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COPPER DEPOSITS OF THE KOTSINA-KUSKULANA DISTRICT ALASKA

BY

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WITH AN INTRODUCTION BY
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INTRODUCTION

COPPER DEPOSITS OF THE CHITINA VALLEY

By Fred H. Moffit

Copper was known in the Copper River region, which includes the Chitina Valley, from the days of the early Russian exploration along the Pacific Coast of Alaska, but it was not the object of special search until the days of the gold stampede in 1898. Exploration in the Copper River drainage basin begun in that year led to the discovery in 1900 of the bonanza ore body of the Kennecott mine and to many other mines and prospects throughout the area.

In early days the principal route of approach to the mining camps of the Chitina Valley was a branch of the military trail from Valdez to Eagle on the Yukon River. This branch left the Eagle Trail, now a part of the Richardson Highway, at Upper Tonsina, crossed the Copper River a short distance above the mouth of the Tonsina River, and skirted the south slopes of the Wrangell Mountains. This was the trail commonly used in summer; travel shifted to the ice of the Tonsina, Copper, and Chitina Rivers in winter. After the completion of the Copper River & Northwestern Railway in 1911 the trail through the Chitina Valley was practically deserted, and transportation was by rail, supplemented to a certain extent by the airplane, until 1938 when operations at the Kennecott mine were ended and the railroad was abandoned. At present (1943) the usual route of travel to points in the Chitina Valley is the Richardson Highway and one of its branches leading to the town of Chitina on the west side of the Copper River opposite the mouth of the Chitina River. At Chitina it is necessary to use a boat or an aerial tram to cross the Copper River, for the railroad bridge has been washed out. East of the river the tracks of the railroad are still in place and are used for hauling freight and passengers by gas-driven motor car, although not without difficulties caused by landslides and especially by the washing out of the Kennicott River bridge in 1943.

The copper-bearing rocks of the Chitina Valley are exposed for the most part on the north side of the valley, in the south slopes of the Wrangell Mountains, and extend eastward from the Kotsina River to Glacier and Young Creeks, a distance of approximately 75 miles. The

rocks of the copper belt are mostly bedded, this term being used here to include lava flows as well as sedimentary beds. The oldest known rocks, those of the Strelna formation of Mississippian age, consist chiefly of schist and slate, locally associated with altered limestone, tuffaceous beds, and lava flows. They are not of particular importance in connection with the copper deposits, although copper minerals have been found in them. They are overlain, probably unconformably, by a great thickness, at least 5,000 feet, of basaltic lavas long known as the Nikolai greenstone. The Nikolai greenstone is in part, if not wholly, of Permian age and is overlain, with structural conformity so far as is known, by the Chitistone and Nizina limestones of Upper Triassic age. The limestone formations are approximately 3,000 feet thick. The Nikolai greenstone and the Chitistone limestone are the host rocks of all the best-known copper deposits. They are overlain by Jurassic and Cretaceous sedimentary rocks, including shale, sandstone, and conglomerate, which for the purposes of this report need no further description. All the bedded rocks have been folded, faulted, and intruded by igneous rocks of different types and ages. The general geology of the region has been described elsewhere by the writer.[1]

Copper and copper-bearing minerals commonly associated with one or more sulfides of other metals have been found in many places in the Nikolai greenstone, but all the known large deposits were in the lower part of the Chitistone limestone. The deposits are distributed in two principal districts, the Kotsina-Kuskulana on the west and the Nizina on the east, and are separated by an area in which evidences of copper are less common.

[1] Moffit, F. H., Geology of the Chitina Valley and adjacent area, Alaska: U. S. Geol. Survey Bull. 894, 1938.

COPPER DEPOSITS OF THE KOTSINA-KUSKULANA DISTRICT, ALASKA

By Ralph E. Van Alstine and Robert F. Black

ABSTRACT

The Kotsina-Kuskulana district of the Copper River region is between the Chitina River and the crest of the Wrangell Mountains. The principal prospects are those on Copper Creek, Clear Creek, Nugget Creek, MacDougall Creek, Berg Creek, and Elliott Creek and the Big Horn and Pierson prospects. A brief description of the location, stratigraphy, geologic structure, and mineralogy is given for each prospect. Detailed maps of the accessible underground workings at Copper Creek and Clear Creek are included.

The prospects are in the Nikolai greenstone and to a less extent in the overlying Chitistone limestone. No large or high-grade deposits of copper ore are known. Two carloads of hand-sorted material and 160 tons of concentrates from Nugget Creek constitute the total shipments of copper ore from the district.

LOCATION AND GENERAL GEOLOGY

The Kotsina-Kuskulana district is between the Chitina River and the crest of the Wrangell Mountains. (See fig. 20.) Extensive prospecting has been carried on in this district. The prospects are in the Nikolai greenstone and to a less extent in the overlying Chitistone limestone, and are near intrusions of diorite and quartz diorite. The copper deposits are in zones of highly faulted or jointed rock and form irregular replacement bodies, disseminations, or veins. The copper-bearing minerals are chalcocite, bornite, enargite, chalcopyrite, covellite, malachite, and azurite. The gangue minerals are chiefly quartz, calcite, and chlorite. No large or high-grade deposits of copper ore have been discovered.

The prospects examined during the field season of 1943 are described on the following pages in some detail, with regard to location, stratigraphy, geologic structure, and mineralogy.

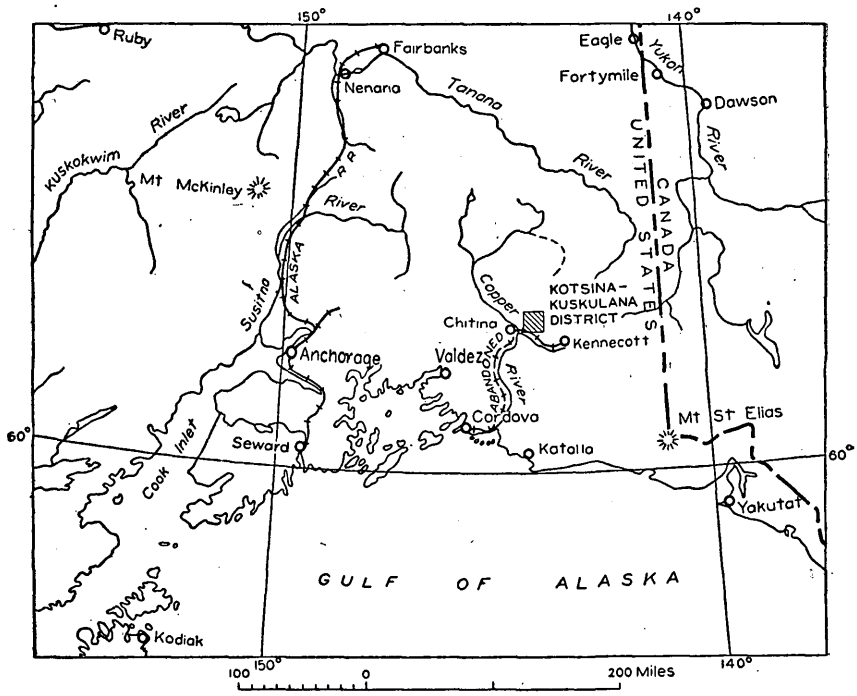

FIGURE 20.—Sketch map of Alaska, showing the location of the Kotsina-Kuskulana district.

COPPER CREEK

Copper prospects on several forks of Copper Creek are from 2½ to 4 miles upstream from the place where this creek empties into the Kotsina River. (See pl. 30.)

A trail from Strelna, an abandoned town on the former Copper River & Northwestern Railway, to Copper Creek by way of Dixie Pass is best for reaching the copper prospects, because bridges across the Kotsina River no longer exist. The distance from Strelna to Copper Creek by this route is about 20 miles and can be covered in 3 days by a pack train. It was necessary to recut and regrade parts of the trail in 1943. In late June travel with horses was difficult across some of the snow-filled canyons near the head of Rock Creek.

GEOLOGY

The copper prospects on Copper Creek are in areas of rugged topography and are near the contact of the Nikolai greenstone and the overlying Chitistone limestone. These rocks are extensively folded and faulted. The adits and prospect pits are on the northeast limb of a large syncline and southwest of a major thrust fault along which the greenstone and limestone were forced northeastward against

younger Triassic limestones and shales.[2] The Chitistone limestone here strikes north and dips 45° W. Small dikes of highly altered diorite cut the Nikolai greenstone and the Chitistone limestone in the Mullen No. 1 adit.

COPPER PROSPECTS

The branches of Copper Creek from west to east are known as Copper Creek, Middle Fork, and East Fork, and the deposits on these streams are discussed in that order. As far as is known, all of the claims but the Mullen group are owned by the estate of Adolph Ammann. The Mullen group of three claims was the property of the Galena Bay Mining Co., but is now held by the Copper Creek Copper Mining Co. Charles Simenstad, mining engineer of Seattle, was in charge of operations for the latter company. This company discontinued work at Copper Creek in 1928 and it is believed that no prospecting has been done there since.

The Ammann prospect is in the Chitistone limestone, and the Mullen and Bunker Hill prospects are partly in this limestone. All other prospects are in the Nikolai greenstone. The accessible underground workings at Copper Creek, representing a total of about 1,775 feet, were mapped in 1943 with an open-sight alidade and steel tape on a scale of 1 inch to 50 feet.

None of the prospects examined, except perhaps the Mullen, appears to contain significant deposits of copper ore.

AMMANN PROSPECT

The Ammann prospect is at an altitude of about 3,800 feet on the divide between Copper Creek and a small tributary stream from the southwest. (See pl. 30, prospect 1.) The workings are about 1,000 feet southwest of the camp site at the forks; they consist of a lower adit about 580 feet long and an upper adit about 25 feet long. The underground work was done since 1914.

The main adit was driven S. 32° W. for 473 feet and then S. 17° E. for 111 feet. The timbering and track extend for about 55 feet in the adit. The adit is in the Chitistone limestone on the nose of a small anticline. Near the portal the limestone strikes N. 75° E. and dips 75° N., but near the face it strikes N. 28° E. and dips 65° W. At the portal and at the face the limestone is cut by a few irregular veinlets of malachite, azurite, and calcite. These veinlets are less than a quarter of an inch thick and are discontinuous. Elsewhere in the adit only small quantities of the copper minerals are present.

[2] Moffit, F. H., and Mertie, J. B., Jr., The Kotsina-Kuskulana district, Alaska: U. S. Geol. Survey Bull. 745, pp. 101–104, 1923.

The upper adit is on the slope about 100 feet above the main adit and is also in the Chitistone limestone. The adit trends S. 5° E. for 25 feet to the face. No copper minerals appear in this adit. It was apparently driven to undercut a discontinuous mineralized zone in the limestone which crops out about 25 feet above the portal. In this outcrop a mineralized breccia zone 2 to 6 inches thick strikes east and dips about 45° S. A polished section of a selected specimen from the breccia zone contains quartz, pyrite, bornite, chalcopyrite, chalcocite, covellite, malachite, and azurite, named in paragenetic order starting with the earliest.

MULLEN PROSPECT

Extensive underground prospecting has been done on some veins of copper-bearing minerals at the Mullen prospect. This prospect is on the west side of Copper Creek at an altitude of about 3,700 feet. (See pl. 30, prospect 2.) The trail from the Kotsina River to the Mullen claims is in fair condition, although the bridge across Copper Creek, downstream from the lower fork, is not usable. The trail reaches timberline at an altitude of about 2,600 feet. A telephone line, for the most part on the ground, follows this trail from the main camp in the Kotsina valley to the upper camp of the Mullen claims.

PREVIOUS WORK AND GEOLOGIC FINDINGS

The lower or main camp was east of the junction of Copper Creek and the Kotsina River. The camp consisted of sawmill, engine house, stable, blacksmith shop, garage, bunkhouse, bath house, warehouse, office, mess hall, assay office, and three storehouses.

The upper camp was at an altitude of approximately 3,500 feet, and about 500 feet upstream from the junction of Copper Creek and a small tributary creek. The camp consisted of three bunkhouses, mess hall, and bath house. The workings are about 700 feet southwest of this camp.

An open cut and two adits with drifts, crosscuts, and inclined shafts (see fig. 21) are near the base of a cliff of Chitistone limestone. The length of the underground workings is 800 feet, exclusive of two inclined shafts of unknown depth, and possible flooded workings on lower levels.

A compressor house and a tool shop are at the portal of the Mullen No. 1 adit. This adit has track in all the drifts except the one extending northeast from station 10. A compressed-air line and galvanized blower pipe are in most of the underground workings.

The Chitistone limestone is exposed in a large part of the workings, but the Nikolai greenstone is exposed near the southern end of several crosscuts. Small bodies of diorite are present at the contact of these

two formations and are also intrusive into them. The diorite is a highly altered medium-grained granitoid rock, commonly of lighter color than the altered basalts of the greenstone. A thin section shows that the original feldspars and other minerals of the diorite are completely altered to chlorite, calcite, talc, leucoxene, quartz and pyrite. Faults are abundant and are especially conspicuous near the bodies of diorite.

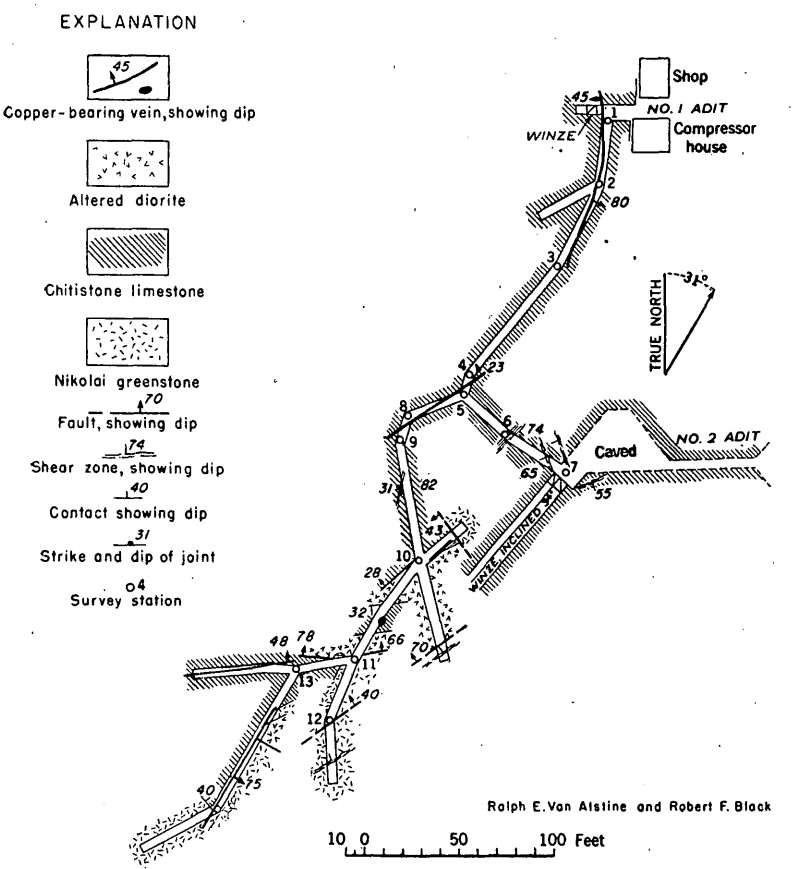

FIGURE 21.—Mullen prospect, Copper Creek.

Several drifts and crosscuts follow both mineralized and barren faults that strike northeast. Near the portal and opposite station 1 of No. 1 adit (see fig. 21) a vein of calcite and copper minerals follows a slickensided fault zone in the limestone. The vein strikes N. 10° W., dips 45° W., and ranges in thickness from half an inch to 4 inches. Calcite and malachite are the chief constituents of this vein, but other minerals, named in decreasing order of abundance, are limonite, azurite, bornite, and pyrite. At station 2 the vein is 2 to 8 inches thick and dips 80° E. The vein bears away from the drift at a point

36 feet south of station 2. Near station 1 an inclined winze, now filled with water, was apparently sunk on this vein.

A second vein of calcite and quartz contains abundant bornite, chalcopyrite, and malachite, and follows the southeast wall of a short drift northeast of station 10. (See fig. 21.) A polished section of a specimen from this vein shows covellite and a little chalcocite and pyrite, in addition to bornite, chalcopyrite, and malachite. The paragenetic sequence of the sulfide minerals is pyrite, bornite, chalcopyrite, and covellite. The vein follows the contact of diorite and limestone but cannot be traced for more than 18 feet along the strike. In this distance it ranges in thickness from a few inches to 1 foot.

The inclined winze near station 7 probably was intended to explore this lens of sulfide minerals at a lower level. The winze is filled with water below a point 85 feet down the incline from station 7. Below this level flooded workings may exist, but the small size of the mine dump precludes the existence of any extensive flooded workings. No copper sulfide minerals were found in the accessible part of this winze.

Copper sulfide minerals were seen underground in two other places. On the southeast wall 37 feet southwest of station 10, bornite, chalcopyrite, malachite, and calcite form a small irregular bunch about 6 inches thick. A vein of calcite, quartz, chalcopyrite, covellite, and malachite occurs in the drift west of station 13. A polished section of a specimen from this vein shows a few grains of pyrite and numerous laths of covellite along cleavage planes in chalcopyrite. The paragenetic sequence is calcite and quartz, pyrite, chalcopyrite, and covellite. The vein follows the north wall for 26 feet and in this distance ranges in thickness from 2 to 6 inches.

At several places in the underground workings, tiny veinlets of calcite, malachite, and azurite appear along fault surfaces and shear zones, but they are too small and too scarce to be of economic interest.

Most of No. 2 adit (see fig. 21) is caved, and timber along the accessible part prevents examination of the walls.

About 120 feet west of the portal of No. 2 adit and on the hillside above, a small open cut exposes some copper-bearing minerals. The limestone is cut by numerous faults, is brecciated, and is cemented with calcite, pyrite, bornite, chalcopyrite, covellite, limonite, malachite, and azurite. Polished sections of material from this open cut show that the chalcopyrite contains abundant covellite and tiny irregular grains of pyrite and bornite. Many laths of covellite are oriented along cleavage planes of the chalcopyrite, and veinlets of covellite cut all other sulfide minerals. In the outcrop the copper minerals are very sparsely distributed and are almost entirely restricted to minute seams in the limestone. An irregular zone with abundant copper stains is about 3 feet thick at one place, but it branches in many directions into

seams about a quarter of an inch thick. Possibly No. 2 adit was intended to undercut this zone.

RESERVES

Two veins of copper minerals and the adjacent wall rocks in the Mullen No. 1 adit, where most of the underground exploration has been done, appear significant enough to justify an estimation of reserves.

The first of these veins is near the portal. (See fig. 21.) A 5-foot channel sample cut at station 1 across the adit, including the vein, contains 1.55 percent of copper, and no gold or silver.[3] The vein is exposed for a length of 76 feet in the drift. A shaft sunk on this vein is now filled with water, so that the vertical extent of the vein is unknown. It is assumed that the depth of the vein is 38 feet, or half of the exposed length. The thickness is taken as 5 feet, the length of the channel sample that was cut across the drift on the vein. The volume of a mineralized body of these dimensions is 14,440 cubic feet. The specific gravity of the material, including limestone and vein material, is about 2.8. It is calculated that 1,263 tons of indicated ore are represented by this volume. The copper content of this tonnage is considered to be 1.55 percent.

The second copper vein of possible significance is the one in the short drift northeast of station 10. (See fig. 21.) A 4-foot channel sample cut across the vein and the mineralized wall rocks 8 feet northeast of station 10 contains 5.82 percent of copper, a trace of gold, and 0.28 ounces of silver to the ton.[4] The vein is exposed in the drift for a length of 18 feet. A depth of 9 feet, or half of this length, is assumed. The thickness is taken as 4 feet, which is the length of the channel sample cut across the drift on the vein. The volume of an ore body of these dimensions is 648 cubic feet. The specific gravity of the material, composed of the vein, limestone, and altered diorite, is about 2.9. It is calculated that this volume represents 59 tons of indicated ore. The analysis of the 4-foot channel sample, as given above, is considered representative of the grade of this tonnage.

CAVE PROSPECT

The Cave prospect is on the west side of Copper Creek at an altitude of about 4,300 feet. (See pl. 30, prospect 3.) It is nearly a third of a mile S. 19° W. from the Mullen No. 1 adit. The development work consists of an adit 223 feet long which trends S. 88° W. in the Nikolai greenstone. The portal is about 30 feet below the contact of the greenstone and the overlying Chitistone limestone, but the exact contact is not exposed. The limestone strikes N. 40° W. and dips 25° SW.

[3] Cress, S. H., analyst, U. S. Geological Survey.
[4] Cress, S. H., analyst, U. S. Geological Survey.

The only mineralized zone in the adit is 23 feet from the portal. A shear zone 2 to 12 inches thick contains sheared greenstone, quartz, malachite, bornite, and a little chalcopyrite. About half the zone is quartz and greenstone. The zone strikes N. 14° W. and dips 7° W. A prominent shear zone 4 feet thick is exposed in the north wall of the adit 87 feet from the portal. This zone strikes N. 65° E., dips 55° SE., and is cut by many veinlets of quartz and calcite. Other unmineralized shear zones are exposed in the adit.

On the surface near the portal a few grains of chalcopyrite were found in a specimen of greenstone. In the limestone above the portal, films of azurite and malachite coat the faces of a few joints.

PEACOCK PROSPECT

The Peacock prospect is on the east side of Copper Creek and opposite the Cave prospect. (See pl. 30, prospect 4.) A short adit in amygdaloidal greenstone is at an altitude of about 4,100 feet and about 200 feet below the Chitistone limestone. The adit trends S. 81° E. and is caved beyond a point 40 feet from the portal. Some specimens of greenstone from the adit, from the dump, and from outcrops near the portal contain a few small grains and veinlets of pyrite, bornite, and chalcocite. The maximum thickness of the veinlets is 1 inch. In a few places malachite and azurite stain the surface of the greenstone.

The greenstone is brecciated above the adit and about 300 feet northeast of it in a small open cut about 75 feet below the contact with the limestone. The breccia is cemented with calcite, epidote, and bornite. One seam of bornite and calcite has a maximum thickness of 2 inches.

MOUNTAIN SHEEP PROSPECT

The Mountain Sheep prospect is on the west side of the Middle Fork of Copper Creek and just over the top of the ridge from the Peacock claim. (See pl. 30, prospect 5.) An adit at an altitude of about 4,900 feet and about 60 feet below the Chitistone limestone was driven N. 65° W. for 20 feet in the greenstone. The greenstone is locally shattered and contains disseminated pyrite, bornite, and a little chalcopyrite. A few zones with a maximum thickness of 1 inch are estimated to contain about 1 percent of bornite by volume. Limonite, malachite, and a little azurite locally stain the greenstone near the adit.

About 200 feet southwest of this adit a small open cut exposes similar small showings of copper minerals.

FORGET-ME-NOT PROSPECT

The Forget-me-not prospect is on the east side of the Middle Fork of Copper Creek and about 200 feet above the stream. (See pl. 30, prospect 6.) A small open cut was made in an irregular fractured zone in

the greenstone. Pyrite and a little bornite are disseminated in some of the greenstone, and malachite coats fractures in the zone. There is no indication of an ore body.

BLUE BIRD PROSPECT

The Blue Bird prospect is on the east side of the Middle Fork of Copper Creek at an altitude of about 5,000 feet. (See pl. 30, prospect 7.) The prospect is east of the Forget-me-not prospect and several hundred feet above it.

The country rock in the vicinity is greenstone cut by shear zones ranging in strike from N. 45° W. to N. 65° W. and dipping vertically. The shear zones are locally stained with malachite and are not persistent along the strike. Epidote and calcite occur along some of the shear planes and in cross-cutting veinlets.

Two small open cuts in greenstone are about 20 feet apart and less than 100 feet stratigraphically below the Chitistone limestone. Both of the open cuts are partly filled with talus. The open cuts and adjacent outcrops show only a few small veinlets and disseminated grains of pyrite, bornite, and enargite.

The prospecting work did not reveal an ore body. About 100 pounds of sorted bornite-enargite ore is piled next to each open cut. A polished section of the sulfide minerals shows enargite partly replaced by bornite. The enargite contains a few grains of covellite. Chalcocite occurs as veinlets along the boundaries of grains of bornite and enargite, as veinlets in bornite, and as irregular patches replacing bornite.

MOUNTAIN BOY PROSPECT

The Mountain Boy prospect is on the west side of the East Fork of Copper Creek. (See pl. 30, prospect 8.) It is about 400 feet above the creek and about 4,700 feet above sea level. The workings are in the greenstone and consist of a short adit trending southwesterly for about 10 feet, and several open cuts. The adit is about 150 feet lower than the Chitistone limestone and on the north side of a small gully. The open cuts are about 300 feet south of the adit.

At the prospect the greenstone contains several veinlets and a few small irregular bunches of bornite and chalcopyrite. Much of the largest vein, which was a few inches thick, has been removed. This vein trends N. 48° E. and dips vertically. Fractures in the adjacent greenstone are commonly stained with malachite.

BUNKER HILL PROSPECT

The Bunker Hill prospect is on the east side of the East Fork of Copper Creek at an altitude of about 5,400 feet. (See pl. 30, prospect 9.) An adit was driven S. 10° E. for 15 feet along a vein in the

Chitistone limestone. The limestone is only 25 feet thick at the prospect, as it is cut off above by a thrust fault which causes the Nikolai greenstone to be repeated above the limestone. The limestone is extensively fractured and contains several veinlets of quartz, calcite, and copper minerals.

The adit follows a veinlet composed of malachite and azurite, with a little bornite, chalcopyrite, calcite, and epidote. The veinlet has a maximum thickness of 1 inch and an average thickness of about a quarter of an inch.

About 100 feet above the adit a fractured zone in the greenstone contains several veinlets of quartz, calcite, malachite, azurite, and epidote, and a little chalcopyrite, bornite, and covellite. The trend of this fractured zone and of a small open cut made in it is S. 30° E. The zone ranges in thickness from 6 inches to 3 feet, dips 75° SW., and is probably part of the same zone that appears in the adit below.

CLEAR CREEK

Clear Creek (see pl. 30), a tributary of the Kuskulana River, is 33 miles west-northwest of Kennicott and 21 miles east-northeast of Chitina.

An abandoned road 12 miles long and heavily overgrown with trees and shrubs connects Strelna, on the former Copper River & Northwestern Railway, and the mouth of Clear Creek. A good trail beginning at the narrow canyon of Clear Creek leads northwest to the main copper prospects 4 miles from the road. The prospects are near the head of Clear Creek, at altitudes ranging from 4,200 to 6,000 feet.

Prospecting work by the Great Northern Development Co. at Clear Creek began in 1906. The group of 58 claims, commonly called the Copper Mountain group, included 35 patented claims in 1916. Three principal adits with a total length of nearly 5,700 feet were driven, and a fourth was started. A disastrous snow slide in the winter of 1912–13 destroyed the gasoline-electric power plant and the principal buildings of the upper camp. Development work was discontinued after this snow slide. The lower camp on Clear Creek at an altitude of about 2,600 feet is no longer usable.

Moffit and Mertie[5] have described the prospects at Clear Creek, and brief references to this locality appear in other government publications.

Apparently no work has been done since 1916, when Moffit last visited the area. In 1943 slightly less than 1,000 feet of No. 1 adit (see pl. 30, prospect 12, and pl. 31) was accessible; No. 3 adit (see pl.

[5] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 71, 83, 94, 95, 126–128.

30, prospect 11) was blocked by ice 100 feet from the portal; No. 2 adit (see pl. 30, prospect 10, and fig. 22) and No. 4 adit (see pl. 30, prospect 13) were completely caved at the entrance. The accessible underground workings were mapped with a plane table, open-sight alidade, and steel tape on the scale of 50 feet to 1 inch. One channel sample and many hand specimens were taken. On the surface, traverses were made over an intrusive body and adjacent greenstone.

GEOLOGY

Clear Creek, which flows over Nikolai greenstone, runs roughly parallel with and close to the contact of the greenstone and the overlying Chitistone limestone. On the west side of the creek the Chitistone limestone dips steeply west-southwest and is overlain by the Nizina limestone and the McCarthy shale. Near the head of the creek and on the east side, the Nikolai greenstone has been intruded by a body of diorite.[6]

The composition and texture of the greenstone vary considerably within a few feet, depending upon the degree and kind of alteration. Much of the greenstone is now an aggregate of pyroxene, plagioclase, chlorite, epidote, calcite, quartz, sericite, kaolin, and zeolites.

The diorite is fine- to medium-grained. Plagioclase of two generations makes up most of the rock. Hornblende occurs as euhedral laths, some of which are zoned. Orthoclase and quartz are present in small quantities. The intrusive rock is largely unaltered in contrast to the highly altered greenstone.

Near No. 1 adit several dikes of hornblende porphyry transect the greenstone. The hornblende porphyry is composed of large euhedral phenocrysts of hornblende and augite in a fine-grained groundmass of plagioclase, chlorite, epidote, kaolin, calcite, quartz, and iron oxides. The phenocrysts are partly altered to chlorite. In the field this rock is easily confused with a type of Nikolai greenstone containing large aggregates of chlorite.

Traverses were made above No. 2 adit along the ridge between Clear Creek and Porcupine Creek to prospect the diorite body and the contact with the greenstone. Dikes, stringers, and irregular masses of diorite cut the greenstone along the main contact and for several hundred feet from it. The diorite contains small inclusions of greenstone and of hornblende porphyry. Several dikelets of aplite cut both the diorite and the greenstone.

Pyrite is disseminated through much of the greenstone near the diorite and to a lesser extent in the diorite itself. A little chalcopyrite is present in these rocks. Limonite stains on the pyrite-bearing rocks are common, but malachite and azurite stains are scarce.

[6] Moffit, F. H., and Mertie, J. B., Jr., op. cit., p. 126.

Small veins of quartz, calcite, aragonite, and stilbite are near the contact of the greenstone and the diorite. Some of the quartz and calcite veins contain pyrite, a little chalcopyrite, and less bornite. One quartz vein has minute grains of galena.

Both the greenstone and the diorite are cut by numerous shear zones and faults. Some of them are probably extensions of prominent faults on the west side of the valley that displace the contact of the Chitistone limestone and Nikolai greenstone.

COPPER PROSPECTS

All of the prospects on Clear Creek are in the greenstone. No deposit of copper minerals of sufficient size or grade to constitute an ore body was observed at this creek.

No. 1 adit (see pl. 31) is on the east side of Clear Creek at an altitude of about 5,000 feet, about half a mile southeast of the upper camp. This adit has two branches, each nearly 1,000 feet long. Only the east branch was accessible in 1943.

The adit throughout its length follows prominent faults. Two hornblende porphyry dikes in the greenstone on the north side of the accessible drift are cut off by the fault along which the drift was driven. These dikes were not found on the south side of the fault. A small hornblende porphyry dike at the portal, however, is not displaced by the fault.

The greenstone locally has been impregnated with pyrite. Large aggregates of chlorite are common in both the hornblende porphyry and the greenstone. Several veins of calcite and quartz cut the greenstone but carry no copper minerals. Limonite stains are common.

At station 4 in this adit a shear zone 2 feet wide is slightly stained with malachite. A channel sample cut 7½ feet east of station 4 contains no copper, silver, or gold.[7] This sample represents a 5-foot section which includes what is apparently the most highly stained part of the shear zone. A little malachite is present also 135 feet east of station 8 in this shear zone. The hornblende porphyry dike 50 feet east of station 9 contains a few veinlets and grains of pyrite, tiny seams of calcite, and a very few grains of chalcopyrite.

No. 2 adit is near the head of the valley, on the east side, at an altitude of about 5,500 feet. It was caved in 1943, but a map of the prospect (see fig. 22) was made from field notes taken by Moffit in 1916. A conspicuous shear zone at the portal strikes N. 30° E. and dips 65° SE. This zone of sheared greenstone is from 2 to 12 inches

[7] Cress, S. H., analyst, U. S. Geological Survey.

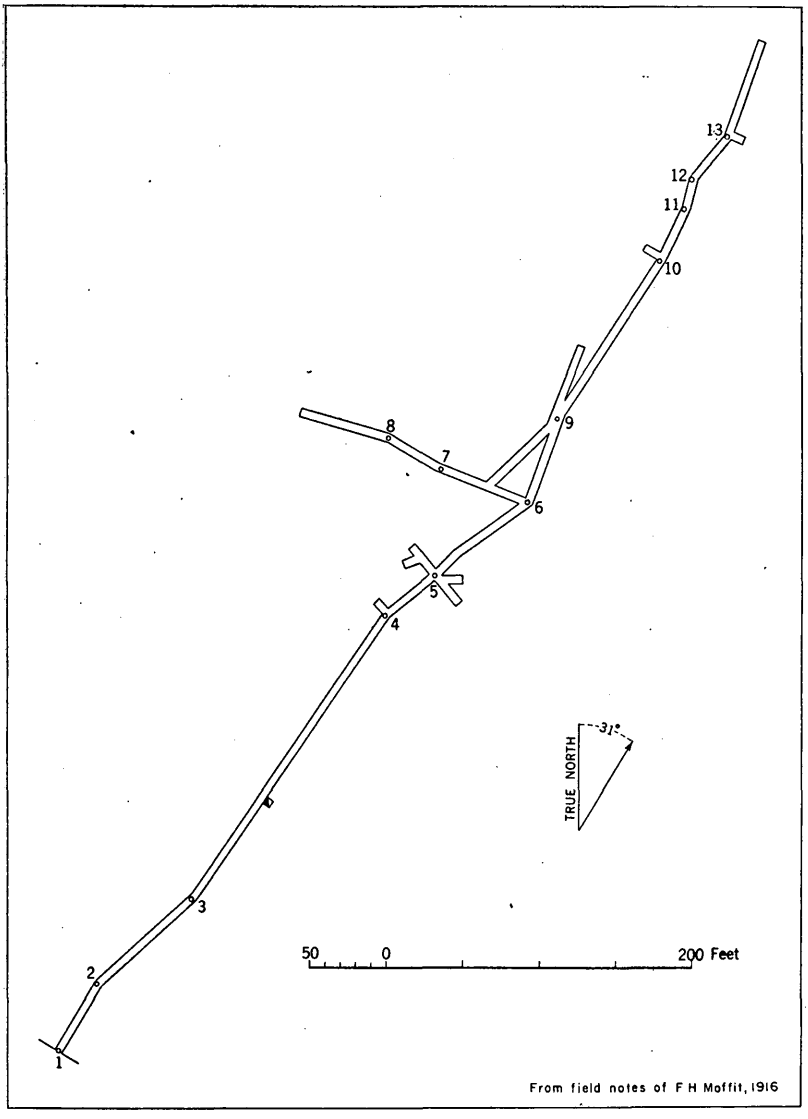

FIGURE 22.—No. 2 adit, Clear Creek.

thick and contains very small quantities of calcite, pyrite, chalcopyrite, bornite, limonite, malachite, and azurite. The copper minerals total less than 1 percent of the material in the vein. Moffit and Mertie [8] state that in No. 2 adit, "pyrite and chalcopyrite are present along many of the fracture planes and show their greatest development in a vein about 2 feet thick in a short crosscut 350 feet from the tunnel mouth."

[8] Moffit, F. H., and Mertie, J. B., Jr., op. cit., p. 127.

A few stains of malachite appear in two small open cuts on the hillside, 50 to several hundred feet above No. 2 adit.

No. 3 adit is in the middle of the valley at an altitude of about 5,200 feet; presumably it was driven to undercut showings of copper minerals in No. 2 adit. No. 3 adit was 2,266 feet long in 1916, but in 1943 it was closed by ice 100 feet beyond the portal. No copper minerals were observed in the short section of the adit not covered by timber or blocked by ice, on the mine dump, or in outcrops near the portal. Moffit and Mertie [9] describe the copper-bearing material as "a granular aggregate of pyrite, chalcopyrite, calcite, and flaky magnetite." They write:

> Chalcopyrite occurs only in very small amount. A polished section of the ores shows that the pyrite is greatly crushed and broken and that chalcopyrite occurs between and partly surrounding the pyrite crystals. Chalcopyrite, together with calcite and magnetite, also cuts through the pyrite. The magnetite and chalcopyrite appear to be of about the same age, and both are definitely later than the pyrite.

No. 4 adit is N. 14° E. of the forks of Clear Creek, at an altitude of 4,200 feet; it was driven presumably to undercut the other three adits. It was completely caved in 1943. Moffit recorded its length as 175 feet in 1916. Material in the mine dump indicates that it extended through talus to the bed rock of greenstone. No copper minerals were found in the dump.

In a narrow dry gulch three-tenths of a mile S. 55° E. of No. 1 adit a quartz-calcite vein contains several lenses of copper minerals. (See pl. 30, prospect 14.) The vein strikes N. 75° E., dips 84° N., and ranges in thickness from a fraction of an inch to 18 inches. It extends up the gulch for more than 500 feet. Much of the vein material has been removed in prospecting operations, and talus almost completely obscures the rest. Pieces of the vein material, in which copper minerals make up most of the specimen, were collected. Lenses of platy and massive chalcocite with a little bornite replace granular quartz and fill the interstices between quartz and calcite grains. Covellite replaces both chalcocite and bornite to a slight extent. Some specimens show microscopic blebs of chalcopyrite oriented along cleavage planes of bornite, and less commonly in chalcocite. No copper sulphide minerals were found in place except near the crest of the ridge, where calcite makes up most of the vein. The greenstone near this vein was examined in detail, but only a few grains and veinlets of chalcopyrite were found. There is no indication of an ore body.

NUGGET CREEK PROSPECTS

The Nugget Creek prospects, presumably still held by the Alaska Consolidated Copper Co., are on the east side of Nugget Creek about

[9] Moffit, F. H., and Mertie, J. B., Jr., op. cit. p. 95.

2½ miles from the Kuskulana River. (See pl. 30, prospects 15 and 16.) The principal prospects are at altitudes between 3,500 and 4,000 feet, on the south side of a rounded hill whose summit is 4,600 feet above sea level. The abandoned Kuskulana road connects these prospects with Strelna.

By 1943 the mining and milling equipment had been removed, all buildings were in poor condition, and all workings were caved. Moffit and Mertie [10] have described the prospects in detail.

All the prospects are in amygdaloidal basalt flows of the Nikolai greenstone. The best indication of copper ore was found in an outcrop on the Valdez claim. A large fault, or a series of overlapping parallel faults, known as the Valdez fault, strikes N. 68° E. and dips 80° N.

The sulfide minerals are bornite, chalcopyrite, pyrite, and a little chalcocite and covellite. They are associated with dolomite and a little calcite. The copper minerals are found either in well-defined veins or as grains, films, and small bodies of irregular shape in the sheared and fractured greenstone. In one of the mine levels chalcopyrite has filled the vesicles of the greenstone.

Exploratory work on these prospects has been more thorough than on any others in the district. Numerous open cuts were made. Underground development work included more than 4,000 feet of adits, shafts, drifts, crosscuts, and winzes. The workings were carried to a depth of 420 feet below the outcrop. This exploration demonstrated that the best ore was at the surface. The failure to find ore on the lower levels led to the abandonment of the claims. The total shipments of ore from Nugget Creek consist of two carloads of high-grade hand-sorted material prior to 1916 and 160 tons of concentrates and hand-sorted ore since that time.

BIG HORN OR FINCH PROSPECTS

The Big Horn or Finch group of claims is on the southwest side of a mountain at the junction of the two lowermost branches of the Kuskulana Glacier. (See pl. 30, prospect 17.) An abandoned trail between Nugget Creek and these prospects crosses the north tributary of the Kuskulana Glacier at the junction of the two glaciers. Moffit and Mertie [11] described the prospects in detail.

All the prospects are in greenstone that is intensely faulted. The lowest adit is about 900 feet above a cabin at the foot of the divide between the glaciers. This adit was about 400 feet long but is now caved. Quartz veins with a little chalcocite were found in pieces of greenstone on the dump. The adit is reported to contain no ore.

Another adit with a total length of 83 feet is N. 30° E. of the lowest adit and about 175 feet higher. The adit was driven northeastward

[10] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 128–133.
[11] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 133–135.

for 48 feet along a fault. At a point 18 feet from the portal a drift diverges to the east for 15 feet and then trends northeast parallel with the main adit for 20 feet. Several fractures trending N. 70° E. to east have small lenses of quartz and chalcocite, locally accompanied by bornite. Several tons of broken ore are piled at the entrance. No copper minerals were found in a fractured and pyritized zone adjacent to the portal.

A lens of chalococite, granular quartz, and a little bornite crops out at a place N. 57° E. of this adit and 200 feet higher. (See pl. 32.) It is about 6 feet long, 1 to 3 feet thick, and has a vertical range of about 8 feet. The lens is delimited by several faults and does not crop out elsewhere in the vicinity. An adit driven underneath the lens for a distance of 40 feet is reported to have disclosed little ore and is now caved. A few tons of ore are piled near the lens.

A second adit, 30 feet long, and a shallow shaft are a few feet northeast of the adit just described. Both are caved and reported to be barren. Numerous open cuts elsewhere on this mountain show only sparse copper minerals.

PIERSON PROSPECT

The Pierson prospect is at an altitude of about 3,000 feet on the southeast side of the Kuskulana River, half a mile below the Kuskulana Glacier. (See pl. 30, prospect 18.) Moffit and Mertie[12] have referred to this prospect.

A short adit, now caved, was driven southwest along the sheared contact of a latite intrusive and the Nikolai greenstone. The latite body is about 30 feet wide at this place and is separated from the Chitistone limestone to the northwest by a few feet of Nikolai greenstone. The shear zone is 2 to 3 feet thick and is stained with limonite and some malachite. It contains a little pyrite and chalcopyrite.

MACDOUGALL CREEK PROSPECTS

MacDougall Creek is on the southeast side of the Kuskulana River opposite the mouth of Clear Creek. Three camps were formerly along the creek. The lower or main camp on the bars of the Kuskulana River has been obliterated by the meandering river. The upper camp, at an altitude of 4,300 feet, has been leveled by a snow slide. The middle camp, at an altitude of 3,250 feet, is in fair condition. These camps formerly were reached from Strelna by the Kuskulana road and a branch road which crossed the Kuskulana River over a bridge that has since been washed away.

[12] Moffit, F. H., and Mertie, J. B., Jr., op. cit., p. 136.

LENS OF CHALCOCITE, GRANULAR QUARTZ, AND BORNITE.

All the prospects were formerly the property of the Chitina-Kuskulana Copper Co. They include 16 lode claims and 5 mill sites. Exploratory work has been done chiefly on the Copper Queen, War Eagle, and Calcite claims. These prospects were described by Moffit and Mertie.[13]

The Copper Queen prospect (pl. 30, prospect 19), now owned by the Mt. Wrangell Copper Co., is about half a mile southwest of MacDougall Creek. An adit on the prospect is at an altitude of about 3,200 feet. A metamorphosed limestone, probably of Triassic age, contains a few veinlets and small irregular bodies of magnetite, pyrite, and chalcopyrite. Diorite porphyry which crops out 200 feet above the adit may have caused the metamorphism and mineralization. Conglomerate and sandstone of Jurassic age unconformably overlie the altered limestone 600 feet above the adit.

In the altered limestone a zone stained with limonite and a little malachite is about 100 feet thick. The zone has a southerly trend and extends from the adit to a point 600 feet above it. Near the portal the altered limestone contains diopside, garnet, and chlorite, and locally it is silicified and impregnated with pyrite. In 1943 the adit was caved at the portal; but according to Moffit and Mertie[14] it followed faults S. 15° E. for 433 feet in metamorphosed limestone, porphyry, and greenstone, and the underground workings revealed a considerable quantity of magnetite, pyrite, and chalcopyrite in greenstone near garnet rock.

The War Eagle adit (pl. 30, prospect 20) is about 900 feet S. 13° W. of the middle camp, at an altitude of about 3,600 feet. It was driven southward for 104 feet in rock that consists essentially of fine-grained pale-green diopside and a little calcite and quartz. About 25 feet from the portal a conspicuous fault strikes east and dips 68° N. Very coarse-grained dark-green diopside forms a zone 2 to 3 feet wide on each side of the fault. Other small faults and small veins of the dark-green diopside are exposed in this adit. No copper-bearing minerals were found.

Several outcrops of a rock rich in magnetite appear between the War Eagle adit and the base of the conglomerate and sandstone of Jurassic age, which is about 1,000 feet above the adit. Most of this site is covered with talus and vegetation, and information gathered from the few outcrops is meager. Apparently diorite and diorite porphyry intruded a limestone later covered by Jurassic deposits. The contact metamorphism resulted in small bodies of magnetite and diopside rock which contain negligible quantities of pyrite, pyrrhotite,

[13] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 137–139.
[14] Moffit, F. H., and Mertie, J. B., Jr., op. cit., p. 139.

chalcopyrite, epidote, chlorite, calcite, and quartz. A channel sample 5 feet long was cut across an outcrop 430 feet S. 4½° E. of the portal of the War Eagle adit. The sample contains 62.07 percent of iron and no copper.[15] The magnetite is of good grade, but the tonnage indicated from surface outcrops is less than 10,000 tons. The pyrrhotite contains no nickel.

The Calcite tunnel (pl. 30, prospect 21) is S. 45° E. of the upper camp, at an altitude of about 4,800 feet. The adit was driven S. 43° E., approximately parallel with the banding in altered Chitistone limestone. The limestone, for a width of 75 to 100 feet, has been altered to a bleached, conspicuously banded rock composed of magnesite, dolomite, and seams of calcite. Dark-green serpentine forms irregular masses in the carbonate rock and is cut by veins of pale-green serpentine. In 1943 the adit was caved at a point 60 feet from the portal. Pyrite, chalcopyrite, and stains of malachite are rare in the exposed parts of the adit and on the mine dump.

The adit is near the contact of the Chitistone limestone and the diorite, and near a zone of faulting along which Triassic rocks are thrust northward over Jurassic rocks. The limestone to the south is only slightly recrystallized and altered, but a garnetized zone with a little pyrite, chalcopyrite, and magnetite occurs to the north, about 100 feet from the portal and near the diorite. This zone is from 1 to 8 feet wide and crops out in a few places up the slope above the adit.

A traverse was made over the diorite body along the northeast side of the valley of MacDougall Creek from the Calcite tunnel to a point opposite the middle camp. Many small veins of epidote and some limonite-stained pyritic zones were found, but only a few malachite-stained specimens of diorite with tiny seams of pyrite and chalcopyrite. There is no indication of an ore body at MacDougall Creek.

BERG CREEK PROSPECTS

The Berg Creek prospects include 18 lode claims, 4 placer claims, and 1 power site. They are on the southeast side of the Kuskulana River and extend for nearly a mile along Berg Creek from a mill site near the river. (See pl. 30, prospect 22.) Moffit and Mertie[16] described these prospects in detail, and earlier reports mentioned them.

The prevailing rock at Berg Creek is the Chitistone limestone. It has been intruded by a fine-grained diorite and a conspicuously porphyritic diorite. Locally the limestone has been altered to an aggregate of silicate minerals. Faults are common in the area. Magnetite, pyrite, and chalcopyrite occur chiefly as veins in the igneous rocks and locally carry gold and silver.

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[15] Cress, S. H., analyst, U. S. Geological Survey.

[16] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 140–141, 143–146.

Five adits representing a total length of about 2,600 feet were driven on the property to prospect for copper minerals. In 1916, the rocks cut by adits 4 and 5 were considered valuable for their gold and silver content, and since then prospecting for copper minerals has been subordinated. In 1943, adits 1, 2, and 3 were caved at the portal. Ice completely blocked No. 4 adit at a point 60 feet from the portal and No. 5 at a point 150 feet from the portal. No. 5 adit is at the upper end of a cable tram that leads 4,600 feet to the north to a mill which had a capacity for milling 20 tons of gold and silver ore a day. No copper was produced, and only a few ounces of gold and silver.

ELLIOTT CREEK PROSPECTS

The writers did not visit the prospects at Elliott Creek but mention them in this report because extensive prospecting work has been done there. The following brief description is taken largely from a report by Moffit and Mertie,[17] who visited the prospects in 1916.

Elliott Creek, a tributary of Kotsina River, is in the western part of the Kotsina-Kuskulana district. (See pl. 30.) Two camps were formerly established on the creek at altitudes of 2,858 feet and 3,611 feet. A pack trail between these camps and Strelna crosses the northwest end of a ridge between the creek and Chitina Valley and joins the Kuskulana road about 2 miles north of Strelna. This trail is now largely overgrown and unusable.

The upper 6 miles of the creek is in an anticlinal valley in which the core of Nikolai greenstone is flanked by Chitistone limestone. Numerous faults make the structure complex. The greenstone is well jointed. On the northeast side of the valley some dikes of quartz diorite porphyry cut both the greenstone and the limestone.

The copper deposits are restricted to the greenstone. They commonly consist of either bornite and chalcopyrite, or chalcocite and bornite. The gangue minerals are quartz, calcite, and epidote. The copper sulfide minerals are deposited as irregular veins filling cavities or replacing the greenstone along fracture planes, as films and veinlets in sheared greenstone, and as grains disseminated through the greenstone near faults and fractures. Some aggregates of the sulfide minerals have sharp, clean-cut boundaries, but others grade into the country rock. Surface stains of malachite are numerous and in many places indicate small bodies of mineralized rock that have little or no value. Most of the work has been done on the Albert Johnson, Elizabeth, and Goodyear claims. As far as is known no prospecting has been done at Elliott Creek since 1916.

[17] Moffit, F. H., and Mertie, J. B., Jr., op. cit., pp. 115–125.

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