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GEOLOGIC REPORT NO. 15

Geology and Mineralization of the Midas Mine and Sulphide Gulch Areas Near Valdez, Alaska

By

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GEOLOGY AND MINERALIZATION OF THE MIDAS MINE AND SULPHIDE GULCH AREAS NEAR VALDEZ, ALASKA

by

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INTRODUCTION

The Midas mine is located in Solomon Gulch about 7½ miles south of the original town of Valdez. This mine has been one of the larger copper producers in the Prince William Sound area, having produced more than a million pounds of copper (Moffit and Fellows, 1950, p.51). The ore was mined mainly in the years 1916 and 1918. In 1919 the mine closed, apparently because of shipping problems, and has not operated since. A brief examination was made of the surface showings in 1953 (Jasper, 1953). Mineralization at the Midas mine and elsewhere in the vicinity is reported to be related to greenstone intrusives present in the slate and greywacke (Johnson, 1919). Previous mapping suggested that a belt of greenstone might be present from Jack Bay eastward, passing just south of the Midas mine. One of the purposes of the work reported here was to visit Midas mine and obtain more detailed data on its geologic setting. East of the Midas mine, the Addison-Powell prospect was described as "a large low-grade copper prospect" in Sulphide Gulch. The reported location fell approximately on the projection of the greenstone belt, and it was planned to visit the prospect and investigate its relation to the greenstone belt. Collection and geochemical analysis of stream sediments from streams flowing into Jack Bay and into Port Valdez and the Lowe River from the south were also planned.

Only two weeks was available for the project. Because of poor weather and logistic problems during the allotted time, the results of the work are incomplete and tentative, but are believed to be of some interest. A total of 3 days work was accomplished in the vicinity of the Midas mine, and about 3½ days mapping was done around the reported location of the Addison-Powell prospect.

The location of "Sulphide Gulch" and the Addison-Powell prospect proved to be a problem. The only map purporting to show this gulch and the Addison-Powell prospect is plate 4 of Moffit and Fellows (1950), which evidently was prepared from older publications and unpublished reports. The drainage shown as Sulphide Gulch on this map is small and extends farther south than the drainage actually present. A USGS topographic map of the Valdez A-6 quadrangle (no woodland overprint) designates a larger gulch south of about mile 4½ on the Richardson Highway as Sulphide Gulch, but on later maps with woodland overprint the name has been removed. Local residents refer to the large drainage south of about Mile 8 as Sulphide Gulch. This drainage curves westward to pass very near the location of the Addison-Powell prospect on plate 4 of Moffit & Fellows (1950). In this report, Sulphide Gulch is used for this large drainage. For convenience, East, Middle and West Forks are distinguished as shown on figure 1.

GENERAL GEOLOGY

Regional Setting and Topography

The rocks of the Valdez area consist largely of interbedded slate and greywacke which have been assigned by earlier workers to the Valdez and Orca groups of probable Mesozoic age. Minor amount of greenstone, conglomerate, sandstone and limestone occur with the slate and greywacke. The greenstone has been regarded as an altered equivalent of both extrusive and intrusive basic rocks by various workers, and both are undoubtedly present in the region. Several small bodies of granite and aplite are reported in the region, including aplite at the head of Solomon Gulch (Johnson, 1915, p.151-2). A later, more detailed report by Johnson (1919) does not mention this aplite.

Timber and thick brush cover the slopes up to about 1500' above sea level, with only low plants above that elevation. The valleys are largely glacial in origin, with wide brush-covered bottoms and very steep sides. All of the larger streams head in glaciers. The geologic features above timberline are generally well-exposed, but in many cases are difficult to reach because of the steep slopes.

Rock Types

Greywacke, Argillite and Slate: The most widespread rock of the area is greywacke. This rock is medium to fine grained, medium gray in color, and commonly shows original bedding. Where appreciable amounts of fine matrix are present, a distinct foliation is present in the greywacke. In thin section the greywackes consist mainly of subangular quartz and albite with variable amounts of chlorite, biotite, epidote, sericite, calcite, and pyrite or pyrhotite. The rocks are poorly sorted, with grains mostly between 0.03 and 0.1 mm in diameter. The micaceous minerals are well oriented, and semischist would be an equally good name for some of the greywacke.

The slate or phyllite is normally black with well-developed slaty cleavage. Some argillite with poor foliation is also present in the sedimentary sequence. The argillite apparently consists essentially of very fine grained rock with composition similar to the greywacke.

In the areas mapped, greywacke and slate are typically interbedded in units a few feet to a few hundred feet thick. In the vicinity of the Midas mine, slate seems to be the dominant sediment present, but elsewhere greywacke is dominant.

Greenstone: There is some indication that the greenstone at the Midas mine differs from the greenstone of the belt passing through the head of Solomon Gulch. At the Midas mine, most greenstone is medium grained, greenish gray in color, and unfoliated. Thin lenses of slate occur locally in the greenstone. Near the north edge of the greenstone body, several outcrops are much finer grained, but thin sections show the composition and mineralogy to be the same as the coarser greenstone and it appears to be a border phase. The less altered greenstone is composed of about 70% actinolite and 25% plagioclase (An_{60}) with minor amounts of quartz, pyrite, and sphene. The grain size is 1-2 mm, and the plagioclase, which shows some zoning, occurs as poorly developed tablets largely enclosed by a complex intergrowth of actinolite crystals of similar or slightly larger size. The actinolite is weakly pleochroic from colorless to pale green, and is probably an alteration product of pyroxene, although no remnants of this could be found. The fine grained border phase has a grain size of 0.1-0.2 mm, but is otherwise similar. Minor amounts of calcite, epidote, sericite and chlorite have formed from alteration, and quartz veins cut the greenstone. The original rock appears to have been a mafic-rich gabbro with a diabasic texture. The original mafic minerals are completely altered to actinolite, but the plagioclase is inferred to have resisted the albitization that has affected other greenstone. This greenstone body appears to be less elongated along the foliation than those in the greenstone belt.

The greenstone in the greenstone belt is mostly fine-grained (0.1-0.5 mm), moderately foliated, and more metamorphosed than greenstone of the Midas mine, although considerable variability is evident. Individual grains are usually difficult to make out in hand specimens. The original composition appears to have been similar to those inferred in the greenstone at the Midas mine, but both the plagioclase and mafic minerals have been partly altered to epidote, chlorite, albite, calcite and quartz. Traces of chalcopyrite, pyrrhotite, and pyrite are common. This greenstone occurs as tabular units from a few feet to several hundred feet thick. At a few localities where exposures are good, the contacts of greenstone can be seen to cross the bedding of the sediments at a low angle, although shearing or foliation parallel to the contact was always observed. The border zone usually appeared more sheared or foliated than the center of the greenstone bodies. The thicker greenstone units could be followed for many hundred feet, but the thinner units seemed to disappear over these distances. Based on local cross-cutting relations to bedding, and alteration on both upper and lower contacts of some bodies (see metamorphism), it seems likely that the greenstone belt consists of sills of basaltic composition, perhaps along with some flows, that have since been metamorphosed and sheared. Possibly some sills or flows disappear because of shearing.

In upper Solomon Gulch, the greenstone belt was mapped by Johnson (1919) as solid greenstone, but where examined along the northern edge it proved to consist of greenstone interlayered with sediments in a zone about a mile wide. In the Sulphide Gulch area, greenstone is present over a width of about 2 miles. The north margin is quite sharp. Traverses across the ridge between Sulphide Gulch and the Lowe River disclosed only sediments. The south limit is less definite. Greenstone appears to be common up to the limit shown on the map, and sparse or absent farther south but a few greenish well-foliated units near the head of the Middle Fork of Sulphide Gulch may have originally been basic igneous rocks.

It seems clear that the greenstone at the Midas mine is a deeper-seated and/or larger intrusive body than the greenstone of the greenstone belt. However, the mineral assemblage in the two occurrences is similar (plagioclase, actinolite, chlorite), suggesting that both have been affected by the same metamorphic episode. Possibly the large size and coarser crystals of the greenstone at the Midas mine have inhibited deformation and extensive mineralogical changes. It is also possible that the two are of somewhat different age.

Metamorphism

Although previous descriptions have always treated the rocks of the Valdez area as sediments, with no mention of metamorphism, both field and thin section observations indicate that they have definitely undergone low grade metamorphism. Evidence for this is the mineral assemblages and the well-developed foliation.

The minerals present in the greywackes are quartz, albite, chlorite, sericite, biotite and epidote. Veins of prehnite (?) are present in one thin section of greywacke. In the greenstones, quartz, actinolite, chlorite, epidote, calcite and minor sericite are present, along with basic plagioclase in many samples. The plagioclase is believed to be an unreacted relic of the original rock. These mineral assemblages suggest the quartz-albite-epidote-biotite subfacies of the greenschist facies (Turner & Verhoogen, 1960). Biotite was observed in only some parts of the area and it is possible that a biotite isograd could be mapped;

but if so, not enough work has been done to define the location of this isograd.

In the Sulphide Gulch area, the slate and argillite adjacent to greenstone have commonly been impregnated with pyrite, and silicified or otherwise hardened. This appears to be a metamorphic effect of the greenstone, but a thin section of this material was so fine grained that no conclusions on the minerals present or the relative ages of the foliation and the contact metamorphism could be reached.

In an area at least several hundred yards in extent at the head of the Middle Fork of Sulphide Gulch, the rock is veined in an intricate and apparently random manner by white quartz veins. In places the quartz makes up 10-20% of the rock. Except for a few specks of pyrite, the quartz shows no evidence of sulfide mineralization.

Structure

As can be seen on figures 1 and 2, the foliation, which in all cases was essentially parallel to bedding, trends east-west and dips moderately to steeply north. In most outcrops the attitude of foliation and bedding is relatively uniform, but in a few places crenulations and small folds are visible. Graded bedding observed between Sulphide Gulch and Lowe River indicates the beds are right side up. Where fold axes were observed they plunged gently to the west. The rocks of the area thus appear to form a monocline or, more likely, are isoclinally folded along axes trending east-west and plunging gently west. Previous mapping by Johnson (1919), shown on figure 1, suggests a large overturned syncline outlined by the slate northwest of the Midas mine.

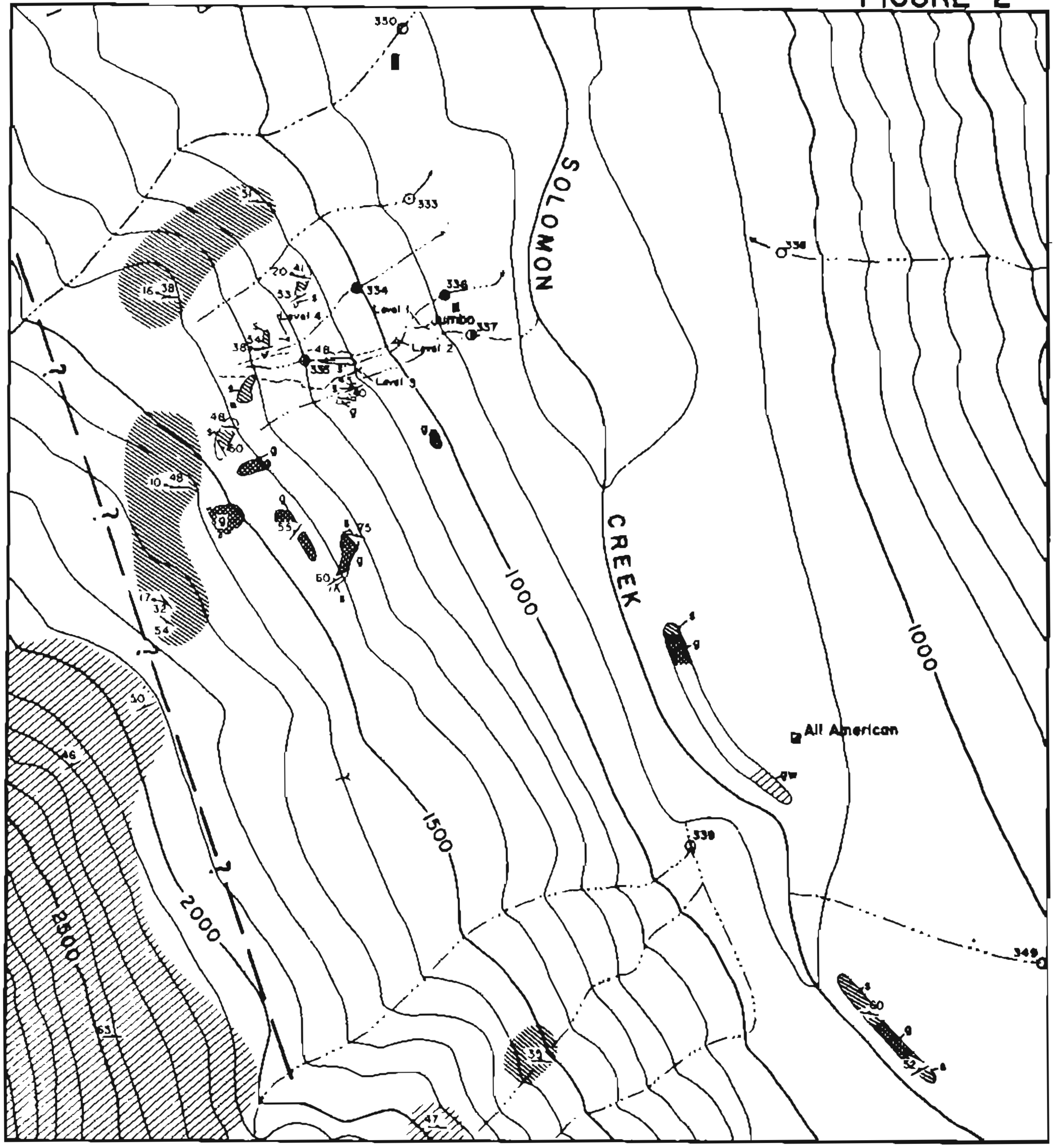
Faults are undoubtedly common in the area, judging by the work of Johnson and others. Most of the faults mapped by Johnson are within about 30° of the strike of the foliation and bedding. Although not shown on Johnson's map, both his mapping and that of the writer suggest a fault trending approximately north-south along the west side of Solomon Gulch. Slate and greywacke units are terminated abruptly along their strike, and near the projection of the fault, bedding shows considerable crumpling and deviation from its normal attitude. This fault would pass about 1000 feet west of the adits of the Midas mine and presumably would cut off the vein.

ECONOMIC GEOLOGY

Midas Mine - Jumbo Lode

The original claims at the Midas mine were staked in 1901. Beginning about 1911, considerable development work was done, and between 1912

FIGURE 2



Geological Map of Midas Mine Area

0 500 1000 1500 2000 feet

N

- Greenstone (g)
- Slate (s)
- Greywacke (gw)
- Dip and strike of foliation
- Fault
- Stream sediment sample and number (337)
- Strongly anomalous stream sediment
- Weakly to moderately anomalous stream sed.
- Shaft
- Adit
- Building

and 1918, ore was shipped over an aerial tramway from the mine to the beach. Most of the shipments were apparently hand-sorted ore. From 1913 on, the mine was owned by Granby Consolidated Mining Co., of Canada. Most of the ore was shipped in 1917 and 1918. According to Granby, 21,000 tons of ore in 1917 averaged 4.15% copper, 0.42 ounces per ton of silver, and 0.062 ounces per ton of gold. In 1918, 25,350 tons averaged 3.24% copper, 0.25 ounces per ton of silver, and 0.05 ounces per ton of gold. About 3000 tons were shipped in 1919. The closing of the mine in 1919 has been attributed to a shortage of shipping, which affected many of the smaller copper mines at this time, but it seems likely that the drop in copper prices also contributed. The group of 15 patented claims was recently purchased from the State of Alaska by Loren St. Amand of Copper Center and Valdez.

Workings at the mine consist of four adits at elevations of about 60,110,200, and 400 feet above the level of Solomon Creek. These workings are on the Jumbo Lode. In August 1964, the lowest level (level 1) was caved shut about 60 feet from the portal, and the second and fourth levels were caved at the portal. The third level was open to the face about 600 feet from the portal and is shown on figure 3. According to patent plats, level 2 has a length of about 700 feet. Level 1 was apparently a haulage level, but its length is not known. A shaft or pit is shown on the patent plat about 500 feet S75W from the portal of the third level and another adit about 1600 feet south of this level, but neither of these were visited. In addition, the All-American lode is located on the east side of the creek about 2500 feet from the Jumbo lode, and was developed by a shallow shaft (now caved) and numerous trenches.

The country rock at the mine is mostly black slate, with some greywacke, striking about east-west and dipping moderately to steeply north. Drag folds suggest the beds are right side up, with an anticline to the south. Just south of the mine, a body of greenstone at least 800 ft. by 1000 ft. in dimension is indicated, although outcrops are poor and at least some slate occurs within the greenstone. The northern border of the greenstone is fine grained, and a thin section was necessary to confirm the lithology. The south side appears relatively coarse right up to the contact, although it is possible that more greenstone is present south of the outcrops mapped. It is not known whether this greenstone body is connected with the greenstone exposed on Solomon Creek to the southwest. Altered and pyrrhotitized greenstone is exposed along the creek southwest of the All-American workings.

A north-south fault is indicated west of the Midas mine by several lines of evidence. A topographic and air photo lineament extends along the west side of Solomon Gulch, and up into bedrock west of the mine. The strike of bedding is deflected above the mine, perhaps by drag on the fault. The pattern of rock types as mapped both by Johnson (1919) and the writer suggests a fault. The location of the fault farther south is not clear.

MAP OF LEVEL 3, MIDAS MINE, VALDEZ AREA

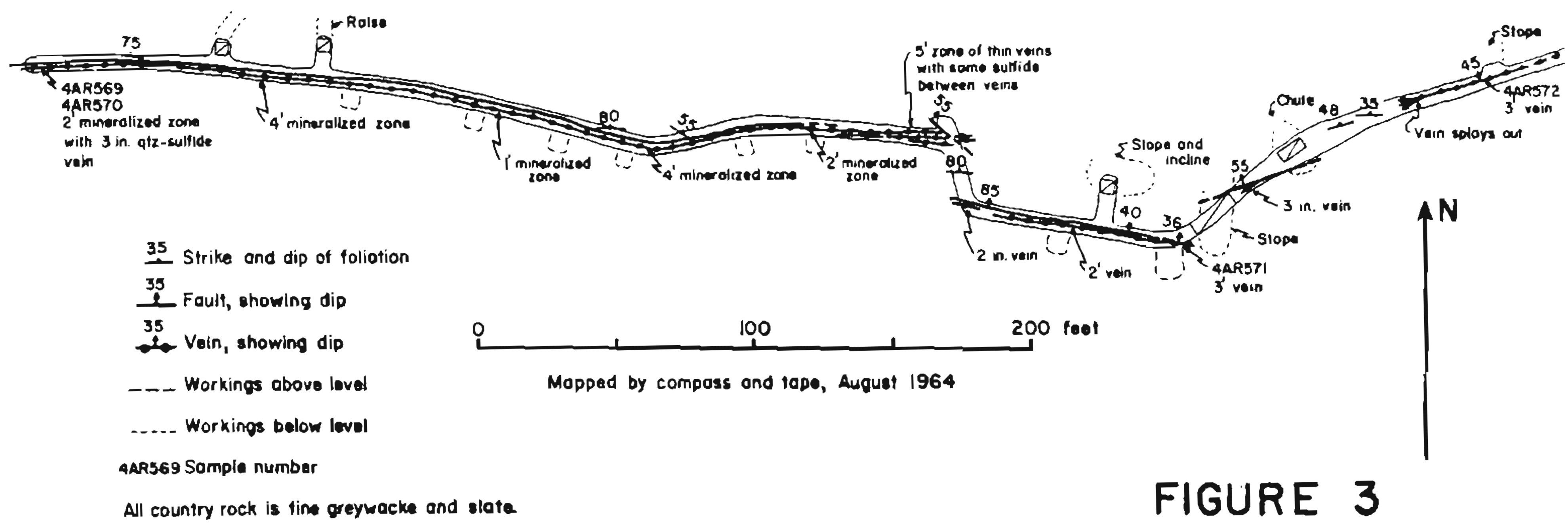


FIGURE 3

Mineralization in the Jumbo lode of the Midas mine occurs as sulfides with some quartz, and as narrow veinlets of sulfide in a sheared zone in the slate and greywacke. As can be seen on figure 3, the vein generally occurs in or adjacent to a fault or shear zone in the slate. In most parts of the mine this shear is parallel to the foliation, but locally it is seen to cut across and disrupt the foliation. In several cases the vein pinches or fingers out, and locally the zone contains several thin veins rather than a single vein. The wide veins near the portal were stoped in several places, but the inner part of the level appears to have been driven mainly to explore the shear zone. Although the grade probably decreases toward the west, a 3 inch vein is still present at the face, in a wider zone of lower grade rock.

The high grade mineralization is composed of pyrite with smaller amounts of pyrrhotite, chalcopyrite and sphalerite. Traces of galena were noted in a polished section. A few tenths of a percent arsenic are present in the ore, but no arsenic minerals were seen. The mineralization in places is crudely banded, but if it has been sheared or deformed, it has been completely recrystallized. Four samples were taken and assayed to obtain an idea of the grade of the rock. (Table 1) Samples 569, 571, 572, and 6 Mi suggest that the massive sulfide material commonly runs about 3-3.5% copper, with variable zinc and silver, and low to moderate gold. Table 2 lists a number of samples collected by Loren St. Amand which contain more copper and gold than the Division of Mines and Minerals samples.

Observations at the surface and underground indicate that sulfides are sparse or absent more than a foot or two from the veins. These narrow zones of disseminated sulfide are oxidized and iron-stained both on the surface and underground.

Levels 1, 2 and 3 appear to be on the same vein system, but level 4 is on a separate vein to the north of the lower workings. The sulfide-bearing material above level 4 occurs in globs associated with small crumples in greywacke (schist) adjacent to a shear zone. The greywacke unit is a few feet thick and is underlain and overlain by black slate. According to Johnson (1919), showings of ore were also found at the surface about 650 feet above the second level.

All-American Lode

The mineralization at the All-American lode on the east side of the creek is in an area of poor exposures in the valley bottom. The ore zone is exposed for only a few feet near the north end of a trench. Rock thrown out of the trench indicates that the slate is pyritized in the vicinity, but most of the trench has sloughed and very little rock is in place. The strongly mineralized zone consists of sulfide replacing slate, and is about 3 feet wide as nearly as can be determined.

TABLE I

Assays of Samples Collected by the Division of Mines and Minerals

Sample No.	Width	%Cu	%Zn	%Pb	Oz. Au	Oz. Ag
4AR569	3 inches	3.1	1.1	< 0.1	0.03	0.77
4AR570	3 feet	0.4	0.2	Tr	0.09	0.85
4AR571	3 feet	3.4	4.2	< 0.1	0.15	1.46
4AR572	3 feet	3.6	7.1	< 0.1	0.05	Nil
4AR596	3 feet	0.8	0.9	0.05	0.03	0.03
2 Mi	Grab	0.71			Tr	Nil
3 Mi	Grab	1.53			0.04	Tr
4 Mi	Grab	2.73			0.01	Tr
5 Mi	Grab	Tr			Nil	Nil
6 Mi	Grab	3.39			0.01	Tr
4AR648	Grab	< 0.1			Tr	.25

Description of Samples:

4AR569	Chip sample of massive sulfide vein, level 3, Midas mine.
4AR570	Chip sample across mineralized zone, including vein of 4AR569.
4AR571	Chip sample across 3' vein of massive sulfide and quartz.
4AR572	Chip sample across 3' vein of massive sulfide and quartz.
4AR596	All-American lode, chip sample across 3' zone of sulfide-rich rock.
2 Mi	Grab sample from numerous points on dump of lowest level, Midas mine.
3 Mi	Grab sample from numerous points on dump of 2nd level, Midas mine.
4 Mi	Grab sample from numerous points on dump of 3rd level, Midas mine.
5 Mi	Grab sample from dump of 4th level.
6 Mi	Sample across 28' of mineralization in outcrop above 4th level.
4AR648	Grab sample of pyritized slate with minor pyrrhotite and chalcopyrite, Middle Fork of Sulphide Gulch near junction with West Fork.

Assays by Division of Mines and Minerals, 1953 and 1964. Analyses for Cu, Zn, and Pb on samples prefixed by "4AR" were by X-ray fluorescence methods. "MI" samples were taken by Jasper in 1953.

TABLE 2

ANALYSES OF SAMPLES COLLECTED BY LOREN ST. AMAND

Sample No.	Copper	Gold	Silver	Zinc
#1	9.95%	0.02 oz/T	0.36 oz/T	5-10% *
#2	5.85	0.26	0.58	3-5 *
#4	6.03	0.28	1.42	5-10 *
#5	3.16	0.02	nil	0.5 *
A	13.25	0.09	1.50	4.1
B	2-5*	0.05	0.40	2-3 *
C	5-10*	0.32	0.80	2-5*

Samples B and C contain 0.1 - 0.3% As

Sample No.	Location	
#1	Outcrop	Don Stein, Alaska Division of Mines and Minerals
#2	#2 Tunnel	Don Stein, " " " "
#4	#3 Tunnel	Don Stein, " " " "
#5	All American lode	Don Stein, " " " "
A,B, and C	Midas Mine	Colorado Assaying Company

*Spectroscopic estimate

Its strike is approximately east-west. Parts of the zone contain considerable chalcopyrite. Quartz is the main gangue mineral. The mineralized zone shows small folds with sizes of a few inches up to 2 feet. The folds are defined by banding in the sulfides and appear to reflect deformation of the bedding. The trench appears to have contained some sulfides for most of its 50 foot length, but the shallow shaft at the south end apparently was in unmineralized slate for at least half of its depth. Sample 4AR596 (Table 1) is a chip sample across the exposed sulfide zone.

Other Showings Near the Midas Mine

Greenstone along the river about 1300 feet south of the All-American lode was observed to contain abundant pyrrhotite and traces of copper. Traces of sulfides were seen a short distance south of the southwest corner of figure 2, and copper as cubanite and chalcopyrite is reported at the Bayview claim in the greenstone belt south of the Midas mine, and in shear zones along the south edge of the greenstone (Johnson, 1919, p. 71).

Sulphide Gulch Area

Several reports of the USGS mention the "Addison-Powell" prospect located in Sulphide Gulch southeast of Valdez (Johnson, 1916, 1918; Moffit & Fellows, 1950). Unfortunately, the prospect is not accurately located on any map, and as mentioned previously, the location of Sulphide Gulch is open to question. The best records of the location of the "Addison-Powell" prospect place it near the terminus of the large glacier in the West Fork of Sulphide Gulch. The prospect was described as "a large low-grade copper prospect" on which 150 feet of open cutting and stripping, and 100 feet of tunneling had been done. Chalcopyrite with a little gold and malachite are the minerals reported. Apparently the prospect was never actually visited by the USGS.

The general area of the East, Middle and West Forks of Sulphide Gulch was visited several times by Carl Aldridge of Valdez, and he reports that the only workings seen on these trips were a shallow shaft in the bottom of a gully near the end of the ridge between the West and Middle Forks of Sulphide Gulch. Plane flights over the area by Aldridge and David Kennedy, who operates a flying service at Valdez, also failed to disclose any workings. A flight by the writer produced a similar lack of results. It thus appears that the reported workings either do not exist or are very inconspicuous. In contrast, even the smaller workings at the Midas mine are readily visible, although they are below the brush line.

The shallow shaft reported by Aldridge was not located in the field, but the bare exposures above the terminus of the West Fork glacier exhibit strong iron staining in slates and argillites adjacent to the numerous greenstone sills. Examination of the rocks shows that low to moderate amounts of fine pyrrhotite and pyrite are present in these iron-stained zones. Traces of chalcopyrite can also be seen. Some thin veins of quartz with traces of pyrite and occasional specks of chalcopyrite are present in the greenstone, but in general the greenstone contains much less sulfide than the slate adjacent to the greenstone.

At an elevation of about 1750 feet on the nose of the ridge between the Middle and West Forks, a lens of chalcopyrite and pyrrhotite about 3 inches thick and 5 feet long was found. The lens is in slate about 5 feet from a greenstone contact, and trends parallel to the foliation and bedding. This was the best mineralization seen in the exposures in this vicinity. However, float containing pods of chalcopyrite and pyrrhotite up to 3 inches in width was picked up at several locations.

Farther up the ridge, south of samples 625 and 626, at an elevation of about 3000 feet on the east side of the ridge and below a hanging glacier, an occurrence of chalcopyrite in small veinlets in a greenstone was found. Minor chalcopyrite is disseminated in the greenstone within a few inches of the veinlets. The veinlets are several feet apart. The greenstone lies above a fine greywacke unit and both rocks are folded into a small anticline adjacent to the copper bearing zone, which has oxidized to green malachite stain visible from a considerable distance. The chalcopyrite veinlets are vertical and approximately parallel to the axial plane of the fold. A set of thin vuggy quartz veins is perpendicular to the axis of the fold, but does not seem to contain any chalcopyrite.

Iron staining was visible along the greenstone belt at least as far east as the ridge between the Middle and East Forks, and westward to the divide between the West Fork and Solomon Gulch. David Kennedy of Valdez reports a similar staining is visible from the air eastward to the Copper River.

A traverse over well exposed rock at elevations of 2500 to 3000 feet on the ridge north of the terminus of the West Fork glacier showed only greywacke with some slate, but no greenstone or iron staining. The staining thus seems related to the greenstone, and the greenstone appears to have a distinct northern limit as shown on the map.

Based on two samples panned by R.H. Saunders, Division Mining Engineer, gravel in the West Fork yielded 0.25-0.35 mg of gold (5-8 colors) per double pan, indicating at least a small amount of gold in the drainage. Other minerals present in the concentrates were pyroxene, garnet limonite, pyrite, chalcopyrite, magnetite, zircon and a trace of scheelite (R. Saunders, personal communication). No gold was detected in an iron-stained and pyritized zone with minor copper stain adjacent to a greenstone body (Sample 4AR648, Table 1).

STREAM SEDIMENT GEOCHEMISTRY

About 80 stream sediment samples were collected from the area and are shown on Figure 1. The results are listed in table 3. Samples of the finer sediment were collected from several spots in the actively flowing stream, and analyzed in the field by University of Alaska Method I for readily-extractable heavy metals in soils (Mukherjee and Mark Anthony, 1957). This method uses a sodium chloride solution and dithizone dissolved in white gasoline. The concentration of dithizone in each batch of gas was checked by use of a standard zinc solution, and it was found that a field test of 3 ml was equivalent to about 1 microgram of zinc. Other tests showed much less sensitivity for lead and copper. In addition the samples were brought to a lab, sieved, and the minus 80 mesh material analyzed for total copper, lead, zinc, and molybdenum. Samples RHS-151 to 181 were collected by Robert H. Saunders and analyzed by Rocky Mountain Geochemical Laboratories in Missoula, Montana. Most of the remaining samples were collected by Walter Phillips, field assistant, and analyzed by Al Gooch of the Division of Mines and Minerals in Ketchikan, with a few checks by Rocky Mountain. Both labs used dithizone for lead and zinc, and biquinoline for copper. Dithiol was used for determination of molybdenum by Gooch. Rocky Mountain used a strong acid extraction, and Gooch used a fusion.

Background for total copper seems to be slightly higher in areas draining greenstone than in areas draining slate and greywacke. In the latter cases, 25-50 ppm copper is the common range, whereas for streams draining greenstone, there are very few values below 50 ppm. Analysis of five specimens of greenstone shows copper contents of 50 to 140 ppm, with the highest values from greenstone in the Sulfide Gulch area. The figure of 100 ppm has been selected as the threshold for anomalous values. A plot of copper content against percentage of greenstone in the float showed an increase of copper with proportion of greenstone, but because no samples composed dominantly of greenstone contained between 100 and 175 ppm copper, it was concluded that nothing could be gained by varying background to allow for different rock types. Samples with copper contents of 105 to 500 ppm are shown as weakly to moderately anomalous on the maps, and above 500 are shown as strongly anomalous.

For lead, most values are in the range of 5 to 20 ppm. Samples containing 30 ppm or more are considered anomalous. Only three

TABLE 3

Analyses of Stream Sediment Samples

Field No.	Field Results (ml of dye), and Color at 1 ml	Copper (ppm)	Lead (ppm)	Zinc (ppm)	Moly. (ppm)	% greenstone in float	Size Strea
RHS151	1 green	80	10	160	3	0	
RHS152	8	250	5	250	3	0	
RHS153	1 green	220	10	85	3	0	
RHS154	1 green	160	10	150	3	0	
RHS155	1 green	35	15	105	3	0	
RHS156	1 green	20	5	115	3	0	
RHS157	1 green	40	5	80	3	0	
RHS158	1 green	50	5	80	2	0	
RHS159	1 green	50	5	95	2	0	
RHS160	1 green	50	5	85	2	25	
RHS161	1 green	25	5	75	2	0	
RHS162	4 clear	85	10	110	2	0	
RHS163	3 clear	70	10	75	2	50	
RHS164	1 green	50	5	90	3	0	
RHS165	1 green	45	20	140	3	0	
RHS166	1 green	45	15	125	3	0	
RHS167	1 green	50	10	90	2	0	
RHS168	1 green	45	10	90	3	0	
RHS169	1 green	35	15	110	3	0	
RHS170	1 green	25	75	110	3	0	
RHS171	1 green	25	30	140	3	0	
RHS172	5	50	20	135	2	0	
RHS173	1 green	20	15	85	2	0	
RHS174	1 green	35	15	85	3	0	
RHS175	8	25	15	95	2	0	
RHS176	1 green	50	10	80	2	0	
RHS177	1 green	50	20	170	3	0	
RHS178	2	50	25	140	3	0	
RHS179	6	35	25	120	3	0	
RHS180	1 green	30	15	125	3	0	
RHS181	1 green	100	140	280	5	0	
WP 333	2 clear	40	10	125	0	0	B
WP 334	25+pink	750	20	130	0	0	A
WP 335	20 purple	200	15	140	0	0	B
WP 336	25+purple	1150	45	245	4	10	B
WP 337	25+purple	225	15	135	0	40	B
WP 338	2 clear	55	15	120	0	30	B
WP 339	4 pink	30	10	105	0	80	B
WP 340	2 clear	40	5	130	0	60	B
WP 341	3 pink	90	5	75	0	60	C
WP 342	1 green	75	5	40	0	35	C
WP 343	2 clear	50	5	85	0	25	D
WP 344	2 clear	90	10	100	0	50	B
WP 345	4 pink	100	5	130	0	0	B

Field No.	Field results (ml of dye), and Color at 1 ml	Copper (ppm)	Lead (ppm)	Zinc (ppm)	Moly. (ppm)	% Greenstone in float	Size Strea
WP 346	7 pink	95	10	85	0	0	B
WP 347	22 yellow*	70	5	80	2	0	C
WP 348	7 violet	85	10	130	0	0	B
WP 349	12 violet	60	15	125	0	0	B
WP 350	8 violet	25	0	90	0	0	C
WP 351	8 violet	65	5	90	0	0	D
WP 352	2	175	20	135	0	40	B
WP 353	9 violet	350	5	140	2	50	C
WP 354	17 violet	150	5	125	0	30	A
WP 355	1 green	160	5	125	0	20	B
WP 356	2 clear	50	5	115	0	25	C
WP 357	4 pink	100	10	170	0	5	B
WP 358	1	45	10	125	0	5	C
WP 359	1	25	5	90	0	5	C
WP 360	1	85	5	120	0	20	B
WP 361	3 pink	45	0	105	0	30	B
WP 362	1 green	290	5	125	0	25	B
WP 363	1 green	95	10	75	0	30	B
WP 364	2 clear	200	0	65	0	40	B
WP 365	1 green	30	10	105	0	Split of 4WP 358	
WP 366	5 pink	200	5	135	0	50	A
WP 367	1	215	0	120	1	25	B
WP 368	4	700	5	100	0	20	B
WP 369	1	100	0	50	0	60	C
WP 370	1	95	15	135	0	10	B
WP 371	2	95	5	95	0	70	B
WP 372	4 pink	35	10	65	0	0	B
WP 373	2 clear	35	25	85	0	0	B
WP 374	1 green	25	15	75	0	0	B
WP 375	2 clear	25	0	105	0	0	B
AR 598	4 pink	25	5	80	0	0	D
AR 625	2	750	5	145	1	50	A
AR 626	6	600	5	105	0	60	A
AR 663	4	100	15	45	0	Split of 4WP 339	
AR 574**		50				Midas mine area	
AR 575**		75				Midas mine area	
AR 595**		50			Greenstone belt south of Midas M		
AR 604**		110			Greenstone belt in Sulphide Gulc		
AR 635**		145			Greenstone belt in Sulphide Gulc		

* Pink at 5 ml

** Rock sample of greenstone

Size Stream: A- less than 2 ft. wide; B- 2-8 ft. wide; C- 8-20 ft. wide; D- greater than 20 ft. wide.

samples (171, 181, and 336) fall in this category.

For zinc, values of 80 to 140 ppm are most common. Only three samples (152,181, and 336) contain more than 180 ppm and are considered weakly anomalous.

Molybdenum contents of 2 or 3 ppm were obtained for all but two samples analyzed by Rocky Mountain, and these values are considered background. The procedure used by Gooch was less sensitive and molybdenum was not detected in any samples analyzed by him.

The anomalies can be divided into three groups, as follows:

1. Anomalies at the Midas mine.
2. Anomalies in the Sulphide Gulch area.
3. Anomalies along Port Valdez.

Four samples are anomalous at the Midas mine, two of these strongly anomalous, and two moderately anomalous in copper. The highest value of 1150 ppm copper (sample 336) is from a stream draining through the main dumps. This sample is weakly anomalous in lead (40 ppm) and zinc (280 ppm). Sample 334 contains 750 ppm copper and is from a stream that passes by the fourth level. Lead and zinc in sample 334 are at background levels. Although the copper may be derived from the dump of the fourth level, or from small exposures of mineralization, the anomaly seems too strong to be attributed to the relatively small amount of mineralization in these known sources. Additional veins may exist in this drainage.

It is of interest to note that samples 351, 3½ miles downstream from the mine, and 169, 5 miles downstream from the mine, show no sign of the mineralization.

In the Sulphide Gulch area, three samples are strongly anomalous and eleven are weakly to moderately anomalous in copper. Sample 152 is weakly anomalous in zinc as well as being moderately anomalous in copper. Sample 368, containing 700 ppm copper, is from a small stream draining into the West Fork glacier. Iron-staining and iron sulfides were observed in the stream bed. Some follow-up work on this stream seems justified. Samples 625 and 626 are from streams draining from a small glacier on the west side of the Middle Fork. Minor amounts of mineralization were noted in the vicinity, and additional prospecting is probably worthwhile, although a source under the glacier is possible and would be difficult to follow up. Of the moderate anomalies, the 220 ppm copper observed in sample 153 from the West Fork of Sulphide Gulch is most interesting because of the large size of the drainage, but here again the source may be beneath the large glacier. The large number of weak to moderate anomalies indicates that mineralization is relatively widespread in the greenstone belt and south of it.

Three samples from streams draining into Port Valdez are weakly to moderately anomalous. Samples 170 and 171 are weakly anomalous in lead. Although the lead may result from contamination related to the presence of a dam on Allison Creek, some follow-up sampling seems needed, especially in view of the large size of the drainage. Sample 181 is moderately anomalous in lead and zinc, and deserves further checking.

In general, the results of the field test do not correlate very well with the lab results. Only 10 of 21 lab anomalies were shown as anomalies by the field test, and 9 samples showed distinct field anomalies but were at background levels by the lab analyses. There are several possible explanations for this behavior.

1. The field test detects only metals readily soluble in a nearly neutral water solution. This field test was designed for use with soils rather than stream sediments. In glaciated areas with youthful topography, there may be very little oxidation of sulfides to furnish soluble metal in stream sediments.

2. The field test is much more sensitive to zinc than copper. Lead has an intermediate sensitivity. Because most anomalies in the area are caused by copper, this field test is probably not the best that can be used.

3. When only a few millimeters of dithizone have been added, strong copper anomalies can show green colors similar to the colors shown by background values. It is therefore possible that anomalous results were overlooked because of this similarity in color, aggravated by fine grains of sample dispersed in the organic solvent. However, a few spot checks of the field results failed to detect any such cases.

4. Metal in solution in a stream can be carried past a lake or other obstacle that will trap particles of mineralized rock, or metal-rich water may be derived by oxidation of mineralization that is not undergoing physical erosion. The metal in solution may later be absorbed by fine sediments, and can then be detected by the field test. The samples anomalous in the field test but not in the lab test may indicate this situation.

The writer tends to favor causes 1 and 2 as the explanation of the discrepancy between field and lab results, but the fourth possibility should be kept in mind.

Recent tests of the samples using the heavy metal field method of Hawkes (1963) indicate more satisfactory correlation of field and lab results.

CONCLUSIONS

Rock types in the Midas mine and Sulphide Gulch areas consist of a thick sequence of greywacke and slate of probable Mesozoic age, intruded by basic sills (possibly including some flows) and by a few small plugs of diabase. The basic rocks are exposed along a relatively restricted belt. The sedimentary sequence has been metamorphosed to greenschist facies, and strikes approximately east-west with moderate to steep dips to the north. The age of the ore and of the basic rocks relative to the metamorphism is not certain. Most of the basic rocks are at least weakly foliated, and all contain a mineralogical assemblage consistent with the greenschist facies, so most of the basic rocks were present during the late stages of the metamorphism, and it is probable that all are pre-metamorphic.

Occurrences of copper mineralization are found along the greenstone belt, and at the Midas mine. Ore at the Midas mine consists of veins containing quartz, pyrite, pyrrhotite, chalcopyrite, and sphalerite. The veins follow a shear zone subparallel to the foliation, and are located adjacent to a plug of meta-diabase. The shear zone locally cuts across the foliation but may have formed during the end stages of metamorphism. A few assays indicate grades of 3-3.5% copper and up to 7% zinc, with low to moderate gold and variable silver values. The vein is up to 4 feet wid on the one accessible level of the mine, but wider portions are reported, Several vein segments are present in the shear zone.

The greenstone belt south of the Midas mine extends in one form or another from Jack Bay at least 15 miles eastward to the Sulphide Gulch drainage, and may extend as far as the Copper River, based on aerial observations. Copper shows occur at several places along the belt. They consist of chalcopyrite with moderate to abundant pyrite and pyrrhotite as small veinlets in the greenstone and as lenses and veinlets in the adjacent metasediments. The largest observed copper-bearing veins have thicknesses of a few inches and lengths of a few feet, although iron sulfides are more extensive and continuous. The Addison-Powell prospect was probably an occurrence of this type, but could not be located on the ground.

Geographically, the copper occurrences of the areas are closely associated with greenstone, and are not found elsewhere, suggesting some genetic relation to the greenstone. Perhaps a larger body of basic rock at depth was the source of the copper and other elements, or alternatively the copper may have been leached out of the greenstone by deep-seated metamorphic or magmatic waters, and redistributed to its present site of deposition. In any case, a combination of greenstone with favorable structure of the proper age appears to be necessary to develop an ore-body. More mapping is needed to work out the structural features of the area.

SUGGESTIONS FOR PROSPECTING

At the Jumbo lode of the Midas mine, a more thorough job of sampling and mapping of the workings and of the surface would allow a better evaluation of the tonnage and grade of ore in the presently known vein system. It would probably be necessary to open the second level to accomplish this, but this work should not take more than a few days by a crew of several men. The presence of several veins at the Jumbo lode, and another vein on the All-American claim suggest that still other veins may be present in the vicinity. Geochemical analysis of soil samples might be effective in locating additional veins.

Outside the Midas mine area, the greenstone belt appears to be the most favorable part of the area for prospecting. The better geochemical anomalies found in this survey should be traced to their source. It appears that the University of Alaska field geochemical method is not adequate in this area and some other method, such as that described by Hawkes (1963), should be used. The remainder of the greenstone belt could be prospected by stream sediment geochemistry and by aerial location of iron-stained (and copper-stained) zones, followed by examination and prospecting on the ground. The lack of anomalies 3-5 miles down Solomon Gulch from the Midas mine indicates that stream sediment sampling must have a relatively close spacing to discover the small to moderate-sized ore bodies expected in this region. Because of the numerous glaciers and large glacial streams, ground examination would probably require use of a helicopter in many parts of the belt east of Sulphide Gulch.

The three stream sediment anomalies along Port Valdez should be investigated by additional stream sediment sampling and prospecting.

BIBLIOGRAPHY

Hawkes, H., 1963, Dithizone field tests: Econ. Geol., v. 58, p. 579-587

Jasper, M.W., 1953, Midas Copper Mine, PE 86-11: Division of Mines and Minerals, unpublished.

Johnson, B.L., 1915, The gold and copper deposits of the Port Valdez district: U.S. Geological Survey Bulletin 622, p. 140-188.

Johnson, B.L., 1916, Mining on Prince William Sound: U.S. Geological Survey Bulletin 642, p. 140.

Johnson, B.L., 1918, Mining on Prince William Sound: U.S. Geological Survey Bulletin 662, p. 185.

Johnson, B.L., 1919, Mineral resources of Jack Bay district and vicinity Prince William Sound: U.S. Geological Survey Bulletin 692 C, p. 153-174.

Moffit, F.H., 1954, Geology of the Prince William Sound region, Alaska: U.S. Geological Survey Bulletin 989 E.

Moffit, F.H., and Fellows, R.E., 1950, Copper deposits of the Prince William Sound district, Alaska: U.S. Geological Survey Bulletin 963 p. 47-79.

Mukherjee, N.R., and Anthony, L.M., 1957, Geochemical prospecting: University of Alaska, School of Mines Publication, Bulletin 3, 81 pp.

Turner, F.J., and Verhoogen, J., 1960, Igenous and metamorphic petrology 2nd ed: McGraw-Hill Book Company, p. 531-560.