

GEOLOGY AND GEOCHEMISTRY OF THE TIN CREEK
ZINC-LEAD-SILVER SKARN PROSPECTS, FAREWELL
MINERAL BELT, SOUTHERN ALASKA RANGE, ALASKA

A
THESIS

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ABSTRACT

Numerous zinc-lead-silver-copper skarn and replacement bodies occur in a 750 km² area near Farewell, McGrath Quadrangle, Alaska. Interest in the extent and localization of these deposits led to detailed examination of skarns at Tin Creek, one of the mineralized areas.

Skarn deposits are of two types: 1) pyroxene (Hedenbergite¹⁵⁻⁸⁶) skarns with sphalerite and minor chalcopyrite, and 2) garnet (Andradite¹²⁻¹⁰⁰) skarns with chalcopyrite and minor sphalerite. Pyroxene skarns exhibit textural zoning. Garnets are compositionally zoned with aluminum-rich cores rimmed by progressively iron-rich garnet. Skarns are spatially zoned, with pyroxene-sphalerite skarns distal to and garnet-chalcopyrite skarns proximal to the dike swarm center. Ore minerals replace earlier formed calc-silicate minerals.

The Tin Creek skarn prospects compare favorably to zinc-lead skarns that form near dikes. Deposits have features, such as structural control of metasomatic fluids and textural and compositional zoning, common to zinc-lead skarns worldwide.

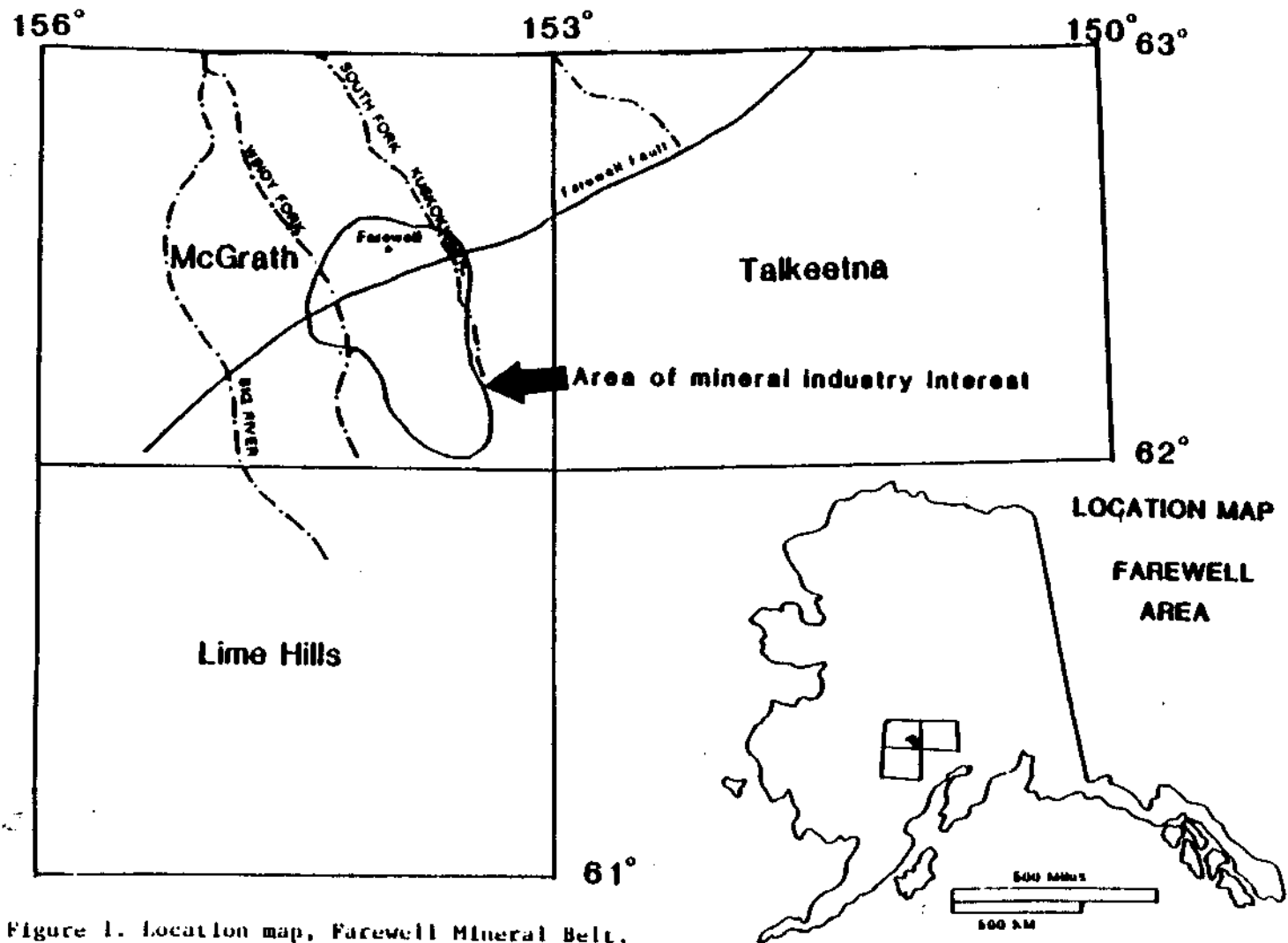


Figure 1. Location map, Farewell Mineral Belt.

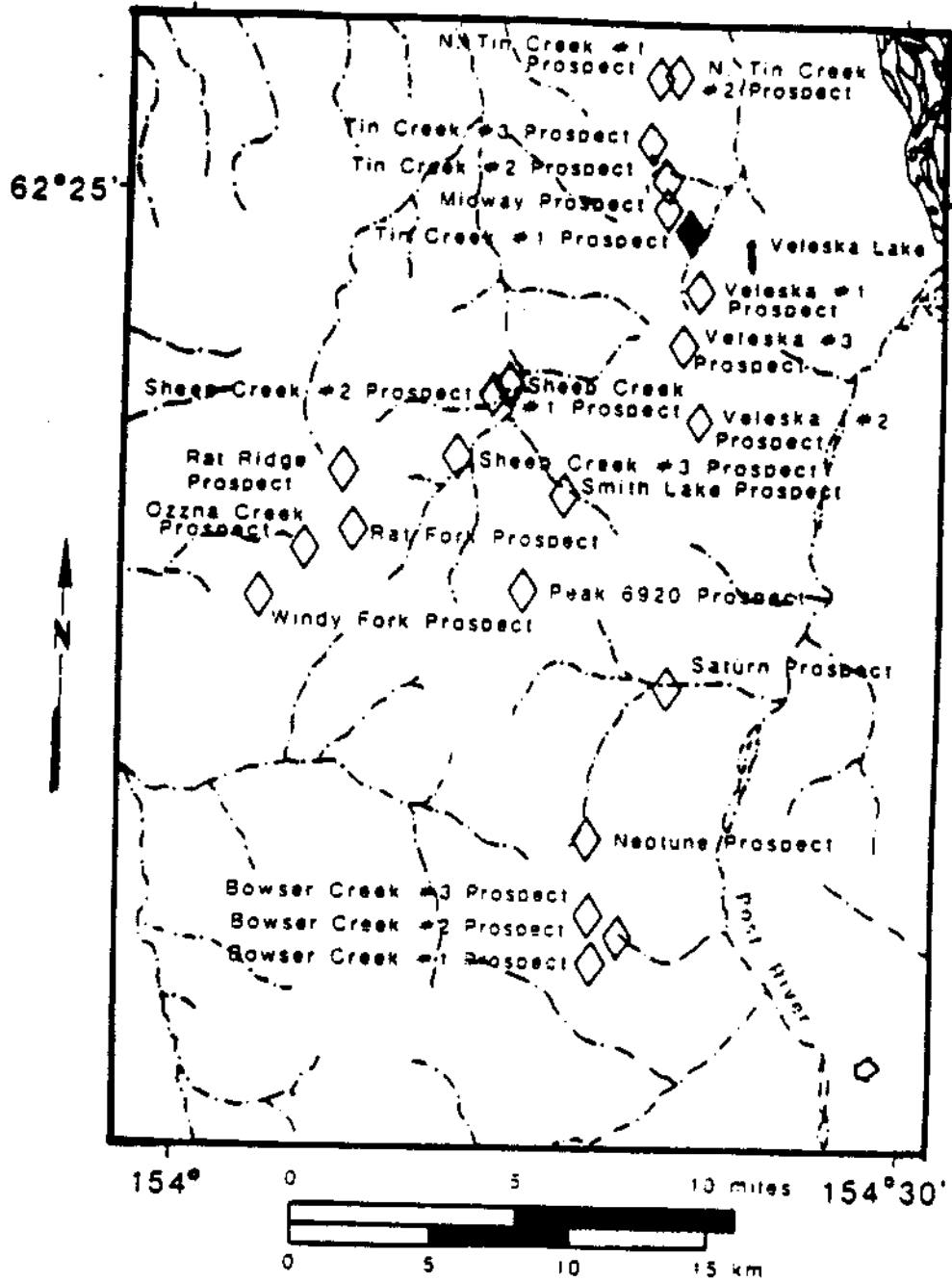


Figure 3. Regional geologic map of the Farewell area, Alaska.

The alteration of pyroxene to amphibole at Tin Creek is similar to alteration described in many Zn-Pb skarn districts. Fibrous amphibole derived from pyroxene is known as uralite, and the process is known as uralization. Uralization involves the oxidation of divalent to trivalent iron; a great loss of calcium; and a gain in silicon, alkalies, and in some localities a gain in magnesium (Allen and Faley, 1957). The oxidation of iron during uralization is indicated at Tin Creek by the occurrence of hematite, pyrrhotite, and chalcopyrite with the amphibole. Allen and Faley (1957) report that amphibole belonging to the cummingtonite-grunerite series replaces pyroxene in the zinc-lead skarn deposits of the Central Mining District, New Mexico. The amphibole from Tin Creek may also belong to this series because of the similarities in the formation of the amphibole.

MINERAL RESOURCE ESTIMATES OF THE FAREWELL AREA

Grade and Tonnage Estimates of a Zn-Pb-Ag Skarn Deposit

Estimation of the grade and tonnage of potential skarn deposits in the Farewell area is a challenging task. The Tin Creek skarn prospects are some of the best explored areas in the McGrath Quadrangle, yet to date there has been only limited drilling and detailed geologic mapping. Estimates based only on knowledge of the local area would be tentative at best due to the high uncertainties involved.

Grade-tonnage estimates for the Tin Creek area can be postulated by examining data from a worldwide collection of zinc-lead-silver skarn deposits. An inherent bias in this approach is the assumption that the Tin Creek area actually contains a skarn deposit and that this deposit is similar to an average of zinc-lead-silver skarn deposits.

Table 9 provides estimates on the grade and the tonnage potential for a zinc-lead-silver skarn deposit in the Farewell area. Data used for these estimations is from Singer and Mosier (1983). Numbers given in each column of table 10 are statistical parameters developed from the worldwide data base. The numbers in the 10th percentile column are minimum grades or tonnages for 10 percent of the zinc-lead skarns examined. The 50th percentile column corresponds to the mean or the average for these deposits.

Estimate of Number of Zn-Pb-Ag Skarn Deposits in the Farewell Area

A similar approach to grade-tonnage estimates can be taken to estimate the number of zinc-lead-silver deposits likely to be present in the Farewell Mineral Belt surrounding the Tin Creek prospects. The Darwin mining district in eastern California has been used in this approach due to the similarity of the geologic environment to the Farewell area, the presence of many zinc-lead-silver skarn deposits in an area comparable to the Farewell area, and the Darwin Quadrangle has been extensively explored.

Table 9.

Grade and tonnage parameters from 47 zinc-lead skarn deposits.

	10th <u>percentile</u>	50th <u>percentile</u>	90th <u>percentile</u>
Tonnage (million of tons)	18.0	2.1	0.25
Zinc grade (percent)	14.0	5.8	2.8
Lead grade (percent)	11.0	3.6	0.54
Silver grade (grams/ton)	390.0	98.0	--
Copper grade (percent)	1.2	0.079	--

Harris (1984) cites numerous examples where analogy methods were used to estimate mineral resources. An area with a known number of deposits in a well established geologic environment is selected as a control area. This control area is also selected so that it is as geologically similar as possible to the area being evaluated. The analogy method of appraisal generally estimates the unknown economic resources of known modes of occurrence (Harris, 1984). Analogy methods are deficient in the long time frame, but the method is suited to the resource evaluation needed for the Farewell area.

The part of the Darwin Quadrangle to be used in this comparative study measures 27 by 22.5 km. The total metal production from the Darwin Quadrangle for the period from 1878 through 1951 was approximately 6,300 ounces of gold, 8 million ounces of silver, 1,000 tons of copper, 65,000 tons of lead, 23,000 tons of zinc, and 35,000 short ton units of WO_3 (Hall and MacKevett, 1962). The Pb-Ag-Zn deposits are concentrated in Paleozoic limestone close to intrusive contacts (Hall and MacKevett, 1962). The largest deposits are adjacent to the stock in the Darwin Hills in the southern section of the quadrangle. The ore bodies occur as bedded deposits, irregular replacement bodies close to major faults, fissure or vein deposits, and small ore bodies in flat lying structures (Hall and MacKevett, 1958). The Darwin deposits have average grades of 6 percent lead, 6 percent zinc, 6 ounces per ton silver, and small amounts of copper (Hall and MacKevett, 1962).

The part of the Darwin Quadrangle selected as a control area (600 sq. km) contains 102 prospects and 9 deposits, with the distinction between prospect and deposit based on distinctions between principal and minor mines in Hall and MacKevett (1962). These numbers lead to a deposit to prospect ratio of 0.09. This ratio can then be applied to the Farewell Mineral Belt (McGrath A-2 and B-2 quadrangles). The number of Zn-Pb-Ag skarn prospects in the Farewell Mineral Belt can be enumerated using Anaconda Minerals Co. data (unpublished) and data from Cobb (1976), Cobb and Reed (1976, 1981) and ADGGS (Bundtzen, personal commun., 1985). These sources list 23 prospects that are Zn-Pb-Ag skarn prospects or related to Zn-Pb-Ag skarns (ex. distal Pb-Ag-Zn veins at Bowser Creek and Rat Fork). The multiplication of 23 prospects and a deposit to prospect ratio of 0.09 results in a analogous number of 2.1 deposits in the Farewell area. Two Zn-Pb-Ag skarn deposits with average grades of 5.8% Zn, 3.6% Pb, 98 grams/ton Ag (3 ounces per ton), and 0.079% Cu and average tonnage of 2.1 million tons as detailed earlier is likely in the Farewell area, given that all of the inherent assumptions of an analogy approach are true.

SUMMARY

- The Tin Creek skarns are structurally localized along dike contacts, high-angle faults, and low-angle thrust faults within interbedded Silurian limestones and clastic rocks.

- The Tin Creek skarns can be divided into two skarn types, pyroxene dominant skarns and garnet dominant skarns. Epidote dominant skarns are a subgroup of both pyroxene and garnet skarns, produced by later alteration of these skarn minerals. Amphibole dominant skarns are a subgroup of the pyroxene dominant skarns.
- Pyroxene in skarns evolve from earlier, fine-grained pyroxene to later, coarse-grained pyroxene.
- Petrographic studies of garnet indicate a paragenetic sequence of early, green, metamorphic garnet to later, clear, metasomatic garnet to latest, brown, dbb, metasomatic garnet. Microprobe analyses indicate that this sequence involves iron enrichment of the garnet compositions throughout the deposition of the calc-silicate minerals.
- The calc-silicate minerals in the Tin Creek skarns are generally iron rich varieties. Pyroxene compositions range from Hd_{15-86} and Jo_{1-18} . Garnet grains range in composition from Ad_{8-100} and $Sp+Al_{0-6}$. Epidote group minerals range in composition from 4 to 32 mole percent Fe, with a maximum of 40 mole percent Fe in natural epidote minerals.
- The Tin Creek skarns have a zoned distribution pattern, with

garnet skarns proximal to and pyroxene skarns distal to the Tin Creek dike swarm center.

- The significant ore mineralization in the Tin Creek area is intimately associated with the skarns. The major mineralization is found within the skarn bodies or along the marble front of the skarns.
- Sphalerite is the dominant ore mineral present in the Tin Creek skarns, with lesser amounts of chalcopyrite and galena.
- Sulfide deposition in the Tin Creek skarn system is intimately associated with the development of the calc-silicate minerals in the skarns. Sulfide deposition occurs after the main skarn forming events. Metamorphic calc-silicate minerals are unaccompanied by ore minerals and early metasomatic calc-silicate minerals are accompanied by minor ore minerals. The main period of sulfide deposition is thus contemporaneous with to later than the waning formation of garnet and pyroxene.
- Sphalerite is preferentially associated with pyroxene dominant skarns and chalcopyrite is usually preferentially concentrated in garnet dominant skarns.

- The preferential association of sphalerite with pyroxene leads to areal zoning of the ore minerals, with garnet-chalcopyrite skarns near the center of the exposed Tin Creek system and pyroxene-sphalerite skarns peripheral to the garnet-chalcopyrite skarns.
- Massive sulfide mineralization at the marble front is only associated with the pyroxene dominant skarns.
- Zn-Pb-Ag ore potential at Tin Creek exists at distances greater than 2 km from the dike swarm center, based on radially oriented cross-sections through the system.
- Porphyry copper potential appears to be low at the Tin Creek prospects.
- The Tin Creek skarn prospects compare favorably to other Zn-Pb skarns. Some common characteristics include: the skarns are associated with structural pathways, the calc-silicate minerals contain significant amounts of both ferrous and ferric iron, pyroxene is usually the dominant calc-silicate mineral, the dominant ore mineral is sphalerite, and the dominant ore sulfides are associated with pyroxene.
- Analogy methods have been used to estimate the number of typi-