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PLACER GEOLOGY OF THE PORCUPINE MINING DISTRICT, SKAGWAY B-4 QUADRANGLE, ALASKA

By

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PLACER GEOLOGY OF THE PORCUPINE MINING DISTRICT SKAGWAY B-4 QUADRANGLE, ALASKA

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INTRODUCTION

During September 5-9, 1984, and June 15-26, 1985, the author investigated the Quaternary geology and heavy mineral placer deposits of the Porcupine mining district in the Skagway B-3 and B-4 Quadrangles about 30 mi northwest of Haines in southeastern Alaska (fig. 1). These investigations were conducted as part of a cooperative study of the Haines subdistrict of the Juneau mining district by the U.S. Bureau of Mines (USBM) and Alaska Division of Geological and Geophysical Surveys (ADGGS). A Quaternary geologic map that includes sample locations, gold fineness results, heavy mineral concentrate analyses, and interpretive text are herein presented. I thank Mark Lockwood and Karen Clautice for assistance during the 1984 and 1985 seasons respectively. I also thank Robert Hoekzema (USBM) for providing placer gold samples that were analyzed for trace elements; informative discussions with him and his colleagues Steve Fechner, Mark Meyer, and Nathan Rathburn also aided this study. Jan Still (USBM), provided logistical support, and Wyatt Gilbert (DGGS) freely gave geologic expertise during the course of the investigation. Mine owners Josephine Jurgeleit and James McLaughlin provided much historical background on past mining activities.

GEOGRAPHY

The Porcupine mining district encompasses a 225 mi^2 region in southeastern Alaska that includes the greater portion of the Lower Klehini River drainage, an eastward flowing tributary of the Chilkat River (fig. 1). The old mining camp of Porcupine is 26 mi northwest of Haines, the nearest commercial center located near the head of Lynn Canal. A circular massif-like upland that makes up most of the district is bounded on the north by the Klehini River, on the east and south by the Tsirku River, and on the west by rugged glaciated mountains along the United States-Canada border.

Relief ranges from 450 ft on the floodplains of the Klehini and Tsirku Rivers to 7,464-ft-high Mt. Henry Clay. Porcupine Peak, about 5,400 feet above sea level, is the geographic center of the mining district. The area is characterized by steep, glacially carved mountains and U-shaped valleys; much of the southwestern portion of the study area is covered by glaciers and ice fields. Modern glaciers extend to the flood plains of the Tsirku River as low as 700 ft above sea level.

Rapid post-glacial downcutting has incised steep, bedrock-walled canyons in the valleys of Porcupine, McKinley, Cahoon, Cottonwood, Nugget, and Summit Creeks and a number of waterfalls are present on most stream drainages. Traversing in vegetated canyon areas during this investigation was sometimes hazardous.

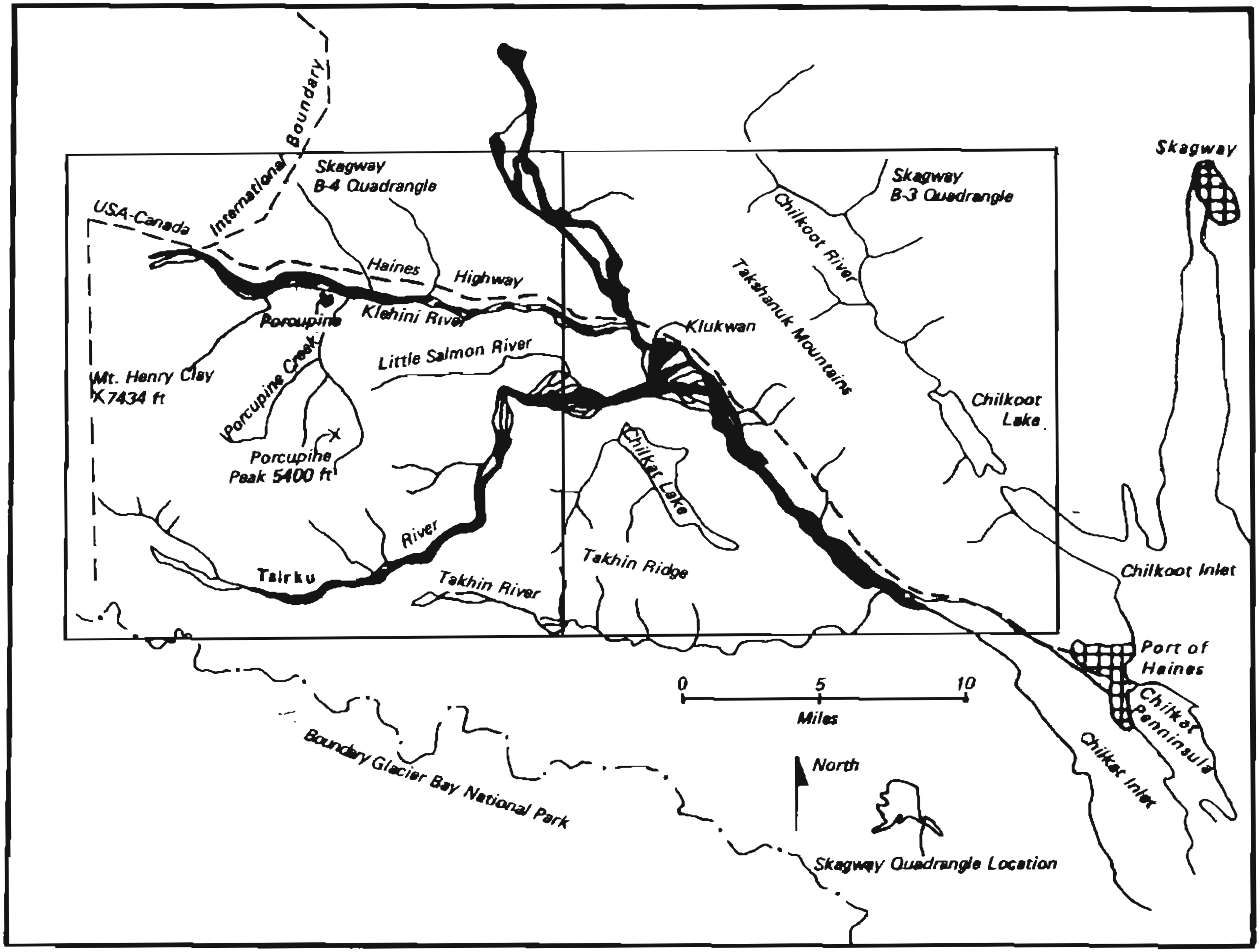

Figure 1. Location map showing location of Porcupine mining district, Skagway Quadrangle, Alaska.

A dense forest of western hemlock, Sitka spruce, and associated underbrush beneath the forest canopy covers much of the hillslopes and terraced, glaciated areas to approximately 3,000 ft elevation. Black cottonwood, alder, birch, and willow grow on modern flood plains of the major streams and on certain hill slopes as high as 3,800 ft. The dense vegetation, which covers approximately 30 percent of the study area, including most of the placer mining areas, obscures bedrock and Quaternary geologic relationships.

Access to the region is provided by a bumpy 9-mi-long logging and mining road from Mile 32 of the Haines Highway to the old mining community of Porcupine near the mouth of Porcupine Creek. From here, logging and mining roads, and foot trails provide additional limited access to the mining camps.

BEDROCK GEOLOGIC SKETCH

Bedrock geology was examined only in mined areas during the investigation. The various sedimentary, metamorphic, and granitic rocks were originally described by Eakin (1919), later by MacKevett and Winkler (1974), and most recently by Redman and others (1985).

Possibly the oldest rock unit in the area is the Middle to Late Paleozoic Porcupine Limestone or Marble, which forms prominent outcrops of carbonate along the access road on the south side of the Klehini River and along canyon walls of Porcupine Creek. Amphipora-bearing zones on Porcupine Creek suggest Devonian or Mississippian ages. Overlying the Porcupine Limestone is the Porcupine Slate, which may range in age from Mississippian to Pennsylvanian (Redman and others, 1985). The slate, sandstone, and siltstone of the Porcupine Slate forms a complex antiform throughout the central portion of the study area. Auriferous lodes cutting this 'slate belt' are believed by many previous workers to be the source of most placer gold in the district. The western and northeastern regions are underlain by pillow basalt, carbonate, and volcaniclastic sediments that may be Triassic in age, based on fossils collected in 1985 (Ken Dawson, oral. commun., 1985). Many of the contact relationships between major layered units are thought to be faults based on the most recent mapping (Redman and others, 1985). The highest portion of the massif-like upland is cored by a 15 mi^2 granodiorite pluton.

GLACIAL GEOLOGY

The study area bears impressive evidence of extensive glaciation but specific limits of the various Pleistocene and Holocene glacial advances are not well understood. The recent nature of glaciation throughout southeastern Alaska has masked all evidence of ice activity prior to about 70,000 yr B.P. (Molnia, 1986; Mann, 1986; Péwé, 1975), and virtually all glacial deposits and landforms observed today in the Porcupine area are probably Late Wisconsin (30,000 to 10,000 yr B.P.) and younger. Glaciers throughout the Alexander Archipelago, including the study area, had a complex history during Late Wisconsin time. Ice expanded radially from islands or mountain massifs at the same time major ice streams were invading the coastline from the interior and the Coast Range mountains. Hence during Late Wisconsin and possibly Early Holocene, large glacial troughs of the Klehini, Chilkat, and

Tsirku Rivers brought ice streams from the interior at the same time ice was expanding from the 'Porcupine Massif' or the high upland that forms the core of the district. The ice streams from both sources combined to form a complex of diffluent and transfluent flow configurations until an ice cap, perhaps up to 3,000 ft thick covered 85 percent of the study area and left only the highest peaks protruding above the ice field (fig. 2). The series of high-level trimlines on the steep canyon walls of the Tsirku and the Klehini Rivers probably reflect this time of maximum ice accumulation during late Wisconsin time. Molnia (1986) and Mann (1986) show that this Late Wisconsin event occurred between 14,000 and 16,000 yr B.P. in nearby Glacier Bay National Park, near Skagway, and in almost all other glaciated terrane of the Southeast Panhandle where absolute age control (that is radiocarbon, lichenometric, or pollen ages) is available. Sea-level changes as much as 600 ft above present levels are known in the Southeast Panhandle (Clague, 1975), but evidence for their existence in the study area were not found. Effects of isostatic rebound following deglaciation and tectonic uplift rates of as much as 6 cm/yr (Hudson and others, 1976) further complicate the influence of marine transgression regionally.

The Holocene glacial chronology worked out by Mann (1986) in the adjacent Glacier Bay region show a four-phase history of glacial maxima at 9,000 to 13,000 yr B.P., 5,000 to 6,000 yr B.P., 2,500 to 3,600 yr B.P., and approximately 1,500 yr B.P., each separated by periods of deglaciation, downcutting or incision of former glacial valleys, and stream aggradation of major trunk meltwater streams. The multi-tiered glacial trimlines, and sets of three hanging valleys in the drainages of the study area could represent at least some of the Holocene advances recognized throughout the Panhandle by other workers (fig. 3). However it is doubtful that the major trunk streams such as the Klehini River had valley ice subsequent to Early Holocene time (J.T. Kline, oral commun. 1986); hence with only a limited amount of absolute age control available for the study area, such correlations are uncertain.

The various Pleistocene ice advances and readvances resulted in at least three, and possibly four, bedrock-incised channels or terrace levels in the valleys of Porcupine, Cahoon, and McKinley Creeks (shown as Qat_1, Qat_2, and Qat_3 on pl. 1). Apparently in most cases the remnants of these channels avoided ice scour and were unaffected by later events except for deposition of glacial drift and erratics. The oldest recognized terrace level occurs at 250 to 300 ft above modern canyon levels of McKinley and Porcupine Creeks, followed downstream by channels at 140 to 200 ft, 50 to 75 ft, and a final and most youthful terrace that is 25 to 40 ft above the modern drainages. The oldest terrace level (Qat_1) may be a composite of fluvial material and drift not incised into bedrock.

Radiocarbon samples were collected from an exposed mine cut at sites directly on the channel base of the "dry channel" as described by Beatty (1937), which corresponds to Qat_3 shown on plate one. The two dates, 2,150 yr B.P. and 2,640 yr B.P. (table 1), suggest that the third terrace level on Porcupine Creek was deposited subsequent to the third recognized Holocene glacial advance shown by Mann (1986) to occur 2,500 to 3,600 yr B.P.

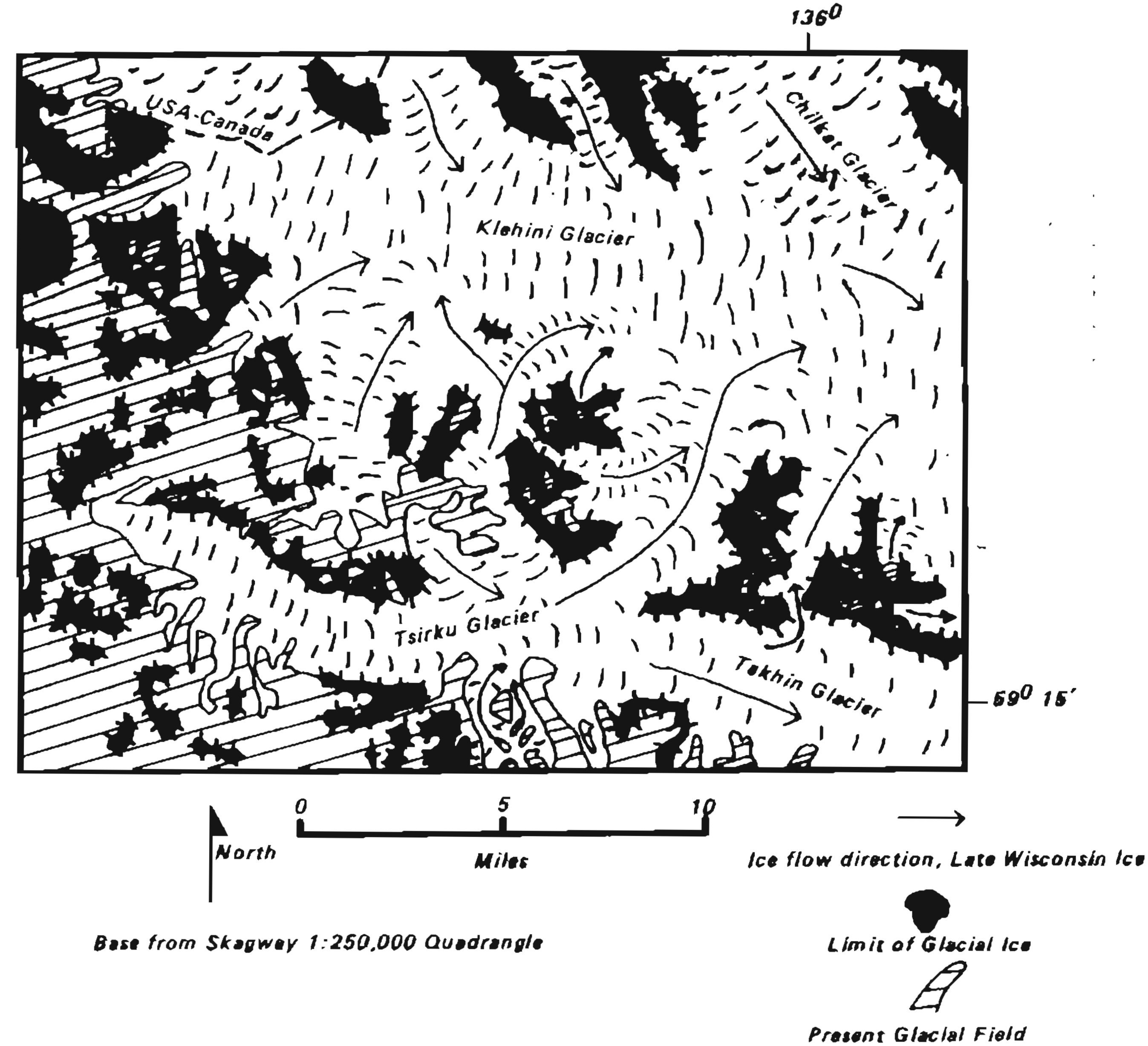

Figure 2. Probable extent of Late Wisconsin glaciation, Porcupine mining district, Alaska.

Figure 3. Deep stream incision in Cottonwood Creek valley. (Note former perched hanging valley at 3,150 ft elevation).

Table 1. Summary of radiocarbon analyses of channel gravels, Porcupine district, Alaska.

Lab number	Field number	C-14 age (yr B.P. ± 1x)	Remarks
Beta 11090	8BTC2	2,190 ± 90 B.P.	Woody material in dry channel near waterfall.
Beta 11091	8BTC3	2,640 ± 100 B.P.	Wood from base of dry channel, western side of Porcupine Creek.

The last Holocene advance [Beatty's (1937) second and final retreat] occupied 1- to 2-mi stretches of Porcupine, McKinley, and Glacier Creek valleys below present glacial termini as clearly indicated by recent morainal limits on air photos. It could correlate with the 1,000 to 1,500 yr B.P. Late Holocene advance described by Mann (1986). Beatty (1937) reports that the active glacier on Cahoon Creek retreated nearly a mile during the years 1898 to 1937, indicating that the region is still undergoing deglaciation following the latest Holocene advance(s).

Besides leaving behind multiple drift limits, bedrock-incised bench channels, trimlines, and hanging valleys, multiple glacial episodes also produced perched alluvial and colluvial fans and ice-marginal meltwater channels (pl. 1). The alluvial fan complex of Porcupine and Glacier Creeks (Qaf unit on pl. 1) has obviously had more than one period of aggradational development and the former fan apex was probably at least 1 mi south of its present position at the breakout of Porcupine Canyon (fig. 4). A distributary channel of this fan probably spilled over into the drainage now occupied by Walker Lake. As Porcupine and other alluvial fans built up, the streams developed multiple distributary channels across their surfaces. The barbed tributary effect of the Glacier and Porcupine fans for the last 1.5 mi of their courses to the Klehini River reflects these changes during fan evolution.

Development of alluvial fans on Cottonwood and Nugget Creeks have been significantly influenced by earlier east to west glacial-meltwater features that drained Late Wisconsin or Holocene valley ice in the Tsirku River. Former ice marginal meltwater channels have left prominently notched, beheaded drainages in the Herman Creek and Walker Lake area, along the Klehini River near the United States-Canada border, and in isolated sections of the Tsirku River (pl. 1). The meltwater channels are incised in glacial drift in contrast to the bedrock incision of fluvial channels previously described.

Elevated, modern terrace alluvium and alluvial fans of Latest Holocene age parallel the modern floodplains of the Tsirku and Klehini Rivers and are a result of recent periods of stream aggradation during distributary channel development.

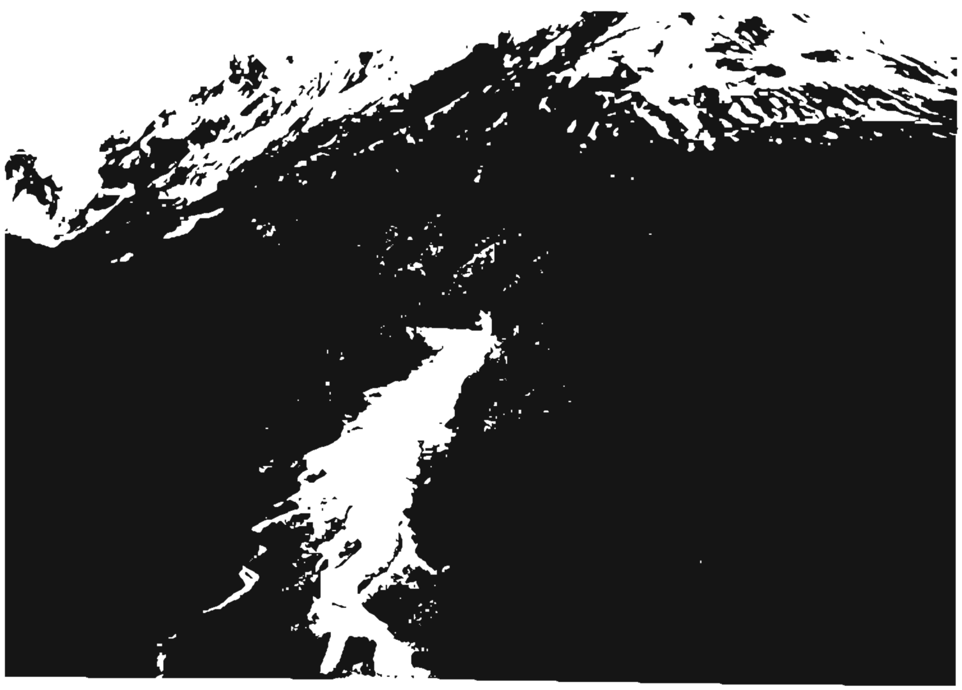

Figure 4. Canyon breakout area of Glacier Creek alluvial fan complex, looking southwest.

MINING HISTORY

Placer mining and sporadic exploration for hardrock deposits have been the principal mineral activities of the region. Mining history has been well documented by Eakin (1919), Rennick and Doogan (1984), Hoekzema and others (1986) and especially Beatty (1937) and will only be briefly summarized here. The principal mine methods have included hydraulic pick and shovel, suction dredge, and limited mechanized 'cat-mining' methods. Prospectors, including well known Jack Dalton, enroute to the Klondike and other interior gold fields found placer gold at the mouth of Porcupine Creek during the summer of 1898. Almost immediately a town sprang up near the discovery site which became known as Porcupine; it rapidly developed into the commercial and logistics center of the mining district. Activity peaked in 1905, but a 1906 flood destroyed most of the mine infrastructure on Porcupine Creek, the principal producer. A large company consolidated most of the best ground in the Porcupine Creek drainage and began production activities in 1908, but another flood in 1915 demolished much of the mine equipment. Yet another flood in 1918 finished off the mining apparatus that survived the 1915 flood. More large-scale activities, especially those of Sunshine Mining Company, continued work through the 1920's and 1930's, but most activities ceased at the onset of World War II. Activities since the second World War have been sporadic, but a brief mining resurgence occurred in 1959-1960, when five small operations employing 15 people worked various claims on Porcupine Creek and its tributaries (Williams, 1960). When gold prices soared in the late 1970's and early 1980's, mechanized 'cat-mining' was employed and produced up to several hundred ounces annually until 1984 (fig. 5). Josephine Jurgeleit, James McLaughlin, Merrill Palmer, and others continue to take out small amounts of gold bullion from their claims.

Based on data by Hoekzema and others (1986), Smith (1933), and DGGS unpublished information, total production for the district is estimated at about 80,000 ounces of gold and 15,000 ounces of silver. Porcupine Creek and tributary streams Cahoon and McKinley Creeks account for almost 95 percent of total district production, but some gold has also been mined on Little Salmon, Glacier, Nugget, Cottonwood, and Boulder Creeks (fig. 1, pl. 1).

PLACER GEOLOGY

Heavy-mineral placer deposits in the Porcupine district formed during multiple glaciofluvial cycles previously described. The excellent work of Beatty (1937) provides many detailed summaries of placer deposits and their exploitation in the district. Heavy-mineral placer concentrations occur in incised bedrock channels, glacial till, alluvial fans, and modern-stream incisions.

Very high bedrock-stream gradients indicate that the district, as a whole, is characterized as very immature and nested in a very high energy fluvial environment; three nested valley profiles are apparent (fig. 6). The average stream gradient of the study area of about 500 ft per mile compares with averages of 80 to 150 ft per mile in many interior Alaska placer districts. Probable bedrock sources of most heavy-mineral concentrations, including the placer gold, have been identified by Eakin (1919), Beatty (1937),

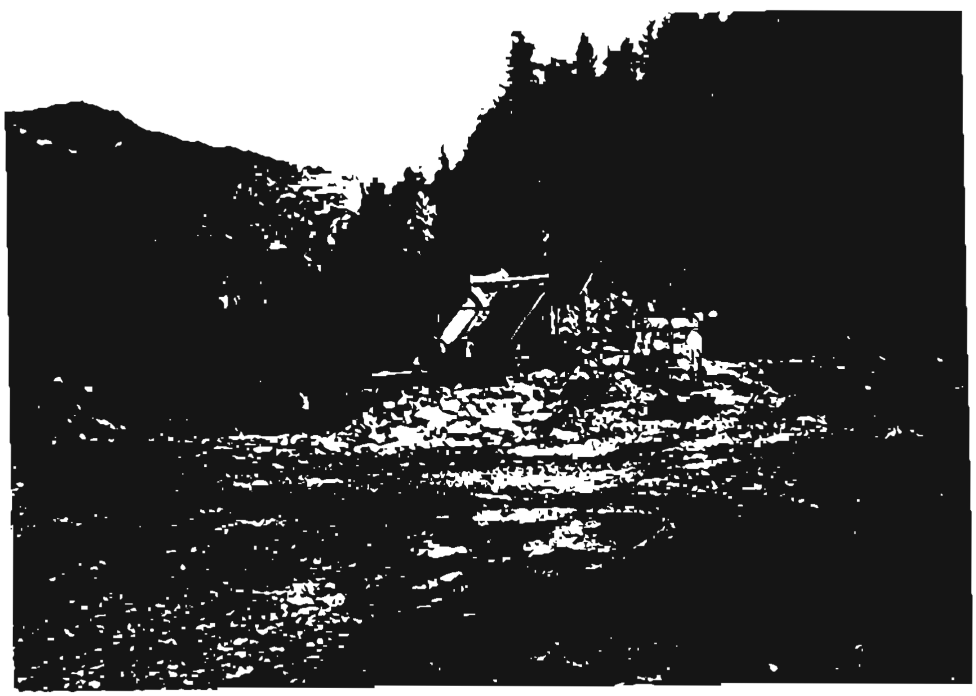

Figure 5. Washing plant at canyon breakout of Porcupine Creek in 1984.

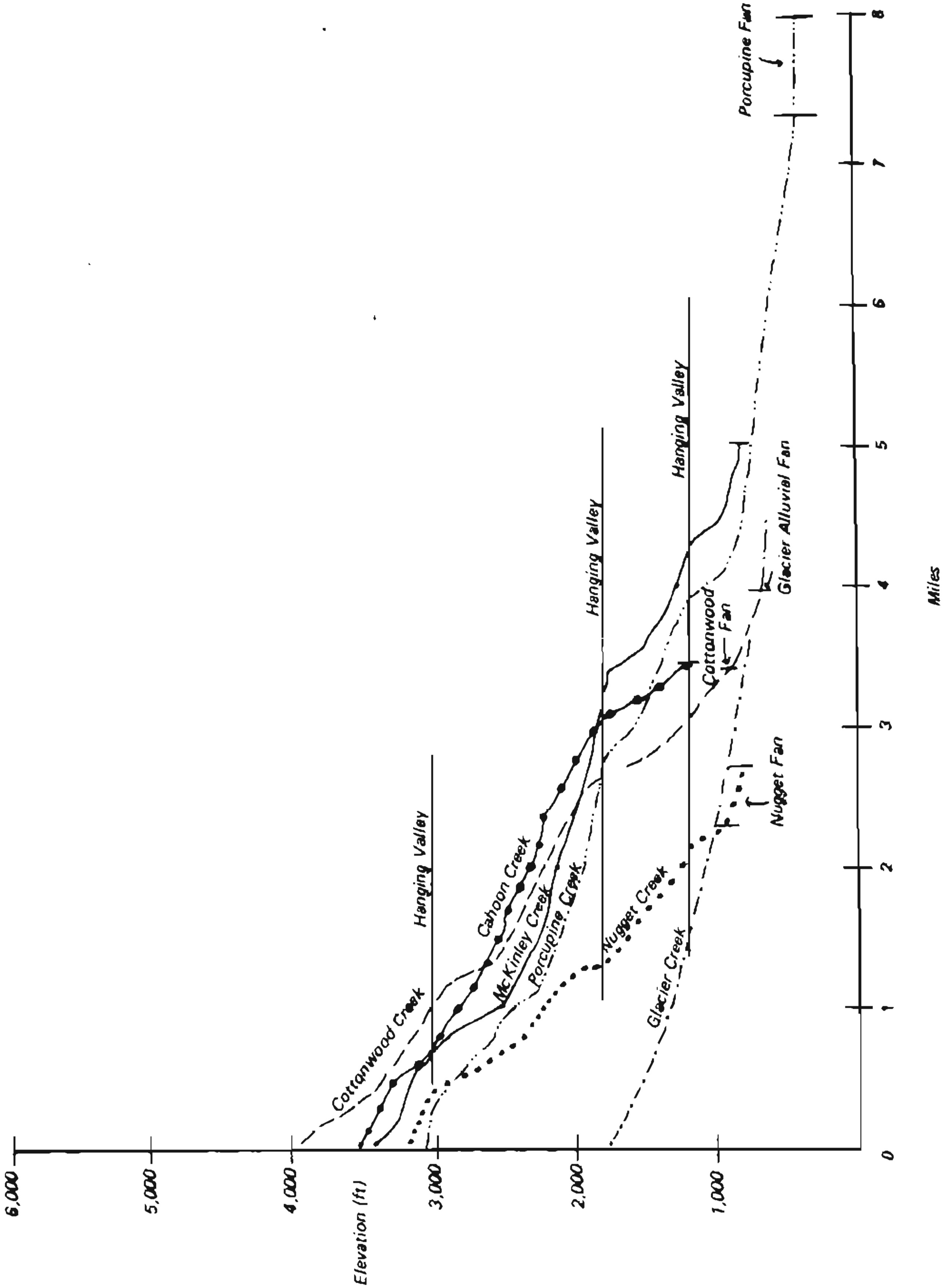

Figure 6. Stream gradients in the Porcupine district, Alaska.

Still and others (1985), and Bundtzen and Clautice (1986). The most likely bedrock sources are crosscutting quartz-sulfide-gold fissure veins associated with altered mafic dikes cutting Porcupine Slate in the McKinley and Cahoon Creek drainages. Localized silver-lead- (gold) deposits, such as those identified in the Summit Creek drainage may also contribute to heavy-mineral placer concentrations (Jan Still, oral commun., 1985). Placer gold in the Glacier Creek drainage and in the Herman Creek area may be derived from deposits in the Porcupine Slate, or alternatively from stratiform metallic mineral deposits in metavolcanic rocks such as the Glacier Creek and Nunatak deposits (MacKevett and Winkler, 1974; Still, 1984).

Table 2 summarizes trace element and gold fineness of placer gold collected during the course of investigations. DGGS samples are mainly reconnaissance concentrates collected from three to five panned samples, while many collected by USBM personnel are derived from processing 1/10 yard channel samples. The gold-fineness results are consistent with features observed in the field but the small sample sizes limit geologic interpretations. Because there are significant impurities in the bullion, gold fineness is expressed as a ratio of gold to silver + gold as suggested by Boyle (1979) and Metz and Hawkins (1981). Gold fineness on Porcupine Creek and its incised bench deposits ranges from 841 to 909 and averages 866(N=7). There does not appear to be a noticeable difference in fineness between the various elevated fluvial channels and the modern stream. Beatty (1937), mentions that the highest bench levels on Porcupine Creek has a distinctly lower fineness than bullion mined in the modern stream.

Placer-gold fineness from McKinley and Cahoon Creeks ranges from 786 to 859 and averages 821(N=4); gold extracted from two lode deposits averages 750. Hence the fineness predictably increases downstream with increasing distance from the probable lode sources in these two drainages (Koshman and Yugay, 1972). Fineness of placer gold on Nugget and Cottonwood Creeks averages 779(N=3), while that of Glacier Creek drainage averages 865(N=2), which is very similar to values found in lower Porcupine Creek.

The average overall fineness from the Porcupine district, using the Boyle (1979) method is 837, compared to 820 reported by Smith (1941), who used four records from the Porcupine Creek drainage for his analysis. The range of fineness in the Porcupine district is consistent with those reported by Moiser (1975) for epithermal and lower mesothermal temperatures of formation. Bullion was analyzed for the trace metals copper, lead, zinc, and antimony besides the precious metals. Significantly, samples containing detectable copper were found in McKinley and Cahoon Creeks, perhaps suggesting recent association with lode sources. The Au to Cu ratio is much too high for typical gold placers of any temperature range, but the presence of antimony in single samples on Cahoon and Porcupine Creeks also suggests formation in epithermal or lower meso-thermal temperature ranges (Moiser, 1975).

Heavy mineral concentrates from nine streams are summarized in table 3. A preponderance of magnetite in virtually all drainages suggests that magnetometer exploration techniques may be useful in delineating buried channels and other heavy mineral concentrations. Pyrite is predictably

Table 2. Trace element and gold fineness analyses from placer gold in the Porcupine mining district, Alaska.[1]

Field no.	Drainage basin locality (creek)	Sample weight (mg)	Gold (ppt)	Silver (ppt)	Copper (ppt)	Antimony (ppt)	Other (ppt)	True fineness[2]	Remarks
9047	Porcupine	21.64	794	140	15	50	1	850	Channel sample, 1/10 yard, Porcupine Creek.
9096	Porcupine	64.01	902	90	- -	- -	8	909	Channel sample 1/10 yard, out below plunge pool.
9081	Porcupine	35.36	817	145	- -	- -	38	849	Channel sample 1/10 yard, modern Porcupine channel.
9043	Porcupine	34.75	812	144	- -	- -	44	849	Channel sample 1/10 yard, bench upstream from cabin.
9002	Porcupine	64.94	822	155	- -	- -	29	841	3 pans on bedrock near landslide on 'a' bench west side of creek.
9037	Porcupine	67.18	838	107	- -	- -	55	886	Channel sample, 1/10 yard.
9119	Porcupine	50.70	838	115	- -	- -	47	879	1/2 pan, MacElvery channel, east-side Porcupine Creek.
9112	McKinley	65.82	811	187	- -	- -	2	813	Channel sample, 1/10 yard, on bedrock.
9109	McKinley	4.97	779	170	- -	- -	51	820	Channel sample, 1/10 yard, boulder layer under colluvium.
9106[3]	McKinley	33.74	669	259	22	- -	50	721	From sulfide vug, 'ladder vein'.
84BT313	McKinley	16.15	855	136	9	- -	0	859	3 pans, modern floodplain, boulder-rich.
84BT317a[3]	McKinley	8.15	780	219	- -	- -	1	780	From-Golden Eagle vug vein.
9054	Cahoon	70.10	738	201	37	11	13	786	Channel sample, 1/10 yard, on and in bedrock cracks.
9005	Glacier	36.60	855	136	- -	- -	9	863	Channel sample, 1/10 yard, 6 in. gravel on bedrock.
85BT25	Christmas	9.01	835	129	- -	- -	36	866	3 pans, from auriferous till on bedrock.
9061	Nugget	60.09	722	236	- -	- -	42	754	Channel sample, 1/10 yard, fluvial gravel and till.
85BT29	Nugget	28.40	756	207	- -	- -	37	785	3 pans, modern floodplain, not on bedrock.
85BT28	Cottonwood	18.30	769	193	- -	- -	38	799	3 pans, modern floodplain, not on bedrock.

[1]Gold bullion derived from channel and grab samples collected by Robert Hoekzema, Steve Fechner, Mark Meyer, and Nathan Rathburn (USBM) and Tom Bundtzen and Karen Clautice (DGGS). All elements presented in parts per thousand; gold and silver determinations by Peter Lee, Chemex Labs, Inc., Vancouver, B.C. V7J2C1, by Bondar Clegg Company, Ltd., Lakewood, Colorado, 80228 and by N.C. Veach, DGGS Mineral Laboratory, Fairbanks, Alaska 99709. Zinc and lead were looked for but not detected.

[2]'True Fineness' as defined by Boyle (1979, p. 197) is the ratio of gold to gold plus silver times 1000 or $\frac{Au}{Au + Ag} \times 1000$.

[3]Gold panned from 'hardrock' quartz-sulfide vein near Golden Eagle prospect (Bundtzen and Clautice, 1986).

- - = not detected.

Table 3. Mineralogical identifications of selected pan concentrates, Porcupine mining district, Alaska.

Field no.	Drainage	Major 15%	Minor (3-15%)	Trace 3%	Remarks/field notes
9043[1]	Porcupine	magnetite (60%)	sulfide	zircon magnetite	32 gold colors iron stained and smoothed on edges.
9012[1]	Porcupine	- -	pyrite magnetite	zircon garnet scheelite	24 gold colors; some shiny and rodlike.
9037[1]	Porcupine	magnetite (25%)	pyrite	zircon garnet	22 gold colors, Fe stained.
85BT32[2]	Porcupine 'Palmer'bench level (Qat_2)	magnetite (30%) ilmenite (10%)	pyrite sphalerite zircon	idocrase cassiterite(?) pyrrhotite	37 flat-shaped colors; 1-2 penny-weight nugget; gold in Fe rug-like features on bedrock; gold heavily Fe stained; derived from pyrite?
85BT35[2]	McKinley	pyrite (65%) magnetite (15%)	sphalerite (6-8%)	scheelite(30 grains) cassiterite pyrrhotite	7 colors - bright rounded 'glacial gold'?
84BT313/[2] 85BT42	McKinley	magnetite (65%) amphibole	garnet pyrite ilmenite	cassiterite bornite	150 colors; both chunky Fe stained type; bright rounded fine 100 mesh; USBM sample contains idocrase.
9054[1]	Cahoon	magnetite (70%)	garnet zircon	sulfide (pyrite)	128 colors of gold; biggest are smooth; some are bright and shiny and haven't traveled far.
85BT25[2]	Christmas Creek	magnetite (15%) ilmenite (10%)	pyrite barite	scheelite undetermined sulfides	6 colors of gold, smooth and bright, sample very clay rich.
85BT44/[2]	Glacier Creek	magnetite (25%) barite (15%)	amphibole/ pyroxene	undetermined sulfide	No gold observed; barite grains up to 0.5 cm diam.
85BT28[2]	Cottonwood Creek	pyrite (30%) magnetite (25%)	pyroxene	zircon	35 rounded to angular colors; USBM sample contains scheelite, olivine.
85BT29[2]	Nugget Creek	pyrite (45%) magnetite (35%)	- -	scheelite amphibole	Rounded colors = transport.
85BT55[2]	Herman Creek	barite (20%) magnetite (15%)	amphibole	- -	Abundant barite grains; no gold.
85BT57[2]	Marble Creek	magnetite (15%) sulfide (pyrite)	- -	ziron garnet	No gold observed, some pyrite as cubes up to 1 cm diam.

[1]Visual inspection including ultraviolet radiation by Steve Fechner, U.S. Bureau of Mines.
[2]X-ray diffraction analyses of 3.3 specific gravity fractions augmented by visual inspection and ultraviolet radiation; 1984 analyses by N.C. Veach; 1985 analyses by T.K. Bundtzen (ADGGS).

abundant in Porcupine, Cahoon, McKinley, Nugget and Cottonwood Creeks, where it could be derived from pyritiferous zones in the slate as well as epigentic-vein deposits. Scheelite and uncommonly cassiterite are present in McKinley, Cahoon, and Cottonwood Creeks but the minor concentrations are probably not economically noteworthy. Barite is abundant in Glacier Creek and in the immature placers of the Herman Creek area. Its presence in the Herman Creek drainage may suggest that barite mineralization may exist in metavolcanics underlying the thick glacial drift that blankets the area. Massive barite-sulfide deposits in metavolcanics at the head of Glacier Creek are probably the source of barite in this drainage.

Placer gold from McKinley, Porcupine, Nugget, and Christmas Creek was examined under the microscope in hopes of delineating characteristics of transport and origin of the bullion that has been mined. Consistently, two distinctive types of gold are present in the analyzed concentrates: well-worn, rounded, bright 'nugget' gold that shows evidence of fluvial transport and small, wire-like grains with quartz and undetermined gangue mineralogy that shows little evidence of stream transport. There may be either more than one lode source present, or alternatively, proximal lode gold and 'nugget' gold that has been transported by fluvial mechanisms.

Hoekzema and others (1986) and Beatty (1937) have noted a general lack of fine gold (150 mesh or smaller) in the Porcupine district. The extremely high-energy nature of placer formation in the district suggests that virtually all fine gold has been flushed down the streams and possibly out of the study area. However, the Glacier, Porcupine, and Nugget alluvial fans represent significantly lower energy fluvial environments than those of the main feeder streams entering the lower valleys, suggesting that alluvial fans may have accumulated part of the fine-gold fraction absent in the main-production streams.

Gold was panned from a thick section of glacial till exposed in Christmas Creek, a tributary of Glacier Creek. The gold was apparently interspersed throughout at least the lower 6 ft of till with no apparent concentration on bedrock. The bullion is very fine-grained, well-worn 'glacial' gold possibly due to milling effects of glaciation. Although Christmas Creek was the only locality where gold was recognized in till, its existence, as well as that mentioned in till by Beatty (1937) in other drainages, suggests that 'glacial gold' may be an intermediate host between hard-rock sources and downstream accumulations in fluvial deposits.

ECONOMIC POTENTIAL

Mining ventures have exploited much of the best ground on Porcupine Creek and its tributaries and account for 95 percent of the production of the district. Hoekzema and others (1986) completed reconnaissance channel sampling efforts and present volume and grade estimates for the placers of the district. Because their sampling efforts are more extensive then those performed here, there will only be brief comments on the most promising potential by drainage. Where data permits, estimates are provided of bedrock footage of unmined channels or paystreaks left in the district.

Porcupine Creek Bench Levels

Figure 7 and plate 1 depict a series of bedrock-incised, ancestral-fluvial channels of at least three ages in Porcupine Creek valley, each formed during glaciofluvial activity previously described. The original channel designations by Beatty (1937) are correlated with the assigned geologic units on plate 1.

According to Beatty (1937):

> "Channels 'a', 'b', 'c', and 'd', because of good bedrock conditions, are considered likely to contain placer concentrations in natural riffles formed by the bedrock. Channel 'a' is the narrowest and the steepest of all; the stream coming down that channel must have been very rapid. These conditions make this less likely to be of value than others. However, the fact that a later wing of the stream cut off the lower portion of this channel, leaving a bluff twenty ft high across the end makes a section where bedrock may quickly be reached for hand prospecting...The greater widths, more gradual slopes (gradients) and considerably greater lengths of channels 'b' and 'e' make these more favorable for consideration...Depth to bedrock in these channels is unknown, but if the upper open channels of 'b' and 'c' prove to be profitable, a geophysical survey of their extensions in bedrock under the patented ground -- the channels to be mined...Porcupine Creek was carrying gold at the time it was occupying these three channels."

Table 4 summarizes estimated bedrock footage of unmined paleochannels of various ages as well as presumably unmined sections of modern streams in the Porcupine Creek. Above the mouth of McKinley Creek, the estimates are quite tenuous because there was little field checking, but below this stream juncture, the estimates are made using 11 field-checked exposures, aerial photographs, and graphic representations originally presented by Beatty (1937). The various paleochannels below the McKinley Creek mouth are estimated to possess 155,000 bedrock ft of potentially auriferous surfaces. When considering poorly exposed bench levels of uncertain correlation in Cahoon and McKinley Creeks, the bedrock footage totals 420,000. The paleochannels of all ages generally cover very irregular bedrock surfaces (figs. 8 and 9); incisions of 3 to 8 ft are common. Important mining considerations are the narrow pay channels and steep, exposed channel areas, which usually preclude the ability to conduct conventional 'cat-mining' techniques. The boulder-rich overburden and fluvial gravels also commonly contain up to 30 percent glacial erratics of 3 to 20 ft diam. The highly irregular nature of the pay surface also precludes conventional scraping and ripper techniques, which usually 'rip' the bedrock to a depth of up to 4 ft, and are often employed in Interior placer districts. However, because some of the earlier ground averaged 0.1 oz/yd (Beatty, 1937), rich pockets remaining in the bench levels may be economically extractable using smaller scale mining methods.

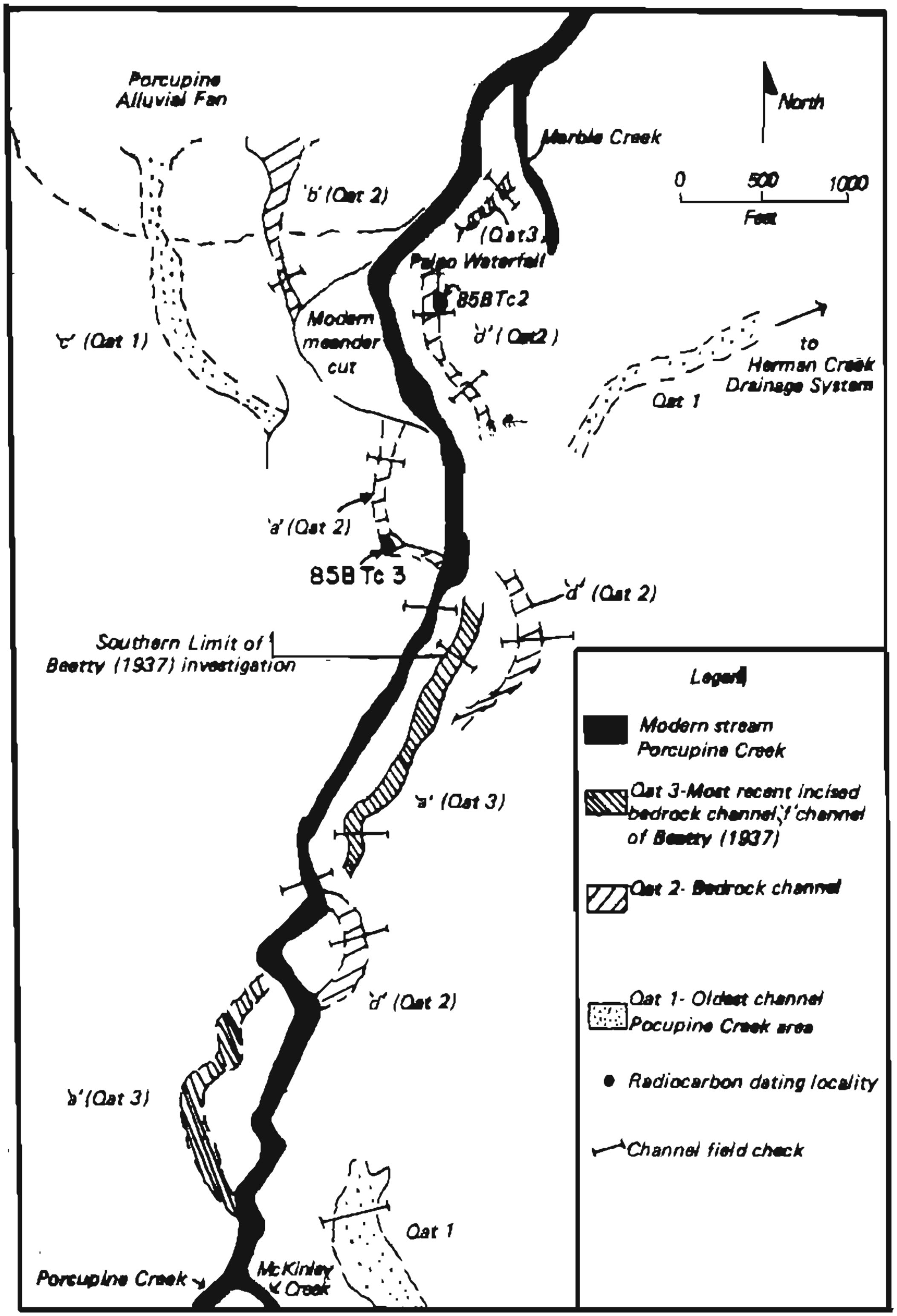

Figure 7. Location of paleo-fluvial channels that are incised into bedrock from the mouth of McKinley Creek to the Porcupine Creek alluvial fan, Porcupine district, southeastern Alaska.

Table 4. Estimated bedrock footage of paleochannels and unmined stream sections, Porcupine Creek drainage, Porcupine mining district, Alaska.

Channel/stream	Estimated bedrock footage	Remarks
Qat_1, Porcupine Creek	15,000	Never exploited width of bedrock incision estimated with aerial photographs.
Qat_2, Porcupine Creek	'b' - 21,000 'a' - 18,750 'd' - 51,750	Bedrock widths based on 5 field checked localities and aerial photographs 'd' channel 35% mined out.
Qat_3, Porcupine Creek	48,500	Bedrock widths field checked in 4 locations only on eastern limit of Porcupine Creek.
Modern stream Porcupine Creek	100,000	Based on previous Beatty (1937) descriptions and 2 field checked localities.
Cahoon Bench (Qat_2?)	65,000	Not field checked, assumed 20-ft-wide channel.
Modern Cahoon Creek	140,000	Not field checked, inference from Beatty (1937).
McKinley Bench (Qat_1(3), Qat_2(?),	200,000	Not extensively field checked; inference from aerial photographs.
Modern McKinley Creek	unknown	

Modern Channel of Porcupine Creek

Almost all of Porcupine Creek from a point 2,400 ft above the confluence of the 'dry' channel (Beatty 1937) to 800 ft below the canyon breakout has been mined out during at least 35 full mining seasons from 1898 to 1960 (Beatty, 1937; Williams, 1960). However, an estimated 3,500-ft-long section of the channel up to its confluence with the mouth of McKinley Creek has had very little mining activity, and was virtually untouched prior to World War II. However, the lack of mining activity reflects the extreme difficulties that must be encountered when attempting to exploit this narrow, precipitous portion of Porcupine Canyon. Conventional 'cat-mining' in the narrow canyon would be very difficult, if not impossible, and some method of stream diversion would be necessary to prepare the modern channel for exploitation. The same conditions of glacial erratics and fluvial material content mentioned for bench gravel also exist for the modern stream. However, existence of rich pockets throughout the canyon suggest small-scale exploitation is possible.

Figure 8. Exposed 'a' channel (Qat_2, fig. 7) on the western limit of Porcupine Creek after mining activities. Note highly irregular bedrock surface.

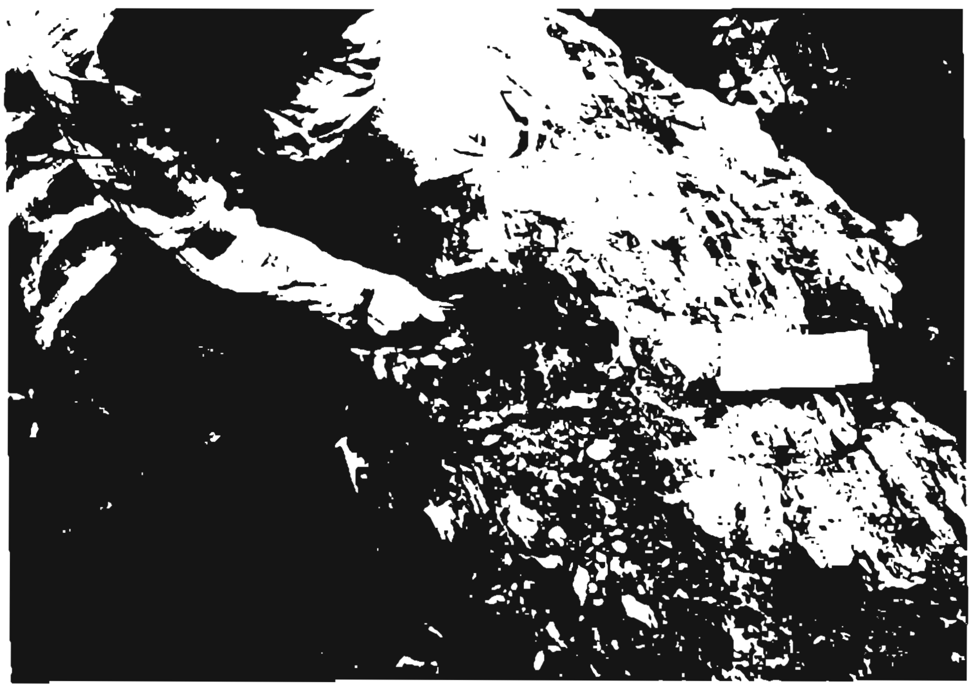

Figure 9. Gossanous cavity on bedrock surface at site shown in figure 8.
Rich pay was panned here.

Bench and Modern Fluvial Channels of Cahoon Creek

Gravels were not examined in the Cahoon Creek drainage. Based on work by Beatty (1937), unworked placers may extend along the entire stream drainage with the exception of the last half mile near the mouth and the section at the head of the creek, immediately proximal to the modern glacier. Cahoon Creek yielded the coarsest gold in the district and 30 pennyweight nuggets were not uncommon.

McKinley Creek

Much of lower McKinley Creek has been thoroughly worked, sometimes as many as four times (J. Jurgeleit, oral commun., 1985). However, much of the upper portion of the creek, especially those sections above the junction of Cahoon Creek, has not been explored because "the early prospectors claimed there was no pay on McKinley Creek above Cahoon Creek" (Beatty, 1937, p. 53). Prospecting and development work by James McLaughlin during the last few years shows pay in the 0.01 to 0.03 oz/yd range at the 1,750 to 1,820 ft elevation of the modern stream. A three-tier bench level on the right limit below the 'second waterfall' also contains significant gold values and deserves to be prospected (fig. 10).

Gold has been successfully exploited at the base of waterfalls on McKinley Creek and cleanups of up to several thousand ounces were said to have been recovered in past years (fig. 10).

Summit, Cottonwood and Nugget Creek Alluvial Fans

The headward portions of both Cottonwood and Nugget Creeks are very high-energy streams originating in a multi-tiered hanging valley on the south side of the study area. These streams cut through slate-phyllite bedrock, and except for small, isolated pockets, do not contain appreciable heavy-mineral concentrations or even fluvial sediments because most of the material has been flushed downstream into the lower valleys of the Tsirku River drainage. The creeks are filled with granitic erratics (3 to 9 ft diam), which account for up to 70 percent of the float by volume.

All three streams form small alluvial fans at the hydraulic flexure point of the lower valley and canyon breakout, and these fans are the principal auriferous prospects. Nugget Creek produced several hundred ounces of bullion in early years and probably is the best prospect of the three. Gold was panned from at least two 'false bedrock' silt surfaces above bedrock, as well as in exposed-bedrock cuts. I roughly estimate that 250,000 and 175,000 bedrock ft exist in multiple-distributary channels of the Cottonwood and Nugget Creek alluvial fans respectively. These two streams reportedly did not contain the rich grades of pay that were encountered in the Porcupine Creek drainage, a fact that probably explains the modest gold production (300 oz) to date. However it is significant that coarse detritus including granitic erratics are largely absent especially in the Nugget Creek alluvial fan. Of all the auriferous gravels known in the Porcupine district, those of Cottonwood and Nugget Creeks are among the most amendable to conventional mechanized 'cat-mining,' the dominant mining method in Alaska today.

Figure 10. Upper or 'second' waterfalls, McKinley Creek, looking north.

Very little is known about auriferous pay on Summit Creek; the mouth is clogged with granitic erratics and coarse detritus in contrast to material at the mouths of Cottonwood and Nugget Creeks.

Glacier and Porcupine Creek Alluvial Fans

Beatty (1937) originally discussed the economic possibilities of this potentially large-yardage prospect. A composite alluvial fan formed by the confluence of Glacier and Porcupine Creeks with the Klehini River covers approximately 800 acres in the northern part of the area. The Porcupine Creek portion of the fan covers about 350 acres and represents the main placer-exploration target. The limits of the Porcupine Creek fan were roughly determined in the field by the presence or absence of greenstone float, which could have only been derived from the head of Glacier Creek.

Drillholes have been sunk to a depth of 75 ft without reaching bedrock and the total depth of the fan is unknown. Figure 11, adapted from Beatty (1937), illustrates the fan configuration. The Klehini River has been pushed against the north wall of the valley through time, allowing the Glacier and Porcupine composite fan to form a broad terrace-like landform south of the river. The probable distal portion of the fan is underneath the active portion of the Klehini channels and is much larger than the terrace-like landform seen today. The fan has accumulated over several glaciofluvial episodes and has corresponding levels and points of apex as it leaves the canyon breakout into the Klehini River valley. Hence, it seems likely that much of the fine gold, presumably eroding from hardrock sources in the Porcupine-Cahoon-McKinley Creek drainage basin, was flushed down the high energy canyon and deposited in the significantly lower energy environment of the fan complex. Sampling by Hoekzema and others (1986) confirms that gold values exist in the fan but a detailed subsurface examination involving either drilling or tracing magnetite strandlines and channels with geophysical methods seems warranted.

REFERENCES CITED

Beatty, W.B., 1937, Geology of the Placer deposits of Porcupine, Alaska: Pullman, University of Washington unpublished Mining Engineering and Geology B.S. thesis, 97 p.

Boyle, R.W., 1979, The geochemistry of gold and its deposits: Geological Survey of Canada Bulletin 280, 584 p.

Bundtzen, T.K., and Clautice, K.H., 1986, Prospect Examination of the Golden Eagle Lode-Gold Prospect near Porcupine, Skagway B-4 Quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data File 86-18, 7 p.

Clague, J.J., 1975, Late Quaternary sea level fluctuations, Pacific Coast of Canada and adjacent areas: Geological Survey of Canada Paper 75-1C, p. 17-21.

Eakin, H.M., 1919, The Porcupine gold placer district, Alaska: U.S. Geological Survey Bulletin 699, 29 p.

Hoekzema, Robert, Fechner, Steve, and Bundtzen, Tom, 1986, Distribution, analysis, and recovery of gold from Porcupine district, Alaska: U.S. Bureau of Mines OFR report, 35 p. (in press).

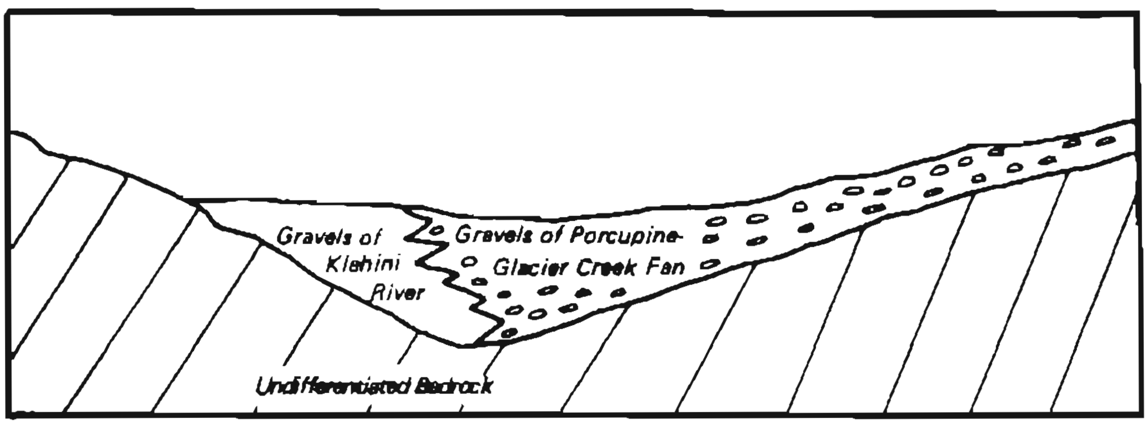

Figure 11. Cross section of Porcupine and Glacier Creeks at confluence of Klehini River, adapted from Beatty (1937).

Hudson, Travis, Plafker, George, and Rubin, Meyer, 1976, Uplift rates of marine terrace sequences in the Gulf of Alaska, in Cobb, E.H., ed., The United States Geological Survey in Alaska---Accomplishments during 1975: U.S. Geological Survey Circular 733, p. 11-13.

Koshman, P.N., and Yugay, T.A., 1972, The causes of variation in fineness levels of gold placers: Geochemistry International, 1972, p. 481-484 (Translated in english from Geokhimixa 6, p. 750-753).

MacKevett, F.M., Jr., and Winkler, R., 1974, Geology of the Skagway B-3 and B-4 Quadrangles, Southeastern Alaska: U.S. Geological Survey Professional Paper 832, 33 p.

Mann, D.H., 1986, Wisconsin and Holocene Glaciation in southeast Alaska, in Hamilton, T.D., Reed, K.M., and Thorson, R.M., ed., Glaciation in Alaska, the Geologic Record: Alaska Geological Society, p. 237-261.

Metz, P.A., and Hawkins, D.B., 1981, A summary of gold fineness values from Alaska placer deposits: University of Alaska Mineral Industry Research Laboratory Report No. 45, 63 p.

Moiser, E.L., 1975, Use of emission spectroscopy for semiquantitative analysis of trace elements and silver in native gold, in Ward, F.N., ed., New and refined methods of trace element analysis useful in exploration: U.S. Geological Survey Bulletin 1408, p. 97-105.

Molnia, B.F., 1986, Glacial history of the northeastern Gulf of Alaska---A synthesis, in Hamilton, T.D., Reed, K.M., and Thorson, R.M., ed., Glaciation in Alaska the Geologic Record: Alaska Geological Society, Anchorage, Alaska, p. 219-236.

Péwé, T.L., 1975, Quaternary Geology of Alaska: U.S. Geological Survey Professional Paper 835, 145 p.

Redman, E.R., Gilbert, W.G., Jones, B.K., Rosenkrans, D., and Hickok, B.D., 1985, Preliminary bedrock geologic map of the Skagway B-4 Quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigation 85-6, scale 1:63,360.

Rennick, Penny, and Doogan, Kathy, editors, 1984, The Chilkat River Valley: Alaska Geographic, v. 11, n. 3, 111 p.

Robinson, M.S., and Bundtzen, T.K., 1979, Historic gold production in Alaska ---a minisummary: Alaska Division of Geological and Geophysical Surveys Mines and Geology Bulletin, v. 28, n. 3, p 1-4.

Smith, P.S., 1933, Past placer gold production from Alaska: U.S. Geological Survey Bulletin 857, 19 p.

Smith, P.S., 1941, Fineness of gold from Alaska Placers: U.S. Geological Survey Bulletin 910C, p. 147-269.

Still, J.C., 1984, Stratiform massive sulfide deposits of the Mt. Henry Clay area, southeast Alaska: U.S. Bureau of Mines Open-file Report 118-84, 65 p.

Still, J.C., Weir, K.R., Gilbert, W.G., and Redman, E.R., 1985, Stream sediment, float, and bedrock sampling in the Porcupine mining area, southeast Alaska: U.S. Bureau of Mines Open-file Report 173-84, 9 p.

Williams, J.A., 1960, Report for the Year 1960: Division of Mines and Geology Annual Minerals Report, 67 p.