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INVESTIGATION OF MERCURY-ANTIMONY-TUNGSTEN METAL PROVINCES OF ALASKA II

by

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INVESTIGATION OF MERCURY-ANTIMONY-TUNGSTEN METAL PROVINCES OF ALASKA II

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Introduction

Mercury and antimony deposits worldwide have been traditionally classified as epigenetic vein deposits of the epithermal zone, whereas tungsten deposits have been classified as contact-metasomatic deposits of the mesothermal zone. Maucher (1976) has shown that much of the cinnabar, stibnite, and scheelite mineralization of the Circum-Pacific and the Mediterranean regions is both isogenetic and stratabound; he summarized the major characteristics of the Hg-Sb-W mineralization of these areas as follows:

1) The fundamental metal supply took place during the early Paleozoic and is genetically associated with basic volcanism.

2) The primary strata-bound Hg-Sb-W mineralization reacted differently to subsequent geotectonic and geothermal events. The strata-bound sequences have generally been metamorphosed to the greenschist facies and are accreted along earlier continental margins.

3) Peculiarities of younger deposits are a function of reactivities and mobilities of the elements and of differences in subsequent magmatic and metamorphic events which transformed, mobilized, and redeposited the ore minerals.

   a. Scheelite, the least mobile of the three elements, is limited to the primary strata-bound sequence except in cases of granitization and intrusion of magma, where the mineralization is localized in reaction skarns and quartz fissures.

   b. Stibnite may be found in the contacts between the primary sequence and younger rocks. During greenschist-facies metamorphism the mineralization is concentrated in lenses along fisures and fractures.

   c. Cinnabar has the greatest mobility and is redeposited in younger horizons with or without stibnite.

4) Mercury deposits are of Mesozoic-Cenozoic age.

5) The source of the Hg-Sb-W is volcanic activity along Cordilleran-type subduction zones.

6) The Hg-Sb-W association is Circum-Pacific as evidenced by investigations in Korea, Tasmania, Bolivia, and California.

The potential for mercury-antimony-tungsten strata-bound mineralization in Alaska was first discussed by Metz (1977) and later by Metz and Robinson (1979). In order to test this hypothesis an examination was made of some of the known mercury-antimony, and antimony-tungsten bearing deposits in the interior of the State.

Hg-Sb-W Metal Provinces in Alaska

Cobb (1970a,b; 1975) has compiled comprehensive bibliographies on the mercury, antimony, and tungsten occurrences in Alaska. Clark and others (1974) have defined five metal provinces in Alaska that include one or more of these elements as a major constituent and five more that have one or more of the elements as a minor constituent (Figure 1 and Table 1).

The fist six provinces listed in table 1 contain tungsten. The country rock types are greenschist-facies metasedimentary and metavolcanic rocks. The country rocks are Paleozoic or older and the intrusive rocks, which range from granodiorite to granite, are both Mesozoic and Cenozoic. At the major occurrences that are associated with intrusive rocks, scheelite is present in the intrusive complex (Byers and Sainsbury, 1956) in reaction skarns or within quartz veins filling fractures in the country rocks. Stibnite occurs within the six provinces as lenses, or 'kidneys,' within fractures and fissures in the schists. Mercury is present only as a minor element.

The Kuskokwim River province contains major mercury and antimony vein mineralization, and the Goodnews Bay province contains minor mercury vein mineralization. The associated country rocks are predominantly Mesozoic and include sedimentary and volcanic sequences. Intrusive rocks near the deposits range from dunite to rhyolite and are Mesozoic and Cenozoic in age. Major tungsten mineralization has not been reported in either province.

The Chugach Mountains-Kodiak Island-Gulf of Alaska province contains several minor tungsten occurrences associated with gold quartz veins. The country rocks are greenschist-facies metamorphics. The parent rocks are trench deposits, including graywacke, shale, and associated mafic volcanic rocks. Tungsten is associated with Cenozoic intrusive rocks, which are mainly quartz diorite. No antimony or stibnite mineralization is present.

Major tungsten mineralization is present in the Hyder intrusive complex. The country rocks are Mesozoic, and the intrusive complex is Cenozoic. There is no mercury or antimony mineralization associated with the complex.

Except for the Hyder district, the major tungsten mineralization in Alaska is found in greenschist-facies metamorphic terranes of Paleozoic or older age. The metamorphic sequences include both

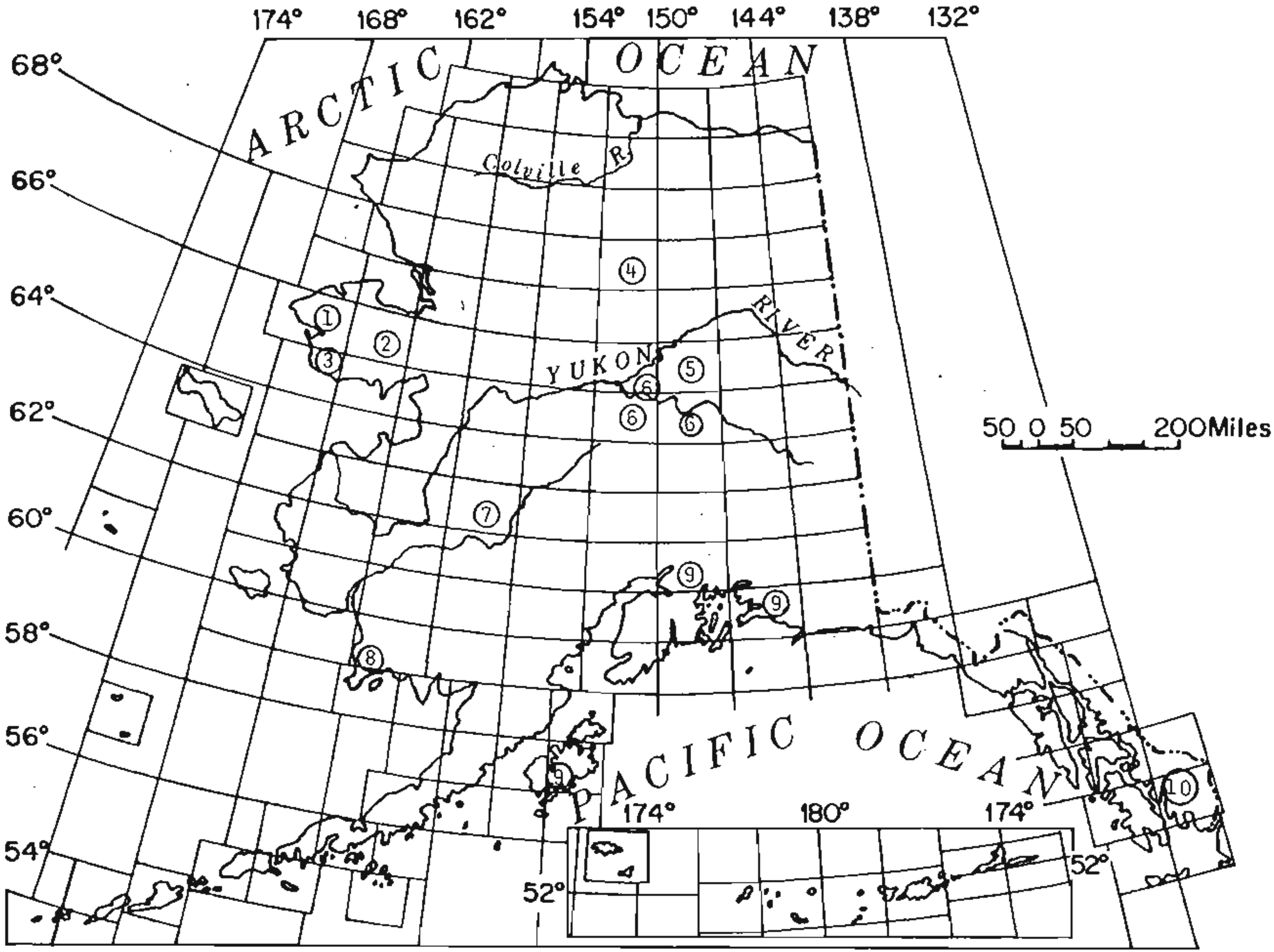

Figure 1. Location of the Hg-Sb-W provinces of Alaska (see Table 1: 1. Northwest Seward Peninsula 2. Central Seward Peninsula 3. Southern Seward Peninsula 4. Central Brooks Range 5. Yukon-Tanana Uplands 6. Fairbanks-Hot Springs 7. Kuskokwin River region 8. Goodnews Bay 9. Chugach Mountains 10. Hyder district)

Table 1. *Metal provinces in Alaska that include either tungsten, antimony, or mercury (after Clark, 1974).*

	Location of belt	Elemental associations Major	Elemental associations Minor	Associated country rocks	Age of country rocks	Associated intrusive rocks	Age of intrusive rocks	Associated major structural features
1.	Northwest Seward Peninsula	Sn-Au-F-Be	W	Siltite, phyllite, graywacke, quartz schist, and graphitic schist.	Paleozoic or older	Granite, quartz monzonite, and monzonite	Mesozoic	Numerous unnamed thrust faults.
2.	Central Seward Peninsula	Au	Hg-Pb-Ag-W	Do.	Do.	Do.	Do.	Do.
3.	Southern Seward Peninsula	Sn-W Au	Sb-Hg-F-Pb-Ag-Bi	Do	Do.	Do.	Cenozoic	Do.
4.	Central Brooks Range	Au	Sb-W	Quartz-mica schist, mafic greenschist, calcareous schist quartzite, and graphitic schist.	Do.	Granite, quartz monzonite, and granodiorite	Mesozoic	Numerous unnamed thrust faults (major east-west fault at Wiseman).
5.	Yukon-Tanana uplands, including Fairbanks district	Sn-W Au-Pb-Zn	As-Cu-Sb-Ag	Quartz-mica schist, calcareous schist, graphitic schist and amphibolite.	Paleozoic or older (minor Mesozoic)	Granite to granodiorite	Mesozoic (minor Cenozoic)	Tintina, Shaw Creek, and Kaltag faults and unnamed faults along the Tatalina and Tolovana Rivers and Beaver and Hess Creeks.
6.	Fairbanks-Hot Springs district and north flank of Alaska	Sb-Au-Ag	Pb-Zn-Hg-W-As	Same as above plus argillite graywacke, phyllite, slate, and marble.	Paleozoic or older (minor Mesozoic and Cenozoic)	Granite to granodiorite, migmatitic granodiorite.	Mesozoic and Cenozoic	Tintina fault and unnamed faults along Tatalina and Tolovana Rivers and Beaver and Hess Creeks.
7.	Kuskokwim River region	Hg-Sb-Au	As	Volcanic graywacke, mudstone, sandstone, and shale.	Mesozoic (minor Paleozoic and Cenozoic)	Rhyolite, dacite, trachyte, and andesite.	Cenozoic (minor Mesozoic)	Farewell, Togiak-Tikchik and Iditarod-Nixon faults.
8.	Goodnews Bay area	Pt-Pd-Au	Hg-Ag-Cu	Siltstone, chert, and mafic volcanics.	Mesozoic and Paleozoic (minor Cenozoic)	Dunite and peridotite.	Mesozoic (minor Cenozoic)	Togiak-Tikchik fault.
9.	Chugach Mountains, Kodiak Island, and Gulf of Alaska	Au-Cu	Pb-Zn-Ag-W	Graywacke, shale, lava, tuff, agglomerate, mafic volcanics, and minor conglomerate.	Mesozoic	Quartz diorite.	Cenozoic	Border Ranges fault and unnamed faults on the south sides of Kodiak and Montague Islands.
10.	Hyder district	Mo-W-Cu-Pb-Zn-Au-Ag		Fine-grained schist, phyllite, and hornfels.	Mesozoic	Quartz monzonite, granodiorite, and quartz diorite.	Cenozoic	Unnamed northeast-trending fault.

metasedimentary and metavolcanic rocks. The major stibnite occurrences, which are found in the Fairbanks and Kantishna districts and the southern Seward Peninsula, are in the greenschist metamorphic rocks. Within the above terranes only minor isolated occurrences of cinnabar have been reported.

Yukon-Tanana Region

The Yukon-Tanana region includes all the area between the Yukon and Tanana river from their confluence to the Alaska-Canada border. The region has been the site of geologic investigations since 1897, when J.E. Spurr of the U.S. Geological Survey traversed the Chilkoot Pass and entered the Yukon River drainage. In 1898, A.H. Brooks, also of the U.S. Geological Survey, ascended the White River, in the Yukon Territory, and portaged to the Tanana River drainage. He then traversed down the Tanana to its confluence with the Yukon River. In 1903, the U.S. Geological Survey established the Division of Alaskan Mineral Resources, and the systematic study of the geology and mineral resources of the Yukon-Tanana region began. The initial investigations in the Fairbanks district were conducted by A.H. Brooks in 1903. In 1911, J.B. Mertie began intensive geologic investigations of the region. These studies continued through 1936 and culminated in the publication of U.S. Geological Survey Bulletin 872, The Yukon-Tanana Region, Alaska by J.B. Mertie, which is still the single best publication on the geology of the Yukon-Tanana Uplands. The most comprehensive study of the lode deposits in the Fairbanks district was produced by Hill (1933) and includes a brief description of the local geology and detailed accounts of the various mining operations in the district. Work by Sandvik (1964) discussed the distribution of ore deposits and metals in central Alaska. Forbes and Brown (1961) and Brown (1962) conducted detailed geologic investigations that were centered in the Cleary Summit Area, about 20 miles north of Fairbanks. This work contributed much to the initial understanding of the outcrop pattern, structure and petrology of the various rock units in the area. Later work by Forbes et al (1968) in the Pedro Dome-Cleary Summit Area examined the gold gradients in relation to the intrusive bodies and the surrounding metamorphic rocks. A companion project by Pilkington et al (1969) resulted in a detailed examination of the gold mineralization in the same area. Recent work by Swainbank (1971) and Swainbank and Forbes (1975) on the eclogitic rocks from the Fairbanks district has resulted in a better understanding of the tectonic framework and origin of many of the rocks found in the area. Work by Britton (1970) resulted in a detailed study of the rocks that constitute the Pedro Dome intrusive complex.

Recent work by Pewe (1975 and 1976) on the geology of the Fairbanks area has resulted in a series of reconnaissance geologic maps.

Regional geologic setting

The rocks that crop out in the Fairbanks district are part of a sequence of metasedimentary and metaigneous rocks, now known as the Yukon-Tanana Uplands Schist (Foster, 1973). This unit was originally described by Spurr (1896). The Birch Creek Schist as Spurr called it at its type locality near the head waters of Birch Creek northeast of Fairbanks, is composed of a sequence of quartz muscovite schist, quartz mica schist, mica schist, feldspathic schist, chlorite schist and a minor proportion of carbonaceous schist, calcareous schist, and crystalline limestone. Swainbank (1971) and others have shown that the unit also contains a wide variety of gneisses, calc-magnesian schist, phyllite, amphibolite and eclogite. As originally described by Spurr (1896) the Birch Creek Schist unit was not subdivided into smaller mappable rock units, however, recent work has shown that certain mappable subdivisions may be present, hence the change in the unit name (F. Weber, U.S. Geol. Survey, Personal Communication, 1979).

Rocks in the Fairbanks district that are part of the Yukon-Tanana crystalline terrane have been subdivided into two sequences that may be in thrust contact (Forbes et al, 1968). The lower sequence, believed to be the older of the two, is exposed in what may be a structural window and consists of eclogites, garnet amphibolites and calc-magnesian rocks containing clinopyroxenes and amphiboles. The upper plate sequence consists mainly of pelitic schists, crystalline schist, micaceous quartzite, quarizite, calc-magnesian schist, crystalline marble and calcareous meta-sediments.

The pelitic schists are typically garnetiferous quartz muscovite and biotite schists that exhibit at least two phases of metamorphism and possibly a third retrograde event. Two phases of muscovite are present, the first phase consists of euhedral grains parallel to the primary S_1 plane and the second later phase defines an S_2 foliation that transects the earlier S_1 foliation. The S_2 foliation also contains subhedral, faintly pleochroic biotite laths (Brown, 1961). Locally the pelitic schists contain deeply resorptive biotite rosettes that may represent late hornfelsing of the schists (Swainbank, 1971). The fabric of these rocks is typically granoblastic and contains untwinned plagioclase porphyroblasts of albite-oligoclase composition. The presence of faintly pleochroic chlorite (pennine) usually signals retrograded rocks. The quartzites and micaceous quartzites of the region are present in the upper and lower plate sequences. The quartzites are granular, fine-grained, thin bedded, compact rocks composed of quartz, muscovite, biotite, garnet and chlorite, with accessory apatite, magnetite, rutile and zircon. The growth of chlorite in the upper plate sequence appears to be related to stable mineral development during the metamorphic process. The presence of chlorite in rocks of the lower plate sequence usually signals retrograded rocks. The quartz mica schist of the upper plate sequence is typically a granoblastic schist composed of quartz, garnet, muscovite, plagioclase, biotite and chlorite. Accessories include rutile, sphene, apatite and opaque minerals.

The calcareous rocks of the upper plate sequence consist of marble and calcium rich metasediments that generally occur in at least two distinct belts that parallel the compositional trends within the metamorphic package (see Figure 2). The southerly belt of carbonate rocks consists of small, discontinuous limestone and marble outcrops that may have constituted one or more continuous carbonate horizons. This zone trends about N 60° E and lies along the north side of Gilmore Dome (see Figure 2). Another belt of carbonate rocks is present along the north side of Pedro Dome and may also represent a carbonate horizon that was dismembered during regional metamorphism. Other calc-magnesian rocks within this package are calc-amphibolites and calc-schists exposed near the contact of the Gilmore Dome stock.

The majority of the calc-magnesian rocks of the Fairbanks district occupy the lower plate sequence and have been broken into three calc-magnesian variants by Swainbank and Forbes (1975). One variant, a garnet-clinopyroxene rock, essentially an eclogite, varies from massive types to mylonitic bands that contain pale-pink garnets that exhibit reaction rims of blue-green amphibole (Swainbank, 1971). Omphacitic pyroxene is the dominant clinopyroxene and albitic plagioclase usually occurs in untwinned grains and is only found in the mylonitic varieties. Quartz occurs in granoblastic aggregates and calcite occurs as an essential phase along with clinopyroxene and garnet (Swainbank and Forbes, 1975).

Calc-magnesian rocks composed predominantly of garnet, clinopyroxene and amphibole make up the second variant and usually occur as fine laminations, although massive varieties are known. The clinopyroxene is usually light-green and the amphibole may be a highly resorptive variety of hornblende. Plagioclase tends to be more calcic in these rocks and generally ranges from albite to oligoclase in composition. Muscovite when present, marks at least two metamorphic events, one represented by an earlier synkinematic fabric and the other by transecting shear planes. Calcite tends to be more abundant than quartz and clinozoisite is a common mineral constituent.

Rocks of the third group are generally composed of garnet and amphibole and occur with massive fabrics and varieties that are crudely foliated. Muscovite and biotite are present in a primary synkinematic fabric and late muscovite marks a discordant S_2 plane.

The intrusive rocks of the Fairbanks district range from granite to quartz diorite in composition. One of the largest plutons in the area extends from Pedro Dome (see Figure 2) west-southwest approximately 4.8 kilometers (3 miles) to the head of

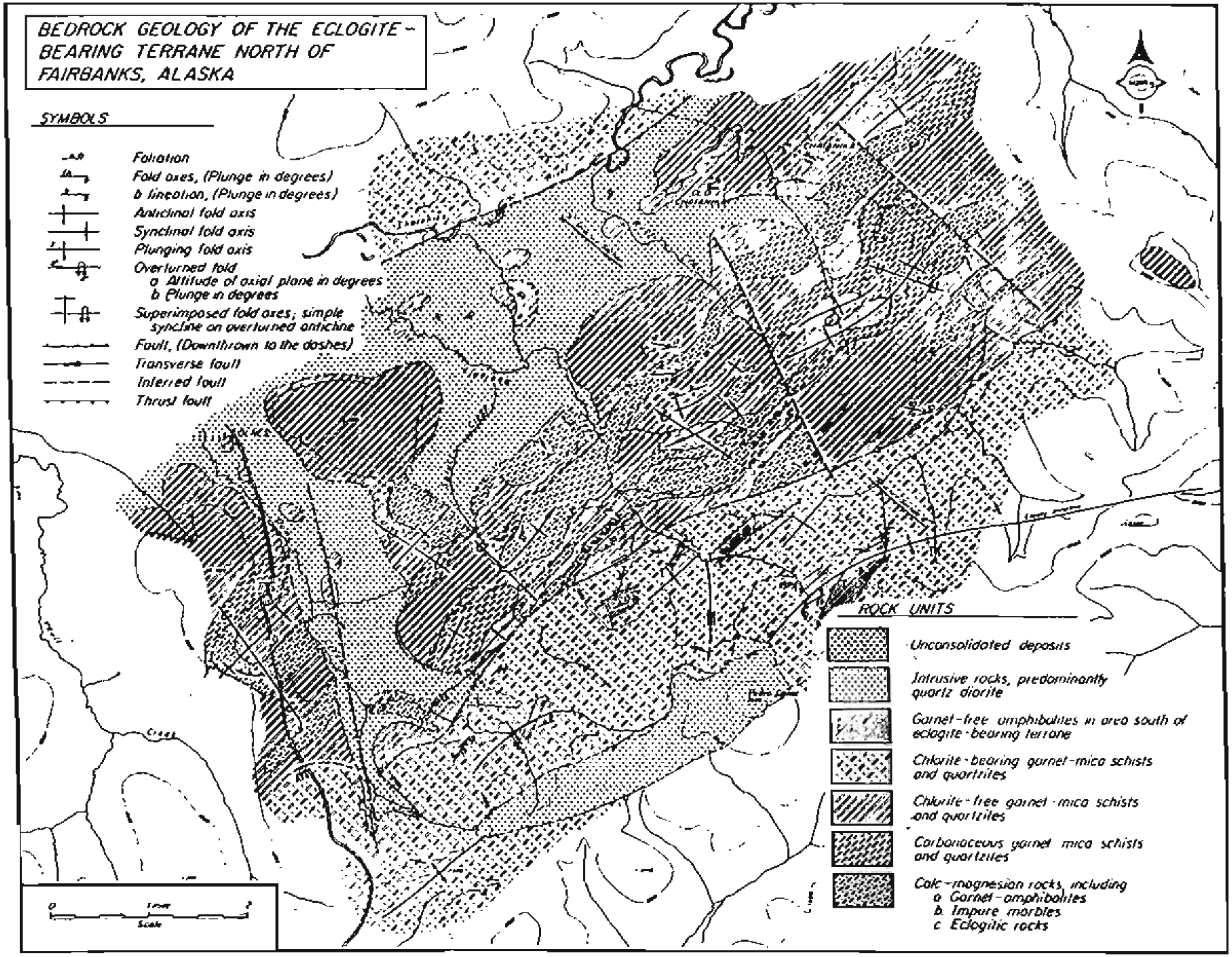

Figure 2. Bedrock geology of the eclogite-bearing terrane north of Fairbanks, Alaska. (From Swainbank and Forbes, 1975)

Moose Creek No. 2. The Pedro Dome pluton is principally a granodiorite and is light gray to dark gray, fine-to medium-grained, hypidiomorphic-granular quartz diorite and varies in composition to granodiorite. Petrographically the rocks are composed of up to 70% quartz, 45% plagioclase (An_{86} to An_{30}) in subhedral to euhedral grains, 10 to 20% biotite, 8 to 12% pyroxene that include major augite and trace hypersthene that often have reaction rims of hornblende. Accessory magnetite, apatite, zircon and epidote are common.

The intrusives in the Fairbanks district are elongate in a northeast to southwest direction, parallel to the structural grain of the region.

Structural geology

Rocks of the Fairbanks district have been affected by at least two major deformational events. The first metamorphic event is associated with a complete recrystallization of the parent rock and with the development of high-grade metamorphic minerals, while the later phase of metamorphism appears to have been less intense and associated with the development of retrograde metamorphic mineral assemblages. The early recrystallization is associated with west northwest-trending folds, while the later phase is associated with folding about northeast-trending axes. Fold styles associated with the early recrystallization appear to be isoclinal and overturned to the northeast. Some folds are arcuate and recumbant (Swainbank and Forbes, 1975). The northwest-trending folds appear to be overturned and (or) recumbant, with axial planes usually dipping to the south. The degree and direction of overturning is variable and related to the superimposed northeast-trending structures (Swainbank and Forbes, 1975).

Hg-Sb-W mineral occurrences in the region

There are at least 151 known Hg-Sb-W occurrences in the Yukon-Tanana region (Cobb, 1972, a, b, c, d, e, f). The occurrences can be tabulated by quadrangle as follows:

1.	Big Delta	8
2.	Circle	14
3.	Eagle	13
4.	Fairbanks	41
5.	Livengood	65
6.	Tanana	10

The largest concentration of occurrences is in the Fairbanks mining district which includes the Fairbanks and the southern Livengood quadrangles. The Tolovana mining district contains 9 occurrences in the central Livengood quadrangle. Since these two mining districts were both accessible and contained a high density of occurrences, they were chosen for study under this investigation.

Hg-Sb-W MINERAL OCCURRENCES IN THE TOLOVANA MINING DISTRICT

The Tolovana Mining district is centered at Livengood which is located approximately 75 road miles northwest of Fairbanks. The district is accessible via the Elliot Highway which is open to traffic all year.

The district has produced approximately 400,000 ounces of placer gold. Minor quantities of antimony have been produced however there is no active load mining in the area.

The oldest rocks in the district are metamorphosed sedimentary and volcaniclastic rocks of lower Paleozoic age (Foster 1968). The sequence includes black and gray banded chert, chert breccia, black marble, volcaniclastic and tuffaceous rocks. The unit is overlain by siliceous dolomite with interbedded gray and black chert. The metasediments and metavolcaniclastics are overlain by dark green metabasalt, serpentinite, and periodotite. The lower Paleozoic sequence is intruded by coarse grained metadiorite.

Devonian black and dark-gray graywacke and argillite unconformably overlie the lower Paleozoic rocks. The sedimentary as well as the metasedimentary and metaigneous rocks have been complexly folded and faulted and intruded by Tertiary age monzonitic rocks. The monzonites have been considered the source for the lode and placer mineralization in the district.

Two of the four lode Hg-Sb-W occurrences in the district were visited. The four occurrences are distributed over an area approximately 6.4 kilometers (4 miles) square. In addition to the four lode occurrences five of the streams in the district contain anomalous quantities of metals in the sediments and Hg-Sb-W minerals have been reported from eight gold placer mining operations in the area (see plate I).

Description of the Lillian Creek prospect

The Lillian Creek prospect is located in the NE 1/4, NE 1/4, section 22, T 8N, R 5W, Fairbanks Meridian. The mineralization is in a limonite stained dike hosted in highly deformed and sericitically altered argillite of Upper Middle Devonian age (?) (Foster, 1968a). The foliation in argillites strikes approximately east-west and is vertical near the occurrence (see Figure 3). Foster (1968a) described the deposits as auriferous arsenopyrite-quartz-scorodite veins associated with an altered monzonitic dike. Joesting (1942) described the mineralization as a zone containing thin seams of stibnite and traces of cinnabar and gold. Mertie

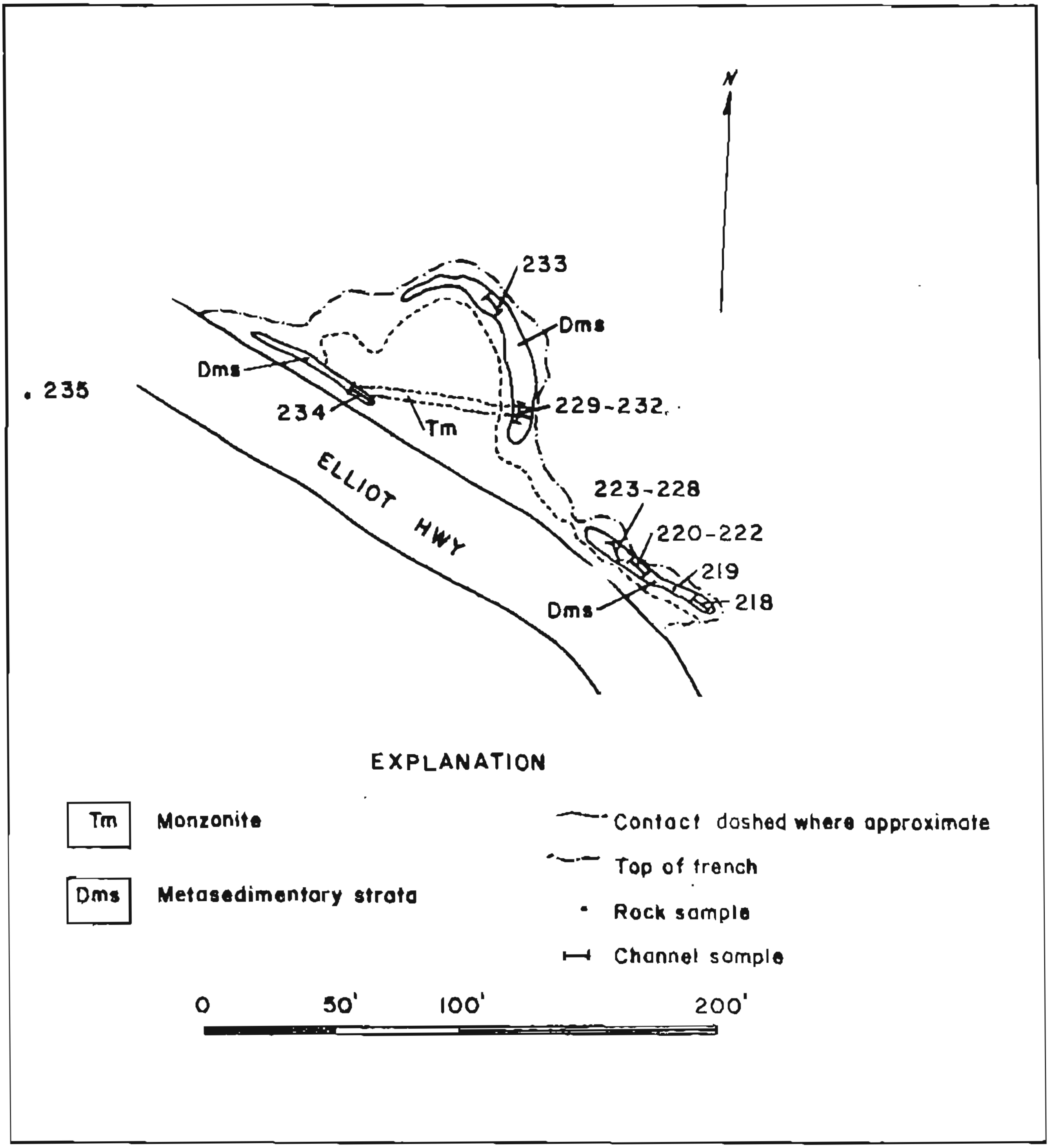

Figure 3. Geologic sketch map of the Lillian Creek prospect (From Foster, 1968).

(1918) noted a variety of minerals in the gold placer concentrates of Lillian Creek. These include magnetite, ilminite, picotite, limonite, cinnabar, scheelite, zircon, pyrite, stibnite and barite.

The workings at the prospect have been completely covered by slumping and debris sliding and no visible mineralization was noted during the current investigation. The ore mineralogy and host rock conposition of the Lillian Creek mineral occurrence as described above can only be confirmed with the removal of the slumped material.

Description of the Sunshine No. 2 prospect

The Sunshine No. 2 prospect is located in the SW 1/4, NE 1/4 section 23, T 8N, R 51 x 1, Fairbanks Meridian. The mineralization is in an altered felsic dike in highly deformed and sericitically altered argillite of Upper Middle Devonian age (?) (Foster, 1968a). The argillites strike northwest and are vertical. Foster (1968a) did not note the presence of visible mineralization in the open trench (see figure 4) however anomalous concentrations of mercury were found in the iron stained dike rocks. All the workings at the prospect were covered by surface slumping. Cinnabar nuggets have been detected in Olive Creek below the prospect.

Table 2 lists the sample descriptions and analyses from Foster (1968a). Foster attributed all the mineralization in the district to the Tertiary intrusive rocks. Figures 3 and 4 and Table 2 do not confirm this hypothesis. The sedimentary host rocks contain concentrations of trace elements equal to or greater than those in the intrusive rocks. The presence of volcanic rocks in the sedimentary sequence suggests the possibility of volcanic sulfide primary mineralization. The intense deformation of the country rock and poor exposure prevented substantiation of this hypothesis at these two localities.

Mineral Occurrences in the Gilmore Dome Area

Tungsten was first discovered in the Gilmore Dome area in September of 1915. Scheelite was known in the placer deposits of the area much earlier and undoubtedly stimulated the search for and discovery of the lode sources. By far the largest and highest grade tungsten deposits discovered to date lie on the northeast side of Gilmore Dome, where a cupola of Yukon-Tanana Uplands Schist is surrounded on three sides by intrusive rocks of the Gilmore Dome quartz diorite stock (see Plate II). To the west, several small tungsten deposits were discovered on Tungsten Hill, about 6 kilometers (5 miles) southwest of the summit of Gilmore Dome. Most of the deposits on Tungsten Hill appear to be small, however the Spruce Hen deposit has a considerable strike length and a moderate potential for tonnage at depth. This factor resulted in the selection of the Spruce Hen property for a detailed examination.

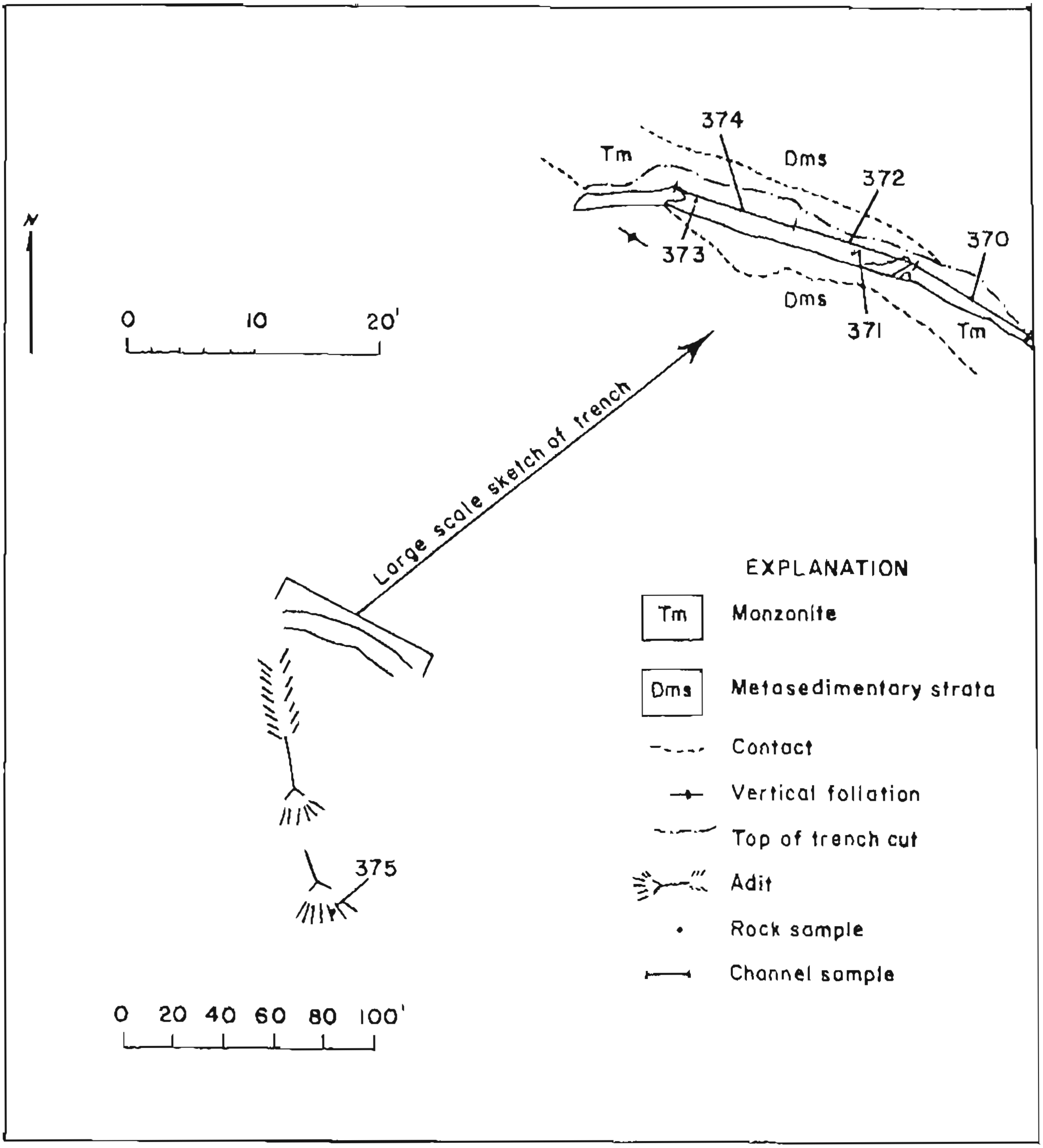

Figure 4. Geologic sketch map of the Sunshine No. 2 prospect (From Foster, 1968).

Table 2 - Sample descriptions and analyses from the Lillian Creek and Sunshine No. 2 prospects (after Foster, 1968) Lillian Creek Prospect

		Concentrations (PPM)												
Sample No.	Sample Description	Ag	As	Au	B	Ba	Cr	Cu	Hg	Ni	Pb	Sb	W	Zn
218	Limonite-stained light gray siltstone	--	--	0.2	--	--	--	--	--	--	--	--	--	--
219	Black argillite-limonite-stained siltstone	--	--	0.02	--	--	--	--	--	--	--	--	--	--
220	Quartz zone in pyritiferous siltstone below argillite	1.5	10,000	4.0	150	1,000	70	150	--	15	50	100	50	200
221	Selected samples from 220	0.5	G	3.5	100	700	10	200	--	10	30	100	70	200
222	Pyritiferous siltstone	--	--	0.02	--	--	--	--	--	--	--	--	--	--
223	Silty mudstone near massive suffosalts	--	--	0.02	--	--	--	--	--	--	--	--	--	--
224	Suffosalts in silty mudstone	1.5	G	30	100	500	50	300	--	7	15	100	ND	200
225	Quartz sulfosalt vein	1.5	G	23	30	300	20	200	--	10	10	100	ND	200
226	Selected samples from 225	2.0	G	48	300	500	50	500	--	7	20	200	ND	200
227	Quartz sulfosalt vein	1.5	G	20	100	200	20	300	--	7	10	100	ND	200
228	Quartz sulfosalt vein	1.5	G	25	70	150	10	500	--	15	10	300	ND	200
229	Altered dike	--	--	0.08	--	--	--	--	--	--	--	--	--	--
230	Grab rock sample; altered dike rock	0.5	G	1.3	10	150	5	15	--	20	10	ND	70	200
231	Siltstone	--	--	0.2	--	--	--	--	--	--	--	--	--	--
232	Sulfosalts from dike	ND	G	1.4	70	50	5	10	--	15	30	500	150	200
233	Limonite-stained siltstone	0.5	1,500	0.05	200	1,000	500	200	--	200	15	150	ND	1,000
234	Altered dike	2.0	10,000	0.7	500	1,000	30	150	--	100	20	1,500	50	300
235	Reddish siltstone with quartz veinlets	1.5	3,000	0.5	200	1,500	50	100	--	100	100	1,500	50	300

Sunshine No. 2 Prospect

		Concentrations (PPM)												
Sample No.		Ag	As	Au	B	Ba	Cr	Cu	Hg	Ni	Pb	Sb	W	Zn
370	Limonitic dike rock	ND	300	0.2	ND	3,000	20	30	10	30	70	ND	ND	150
371	Altered dike rock	0.5	700	0.2	20	5,000	30	30	10	2	50	ND	ND	200
372	Altered dike rock and argillite	ND	1,000	0.2	200	3,000	150	30	10	30	50	ND	50	200
373	Altered dike rock	0.5	10,000	0.8	10	700	20	30	10	3	30	100	50	300
374	Limonitic dike rock and argillite	ND	3,000	0.2	70	3,000	100	70	1.4	50	70	ND	50	300
375	Limonitic tailings	ND	2,000	0.5	100	2,000	300	30	7.5	30	50	ND	70	200

NOTE: Analyses semiquantitative spectrographic except Au and Hg by atomic absorption.
G = greater than 10 percent; -- = not examined for; ND = not detected.

The deposits near the summit of Gilmore Dome were extensively explored by the U.S. Bureau of Mines during World War II and much of the information about the Gilmore Dome deposits was produced as a result of the Bureau's efforts.

The Cleary Hill tungsten mine, also known as the Stepovich property, is located about 80 meters (300 feet) north of summit of Gilmore Dome in section 21 of Township 2 north and Range 2 east of the Fairbanks meridian (see Plate II). This deposit, originally discovered in 1915, has produced by far the most tungsten of any lode in the Fairbanks district. From 1915 to 1918, approximately 60 tons of concentrates containing 65 to 70% tungsten trioxide were produced. The deposit has been described by Mertie and Overstreet (1918) as follows:

> "The tungsten ore occurs as a contact metamorphic deposit. The ore appears generally to follow calcareous zones in the schist, but in places scheelite also occurs with both types of vein quartz, though only with the later veins of quartz is any genetic relationship apparent. The ore shoots are distributed in zones parallel to the cleavage but are not restricted to a single layer of the country rock, penetrating instead along joints and fractures into adjacent horizons. Hence the ore deposits are small, irregular and discontinuous."

This description of the Stepovich deposit apparently describes a clearly contact metamorphic tungsten deposit, however, what Mertie failed to mention, was that most of the high-grade ore shoots were underlain by an amphibolitic layer. It was the presence of the amphibolite layer that prompted the authors to examine these deposits in detail to determine if they are the result of the intrusion of the Gilmore Dome stock, or if they are remobilized syngenetic tungsten deposits. In either case, the proximity of the deposits to the Gilmore Dome stock has made this determination difficult.

Trenching and surface stripping done during the mid 1940's at and near the Stepovich property are all but overgrown by willows and alders, and filled with slumped colluvium, making examination of the bedrock exposures within the trenches impossible. However, the Yellow Pup tungsten property, located about 1,000 meters (3,200 feet) northeast of the Stepovich property is currently being mined and the open cut at the Yellow Pup locality (see Figure 5) afforded an excellent opportunity to examine the scheelite-bearing horizons as well as the enclosing non-scheelite-bearing metamorphic rocks.

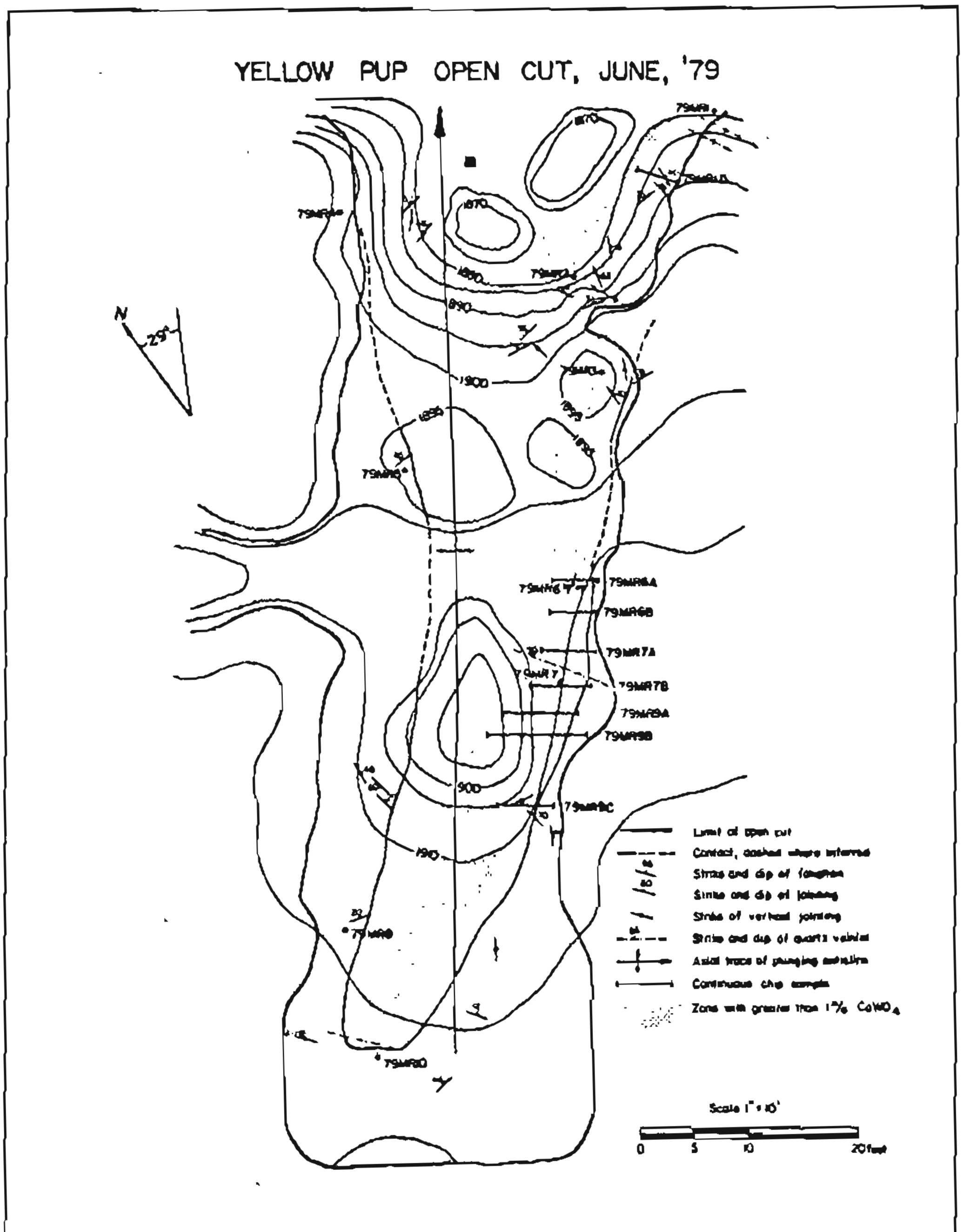

Figure 5. Sketch map of the Yellow Pup tungsten deposit

Description of the Yellow Pup tungsten deposit

The Yellow Pup tungsten deposit is located about 300 meters (1,000 feet) northeast of the Colbert tungsten property on the north side of Gilmore Dome (see Plate II). The deposit was originally discovered by Elmer Stohl, William Birklid and M.S. Anderson in 1943. The deposit is currently owned by Vincient Monzulla of North Pole, Alaska.

During the past three years the owner has been mining the Yellow Pup deposit using a small hydraulic backhoe and mining at a rate of about 8 tons per day, during the summer months. Figure 5 shows the size and extent of the Yellow Pup open cut in June of 1979.

The mineralization at the Yellow Pup locality is hosted in a contact metamorphosed sequence of quartz mica schist, micaceous quartzite, feldspathic schist, marble and impure calcareous metasedimentary rocks. Contact metamorphism of the rocks in the contact zone of the Gilmore Dome stock has produced an upper pyroxene hornfels facies mineral assemblage in the rocks associated with the tungsten mineralization.

The non-tungsten bearing rocks within the metamorphic sequence are generally quartz-rich mica schist, feldspathic schist and micaceous quartzite. The mica schist is typically a light brown, thinly foliated, fine-to medium-grained, biotite, muscovite quartz schist; which is composed of approximately 50-70% quartz, 10-15% muscovite, and 5-10% biotite, with generally less than 5% garnet, tremolite, rutile, plagioclase, and chlorite. Where the mica schist has been hornfelsed, it contains subhedral grains of blue-green tourmaline and an increase in the amount of biotite. The feldspathic schist is generally light-brown to grey, fine-to medium-grained, well foliated, garnetiferous, quartz, muscovite, feldspar, schist with biotite outlining the dominant foliation. Petrographically, the feldspar schist is composed of 5-20% quartz, 10-15% muscovite, 5-10% potassium feldspar, 2 to 15% plagioclase (An_{25}), 10-30% biotite and generally less than 5% spinel, sericite, garnet, opaques and tourmaline. Most of the biotite and all of the tourmaline in these rocks appears to be the result of contact metamorphism. The micaceous quartzites within this sequence are very quartz-rich rocks that are characterized by a fine-grained, granular intergrowth of quartz, biotite and muscovite, with minor garnet, rutile, tourmaline and chlorite. Where these rocks contain an appreciable mica component, the quartzites are crudely foliated. At the Yellow Pup mine site, this sequence of hornfelsed schist and quartzite is present in the hanging wall and in the footwall of the ore zone.

The scheelite-bearing rocks that constitute the ore zone at the Yellow Pup mine site are marble, calc-schist and calcium-rich metasedimentary rocks that have been thermally metamorphased to the pyroxene hornfels facies. The marble is highly crystalline and composed of a medium-to coarse-grained mosaic of anhedral calcite and minor calc-silcate minerals. The calc-schists are essentially micaceous amphibolites and are crudely foliated. The dominant scheelite-bearing rock in the ore zone is characteristically a dark-green, fine-to medium-grained amphibolite. Petrographically, the amphibolite is composed of 25-30% blue-green hornblende, 5-10% calcite, 20-30% quartz, up to 20% diopside, and generally less than 5% tremolite, muscovite, epidote, clinozoisite, garnet, plagioclase, chlorite and sericite. Scheelite concentrations as high as 15% are present locally. An appreciable powellite content is present in the scheelite-bearing rocks, and grains of powellite are usually surrounded by scheelite.

The scheelite-bearing amphibolite at the Yellow Pup mine site can be traced continuously for about 100 feet. The amphibolite layer is stratabound between barren quartz, mica schist and micaceous quartzite.

Close examination of the metamorphic sequence near the Yellow Pup deposit suggests that the metamorphic rocks were originally deposited as pelitic sediments. The layers within the sequence represent contact metamorphosed calcium-rich layers that have been thermally and chemically altered by the intrusion of the Gilmore Dome stock.

Rocks in the hanging wall sequence are identical to those in the footwall. The rocks in the ore zone are arched into a shallow north plunging, asymetrical anticline, and the tungsten mineralization is restricted to the amphibolite layer near the crest and eastern limb of the fold. The mineralized horizon appears to thicken to the east and south and the extent of the mineralization in these directions is unknown. Seven continuous chip samples across the mineralized horizon, from unmineralized hanging wall to unmineralized footwall were taken during the field investigation. Table 3 lists the sample widths and grades obtained from these samples.

Table 3 - Tungsten concentration in samples from the Yellow Pup Prospect.

Sample Number	Length of Sample	Average Tungsten Concentration
79MR1D	4 feet	0.7%
79MR6A	5 feet	1.25%
79MR6B	5 feet	1.20%
79MR7B	6 feet	.18%
79MR7B	6 feet	0
79MR9A	8 feet	0
79MR9B	9 feet	0.1%
79MR9C	5 feet	0.4%

Description of the Spruce Hen deposit

The Spruce Hen tungsten deposit is located on Tungsten Hill, approximately 6 kilometers (5 miles) southwest of the Yellow Pup tungsten deposit (see Plate II). The Spruce Hen deposit is one of several small tungsten occurrences on Tungsten Hill, all of which were discovered in 1915. No significant production has occurred from these deposits, however several of the lodes have been explored by extensive surface trenching and some underground work has been done.

The country rock of Tungsten Hill area consists of a contact metamorphosed sequence of quartz muscovite and biotite schist, quartz biotite schist, quartzite and limestone. This sequence is similar to the metamorphic sequence near the Yellow Pup deposit but differs in the grade of contact metamorphism. The difference in contact metamorphic grade is explained by the proximity of the Spruce Hen deposit to intrusive rocks of the Gilmore Dome quartz diorite stock. A tongue of quartz diorite is present a short distance from the Spruce Hen deposit and undoubtedly underlies the prospect area at depth (see Plate II). Mertie (1918) examined the Tungsten Hill area and described the tungsten deposits as "stringer lodes". Although some of the tungsten mineralization occurs associated with quartz veins, the majority of the tungsten mineralization is hosted in zones of calc-silicate marble.

The marbles occur in a northwestward dipping metamorphic sequence of biotite schist and biotite, muscovite schist. Mertie (1918) also described a "basic igneous rock" at the Spruce Hen deposit, that was intercepted at depth in one of the underground openings. The occurrence of this rock-type, essentially a calc-amphibolite, is similar to the footwall amphibolite at the Stepovich property and is interpreted as being a contact metamorphosed calcium-rich sediment, perhaps a calcareous siltstone, at both localities.

The hangingwall of the scheelite-bearing zone is dominated by muscovite schist that is characteristically a thinly foliated, dark gray to brown, brown-weathering, fine-to medium-grained, quartz, biotite, muscovite schist. Petrographically, the muscovite schist is composed of 30-40% quartz, 45 to 50% muscovite, 10-20% biotite, up to 5% garnet and generally less than 1% tourmaline. The tourmaline and some of the biotite in this rock may reflect hornfelsing of the schist.

The footwall of the scheelite zone is dominated by quartz, biotite schist. The biotite schist is typically a dark gray to black, fine-to medium-grained, garnetiferous, quartz, muscovite, biotite schist, that is felspathic locally. Petrographically, the biotite schist is composed of up to 60% quartz, 20-30% biotite, 5-10% muscovite, 5-10% feldspar and minor calcite, garnet, sericite and chlorite.

Stratabound between quartz, muscovite schist and biotite schist, is a zone of calc-silicate marble. The marble layer is highly irregular and appears to thicken to the southwest (see Figure 6).

Several distinct types of skarns are recognized within the calc-silcated marble zone. One type, found in the northeastern part of the area is typically a light-green to off-white, fine-to coarse-grained, highly crystalline, forsterite marble. The marble is composed of up to 90% calcite, 10-50% vesuvianite, 5-10% quartz, 5-10% forsterite, 5-10% quartz and minor tremolite, potassium feldspar, tourmaline and clinozoisite. The calc-silicate minerals are set in a coarse-grained mosaic of calcite and probably developed as a result of contact metamorphism of a siliceous dolomite or siliceous dolomitic limestone.

Near the center of the prospect area, the marble zone is dominated by banded, impure marbles that are typically dark-gray, coarse-grained, granular marbles composed of up to 80% calcite with minor garnet, vesuvianite, quartz, clinopyroxene and forsterite.

Near the southwestern end of the prospect area, the marble zone is dominated by complex calc-silicate rocks that are characteristically dark-green to red, fine to medium-grained, dense, skarns and tactites that are composed of 15-30% garnet that has anomalous birefringence, 10-40% vesuvianite, 10-15% quartz, 10-50% diopside and up to 30% fluorite. Minor calcite, blue-green hornblende, forsterite and actinolite also occur. The high fluorite content is of interest and has not been described previously. Further work is needed to examine the fluorite potential.

It is interesting that there seems to be an increase in contact metamorphic grade from northeast to southwest across the prospect area. This increase may be due to a relatively shallow emplacement of intrusive rocks to the southwest.

The tungsten content of the rocks in the calc-silicate zone is highly variable. Table 4 lists sample widths and tungsten contents for several continuous chip samples.

Table 4 - Tungsten concentrations in sample from the Spruce Hen prospect.

Sample Number	Length of Sample	Average Tungsten Concentration
79SH34	23 feet	.05%
79SH35	11 feet	0
79SH36	13 feet	.04%
79SH37	16 feet	.06%
79SH38	22 feet	.28%

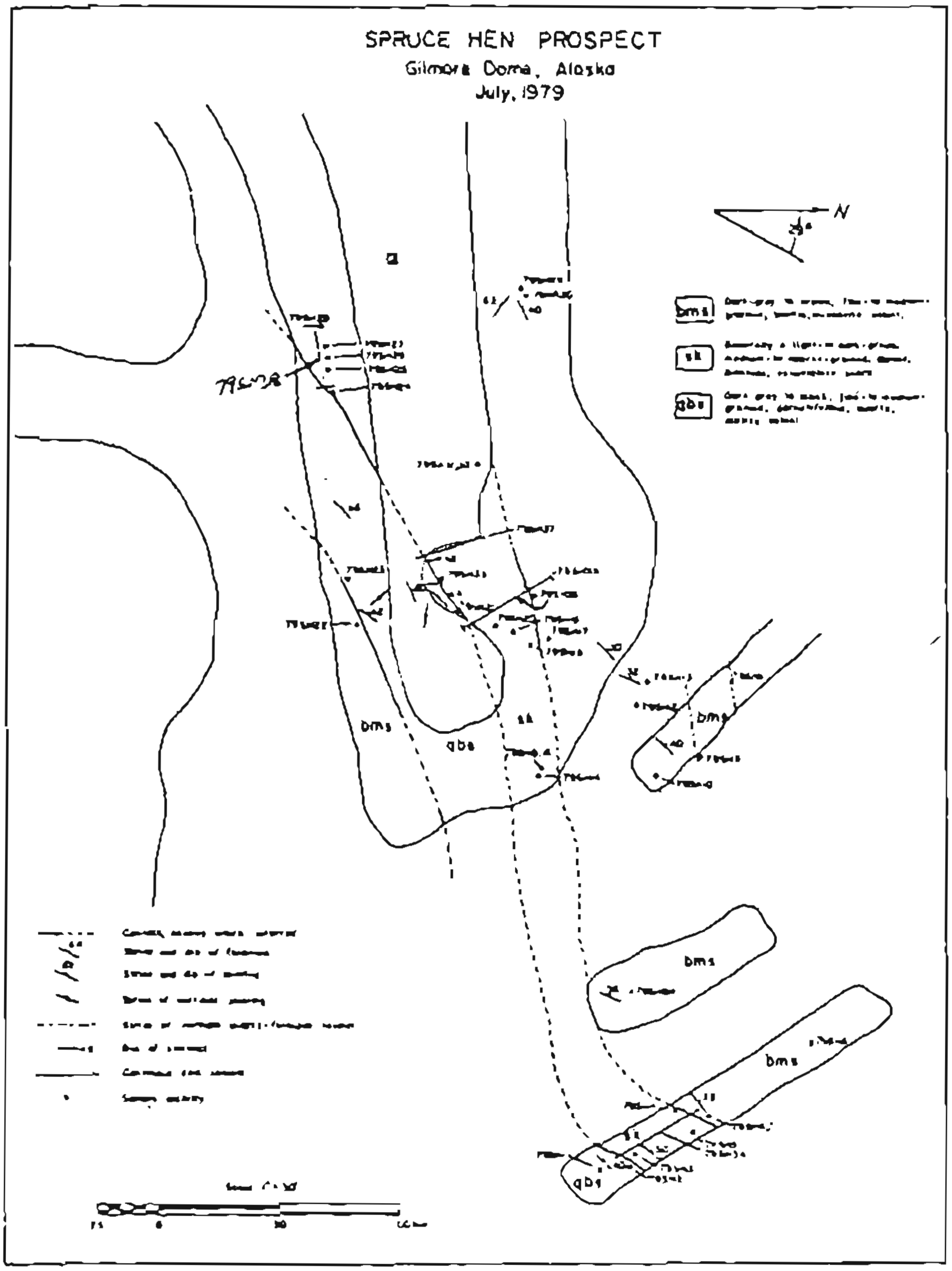

Figure 6. Sketch map of the Spruce Hen prospect

It is also interesting to note that the average tungsten content of the complex skarns and tactites from the southwestern part of the Spruce Hen property is higher than elsewhere on the property. The higher tungsten values are also accompanied by a substantial fluorite content. Further work is clearly needed in this area.

Hg-Sb-W Mineral Occurrences in the Pedro Dome-Cleary Summit Area

Description of the Wackwitz Mine

The Wackwitz antimony mine is located in Sec. 31, T 3N, R 2E, Fairbanks Meridian (see location 41, Plate III). The deposit was first described by Chapman and Foster (1969), as quartz veins and mineralized zones in quartz mica schist of the Birch Creek Schist. The ore minerals include stibnite, galena, sphalerite, jamesonite, arsenopyrite and pyrite. Traces of gold and silver occur in the sulfides.

Plane table mapping during this investigation (see Figure 7) of the Wackwitz open cut indicates that the antimony mineralization is totally within a quartz muscovite schist unit of the Yukon-Tanana Uplands Schist. The quartz muscovite schist unit is bound both below and above by a pelitic biotite garnet schist unit. The schists are isoclinally folded and the foliation and compositional layering strikes approximately N60E and dips to the SE. The quartz muscovite schist lenses have a maximum thickness of 4 meters (12 feet) but are generally only a meter (3 feet) thick. A lense of amphibolite occurs approximately 2 meters (6 feet) above the upper contact of the main quartz muscovite schist lense.

The quartz muscovite schist is light brown and weathers to a bright yellow to orange rock and is composed of 40-60% quartz, 20-60% muscovite, 0-5% K-feldspar, 0-5% plagioclase feldspar and minor garnet, chlorite, and opaques. The biotite garnet schist is composed of 50-70% quartz, 10-20% biotite, 5-10% garnet, 0-5% muscovite and minor actinolite, chlorite, plagioclase feldspar, sphene and opaques. The amphibolite unit is composed of 40-60% actinolitic hornblende, 20-30% plagioclase feldspar, 10-20% chlorite, 5-10% biotite, 5-10% sphene, and minor garnet, calcite and opaques.

A channel sample at locality 79 CSW001 was taken of the massive sulfide lense and ten polished sections of the ore were examined. The presence of stibnite, jamesonite, and galena as reported by Chapman and Foster (1969) was confirmed, and in addition sphalerite, arsenopyrite, and pyrite were identified. The ore minerals are compositionally layered but no consistant pattern was recognized in the lense. Individual grain size ranges up to 0.5 cm. The maximum thickness of the mineralized

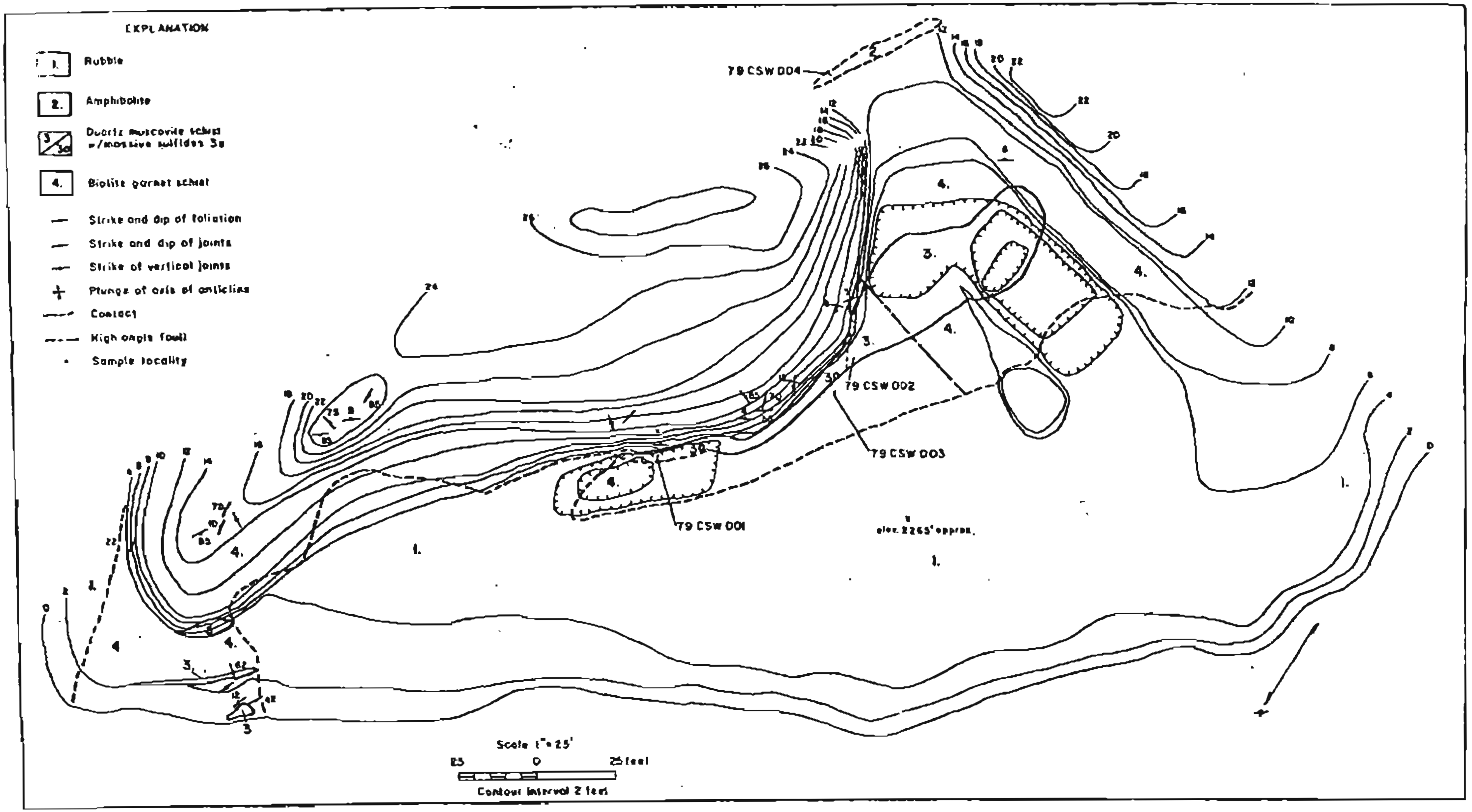

Figure 7. Sketch map of the Wackwitz antimony mine

zone is 1 meter (3 feet) and extends for approximately 26 meters (80 feet) along strike. The third dimension of the lense is unknown. The relative percentages of the ore minerals through the lense at locality 79 CSW001 are stibnite 90%, sphalerite 5%, galena 2%, jamesonite 1%, pyrite 1% and arsenopyrite 1%.

Description of the Johnson and Martin Prospect

The Johnson and Martin antimony-tungsten prospect is located in Sec. 4, T 3N, R 1E, Fairbanks Meridian (see location 32, Plate III). The prospect was first described by Joesting (1943) as massive stibnite enclosed in a wide quartz zone. Scheelite was noted on the prospect pit dump but was not described in place.

Sketch mapping during this investigation (see Figure 8) indicates that the antimony-tungsten mineralization is within a section of quartz muscovite schist of the Yukon-Tanana Upland Schist. The foliation and compositional layering in the schist strikes N 60 E and dips 25° to the NW. The mineralization is totally within the quartz muscovite schist unit. The upper and lower contacts of the unit were not exposed. A small lense of quartzite occurs in the unit about 8 meters (25 feet) south of the mineralized horizon. The quartzite lense is about a meter (3 feet) thick and is exposed for 8 meters (25 feet).

The quartz muscovite schist is light brown and weathers orange to bright red. The unit is composed of 50-60% quartz and 40-50% muscovite with minor garnet, chlorite, K-feldspar and pyrite. The quartzite unit is 90% quartz and 10% muscovite.

A channel sample at locality 79 OTSB 02 was taken of the massive sulfide lense and five polished sections of the ore were examined. The presence of stibnite, scheelite, pyrite and arsenopyrite were confirmed. The stibnite occurs both as fine disseminations in the quartz muscovite schist at the margins of the lense and as massive ore with individual grains up to 5 cm (2 inches) long. Scheelite occurs as a compositional layer within the massive stibnite. Individual grains of scheelite are up to 2.0 cm (0.8 inches) in diameter.

The mineralized zone was only exposed in a test pit 3 meters (9 feet) by 7 meters (21 feet). The massive sulfide horizon is about 0.7 meters thick. The relative percentages of the ore minerals in the mineralized zone are stibnite 95%, scheelite 4%, arsenopyrite and pyrite 1%.

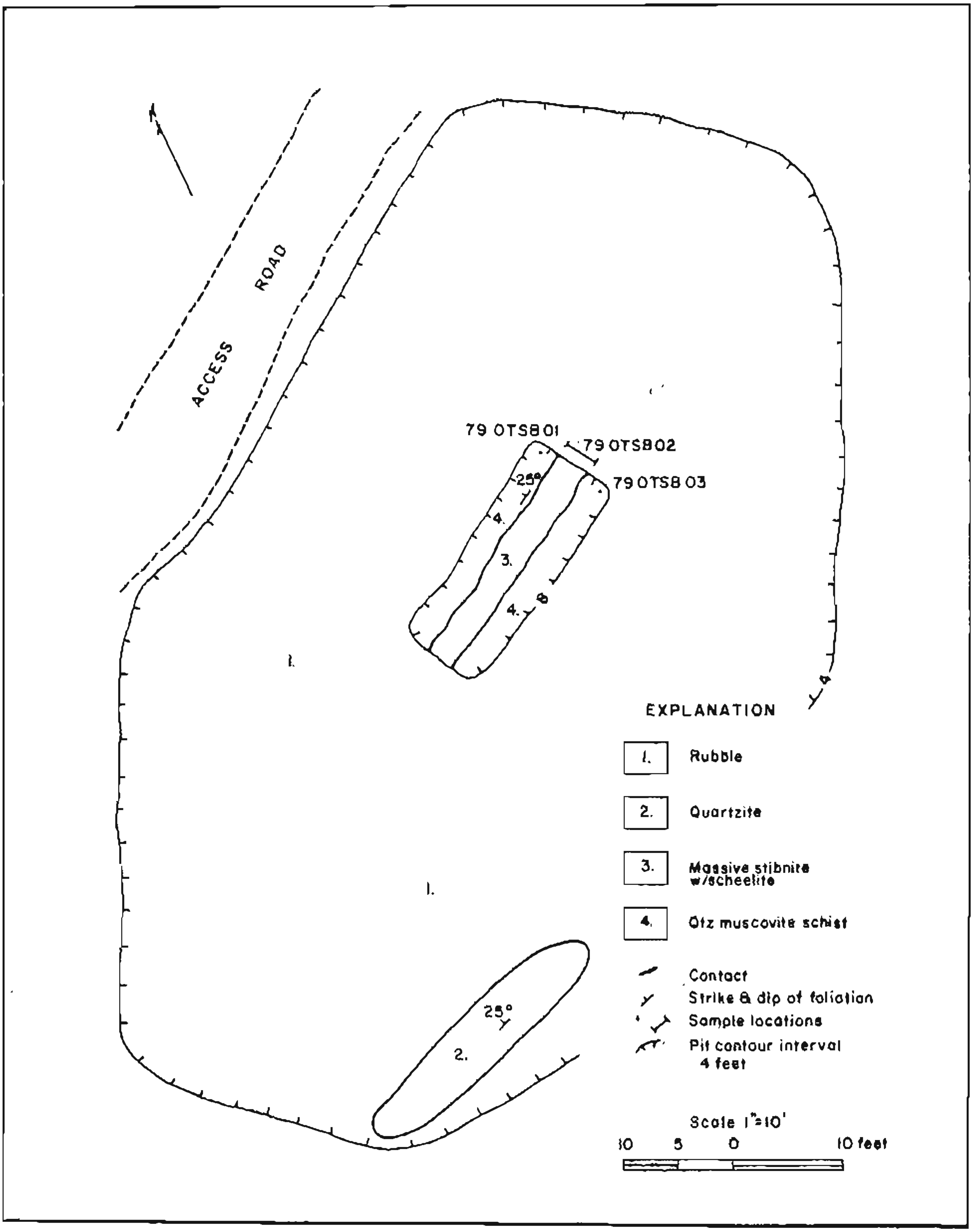

Figure 8. Sketch map of the Johnson and Martin antimony-tungsten prospect

Summary

The descriptions of the Hg-Sb-W occurrences in the Tolovana mining district of Alaska are summarized in Table 5. The lode antimony and mercury occurrences are hosted in lower Paleozoic age metasedimentary and metavolcanic rocks that have been intruded by Tertiary age quartz monzonites. Previous hypotheses attributed the lode antimony and mercury mineralization to the Tertiary intrusives. The tungsten placer concentrates were believed to have been derived from similar sources. The geochemistry of the host rocks and the presence of metavolcanics in the sequence suggests the possibility of volcanic exhalations as the primary source of the mineralization rather than the intrusive rocks.

The descriptions of the Hg-Sb-W occurrences in the Fairbanks mining district are summarized in Table 6. Twenty-five of the ninety-five occurrences have been described by previous investigators as hosted in a muscovite schist in the Yukon-Tanana Upland Schist. The question of mode of origin of the mineralization may be addressed quantitatively if the distribution of the ores in the host rocks can be tested. The following is a test of the null hypothesis that there is no difference in the character of the host rocks for the Hg-Sb-W occurrences in the district. Assuming 8 major categories of host rock type in Table 6, an equal probability of the ores occurring in all eight types and a binomial distribution, i.e. the ores occur in mica schist with a probability of 0.125 and other rock types with a probability of 0.875, the mean of the distribution is 11.85 and the standard deviation is 3.22 for $n = 95$. Assuming a 99% significance level, the rejection region by the normal approximation method would be above $x = 19.38$ or 20. Since $x = 25$, the null hypothesis is rejected and the alternate hypothesis that there is a difference in the character of the host rocks is accepted.

The hypothesis of the mode of origin of the Hg-Sb-W mineralization in the Fairbanks district must also take into consideration the areal distribution of the occurrences. The occurrences containing only Sb-W extend from the Mizpah (see no. 5, Plate III) to the Leslie (no. 51, Plate III) which is a distance of 14 kilometers (9 miles). Of these, only the Leslie is spacially associated with an intrusive body. The occurrences that contain only W extend over the entire length of the Gilmore Dome intrusive which is a distance of 11 kilometers (7 miles).

In addition to the association of the Sb-W mineralization with the muscovite schists there appears to be an association with amphibolites at several of the occurrences. At the Wackwitz occurrence the amphibolite is probably a metabasite. The petrology of the muscovite schist and the amphibolites, and the

Table 5 - Summary descriptions of the Hg-Sb-W lode occurrences in the Tolovana mining district, Alaska.

	Occurrence	Elements	Host Rock
1.	Ruth Creek prospect	Sb, Cr, Cu, Ni, Ag	Pyritized and brecciated intrusive in Devonian age argillite
2.	Lillian Creek prospect	Hg, Sb, Au	Altered dike rock intruding Devonian argillite
3.	Sunshine No. 2 prospect	Hg, Au	Altered dike rock intruding Devonian argillite
4.	Livengood Creek prospect	Sb	Lower Paleozoic black and gray banded chert breccia, black marble, volcaniclastic and tuffaceous beds

Table 6 - Summary descriptions of the Hg-Sb-W lode occurrences in the Fairbanks mining district, Alaska.

* = recorded production

Occurrence	Elements	Host Rock
* 1. Hi-Yu mine	Sb, Au, Pb, Ag, Zn	Silicified schist
* 2. Rob and Roy	Sb, Au	Schist, undifferentiated
* 3. Whitehorse mine	Sb, Au, Pb	" "
* 4. Ohio mine	Sb, Au, Pb, Ag	" "
* 5. Mizpah mine	Sb, W, Au, Pb, Ag	Quartzite schist
6. Excelsior	Sb, Pb, Ag	Quartzite & graphite schist
* 7. McNeil	Sb, Pb	Quartz-mica schist
8. Cross vein	Sb, Pb, Ag	Schist undifferentiated
9. Perrault	Sb, Au, Ag	" "
10. Kellen	Sb, Au	Schistose quartzite
*11. McCarty mine	Sb, Au, Pb, Zn	Quartz muscovite schist
*12. Henry Ford No. 3 mine	Sb, Au	Schist undifferentiated
*13. Pioneer vein mine	Sb, Au	" "
14. Willie	Sb, Au, Pb, Ag	" "
*15. Homestake mine	Sb, Cu, Au, Ag	Mica schist
16. Solomon	Sb	Schist undifferentiated
*17. Vetter mine	Sb, Cu, Au, Pb, Ag, Zn	Quartz-mica schist
18. Kawalita	Sb, Cu, Au, Pb, Zn	" " "
*19. Chatham mine	Sb, Cu, Au, Ag, Zn	Schist undifferentiated
20. Harris and Brown	Sb, Pb	" "
*21. Wyoming	Sb, W, Be, Au, Pb, Mn, Mo, Ag	Quartz-mica schist and marble
22. Quemboe Bros.	Sb, Au	Schist undifferentiated
23. Anna-Mary	Sb, Au, Pb, Ag	" "
24. Pioneer mine	Sb, Au, Zn	" "
25. Butler and Petree	Sb, Au, Pb, Zn	Mica schist
26. Cunningham	Sb, Au	Schist undifferentiated
27. Sunrise	Sb	" "
*28. Cleary Hill mine	Sb, W, Cu, Pb, Ag, Sm, Zn	Quartz-feldspar-muscovite schist
29. Bobbie	Sb, Pb, Ag	Schist undifferentiated
30. Hess and Burnett	Sb	" "
*31. Stibnite mine	Sb, Au, Pb, Ag	Schistose quartzite

Table 6 - Continued

Occurrence	Elements	Host Rock
32. Johnson and Martin	Sb, W	Quartz-muscovite schist
*33. Tolovana mine	Sb, W, Au, Ag	Quartz-muscovite-biotite schist
34. Westonvitch	Sb, Cu, Au, Pb, Ag, Zn	Quartz-biotite schist and marble
35. Moore-Shelden	Sb	Calc-schist
36. Steil	Sb	Greenstone
*37. Newsboy mine	Sb, Cu, Au, Zn	Quartz muscovite schist
*38. Mohawk	Sb, Au	Schist undifferentiated
39. Mother lode	Sb, Au	Quartz-muscovite schist
*40. Jackson	Sb, Au, Pb, Ag	Mica schist
*41. Wackwitz mine	Sb, Au, Pb, Ag, Zn	Quartz-muscovite schist
42. Pinnacle	Sb, Au, Pb	Schist undifferentiated
*43. Rainbow mine	W, Au, Pb, Zn	" "
44. Skoogy Creek & North Star	Sb, Au	Schist undifferentiated
*45. Burnet Galena	Sb, Pb, Ag	Quartz diorite
46. Egan	W	Granodiorite
*47. Birch and Anderson mine	Sb, Au	Quartz-mica schist
48. Rowley-Shumeff	Sb, Pb, Ag	Quartz diorite
*49. Silver Fox mine	Sb, Cu, Ag, Pb, Mo, Ag	" "
50. Verdin	W, Mo	Schist undifferentiated
51. Leslie	Sb, W, Mn, Mo	Quartz-mica schist
*52. Soo mine	Sb, Au, Pb, Ag	" " "
*53. Markovitch mine	Sb, Cu, Ag, Zn	Schist undifferentiated
54. Woods	Sb, Au, Pb, Mn	" "
*55. Fredericks mine	Sb, Au	" "
*56. Gilmer mine	Sb, Au, Ag	Mica schist
57. Goodwin	Sb	" "
*58. Scrafford mine & Eagle lode	Sb, Au, Pg, Ag	Quartz-mica schist
59. Antimony Ridge	Sb	Schist undifferentiated
*60. Goodwin mine	Sb	" "
61. White Association	W	Mica schist and Hornblende schist
*62. Ferrault & Murphy mine	W, Au	Quartzite
*63. Yellow Pup	W	Garnet tactite & hornfelsed schist
64. Edward Vogt	W, Bi, Au, Te	Biotite granite

Table 6 - Continued

Occurrence	Elements	Host Rock
65. Tungsten	W	Pyroxene-hornblende-biotite skarns
66. Scheelite	W	" " " "
*67. Colbert and Stepovich	W, Be, Mn, Mo, Sn	Quartz mica schist, marble & amphibolite
68. Schubert & Zimmerman	W	Skarn, granite schist contact
69. Rose Creek	Sb	Schist undifferentiated
70. Spruce Hen	W, Mo	Diopside-garnet-skarn
71. Columbia	W	Schist & granite contact
72. Tanana	W, Au	Quartzite
73. Tungsten Hill and Anderson	W, Au	Quartz mica schist
74. Blossom	W	Quartz-biotite schist & granite
75. Mohawk mine	Sb, Au, Pb, Zn	Biotite-quartz schist
76. Ryan mine	Sb, Au, Ag	Schist undifferentiated
*77. McDonald mine	Sb, Au	Schist undifferentiated
*78. Little Eva mine	Sb, Au	" "
*79. Billy Sunday mine	Sb, Au, Pb, Zn	" "
*80. St. Paul mine	Sb, Au	Quartz mica schist
*81. Clipper mine	Sb, Au	Biotite schist and quartzite
*82. Stibnite lode mine	Sb	Schist undifferentiated
83. Last Chance mine	Sb, Au	" "
*84. Bondholder mine	Sb, Au	Quartz mica schist
85. Prometheus	Sb, Cu, Au, Pb, Ag	Schist undifferentiated
86. Dorothy and Dorice	Sb	" "
*87. Grant mine no. 2	Sb, Au	Quartzite
88. Blue Bonanza	Sb, Cu, Au, Pb, Ag	Schist undifferentiated
89. Farmer lode	Sb	" "
90. Prospect	Sb	Quartz mica schist
*91. McQueen mine	Sb	Schist undifferentiated
92. St. Judy	Sb, Au	" "
93. Vuyovich	Sb, Au	Quartz mica schist
*94. Ready Bullion mine	Sb, Au	Schist undifferentiated
95. Maloney	Sb	" "

association of low temperature mineral stibnite with scheelite in the schist provides strong preliminary evidence that the Sb-W mineralization in the Fairbanks district is strata form and volcanogenic. This association increases the potential for the development of lower grade but large scale open cast mining operations.

References

Britton, J.M., 1970, Petrology and petrography of the Pedro Dome plutons, Alaska: Univ. of Alaska M.S. Thesis, 52 p.

Brown, J.M., 1962, Bedrock geology and ore deposits of the Pedro Dome area, Fairbanks mining district, Alaska: Univ. of Alaska M.S. Thesis.

Byers, F.M., Jr. and Sainsbury, C.L., 1956, Tungsten deposits of the Hyder district, Alaska: U.S. Geol. Survey Bull. 1024-F, p. 123-140.

Chapman, R.M. and Foster, R.L., 1969, Lode mines and prospects in the Fairbanks district, Alaska: U.S. Geol. Survey Prof. Paper 625-D, D1-D25.

Clark, A.G., Berg, H.C., Cobb, E.H., Eberlein, G.D. and Miller, T.P., 1974, Metal provinces of Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-834.

Cobb, E.H., 1970a, Mercury occurrences in Alaska: U.S. Geol. Survey Mineral Inv. Resources Map MR-54.

Cobb, E.H., 1970b, Antimony occurrences in Alaska: U.S. Geol. Survey Mineral Inv. Resource Map MR-52.

Cobb, E.H., 1972a, Metallic mineral resource map of the Tanana quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 371, scale 1:250,000.

Cobb, E.H., 1972b, Metallic mineral resource map of the Big Delta quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 388, scale 1:250,000.

Cobb, E.H., 1972c, Metallic mineral resource map of the Circle quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 391, scale 1:250,000.

Cobb, E.H., 1972d, Metallic mineral resource map of the Eagle quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 393, scale 1:250,000.

Cobb, E.H., 1972e, Metallic mineral resource map of the Fairbanks quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 410, scale 1:250,000.

Cobb, E.H., 1972f, Metallic mineral resource map of the Livengood quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 413, scale 1:250,000.

Cobb, E.H., 1975, Tungsten occurrences in Alaska: U.S. Geol. Survey Mineral Inv. Map MR-661.

Forbes, R.B. and Brown, J.M., 1961, Preliminary geologic map of the Fairbanks mining district, Alaska: Alaska Div. Mines and Minerals Rept. no. 194-1.

Forbes, R.B., Pilkington, H.D., and Hawkins, D.B., 1968, Gold gradients and anomalies in the Pedro Dome-Cleary Summit area, Fairbanks district, Alaska: U.S. Geol. Survey open-file rept., 43 p.

Foster, R.L., 1968, Descriptions of the Ruth Creek, Lillian Creek, Griffin, Old Smokey, Sunshine No. 2 and Olive Creek lode prospects, Livengood District, Alaska: U.S. Geol. Survey open-file rept. 322, 21 p.

Foster, R.L., 1968a, Potential for lode deposits in the Livengood gold placer district east-central Alaska: U.S. Geol. Survey Circ. 590, 18 p.

Foster, H.L., Weber, F.R., Forbes, R.B. and Brabb, E.E., 1973, Regional geology of Yukon-Tanana Uplands, Alaska: Am. Assoc. Petroleum Geologists, Memoir No. 19, p. 388-395.

Hill, J.M., 1933, Lode deposits of the Fairbanks district, Alaska: U.S. Geol. Survey Bull. 849-B, p. 19-163.

Joesting, H.R., 1942, Strategic mineral occurrences in interior Alaska: Terr. of Alaska Dept. of Mines Pamphlet No. 1, 28 p.

Maucher, Albert, 1976, The stratabound cinnabar-stibnite-scheelite deposits: in Wolff, K.H., eds., Handbook of strata-bound and stratiform ore deposits, Elsevier Scientific Publishing Company, New York, 1976, v. 7, p. 477-503.

Mertie, J.B., Jr., 1918, Lode mining in the Fairbanks district: U.S. Geol. Survey Bull. 662, p. 403-424.

Metz, P.A., 1977, Comparison of the mercury-antimony-tungsten mineralization of Alaska with stratabound cinnabar-stibnite-scheelite deposits of the Circum-Pacific and Mediterranean regions, in Short Notes on Alaskan Geology-1977: Alaska Div. of Geol. and Geophys. Surveys Geol. Rept. 55, p. 39-41.

Metz, P.A. and Robinson, M.S., 1979, Tungsten in Alaska: Alaska Div. of Geol. and Geophys. Surveys Mines and Geology Bull. v. 28, no. 1, p. 1-3.

Pewe, T.L., 1975, Quaternary geology of Alaska: U.S. Geol. Survey Prof. Paper 835, 145 p.

Pilkington, H.D., Forbes, R.B., Hawking, D.B., Chapman, R.M. and Swainbank, R.C., 1969, Preliminary investigation of gold mineralization in the Pedro Dome-Cleary Summit area, Fairbanks district, Alaska: U.S. Geol. Survey open-file rept., 47 p.

Sandvik, P.O., 1964, Relations of structure to mineral deposition at the Grant Mine, Ester Dome, Alaska: Univ. of Alaska B.S. Thesis, 28 p.

Spurr, J.E., 1896, Geology of the Yukon gold district, Alaska: U.S. Geol. Survey Eighteenth Annual Rept.

Swainbank, R.G., 1971, The geochemistry and petrology of eclogitic rocks near Fairbanks, Alaska: Univ. of Alaska Ph.D. dissertation.

Swainbank, R.G. and Forbes, R.B., 1975, Petrology of the eclogitic rocks, Fairbanks district, Alaska, in Contributions to the geology of the Bering Sea region: Geol. Soc. Amer. Spec. Paper 151, p. 77-123.