension beyond this point, if it exists, is to be sought north of our route of travel. To the west, the same zone seems to extend to the upper White River, a distance of about 30 miles. The streams entering the upper White River flow from the south. As far as examined all carry copper colors, and the gravels are similar in character to the rocks of Kletsan Creek."

Middle White River.—Prospectors entering the country by way of the Valdes route during the past two seasons are reported to have been headed for copper prospects on "Swamp" Creek, which is said to be a tributary of the White, in the

region of the Donjek or Nisling rivers. Nothing definite, however, can be stated concerning this particular locality, but in the region of the international boundary, north of the Nutzotin Mountains and between the White and the Attul[a] rivers, copper has been reported by prospectors, among whom may be mentioned Mr. D. K. Van Cleef, who visited this region in 1899.

The geology of this section is inferred from Van Cleef's notes to be much like that on the upper White, and apparently consists in the main of limestone and "Nikolai greenstone capped by a coal-bearing formation," probably of Permian or Mesozoic age.

Numerous copper nuggets are reported along the base of the Nutzotin Range between the White and Chisana rivers and "in the first and second cross ranges of mountains down White River, at distances of 40 and 50 miles below Skolai Pass." Some were also found to the east of this in the "upper canyon of White River about 2 miles above the mouth of the canyon, in slide from a hill east of the river at about 100 yards above the mouth of a large creek from the west." "Just below the slide, in the bed rock at the edge of the river, is a cap of what appears to be an ore chute containing pyrites." In his sketch Van Cleef locates the second or upper canyon of the White about midway between the mouth of the Donjek River and Koidern Creek.

ECONOMIC CONSIDERATIONS.

It is, of course, impossible to develop copper properties in the interior of Alaska without transportation facilities, and when these shall have been established the exploitation will be a matter of considerably greater cost than in the less remote districts of the United States where climatic conditions are not so severe. At best, the manipulation of copper ores requires heavy investments of capital in complete and carefully planned reduction works, the cost depending on the conditions of concentration and association of the ores. Since no plants have been erected in the Copper River country, and there are, therefore, no experiments upon which to base a prediction, no definite estimate can be made as to the richness necessary for profitable exploitation. This difficulty is increased by the undeveloped condition of the majority of the prospects, but it may be estimated roughly that ores assaying much below 10 per cent will not be likely to prove profitable.

Another important element to consider in relation to the future development of the region is the probable condition of the deeper-lying ores and the presence or absence of bonanzas. In 1900, when Messrs. Schrader and Spencer examined

[a] Attul River is supposed to be the upper part of Snag River. Its connection with Snag, however, has not yet been traced.

the Nikolai mine, a shaft had been sunk to a depth of 30 feet, and a tunnel in the Warner prospect, which has now been driven 18 feet, was examined in 1902. Except in these two cases we have no evidence as to underground conditions in the region itself, but reasoning by analogy from other regions on the basis of the surface conditions there, certain probabilities may be indicated.

Climatic conditions are believed by geologists generally to be potent factors in the alteration of mineral deposits by surface water, in the oxidation of a surface zone, the leaching of this oxidized zone, and the redeposition of the derived products in depth, as oxide or sulphide enrichments. The low temperatures of interior Alaska at present and the lower temperatures, or at least the more uniformly low temperatures, during the recent geologic past, when glaciation was much more extensive than now, are conditions unfavorable to those chemical processes to which certain important enrichments are believed to be due.

The region is extensively glaciated, but the present glaciers are but insignificant remnants of their predecessors. Probably no single occurrence of ore is described here which has not recently been buried under an ice mass and subjected to an unknown amount of ice erosion, resulting in the removal of those surface forms of the ores which may previously have accumulated.

The present surface ores are usually the richer sulphides, bornite and chalcocite. No gossan cap over any of the veins and no extensive deposits of oxides or carbonates have been observed, the latter minerals, where seen, being mere surface films and obviously due to recent atmospheric action.

It is probable, then, that there has been no deep alteration, because of climatic conditions, and that glacial action has recently removed much of that shallow altered zone which perhaps did exist, these conditions resulting in the presence of bornite and chalcocite as the surface ores, and leading us to expect no general increase in richness with depth. The present surface zone is the one that corresponds to the bonanzas due to secondary enrichment, in mines farther south, and the changes to be expected in deeper explorations are changes from the richer sulphides to chalcopyrite.

GOLD.

NABESNA RIVER REGION.[a]

Gold was discovered at the head of the Nabesna in 1899. Thus far, however, but little development work has been done, and, so far as known, no gold in paying quantity has been taken out. The principal localities are Monte Cristo Gulch, California Gulch, and Orange Hill. The gold here differs from that in most parts of Alaska in that it is not in placer form. No placer gold was found by the writers, nor, so far as known, has any been reported by prospectors. The

[a] The geology of this region is outlined under the heading "Copper."

metal is found in the mineralized Monte Cristo diorite, in which it seems to be combined with the pyrite so freely disseminated throughout the rock. Though the gold seems to vary considerably in degree of concentration at different points, it is believed, both from assays made by others and from those we have made, to be distributed more or less generally throughout the entire rock mass. Numerous assays made by the Millard party are reported to give from $2.30 to $35 in gold per ton, and to have yielded an average of $8.60 a ton. Assays of 20 samples that we collected, however, did not yield results at all comparable to these. While no samples collected from the rock in place failed to show at least a trace of gold, none yielded over 0.02 ounce, a money value of about 40 cents per ton. These better samples were collected from the upper west face of Orange Hill near the north end (see fig. 3). Here the rock, like most of that in Monte Cristo and California gulches, is so disintegrated that it can readily be loosened with a pick (Pl. VIII, *B*). It has weathered to a reddish-brown or dark orange color, is rich in disseminated iron pyrite, and is traversed by numerous veinlets of talcose material, along which occurs a little more or less honeycombed quartz.

Some of the best assays we obtained in the Nabesna field were those of rocks derived from glacial gravels. One of these was an altered diorite bowlder containing iron pyrite. It yielded 0.03 ounce in gold and 0.01 ounce of silver, a money value of 63 cents per ton. This specimen, though its minerals show much alteration, is a relatively firm rock and exhibits none of the disintegration prevalent in most of the Monte Cristo diorite, to which it appears to be related. Another assay, from a bowlderet of dense pyritiferous quartz, yielded 0.02 ounce, or 40 cents, in gold per ton.

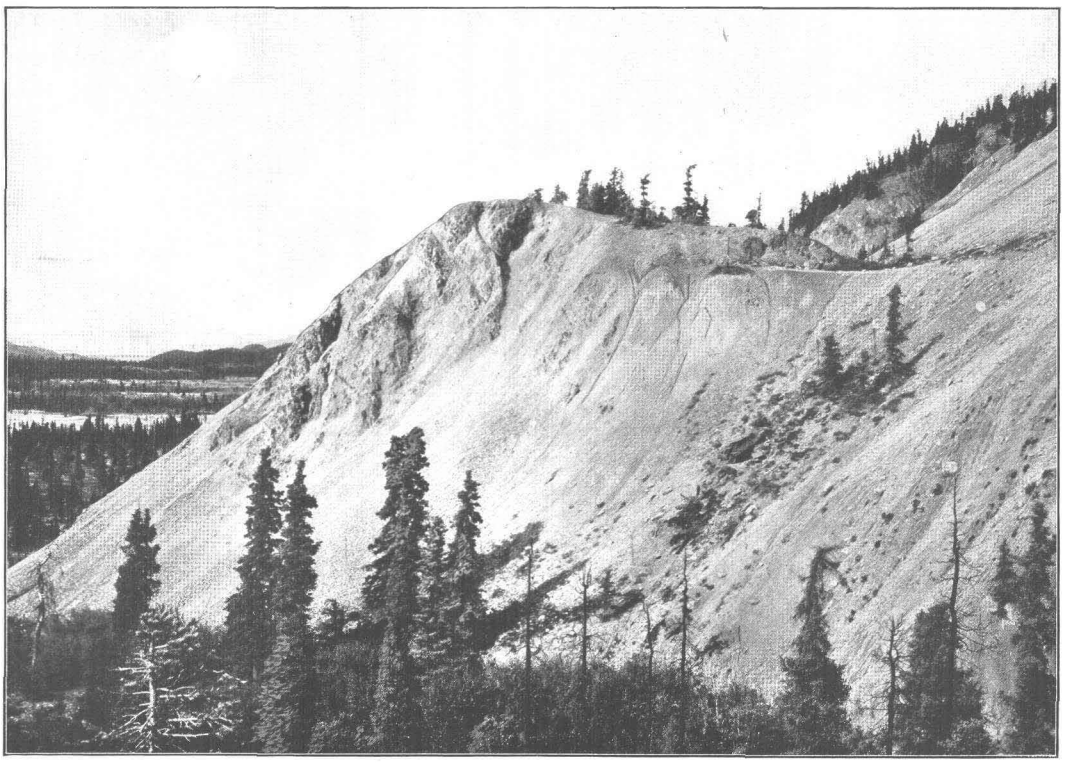
These two specimens were collected near the foot of the Nabesna Glacier, on the west side. Though they are glacial, they were probably not transported far. Their mineral content, considered in connection with the occurrence of mineralized areas seen at a distance, but not visited, suggests the presence of considerable gold-bearing rock in the region northwest of the foot of the glacier. At any rate, the area seems worthy of examination.

On the east side of the Nabesna Glacier, about 2½ miles above Niconda Creek, is a pyritiferous diorite, which was found on assay to carry a trace of gold. No assays were made of the diorite occurring east of lower Niconda Creek and on the southern tributaries of Bond Creek, both of which areas may be worthy of attention.

We regret our inability to present as encouraging a report for this section as has been made by the prospectors referred to, and feel that all that can be safely affirmed is that a considerable amount of low-grade gold-bearing rock exists

A. MONTE CRISTO DIORITE ON MONTE CRISTO CREEK.

Looking northeast.



B. VENATION AND DISINTEGRATION IN MONTE CRISTO DIORITE.

View from California Gulch, looking north down Nabesna Valley.

at the head of the Nabesna River, in which economic values may be found in the future.

To parties intending to prospect in the region we would call attention to the fact that on both Monte Cristo Gulch and California Gulch the ground has been staked. Some ground is also staked on the southwest slope of Orange Hill, on Niconda Creek, and on a branch of Dike Creek, just north of California Gulch.

It should also be noted, in connection with the Nabesna deposits, that in the diabase along the southwest side of Jacksina Creek, below Waite Creek, pale green, vein-like material, which is probably shear-zone matter, was found on assay to carry a trace of gold.

About 15 miles west of the Nabesna, on the north side of Jack Creek, an outcrop is exposed which seems to represent the breccia of a shear zone in diorite-porphyry. The rock is highly altered, traversed by secondary quartz veinlets, contains considerable freely disseminated iron pyrites, and proved by assay to carry a trace of gold.

On a south side gulch of Cooper Creek, several miles west of Cooper Pass, colors of fine gold were panned by the writers. Though the gulch at this point lies in the diabase, the gold may have come from the Nabesna limestone or the Mesozoic series, which occur in the mountains lying farther south, from which gravels have been carried northward by glaciation.

CHISANA RIVER REGION.

On the Chisana no gold was found above the Nutzotin Mountains. The Mesozoic rocks of the Nutzotin Range, however, consisting of slates, schists, greywackes, shales, limestones, and conglomerates, beyond doubt contain some gold. In these rocks one would expect the quartz, which occurs either as veinlets or stringers along the bights of folds or in the crushed material along faults and shear zones, to be the most favorable places to look for gold. An assay of a sample of quartz collected in a shear zone at the head of the canyon on the west side of the river gave a trace of gold. From a similar occurrence of quartz and calcite in crumpled schistose limestone and slate on Mound Creek a specimen was collected for assay. The returns gave 0.03 ounce of gold and a trace of silver, a money value of 60 cents per ton.

WHITE RIVER REGION.

From accounts of prospectors who visited the upper White River during the years 1898 and 1899, there seems to be no doubt that placer gold occurs on its headwaters, but so far as known the deposits give no promise of yielding the metal in commercial quantities.

MENTASTA MOUNTAIN REGION.

ROUTES AND TRAILS.

The principal route across the Mentasta Mountains in a northerly direction is the well-known government trail by way of Mentasta Pass (Pl. III). Another route across the range is from Batzulnetas northeastward by way of Lake Suslota and Suslota Pass to the Little Tokio. To the northwest of Mentasta Pass, Siconsina and Gillette passes are also said to be feasible for pack animals. Roughly considered, the Mentasta Mountains between the government trail and the Nabesna may be traversed in almost any direction by pack train. There are also several routes running parallel with the range in a northwest-southeast direction. Of these, the principal is that in the southern part of the region, which leads from the Chesna southeastward by way of the upper Slana River, Suslositna Creek, Lake Suslota, upper Suslota Creek, upper Jack Creek, and Platinum Creek to the Nabesna. This is the route followed by miners and prospectors, as well as by the natives, going from the upper Chistochina to the upper Tanana and White River countries. There is a good trail much of the way.

Another route, more nearly along the heart of the range, is from upper Platinum Creek by way of upper Bear Creek and Buck Creek, westward through a low pass to the Slana and the Government trail or northwestward to Mentasta Pass.

GEOLOGIC SKETCH.

From the Nabesna, the Nutzotin Mountains, continued to beyond Mentasta Pass, are known as the Mentasta Mountains, and though the Mesozoic series, with some intrusive granitic masses, continues to Mentasta Pass, two other important classes of older rocks should also be noted, both of which seem to underlie the Mesozoic series. Of these the first is the Suslota series or Upper Carboniferous limestone, occurring west of Suslota Pass, where it plays a prominent part in the make-up of the mountains in that locality. This limestone, which may represent the basal portion of a calcareous terrane that continues upward to the horizon of the Nabesna Permian beds, is medium to heavy bedded. It dips northward at varying angles and is intruded by and apparently interbedded with igneous rocks, some of which are of the diabasic type. Westward on the Slana, from 3 to 4 miles east of Lake Mentasta, high up in the mountains, apparently the same limestone is exposed, outcropping beneath the Mesozoic series. It again appears at the base of the mountains in the north end of Mentasta Pass about 10 miles northeast of the summit on the Little Tokio drainage.

The second class of older rocks belongs to the quartz-schist type. It was first encountered in the mountains on the Little Tokio about 7 miles northeast of Suslota Pass, opposite the mouth of Buck Creek. Farther west it becomes

more and more prominent, constituting a large part of the mountains northwest of Mentasta Pass and the great mass of the Alaskan Range in the vicinity of the Chistochina.

This schist is frequently highly folded and somewhat faulted. It is often micaceous and garnetiferous, and contains locally more or less quartz in veinlets or stringers and small irregular bodies, in association with which gold is known to occur, as will be seen in an account of assays which follow.

That portion of the Mentasta Mountains which lies south and west of the upper Slana and which is crossed by the Government trail seems to be composed essentially of diorite and some diabasic rocks.

GOLD OCCURRENCES.

Gold was discovered in the Mentasta Mountains as early as the summer or fall of 1898, when shallow shafts were sunk and coarse gold was found in the gravels just west of what is now Mentasta signal station, at the summit of Mentasta Pass. About this time a camp of a dozen or more prospectors is reported to have been located at the head of Mentasta Lake. According to the reports of some of these prospectors, only very fine gold, however, was found in this part of the region.

An assay of a sample of quartz and schist representing several pebbles collected from the creek gravels on the west side of the pass about 4 miles northeast of the summit showed a trace of gold. A trace was also found in a similar sample of garnetiferous quartz collected from a talus slope about 7 miles northeast of the summit.

An assay of a bowlder of pyrite-bearing diabase, which seems to be associated with the Suslota limestone west of Suslota Pass, yielded 0.02 ounce gold and a trace of silver, making a total money value of about 40 cents per ton.

In a diorite area on the south side of the Slana, at the entrance to Slana Pass, some altered material containing iron pyrites, taken from what is probably a shear zone in the diorite, showed on assay a trace of gold.

Along the north slope of Slana Pass, about a mile from the summit, there is a large area of light reddish or yellowish brown rock, which seems to be a mineralized diorite. A sample of this material collected in the gulch at the base of the mountain yielded on assay 0.02 ounce of gold, a money value of about 40 cents per ton.

Gold has also been found in the stream gravels of Ahtell Creek. Claims have been staked several miles above its mouth near the point where the Government trail crosses it.

In conclusion it may be stated that, although gold has been proved to be present at a number of localities throughout the Nutzotin and Mentasta Mountains,

all of the ores that are known are of very low grade, too low to have any value at present. The most promising formation from the point of view of possible gold production is the quartz-schist series, which extends westward from the head of the Little Tokio to and beyond the Delta River.

CHISTOCHINA GOLD FIELD.*

LOCATION.

The Chistochina gold field (Pl. IX) covers a small area in the northwestern part of the Copper River Basin. It lies just south of the main mass of the Alaskan Range, near the headwaters of a few small streams that are tributary to the Chistochina River. It is crossed by the one hundred and forty-fifth meridian of west longitude and is a few miles north of the sixty-third parallel of north latitude.

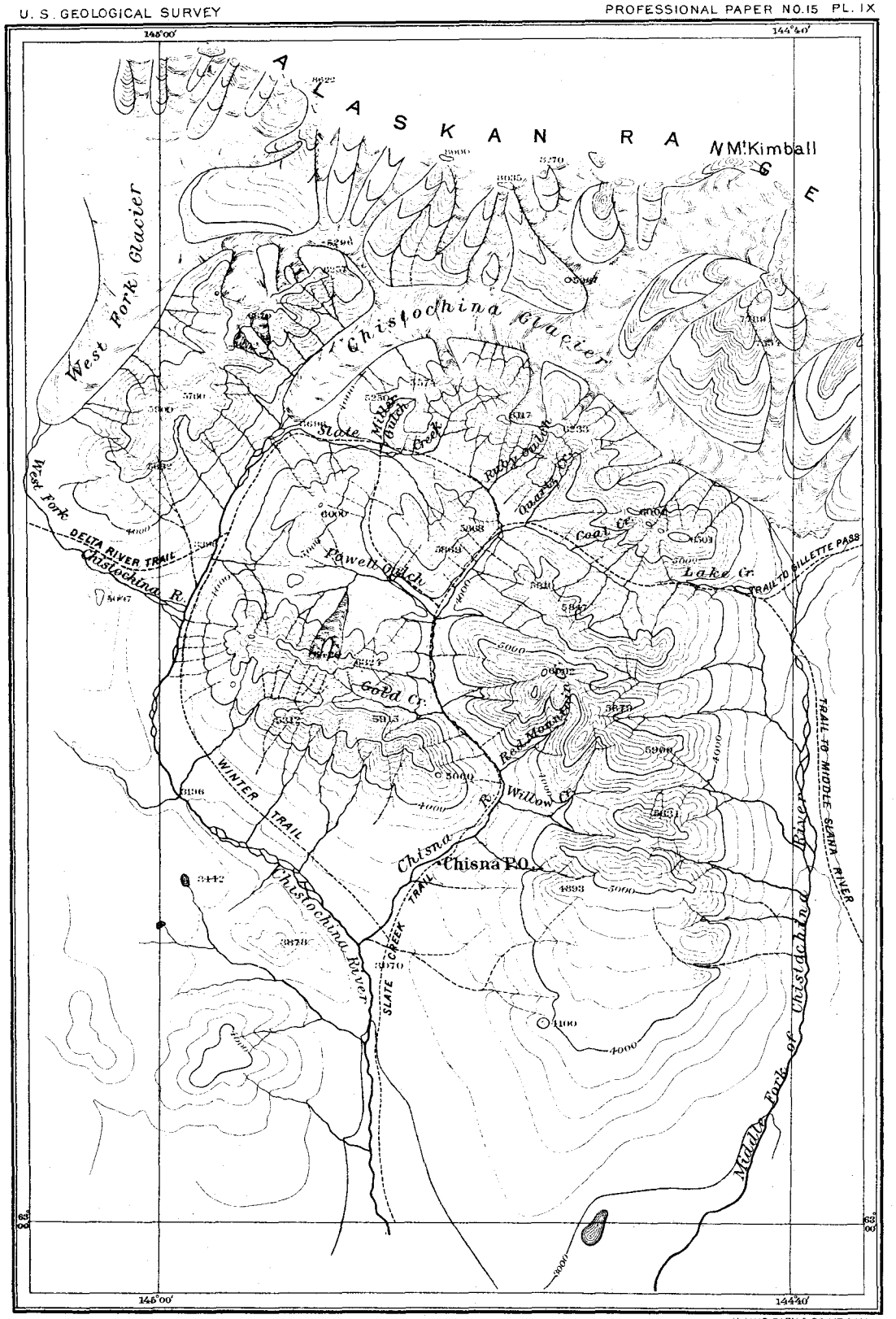
GEOGRAPHY AND DRAINAGE.

The gold field does not lie in the Alaskan Range proper, but in a group of foothills that are separated from the main chain by a conspicuous piedmont valley, which extends twenty or thirty miles east of the head of the Chistochina River and is occupied by the Chistochina Glacier and the upper courses of the Middle Fork, the Slana, and the Tokio, and the various passes which connect these streams.

North of this feature the peaks of the great range rise abruptly to elevations of 8,000 or 9,000 feet. South of it the nearest foothills are 6,000 or 6,500 feet in height, but decrease in altitude as their distances from the axis of the range increase. These foothills are in detached groups, which, near the main range, occupy relatively large areas, the valley lowlands separating them occupying relatively small areas. This relation is in a measure reversed along the lower Chistochina near the Copper, where the foothills are often small islands rising above the general gravel plain of the Copper Valley.

The particular foothill group in which are found all of the producing claims of the district lies between the main Chistochina and its Middle Fork and south of the western end of the piedmont valley that has been described. It is drained by tributaries of one or the other fork of the Chistochina, the largest of these tributaries being the Chesna. This small river rises in a cirque 3 or 4 miles south of the east end of Chistochina Glacier. It flows north of west for 2 miles or more, directly toward a low pass leading to Slate Creek, then turns abruptly southward and joins the Chistochina 7 or 8 miles below the mouth of the West Fork. Its total length is only 12 or 13 miles. Slate Creek lies west of the

*The writers are indebted to Messrs. Hazelet and Meals, Tully, Jacobson, Dempsey, and others, for information concerning this district.



JULIUS BIEN & CO. LITH. N.Y.

MAP OF CHISTOCHINA GOLD FIELD, ALASKA

T. G. Gerdine, topographer

Scale

1 0 1 2 3 4 miles

upper Chesna, its lower course occupying the western end of the same depression which has controlled the upper course of the larger stream. Before entering this cross valley it flows southward for a little more than a mile and a half from the two small glacial remnants in which it rises, and after entering it follows it westward for 2 miles to the Chistochina, which it joins just at the foot of the glacier. Its total length, therefore, is not over 4 miles. Miller Gulch, the most important producer of the district, is a small northern tributary of Slate Creek, less than a mile long.

HISTORY.

The first locations in the Chistochina gold field were made by Hazelet and Meals, in the summer of 1899. These gentlemen were among the army of argonauts who crossed the Valdes Glacier in the spring of 1898 with the idea of prospecting within the Copper River basin. Building a boat on the Klutina, they descended that stream and ascended the Copper and the Chistochina, reaching the present location of Chesna post-office in early July. They found encouraging prospects here, but their provisions becoming exhausted, they returned to Copper Center for a larger supply, reaching the Chesna again in August of the same year. In September they returned to Copper Center and during the following winter sledded supplies to a point on the Chistochina near the mouth of the East Fork, and from this base continued their work on the lower Chesna throughout the summer of 1899. Coarse gold was discovered at this time, and several locations were made.

In the spring of 1900 these operators, together with a number of the present Miller Gulch and Slate Creek claim owners, returned to the Chistochina with a good stock of supplies, a sawmill, and some hydraulic machinery. During this summer gold was discovered on Slate Creek and Miller Gulch by Coles, Jacobson, Kramer, and Levell, the ground staked at that time having since proved to be much the richest in the district.

Since that time the activities within the district have been chiefly in the form of development of properties already staked, although some further locations have been made in the the region between the Gakona and the Chistochina on Excelsior Creek and the headwaters of the Shnu.

TRAILS.

The route usually followed from Valdes to the Chistochina gold field is along the well-established military trail to the mouth of the Chistochina River. From this point the Slate Creek operators follow the Chistochina to the mouth of the Chesna, and, ascending this stream, pass through Powell's Gulch to Slate Creek, at the mouth of Miller Gulch. The total distance from Valdes to Slate Creek by this route is about 225 miles.

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A shorter route was established by Hazelet and Meals in 1900 by way of the Gakona River. This so-called Gakona trail leaves the military trail about 5 miles north of the Gakona ford and swings westward to the bank of the Gakona River, which it follows northward to a point almost directly south of Chesna. Thence it crosses to the Chistochina through a series of low passes which afford a very direct route, but are reported to give soft footing during the early summer months.

In addition to these direct lines of approach from Valdes, the Chistochina field may be readily reached from the Tanana River by way of the Delta, which is ascended through the Alaskan Range to the head of its east fork, known as Phelan Creek. From the foot of the glacier, in which the latter stream and a branch of the Gulkana rise, a route leads eastward across the headwaters of another branch of the Gulkana to the Gakona, at the foot of the glacier, and, crossing this stream, descends the west fork of the Chistochina to its junction with the main river, which is reached in a distance of about 26 miles from the source of the Delta. This route lies entirely above timber line from the Delta to the Chistochina, but does not involve high climbs, and throughout the greater part of the distance is marked by a well-established trail followed by the Delta River stampeders of 1901.

The military trail to Eagle is easily reached from the Chistochina district by ascending the Chesna to the low pass leading from its head to the Middle Fork of the Chistochina, whence Gillette Pass and the Tokio River are approached by either of two routes. The northern route follows the Middle Fork to its head and crossing a low pass to the upper Slana descends the latter 5 or 6 miles to the mouth of the small stream draining from Gillette Pass. The southern route involves the descent of the Middle Fork a distance of about 5 miles to the Mankomen Valley. Following this eastward the trail reaches the Slana 4 or 5 miles below Gillette Pass, at a point where its course changes from south to east. Having reached the Slana, the traveler may ascend it and cross to the Tokio by way of Gillette Pass, or descending it may reach the military trail just below Mentasta Pass. The total distance from Miller Gulch to the Slana by way of the more southerly route is not over 25 miles. The northern trail is somewhat shorter. Either is entirely practicable for packers or pack animals.

MAIL AND TELEGRAPH FACILITIES.

With the establishment of the United States mail route from Valdes to Eagle, and later of the Signal Service telegraph over the same line, facilities for communication with the outside world were greatly improved for the Chistochina field, as for the Copper Valley generally. A telegraph office at the mouth of

the Chistochina River is only about 35 miles from the gold field, and a post-office—Chesna—with service twice a month in summer and once a month in winter, has been established 1½ miles above the mouth of the Chesna River, in the southern edge of the district.

GEOLOGIC SKETCH.

The geology of the Chistochina gold field may be briefly outlined as follows: That part of the great Alaskan Range lying north of the gold area and forming the general divide between the Tanana and Copper River systems is made up of micaceous schists, whose thickness and age are unknown. These schists are separated on the south from the immediately adjacent unaltered or but little altered shales and limestones of Permian age by a fault of unknown but no doubt great throw, the displacement, it is believed, being not less than 10,000 feet, since the upper part of the Permian, itself from 5,000 to 7,000 feet thick and overlying an undetermined amount of Carboniferous and older rocks, is brought by the fault into juxtaposition with the mica-schists.

This great fracture finds topographic expression in the piedmont valley already described, which parallels the range and lies just along its southern base. In it the various tributaries of the Chistochina rise, sometimes as ice streams, and flow east and west, until they unite to form the main trunk branches, which break through the foothills to the south, on their way to the Copper. The upper course of the Slana also lies in this fault valley and along its projection eastward is Gillette Pass leading to the upper Tokio.

The Permian beds south of the great fault occupy a belt 18 or 20 miles long and from 3 to 10 miles wide. This belt trends a little north of west from the upper course of the Slana to the West Fork of the Chistochina, and is much wider near its eastern than near its western end. Here, along the northern border of Mancomen Valley, the basal portion of the section, a series of interbedded limestones, tuffaceous sandstones, and igneous sheets, is well exposed. Since the dips in this region are generally toward the north, although at low angles, the upper members of the Permian appear along the northern edge of this part of the belt and extend thence westward, where the basal beds are not represented. In this upper series fossiliferous limestones and black shales constitute the mass of the formation, but many basic intrusives are present. They are particularly abundant near the great fault.

The Permian belt is limited toward the south, at least near its western end, by a second fault, less profound and less extensive than the northern one, but marked, like it, by a series of transverse valleys and low connecting passes. Slate Creek and the upper Chesna and the pass connecting them are on the line of this second fracture. The Permian beds, as a whole, represent an orographic

block dropped down between older rocks in the course of adjustment to the stresses to which the region has been subjected.

South of the second fault is a complex terrane, which at present will not be subdivided. It includes quartzites and quartzose conglomerates, and a great body of tuffaceous and effusive rocks, which in the region just south of Slate Creek and the upper Chesna have been intruded by later granitic and porphyritic masses and considerably altered. A very general impregnation by pyrite accompanied the alteration, so that the rocks turn rust-red on weathering.

Effusive representatives of this latest intrusive activity have been recognized capping the summits at one or two localities, but the greater part of the rock outcrops examined between the Permian area and Copper River belong to the older more or less altered igneous series.

Patches of a younger sedimentary series, in part at least Miocene in age, are infolded with the Permian beds on the Chesna and on Slate Creek. In the region between the West Fork and the Gakona they occupy a large area.

Unconsolidated clays and gravels, primarily or secondarily of glacial origin, occur in the valleys generally. Near the sources of the streams they are confined to flood plains or narrow bordering terraces, but downstream they broaden until they merge with the general Pleistocene filling of the Copper Basin, from whose borders the isolated bed rock areas rise as islands.

In addition to these Pleistocene deposits in the lowlands, a thin sheet of cobbles, called by the prospectors the "round wash," is conspicuous on the hilltops about the head of Slate Creek, Miller Gulch, and some of the tributaries of the upper Chesna.

GOLD OCCURRENCES.

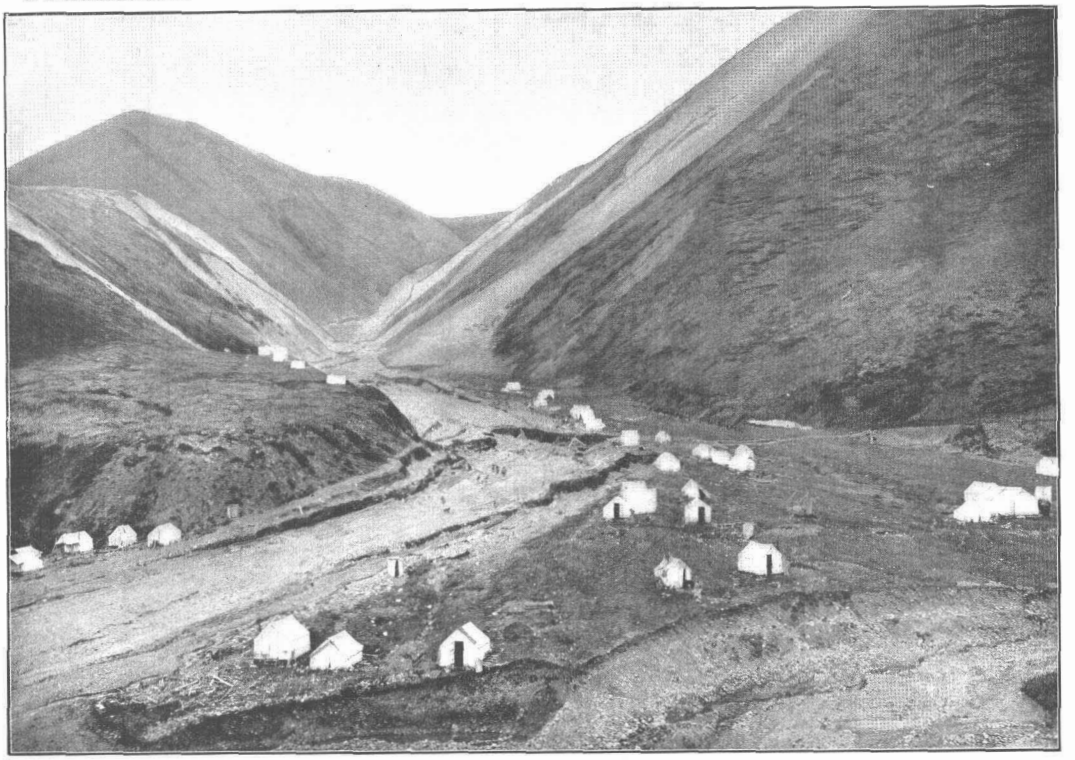
OUTPUT.

It is estimated by Mr. G. C. Hazelet that the camp produced $25,000 in 1900 and $115,000 in 1901. Placing the yield for 1902 at $225,000, the total output since the discovery of the district becomes $365,000.

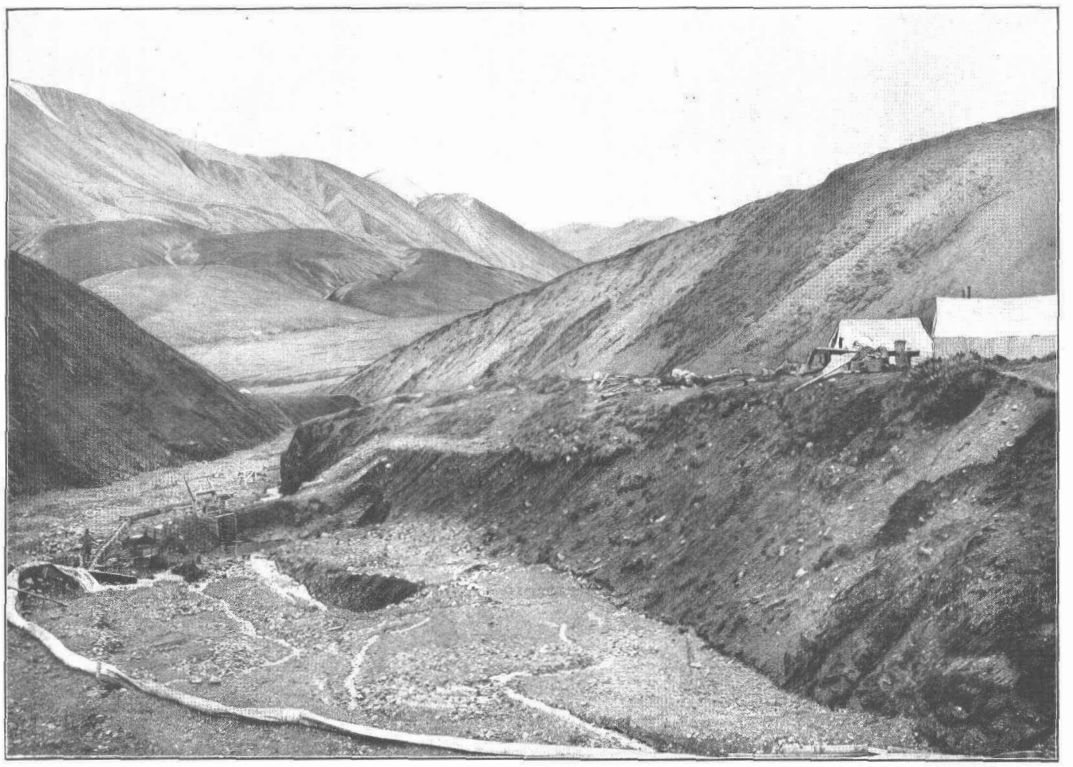
Of the yield for 1902, Miller Gulch probably furnished $175,000, the balance, $50,000, being divided between Slate Creek and Chesna River.

MILLER GULCH.

This narrow gulch (Pl. X, *A*), whose yield is thus seen to be much greater than that of all other streams in the district combined, is a steep ravine less than a mile long. Eight 600-foot claims have been staked upon it, this length having been agreed upon by the original discoverers in order that each might secure a share of the property there. The eight claims cover the gulch from



A. MILLER GULCH.



B. VIEW OF UPPER RUBY GULCH, SHOWING LOWER END OF JACKPOT CLAIM.

source to mouth, and each is worked with profit when there is sufficient water; but during dry seasons the claim holders near the source of the gulch are forced to close during a part of the summer.

The bed-rock floor of the gulch is sheeted over with coarse gravel to a depth of from 4 to 8 feet. This gravel is derived principally from the slate country rock and its diabasic and "bird's-eye porphyry" intrusives, but contains also noticeable percentages of granitic cobbles derived from the "round wash" which covers the surrounding hills. The gold is reputed to be generally distributed horizontally across the gulch, without definite pay streaks, but vertically it exhibits the usual concentration near bed rock. Ill-defined benches exist on either side of Miller Gulch at 100 or 200 feet above creek level. They are reported to prospect well, but are not now worked for lack of water. Their origin is probably connected with the glacial history of the region.

The gold of the gulch is usually flat and smooth and is very rarely found attached to quartz or country rock. It occurs as rather coarse dust and small nuggets, the largest of these reported so far weighing about 4 ounces. One-ounce nuggets are not at all rare. The gold increases in average coarseness toward the head of the gulch, whence most of the finer dust has been removed. Its assay value is said to be about $18 per ounce.

Small copper nuggets, bits of cinnabar, magnetite grains, and an occasional silvery-white fragment of osmiridium are found associated with the gold in the sluice boxes.

The estimated output of $175,000 includes the gold taken from the rich claim at the mouth of the gulch, which lies partly on Slate Creek. This relatively heavy output is, of course, due primarily to the superior richness of the Miller Gulch gravels, but other factors have been their shallowness and the gradient of the stream, which have made it easy to win the gold by simple, inexpensive sluicing methods. These combined factors have caused the early development of Miller Gulch to a maximum of production, while the poorer or deeper diggings in other creeks, where in some instances expensive plants are required, have been neglected. It is estimated that the present rate of output should be maintained for two or three years to come.

SLATE CREEK.

Slate Creek, like Miller Gulch, has been staked throughout its length, but as most of the claim owners are also interested in the richer Miller Gulch property, where they have concentrated their energies, it has received comparatively little attention. Furthermore, conditions are not so favorable on this larger stream for placer operations, both because of the comparative paucity of gold except in two or three of the claims immediately below the mouth of Miller Gulch, and because

of the generally greater depth of gravel and irregularity of bed rock throughout much of its length.

During the recent glaciation of the region the drainage has been considerably disturbed, and in this disturbance the channel of Slate Creek has been much modified. Two shafts sunk during the last two years just east of the bed of Slate Creek, opposite Chesna Pass, reached rock at 75 and 90 feet respectively, that is, at from 40 to 55 feet below bed-rock level in Slate Creek, less than 100 yards away, a difference probably attributable to the shifting of the channel of the creek during the late occupancy of the valley by ice.

It is to be noted in this connection that if the Chistochina Glacier were to advance slightly the waters of Slate Creek would be dammed and forced out over the Chesna divide, thus reproducing a condition which has probably prevailed in the recent geologic past.

Difficulty is also encountered in the attempt to reach bed rock on the claims immediately above the mouth of Miller Gulch. The difficulty here is probably due more to the filling from a tributary stream whose fan has spread out over the Slate Creek bottoms than to any extensive excavation because of glacial action.

In that part of the upper Slate Creek channel where any sluicing has been done, the gravels are from 4 to 10 feet in depth and the yield has been practically the wage of the district, $10 to $15 per day per man. As has been stated, one or two of the claims just below Miller Gulch are rich, and are being extensively worked at a profit, but the other workings on the lower part of the creek, like those on the upper, are erratic and yield scarcely more than wages.

A narrow bench 10 or 15 feet above the level of the bed of Slate Creek, opposite the mouth of Miller Gulch, was one of the first areas in the district worked. Several thousand dollars were sluiced here from a space covering a few hundred square feet. The bench presumably represents a portion of the old Miller Gulch fan, and the gold is regarded as derived from the gulch.

The Slate Creek gold is similar in form, color, and purity to that of Miller Gulch, but is not quite so coarse.

BIG FOUR CLAIMS.

A small stream drains the steep slope north of the head of Miller Gulch and empties into the Chistochina Valley a mile or two above the lower end of the glacier. Two or three claims have been staked on this creek and a limited amount of work is being done there. The gold thus far won is much finer than that taken from Miller Gulch, and the yield has been less, not more than $10 or $20 a day per man.

CHESNA RIVER.

In 1902 the developments on the Chesna were limited to two groups of properties, one near the source of the stream, and the other a short distance above its mouth. In both of these regions bed rock had been reached on some of the claims at varying and usually not excessive depths, and wherever found it carried sufficient gold to enable the operators to wash the gravel at a profit.

Throughout the intermediate portion of the river the bedrock lies at unknown depths beneath a mantle of glacial material. In one place, one-half mile above the mouth of Powell Gulch, a shaft was sunk from creek level through 21 feet of compact till into an underlying bed of sand which admitted water and forced a suspension of operations. It is improbable that the sorting and concentrating effect of water throughout this middle portion of the Chesna Valley has at any post-Glacial time been operative down to bed rock, so that, even could the latter be reached, it is unlikely that gold in sufficient quantities for profitable exploitation would be found. The clay layers within the glacial deposits which are reached in prospecting carry colors, but are not sufficiently rich to invite extensive operations.

Upper Chesna–Ruby Gulch.—The operations in 1902 on the upper Chesna were confined to the small tributary known as Ruby Gulch. On the lower portion of this brook ground sluicing was in progress, and 3 or 4 feet of gravel were removed to a "clay bed rock." The operations were chiefly in the nature of development work, but the operators report that the clean-ups about paid expenses.

In the upper portion of the gulch, on the Jackpot claim (Pl. X, *B*), the stream is confined to a narrow but shallow canyon, 20 to 40 feet wide, with gravels generally 2 to 4 feet deep. Near the lower end of this claim there is a deep hole, perhaps representing a large glacial mill, which has been explored to a depth of 20 feet without finding bottom. Below this hole bed rock is again within reach of the operations, and here, as above, mining has proved profitable. The gravels are derived generally from the slightly metamorphosed Permian shale bed rock, but there is some admixture of granitic and greenstone bowlders, derived from the "round wash" which is found on the divide at the head of the gulch.

One line of sluice boxes serves to handle the gravel, and a small glacial remnant at the upper end of the gulch supplies water throughout the season.

The gold is similar to that of Miller Gulch, bright yellow, smooth, and flat, only occasionally rough or in rounded pellets. A number of small nuggets have been found, the largest of which is worth $12.75. The assay value of this gold is reported to be $18 or $18.50.

Lower Chesna.—The operations along this portion of the Chesna Valley are confined to a group of properties within 2 or 3 miles of the mouth of the river. They extend through the canyon and for short distances above and below it, where alone bed rock is accessible. More capital has been expended here in systematic development than elsewhere within the Chistochina field, and as a result the principal operators, Hazelet and Meals, now have in operation just below the canyon a hydraulic plant with a head of 125 feet. The ditch that furnishes this pressure taps the Chesna some distance above the canyon and follows the south bank to the lower end of the gorge. Water may be taken from it for use through and above the canyon, or greater head may be secured by a longer ditch, the Chesna having abundant fall.

Bed rock is easily accessible through the canyon, but the latter is so narrow that the bars not swept by the swift current are very small and probably carry but little gold. At the mouth of the canyon bed rock is easily reached, but having a somewhat greater slope downstream than the river, it soon passes below a point where it is at present practicable to operate on it. It is reported that bed rock lies only from 4 to 8 feet below the surface of the flood plain for a considerable distance above the canyon, but since there are many coarse bowlders in the flood plain material, it can not be handled to advantage by ordinary sluicing methods. It is expected that hydraulic work at this point will prove profitable.

The gravels contain a considerable variety of rock types, contrasting strongly in this respect with those of Slate Creek, Miller Gulch, and the upper Chesna. Such a contrast is of course to be expected, because the gravels of the latter streams are derived from limited areas within the small drainage basins of the creeks themselves, where few rock varieties are known, while to the gravels of the lower Chesna all the various types in the much larger Chesna Basin have contributed, and probably material has been brought from outside sources by glacial action.

The gold from the lower Chesna is much like that from Slate Creek and Miller Gulch in general appearance, but is finer and somewhat more uniform in grain. Nuggets are rare, but flakes one-eighth inch or more in diameter are abundant. An assay value of $18.72 per ounce is reported.

The developments have not yet determined fully the values to be won, but the gravels below the canyon are said to run from 1.7 to 5.5 cents per pan, with a maximum of $1 on bed rock. A small corner of Discovery claim, just at the head of the canyon, is reported to have yielded $1,000 as the result of a few weeks' work with a short string of sluices, so that the available gravels here, if carefully handled by hydraulic methods, should yield a good profit.

ORIGIN OF THE GOLD.

The coarsest gold of the Chistochina field is found in Miller Gulch, in Slate Creek, and at the head of the Chesna. That taken from the lower Chesna is finer in grain and has a higher assay value, although in other respects it resembles the product of the headwaters. It is therefore considered probable that all of the gold of the field has been distributed from the region about the sources of the producing streams, but there is a lack of unanimity as to the manner of its occurrence there.

Many operators very plausibly maintain that it is derived from the "round wash," which is particularly heavy about the head of Miller Gulch and Slate Creek. This deposit of cobbles is also present on the divide between Ruby Gulch and the stream next east, so that the advocates of this theory are able to prove that each stream at present worked to a profit drains an area in which the "round wash" is found. They likewise regard the smooth surface of the gold as evidence that it is waterworn and has therefore been brought, like the "round wash," from some extraneous source.

Some facts, however, are distinctly opposed to this hypothesis. Others seem to admit of as ready explanation on another basis.

A small stream on which a group of claims known as the "Big Four" has been staked heads opposite Miller Gulch and flows down to the Chistochina glacier. The heaviest deposit of the "round wash" known in the region occurs on the slopes drained by this brook, which seems therefore to be more favorably situated than Miller Gulch relative to this deposit as a source of gold; but the Big Four claims yield fine gold in moderate amount and are not to be compared in richness to Miller Gulch. Furthermore, Ruby Gulch and the creek next east of it seem to be equally favorably situated in relation to the deposit of the "wash" which occupies the divide between them, yet one has yielded operators a handsome return and the other is not profitable.

It is even more significant that the sources of the gold-bearing creeks are all within an area whose extent coincides with a region of local metamorphism in the Permian shales and that no other metamorphosed areas of these beds and no other gold districts within them are known. Where they have been metamorphosed an incipient cleavage is developed and the shales carry a few narrow quartz stringers. It is believed that the flat, smooth character of much of the gold is sufficiently accounted for by its origin in these shales and by its purity and consequent softness, which lead to a rapid smoothing and polishing with but little transportation.

It is therefore concluded that the gold originates in these Permian beds and that in its genesis it is related to the local metamorphism which they have

suffered. It is evidently post-Permian in age, and since Eocene beds deposited unconformably upon the Permian are but little folded and wholly unmetamorphosed it is probably also pre-Eocene.

INFLUENCE OF GLACIATION.

Ice has been an important and often disturbing agent in the distribution of the gold within the district. To this agent must be attributed the irregularities in depth of bed rock, the potholes which occasionally exist in the stream bed, and the changes in drainage which are to be inferred in many instances. The coarseness of the gold now found in the lower Chesna, if, as is believed, it has been derived from the district at the heads of the Chesna and of Slate Creek, is probably due in part to the action of the ice as a carrier. Furthermore, the canyon on the lower Chesna, with the short stretches above and below it within which bed rock is accessible, is no doubt due to the superposition of the stream, in the process of readjustment during the withdrawal of the ice from the lower Chesna Valley, upon the granite ridge through which the canyon is cut. To this agent again must be attributed the heterogeneous filling of the middle Chesna Valley and the burial of bed rock there beyond the reach of the miner.

ECONOMIC CONDITIONS.

One of the greatest difficulties which the prospector and later the operator have encountered in the Chistochina field is due to its remoteness from the source of supplies. Mining machinery and subsistence must be transported by trail from Valdes, a distance of 225 miles. The first prospectors reached the district in 1898 by sledding their outfits across the Valdes Glacier and down the Klutina to Copper Center, where they were transferred to boats after the ice had run out of the Copper, and laboriously tracked up the latter stream and the Chistochina. The greater part of the first year was thus occupied in reaching the field of operations. Since that time transportation facilities have improved, a very important element in this improvement being the construction of the military trail from Valdes to the interior by way of Thompson Pass. It is customary for operators now to take in their supplies in the late winter by sled over this trail to Copper Center and thence over the ice of the Copper and Chistochina rivers to the gold field. If additional supplies are required during the summer, they may be secured by pack train, a more costly method of transportation than sledding, but very much cheaper than the original plan of tracking and packing on men's backs. Even now, under the improved conditions, supplies in the Chistochina field sell for from 50 cents to $1 a pound, and labor is proportionately high, the usual wage being $90 per month, subsistence and lodging furnished, or $1 to $1.25 an hour, the laborer supplying his own food

and shelter. These conditions mean, of course, that only high-grade properties can be operated.

Another condition which tends to raise the cost of production in the region is the absence of wood on the upper Chesna and on Slate Creek and Miller Gulch. These streams lie well above timber line, and wood, for whatever purpose desired, must be hauled from the nearest timber, 5 or 10 miles distant. This work is accomplished in the early spring over the snow, before it is possible to begin mining operations, but with the high wages that prevail this increases considerably the cost of living. On the lower Chesna there is sufficient timber for all present needs.

The length of the working season is rather short on the upper creeks, where the water freezes in the sluice boxes usually by September 15 or 20, and it is sometimes as late as July before the snow is melted from the upper portions of the gulches, so that a working period of not more than three months is to be counted upon for this part of the district. Here again the lower Chesna is more favorably situated, since the fall freezing is delayed for two or three weeks and the snow melts away earlier in the spring.

DELTA RIVER DISTRICT.[a]

In July, 1900, two prospectors, Mr. Blix and Mr. Torgerson, started from Chesna River with three pack animals and worked westward to the head of Delta River, prospecting as they went. They found colors generally on the stream bars, and what they regarded as fair prospects on Wilder Creek, or, as they called it, Rainy Creek.

After the return of these men to the Chesna a larger party was outfitted and, returning to the region, organized the Eureka mining district.

In the following spring (1901), from 200 to 250 people entered the new district and 20 or 30 of them began sluicing, but the results being unsatisfactory the field was abandoned.

NIZINA GOLD FIELD.

In June and July, 1902, reports reached Valdez to the effect that coarse gold had been found on the upper Nizina. The reports were sufficiently definite to cause considerable excitement in the town, and many who were free to go promptly stampeded to the new district, only to find that through the abuse of the power of attorney practically all of the available property had been staked.

The Nizina field (fig. 5) includes the drainage basins of three southeast tributaries of the upper Nizina River—Young Creek, Chititu Creek, and Dan Creek.

[a] Information concerning the Delta River stampede has been furnished by Mr. R. Blix, of Copper Center.

The stream first staked and the one for whose richness most definite claims have been made is Chititu Creek, a small stream 10 or 12 miles long, which flows into the Nizina 20 miles above its mouth. It has two main branches, known as Rex

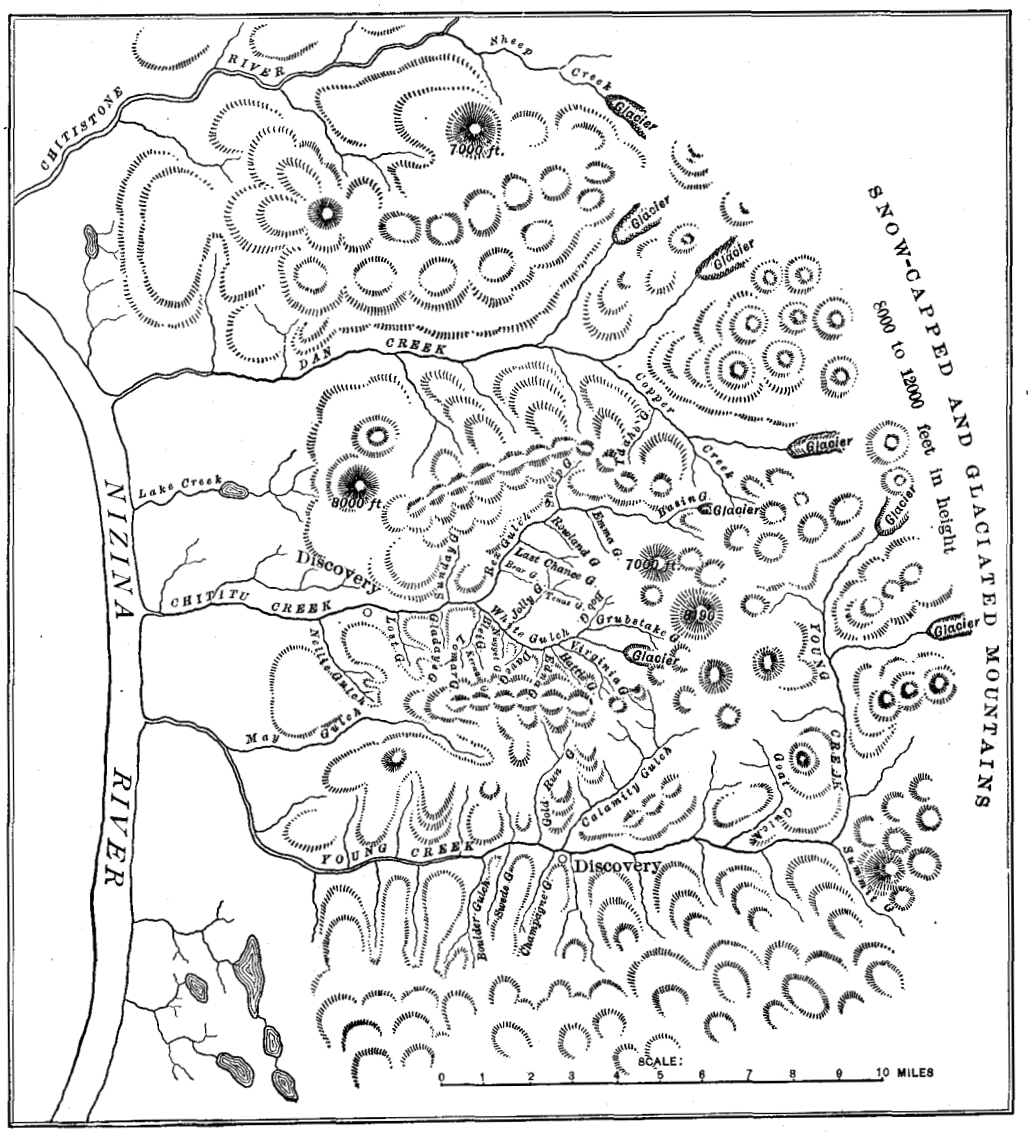


FIG. 5.—Sketch map of Nizina gold field, reduced from map by Geo. M. Esterly.

Gulch and White Gulch, which unite at the Forks to form the Chititu proper. Many minor tributaries have been staked and named by prospectors.

Dan Creek empties into the Nizina about 4 miles above the mouth of Chititu Creek. It rises among the high peaks east of the Nizina, whose glaciers are

tributary to the Chitistone River, to Young Creek, and to the upper Chitina. It is reported to carry a somewhat greater volume of water than the Chititu and to flow throughout the greater part of its course in a steep-walled canyon, so that during high water no work can be done along it.

Young Creek is considerably the largest of the three streams, and its crescent-shaped basin surrounds that of Chititu Creek on the east, south, and west. Calamity Gulch and Gold Run are among the tributaries of Young Creek most frequently mentioned. These flow south from the ridge whose north slope is drained by branches of White Gulch, one of the forks of Chititu Creek.

The rocks throughout the greater part of the district are reported by Schrader and Spencer to be the black shales and thin limestones of the Triassic, but in the northern part of the basin of Dan Creek the Nikolai greenstone and the overlying heavy-bedded Chitistone limestones outcrop. There is a doubtful region about the head of Young Creek where these older rocks may also be found.

The black Triassic shales are reported to be intruded in this region, as they are known to be in other localities, by abundant porphyritic dikes, and the gold may be found to be genetically connected with these intrusives.

Although the district was staked early in 1902, but little work, except hasty preliminary prospecting, seems to have been done in it during the summer. It is reported that only one short string of sluice boxes was in use, so that, although there can be no doubt that gold is present, the richness and extent of the deposits have yet to be proved.

The earliest and most definite reports are from Chititu Creek and its tributaries. The gravel is said to be from 2½ to 5 feet deep on this creek in the vicinity of the Forks, and to be free from large bowlders. The creek bottom is from 100 to 200 yards wide and water is plentiful. The gold which has been brought out is flat and is bright yellow in color, much resembling that of Chesna River, but somewhat cleaner looking.

The district may be reached by following the McClellan trail from the Copper at the mouth of the Tonsina nearly to the Nikolai mine, and then turning southward across the flats to the Nizina, which is crossed near the mouth of Chititu Creek. A southern route from Taral by way of Hanagita Valley is also available.

The region is abundantly supplied with timber for the building of cabins or the construction of sluices, and, in the upper courses of the streams, at least, abundant fall exists to carry off the tailings. In the present embryonic state of development it is not possible to predict with any definiteness the future of these creeks as gold producers. It is thought, however, that a district may be created here which will yield as well as the Chistochina. More than this is scarcely to be expected.

BREMNER DISTRICT.[a]

During the late summer of 1901, a party of seven prospectors from Valdes reached the head of Bremner River by way of Lowe River, Marshall Pass, and the Tasnuna. Pack animals were used for the first part of the trip, but these were abandoned 15 miles above the mouth of the Tasnuna, and boats were used from this point to the forks of the Bremner.

The prospects found in 1901 were deemed promising enough to justify further work, and supplies were taken in over the snow during the winter and spring of 1902, but when news of the Nizina strike reached the camp the majority of the prospectors there joined the stampede to the new field.

The Bremner is reported to be nearly 50 miles long, and to be navigable with difficulty by small boats to the forks, 25 miles above the mouth. Below the forks there is one canyon 3 miles in length, and the north branch issues at the forks from another, 9 miles in length and obstructed by several small falls. Above this obstruction the valley spreads out to a width of about 2 miles. The stream rises in a glacier, which is also the source of a branch of the Tana.

Golconda Creek, on which several claims have been staked, is a tributary of the North Fork. It is about 10 miles long and flows for the lower 2½ miles through a rough gorge. Near its headwaters, on two claims, No. 4 above on Golconda Creek and No. 1 above on Summit Creek, some work has been done, and it is reported that a small hydraulic plant will be taken in during the winter (1902–3) for work during the summer of 1903.

The region has been intensely glaciated, and as a consequence rock benches are found from 10 to 40 feet above the level of the creek, and some pay has been found on these. A few thousand dollars are reported to have been taken from the claims.

TIEKEL AND TONSINA DISTRICT.

The following statement concerning the Fall Creek and Quartz Creek placers is quoted from the report of Messrs. Schrader and Spencer, written in 1901.[b]

"*Fall Creek.*—Gold was discovered on Fall Creek, near the head of Kanata River, in 1898. It is estimated that $500 was produced during the summer of 1899. The diggings begin about a mile above Kanata River and extend for 5 or 6 miles up the creek. The gravels are from a few feet to 600 feet in thickness, and from their mode of occurrence are supposed to be of glacial origin. From these gravels the gold has been concentrated by the action of running water and is found where bed rock can be reached. Some of the gold is coarse, nuggets having been found up to $5 or $6 in value. It is hardly probable that the Fall Creek placers will ever become important producers.

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[a] The writers are indebted to Mr. Ralph Wheaton for information concerning this field.

[b] The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, 1901, p. 90.

"*Quartz Creek.*—Gold was discovered in the tributaries of Tonsina River in 1898, and assessment work has been done on a few claims each year since. The origin of the gold is probably similar to that suggested for the deposits of Fall Creek. The entire production of the creek to date [March, 1901] is probably not in excess of $1,200."

Since this account was written, practically no work has been done in these localities, the rich gold camps of the interior and the copper deposits of the Nizina attracting prospectors from these more readily accessible but low-grade diggings. With the further economic development of the country, however, work on a small scale may be resumed here.

OTHER MINERALS.

SILVER.

Silver has been reported from Chititu Creek, where it is said to occur native. According to the accounts, it is caught in sluice boxes with nuggets of copper. The writers have seen no specimens of this native silver, but the reports as to its occurrence are so circumstantial as to lead to the conclusion that they are worthy of credence.

PLATINUM.

Since 1899, reports have been persistently circulated to the effect that platinum in considerable quantities exists in the gravels of the Nadina River. In some cases most extravagant claims have been made, a St. Louis company professing to have tested sands that yielded over $29,000 per ton in platinum and a few dollars in gold. Another company, with headquarters at Chicago, advanced more modest claims, to the effect that from $100 to $135 in platinum was contained in a ton of screened sand, and that gold values of $16 to $20 were yielded by the same material.

The Nadina River, where this platinum is supposed to have been found, rises in a glacier which flows from the precipitous amphitheater that forms the southern side of Mount Drum (Pl. I, *B*). This glacier is about 8 or 9 miles long, and from its southern end several small streams flow. These unite presently, forming the Nadina River, which joins the Copper about 16 miles from the lower end of the glacier. Throughout the upper 4 or 5 miles of the Nadina Valley the stream is overloaded and its valley is of the filled type. Below this upper portion it has cut into the Pleistocene terrane of the Copper River Valley, the gorge deepening toward the Copper. Platinum claims have been staked along the Nadina from its mouth to the foot of the glacier, and even up over the glacier and along the lateral valleys. The most active prospecting, however, has been carried on throughout the stretch extending 4 or 5 miles

down stream from the foot of the glacier. Cabins have been built along this stretch, and shafts have been sunk at various places, one to a reported depth of 67 feet, but bed rock is not reached, and the depth to it is entirely problematical, for the valley of the Nadina is incised in unconsolidated Pleistocene deposits of uncertain but probably considerable thickness. No rock that is certainly in place is encountered below a point 5 or 6 miles above the foot of the glacier.

The rocks that are represented in the recent Nadina gravels are derived almost exclusively from Mount Drum itself, and represent various phases of andesitic lavas and the tuffs which are associated with them, all entirely unaltered. An occasional bowlder of basalt, as fresh as the andesites, and here and there a pebble of some schistose or calcareous type, derived from the valley walls of heterogeneous Pleistocene wash, is found mingled with the andesitic gravel. Samples of pan concentrates were taken with care at various points along the Nadina Valley, both from the stream deposits and from the Pleistocene material forming the valley walls. These were submitted to Dr. E. T. Allen, of the Survey laboratory, for assay, and he reports that neither gold nor platinum is present, at least in commercial quantities. Pannings from the material thrown out of the various shafts yielded the same results, and not a single color of either of the precious metals was found at any time during the summer.

Platinum is usually associated with peridotites or other basic eruptive rocks, but has been reported in a few instances from gold-bearing veins and in others from certain copper minerals. It is not to be expected in wholly unaltered stratified rocks or in fresh effusive igneous rocks of andesitic character. Theoretically, then, the conditions in the Nadina Valley are not such as to indicate platinum. Practically all the tests made by the writers support this theoretical conclusion. The opinion is forced upon one that the assay returns which have led prospectors to believe that platinum exists in commercial quantities in the region, and have furnished a basis for the organization of companies to exploit the reputed deposits must have been faulty. We do not believe that the metal, beyond possible occasional traces, exists in the Nadina field.

TIN.

Tin has been reported at various times from different parts of Alaska, and the Copper River field has yielded its share of these reports. As early as 1899 tin deposits were reported from Surprise Creek, on the upper Kotsina, but subsequent work has failed to confirm these reports. In 1902 similar circumstantial accounts of the finding of tin ore from the upper Chetaslina Basin were circulated in Valdez. Samples of the rock that was supposed to carry the tin were collected by the writers and submitted to assay tests, but proved not to carry the metal.

Other specimens, submitted by Mr. A. W. Tibbitts, were subjected to similar tests with the same result, and although massive rocks, granitic or dioritic in character, somewhat veined and affected more or less by mechanical alteration exist in the region, they have not been proved to be tin bearing.

MERCURY.

The sluice boxes in Miller Gulch catch small fragments of a soft, red mineral, which proved to be cinnabar, the sulphide of mercury. It has not thus far been reported from any other section of the Copper Basin.

OSMIRIDIUM.

The Miller Gulch sluice boxes catch occasional scales of a hard, silver-white metal, which proves, when tested, to be a compound of osmium and iridium.

IRON.

Nabesna region.—It has been noted that rocks of the diabase series have magnetite freely disseminated through them. Furthermore, in the mountains on the east side of the Nabesna, between Bond Creek and the head of Camp Creek, along the contact between the intrusive diabase and the Nabesna limestone deposits of magnetic iron ore are of common occurrence. These vary from mere films to deposits 2 or more feet thick. They are confined strictly to the contact, where they are found still adhering to the limestone after the diabase has broken down or weathered away.

The largest of these deposits seen by us is at an elevation of about 6,000 feet. Though the mountain slope is steep at this locality, the deposit is easily accessible. It is a ledge 2½ feet thick, which is exposed for a distance of about 40 feet. It trends nearly east and west, and dips 80° N., hence is nearly vertical. The outcrop rises several feet above the surface, very plainly showing the ore adhering to the limestone country rock, while on the opposite side the intruded diabase has become detached and broken down. The 40 feet exposed give no measure of the extent of the ledge, for it shows no signs of decrease in thickness either at the lower end of the exposure, where it disappears beneath the talus, or at the upper end, where it is cut off by a fault. In the talus below are pieces of ore several inches to a foot in diameter.

The fact that the diabase is intrusive, that it is known to be rich in magnetite, and that there is but little gangue of any kind in the deposit, considered in connection with the cleanness, sharpness, and regularity of the contact with the limestone, leads naturally to the inference that the iron ore represents a magmatic segregation in the diabase. If it were a replacement deposit, one would expect

to find an irregular contact with pockets and irregular bodies of the ore extending into the limestone.

The ore examined consists of almost pure magnetite. It contains no copper, titanite, or other minerals. On a freshly fractured surface much of it has a steel-blue color, but when weathered it is iron black.

Gakona-Chistochina region.—The moraines of the eastern tributaries of the Gakona Glacier and the western tributaries of the West Fork Glacier contain quantities of a coarse-grained igneous rock consisting of large crystals of hornblende, basic feldspar, and magnetite. Fragments of the latter ore, as much as 4 inches in diameter, may occasionally be picked up. They probably represent a marginal facies of the coarse intrusive with which they are associated, and are to be sought in place among the ice fields high up on the ridge between the Gakona and the Chistochina drainages. It is not expected that they will ever have any practical value.

COAL.

Chistochina River.—Within 1½ miles of the head of the Chesna, along the north wall of the valley, from 600 to 700 feet above the stream, there is an outcrop of soft, greenish and buff shales with loose sandstone and fine conglomerates, the shales frequently exhibiting imperfect plant impressions. These beds strike about parallel with the Permian shales with which they are infolded, but have very much lower dips to the north, and are regarded as having been unconformably deposited on the older rocks. Fragments of glossy lignite showing conchoidal fracture were gathered from the gully below these outcrops and submitted to Mr. E. T. Allen for analysis. He reports:

Analysis of lignite from Chistochina River.

	Per cent.
Water	15.91
Volatile combustible matter	60.35
Fixed carbon	19.46
Ash	4.28

Fuel ratio, 0.32.

These constituents indicate a typical lignite of medium grade. The coal was collected by some of the Slate Creek miners and used in the forge for blacksmithing purposes. They report favorably upon its qualities as a fuel.

One-third of a mile below the mouth of Miller Gulch, along the bluffs of Slate Creek, there are imperfect exposures of coarse and fine sandstones and shales, containing plant impressions, and in the bed of the creek on the California claim an outcrop of coal has been exposed by mining operations. A few bushels of the fuel were mined and used locally with gratifying results. At the time of

our visit the outcrop had been covered and the thickness of the bed could not be measured.

Gakona River.—The area between the head of the Gakona and the west fork of the Chistochina is occupied almost entirely by Miocene or Eocene clay and sand beds, with occasional thin conglomerates. The clays are well consolidated, locally becoming shales. They are usually blue, but are sometimes yellowish and iron-stained, and occasionally carry fragments of fossil leaves. Lignite occurs sparingly throughout this formation, generally as single trunks in the conglomerate or finer arenaceous beds. The woody fiber and structure are well preserved in the flattened trunks, which are often still flexible even when dry. Although the lignite is widely distributed throughout the Tertiary area, and all streams flowing from it contain the coaly float, no deposits were seen that possess any actual or prospective value as fuel.

White River.—Though coal has been reported by prospectors in considerable quantity on White River, between the head of the Attul and the mouth of the Donjek, nothing more definite can be stated concerning it than that, judging from what is known of the rocks in the Nutzotin Mountains to the south of the region in question, the coal is probably of Mesozoic age. The Mesozoic coals of the Territory are generally of higher grade than those of Tertiary age, sometimes proving to be bituminous and of good quality, so that fuels of value may be found in the White River area. It should be stated, however, that carbonaceous shales and possibly coal are found associated with the Permian. They probably have no fuel value.

Tazlina River.—In 1898 one of the writers described thin beds of coal which occur in the bluffs of Bubb Creek, one of the principal tributaries of the Tazlina, and the character of the formations about the head of this stream and in the adjacent portions of the Chugach and Talkeet mountains is such that it is believed that coals will be found here if a sufficiently urgent demand should arise to encourage a search for it.

Chitistone River.—During the summer of 1902 prospectors brought to Valdez from the upper Chitistone blocks of dark-gray coal which has some of the physical and chemical characteristics of cannel. It is reported to occur in the shales of the Triassic or Jura-Cretaceous formations and to exist in considerable bodies. A proximate analysis by Mr. E. T. Allen of the Survey laboratory yielded results as follows:

Analysis of coal from upper Chitistone River.

	Per cent.
Water	1.65
Volatile combustible matter	51.60
Fixed carbon	40.75
Ash	6.10

Fuel ratio, .79+.

The deposit has not as yet been examined by any of the geologists of the Survey, but its reported occurrence in rocks older than the Eocene, the usual lignite-bearing formation of Alaska, and its analysis, together indicate a fuel of unusually good quality for the Territory.

Cheshnina River.—Along the middle part of the Cheshnina, near the upper end of the gorge in which the lower portion of that stream flows, outcrops of soft, friable sandstones and conglomerates, dipping 20° or 30° downstream, were examined during the summer of 1902. These sediments are similar in character to the rocks of upper Eocene age which are so abundantly distributed throughout the Territory and are so frequently coal bearing. Furthermore, prospectors report having found coal in this vicinity. No details as to bed sections are available.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Professional Paper No. 15.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the twenty-fifth in Series A and the thirtieth in Series B, the complete lists of which follow. (B=Bulletin, PP=Professional Paper, WS=Water-Supply Paper.)

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