TUNGSTEN INVESTIGATIONS NEAR VABM BEND, EASTERN ALASKA

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UNITED STATES DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

BUREAU OF MINES

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TUNGSTEN INVESTIGATIONS NEAR VABM BEND, EASTERN ALASKA

BY

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ABSTRACT

Numerous scheelite occurrences in the Charley River area of east-central Alaska suggest the existence of a broad geographic zone having potential for economic deposits of tungsten. This trend strikes northwesterly across a region of diverse geology from the Seventymile district to Pinnell Mountain.

Tungsten mineralization occurs on a tributary of Crescent Creek in the Charley River drainage as disseminated grains and aggregates up to 2 cm. across in banded, hornfelsic calc-silicates; disseminated grains in biotite-quartz monzonite; and concentrations in siliceous veins less than 1 cm. across in leucocratic igneous rocks. Weathering of these rocks has led to concentration of scheelite in placer deposits.

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INTRODUCTION

Location and Access

The area investigated for this report is in the Charley River A-6 and the Eagle D-6 1:63,360 quadrangles, Alaska. These and surrounding areas, including portions of the Circle and Big Delta quadrangles, are shown in Figure 1. There are no roads in the area and access is limited to rotary winged aircraft, and river boat traffic via tributaries of the Yukon River.

Previous Work

The earlist geologic reports on the area are summarized by Mertie (10-11) 3/ and later work includes a report on the Yukon-Tanana Upland by Foster and others (8) and 1:250,000 scale geologic maps of the Charley River (4), Eagle (6) and Big Delta (17) quadrangles. Geochemical reports include results of analyses on stream sediment and rock samples in the Eagle (5, 9) and Big Delta (15) quadrangles, and a report on stream sediment and panned concentrate samples in the Yukon-Tanana Upland (2). No detailed work has been published on the economic geology of the area. During the 1977 field season, reconnaissance work disclosed an area having anomalous tungsten (W) and tin (Sn) concentrations in stream sediment samples collected on Beverly Creek, five miles southeast of VABM Bend in the southwestern Charley River quadrangle (Appendix A) (2). During the following season (1978), analyses of heavy mineral concentrates from additional stream sediment samples confirmed the

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3/ Underlined numbers in parentheses refer to references cited at the end of this report.

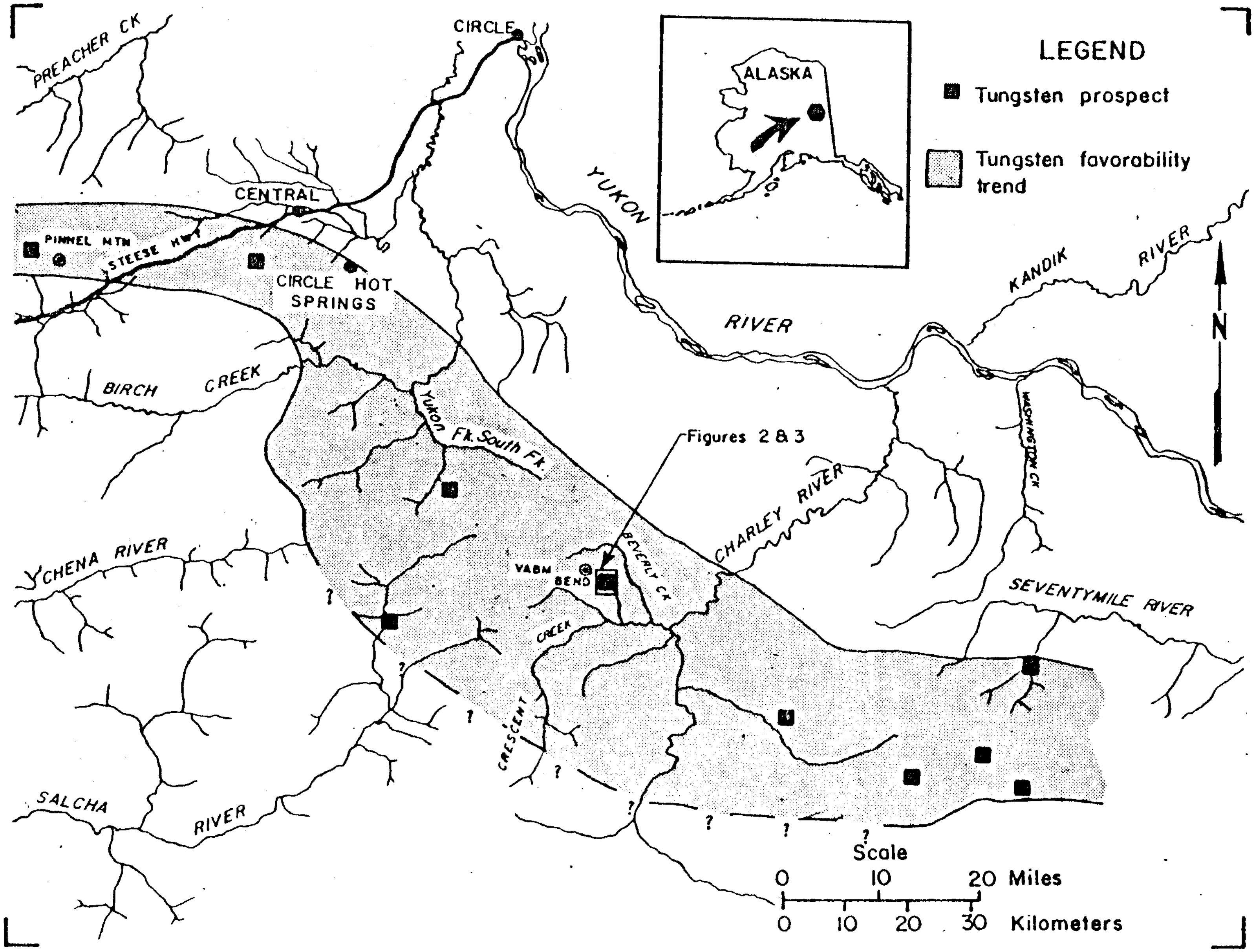

FIGURE 1.--Location Map

presence of scheelite. Scheelite was also observed in massive boulders near the confluence of two tributaries of Crescent Creek, which is a tributary of Charley River in the northwestern Eagle quadrangle.

Occurrences mentioned in the previous references are shown in Figure 1 as tungsten prospects and they roughly define a region which has potential for economic tungsten mineralization that extends eastward from Pinnell Mountain to near the Canadian Border in the eastern Yukon-Tanana Upland. Some of these occurrences are also shown on the recent Arctic Environmental Information and Data Center (AEIDC) minerals compilation "Mineral Terranes of Alaska" (1) as tungsten or tungsten, molybdenum and tin deposits within areas of granitic and syenitic rocks and associated, undifferentiated terrane. Tungsten occurrences referred to in the testimony by Doyon Ltd. (18) and in the AEIDC compilation are also shown in Figure 1 of this report.

Purpose and Objectives

The VABM Bend area was chosen for study on the basis of anomalous tungsten concentrations in stream sediment and pan concentrate samples (see Appendices A and B) and the identification of scheelite in the heavy mineral fraction of panned samples. These samples were collected in the VABM Bend area during a brief reconnaissance survey by U. S. Bureau of Mines (USBM) personnel during 1977 and 1978. This effort was conducted in response to numerous reports of tungsten mineralization in the Yukon-Tanana Upland as shown in Figure 1. These reports include numerous claims located where tungsten mineralization occurs (14); tungsten occurrences listed in testimony presented to the U. S. Senate Subcommittee for Energy and Minerals on behalf of Doyon Ltd. (18); and reports of anomalous tungsten and tin concentrations in placer concentrates from the Eagle quadrangle (13). This project was undertaken with the intent of defining exploration targets for tungsten and associated mineralization in the central and eastern Yukon-Tanana Upland.

ACKNOWLEDGEMENTS

The topographic and geologic maps used in this report were adapted from U. S. Geological Survey (USGS) published maps.

The Bureau of Mines was also assisted by R. C. Swainbank, Vice President, Resource Exploration Consultants, who was contracted to provide air photo interpretation of the eastern Yukon-Tanana Upland from Landsat imagery and black and white aerial photography. Analyses were also performed by the Bureau of Mines Reno Metallurgical Laboratory under the direction of Howard Heady. All sediment and rock samples referred to in this report are also being analyzed by the Department of Energy for 44 elements including uranium and thorium using neutron activation and fluorometric procedures. Results will be concurrently open-filed by that department. The text was reviewed by T. K. Bundtzen, and J. T. Kline of the Alaska State Division of Geological and Geophysical Surveys, T. C. Mowatt of the USBM, and by H. L. Foster of the USGS.

GEOLOGY

The Charley River drainage heads in the Yukon-Tanana Upland, a major physiographic unit within the Northern Plateau Province of Alaska (16). This area lies between the Yukon and Tanana Rivers and is characterized by low, mountainous terrane having rounded ridge tops and summits with maximum elevations on the order of 1600 m. (+5000 ft.). Many valleys head in cirque basins and eroded remmants of morainal deposits are common. The entire region lies within the zone of discontinuous permafrost.

Periglacial features such as stone polygons, altiplanation terraces, striated soils and thaw lakes are common throughout the region. The upper Charley River occupies a deeply incised canyon indicating local rejuvenation or tilting. Conversely, the lower portion of the river occupies a broader valley filled with outwash and over which a meandering channel drains northward into the Yukon River.

The regional geology of the Yukon-Tanana Upland is well summarized by H. L. Foster and others (8). Structurally the region is truncated to the north by the Tintina fault zone and is bounded on the south by the Denali-Shakwak fault system, both of which extend well into the Yukon Territory. The Yukon-Tanana Upland constitutes the northernmost portion of the Yukon Crystalline Terrane which also extends into Canada. The Yukon Crystalline Terrane incorporates portions of the Omineca Crystalline Belt, Intermontane Belt and Coast Plutonic Complex (12). The area shown in Figure 1 lies within the central and eastern portions of the upland and is underlain by a metamorphic complex of rocks which range from lower-greenschist to amphibolite facies (8). This metamorphic complex includes abundant quartz-mica schist, mica schist, greenschist, amphibolite, garnetiferous quartz-mica gneiss and schist, and greenstone. Subordinate lithologies include eclogite, augen gneiss, quartzite, calcareous schist and marble. Fossil evidence, radiometric ages and stratigraphic relationships indicate these rocks range from Precambrian to Paleozoic in age (8).

The metamorphic rocks of the Yukon-Tanana Upland have been intruded by igneous rocks of ultramafic to felsic composition. In the Charley River region, igneous rocks are largely restricted to biotite-quartz monzonite and more felsic segregations. These are part of a much larger intrusive complex which is truncated on the north by the Tintina fault zone and extends southward into and throughout most of the Eagle quadrangle. The larger plutons are probably Mesozoic in age but may include some Tertiary intrusives (6). Potassium-argon age determinations by D. L. Turner, Geophysical Institute, University of Alaska, on a granodiorite collected southeast of Arctic Dome in the Eagle quadrangle, yielded 89 m.y. on hornblende and 92.8 m.y. on biotite (6).

Regional mapping by USGS workers shows a unit of regionally metamorphised biotite-gneiss and amphibolite north of Crescent Creek with subordinate quartz-biotite-gneiss, schist, and marble (4, 6). These rocks are locally retrograded by thermal metamorphism to hornfels (6). Thermal metamorphic mineral assemblages include abundant garnet with uncommon staurolite and Al_2SiO_5 polymorphs, andalusite and sillimanite. These rocks are bordered by a unit of intermixed gneiss and granitic rocks south of Crescent Creek and are intruded by quartz-monzonite to the northwest of the vicinity of Beverly Creek and VABM Bend (Figure 2).

Northwest of the area shown in Figure 2 and along the Yukon Fork, South Fork of Birch Creek the authors observed adamellite intruding quartz-plagioclase-biotite schist and gneiss, amphibolite, marble, banded calc-silicate hornfels and graphitic schist. A thick sequence of the mica-schists overlies a unit of banded hornfels which in turn rests on a faulted contact separating structurally lower, massive bedded limestone.

Associated with this discordant, granitic body are aplite dikes and segregations, both of which are, in part, the source of the placer scheelite discovered on tributaries of Crescent Creek.

Petrographic descriptions of selected granitic rocks and one hornfels sample are summarized in Table 1. Sample locations for rock, stream sediment, pan concentrate and one soil sample are shown in Figure 3.

TABLE 1. PETROGRAPHIC SUMMARY OF VABM BEND ROCK SAMPLES

MINERALOGY

Sample	Rock Type	Quartz	Plagioclase	K-Feldspar	Biotite	Muscovite	Hornblende	Clinopyroxene	Garnet	Vesuvianite	Tourmaline	Carbonate	Epidote/Zoisite	Chlorite	Sericite	Kaolin	Fe-Oxide	Apatite	Zircon	Scheelite	Sphene	Opaques	Texture
UP10435R	Leucocratic Aplite Dike	40	25	30					1						X		X	X					Fine-medium grained xenomorphic
UP10438R	Leucocratic Aplite Dike	35	35	25		1					X				X	X	X	X					Fine-medium grained xenomorphic
UP10601	Scheelite Bearing Quartz Monzonite	35	25	20	5								2	X	X		X	X	X	X		X	Med-coarse grained hypidiomorphic, inequigranular with granophyric intergrowths
UP10603	Quartz Monzonite	25	25	40	8		2		2					X	X	X	X	X	X			X	Coarse grained porphyritic with perthitic microcline phenocrysts and granophyric intergrowths in fine granular groundmass
UP10606	Leucocratic Quartz Monzonite	40	25	30									X		X	X	X	X					Coarse grained porphyritic with phenocrysts of microcline and oligoclase in fine, granular groundmass
UP10608	Muscovite Bearing Quartz Monzonite	35	30	25							X												Medium grained, hypidiomorphic granular with poikilitic, primary muscovite
UP10609	Scheelite Bearing Aplite	40	15	40											X	X	X	X		X			Fine grained xenomorphic granular
UP11438A	Leucocratic Quartz Monzonite	30	30	30	2						X		2	X	X	X	X	X					Medium grained hypidiomorphic granular
UP11438B	Leucocratic Quartz Monzonite	40	35	20					2						X	X	X	X					Medium grained hypidiomorphic granular
UP11441	Biotite Quartz Monzonite	35	25	30	8	4					X			X	X	X	X	X	X				Medium grained hypidiomorphic, inequigranular with granophyric intergrowths
UP11442	Pyroxene Hornfels	12	30					27	5	10		5	3							4	3	X	Fine grained plagioclase-pyroxene hornfels

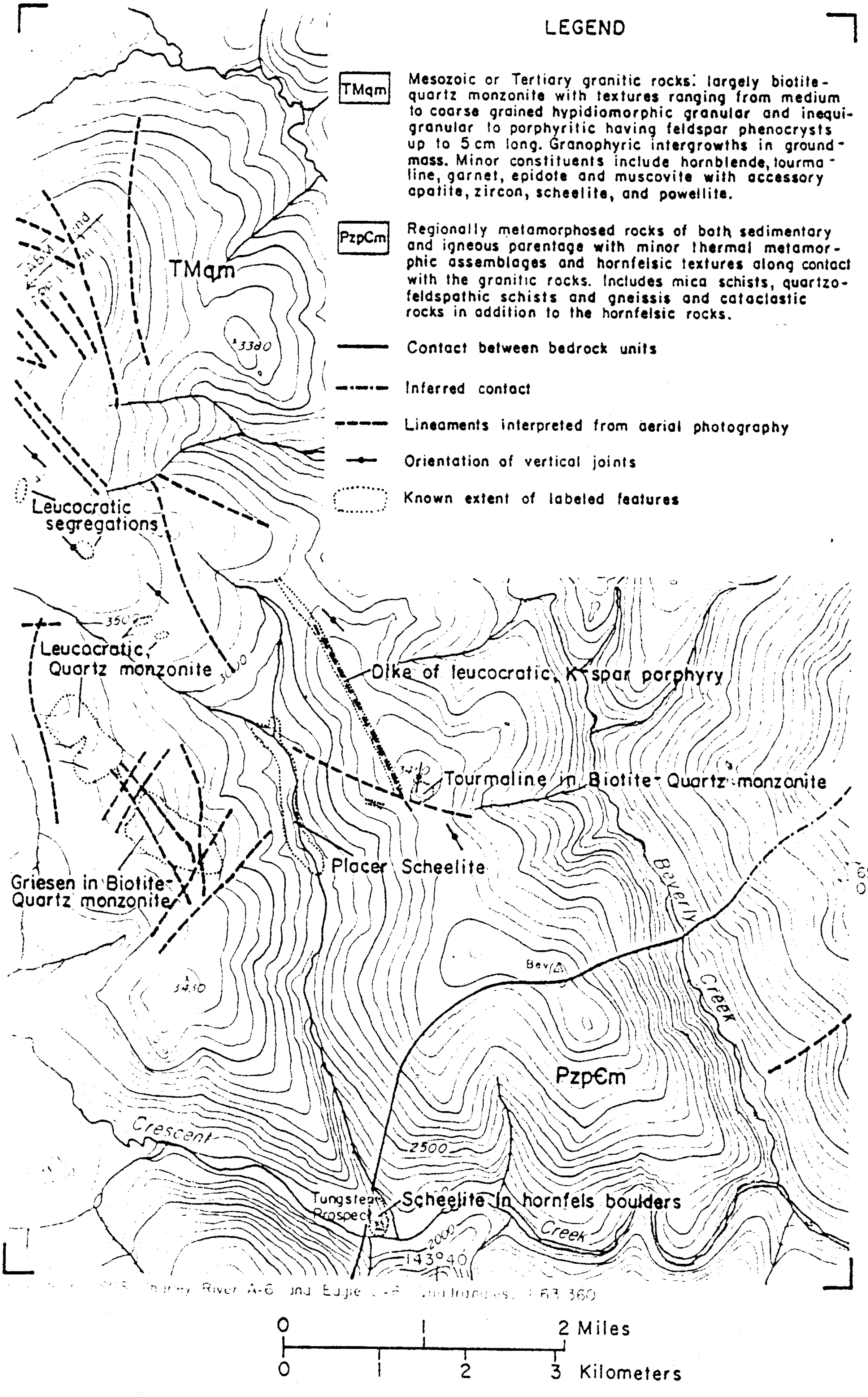

Figure 2. - Generalized geologic map of Beverly Creek area

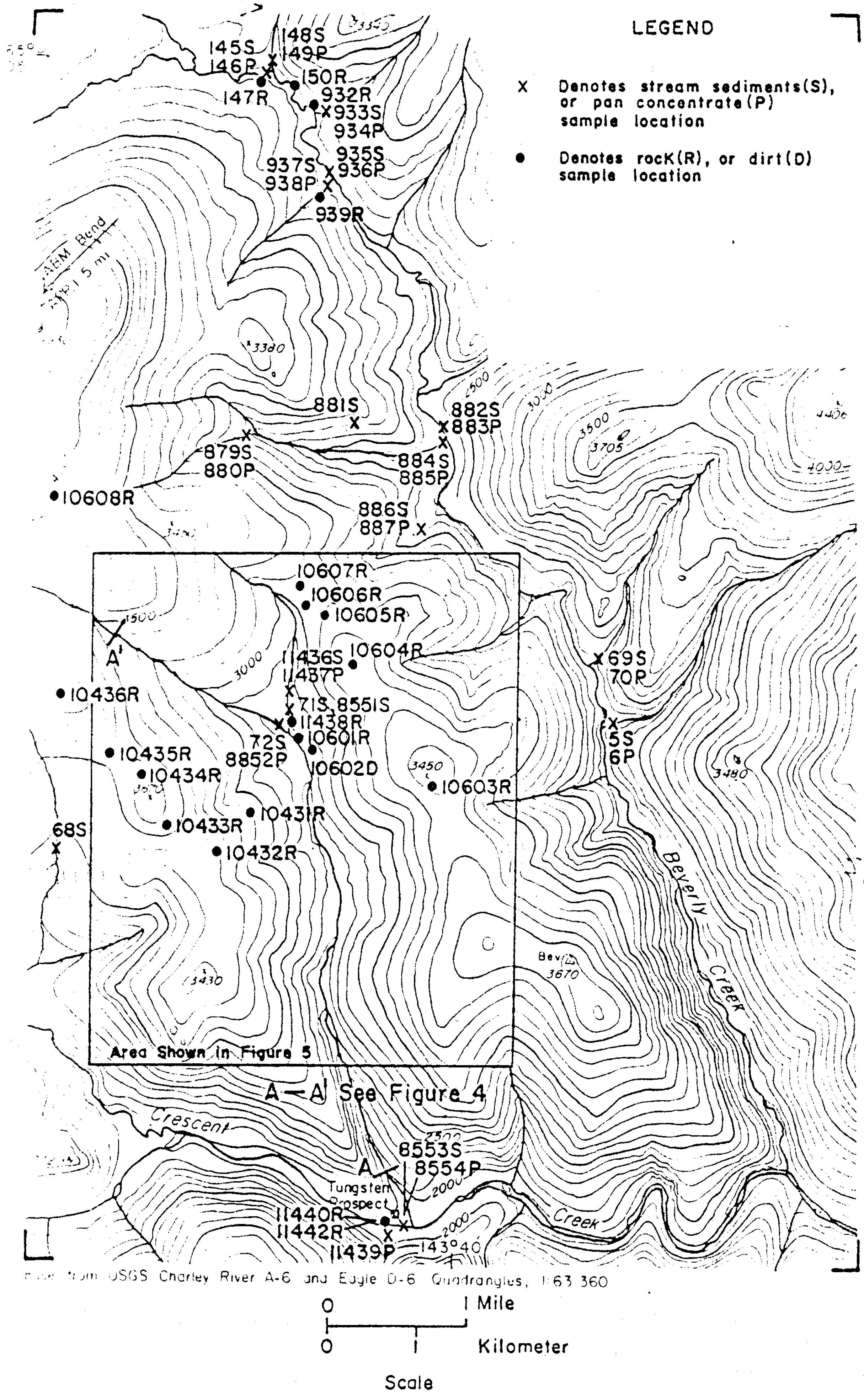

Figure 3. - Sample location map

The most common granitic rock seen in the field is a biotite-quartz monzonite (adamellite) with textures ranging from medium to coarse grained hypidiomorphic-granular and inequigranular to coarse grained porphyritic. The latter contains phenocrysts of both plagioclase (An_{15-28}) and microcline perthite, up to 5 cm. long. The groundmass of both textural varieties is made up of medium grained, anhedral quartz and anhedral to subhedral feldspar commonly containing granophyric intergrowths of quartz and feldspar. Euhedral brown biotite and subordinate anhedral green to brown pleochroic hornblende are the major mafic components which comprise up to 10 percent of the rock. Minor components include garnet, tourmaline, primary muscovite, and epidote minerals, all occurring interstitially and as inclusions in feldspars. Dravite which is confirmed by x-ray analysis, occasionally occurs as an earthy vein filling. Accessory minerals include apatite, zircon, pyrite and the tungsten mineral scheelite. Alteration products include chlorite and iron oxide after biotite and sericite, kaolin and iron oxide after feldspars.

Leucocratic dikes and segregations within the biotite-quartz monzonite contain quartz, plagioclase and K-feldspar in near equal proportions. Textures range from aplitic to coarse grained, porphyritic. These rocks also contain minor garnet, scheelite, and commonly, tourmaline. Scheelite occurs as disseminated, interstitial grains within these dikes and within quartz-rich veinlets cutting across the normal fabric of the rock.

In addition to the quartz monzonite and leucocratic variants there is a sericite rich, altered rock resembling greisen. This occurs as local segregations within the typical quartz monzonite, and in some cases along linear structural features interpreted as joints on aerial photographs.

Tungsten mineralization was also discovered as layered disseminations and aggregates in a green siliceous, carbonate bearing rock on Crescent Creek (Sample UP11442, Tables 1 and 2, and Figure 3). This rock has a hornfelsic texture with the major components being clinopyroxene and plagioclase feldspar with subordinate quartz, interstitial carbonate, and vesuvianite. Minor components include garnet, sphene, opaques and scheelite.

ECONOMIC GEOLOGY

Tungsten mineralization associated with granitic rocks and in related intrusive rocks within the study area (Tables 1 and 2), along with other reports of tungsten mineralization throughout the region, indicates the possibility of economic hardrock mineral deposits in east-central Alaska. Future exploration should include comparison of previously mentioned deposits, differentiation and detailed mapping of the granitic intrusives and neighboring rocks and more detailed, comprehensive geochemical sampling throughout the entire region. This geochemical survey should include analysis of indicator elements as well as analysis of commodities. Within the Beverly Creek and Crescent Creek areas, monzonitic rocks possess a high background of lithium (Li). Beus discusses lithium in terms of its value as an indicator for deposits of tin, tungsten and other elements in granitic rocks (3). Beus states that ore-bearing granites and barren granites can be differentiated in terms of their average content of both indicator elements and their average content of valuable elements. Lithium averages 37 $\pm$ 6 ppm in barren granites and greater than 80 $\pm$ 20 ppm in ore bearing granites. Similarly, average tungsten values for barren granites and for ore-bearing granites respectively are 2 $\pm$ 0.3 ppm and 5 $\pm$ 1 ppm. Fourteen granitic samples from the Beverly Creek area were analyzed for lithium

TABLE 2. ANALYSES OF ROCK AND SOIL SAMPLES

Sample No.	Li	W	Pb		Zn		Cu		Mo	Ag	Au	U	Sn	Description
		2/	1/	2/	1/	2/	1/	2/	2/	2/	1/	1/		
UP 147R				62		260		19	6	*				Aplite
UP 932R				16		47		7	*	*				Aplite
UP10431R	200	18	-30	2	100	50	-5	2	-1	-.1	*	5.9	-5	Biotite-Quartz Monzonite
UP10432R	100	-5	-30	25	210	22	-5	-1	-1	-.1	*	9.1	-5	Biotite-Quartz Monzonite
UP10433R	90	-5	-30	4	50	25	10	3	-1	-.1	*	3.6	6	Biotite-Quartz Monzonite
UP10436R	+400	11	-30	14	100	40	-5	3	-1	-.1	Tr.	7.5	-5	Biotite-Quartz Monzonite
UP10439R	+600	7	-30	-1	60	6	-5	-1	-1	-.1	*	2	-5	Biotite-Quartz Monzonite
UP10601R	+1000	1357	-30	18	180	58	10	9	1	-.1	*	4.9		Quartz Monzonite
UP10602D	100	*	60	12	130	70	10	8	-1		*	7.2	*	Soil Sample
UP10603R	100	14	-30	9	125	59	-5	3	-1		-.1	2.8	-5	Quartz Monzonite
UP10604R	80	9	-30	11	110	50	-5	1	-1		*	2.6	-5	Biotite-Quartz Monzonite
UP10605R	-20	*	-30	2	60	11	-5	2	-1		*	3.7	*	Leucocratic Quartz Monzonite
UP10606R	-20										*			Leucocratic Quartz Monzonite
UP10607R		5	-30	4	70	12	-5	2	-1	-.1	*	7.7	-5	Muscovite Bearing Quartz Monzonite
UP10608R	-30	-5	80	68	130	71	20	22	2	-.1	*	3.4	-5	Leucocratic Quartz Monzonite
UP11438R					-3		7							Leucocratic Quartz Monzonite
UP11442R		96	-30	-1	10	11	90	42	-1	-.1	Tr.		-5	Pyroxene Hornfels

Tr. = trace
(*) = not detected

All sample analyses reported in parts per million
Lithium analyzed by emission spectrography; tungsten by colormetric methods; uranium by fluorometric and gold by fire assay. Remaining elements analyzed by atomic absorption.

1/ Analyses by Reno Metallurgical Laboratories
2/ Analyses by Resource Associates of Alaska

and eleven were analyzed for tungsten (Table 2). Arithmetic averages for these are greater than 200 ppm lithium and 5.8 ppm tungsten. Lithium values range from less than 20 ppm to greater than 1000 ppm.

Cassiterite was detected by x-ray diffraction analyses of six heavy mineral samples (Table 3) described in the following section. The source of the cassiterite is not presently known.

PLACER INVESTIGATION

Systematic bulk sampling of the unnamed tributary of Crescent Creek (Figure 3) has indicated that the alluvial and bench gravels are consistently enriched in scheelite and to a lesser degree with cassiterite. The creek heads on the south side of VABM Bend and appears to have continuous flow throughout the summer season.

As represented on Figures 4 and 5, sampling was done in the lower gradient segment approximately mid-way down the creek. The alluvial channel both above and below this segment was much narrower, steeper in gradient, more deeply incised and choked with large boulders. As a result, only the 1.5 to 3.0 km. section represented by the sampling would contain significant reserves and be suited for efficient mining methods. The headward portions of the creek bed, while having some gravel reserves, are reworking glacial drift and as such are not considered favorable for significant heavy mineral concentration.

This region is within the zone of discontinuous permafrost and all gravel benches above the relatively flat alluvial floor are likely to be frozen. The width of the terrace gravels and active channel averaged about 61 m. (200 ft.) in the lower two thirds of the sampled segment and about 122 m. (400 ft.) in the upper portion. Depth to bedrock is unknown.

TABLE 3. ANALYSES OF HEAVY MINERALS

X-ray Diffraction Analyses

UP - 10440	Scheelite, Zircon, Cassiterite
10450	Zircon, Scheelite, Cassiterite (?)
10451	Zircon, Scheelite, Amphibole
10456	Zircon, Scheelite
10600	Scheelite, Zircon

Major minerals only - approx. 5% +
Analyses by Thomas C. Mowatt, U. S. Bureau of Mines, Juneau.

Semi-quantatative Emission Spectrographic Analyses

ELEMENT	UP 10440	10450	10451	10456	10600
Fe	2%	2%	3%	5%	2%
Ca	15%	1.5%	5%	10%	15%
Mg	0.7%	1.5%	1%	1.5%	0.5%
Ag	10	-1	70	-1	-1
As	-500	-500	-500	-500	-500
B	70	50	200	200	50
Ba	100	50	100	100	100
Be	-2	-2	2	-2	-2
Bi	1000	700	500	200	500
Cd	-50	-50	-50	-50	-50
Co	-5	-5	-5	-5	-5
Cr	20	50	70	50	20
Cu	-2	50	30	30	30
Ga	-10	-10	-10	-10	-10
Ge	-20	-20	-20	-20	-20
La	1500	2000	5000	1500	2000
Mn	-10000	-10000	-10000	-10000	-10000
Mo	200	70	100	200	200
Nb	700	200	150	500	500
Ni	-5	50	-5	50	-5
Pb	30	70	30	10	100
Sb	-100	-100	-100	-100	-100
Sc	200	200	300	300	300
Sn	7000	500	2000	1500	5000
Sr	-100	-100	-100	-100	-100
Ti	7000	+10000	10000	10000	7000
V	100	70	70	200	50
W	+10000	3000	+10000	+10000	+10000
Y	5000	7000	7000	5000	5000
Zn	-200	-200	-200	-200	-200
Zr	7000	+10000	10000	10000	10000

(-) = Less than
(+) = More than
Analyses by Skyline Labs, Inc. Wheatridge, Colo.

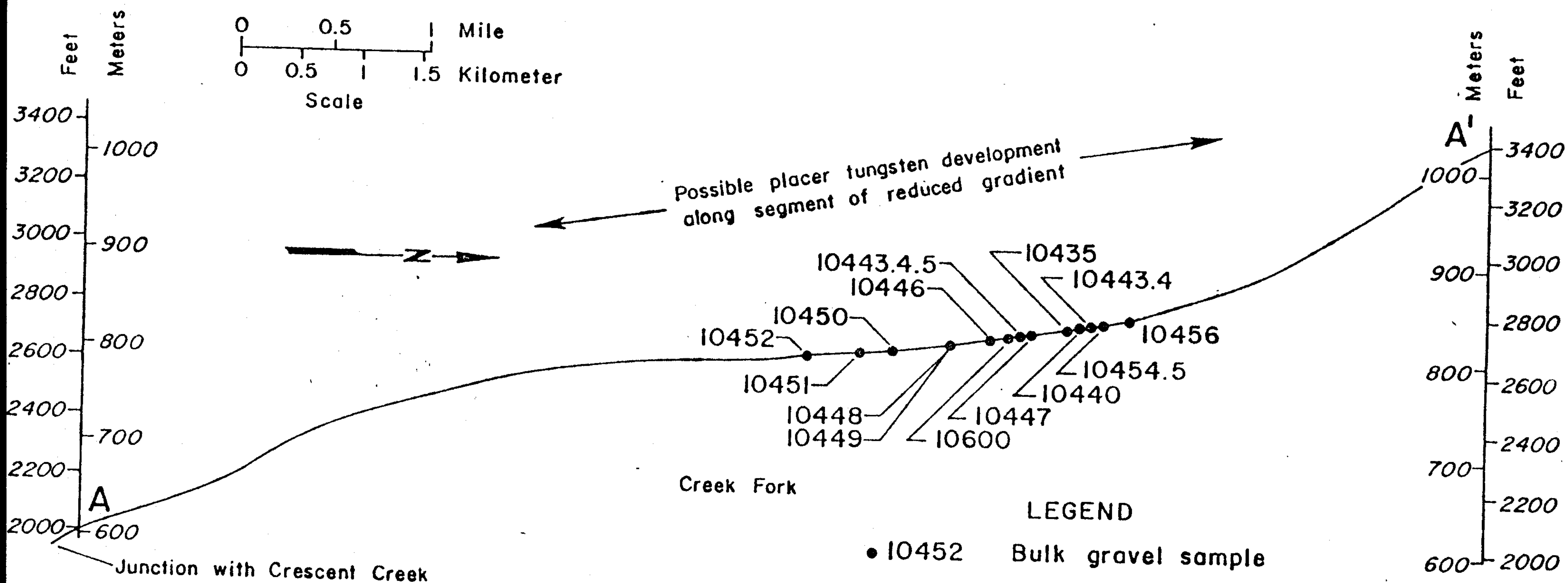

Figure 4. - Profile of placer investigation

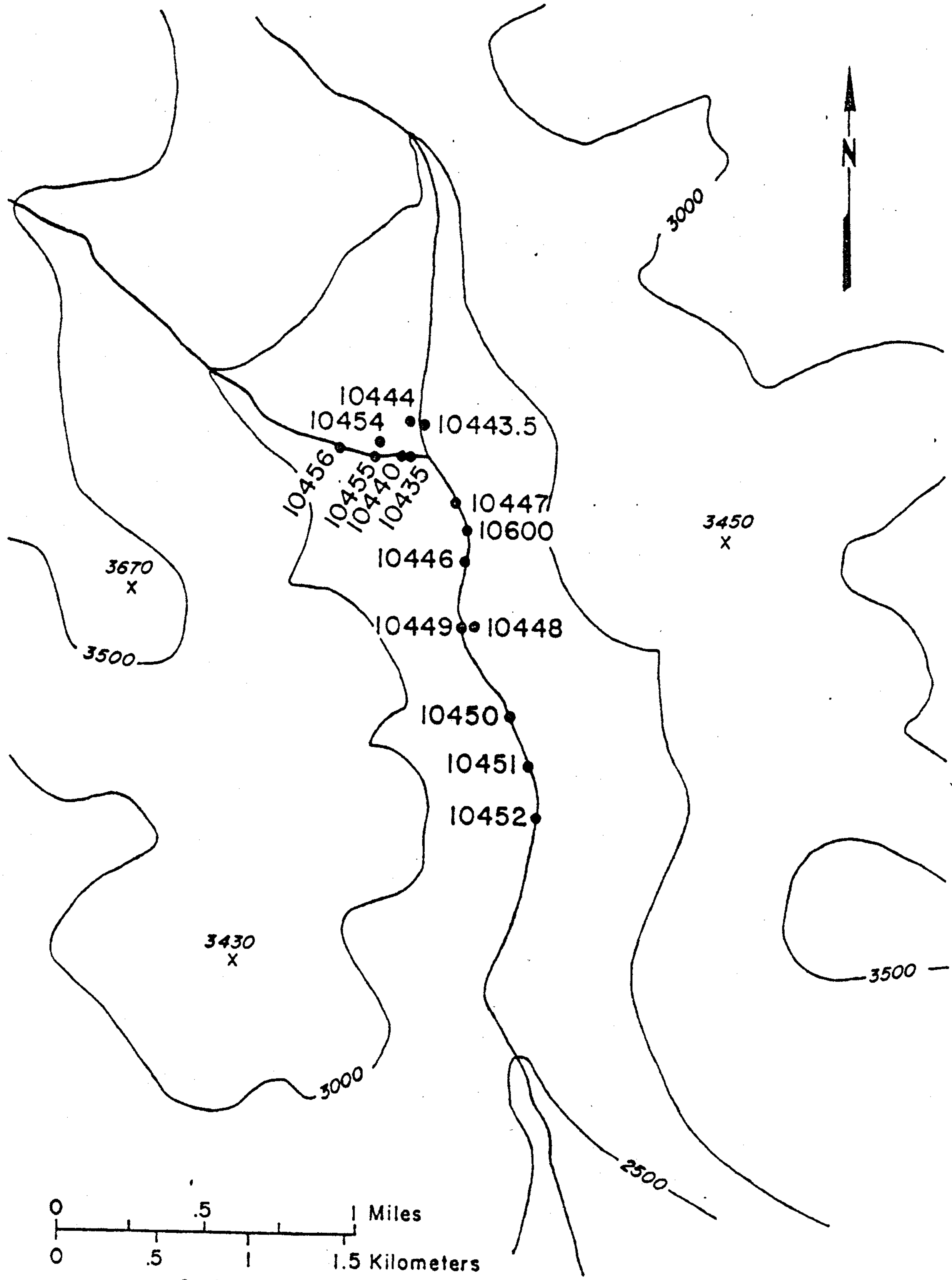

Figure 5. - Location of placer samples

Creek alluvium consists of sorted granitic sands and gravels with a high percentage of cobbles, and a very minor silt fraction. Boulders up to a meter in diameter are present.

All samples are surface samples taken from the creek bed or bank material. Quantitative values listed in Table 4 are therefore only an indication of concentrates that may exist at depth.

Samples were reduced from the gravel volumes listed in Table 4 by hand panning. The rough concentrate was then further cleaned by magnetic separation and heavy liquid treatment (bromoform) to remove the +2.85 sp. gr. minerals. All assays and mineral identifications (Table 4) were performed on the -14 mesh (1190 microns) fraction of the concentrate.

SUMMARY

A broad metallogenic zone exists within the Yukon-Tanana Upland in eastern Alaska. Numerous tungsten occurrences within this zone are shown in Figure 1 and it is upon these occurrences that delineation of the trend is based. This zone has potential for economic placer and hardrock deposits of tungsten.

Tungsten mineralization occurs in three modes within the vicinity of VABM Bend: 1) as disseminated scheelite in plutonic rocks consisting of biotite-quartz monzonite and in more felsic segregations of the same magmatic source; 2) as disseminations and aggregates of scheelite in hornfelsed country rock intruded by the igneous rocks mentioned above; and 3) as placer scheelite concentrated by erosion of the hard rock sources. One of these placer occurrences was examined in detail and results are presented in this paper.

TABLE 4. RECOVERY OF TUNGSTEN IN SURFACE GRAVEL SAMPLES

Sample No.	Volume of Sample (cubic yds)		wt(grams) of N.M. conc. +2.85 sp.gr.		% W in conc. 2/	estimated lb. WO_3 per yd^3	grams-W per yd^3
	-4 inch	-1/2 inch	+14m	-14m			
UP10440	.032	.016	2.08	7.90	31.0%	.268	96.68
UP10443	.032	.017	.57	4.75	22.8	.105	37.90
UP10444(bank)	.003	----	.07	.82	9.8	.081	29.07
UP10445	.016	.015	3.16	3.52	23.9	.277	99.78
UP10446	.013	----	.39	2.43	9.2	.055	19.96
UP10447	.032	.028	.63	4.95	19.0	.092	33.13
UP10448	.032	.019	1.23	2.59	9.2	.030	10.98
UP10449	.016	.009	.35	1.33	2.0	.006	2.1
UP10450	.032	.029	.58	7.45	9.3	.064	23.34
UP10451	.032	.023	2.46	5.57	14.1	.098	35.38
UP10452	.032	.019	.33	1.94	7.0	.013	4.96
UP10454	.016	.01	.21	1.97	8.9	.034	12.13
UP10455	.032	.021	.31	3.26	7.3	.023	8.14
UP10456	.032	.021	1.04	5.57	18.3	.105	37.80
UP10600	.016	.019	.08	5.85	21.3	.219	78.94
UP11435	.006	----	.20	1.61	19.2	.161	57.92

1/ Volumes are corrected from actual volume measurements using a 25% swell factor.
2/ Analyses by colormetric procedures, Skyline Labs Inc., Wheat Ridge, Colo.

Future exploration models within the region should include, but not be restricted to large tonnage-low grade deposits of disseminated tungsten minerals in rocks of biotite-quartz monzonite composition and high-grade deposits of tungsten and associated minerals in vein and contact metamorphic environments within and adjacent to the granitic intrusives. Structural control for the latter type of mineralization may be provided by the numerous joint sets within these plutons.

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Appendix A - Analyses of Stream Sediments

Sample No.	UP148	UP145	UP933	UP935	UP937	UP879	UP881	UP882	UP884	UP886	UP11437 1/	UP71	UP8551 1/	UP72	UP69	UP5	UP68	UP855 1/
Mn	5000	1500	1500	1000	300	5000	500	2000	300	700		1500		300	500	1500	500	
Ag	5	1	2	2	N	N	1	N	1	1	N	L	N	1	1	L	L	N
As	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Au	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
B	100	150	50	150	30	50	50	150	20	30		50		50	20	30	50	
Ba	3000	1000	1000	N	N	N	N	L	N	N		N		N	N	N	N	
Be	5	1	2	2	1	N	3	N	5	7		5		5	L	2	5	
Bi	L	L	L	20	N	N	20	N	N	20		10		N	L	20	N	
Cd	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Co	50	N	N	N	N	N	N	N	N	N		N		N	20	N	N	
Cr	500	50	100	200	L	200	70	50	100	200		150		50	50	100	L	
Cu	150	15	15	15	5	15	7	10	10	10	11	20	8	20	7	30	15	10
Ga	50	0.5	1.5	2	L	3	1	1	0.5	L		N		N	0.5	L	N	
La	N	N	N	N	N	N	N	L	N	N		L		N	N	N	N	
Li	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Mo	70	N	N	N	N	N	N	N	N	N	N	N	N	L	N	N	N	N
Nb	N	L	N	N	N	N	N	N	N	N		N		N	L	L	N	
Ni	300	15	100	100	L	150	50	15	100	150		100		150	10	100	20	
P	1000	L	1000	2000	1000	2000	1000	2000	1000	L		L		1000	1500	1500	L	
Sb	N	N	N	N	N	N	N	N	N	N		N		N	N	L	N	N
Sc	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Sn	N	N	N	150	N	N	N	N	N	N		N		N	N	N	N	
Sr	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Ta	N		N	N	N	N	N	N	N	N				N		N	N	
V	300	20	70	150	L	300	20	150	20	20		N		N	L		N	
W	N	N	N	N	N	N	N	N	N	N		5000		N	N	N	N	
Y	N	N	N	N	N	N	N	N	N	N		N		N	N	N	N	
Zn	N	N	N	N	N	N	N	N	N	N	76	N	54	N	N	N	N	
Zr	500	L	G	200	300	1000	N	L	G	N		G		L	G	N	N	56
Th 2/	21	12	28	14	25		37	16	34	18				23	25	500	300	
U 3/	6.8	2.6	21.3	4.9	16.1		11.9	7.6	19.8	6.6				19.9	24.9	16.5	19	
W 1/											5		77			5.1	11.5	
																N		46

1/ Analyses by atomic absorption, USBM Reno Metallurgical Laboratory
2/ Thorium by colormimetric analyses, Atomic Energy of Canada Ltd. Ottawa
3/ Uranium by fluorometric analyses, Atomic Energy of Canada Ltd. Ottawa
All other analyses by 6-step semi-quantatative emission spectrography, University of Alaska, Mineral Industry Research Labortory

Appendix B - Analyses of Pan Concentrate Samples

Sample No.	UP149	UP146	UP934	UP936	UP938	UP880	UP883	UP885	UP887	UP11436	UP8552	UP70	UP6	UP11439	UP8554
Ag	5	10	10	10	10	7	15	7	15	30	30	10	5	30	30
As	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Au	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B	300	700	150	300	100	50	300	150	7000	2000	2000	150	30	700	700
Ba	L	1000	1500	1500	N	N	N	1000	1000	N	N	N	N	N	L
Be	3	5	10	N	15	3	2	30	10	+1000	L	15		L	30
Bi	N	N	N	N	N	N	L	20	N	+1000	+1000	N	N	N	N
Ce	N	N	N	L	N	N	N	N	N	L	+3000	N	N	N	N
Co	50	70	N	N	N	N	50	N	50	700	700	N	30	1000	1000
Cr	700	1000	300	500	300	100	1000	100	300	L	1500	700	150	N	5000
Cu	50	50	20	150	50	5	150	10	100	150	300	50	10	70	50
La	N	L	1	N	N	L	N	L	N	L	N	N	500	L	L
Mo	30	N	N	L	N	N	N	N	N	700	+2000	N	N	N	N
Nb	L	L	L	L	L	L	L	L	L	N	N	L	L	N	N
Ni	100	150	N	200	N	L	300	N	300	500	L	N	50	L	7
Pb	N	N	N	N	N	N	N	50	150	N	3000	N	N	N	N
Pt	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sb	L	N	N	N	N	N	150	L		N	N	N	N	N	N
Sn	N	150	100	300	150	N	L	50	150	1000	7000	150	N	700	L
V	200	200	300	1000	500	300	200	300	300	300	700	300	200	1500	1500
W	7000	200	7000	10,000	7000	10,000	N	5000	N	+1000	+10,000	N	N	N	N
Y	500	700	1000	N	700	200	500	700	1000	+2000	+2000	700	N	700	300
Zn	L	500	2000	N	2000	N	700	3000	N	1500	N	1500	N	N	N
Zr	G	G	G	G	G	G	G	G	G	G	G	G	N	G	+1000

Analyses by semi-quantatative, six step emission spectrography, University of Alaska, Mineral Industry Research Laboratory
L = element present but below detection limits
G = greater than detection limits
N = not present
(+) more than