Zinc-Copper Deposit at Tracy Arm Petersburg District Alaska

GEOLOGICAL SURVEY BULLETIN 998-A

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By H. R. GAULT *and* R. E. FELLOWS

ZINC AND LEAD DEPOSITS OF SOUTHEASTERN ALASKA

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A study of the Tracy Arm zinc-copper prospect

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PREFACE

As a part of its investigations in southeastern Alaska between 1941 and 1948, the U. S. Geological Survey studied in detail eight deposits that contain sphalerite or sphalerite and galena as the predominant ore minerals with lesser amounts of chalcopyrite in a few deposits. These deposits are at Tracy Arm, Groundhog Basin, Glacier Basin, the Lake claims east of Virginia Lake, Berg Basin, Moth Bay, Mahoney Creek, and Dora Lake. These deposits are described in the several chapters of this bulletin.

Zinc and lead minerals are also known or reported at the Hyder district, Whiting River, and Farragut River on the mainland, Cornwallis Peninsula on Kuiu Island, the Keku Islets north of Kuiu Island, Cholmondeley Sound and Beaver Mountain on Prince of Wales Island, Woewodski Island, Taylor Creek on Kupreanof Island, and Coronation Island. Some of these occurrences are noted elsewhere in the geological literature.

To date (1953) no major zinc or lead deposit in Alaska has come into production. Lead has been produced as a byproduct at the Alaska-Juneau gold mine and from the Riverside mine, Hyder district. In 1947 and 1948 about 70 tons of zinc and lead concentrates were shipped from Mahoney Creek to Kellogg, Idaho.

CONTENTS

ILLUSTRATIONS

ZINC AND LEAD DEPOSITS OF SOUTHEASTERN ALASKA

ZINC-COPPER DEPOSIT AT TRACY ARM, PETERSBURG DISTRICT

By H. R. GAULT and R. E. FELLOWS

ABSTRACT

The zinc-copper deposit at Tracy Arm lies in a sequence of metamorphic rocks that flank the west side of the Coast Range batholith. Three zones of metamorphic rocks are recognized in the area: a zone of light-colored brown schists; a zone of dark-green schists, black phyllites, and gray-green schists; and a zone of light-green chlorite schists. In addition to the Coast Range batholith a large quartz diorite sill and numerous quartz diorite and mafic dikes have intruded the metamorphic rocks in this area. The zinc-copper deposit is a replacement vein in a shear zone that parallels the foliation of the metamorphic rocks. The deposit is partially exposed for a length of 1,140 feet, but the greatest amount of ore is confined to the southern 830 feet. The vein averages 4.8 feet wide over the 830-foot interval, but the depth to which it extends is not known. The average grade of ore, as calculated from available analyses, is 3.9 percent of zinc, 1.5 percent of copper, 0.013 ounce of gold per ton, and 0.76 ounce of silver per ton. Reserves of ore are estimated to be about 40,000 tons per 100 feet of depth.

INTRODUCTION

Tracy Arm is a long and impressive fiord extending inland from Holkham Bay, a wide inlet on the east side of Stephens Passage about 47 miles southeast of Juneau. (See fig. 1 and pl. 2.) The area is characterized by steep slopes, a thick growth of brush and timber, and generally rugged relief with peaks as high as 6,600 feet. Timberline is at an altitude of about 2,500 feet.

During 1944 a study of the Tracy Arm zinc-copper prospect was made as part of the strategic minerals program in Alaska of the U. S. Geological Survey. The geology of the zinc-copper deposit and the general geology of an area of about 50 square miles surrounding the deposit were mapped. The writers were in the area from June 6 to September 14, 1944. June and part of July were spent in detailed mapping of the deposit and its immediate vicinity. The remainder of the field season was spent mapping the metamorphic rocks that extend southward from the deposit to a point on the northeast shore of Endicott Arm opposite Sumdum Island and including Sumdum and Bushy Islands.

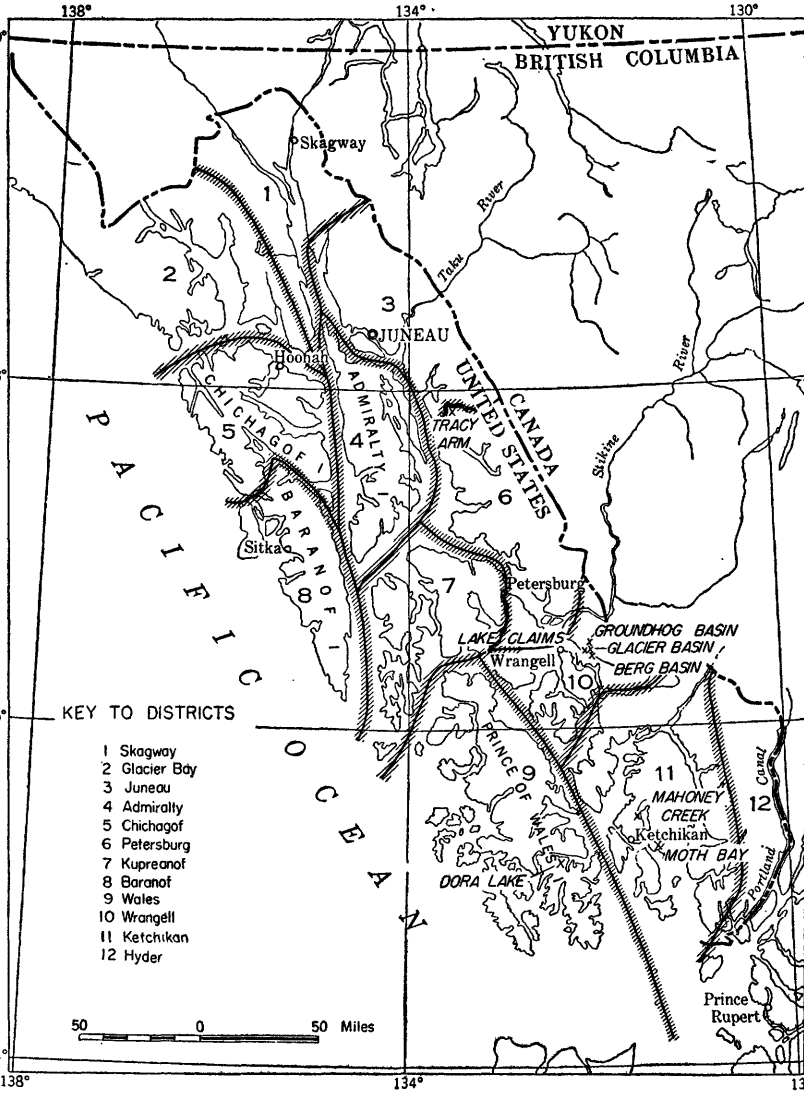

FIGURE 1.—Sketch map of southeastern Alaska showing location of some lead-zinc deposits.

This investigation included detailed mapping of 23 surface pits, one of which includes a 16-foot shaft, and locating the north and south limits of the deposit. (See pl. 1). All the old pits were cleaned out and enlarged, the shaft was bailed out, and 5 new pits were dug. Sampling of the deposit by previous investigators was considered adequate and therefore no ore samples were collected for laboratory analysis by the writers. Detailed microscopic studies were made of the various rock types, but only part of these data are included here.

Information on some of the older mining properties in the area and summaries of the general geology of southeastern Alaska are available in reports by Spencer [1] and by Buddington and Chapin. [2]

W. S. Twenhofel and G. M. Flint, Jr., of the Geological Survey, visited the writers in July to assist in certain phases of the work. Harry Townsend, the owner of the property at this time, spent a week in July at the writers' camp and grateful acknowledgment is made to him for many constructive discussions in the field. The hospitality and cooperation of Ernest Kohlhase, of Harbor Island, is greatly appreciated.

GEOLOGY

The area in the vicinity of Tracy Arm is underlain mainly by a group of northwest-trending metamorphic rocks that flank the west edge of the Coast Range batholith. (See pl. 2.) These rocks are here subdivided into three zones: an eastern zone of light-brown schists; a central zone of dark-green schists, black phyllites and gray-green schists; and a western zone of light-green chlorite schists. The boundaries, based in part on lithology and in part on degree of metamorphism, are not sharply defined.

The metamorphic rocks are bordered on the east by quartz diorite gneiss of the Coast Range batholith. Silicic dikes and sills that seem to be genetically associated with the batholith also have intruded the metamorphic rocks. Lamprophyre dikes are the youngest igneous rocks in the area and intrude both the quartz diorite gneiss and the schists.

METAMORPHIC ROCKS

The easternmost of the three zones of metamorphic rocks consists predominantly of light-brown schists interbedded with minor amounts of dark schists and gneisses. These brown schists are composed largely of quartz-biotite-feldspar, quartz-muscovite-biotite, and quartz-muscovite-feldspar varieties. Amphibolites and dark phyllites are present locally. Some of the phyllite bands contain several percent of sulfide minerals, principally pyrite and pyrrhotite.

Narrow discontinuous marble beds crop out near the contact of the metamorphic rocks with the batholith about 8 miles south of the elbow of Tracy Arm. Carbonate schists and very impure marble crop out farther to the south and are well exposed in the long valley on the east shore of Endicott Arm opposite the middle of Sumdum Island. (See pl. 2.)

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[1] Spencer, A. C., 1904, The Juneau gold belt, Alaska, *in* Contributions to economic geology, 1903, by S. F. Emmons and C. W. Hayes, U. S. Geol. Survey Bull. 225, p. 28–42.

[2] Buddington, A. F., and Chapin, Theodore, 1929, Geology and mineral deposits of southeastern Alaska: U. S. Geol. Survey Bull. 800.

The central zone is slightly more than a mile wide. The metamorphic rocks are more heterogeneous and generally darker than the light-brown schists of the eastern zone. Amphibole, amphibole-biotite, amphibole-plagioclase, quartz-mica, quartz-feldspar, and amphibole-garnet-feldspar schists form the bulk of the rocks in this zone. A few of the garnet-bearing schists contain quartz and calcite lenses and pods many of which are from several inches to several feet long and from 1 to 6 inches thick.

Chlorite, chlorite-epidote-carbonate, chlorite-quartz, amphibole-chlorite-biotite, and amphibole-chlorite schists are the dominant rock types in the westernmost zone. Intercalated with the schists are narrow bands of black phyllite and quartz-mica, quartz-feldspar, amphibole-feldspar, and mica schists. Many of the rocks in this zone contain quartz veins and lenses some of which parallel the foliation and range up to several feet in length.

IGNEOUS ROCKS

The igneous rocks in the Tracy Arm area include the quartz diorite gneiss of the Coast Range batholith, the sills and dikes genetically associated with it, and the younger lamprophyre dikes that cut both the Coast Range intrusive masses and the metamorphic rocks.

The western edge of the batholith forms the eastern limit of the zone of metamorphic rocks. The gneiss is most commonly a coarse-grained rock composed of quartz, biotite, hornblende, and plagioclase, with accessory orthoclase, sphene, apatite, and magnetite. Numerous medium- to fine-grained dikes, mostly quartz diorites, alaskites, and a few pegmatites, have intruded the metamorphic rocks. A thick quartz diorite sill crops out just south of the elbow of Tracy Arm and about 2,200 feet west of the contact between the metamorphic rocks and the batholith. The intrusion of this sill probably was an important factor in the genesis of the ore deposit.

Schistose inclusions are numerous within the batholith, particularly near its western border. These inclusions reach a maximum length of several feet but most of them are only a few inches long. The inclusions are consistently alined parallel to the foliation in the batholith.

Within the quartz diorite intermediate andesine is the most abundant mineral. Moderate zoning of the plagioclase is characteristic throughout the quartz diorite mass. The other essential minerals in order of decreasing abundance are hornblende (var. pargasite), biotite, and quartz. Accessory constituents are orthoclase, sphene, apatite, and magnetite. Secondary minerals are sericite, chlorite, calcite, and epidote. Orthoclase is abundant enough in a few specimens to permit them to be classified as granodiorites although the distinction is slight and only locally applicable. The average of the modes of representative samples selected in 1944 from the batholith in the Tracy Arm area compares closely with the mode determined by Buddington and Chapin [3] for five quartz diorites from southeastern Alaska:

Comparison of the average of modes (in percent) of representative quartz diorite samples

	15 samples, 1944, Tracy Arm area [Determined by R. E. Fellows]	*5 samples, Southeastern Alaska* [Determined by Buddington and Chapin]
Plagioclase	58	54.5
Hornblende	16	15
Biotite	10	7
Quartz	13	19
Orthoclase	2	3
Accessory minerals	1	1.5

The quartz diorite in the thick sill west of the ore deposit does not differ appreciably from that in the parent mass. Hornblende laths, plagioclase laths, biotite flakes, and small quartz augen are generally well alined.

Compositional and textural variations are seen near and at the contact of the batholith with the metamorphic rocks although some of the exposed contacts are sharply defined with no affected border zone. The variant facies include a dark medium-grained massive rock composed wholly of hornblende and calcic andesine, and an extremely coarse-grained massive rock composed of hornblende crystals with a maximum length of 18 millimeters set in a white matrix of coarse intermediate andesine crystals.

The numerous dikes of intermediate to acid composition that cut the metamorphic rocks are probably differentiates from the main quartz diorite magma. They include diorites, quartz diorites, alaskites, and a few small pegmatite stringers. These dike rocks are medium- to fine-grained gray aggregates of plagioclase, hornblende, biotite, quartz, apatite, and sphene. Alteration products are chlorite, sericite, and calcite. The dikes that cut the zinc-copper ore body are metallized with minor amounts of chalcopyrite, sphalerite, and pyrrhotite. These dikes seldom exceed a few feet in thickness, but are locally as much as 25 feet thick and commonly intersect each other.

The quartz diorite dikes can be separated into two varieties on the basis of the presence of hornblende and the composition of the feldspar. One variety is hornblende-rich with calcic andesine; the other is lacking in hornblende and contains intermediate andesine.

Foliation, which is nearly parallel to that of the metamorphic rocks, is more noticeable in the diorite dikes than in the quartz diorite dikes.

[3] Buddington, A. F., and Chapin, Theodore, op. cit., p. 212 (item 3 in table).

Alaskite dikes cut the metamorphic rocks, the sill, and probably also the main batholith. They contain sodic plagioclase, potash feldspar, and quartz but are practically barren of dark minerals.

The basic dikes are light- to dark-green very fine to medium-grained lamprophyres. Brown hornblende and plagioclase are the principal primary minerals of the basic dikes along with minor amounts of pyrite, sphene, quartz, and magnetite. Epidote, sericite, chlorite, and calcite are alteration products of the hornblende and plagioclase. The maximum thickness of the dikes is 30 feet, but thicknesses ranging from 1 to 2 feet are more common. The thicker dikes have chilled margins; and some are porphyritic.

Quartz diorite dikes, most of which are near the borders of the large intrusive masses, are most abundant. The lamprophyres are second in abundance and crop out principally in the northern half of the area.

STRUCTURE

The structure in the Tracy Arm area conforms in general with the major features known throughout southeastern Alaska. The regional trend of the rocks is northwest. Lineations in the gneiss show a consistent and steep northward plunge. The contact of the batholith with the metamorphic rocks is slightly discordant as revealed by a comparison of the attitudes of foliation in the quartz diorite and in the schists. The discordance also becomes apparent over a distance of several miles by an increase in width of the easternmost metamorphic rock units and the appearance of new members toward the south.

Isoclinal folds are common in the metamorphic rocks. The fold axes plunge somewhat more steeply southward in the northern half of the mapped area than in the southern half. In the northern part of the area the foliation in the schists strikes N. 10°–15° W., whereas in the southern half the strike is more westerly.

The metamorphic rocks are largely recrystallized. Thickening in the crests of folds is prominent in quartzites as well as in phyllites and in many places amounts to 200 percent in the quartzites and several times that amount in less competent rock units. The direction of the stretching of quartz grains and pyrite cubes is generally parallel to the fold axes although discrepancies occur.

The dominant set of joints in the area strikes N. 45° E. at an angle of about 65° to the strike of the foliation and dips steeply northwest. (See fig. 2.) Wherever detailed studies have been made in the Wrangell–Revillagigedo belt of metamorphic rocks, this set of joints predominates. The pattern of joints in the quartz diorite gneiss conforms to that in the schist.

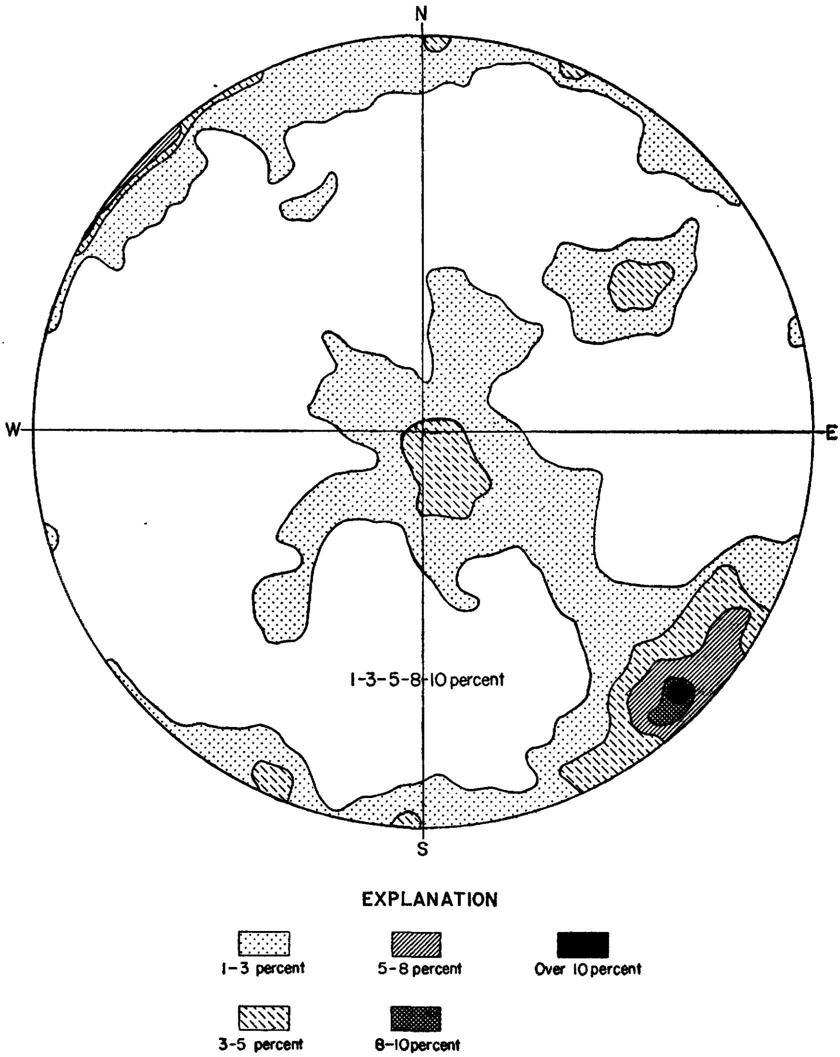

FIGURE 2.—Equal area plot showing distribution of poles of 334 joint planes measured at Tracy Arm and vicinity.

ZINC-COPPER DEPOSIT

The zinc-copper deposit is on a poorly defined topographic bench about 1 mile south from the elbow and on the east side of Tracy Arm at an altitude of 780 to 850 feet. (See pls. 2 and 3.) A trail 1 mile long leads to the deposit from the mouth of a stream that flows through a prominent notch and empties into Tracy Arm about 800 feet south of the elbow.

Roehm,[4] who visited the property in 1942, has recorded that the deposit is reported to have been discovered by Alex Butterbaugh in 1916. Buddington[5] examined the property briefly in 1923 and stated that it was relocated in 1922 and 1923 by Eugene Owens as the Neglected Prize. The deposit was again relocated by Harry Townsend in 1943. Samples were cut by Roehm in 1942 and by the U. S. Bureau of Mines in 1943. J. C. Reed and W. S. Twenhofel, of the Geological Survey, spent 3 days at the deposit in 1943, and it was on their recommendation that the present work was performed.

Field work leading to this report entailed the mapping of 23 surface pits and determining the north and south extent of the deposit. (See pl. 1.) All the old pits were cleaned out and enlarged, the shaft was bailed out, and 5 new pits were dug. Harry Townsend returned to the deposit for a few days in September after the writers had left and later reported that he dug a long trench normal to the strike of the vein at the shaft.

Pyrite, pyrrhotite, and much less abundant chalcopyrite, sphalerite, and magnetite are disseminated through a large part of the section of metamorphic rocks at Tracy Arm and Endicott Arm. Most of the rocks that contain disseminated sulfide minerals are black phyllites and light-colored quartz-rich schists. Many small quartz veins in the metamorphic rocks contain pods and disseminated grains of pyrite and pyrrhotite, but only at the Tracy Arm zinc-copper prospect are the sulfide minerals sufficiently concentrated to constitute an ore deposit.

DESCRIPTION

The zinc-copper deposit is a replacement vein in a shear zone that parallels the foliation of the country rock. The shear zone, which can be traced along its strike to a point 75 feet south of the southern limit of the vein, is in the easternmost belt of light-colored schists. Northward from the vein the shear zone is marked by a poorly defined gully that leads to the shore of Tracy Arm.

This shear zone, as well as others in the area, is characterized by small tight drag and shear folds, granulated country rock, brecciation, and offsetting of dikes and beds. The shear zone that contains the vein grades along the strike into unsheared country rock. The walls of the shear zone are fairly well defined; the width of the zone, where measurable, ranges from 1 to 12 feet.

The zinc-copper vein can be traced for 1,140 feet horizontally and 110 feet vertically. The northern 310 feet consists of a discontinuous band of sulfide minerals 4 to 6 inches wide. Within the 830-foot

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[4] Roehm, J. C., 1942, Mining investigations in southeastern Alaska for 1942: Alaska Territorial Dept. Mines. [Unpublished report.]

[5] Buddington, A. F., 1925, Mineral investigations in southeastern Alaska: U. S. Geol. Survey Bull. 773-B, p. 130-131.

southern portion the vein consists of massive and banded ore, with slightly metallized quartz diorite dikes, alaskite dikes, and quartz veins.

Sphalerite and pyrrhotite are concentrated largely in the central part of the vein and is designated as massive ore. A few small barren blocks of schist occur within the massive ore. The massive ore is ¼ to 3¾ feet wide (pl. 1) and consists of an aggregate of sphalerite, chalcopyrite, and pyrrhotite together with a very minor amount of galena in a matrix of light-colored silicate minerals.

The massive ore is generally bounded by banded ore that ranges in width from 1 to 12 feet. The banding is produced by slight variations in grain size and composition in the light-colored quartz-rich schists. Banded ore is distributed most commonly on both sides of the massive ore. The minerals in the banded ore are the same as those in the massive ore, but chalcopyrite is the predominant sulfide. The ore minerals, owing to selective replacement, are confined to thin lamellae in the schist. The amount of sulfide minerals in the banded ore decreases outward from the center of the vein, and not all the banded material can be classed as ore.

Several quartz diorite and alaskite dikes cut the shear zone. The margins of the dikes are slightly metallized where they are in contact with the vein, and locally the alaskite bodies contain sufficient amounts of sulfide minerals to constitute banded ore.

A brief study of polished sections of the ore shows that pyrrhotite was the first sulfide mineral to be deposited. It was followed by sphalerite, chalcopyrite, and galena. Quartz, mica, and feldspars form the gangue and together constitute 50 percent or more of the ore.

Chalcopyrite fills several small fractures in the vein near the shaft at pit 12. The ratio of sphalerite to chalcopyrite here is roughly 2 to 1. In general the proportion of sphalerite is slightly higher in the massive ore than in the banded ore. Pyrrhotite is a minor constituent except in the dense central part of the massive ore. This concentration of pyrrhotite is thought to represent a replaced zone of gouge. Galena is sparse and was identified only in polished sections of samples from pit 12 south of the shaft. Pyrite impregnates the country rock for 10 to 15 feet on either side of the shear zone, especially near the northern portion of the deposit.

The best massive ore is in the central part of the southern 830 feet of the vein where the combined width of massive and banded ore ranges from 2 to 12 feet. The vein is characterized by pinching and swelling along its strike. Its vertical extent is not known, but, because the ore at the surface is continuous, it seems reasonable that the ore may extend at least a few hundred feet below the surface.

The solutions that impregnated the shear zone and formed the vein are probably genetically related to the quartz diorite sill that crops out 600 feet west of the ore body. (See pl. 3.) The vein is in that part of the shear zone nearest the sill.

Other shear zones with the same general topographic expression and length as the one containing the vein are present in the surrounding area. Most of these are also parallel to the foliation of the metamorphic rocks, but a few strike northeastward. One of the zones lies 100 feet west and parallel to the zone which contains the vein. About 1,500 feet of the trail leading from the deposit to the beach lies in a prominent notch which is the trace of another zone.

Pyrite, pyrrhotite, and chalcopyrite are only slightly more abundant in the shear zones than in the unsheared country rock. Bands of material several inches wide and a few tens of feet long containing 10 to 15 percent of sulfide minerals are exposed in other shear zones near the deposit.

RESERVES

Several investigators have sampled the deposit since its discovery in 1916. The results of their analyses are shown in the table. The writers did not attempt to sample the deposit thoroughly because the earlier analyses are believed sufficient in number and distribution to give a reasonably accurate estimate of the grade of ore. The weighted average of ore, calculated from the analyses given in the table, omitting several values obviously much higher than the average, is 3.2 percent of zinc, 1.5 percent of copper, 0.013 ounce of gold per ton, and 0.75 ounce of silver per ton.

The tonnage of ore in the vein is classed as inferred ore and is estimated to be about 40,000 tons per 100 feet of depth. This figure is based on an average width of 4.8 feet, a length of 830 feet, and a conversion factor of 10 cubic feet of rock per ton. The depth to which the ore extends is not known.

Summary of assay data derived from samples taken at the Tracy Arm zinc-copper deposit

Pit no.	Zinc (percent)	Copper (percent)	Gold	Silver	Width of sample (feet)	Sampler
			(ounces per ton)			
5	3.21	1.32	0.01	1.40	5.9	Muir.
7	2.04	1.80	None	None	4.5	Reed, Twenhofel.
7	1.53	2.60	.10	.50	5.0	Roehm.
7	1.60	2.42	Tr.	.66	4.5	Townsend.
7	1.36	1.18	.03	1.00	1.8	Muir.
7	.39	.53	.01	1.00	2.1	Muir.
7	2.52	.50	.01	.90	1.7	Muir.
9	3.06	2.80	.06	.70	5–6	Roehm.
9	2.28	1.85	.01	.90	4.0	Muir.
10	5.31	5.50	.12	1.20	4.0	Roehm.
10	4.40	3.26	.02	1.34	3.0	Townsend.
10	2.42	2.34	.02	.70	5.0	Muir.
12	6.70	3.87	.04	3.92	3.0	Townsend.
12	9.54	4.70	.02	1.60	3.5	Roehm.
12	6.84	4.25	None	None	3.0	Reed, Twenhofel.
12	7.29	2.94	.03	.70	3.0	Muir.
12	6.41	2.42	.03	1.20	3.3	Muir.
12	4.08	2.08	.02	1.00	3.6	Muir.
14	5.80	1.91	Tr.	.72	4.0	Townsend.
14	10.44	3.20	.02	Tr.	4.0	Roehm.
14	8.64	2.52	.01	.80	3.8	Miur.
15	13.50	6.30	.09	1.30	4–5	Roehm.
15	7.28	1.48	.01	.80	3.8	Muir.
15	.39	.15	.01	.80	2.6	Muir.
17	5.40	1.35	Tr.	.28	6.0	Townsend.
17	3.24	2.52	Tr.	.40	5–6	Roehm.
17	6.11	1.28	.10	1.00	7.0	Muir.
19	4.40	1.11	Tr.	.26	6.0	Townsend.
19	4.59	2.41	Tr.	.50	8–10	Roehm.
19	3.49	.71	Tr.	Tr.	9.4	Muir.
20	3.21	1.59	.01	.20	6.7	Muir.
21	4.46	.66	None	1.00	.7	Muir.
21	1.16	.33	Tr.	.80	3.3	Muir.
22	4.17	2.71	.01	1.60	2.7	Muir.

INDEX