INVESTIGATION OF TIN-RARE EARTH ELEMENT PLACERS IN THE RAY RIVER WATERSHED

By James C. Barker

**OFR 34-91

UNITED STATES DEPARTMENT OF THE INTERIOR

Manuel Lujan, Jr., Secretary

BUREAU OF MINES

T S Ary, Director

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UNITS OF MEASURE ABRREVIATIONS USED IN THIS REPORT

cm	centimeter
cps	count per second
ft	foot
g	gram
in	inch
long	longitude
lat	latitude
lb	pound
lb/yd^3	pounds per cubic yard
mg	milligram
mi	mile
mm	millimeter
ma	million years
pct	percent
ppm	parts per million
μm	micrometer, micron
st	short ton
yd^3	cubic yard

INVESTIGATION OF TIN - RARE EARTH ELEMENT PLACERS

IN THE RAY RIVER WATERSHED

By James C. Barker[1]

ABSTRACT

Alluvial cassiterite concentrations are widespread in river gravel and high level terraces within the Ray River watershed. The area lies in unglaciated terrain of Alaska's northern interior. Cassiterite originates from several calc-alkaline plutons of the Ruby batholith. Extensional stresses resulted in graben-like Tertiary basins that were flooded by a 200 ft thick section of mid- to late- Tertiary basalt flows. Basalt blocked local drainages, and 50- to 100-ft of terrace gravel was eventually deposited on top of the flows. Further downwarping and eventual fluvial downcutting of the flows resulted in cycles of accelerated sediment transport, deposition, and reconcentration. Repeated erosional cycles concentrated heavy minerals and resulted in development of tin placers.

Preliminary resource estimates of contained tin in Recent alluvium range from 62 to as much as 172 million lbs-Sn in 300 million yd^3. Grade of about 90% of the gravels is estimated to range between 0.2- to 0.5- lbs-Sn/yd^3. Associated gold and rare earth elements (REE) in monazite and xenotime may be recoverable.

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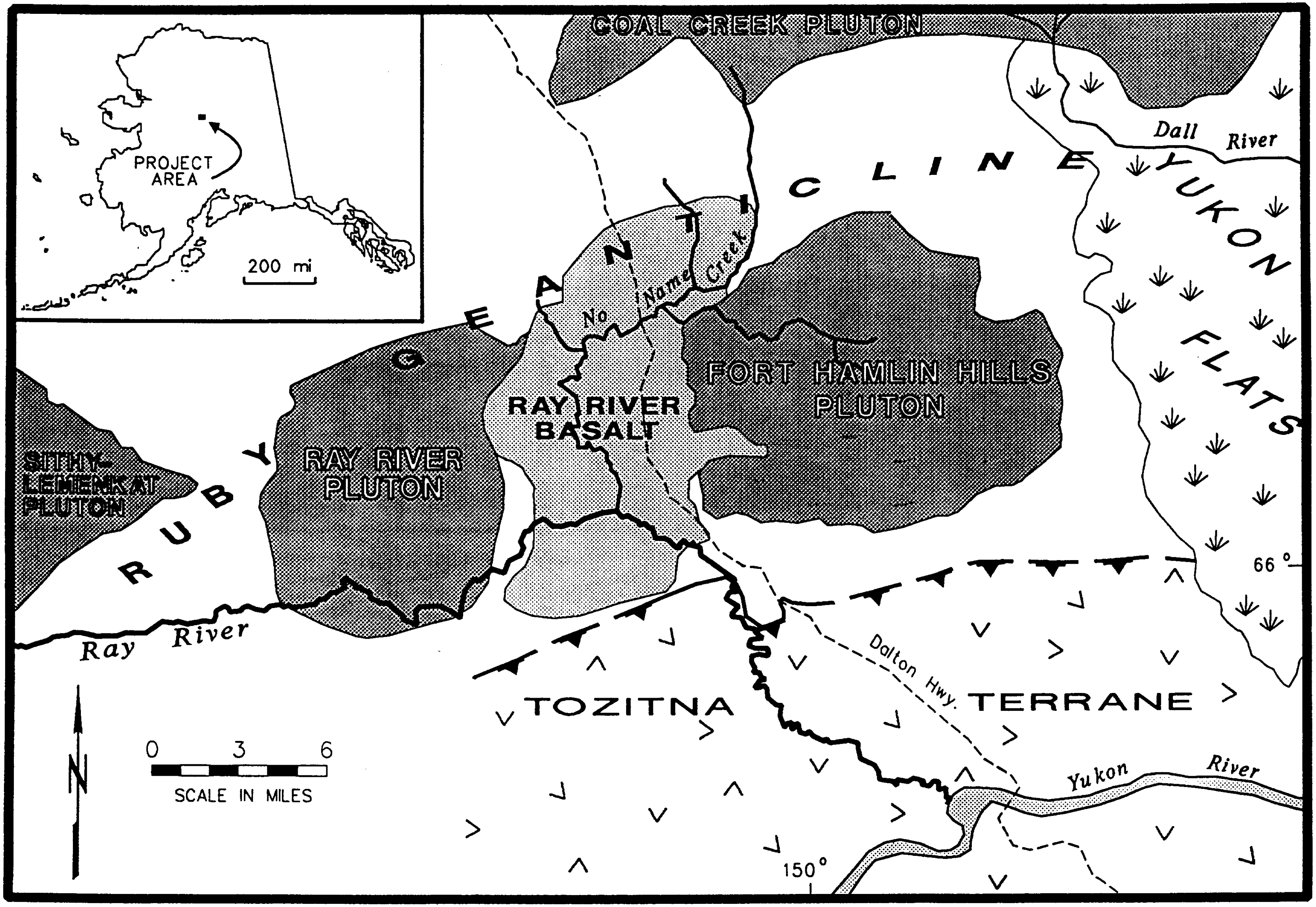

Figure 1. - Location of the Ray River and Ft. Hamlin Hills area in north central Alaska.

Most of the tin is considered a subeconomic inferred resource, though, at least some of the gravels contain 2- to 6- lbs-Sn/yd³. Estimates are projected on the basis of surface sampling and several auger drill holes and are provided for the purpose of land-use management planning.

INTRODUCTION

The Ray River area is located immediately north of the Yukon River within the densely wooded rolling hills of northern interior Alaska (figs. 1 and 2). The project area is approximately 150 mi northwest of Fairbanks, and the Dalton Highway, constructed in 1975 as part of the Alyeska Pipeline project, has provided the first overland access to the region.

Investigations of mineral resources in the Ray River and Ft. Hamlin Hills area has been conducted intermittently by the U.S. Bureau of Mines during the years 1975 through 1989. Initially the work was part of a broader Trans-Alaska pipeline corridor reconnaissance conducted at the time of excavations associated with pipeline construction. The region contains very poor bedrock exposure and little was known of the geology prior to the construction.

Indications of tin mineralization near the Ft. Hamlin Hills were found in 1978 and later reported in 1983 (1)[2]. Beginning in

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2 Underlined numbers in parentheses refer to the list of references at the end of the report.

Figure 2. - Up to 50 ft of Quaternary quartz gravels (Qg) overlie dissected Tertiary basalt flows, (Tb) which in turn overlie Tertiary white channel gravels (Twg). The Qg was deposited after basalt flows dammed local drainages from the granitic highlands into a subsiding Ray River basin nearby. Here the Qg is being eroded and further concentrated as recent terraces on the valley floor (Qt). Photo taken south of the gravel pit prospect #1.

1985, the northern Ft. Hamlin Hills were further studied as part of the Bureau's Alaska Critical and Strategic Minerals Program. Field observations in those years indicated that vast areas of granitic source rock favorable for tin existed (2). This terrane has experienced repeated erosional cycles due to regional uplift. Much of the sediment was deposited over fissure flood basalts in graben-like depressions that subsequently have been downcut by further alluvial processes. These events pose geologic opportunities by which tin placer deposits can form.

The specific objectives of the project are to determine if tin enriched source rock and Tertiary through Quaternary geologic processes in the northern Ft. Hamlin Hills-Ray River area have resulted in, 1) deposits of placer tin and rare earth elements (REE) and 2) a significant regional tin resource provenance. Furthermore, the project included, 3) an investigation of mineralogy and probable bedrock source of the placer tin and REE and 4) preliminary estimation of potential resources of inferred subeconomic to economic placers.

Resource estimates given in this report are based largely on surficial sampling and must be considered very preliminary. They are provided as an approximation to serve as resource data for land-use management and planning purposes.

In retrospect, this study provides an excellent example of the usefulness of heavy mineral sampling in fluvial and colluvial sediments. Heavy mineral sampling is particularly useful in areas such as the Ft. Hamlin Hills-Ray River area, where bedrock is obscured by vegetation, organic ground matt, underlying loess, and permafrost conditions.

ACKNOWLEDGEMENTS

The following report was prepared with the assistance of several individuals. Field mapping was contributed by Dean Warner, Physical Scientist, formerly with the U.S. Bureau of Mines, Fairbanks, AK, and Roger Burleigh, Geologist, and Jeff Foley, Physical Scientist, U.S. Bureau of Mines, Fairbanks, AK. Mineralogical studies were performed by William O'Connor, Mineralogist, of the Bureau's Albany (Oregon) Research Center.

Acknowledgement is also due the Alyeska Pipeline Company for permission to utilize the pipeline right-of-way and gravel pits for access and sampling, and allowing a review of centerline borehole data. Funding for the original portions of this project (1975-1978) was provided by the U.S. Bureau of Land Management.

PREVIOUS WORK

Detrital tin was first detected in geochemical stream sediment samples from central Alaska (about 40 mi northwest of Ft. Hamlin Hills) by Herreid (4). Further work by Barker and Foley (2) in the Sithylemenkat pluton region identified significant tin placer mineralization and suggested that other granitic plutons in the area were favorable sites for tin mineralization. In 1983, a heavy mineral survey of the pipeline corridor north of Livengood indicated several areas of anomalous tin; included were a cluster of anomalies in the vicinity of the inferred northern extent of the Ft. Hamlin Hills pluton (1). There were no previously known tin deposits or prospects in the Ft. Hamlin Hills or the adjoining Ray River drainage.

METHODS

The Ft. Hamlin Hills-Ray River project was conducted intermittently from 1975 to 1989. Field studies were conducted on foot from the Dalton Highway and the pipeline right-of-way, and from several helicopter spike camps located on upper No Name Creek. Canoe traverses of both the Ray River and No Name Creek (beginning at the Dalton Highway) were made using back-packable inflatable canoes.

Heavy mineral samples were collected from sites individually described in the tables of this report. The total prescreening weight and volume of each sample were determined as documented in the tables. Concentrates were produced by screening at 0.5 in, then at 16 mesh (1 mm), followed by either hand panning or tabling the undersize depending on the sample size. By weighing representative gravel samples, the average weight of one wet cubic foot of gravel was found to be 118.5 lbs. Using this weight, without application of a swell factor, all sample weights were converted to volumes.

Seven auger drill holes were drilled using a gas-powered, helicopter-portable, 2.5-in-diameter, solid-stem auger drill. Cuttings were collected as the specified intervals were drilled. Efficiency of recovering heavy minerals using this technique is unknown but probably less than 100 pct. Auger samples were diluted to some unknown extent due to pebbles from the sides of the hole mixing with the cuttings as they rose along the drill stem. Cuttings were weighed, slimed, screened, and tabled to produce a concentrate that contained all heavy minerals (>4.0 specific gravity).

Analyses for Sn and W were by X-ray fluorescence (XRF) and neutron activation methods, respectively; other multi-element analyses for Nb, Ti, REE, Y, and Zr were by inductively coupled plasma (ICP)-mass spectrometry (MS). The lower detection level by the XRF procedure is 5 ppm, whereas for the MS-ICP method they are 0.01%. Tin values exceeding the 20,000 ppm upper detection limit of the XRF procedure, or where interference was encountered, were assayed following multi-acid total digestion. Major oxide analyses used borate fusion extraction followed by plasma emission spectrography with a lower detection
limit of 0.01%.

Following analysis, the contained grade of tin for each sample site was calculated in units of lbs-Sn/yd^3. The following calculation was used:

$$\frac{27}{\text{Volofsample}(ft^3)} \times \frac{\text{Recovered heavy mineral conc (g)}}{454} \times \text{Sn analysis (pct)} = \frac{\text{lbs-Sn}}{yd^3}$$

In this manner the grade (lbs-Sn/yd^3) for any given sample site can be readily compared to other sample sites, as well as evaluated for economic merit.

BEDROCK GEOLOGY

The project area includes two granitic plutons (Ray River and Ft. Hamlin Hills) and parts of the Coal Creek and Sithylemenkat plutons that intrude Paleozoic schist, phyllite, quartzite, greenstone, and limestone (figs. 1 and 3 (backpocket)). The plutons are possibly connected at shallow depth. The area is located along the southeast flank of the Ruby Geanticline, which forms a broad northeast-trending belt of crystalline rock in north central Alaska (3).

As elsewhere in the interior, bedrock exposure is scarce and limited to patches of rubble on steeper hillsides and in a few cutbanks along the major drainages. Permafrost loess deposits and vegetation limit outcrop or even rubble exposure to much less than one percent of the land surface. Reconnaissance scale (1:250,000) geologic mapping within the Ray River drainage is included on four USGS quadrangles: Livengood (5), Tanana (6), Bettles (7), and Beaver (8).

The oldest rocks (Pzp) are quartz-mica schist, light-colored quartzite, and phyllite, which exhibit thermal alteration in the vicinity of the granitic intrusions (fig. 3). The Pzp may also include a mafic schist to greenstone unit that is best exposed along the Dall River to the northeast of the Ft. Hamlin Hills. White vein-quartz, quartz-carbonate veins, and quartz stockwork are abundant in the Pzp unit, particularly the phyllite. Phyllite is exposed in road cuts along the Dalton Highway and in river banks for several miles below the confluence of No Name Creek. Overlying the Pzp is a Paleozoic quartzite and limestone unit (Pzl) that is altered to marble and calc-silicate rock near the plutonic contacts. The quartzite and limestone were only found at higher elevations, for example in a large roof pendant near Lat 66°05' Long 150°00' (fig. 3).

Granitic rocks generally underlie the higher terrain. They are separated from each other by approximately flat-lying flows of fissure basalt and Tertiary sedimentary rock, preserved in poorly definable graben-like basins. The plutons are broadly domed and each has lateral extent of several hundred square miles.

The plutons are multi-phased, but are composed largely of coarse equigranular to porphyritic potassium feldspar-biotite-quartz monzonite and granite. Subordinate phases include aplite, fine-grained tourmaline quartz monzonite, fine-grained quartz porphyry, and tourmaline pegmatite. Major oxide analyses of representative chip samples indicate the plutons are peraluminous calc-alkaline granite (table 1).

The Ft. Hamlin Hills, Sithylemenkat, Ray River, and Coal Creek plutons are considered to be among more than a dozen similar calc-alkaline plutons of the Cretaceous-age Ruby batholith (3). Source of the magmas for the Ruby batholith is believed to be within deeper heterogenous parts of the Proterozoic to Paleozoic crust

Table 1. - Major oxide analyses and normative mineralogy (in pct) of whole rock samples from the Ray River area.

ROCK TYPE AND LOCATION	Ray River Pluton								
Latitude	66° 00.3'	66° 00.6'	66° 00.9'	65° 57.7'	65° 59.5'	66° 01.3'	66° 00.5'	65° 59.3'	65° 58.7'
Longitude	150° 33.7'	150° 33.7'	150° 33.7'	150° 33.5'	150° 30'	150° 28.8'	150° 29'	150° 29'	150° 23.3'
	Peralum. granite	Peralum. granite	Peralum. granite	Peralum. granite	Peralum. granite	Peralum. granite	Peralum. granite	Peralum. granite	Alk. granite dike
Major oxides									
SiO_2	79.05	76.62	76.19	73.28	76.41	72.26	73.32	76.05	64.76
Al_2O_3	10.74	12.23	12.29	12.83	12.20	14.04	13.59	12.42	13.99
CaO	0.32	0.39	0.52	0.55	0.61	0.87	0.89	0.68	0.64
MgO	0.01	0.01	0.01	0.37	0.01	0.01	0.31	0.01	2.30
Na_2O	2.49	2.78	3.18	2.58	2.88	2.80	2.76	3.45	1.86
K_2O	4.73	5.26	5.07	4.85	4.65	5.85	5.78	4.69	5.80
Fe_2O_3	1.54	1.46	1.59	3.06	1.62	2.36	2.16	2.04	7.70
MnO	0.02	0.01	0.02	0.03	0.02	0.05	0.05	0.04	0.09
TiO_2	0.10	0.11	0.10	0.38	0.14	0.26	0.28	0.14	1.04
P_2O_5	0.06	0.06	0.06	0.21	0.09	0.13	0.16	0.08	0.16
LOI	0.84	0.79	0.54	---	0.78	0.71	0.63	0.43	1.58
Normative Minerals (CIPW)									
Quartz	45.92	39.66	37.22	38.54	40.91	31.87	32.91	36.33	25.74
Orthoclase	28.24	31.45	30.28	29.26	27.89	35.10	34.44	27.86	35.04
Albite	21.29	23.80	27.20	22.29	24.73	24.06	23.55	29.35	16.09
Anorthite	1.21	1.56	2.21	1.39	2.48	3.52	3.40	2.87	2.18
Corundum	1.10	1.41	0.78	2.90	1.56	1.86	1.57	0.63	3.96
Diopside	---	---	---	---	---	---	---	---	---
Hypersthene	1.11	1.02	1.15	2.80	1.12	1.56	2.10	1.47	10.84
Olivine	---	---	---	---	---	---	---	---	---
Magnetite	0.79	0.75	0.82	1.59	0.84	1.22	1.10	1.04	3.76
Ilmenite	0.19	0.21	0.19	0.74	0.27	0.50	0.54	0.27	2.02
Apatite	0.14	0.14	0.14	0.50	0.21	0.31	0.37	0.19	0.38

Table 1. - Major oxide analyses and normative mineralogy (in pct) of whole rock samples from the Ray River area (cont.).

	ROCK TYPE AND LOCATION				
	Ft. Hamlin Hills Pluton				Ray River Basalt
Latitude	66° 05.3'	66°07.4'	66°07.6'	66°07.7'	66°04.6'	66°00.5'
Longitude	149° 59'	150°03.8'	150°04.2'	150°04.4'	150°09.7'	150°10.3'
	Peralum. granite	Contam. granite[1]	Peralum. granite	Peralum. granite	Basalt[2]	Trachy-Basalt
Major oxides						
SiO_2	70.80	46.85	76.29	74.26	51.29	55.20
Al_2O_3	14.40	15.82	12.66	13.92	16.89	14.60
CaO	1.00	13.87	0.20	0.33	10.04	5.94
MgO	0.46	10.76	0.14	0.25	6.01	2.65
Na_2O	3.84	0.95	2.96	3.16	3.13	4.58
K_2O	5.45	0.32	4.74	4.55	0.87	2.30
Fe_2O_3	2.84	8.48	0.37	1.44	8.20	10.25
MnO	0.07	0.16	0.03	0.02	0.16	0.13
TiO_2	0.37	0.57	0.09	0.13	1.75	2.42
P_2O_5	0.00	0.35	0.26	0.32	0.29	0.69
LOI	---	1.50	1.00	1.30	---	2.03

(CIPW) Normative Minerals						
Quartz	24.76	---	41.59	38.32	2.82	6.26
Orthoclase	32.45	1.94	28.66	27.36	5.24	13.85
Albite	32.74	8.25	25.63	27.20	26.99	39.49
Anorthite	5.50	38.93	---	---	30.03	12.73
Corundum	0.19	---	2.72	3.86	---	---
Diopside	---	23.44	---	---	14.91	10.31
Hypersthene	1.15	16.56	0.56	1.60	11.15	5.26
Olivine	---	5.87	---	---	---	---
Magnetite	1.98	3.08	0.19	0.75	4.80	5.79
Ilmenite	0.71	1.11	0.18	0.25	3.39	4.68
Apatite	---	0.83	1.20	1.97	0.68	1.63

[1]Representative chips of contaminated granite(?), including biotite, actinolite, tourmaline, and quartz in a schistose texture.
[2]Adapted from Albanese (9).

represented by currently exposed country rocks of the Ruby Geanticline. Neither the Ray River nor the Ft. Hamlin Hills pluton has been age-dated, however compositional similarities with the Cretaceous (106±3 ma) Sithylemenkat pluton (7), the Ray Mountains pluton (109-112 ma) to the west, and the Hodzana pluton (112 ma) to the north (3), suggest similar ages.

Fine-grained intrusive phases exhibit locally intense tourmalization, silicification, and a variable degree of sericitization. Alteration features are most readily observed in outcrops near the southern fork of No Name Creek (Lat 66°07', Long 150°04'), and similar rubble occurs in the road cut three miles south of No Name Creek. The tourmaline alteration, accompanied by silicification and sericitization, is apparently much more extensive than mapped (fig. 3), as indicated by the widespread abundance of quartz-tourmaline pebbles in high level gravel throughout the northern and eastern Ft. Hamlin Hills (Appendix A). Massive silicification and quartz stockworks, locally containing tourmaline, are also present at the higher elevations on the Ray River pluton.

Tertiary-age, coal-bearing sedimentary rocks (Ts) are mapped at several locations on figure 3. The Ts is composed of volcaniclastic mudstone with ash beds, arkosic sandstone and conglomerate, and lignitic coal. Mudstones locally contain carbonized plant fragments. The coal-bearing strata are underlain by upward-fining sequences of well-rounded quartz-pebble conglomerate and sandstone. Regressive weathering of the Tertiary rock and the susceptibility of coal to forest fires severely limit the mappable exposures of the Ts unit. Pieces of coal float on gravel bars of the Ray River suggest that Tertiary rocks underlie much of the river valley floor.

The Ts rocks were largely deposited during the early- to mid-Tertiary. Tertiary sedimentation was originally composed of fluvial gravels but later evolved into lower-energy deposition in peat bogs cut by meander channels and intermittently covered by ash falls. An upward-fining sequence of quartz-pebble conglomerate and sandstone, beneath the coaly sediments, is exposed at Lat 66°02', Long 150°16', and is also seen along Coal Creek, a tributary to the Dall River. Tertiary rocks are also exposed near Lake 392 where a bedrock knob is composed of arkosic conglomerate and shale. In a single outcrop two miles above the mouth of No Name Creek, a 50-ft-thick sequence of coaly volcanic ash, carbon-rich volcaniclastic rock, coal, arkosic (granitic) sands, and semi-consolidated, white-weathering fluvial gravels are overlain by basalt. Near the Dall River alternating beds of mudstone and ash overlie an 18-ft-thick coal bed, which in turn overlies the conglomerate. A K-Ar age determination on an ash bed overlying the coal gave an Eocene date of 38.6 ± 1.6 m.a. (10). Apparently volcanic activity was initiated during this coal-forming period and continued until the basalt flows occurred.

The Ts unit is locally overlain by a poorly consolidated and conspicuously white quartzose gravel (Twg). The Twg also characteristically contains clasts of silicified schist and hypabyssal felsic rocks. Thickness of the Twg is unknown but was not observed to exceed 10 ft.

Basalt lavas (Tb) form the youngest bedrock unit and are inferred to underlie about 60 square miles of the Ray River drainage. Basalt was also found at a site near the confluence of Coal Creek and the Dall River. Texture ranges from vesicular to massive, and compositions vary from olivine basalt to andesite. Vesicules are locally filled with calcite, quartz, or native sulfur. Most commonly the basalts are fine-grained to aphanitic, but locally grade to a medium-grained texture of lath-like crystals of plagioclase randomly intergrown in a matrix of anhedral clinopyroxenite. The latter type was best exhibited near Lake 392 (Lat 66°00.5', Long 150°10'). At the outcrop on the Ray River two miles upstream of No Name Creek, at least three flows of fine-grained basalt featuring columnar jointing are stacked together. The total section of basaltic flows has a thickness of about 200 ft, is flat lying, and lies between 475 and 725 ft elevation. In a road-cut outcrop near the No Name Creek crossing the uppermost flows also exhibit columnar jointing, but are separated by unconsolidated gravel.

Albanese (9), who examined a basalt flow exposure in a road cut three miles south of No Name Creek, suggested a tholeiitic or alkaline affinity comparable to basalts from extensional systems. The flows have no exposed source.

The base of the flows could only be examined in the previously mentioned Ray River outcrop (Lat 66°02', Long 150°16'), where it overlies Tertiary coaly sediments and exhibits a carbonaceous contaminated basal zone. A quenched fracture stockwork, including thin (2 cm) selvages of obsidian and traces of phosphate staining, occurs at the river level and signifies the abrupt end of organic accumulation in a wet peat bog. Eastward of the outcrop, the Ts unit has been downfaulted and is now capped by the 3 basalt flows.

Basaltic flows overlie Eocene (38.6±1.6 ma) ash beds (10) and a basalt age determination by K-Ar methods reported an Oligocene date of 30.59±.92 ma (9). The flows are locally capped by a cliff-forming basalt-quartz pebble conglomerate (fig. 4). Elsewhere the flows are disconformably overlain by the terrace gravel unit (Qg).

REGIONAL STRUCTURAL GEOLOGY

The project area is included in the Ruby Geanticline crystalline terrane. Mafic volcanic rock, gabbro, and chert of the Tozitna Terrane abut the Ray River area to the south. The boundary is a poorly exposed major overthrust boundary associated with the Kaltag Fault zone. Evidence of a nearly flat-lying thrust fault can be viewed where the fault crosses the Ray River, and Jurassic andesite (Jv) lies in fault contact on Paleozoic phyllites (Pzp) (fig. 3).

Figure 4. - Conglomerate of basalt clasts ranging from pebbles to boulders mixed with white quartz pebbles. The conglomerate forms a resistant cliff overlying about 200 ft of olivine basalt flows. The flows overlie Teriary coal-bearing bedrock of the Lower Ray River Basin in background.

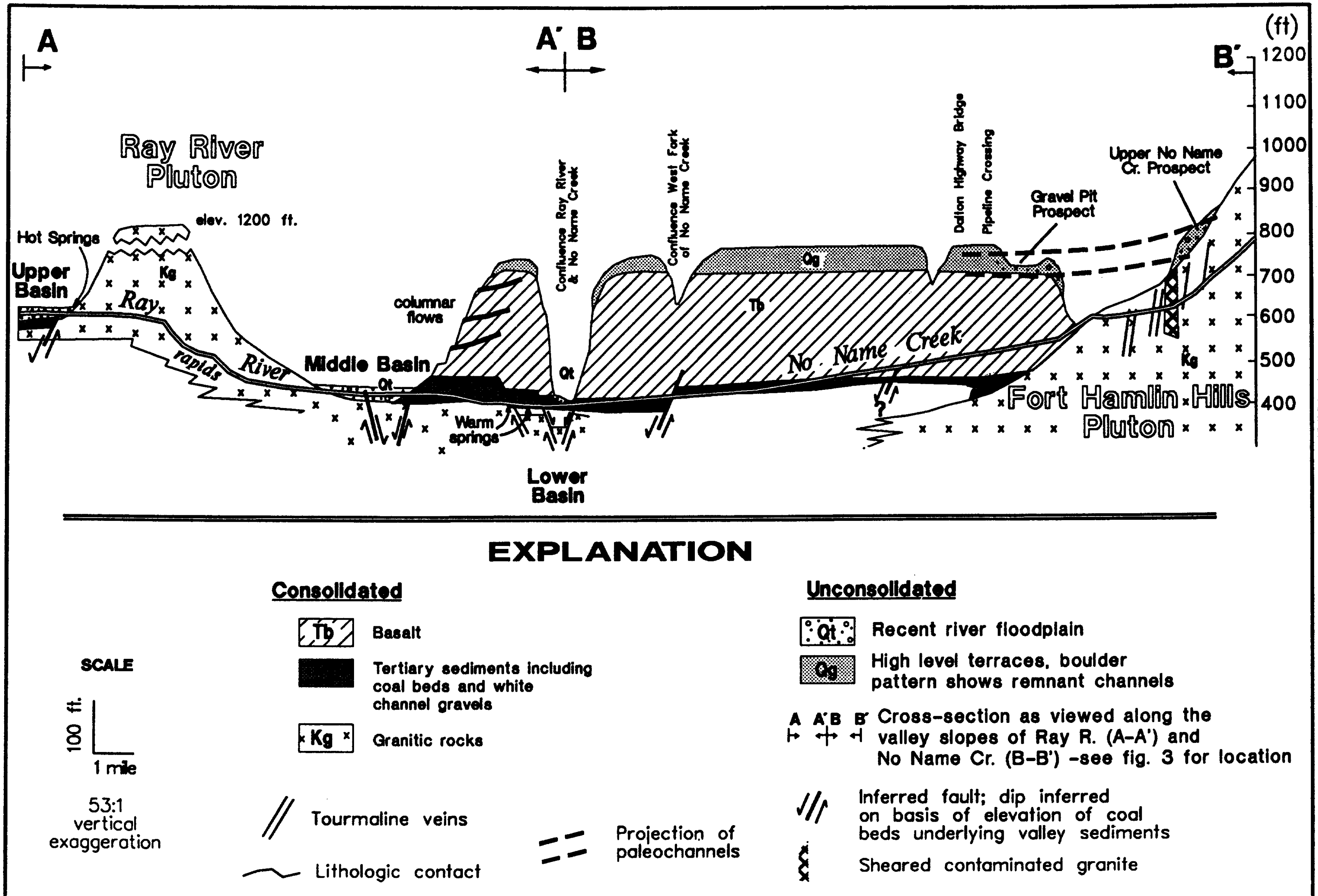

Figure 5. - Interpretive valley floor profile of No Name Creek and Ray River.

The Tertiary rocks have been structurally disrupted by apparent dip-slip faulting that has created a series of small, graben-like, stepped basins containing remnant Tertiary rock. An example of a dip-slip Tb/Ts fault contact is visible in the outcrop two miles above the mouth of No Name Creek, and others can be inferred from aerial photography (fig. 3). As a consequence of faulting, the coal-bearing unit is found at decreasing elevations toward the center of obscured, graben-like features between the plutons (fig. 5). Each of these basins contains Tertiary coal-bearing rock near, or below, the elevation of the valley floor as indicated by local concentrations of coal rubble on gravel bars where pre-Ts bedrock outcrops on the valley slopes. An interpretive cross-section shown in figure 5 demonstrates the structural relationships as viewed along the valleys of No Name Creek and the Ray River. Location of this cross-section is shown on figure 3. In the intervening area between the Ft. Hamlin and Ray River plutons, Tertiary rock or rubble occur in basins at progressively lower elevations of 425, 400, and 375 ft. Coal is also found on gravel bars at 625 ft immediately west of the Ray River pluton.

GEOMORPHOLOGY

Present geomorphology in the Ray River area includes rounded hills and wide, sediment-filled river basins that generally exhibit asymmetric cross-sections (steeper valley slopes north-oriented).

Three periods of unconsolidated sediment deposition can be determined as shown on figure 3: pre-basalt (Twg), post-basalt (Qg), and Recent (Qt).

Land forms prior to extrusion of the mid-Tertiary basalt flows apparently featured similar or less relief than present. The Twg is the product of fluvial downcutting of the surrounding crystalline highlands. Highly silicious Twg sediments, composed of quartz, silicified schist, and lesser hypabyssal felsic rock, indicate the granitic complexes were initially unroofed at this time. Sediments were transported by low-energy meander fluvial systems into basins that were largely peat bogs. On the basis of the available age dates, it can be inferred that the pre-basalt erosion apparently began at least by mid-Tertiary time, possibly earlier, and ended abruptly when the basalt flows occurred.

Deposition of nearly 100 square miles of terrace gravel (Qg) followed the mid- to late-Tertiary basaltic flows. The flows blocked previous fluvial systems from the highlands, and fluvial sediment (Qg) began to accumulate over top of the flows and marginal uplands. The Qg is at least 50- to 100- ft thick and is composed of cross-channeled fluvial sand and gravel, mostly of granitic origin, cut by paleochannels of coarse bouldery gravel with stream flow patterns similar to present streams. The massive total volume of Qg material, relative to the Twg, indicates that accelerated erosional attack of the highland crystalline bedrock took place, due most likely to nearby emerging basins relative to the highlands. Later fluvial breaching of the basalt flows occurred and consequently much of the original 100 square miles of Qg was reworked. There now remains a dissected array of remnant Qg terraces perched several hundred feet or more above the present stream beds (figs. 3 and 5). Thickest deposits of Qg are found southeast of the Ray River pluton (e.g. Lat 65°59', Long 150°16').

The present-day Ray River is actively reworking the Qg and depositing gravel (Qt) in each of the semi-closed basins (figs. 3 and 5). Further erosion of the regional base level is continuing, as exemplified by the river rapids shown on figures 3 and 5. As a result of fluvial downcutting of the basalt flows and marginal uplands, much of the original volume of high-level terrace gravel (Qg) has subsequently been eroded and entrained to present stream beds and floodplains (Qt).

During the Pleistocene glaciations (Wisconsin and Illinoisan), deposition of wind-blown loess (Ql) occurred. Thickness of the Ql ranges from a few inches on higher slopes to 50 ft or more where it has accumulated in low, topographically protected areas such as margins of river basins. Although the Ray River and lower No Name Creek have breached the Ql, most secondary tributaries remain choked with accumulations of ice- and organic-rich silt. An auger hole to 30 ft depth on upper No Name Creek failed to penetrate the Ql. Elsewhere, exposures of Ql exhibiting stratification and dune-like features can be observed in cutbanks along the Ray River.

PLACER DEPOSITS

Extrusion and downcutting of the basalts, associated with accelerated erosion of stanniferous granitic highlands, provided a mechanism by which massive quantities of alluvial sediments were impounded and later reworked and concentrated by fluvial processes. The process has occurred over a period of at least 30 ma and provided an erosional environment for formation of significant placer deposits. The fluvial downcutting of the regional base level particularly accelerated erosion of the tin-bearing western side of the Ft. Hamlin Hills pluton. To the west, one more cycle of downcutting by the Ray River of the Ray River pluton is still in progress and has not yet breached the semi-closed gravel-filled basin upstream of the river rapids west of the granite pluton (figs. 3 and 5). This western "upper" basin is filled with tin- and REE-bearing sediment derived from the Sithylemenkat pluton. East of the rapids, older terrace gravel and paleo-river channels have been redeposited in two basinal areas further downstream.

Placer tin is found in at least trace amounts to 0.04 lbs-Sn/yd^3 throughout the high level terrace gravel (Qg) and is particularly concentrated in paleochannels. Gravel pits and road cuts associated with construction of the Alyeska Pipeline expose several examples of tin-bearing fluvial paleochannels. Gravel from paleochannels in the Qg was typically found to contain 0.04- to 0.25- lbs-Sn/yd^3. Furthermore, and in accordance with the higher degree of reworking and heavy mineral concentration, the tin content in modern floodplain deposits, river channels, and low benches (Qt) is substantially higher (0.03- to 6.25- lbs-Sn/yd^3). Sample results, mapping, and descriptions of examples of each placer deposit-type will follow.

PLACER TIN DEVELOPMENT IN HIGH-LEVEL TERRACE GRAVEL

Gravel Pit Prospect #1

Detailed sampling and mapping to test for tin placer in the Qg was conducted within the vicinity of a 1,200 ft by 1,200 ft gravel pit perched on basalt flows about 150 ft above No Name Creek (fig. 6).

The Qg at this location is characterized by stratified layers of well sorted sand, gruss, and fine-sized gravel, generally not exceeding two inches in diameter. Cross-bedding features are common (fig. 7a).

Within the pit area (fig. 6) at least two paleochannels of the ancestral No Name Creek occur. Paleochannel gravel is coarse and cobbly consisting of poorly stratified clasts of granitic rock, quartz, and schist. The base of the principle paleochannel was not exposed, therefore sample values are not available for gravel lying directly on bedrock. Samples within the paleochannels contain between trace and 0.12 lbs-Sn/yd^3 (table 2), whereas samples of finer cross-bedded sand and gravel contain trace and 0.03- lbs-Sn/yd^3.

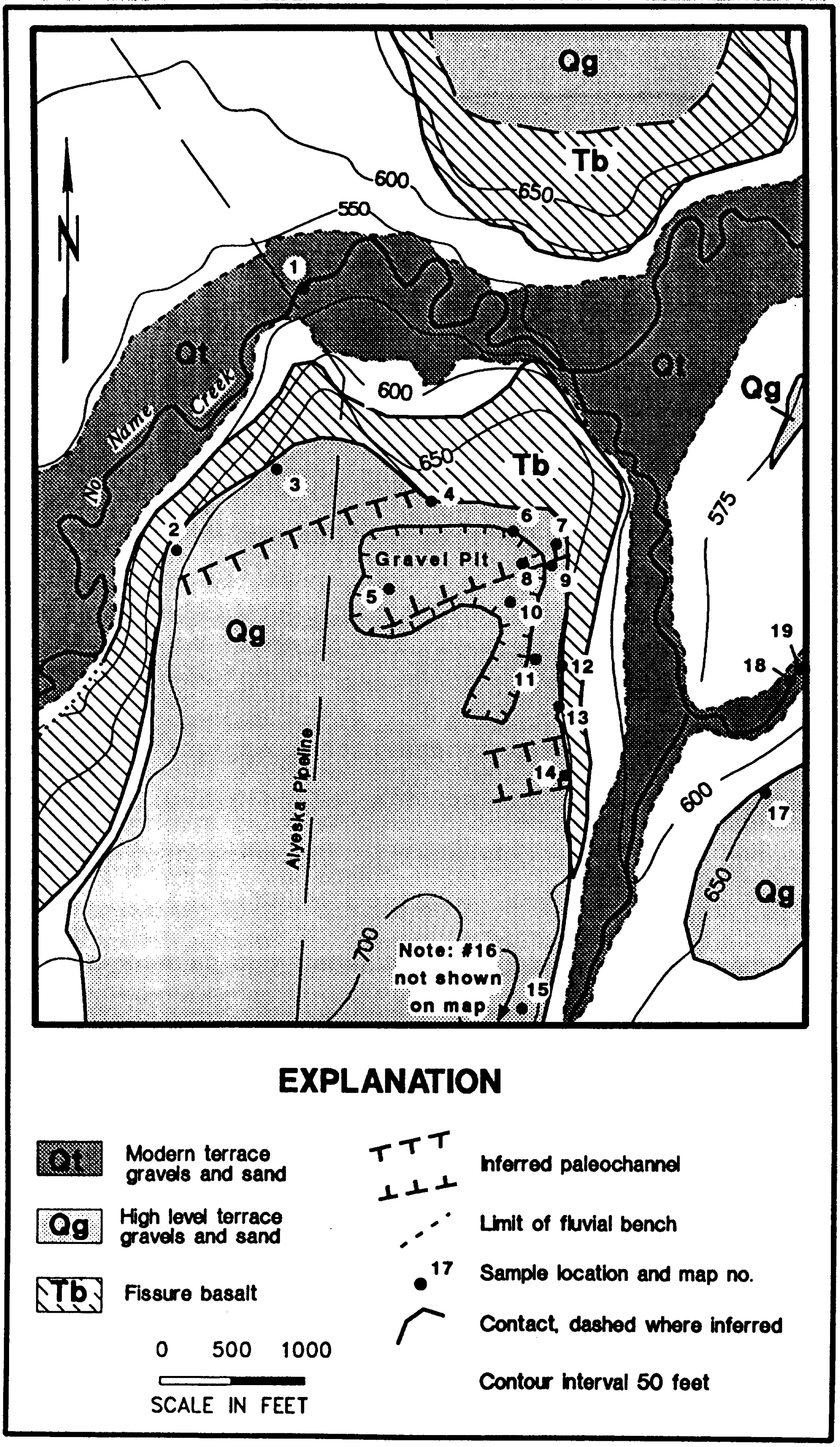

Figure 6. - Gravel Pit prospect #1.

Several samples were taken for comparison purposes from channel sediment of present No Name Creek downhill of the gravel pit. Although available sediment for sampling was limited to washed sand, silt, and woody material in a boggy setting, the contained tin was nevertheless calculated at about 0.02 lbs-Sn/yd^3. A single gravel exposure immediately upstream of the pipeline crossing contained 0.17 lbs-Sn/yd^3 (map no. 1, fig. 6). This datum indicate possibly higher grade floodplain sediments (Qt) at depth.

Gravel Pit Prospect #2

A construction materials pit in weathered granite and Qg gravel 6.5 mi south of the No Name Creek crossing (fig. 3) exposes a coarse gravel-filled paleochannel cut into bedrock (Lat 66°02', Long 150°07'). The channel trends east southeast. A sample (RM 27636-21, table 3) consisting of 0.76 ft^3 of gravel from the lowermost 4 ft of the channel gravels contained the equivalent of 0.24 lbs-Sn/yd^3. The tin content of this channel suggests that a similar or higher grade of tin may be found in the gravel bed of the present Ft. Hamlin Hills Creek 0.5 mi north and about 300 ft lower elevation. Sampling, however, of the present creek channel was not possible due to thick frozen loess deposits.

Other High-Level Terrace Placer Occurrences

A hilltop road-cut three miles south of the No Name Creek

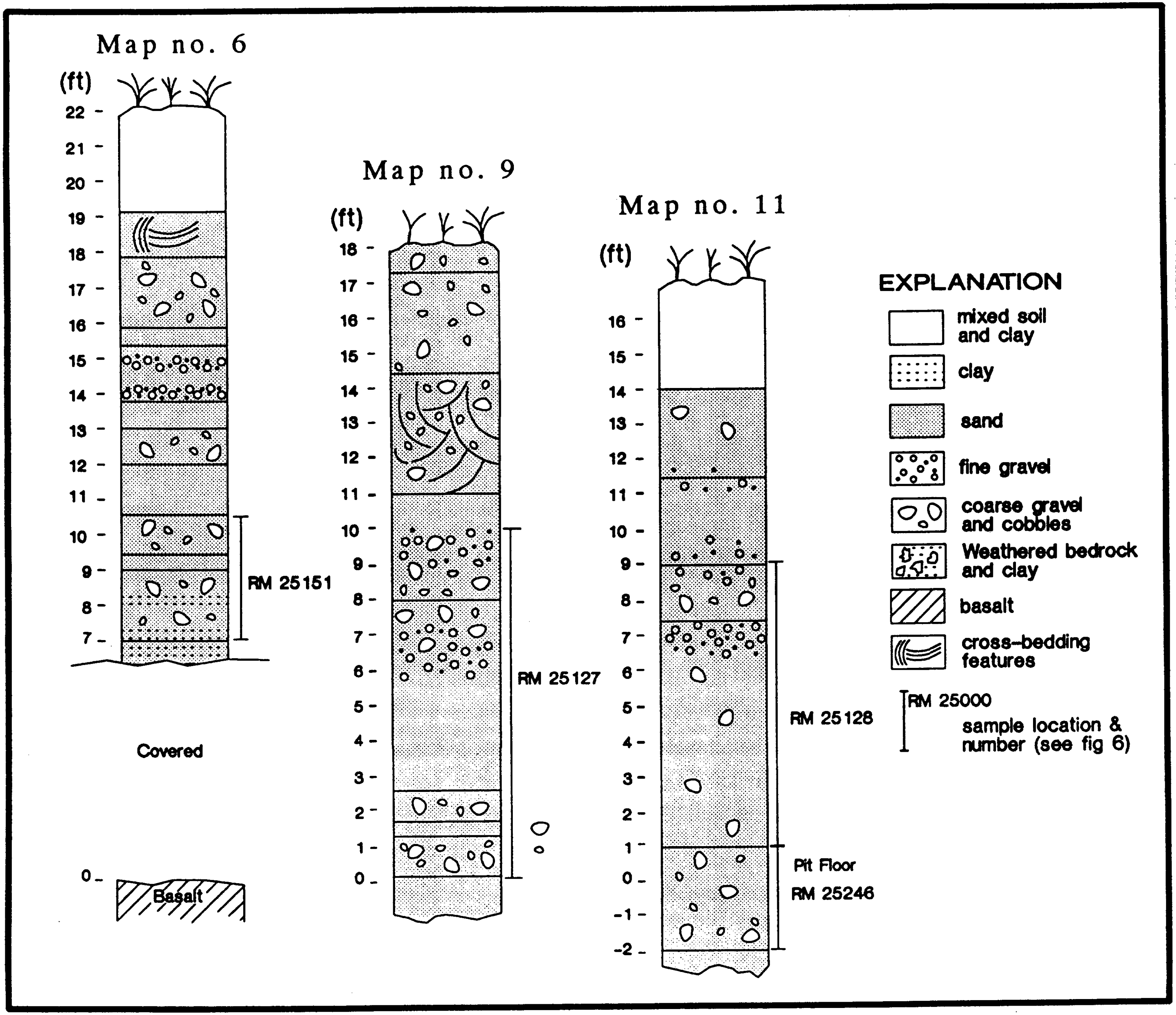

Figure 7a. - Profiles of exposed sections at the gravel pit prospect #1.

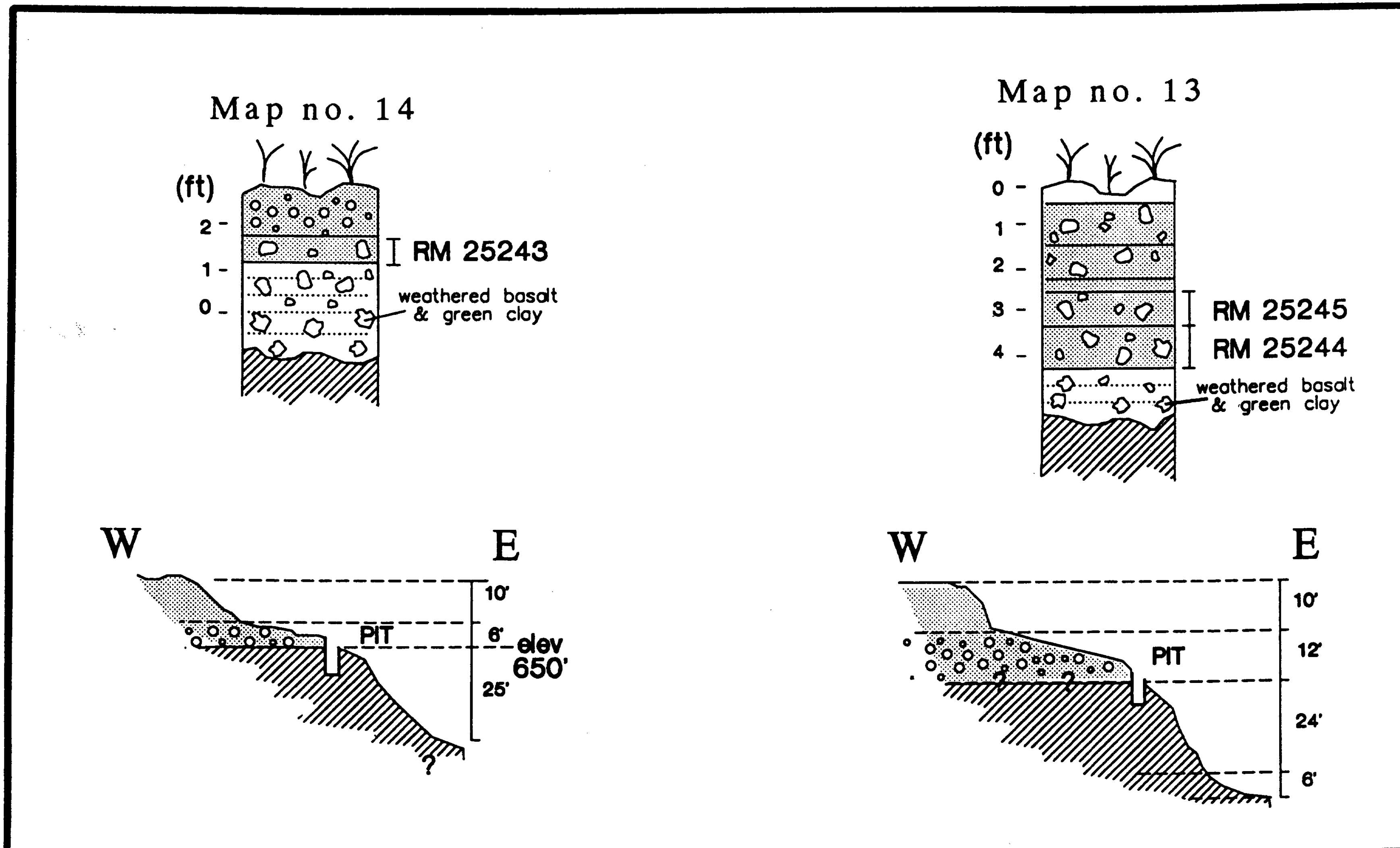

Figure 7b. - Profiles of exposed sections at the gravel pit prospect #1.

Table 2. - Gravel pit prospect #1.

Sample Number	(Fig. 6) Map Number	Sample Volume[1] (ft³)	Heavy mineral Analyses concentrate (grams)	Sn (pct)	Calculated[2] lb-Sn/yd³	Descriptions
RM 25250	1	0.09	30.7	0.84	0.17	Silty loose sand with schist and quartz pebbles.
25153	2	0.10	34.1	0.20	0.04	Coarse gravel in red and blue clayey matrix.
25152	3	0.10	36.5	0.02	Ng	Sand with rounded quartz pebbles.
23722	4	0.68	16.7	0.09	Ng	Sandy gravel with mixed lithologies.
23752	5	0.42	12.5	1.13	0.02	Sandy gravel with mixed lithologies.
25151	6	2.70	45.8	7.08	0.07	Coarse gravel with channel features.
27630	6	2.70	46.1	3.90	0.04	Coarse gravel with channel features.
25238	7	0.27	20.8	0.70	0.03	Clay-rich basaltic and quartz gravel on basalt bedrock.
25239	7	0.27	33.4	0.18	0.01	Coarse pebbly gravels overlying sample above.
25240	7	0.27	43.7	0.32	0.03	Orange-red gravel overlying sample above.
27629	8	2.70	31.6	2.04	0.01	Section includes coarse clayey gravels.
25127	9	2.70	43.1	I	---	Sandy gravel, mixed lithologies.
25216	10	0.08	33.1	0.28	0.07	Clay-rich gravel in floor of pit.
25246	11	2.70	53.5	0.79	0.01	Clayey and sandy coarse gravel with basalt fragments.
25128	11	2.70	31.5	0.51	Ng	Sandy gravel, mixed lithologies.
25235	12	0.10	40.3	0.11	0.03	Clayey sand and some gravel overlying basalt bedrock.
25236	12	2.70	44.0	I	---	Sand and gravelly sand overlying sample above.
25237	12	0.10	38.5	0.05	0.01	Pebbly sand overlying sample above.
25244	13	0.08	37.6	0.03	0.01	Gray sandy gravels.
25245	13	0.08	44.1	0.06	0.02	Orange sandy gravels overlying sample above.
25243	14	0.08	41.6	0.39	0.12	Sandy gravel overlying basalt bedrock.
25242	15	0.08	39.4	0.04	0.01	Sandy gravel with mixed lithologies.
25241	16	0.08	41.0	0.06	0.02	Sandy gravel with mixed lithologies.
27591	17	0.11	16.9	0.43	0.04	Gruss and quartz pebbles, abundant quartz-tourmaline.
21656	18	0.26	61.0	0.18	0.05	Loose sand, few quartz pebbles.
21657	19	0.07	35.0	0.08	0.02	Sand, gruss, wood and organic-rich mud.

[1]Unscreened volume of gravel from sample site.

[2]lbs-Sn calculated as follows: $\frac{27}{\text{Volume(ft}^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs-Sn}}{\text{yd}^3}$

Ng Negligible trace value. L Less than detection limit of 0.01

\- Not analyzed, due to interferrance (I).

Table 3. - Road cut and gravel pit prospect #2.

Sample Number	Sample Volume[1] (ft³)	Heavy mineral Analyses concentrate (grams)	Sn (pct)	Calculated[2] lb-Sn/yd³	Descriptions
RM27636-21	0.76	66.71 (+16m) 352.89 (-16m)	0.28 0.83	0.24 inc. above	Coarse gravel channel incised into weathered granite bedrock, abundant quartz-tourmaline gravel/cobbles (Lat 66°02' Long 150°07')
27686-22	0.16	50.89	1.01	0.19	2- to 8-ft thick section of white clay, gruss, tourmaline quartz, and quartz pebbles in paleochannel overlying basalt in road cut (Lat 66°04.6' Long 150°09.7')

[1]Unscreened loose volume of gravel from sample site.

[2]lbs-Sn calculated as follows: $\frac{27}{\text{Volume(ft}^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs-Sn}}{\text{yd}^3}$ NOTE- result includes both plus and minus 16 mesh fractions

bridge exposes a broad channel feature lying on highly weathered basalt flows (fig. 3). The channel is approximately 400 ft wide and is filled with clay, basalt, and gravel predominantly composed of quartz-tourmaline and tourmaline granite pebbles and cobbles. A channel sample of this material (sample RM 27686-22, table 3) was concentrated and found to contain 0.19 lbs-Sn/yd^3.

High-level terraces were also sampled on the eastern flank of the Ray River pluton. Results listed in table 4 indicate low but persistent presence of tin. Due to the lack of exposures, no examples of well developed paleochannels could be sampled. As depicted on figure 3, there is air photo evidence of extensive paleochannels lying south of, and 75- to 100-ft above, the upper Ray River. The channel-like features are indicated by photo linears that follow surficial depressions parallel to the present river bed. The photo linears, however, are densely vegetated and no exposed gravel was observed.

PLACER TIN DEVELOPMENT IN RECENT ALLUVIUM

Ray River and Lower No Name Creek

Gravel exposed in low cut-banks along lower No Name Creek and the Ray River were sampled at water level during canoe traverses (fig. 8). Samples represent meander fluvial deposits formed during high water events that contain a low percentage of fine sediment. Typically the surface material is loose, uncompacted, rounded pebbles and coarse sand with little or no silt/clay

Table 4. - High level and Tertiary gravels in the Ray River area.

Sample Number	Map Number	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lb-Sn/yd^3	Descriptions
25987	23	0.13	17.3	L	Ng	Brillant white-colored bluff of quartz pebble gravel and sericite clays; section is at least 100 ft thick overlying basalt, Lat 65°59.7'N, Long 150°15.6'.
26019	24	0.064	17.5	0.15	0.02	High level gravels and granite boulders, Lat 65°57.8',Long 150°23.6'.
26026	25	0.064	15.3	0.01	Ng	High level gravel w/ tourmaline granite, Lat 65°58.5',Long 150°23.6'.
26018	26	0.128	14.6	0.05	Ng	High level gravel with gruss, and granite pebbles, Lat 65°58.3', Long 150°23.5'.
26674	27	0.064	15.8	0.02	Ng	High level white channel gravels overlying Tertiary sandstone, Lat 66°02.1', Long 150°17.5'.
27599	28	0.13	52.48	L	Ng	Gruss with rounded quartz grains, footwall to coal bed.
27600	29	0.42	60.03	0.21	0.02	Tertiary white channel gravels in outcrop, Lat 66°01.5',Long 150°15'.

[1]Unscreened loose volume of gravel from sample site.

[2]lbs-Sn calculated as follows: $\frac{27}{\text{Volume}(ft^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs-Sn}}{yd^3}$

Ng Negligible trace value. L Less than detection limit of 0.01

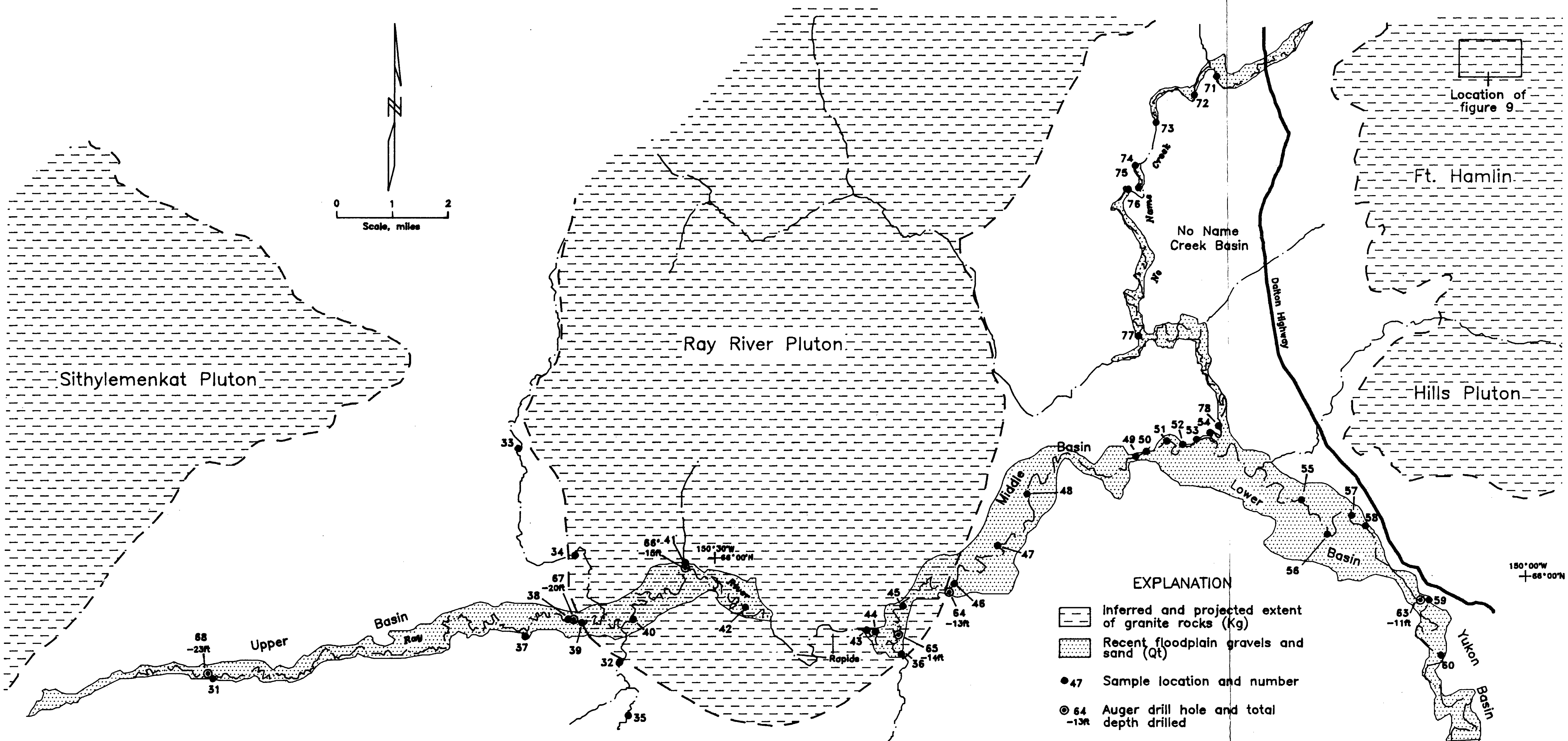

Figure 8. - Ray River placer sample locations.

fraction. About 25% of the sample will pass 16 mesh, but only an insignificant volume will pass 35 mesh. Auger drilling shows the silt/clay fraction to increase markedly at depths of 7- to 10-ft, however, the auger cuttings, mixed with surface gravel, was unsuitable for seive tests. At depths below 7- to 10-ft, gravel was mixed with white silty clay and fine sand. The lack of a fine-grained fraction in the surface samples is indicative of flood washing of the surface gravels and also suggests that the heavy minerals are disproportionally under represented. Scope of this investigation did not permit sampling of subsurface Ray River gravel except for 5 auger holes drilled to depths of 11- to 23- ft. Analytical results for tin concentrated from gravel samples and auger hole cuttings are presented in table 5 for Ray River and in table 6 for lower No Name Creek.

Sample data indicate cutbank gravels of the Ray River contain 0.02- to 0.78- $lbs\text{-}Sn/yd^3$. Sample sites were picked at random while traversing the river. No discernible variation in tin content is seen between sample sets from each of the three basins along the Ray River; all surface gravel in each basin contain tin values, and higher values are erratically dispersed. The Ray River gravel is well-mixed lithologies, the product of multiple cycles of erosion from widespread sources, and consequently sample data lack anomaly trends or clustering that would otherwise suggest an obvious point source of cassiterite in bedrock.

Smaller tributaries generally contain significantly less tin.

Table 5. - Analytical results for tin, Ray River placer prospect.

Sample Number	Map Number (Fig. 8)	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lbs-Sn/yd^3	Descriptions
Secondary Streams						
RM27684	31	0.08	21.2	0.15	.02	Clay cemented quartz-rich gravels forming 150-ft-high bluff.
26000	32	0.52	19.1	0.32	.01	Cut bank below confluence of tributaries, overlain by 12 ft loess.
24606	33	0.46	34.7	0.34	.02	Silty gravel overlying vegetative muck in narrow creek bed.
24605	34	0.26	17.5	0.55	.02	Stream bed, schist and vein quartz.
24611	35	0.26	12.8	0.53	.02	Stream bed below granite-hornfels contact.
26017	36	0.26	16.6	0.13	Ng	Stream bed of phyllite, vein quartz, and schist.
Ray River Channels						
26011	37	0.65	72.9	0.97	.06	Composite of 5 cut bank sites, inc. schist, quartz and granite.
26012	38	0.26	12.4	0.70	.02	Loose silty gravel cut bank.
24604	39	2.19	415.1	6.96	.78	Low cut bank of loose gravel and gruss below hot springs.
26013	40	1.27	26.9	*3.5	.04	Low cut bank of loose gravel and gruss.
26014	41	0.52	144.1	1.90	.13	Low cut bank of loose gravel and gruss.
26016	42	1.27	114.5	1.21	.06	Low cut bank of loose gravel and gruss.
26030	45	1.27	98.9	*1.7	.08	Loose, stratified gravel cut bank.
26031	46	1.27	75.7	4.10	.14	Loose, stratified gravel cut bank.
26032	47	1.27	61.6	1.00	.03	Loose, stratified gravel cut bank.
26033	48	1.27	48.8	0.81	.02	Loose, stratified gravel cut bank.
26042	43	1.27	88.3	*4.7	.19	Gravel with very little silt and sand.
26043	44	1.27	47.7	*1.7	.04	Gravel with very little silt and sand.
26041	49	1.27	108.96	0.70	.04	Loose, stratified gravel cut bank.
26590	50	0.41	58.83	1.10	.09	Gravel cut bank with numerous basalt cobbles.
26591	51	0.41	27.84	*3.75	.15	Gravel is predominently highly silicic schist and quartz from white gravel unit; inc. basalt cobbles.
25444	53	0.78	90.4	*4.65	.32	Gravel is predominently highly silicic schist and quartz from white gravel unit; inc. basalt cobbles.
26592	52	0.82	53.05	0.91	.04	Gravel is predominently highly silicic schist and quartz from white gravel unit; inc. basalt cobbles.
26589	54	0.41	27.49	0.28	.01	Gravel is predominently highly silicic schist and quartz from white gravel unit; inc. basalt cobbles.
27568	60	0.13	16.10	0.31	.02	Loose, stratified gravel cut bank.
27180	56	0.85	48.19	0.73	.02	Coarse gravel in center of active river bed.
27181	56	0.57	37.40	0.57	.02	Loose, stratified gravel cut bank near above sample site.
27182	55	0.42	19.05	0.59	.02	Very loose gravel, no fine silt fraction, taken from both cut banks.
27565	57	0.21	21.42	1.27	.08	Particularly coarse gravel and cobbles in river bed at this site.
27566	58	0.85	75.42	0.84	.04	Very loose gravel, no fine silt fraction, taken from both cut banks.
27567	59	0.10	15.04	0.81	.07	Particularly coarse gravel and cobbles in river bed at this site; bluff parallel to river.

See footnotes at end of table.

Table 5. - Analytical results for tin, Ray River placer prospect (cont.).

[cropped]ger Drill [cropped]les	Map Number (Fig. 8)	Total Volume	-16 Mesh	Heavy Min. Concentrate (grams)	Sn (pct)	lbs-Sn/yd^3 Total Volume	lbs-Sn/yd^3 -16 Mesh	Descriptions
25983	63	0.25	--	24.59	0.51	0.03	---	Auger hole cuttings, 9-to 11-ft depth, hole bottom at bedrock.
25984	64	0.55	0.15	125.16	0.43	0.06	0.213	Auger hole cuttings, 8-to 13-ft depth, hole bottom in clayey gravels.
25985	65	1.14	0.28	50.30	1.06	0.03	0.113	Auger hole cuttings, 8-to 14-ft depth, hole bottom in silty gravels, cuttings include gravel slough from above.
27635	66	1.02	0.41	198.47	2.63	0.30	0.757	Auger hole cuttings, 11-to 15-ft depth, hole bottom in clay-rich gravel.
25988	67	6.10	0.42	435.12 +16m 758.01 -16m	0.19 0.71	0.06 inc.	0.879 above	Auger hole cuttings, 12-to 20-ft depth, hole bottom in clay-rich gravel, sample includes much gravel slough from above, only 6.6% of sample passes 20 mesh.
25989	68	0.80	0.35	152.04	1.88	0.21	0.486	Auger hole cuttings, 10-to 15-ft depth, hole bottom in clayey gravel at 23 ft but no cuttings could be collected below 15 ft.

[cropped]nscreened loose volume of gravel from sample site.

[cropped]bs-Sn calculated as follows: $\frac{27}{\text{Volume}(ft^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs-Sn}}{yd^3}$

Negligible trace value

Not analyzed.

Interference during XRF analysis due to higher contents of Sn and REE; reported analyses by multi-acid assay technique.

TABLE 6. - Analytical results for tin, Lower No Name Creek.

Sample Number	Map Number (Fig. 8)	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lbs-Sn/yd^3	Analyses Au (ppm)	Descriptions
25437	71	0.52	60.5	0.80	0.06	3.4	Cut bank gravel, cross-bedded, well graded, few fines.
25438	72	0.46	44.5	0.43	0.03	2.5	do.
25439	73	0.52	42.9	0.74	0.04	5.5	do.
25440	74	0.52	45.8	0.25	0.01	0.3	do.
25441	75	0.26	59.9	0.33	0.05	0.2	do.
25442	76	0.46	35.4	0.24	0.01	1.0	do.
25443	77	0.52	40.0	0.28	0.01	1.7	do.
26588	78	0.41	34.3	0.60	0.03	Ng	do.

[cropped]nscreened loose volume of gravel from sample site.

[cropped]bs-Sn calculated as follows: $\frac{27}{\text{Volume}(ft^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs-Sn}}{yd^3}$

Negligible trace value.

Not analyzed.

The sediment is derived more directly from colluvium sources and therefore is not upgraded to the same degree by sediment reworking (and concentration) as are the sediments of the main river. Note map locations nos. 31 through 36, table 5.

It is not known how far tin values persist upstream in the Ray River valley beyond present sampling. The river above the Ray River pluton slowly meanders in a basinal feature (upper basin, fig. 5) and generally lacks cutbank gravel exposures. A single auger drill hole that did not reach bedrock (map no. 68, fig. 8), contained 0.21 lbs-Sn/yd^3 (0.49 lbs-Sn/yd^3 in the -16 mesh fraction), and infers similar tin values occur upstream as far as the Sithylemenkat pluton.

The heavy mineral suite in the Ray River samples is dominated by ilmenite. Cassiterite occurs as rounded sand-size grains, black in color. Concentrates contain minor amounts (1% to 5%) of REE minerals as monazite and xenotime. Monazite is at least four times as abundant as xenotime.

All heavy mineral concentrates from the Ray River and lower No Name Creek were found to contain several to several dozen minute gold particles. Due to the particulate nature of the gold, analyses for gold in small sample splits prepared for DCP procedures (directly coupled plasma) detected gold only on a random basis. Visual scanning of the heavy mineral fraction in samples from No Name Creek found fine-grained gold particles in all samples extending downstream from map no. 71, (table 6 and fig. 8).

Occurrence of gold in lower No Name Creek is spatially associated with the Tertiary white channel gravel (Twg). Map no. 71 approximately coincides with the farthest upstream exposure of the Twg unit. No gold was observed in creek bed samples above this area or in any of the gravel pit terrace Qg samples further upstream.

Samples from lower No Name Creek (table 6) were less enriched with tin than those from the Ray River, possibly a result of the greater distance to potential source rocks in the Ft. Hamlin Hills, or possibly the Twg is partially derived from non tin-bearing bedrocks. Lower No Name Creek contains gravel composed of white vein quartz and highly silicified and sericitic schist and felsic hypabyssal rocks. Basalt is also a common pebble type. Tin content of cutbank samples from lower No Name Creek ranged from 0.01- to 0.06- lbs-Sn/yd^3.

Upper No Name Creek

The upper No Name Creek valley (fig. 9) is deeply in-filled with Quaternary loess (Ql) and the creek is a slow, sluggish, meandering stream choked with decaying vegetation (fig. 10). A 30-ft auger hole, drilled in frozen organic-rich loess (upper left, figure 9), was unable to reach either gravel or bedrock. Consequently, placer sampling of this stream was not practical.

A reconnaissance of the northern Ft. Hamlin Hills was conducted to locate examples of either exposed placer gravel or tin-bearing bedrock sources. A total of 120 samples of

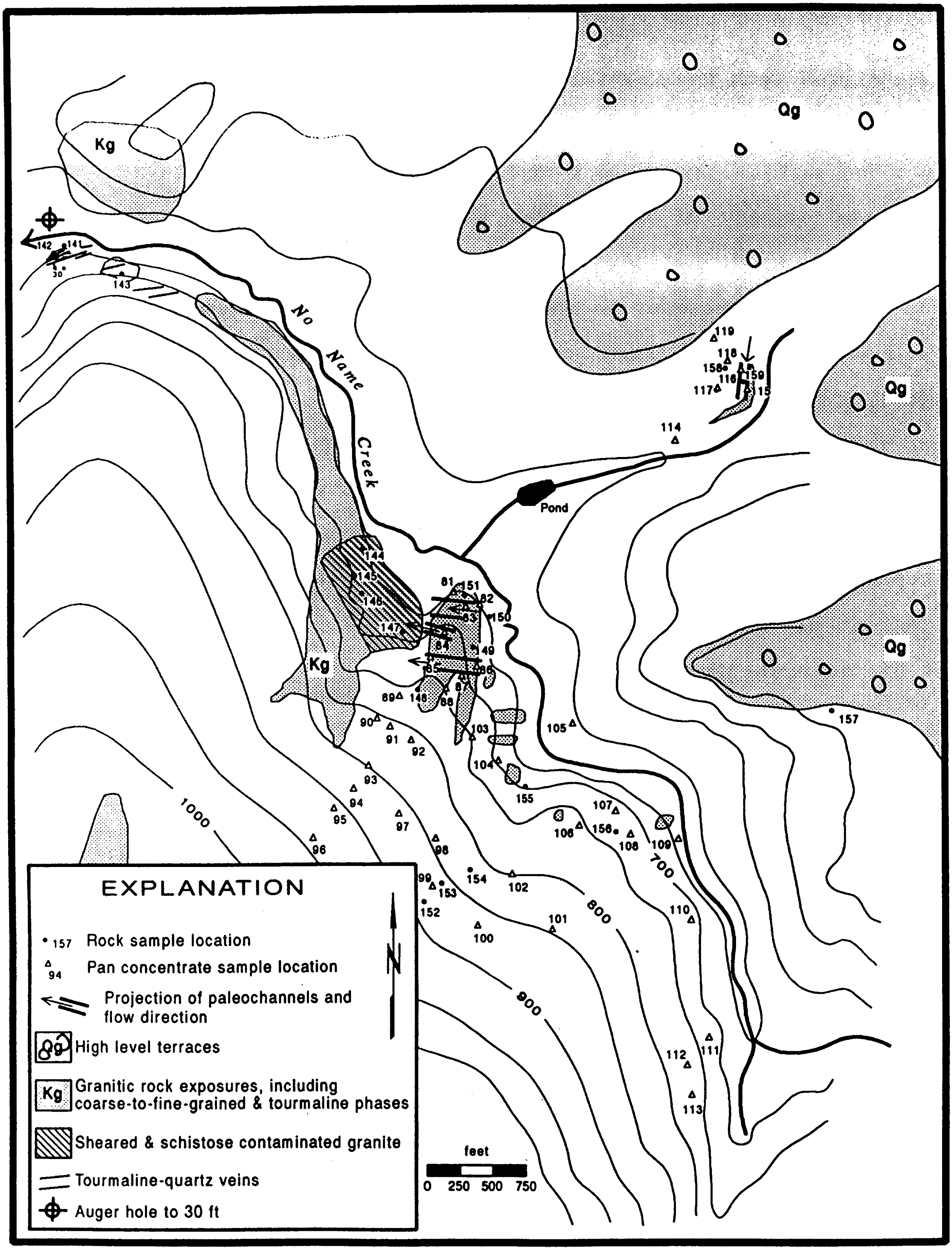

Figure 9. - Upper No Name Creek prospect.

Figure 10. - Upper No Name Creek and low rounded hills of the Ft. Hamlin Hills pluton. Vegetation and underlying permafrost are continuous. Valleys are deeply filled with ice-rich Quaternary fine-grained loess. A 30-ft-deep auger hole to the left of the photograph encountered only frozen organic-rich loess.

Table 7. - Panned soils and gravels, upper No Name Creek prospect.

Sample Number	Map Number (Fig. 9)	Sample Volume[1] (ft^3)	Heavy mineral Analyses concentrate (grams)	Sn (pct)	Calculated[2] lbs-Sn/yd^3	Descriptions
RM 23417	81	0.61	24.2	0.22	0.01	Granite colluvium and gruss.
23416	82	0.61	35.0	5.60	0.19	Gruss and mixed pebbles.
27596	83	8.47	128.65	18.00	2.97	Bulk sample for mineral processing tests. +16m
	83		6853.65	5.83	inc. above	Bulk sample for mineral processing tests. -16m
23424	83	0.59	183.6	33.75	6.25	Orange clay over weathered bedrock.
23418	83	0.17	67.8	20.6	4.88	Sandy soil with rounded meta-sediment and quartz pebbles.
23419	83	0.17	37.3	3.13	0.41	Angular gruss and granite.
23465	84	0.17	47.8	5.15	0.86	Gruss and granite gravel.
23420	85	0.17	27.4	0.47	0.04	Gruss, angular granite, and few metased pebbles.
25042	86	0.17	88.3	1.20	0.37	Oxidized pebbly gruss.
25073	87	0.17	23.6	0.02	0.00	Gruss.
23422	88	0.17	34.4	0.53	0.06	Gruss with fine gravel horizons, 2-ft-depth.
23423	89	0.17	48.0	6.96	1.17	Pebble horizon, inc. tourmaline, in gruss.
25029	90	0.17	22.9	16.00	1.28	Gruss and granite gravel.
25043	91	0.17	27.6	11.00	1.06	Red oxidized gruss and gravel inc. altered granite, schist.
25044	92	0.17	22.9	0.06	0.01	Orange gruss and decomposed granite fragments, depth 3 ft.
27621	92	0.13	85.81	L	Ng	Fine to med. gruss at 2.5-ft-depth.
25045	92	0.17	23.3	0.54	0.04	Gray-black clay on weathered bedrock, depth 4 ft.
27624	93	0.13	61.36	L	Ng	Gruss at 3-ft-depth.
27625	94	0.18	27.84	1.48	0.14	Gruss and angular granite including quartz-tourmaline from 3-ft-depth.
27626	95	0.13	65.22	0.09	0.03	Gruss at 2-ft-depth.
27627	96	0.13	19.3	0.17	0.02	Gruss and angular granite from 2.5-ft-depth.
25030	97	0.17	29.6	0.23	0.02	Gruss and granite gravel on permafrost.
25251	98	0.17	29.7	7.28	0.76	Sandy silt, cobbles, with subrounded granite and schist.
25112	99	0.17	22.2	1.10	0.09	Gruss and clay with abundant greisen fragments, 4-ft-depth
25046	100	0.17	19.8	0.05	0.01	Orange gruss, quartz vein and granite 2.5-ft-depth.
25146	101	0.17	31.7	0.08	0.01	Gruss and schist fragments.
25110	102	0.17	31.2	0.08	0.01	Orange sandy clay with subrounded granite pebbles, 2-ft-depth.
25074	103	0.08	11.8	0.01	Ng	Gruss.
23466	104	0.17	14.1	0.05	Ng	Gruss.
25092	105	0.17	32.2	0.04	Ng	Gruss.
25075	106	0.08	21.8	0.01	Ng	Gruss and gravel.
27623	107	0.20	42.55	0.03	Ng	Gruss with mixed alluvial pebbles.
25076	108	0.08	23.26	0.03	0.01	Red-brown coarse sandy gruss.
25147	109	0.17	28.9	0.01	Ng	Stream bed granite and gruss.
25078	110	0.17	28.1	0.01	Ng	Sandy gruss with granite fragments.
25079	111	0.17	17.7	0.59	0.04	Gravel, schist and granite.
25039	112	0.17	24.1	0.08	0.01	Clayey gruss with few pebbles.
25038	113	0.17	23.7	0.33	0.03	Quartz pebble horizon in gruss.
27628	114	0.13	34.52	0.24	0.04	Sandy gruss and a few alluvial pebbles at 4-ft-depth.
25570	115	0.34	147.6	9.54	2.46	Fragments of silicified granite, tourmaline, quartz and granite, hornfels phyllite, and gruss colluvium on jointed granite bedrock.
27592	115	0.17	61.99	13.00	2.82	2.0-ft-section of gravel with fragments of silicified granite, tourmaline, quartz and granite, hornfels phyllite, and gruss colluvium on jointed granite bedrock.
27593	116	0.08	9.02	0.11	0.01	0.7-ft-section of gravel with pebbles of silicified granite, tourmaline, quartz, and granite, hornfels phyllite, and gruss.
27594	116	0.08	26.00	2.44	0.47	0.7-ft clay-gravel underlying sample 27593.
25120	116	0.17	31.2	1.10	0.12	Sandy gruss with few quartz pebbles.
25574	117	0.51	105.0	0.01	Ng	Sandy gruss with few quartz pebbles.
25121	118	0.17	30.4	0.85	0.09	Fluvial iron-stained gruss and tourmaline-quartz-mica-chlorite pebbles.
25572	119	0.25	103.8	0.01	Ng	Gruss.

[1]Unscreened loose volume of gravel from sample site.

[2]lbs-Sn calculated as follows: $\frac{27}{Volume(ft^3)} \times H.M.\ conc(g) \times \frac{Sn(pct)}{454} = \frac{lbs\text{-}Sn}{yd^3}$

Ng Negligible trace value.

colluvium and Qg were collected, concentrated, and analyzed for tin (Appendix A). Several high-level Qg gravel terrace sites were found that are anomalous in tin. Although not further evaluated, these occurrences are typified by the previously described gravel pit prospects.

The search for exposed bench gravel that would be comparable to the present buried channels of No Name Creek did successfully locate two sites, both containing tin. The first, located three miles east of the highway crossing (Lat 66°07', Long 150°04'), is a series of channel remnants preserved on a low resistant bedrock spine that juts perpendicular to and partially across the creek valley (figs. 9 and 11). At least three separate channels were sampled at increasing elevations between 30- and 50-ft above the present creek. Tin content of these channels ranges up to 6.25 lbs-Sn/yd^3 (map nos. 82-86, table 7 and fig. 9). Because these channels are obvious precursors to the present stream bed, they more closely represent the Qt gravel unit, rather than the higher, sheet-like Qg terrace unit.

Further uphill, additional unexposed channels are evident. At elevations up to 200 ft above the present valley, test pits encountered cassiterite-bearing, well-rounded quartz gravels mixed with side-hill colluvium and loess (samples 88-91, 98). Samples of the higher elevation mixed gravel and colluvium contain nil to as much as 1.3 lbs-Sn/yd^3. The higher grade samples directly correlate with the abundance of alluvial gravel in the test pits. The gravel at these locations contains well-rounded pebbles and

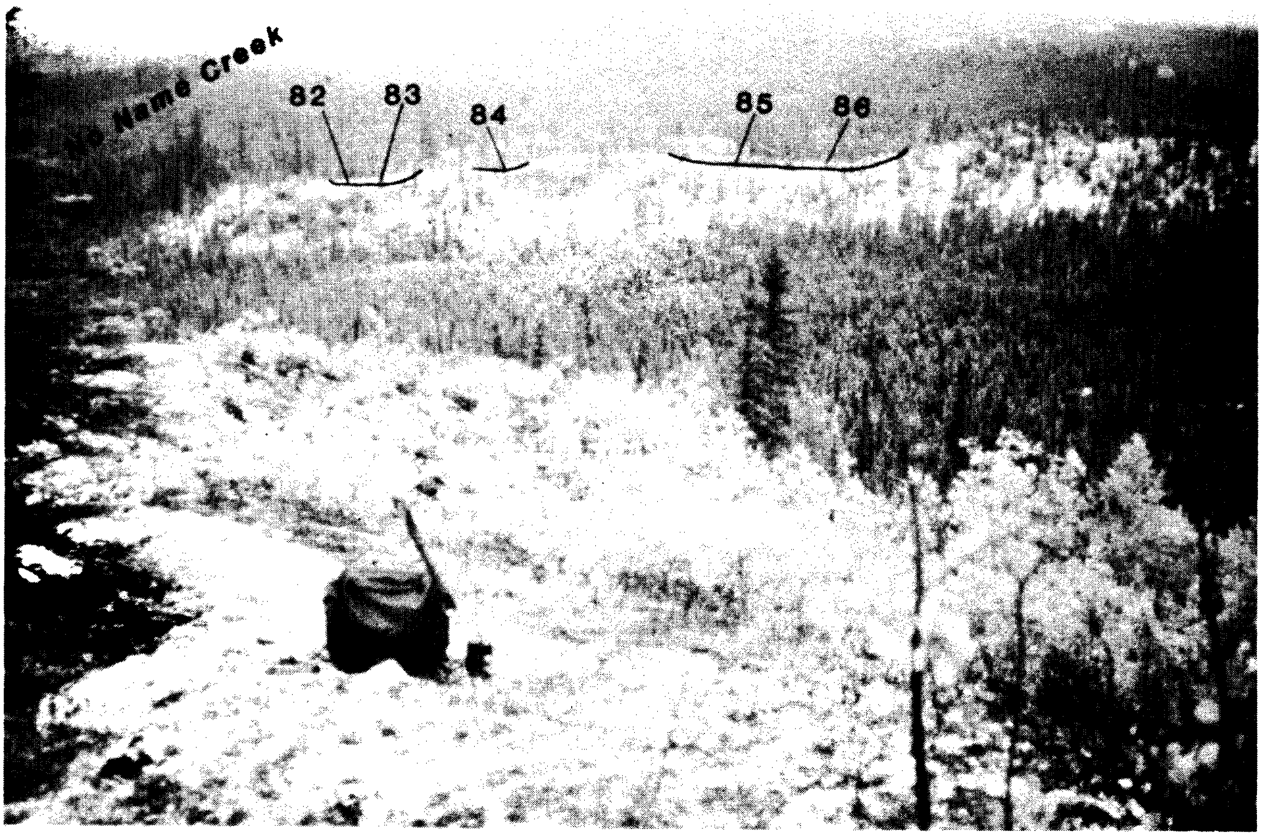

Figure 11. - Low bedrock spine with exposed tin placer channels on upper No Name Creek. Short lengths of remnant cassiterite-rich paleochannels have been preserved where they are incised into the bedrock. Numbers denote map numbers listed in table 7 and shown on figure 9. Note helicopter for scale. Elsewhere these channels have been entirely reworked by further downcutting of the present stream bed (extreme left). Bedrock in foreground is tourmaline granite and schistose contaminated granite(?).

cobbles of quartz, tourmaline-quartz, granite, chlorite greisen, and hornfels phyllite. Examination of hillslopes both upstream and downstream of this area found only eroding granite bedrock. The original bench deposits in both directions have been destroyed by erosion and transported downslope into the present creek bed.

It is evident that upper No Name Creek has been eroding cassiterite-bearing source rocks at some nearby location(s). Meanwhile, valley downcutting through at least 300 vertical ft has occurred. This extensive downcutting would suggest its cause and time span to be roughly equivalent to the downcutting of the basalt flows. Sample data indicate successively lower channels became increasingly rich in cassiterite as gravels in higher channels were repeatedly reworked. The present buried channel of No Name Creek would therefore be the product of still further reworking.

The second site, about 0.5 mile northeast, is a remnant gravel bench on a low bedrock escarpment above a small side tributary to No Name Creek (fig. 9). The bench gravel lie about 15 ft above the adjoining stream, and test pits indicated a channel width of 130 ft and a maximum thickness of 2.0 ft. Samples from map locations 115 and 116 contained up to 2.82 lbs-Sn/yd^3 in coarse, well-rounded gravel composed of quartz, silicified granite, tourmaline-quartz, and silicified phyllite and hornfels. Pebble tilt measurements indicated a south- southwest flow direction, similar to the present stream.

Heavy mineral concentrates from upper No Name Creek remnant channels contain abundant cassiterite with rounded grains up to 0.3

Figure 12. - SEM backscatter electron photomicrographs of heavy mineral concentrate from upper No Name Creek. Top photograph shows ilmenite (A) as light gray, cassiterite (B) as white , zircon (C) exhibits an inclusion of monazite (E), and xenotime (D) shows as cream color. Other darkcolored grains are silicate gangue minerals. The bottom photograph is an enlargement of the ziron grain with monazite inclusions.

in (1 cm) in size (fig. 12). Only a few crystalline and twinned cassiterite grains were noted. Ilmenite is the most abundant of the heavy minerals. Scanning electron microscope examinations of the heavy minerals indicated the ilmenite is manganese-rich and contains minor inclusions of Sn, Ta, and Nb oxides. Xenotime (YPO_4), with anomalous Yb and Er, was noted by SEM as a minor REE constituent of the heavy mineral suite and more abundant than monazite. In figure 12 monazite is seen as an inclusion in euhedral zircon. Tourmaline is also abundant, and yellow to clear zircon was commonly observed. Wolframite, an Fe-Al spinel, and uranothorite were each noted in trace quantities.

BEDROCK SOURCE OF TIN, UPPER NO NAME CREEK

Investigations to delineate the source of tin minerals were unsuccessful due to the paucity of outcrop in Ft. Hamlin Hills. The widespread occurrence of placer cassiterite suggests multiple bedrock sources. However, the coarseness of the cassiterite in bench channels along upper No Name Creek (e.g. at map no. 83) points to at least one relatively close source. The abundant cassiterite found in bench gravel near map location 115 indicate another source area. Associated gravel at both sites include numerous highly altered and silicified well-rounded rocks.

The area of figure 9 is surrounded by several phases of fine- to coarse-grained granite exhibiting alteration types generally associated with tin mineralization. In low bluffs along the left limit of the creek are outcrops of tourmalinized white mica granite, black-colored tourmaline granite, and black fine-grained schistose rock composed primarily of biotite, actinolite, and quartz. Brosge' mapped similar rock as contaminated granite at a site in the eastern Ft. Hamlin Hills (8). These rocks are bounded on the west by fine-grained, light-colored granitic rocks, typically containing both white mica and biotite, and cut by tourmaline-quartz veins several feet thick.

Altered and/or mineralized rock samples collected as float and from test pits in colluvium were analyzed for tin (table 8). The sample data indicate the altered quartz tourmaline and tourmaline granitic rock contain only low levels of tin, whereas chlorite greisen rocks contain 0.002- to 0.08% Sn. No specimens were found, however, that would explain the coarse-grained cassiterite found in the placer gravels.

BY-PRODUCT COMMODITIES ASSOCIATED WITH PLACER TIN

In addition to gold, several other minerals are also concentrated with cassiterite in placer gravels. On upper No Name Creek the placer concentrates included minor amounts of wolframite and xenotime. Analysis of sample RM 27596 from map location 83 (table 9) indicates Y:Ce+La to be 4:1. The greatest potential, however, for by-product REE recovery is from the more extensive Ray River gravel. Samples from the Ray River contained REE in minor monazite and lesser xenotime (Y:Ce+La is 1:3.8), as well as

Table 8. - Analytical Results From Rock Chip and Float Samples

Upper No Name Creek.

Sample Number	Map Number (Fig. 9)	Analyses Sn (ppm)	Descriptions
RM25718	141	L	Fine-grained 2-mica granite, locally grades to aplite.
23749	142	74	Boulder 0.5 x 1.5 ft, massive tourmaline.
25717	143	L	Fine-grained, actinolite foliated black contaminated (granite?).
25716	144	L	Biotite, porphyritic, quartz monzonite.
25715	145	L	Fine-grained, actinolite, tourmaline, foliated black contaminated (granite?), outcrop trends east-northeast.
25714	146	L	Fine-grained, actinolite, tourmaline, foliated black contaminated (granite?), outcrop trends east northeast.
25713	147	L	Fine-grain, actinolite foliated black contaminated (granite?).
25728	149	270	Well-rounded quartz, chlorite, sericite cobble from pit on ridge.
23464	149	7	Random chips of rounded quartz-tourmaline altered granite.
25040	150	250	Well-rounded tourmaline altered schistose rock in float.
25114	151	600	Well-rounded, chlorite-altered granite and quartz.
25113	152	2	Rounded quartz-tourmaline fragments in clay soil in 4.5-ft-deep pit.
25111	153	575	Chlorite greisen altered granite pebbles in gravel.
25047	154	135	Quartz-chlorite alterd granite.
25041	155	12	Quartz-tourmaline altered granite, fine-grain with rounded quartz eyes.
25077	156	4	Coarse cockscomb 3 in quartz vein cutting granite and tourmaline.
25094	157	L	Red-orange clay layer 1.0 ft deep.
25122	158	495	Rounded pebbles of quartz,tourmaline,sericite$\pm$ chlorite altered granite.
25084	160 [1]	L	Granite float with cross-cutting quartz-tourmaline veins.
25085	161 [1]	58	Sericitically-altered and tourmalinized coarse grained granite.
25086	162 [1]	50	Sericitically-altered and tourmalinized coarse grained granite.

[1]Samples from roof pendent 2000 to 2500 ft SSE of sample 113, not shown on figure 9.

L Less than detection limit of 0.01%.

abundant ilmenite, minor quantities of zircon, and trace wolframite. A group of representative heavy mineral sample splits from the Ray River was re-analyzed for Nb, Ti, W, Zr, and REE (table 9). Sample results indicate concentrates produced from alluvial Ray River material will contain minor quantities of these metals which could be recoverable, if warranted. Generally the heavy mineral fraction contains 0.75- to 2.0-pct REE, 0.25- to 0.50-pct Zr, about 5.0- to 15.0-pct Ti, and 0.01- to 0.1-pct each of Nb and W.

Comparison of the data for tin (table 5) to the data for by-product metals in the same samples as listed in table 9 shows only a vague correlation of higher REE, Ti, and Zr values to corresponding higher Sn values. The tin content of the samples tends to be somewhat erratic in comparison to the other metals. Nevertheless, calculated average ratios for Sn to REE, Ti, and Zr are 2.21, 0.34, and 7.87, respectively.

RESOURCE POTENTIAL OF PLACER TIN

Data indicate that a significant resource of tin, associated REE, and other metals exists in the Ray River watershed. The persistent presence of elevated tin values due to cassiterite in all heavy mineral samples from the Ray River and No Name Creek, and a reasonable projection of grade at depth in the gravel, permit a preliminary range of estimates of the inferred resource. Although a wide margin of error must be accepted, it is apparent that any

Table 9. - Multi-element analyses (in pct) of heavy mineral concentrates[1].

Sample No.	Nb	Ti	W	Zr	Ce	Pr	Yb	Er	Gd	Dy	Sm	La	Y	Nd	Lu	Eu	Ho	Tm	Au (ppm)
RM 27596	--	--	.140	0.43	0.27	--	0.04	--	--	--	0.02	0.07	0.28	--	L	--	--	--	--
26011	.049	8.8	.069	0.50	0.56	0.06	0.02	0.02	0.03	0.03	0.02	0.24	0.16	0.21	L	L	L	L	Tr
26012	.037	5.8	.062	0.43	0.47	0.02	0.01	0.01	0.02	0.02	0.01	0.21	0.12	0.18	L	L	L	L	--
26013	.055	16.0	.076	0.40	0.69	0.07	0.03	0.03	0.04	0.04	0.02	0.30	0.28	0.25	L	L	L	L	Tr
26014	.022	2.9	.050	0.18	0.36	0.04	0.01	0.01	0.02	0.02	L	0.14	0.12	0.14	L	L	L	L	1.1
26016	.034	6.1	.029	0.26	0.31	0.03	0.01	0.01	0.02	0.02	L	0.13	0.14	0.11	L	L	L	L	13.0
26030	.036	6.6	.046	0.35	0.41	0.04	0.01	0.01	0.02	0.02	L	0.17	0.14	0.15	L	L	L	L	Tr
26031	.038	8.1	.048	0.33	0.31	0.03	0.01	0.01	0.02	0.02	L	0.13	0.11	0.11	L	L	L	L	1.6
26032	.030	5.4	.024	0.28	0.24	0.03	0.01	0.01	0.02	0.02	L	0.10	0.12	0.09	L	L	L	L	Tr
26033	.039	8.5	.029	0.32	0.28	--	--	--	--	--	--	0.18	0.11	--	--	--	--	--	Tr
26041	.036	6.5	.034	0.35	0.40	0.04	0.01	0.02	0.02	0.02	L	0.16	0.15	0.15	L	L	L	L	2.8
26042	.029	4.3	.086	0.37	0.45	0.05	0.02	0.02	0.03	0.03	L	0.20	0.18	0.17	L	L	L	L	Tr
26043	.030	4.6	.040	0.22	0.28	0.03	0.01	0.01	0.02	0.02	L	0.12	0.11	0.10	L	L	L	L	Tr
24604	.055	14.0	.120	0.24	0.86	0.08	0.03	0.03	0.04	0.04	0.03	0.37	0.28	0.32	L	L	L	L	3.0
24611	--	--	.020	--	0.21	--	--	--	--	--	--	0.04	0.07	--	--	--	--	--	Tr

Sample No.	Total REE	Sn:REE	Sn:Ti	Sn:Zr	Y/Ce+La
RM 27596	--	--	--	13.56	4.00
26011	1.35	.72	.11	1.94	0.20
26012	1.07	.65	.12	1.63	0.18
26013	1.75	2.00	.22	8.75	0.28
26014	.86	2.21	.66	10.56	0.24
26016	.78	1.55	.20	4.65	0.32
26030	.97	1.75	.26	4.86	0.24
26031	.75	5.47	.51	12.42	0.25
26032	.64	1.56	.19	3.60	0.35
26033	--	--	.10	2.53	0.24
26041	.97	.72	.11	2.00	0.27
26042	1.15	4.09	1.09	12.70	0.28
26043	.70	2.43	.37	7.73	0.28
24604	2.08	3.35	.50	29.00	0.23
24611	--	--	--	--	0.28
AVERAGE	1.09	2.21	.34	7.87	0.26

L Less than detection limit. Tr Trace value detected. - Not analyzed.

[1]Samples are selected suite of samples from lists shown in tables 5 and 7, selection based on samples most representative of potential placer resource; Analyses by inductively coupled plasma mass-spectrometry (ICP) except Ti, Nb, W, by X-ray fluorescence.

estimate with available data using inferred dimensional criteria will indicate a large contained resource. It must be emphasized, however, that these estimates are made without the benefit of reliable subsurface information. Furthermore, although the resource potential estimates consider the entire resource, in actuality some areas may be found to contain a grade below the minimum cut-off for mining. Other areas may be richer. Grade is inferred from available surface sample data and the indication of increasing grade at depth (analyses of auger drill cuttings and exposures of bench and paleochannels lying on or near bedrock). The presumption is therefore made that grade will increase substantially at depth and on bedrock, as is typical in placer deposits elsewhere.

No attempt was made to produce a cassiterite-only concentrate from the samples. All analyses are performed on the total heavy mineral (>4.0 specific gravity) fraction.

Due to the inadequacy of data, no resources are calculated for streams other than the main valleys of No Name Creek and the Ray River. It is likely that streams such as Ft. Hamlin Creek also contain placer values as suggested by the occurrence of tin-bearing paleochannels on the hill above the valley (table 3). Furthermore, no reserve potential is estimated for the Qg gravels. It was impossible to establish meaningful strike lengths for any paleochannels in the Qg, and grade is generally lower in these deposits.

Resource estimates are calculated for only tin and by product

REE. The REE estimates are simply based on the ratio of Sn:REE developed in table 9. Although gold, ilmenite, zircon, wolframite, and minerals of several other metals occur in the concentrates, their values are either uncertain, as in the case of gold, or too low to be included in this preliminary level resource assessment (i.e. they are of questionable economic importance).

Estimated average grade of 0.2- to 0.5- lbs-Sn/yd^3 for the Ray River gravels is most likely subeconomic for a mineral deposit in Alaska at this time. Elsewhere in the world, however, tin dredges commonly work ground containing 0.3- to 0.4- lbs-Sn/yd^3. Malaysian tin dredges have successfully operated in ground containing as little as 0.18 lbs-Sn/yd^3 (11).

RAY RIVER INFERRED RESOURCE POTENTIAL

Inferred resource potential for the Ray River is calculated for each of the three larger basins shown on figures 3 and 8. It is uncertain if additional significant concentrations of cassiterite occur further downstream as the Ray River enters the basin level of the Yukon River. Gravel samples from downstream cutbanks and the river bed contain cassiterite, but very little tin was found in the cuttings from a single auger hole that reached bedrock at map location no. 63 (fig. 8). Tin-bearing gravel in the upper basin is calculated to extend from the upper forks near the Ray River Hot Springs about 14 miles downstream as far as the rapids. Above the upper forks, there is little resource potential due to the higher gradient and narrowing of the river valley.

Previously noted evidence of raised paleochannels subparallel to the upper Ray River (fig. 3), are not included in the resource estimates, due to lack of sample data.

Estimated resources for tin and REE are listed in table 10. The average tenor of surface samples from the three Ray River basins (ignoring side tributaries) is about 0.1 lbs-Sn/yd^3. Five auger drill holes were located within the three Ray River basins, and each encountered sand/silt/clay-rich sediments, though none reached bedrock. The calculated average grade of 0.13 lbs-Sn/yd^3 for auger cuttings may be conservative due to uphole contamination. Therefore, a grade in excess of 0.13 lbs-Sn/yd^3 is considered minimal for the Ray River. Note that tin grade of paleochannels in the Qg is generally 0.1 to 0.25 lbs-Sn/yd. The upper grade limit is keyed to the concentration of tin in the fine sediment in auger cuttings. Eliminating the coarse sand and pebbles and recalculating the average grade of only the -16 mesh (1 mm) fraction auger cuttings, a tenor of 0.49 lbs-Sn/yd^3 is determined. Calculated values for both the total volume and the -16 mesh auger cuttings are given in table 5. For the purpose of a preliminary resource estimate based on the currently available surface and drill data and assuming an increasing grade near bedrock, an overall tenor of 0.2- to 0.5- lbs-Sn/yd^3 is projected for the entire alluvial section.

Total sediment depths are estimated to range from 0 ft at the valley margin to 40 ft at the deepest point of the basin center.

Given the asymmetric cross-section of the alluvial basins, an average depth of 27 ft is inferred. Note that auger drilling to depths of 13- to 23-ft did not encounter bedrock. Only drill hole RM 25983 at map location 63 (fig. 8), located below the lower basin in a valley bedrock constriction (three miles downstream of the confluence with No Name Creek), reached bedrock at 11 ft. For the lower basin, therefore, gravel thickness may decrease to the east; an average depth of 20 ft is assumed.

Width of the floodplain underlain by alluvial tin-bearing material is interpreted from available high-level aerial photographs[3] and depicted on figure 8. Basinal areas were calculated first on the basis of obvious floodplain features (oxbow lakes, meander scars, fluvial scarps), and a second time with the inclusion of probable fluvial sediment areas that are now covered by loess and solifluction features. Resource estimates are determined as a range between the two area estimates; total combined surface area estimates for the three Ray River basins range between 11.64 mi^2 and 12.45 mi^2. Contained tin and REE of each basin are calculated on the basis of the area estimates and the foregoing estimates of grade and depth. Within the Ray River valley a total of 296.5- to 318.2-million yd^3 is estimated to contain 59.3- to 159.1-million lbs-Sn.

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3 False-color U-2 photography avialable from the Remote Sensing Library, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775.

Table 10. - Inferred placer reserve potential summary.

Basin (fig. 8)	Grade ($lb-Sn/yd^3$)	Depth (ft)	Area (mi^2)
Upper Ray River	0.2 to 0.5	27	4.45 to 4.85
Middle Ray River	0.2 to 0.5	27	3.32 to 3.60
Lower Ray River	0.2 to 0.5	20	3.87 to 4.00
Lower No Name Creek	0.1 to 0.5	15	1.27 to 1.45
Upper No Name Creek	1.0 to 1.4	8 to 12	0.08 to 0.11

Basin	Volume (yd^3 X 10^6)	Sn (lbs X 10^6)	REE (lbs X 10^6)
Upper Ray River	124.06 to 135.21	24.81 to 67.61	11.23 to 30.59
Middle Ray River	92.56 to 100.36	18.51 to 50.18	8.38 to 22.71
Lower Ray River	79.92 to 82.60	15.98 to 41.30	7.23 to 18.69
Lower No Name Creek	19.67 to 22.46	1.97 to 11.23	0.89 to 4.06
Upper No Name Creek	0.66 to 1.36	0.66 to 2.04	0.30 to 0.92
TOTAL	316.87 to 341.99	61.93 to 172.36	28.03 to 76.97

LOWER NO NAME CREEK INFERRED RESOURCE POTENTIAL

An inferred resource can be calculated for lower No Name Creek, extending from one mile above the Dalton Highway bridge downstream to the confluence with the Ray River using similar methods as for the Ray River. Sample data from the upper portion of the creek suggest the tenor of the gravel is likely to exceed a grade of 0.2- to 0.5- lbs-Sn/yd^3 for the area near and above the Dalton Highway but decrease in the downstream direction, and in the vicinity of the confluence it is substantially less than the Ray River (table 6). An overall grade of 0.1- to 0.5- lbs-Sn/yd^3 is assumed. The valley width, also inferred from aerial photography, is notably narrower than the Ray River and generally confined by basalt escarpments. No auger drill testing of the stream bed was possible, however, the average depth of tin-bearing gravels is estimated to be no more than 15 ft. No data are available for tin content in sediments of the western fork to the creek. The main valley of No Name Creek is estimated to contain 19.7- to 22.5-million yd^3 of gravel with 2.0- to 11.2-million lbs-Sn.

UPPER NO NAME CREEK INFERRED RESOURCE POTENTIAL

No gravels are exposed in the present stream bed of upper No Name Creek. Several samples were collected: they consisted of floodwash gruss and vegetative matter. Nevertheless, these samples (table 2 and appendix A) contained a grade of about 0.02 lbs-Sn/yd^3. No significant data are available for the northern fork.

Volume estimates are based on the creek valley extending from one mile upstream of the Dalton Highway bridge and continuing upstream to near the headwaters of the southern fork of the creek, a linear distance of about five miles. Width of the valley gravel ranges from about 200 ft above the confluence of the southern and northern forks, to about 50 ft on the upper southern fork. The thickness of gravel underlying upper No Name Creek is estimated to be about 8- to 12-ft based on a geomorphic setting similar to other placer streams in interior Alaska. The gravel section is buried below a considerable thickness of barren, frozen loess.

Placer samples from the low remnant bench exposures are likely most representative of the present stream channel of No Name Creek. Bench channel samples of gravel and weathered bedrock contained an average of 2.0 lbs-Sn/yd^3 (samples 82, 83a-d, 84, 85, and 86, fig. 9). Because these samples were collected from within three feet of bedrock they likely represent a higher grade than the average of the entire gravel section. The gravel deposited under the present stream bed is therefore estimated to contain a similar tenor in the lower three feet but average about 1.0- to 1.5- lbs-Sn/yd^3 over their entire thickness of 8- to 12- ft. A total of 0.7- to 1.4-million yd^3 of gravel is estimated to contain 0.7- to 2.0-million lbs-Sn.

CONCLUSIONS

A substantial tin resource, between 62- and 172-million lb-Sn, occurs in the Ray River watershed. A resource potential of up to 159.1 million lbs-Sn is estimated for the Ray River valley at a grade of 0.2- to 0.5- lbs-Sn/yd^3. Smaller resources occur in the No Name Creek valley, where grade ranges as high as 6.2 lbs-Sn/yd^3. By-product gold and REE as monazite and xenotime may be recoverable, and zircon, ilmenite, and traces of wolframite may also be of interest. Estimates are based on widespread surficial sampling, several auger holes, and a few bench channel outcrops, and are consequently subject to a wide margin of error. It is assumed that grade will increase with depth as indicated by the auger drilling and sampling of exposed paleochannels near bedrock. Increasing grade at depth is typically observed in placers elsewhere. Estimated average grade of 0.2- to 0.5- lbs-Sn/yd^3 for the Ray River gravels is most likely subeconomic for a mineral deposit in Alaska at this time. Elsewhere in the world, however, tin dredges commonly work ground containing 0.3 to 0.4 lbs-Sn/yd^3. Malaysian tin dredges have successfully operated in ground containing as little as 0.18 lbs-Sn/yd^3.

Investigation of the Ray River area found the placers developed as the result of unique long-term and repeated erosional cycles affecting large surface areas of favorable source rock. The present-day river gravel, floodplain, and benches (Qt) are the product of accelerated erosion of several Cretaceous granitic plutons due to formation of mid-Tertiary graben-like features underlying adjacent sedimentary basins. Although the area is extensively covered, an extensional terrane in which grabens have induced cycles of sedimentation is suggested. The occurrence of alkaline fissure basalts, geothermal activity, and the stepped elevations of the Tertiary age coal beds are consistent with an interpreted formation of northeast-trending grabens situated between the granitic plutons. Tertiary basalt flows, approximately 200 ft thick and covering about 60 mi^2, later blocked local drainages from the granitic highlands. As a result, about 50- to 100-ft of alluvial gravels (Qg) were impounded in front of and on top of the flows. The basalt flows have since been downcut and subsequent fluvial processes have reworked much of the high level gravel, transporting the sediments in several stages to the present alluvial basins. The abundance of cassiterite and other heavy minerals correlates with the degree of fluvial reworking that has occurred.

The Ray River area is located in the north central interior of Alaska and is accessible from the Dalton Highway. Although the region is extensively covered by permafrost loess deposits and continuous vegetation, the use of heavy mineral sampling readily characterizes the Ray River watershed as a favorable terrane for tin placer and associated lode sources.

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Appendix A. - Tin content of heavy mineral concentrates, northern Ft. Hamlin Hills.

Sample Number	Map Number (Map A)	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lbs-Sn/yd^3	Descriptions
RM 25154	A 1	0.08	55.3	L	Ng	Brown clays and sand with few quartz pebbles.
25155	A 2	0.10	36.8	0.03	0.01	White gravel of quartz and schist in sand and clay.
25156	A 3	0.08	35.3	0.02	0.01	White gravel of quartz and schist in sand and clay.
25157	A 4	0.08	23.8	0.05	0.01	Coarse gravel of quartz and schist and sand, basalt pebbles.
23723	A 5	0.51	16.7	0.04	Ng	Sandy gravel, mostly of chloritized metased and gruss.
27632	A 6	1.27	43.4	L	Ng	Cross-bedded coarse gravel and cobbles between 0 and 3.5 ft above pit floor.
25247	A 7	0.13	54.9	0.01	Ng	Gravel from 6 ft below terrace top.
25248	A 8	0.15	30.4	0.02	Ng	Gravel, mostly schist, and clayey sand.
25249	A 9	0.11	30.1	0.01	0.01	Gravel, mostly schist, and clayey sand.
23751	A 10	0.39	13.9	L	Ng	Sand and organic-rich silt.
25793	A 11	0.04	20.8	0.06	0.02	Colluvium inc. hornfels, quartz, and schist.
25792	A 12	0.07	35.2	0.07	0.02	Gravel bench approx. 30 ft above creek
25789	A 13	0.04	17.0	L	Ng	Colluvium inc. quartz and schist.
21658	A 14	0.26	35.0	0.10	0.01	Stream bed gravel, mostly granite.
25790	A 15	0.07	25.0	L	Ng	Granite colluvium with tourmaline pegmatite fragment.
25787	A 16	0.05	30.8	L	Ng	Clayey gruss with some rounded pebbles.
25573	A 17	0.13	64.6	---	---	Gray gruss with quartz-tourmaline pebbles.
25785	A 18	0.13	45.3	0.10	0.02	Gruss, clay, and gravel.
25786	A 18	0.07	29.3	L	Ng	Clayey gruss underlying gravel in above sample.
25782	A 19	0.08	17.6	L	Ng	Silty gravel with mixed lithologies.
25784	A 19	0.08	23.5	L	Ng	Gruss with quartz pebbles.
25775	A 19	0.06	22.7	L	Ng	Gruss with quartz pebbles.
25777	A 20	0.05	19.8	0.01	Ng	Sandy gruss underlying fluvial gravel.
25776	A 20	0.04	11.3	L	Ng	Sandy gravel overlying sample above.
25783	A 21	0.05	20.1	L	Ng	Granite gruss and clay.
25780	A 22	0.04	30.3	L	Ng	Gruss with few pebbles, 0- to 2-ft depth.
25230	A 22	0.51	24.9	L	Ng	Gravelly sand, 7- to 8-ft depth, underlying above sample.
25778	A 23	0.08	16.1	<0.06	Ng	Gruss.
25779	A 24	0.04	6.6	L	Ng	Granite and schist colluvium.
25797	A 25	0.04	13.4	L	Ng	Gruss and schist.
25781	A 26	0.04	26.0	L	Ng	Granite and schist colluvium.
25267	A 27	0.20	35.5	0.53	0.06	Creek gravel, mixed lithology.
23750	A 28	0.39	16.6	L	Ng	Sandy gruss, very loose flood sand.
25226	A 29	0.13	26.7	L	Ng	Sandy gruss, very loose flood sand.
25265	A 30	0.1	15.1	L	Ng	Schist and vein quartz, silty gravel.
25266	A 31	0.1	25.2	L	Ng	Gruss with quartz and schist cobbles.
25228	A 32	0.08	31.0	0.01	Ng	Schist pebbles and gruss.
25229	A 33	0.07	29.6	L	Ng	Schist pebbles and gruss.
25794	A 34	0.07	45.8	0.02	0.01	Clay gruss with quartz schist and chert pebbles, 1 ft deep.
25795	A 34	0.06	34.2	L	Ng	Same location as above gruss, 3 ft deep.

See footnotes at end of table.

Appendix A. - Tin content of heavy mineral concentrates, northern Ft. Hamlin Hills - (cont.).

Sample Number	Map Number	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lbs-Sn/yd^3	Descriptions
25796	A 35	0.05	30.9	0.01	Ng	Gruss and schist pebbles.
25233	A 36	0.08	37.4	L	Ng	Red sandy silt with schist pebbles.
25234	A 37	0.08	39.8	L	Ng	Gruss.
25231	A 38	0.08	38.7	0.02	0.01	Gruss with granite and schist pebbles.
25232	A 39	0.08	35.0	L	Ng	Gruss with granite and schist pebbles.
25773	A 40	0.03	18.3	L	Ng	Gruss with granite and schist pebbles.
25257	A 41	0.10	24.7	0.02	Ng	Gruss with schist fragments.
25258	A 42	0.03	36.0	L	Ng	Gruss, 2 ft deep.
25772	A 43	0.03	28.0	L	Ng	Gruss, 2 ft deep.
25771	A 44	0.03	27.4	0.01	0.01	Clayey gruss with quartz and meta-sediment pebbles.
25770	A 45	0.03	21.7	L	Ng	Orange clayey gruss, 2- to 3.5-ft deep.
25761	A 46	0.08	27.0	L	Ng	Clayey gravel and gruss.
25051	A 47	0.13	38.6	0.02	Ng	Clayey gruss.
25256	A 48	0.10	26.9	L	Ng	Gruss.
25052	A 49	0.10	25.5	L	Ng	Hematite stained gruss.
25053	A 50	0.10	33.7	L	Ng	Hematite stained gruss.
25054	A 51	0.10	29.4	L	Ng	Hematite stained gruss.
25758	A 52	0.04	16.6	L	Ng	Chocolate brown gruss with tourmaline-quartz pebbles.
25760	A 53	0.08	55.3	L	Ng	Sand and gruss with quartz and schist cobbles.
25759	A 54	0.10	22.7	L	Ng	Hematite stained gruss.
25757	A 54	0.02	23.1	L	Ng	Gruss from 3 ft deep.
25769	A 55	0.21	32.5	L	Ng	Gruss from 15 ft cut-bank.
25036	A 56	0.13	32.0	0.02	Ng	Loose gruss and schist fragments.
25222	A 57	0.13	28.9	L	Ng	Gray clay-rich gruss, noted quartz-tourmaline pebbles.
25059	A 58	0.13	32.1	L	Ng	Gray clay-rich gruss, noted quartz-tourmaline pebbles.
25057	A 59	0.07	35.9	0.01	Ng	Clayey pebble gruss.
25058	A 60	0.10	22.9	L	Ng	Clayey gruss and mixed gravel.
25223	A 61	0.10	21.3	L	Ng	Clayey gruss and mixed gravel.
25056	A 62	0.10	35.9	L	Ng	Gray gruss underlying pebble horizon.
25224	A 63	0.08	24.2	L	Ng	Gruss with granite, quartz, and schist pebbles.
25225	A 63	0.08	24.2	L	Ng	Gray gruss underlying sample above.
25767	A 64	0.02	32.3	L	Ng	Silty gruss.
25768	A 65	0.03	14.1	L	Ng	Silty gruss.
25766	A 66	0.02	30.9	L	Ng	Silty gruss.
25765	A 67	0.04	38.3	L	Ng	Clayey gruss and mixed gravel.
25264	A 68	0.13	31.3	L	Ng	Gruss.
25037	A 69	0.13	61.7	0.04	0.01	Sandy gravel with quartz and quartz-tourmaline.
25762	A 70	0.03	56.9	L	Ng	Sandy gravel with quartz and quartz-tourmaline.
25764	A 70	0.03	38.7	L	Ng	Same site as above, 7-ft-depth, more clay some ferricrete gravel.
25263	A 71	0.10	32.2	---	---	Gravel includes schist, quartz, and quartz-tourmaline.
25262	A 72	0.10	28.7	L	Ng	Medium-grained gruss.
25259	A 73	0.10	33.8	L	Ng	Medium-grained gruss.

See footnotes at end of table.

Appendix A. - Tin content of heavy mineral concentrates, northern Ft. Hamlin Hills - (Cont.).

Sample Number	Map Number	Sample Volume[1] (ft^3)	Heavy mineral concentrate (grams)	Analyses Sn (pct)	Calculated[2] lbs-Sn/yd^3	Descriptions
RM 25260	A 73	0.10	29.8	L	Ng	Coarse gruss with quartz and schist cobbles.
25261	A 73	0.10	31.1	L	Ng	Gravel with quartz and schist pebbles.
25035	A 74	0.13	51.3	0.02	0.01	Fe-stained mixed gravel and gruss, 2- to 3.5-ft depth.
25756	A 75	0.17	44.3	0.01	Ng	Clayey, granite gravel, 3 ft deep.
25034	A 76	0.13	51.1	0.11	0.03	Gruss with quartz, schist, & quartz tourmaline 1.5-2.5 ft depth.
25125	A 77	0.03	23.5	0.02	0.01	Gray, clayey gruss with schist and quartz tourmaline, 2.0 ft deep.
25126	A 77	0.03	25.2	0.02	0.01	Same site as above but from 3 ft deep.
25032	A 78	0.02	61.6	---	---	Gruss, quartz-tourmaline granite, 1.5 ft deep.
25033	A 78	0.13	39.1	0.04	0.01	Silty gruss with quartz and quartz-tourmaline pebbles 2.5 ft deep.
25101	A 79	0.26	42.3	L	Ng	Gruss with tourmaline pebbles.
25098	A 80	0.26	29.0	L	Ng	Sand and gruss, 1.5 ft deep.
25140	A 81	0.10	13.6	L	Ng	Gruss.
25102	A 82	0.26	40.2	L	Ng	Gruss.
25099	A 83	0.17	22.5	L	Ng	Fe-stained gruss with tourmaline pebbles.
25103	A 84	0.30	22.3	L	Ng	Sandy gruss.
25104	A 85	0.17	22.4	L	Ng	Clayey gruss.
25753	A 86	0.26	27.2	L	Ng	Gruss 0- to 3-ft deep.
25100	A 87	0.25	25.5	L	Ng	Sandy red-brown gruss.
25141	A 88	0.10	26.2	0.09	0.01	Gruss, 2- to 3-ft deep.
25143	A 89	0.39	23.1	L	Ng	Intermittent stream bed.
25144	A 90	0.10	26.0	L	Ng	Gruss and granite fragments.
25145	A 91	0.10	27.4	L	Ng	Gruss and granite fragments.
23473	A 92	0.10	16.3	L	Ng	Clayey gruss and gravel.
25097	A 93	0.17	19.2	L	Ng	Gruss.
25096	A 94	0.25	38.0	L	Ng	Gruss.
25095	A 95	0.21	32.6	0.05	0.01	Gruss.
25080	A 96	0.10	22.6	L	Ng	Gruss, 2 ft deep.
23463	A 97	0.26	14.1	L	Ng	Small stream bed of gruss.
25150	A 98	0.13	28.9	0.01	Ng	Gruss with schist fragments, 3 ft deep.
25087	A 99	0.10	29.8	L	Ng	Sand 1 ft deep.
25088	A100	0.10	27.6	0.01	Ng	Gruss and schist.
25082	A101	0.26	19.4	0.19	0.01	Stream bed with granite and schist.
25090	A102	0.10	16.8	L	Ng	Gruss with quartz-tourmaline fragments, 1.5 ft deep.
25107	A103	0.13	22.3	L	Ng	Gruss with calc-silicate and vein quartz.
25108	A104	0.17	33.4	L	Ng	Gruss with calc-silicate and vein quartz.
25215	A105	2.70	36.5	L	Ng	Orange clayey terrace gravel above basalt.
27631	A106	1.27	44.0	3.70	0.08	Coarse gravels containing little granite material, lower 3.5 ft of gravel section exposed in gravel pit.

[1] Unscreened loose volume of gravel from sample site.

[2] lbs-Sn calculated as follows: $\frac{27}{\text{Volume } (ft^3)} \times \text{H.M. conc(g)} \times \frac{\text{Sn(pct)}}{454} = \frac{\text{lbs - Sn}}{yd^3}$

Ng Negligible trace value. L Less than detection limit of 0.01

\- Not analyzed.

Figure 3. - EXPLANATION

UNCONSOLIDATED SEDIMENTS

QlLoess, tan to gray, local dune features, much more extensive than shown.
QtAlluvial sand and gravel deposits forming floodplains and low benches along major drainages (shown only on figure 7).
QgHigh level terrace gravels and sands, coarse sand commonly of granitic origin; arrow indicates paleochannel direction.
QTcBasalt conglomerate with quartz pebbles, forms cliffs on top of flows.
TwgWhite fluvial quartz gravels commonly weather white due to films of clay and mica.

BEDROCK

TbFissure basalts. Olivine basalt, locally vesicular, with columnar jointing observed in river bluffs.
TsTertiary coal-bearing mudstones, conglomerate fining upward to sandstone sequences, tuff and volcanic ash beds; thickness unknown; K-Ar date on ash is late Eocene (Barker, 1981).
JvMafic andesite volcanics, gabbro, diorite, and chert of the Tozitna terrane.
JuUltramafic rocks including clinopyroxenite, peridotite, and dunite.
KgGranitic rocks undivided, including quartz monzonite and granite. Equigranular to porphyritic K-feldspar.
KaAplite
KfgFine-grain equigranular granitic rocks.
KcgMed- to coarse-grained equigranular granitic rocks.
KpgPorphyritic granitic rocks.
KtTourmaline-bearing fine-grained granitic and leucrocratic phases; commonly display silica and sericite alteration, two-mica granite.
MzPzgGreenstone, described by Brosge' (1973)
PzlPaleozoic limestone, marbles, locally altered to calc-silicate; includes minor quartzite.
PzpPhyllite, quartz-mica schist and quartzite.
Thermal springs, temp. in fahrenheit.
Gravel pit.
Quartz and quartz stockwork.
Coal, including concentrations of coal rubble in stream beds.
Contact, dashed where inferred, dotted where projected.
Inferred fault or pronounced photo linear.
Dip and strike of bedding.
Paleochannel, arrow indicates direction of flow.
Note: Geology in shaded areas confirmed by ground traverse.

\- Not analyzed.