Placer Gold of the Kenai Lowland

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Abstract

A geochemical survey of the Kenai lowland, Cook Inlet basin, Alaska, produced stream-sediment and heavy-mineral-concentrate samples that were consistently anomalous in gold. Stream-sediments with as much as 2.8 ppm Au and heavy-mineral-concentrate samples with up to 700 ppm Au are believed to reflect reworked material from Quaternary glacial deposits and (or) from the upper part of the Tertiary Kenai Group. Gold grains are generally concentrated in the -35-mesh to +230-mesh size fractions. Concentrations of heavy minerals from an outcrop of Quaternary or Tertiary partly lithified conglomerate along the Fox River reveal that at least some of the gold was derived from the Chugach terrane to the east. Although no specific placer or lode occurrences that have resource potential have been identified, geomorphic processes in the Kenai lowland may have formed small, locally economic, undiscovered placer concentrations.

INTRODUCTION

Metallic mineral resources are largely unrecognized within the southern Kenai lowland of south-central Alaska (fig. 1). The only confirmed mineral production in the study area (fig. 1) is from a small placer gold occurrence mined intermittently from 1889 to 1911 at the mouth of the Anchor River (Cobb, 1973). Fine gold was found in thin layers of gravel <1 m below the surface of the beach (Martin and others, 1915). Platinum was rumored to occur with the gold (Cobb, 1973). Martin and others (1915) also reported placer activities in the Kenai lowlands to the north of the present study area, near Ninilchick and between the Killey River and Kenai, but the success of these operations is unknown. Presently, placer-gold claims exist along Cook Inlet at Anchor Point and about 2 km north of the mouth of Diamond Creek (U.S. Bureau of Mines MAS deposit listings). A lode-gold claim is also recorded from the beach within 1 km of the mouth of Diamond Creek. Little is known about this claim, but it most likely includes rocks of the Tertiary Kenai Group and (or) overlying Quaternary gravels exposed in the beach cliffs.

As part of the Alaska Mineral Resources Appraisal Program (AMRAP) study of the Seldovia 1° by 3° quadrangle, we conducted geological and geochemical studies in the southern Kenai lowland. Results from the studies indicate a widespread distribution of detrital gold grains in stream alluvium. This report details and discusses the significance and possible origin of widespread, anomalous gold values in stream-sediment and rock samples from this area. These findings are surprising because previous reports of gold in this populated region are restricted to the beach claims described above.

REGIONAL GEOLOGY

The Kenai lowland is part of the Cook Inlet Basin, an active forearc basin of the present day Aleutian-Alaska Range subduction zone (Magoon and Egbert, 1986). The basin is flanked to the west by active volcanoes that are built on older arc basement and to the east by an uplifted Mesozoic accretionary prism (the Chugach terrane) composed mainly of mafic volcanic rocks, chert, argillite, and graywacke. The Kenai lowland is characterized by gentle to flat topography, except near shoreline escarpments, and by an abundance of fair to poorly drained marshland. The lowland is covered by Quaternary alluvial and glacial deposits that are underlain by sedimentary rocks of the Tertiary Kenai Group (Magoon and others, 1976). Only the two youngest formations of the Kenai Group—the Beluga Formation and the overlying Sterling Formation—are exposed within our study area.

The Miocene Beluga Formation consists of up to 1,525 m (5,000 ft) of claystone, siltstone, thin sandstone, and subbituminous coal (Hartman and others, 1972). The Beluga Formation crops out in cliffs along the shore of Kachemak Bay to the northeast of Homer and along the shore of Cook Inlet northwest of Homer. Only the upper few hundred meters are exposed; the remainder is known from subsurface studies (Hayes and others, 1976). Paleocurrent directions are toward the west-northwest (Rawlinson, 1984). The most abundant sandstone framework grains in the Beluga Formation are weakly metamorphosed sedimentary rocks comparable to those exposed in the Kenai Mountains to the east (Hayes and others, 1976). The heavy-mineral assemblage, which is dominated by epidote, garnet, apatite, and zircon, also is consistent with an easterly source (Hayes and others, 1976). Flores and Stricker (this volume) interpreted the Beluga Formation as having been deposited by an anastomosing fluvial system; alternatively, Hayes and others (1976) and Rawlinson (1984) interpreted it as having been deposited by braided streams.

The late Miocene and Pliocene Sterling Formation consists of more than 3,050 m (10,000 ft) of massive sandstone and conglomerate, which are interbedded with thin claystone and lignite (Hartman and others, 1972). Rocks of the Sterling Formation are intertongued with those of the underlying Beluga Formation. Extensive exposures of the Sterling Formation occur along Kachemak Bay, along the Fox River north of Kachemak Bay, and around Epperson Knob and Lookout Mountain in the Anchor River drainage. Only the lowest 700 m of the Sterling Formation crops out, the remainder being known in the subsurface. Evidence summarized by Hayes and others (1976) indicates that the Sterling Formation was mainly derived from sources to the west. West-northwesterly paleocurrent directions measured at Kachemak Bay near the eastern basin margin, however, also indicate a sediment source in the Kenai Mountains (Rawlinson, 1984). Sandstone framework grains in the Sterling Formation consist of quartz, plagioclase, biotite, and glassy volcanic rock fragments and suggest derivation from the magmatic arc to the west (Hayes and others, 1976). The heavy-mineral assemblage, which is dominated by hornblende and pyroxene, also suggests an arc source (Kirschner and Lyon, 1973; Hayes and others, 1976). A meandering stream depositional environment has been widely accepted for the Sterling Formation (Hayes and others, 1976; Rawlinson, 1984: Flores and Stricker, this volume).

Quaternary surficial deposits form a discontinuous mantle that unconformably overlies the Kenai Group. These deposits of till, outwash, and glaciolacustrine mud vary in thickness from 0 to 320 m; the thickest Quaternary section is in an exploratory well near Kenai (Calderwood and Fackler, 1972). At least five major Pleistocene and two minor post-Pleistocene glaciations

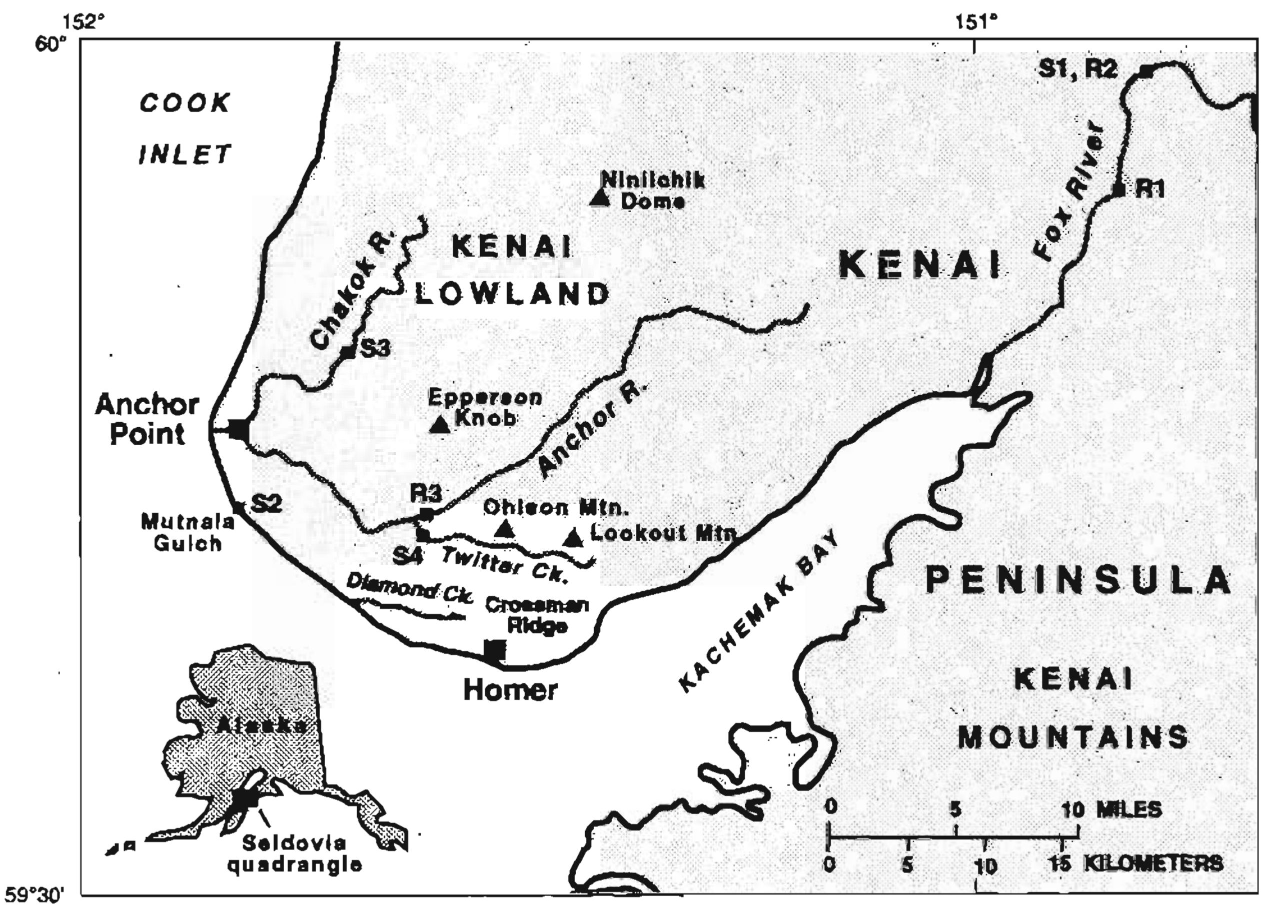

Figure 1. Site location map for sluice-concentrate and rock samples in Kenai lowland.

have been identified in the Kenai lowland (Karlstrom, 1964). In the Seldovia quadrangle, direct evidence for four Pleistocene ice advances is provided by moraines and related ice-marginal deposits of the Caribou Hills, Eklutna, Knik, and Naptowne (listed from oldest to youngest; Karlstrom, 1964).

Tertiary strata in the Kenai lowland generally can be discriminated from the Quaternary deposits on the basis of two characteristics—the presence of coal, and partial to complete lithification. However, a problematic succession of variably lithified, gold-bearing gravel and conglomerate occurs in 50-m-high bluffs along the upper part of the Fox River at location S1 (fig.1); these deposits deserve special mention. Weakly statified, clast-supported gravels occur in beds up to 10 m thick and are associated with thick beds (several meters thick) and thinner lenses of weakly lithified to unlithified sand. Some conglomerate beds are sufficiently lithified to occur as talus blocks at the foot of the bluff. Clasts (the largest are about 20 cm long) include melange, graywacke, and greenstone; chert of the McHugh Complex; and hornfelsed metapelite of the Valdez Group. The clasts indicate an easterly sediment source in the Kenai Mountains. Bedding dips about 15° W. Similar deposits that fill paleovalleys among the the southeastern shore of Kachemak Bay have been assigned to the Tertiary Kenai Group on the basis of abundant plant fossils (Magoon and others, 1976). However, published maps of the regional bedrock geology (Magoon and others, 1976) and surficial geology (Karlstrom, 1964) have assigned the unfossiliferous upper Fox River outcrops to the Quaternary. In light of bedding dips, degree of lithification, and similarities to known Tertiary strata along the Kenai Mountain front, we favor the interpretation that the upper Fox River gravels are Tertiary in age and represent proximal alluvial-fan deposits that are laterally equivalent to fluvial deposits of the Beluga and (or) Sterling Formations. However, the possibility that the gold-bearing conglomerates and gravels are indeed Quaternary remains viable.

REGIONAL GEOCHEMISTRY

Stream-sediment and heavy-mineral-concentrate samples were collected at 75 sites within the Kenai lowland as part of an extensive regional geochemical reconnaissance survey of the Seldovia 1° by 3° quadrangle. Samples were collected between Cook Inlet and the Fox River, with the majority located south of Ninilchik Dome along first- and second-order tributaries to the Chakok and Anchor Rivers. At least five grab samples were collected at each site along a 9-m stretch of stream channel. The grab samples were composited into a single sample, air-dried, sieved in the laboratory using a stainless-steel 80-mesh screen, and pulverized prior to chemical analysis. Heavy-mineral-concentrate samples were collected at all sediment sites using a 14-in.-diameter gold pan. Typically, 3 to 4 kg of composited sediment were collected and panned, yielding the desired 30 to 60 g of concentrate. Remaining lightweight material was separated by floatation in bromoform (specific gravity 2.86), and the resulting heavy-mineral fraction was separated into magnetic, semimagnetic, and nonmagnetic fractions using a Frantz Isodynamic Separator.

Both the stream-sediment sample and the nonmagnetic heavy-mineral-concentrate fraction were analyzed for minor and trace elements by emission spectrography according to the method outlined by Grimes and Marranzino (1968). Owing to the relatively high lower limits of detection for emission spectrography, more sensitive analytical methods were used on stream-sediment samples. They were analyzed for Ag, As, Au, Bi, Cd, Cu, Mo, Pb, Sb, and Zn by inductively coupled plasma spectroscopy (ICP) following the method of Motooka (1988). Lower determination limits for the method for gold and silver are 0.045 and 0.15 ppm, respectively. Gold concentrations were also determined by flame atomic absorption (Thompson and others, 1968) for about half the stream-sediment samples and by graphite furnace atomic absorption spectrophotometry (Meier, 1980) for the remaining stream-sediment samples. Samples that registered below the lower determination limit for flame atomic absorption were analyzed using the graphite furnace method. Lower determination limits are 0.05 and 0.002 ppm for the two methods, respectively.

Anomalous concentrations of gold were identified in stream-sediment samples from 27 of the 75 sampled sites. Graphite furnace atomic absorption data indicate an anomaly threshold value of 0.007 ppm for gold in stream sediments from the Kenai lowland. Fourteen of the sediment samples contain at least 0.012 ppm Au, and eight of these contain 0.3 to 2.8 ppm Au. Highest values were found in samples collected just above the beach in Mutnaia Gulch (1.0 ppm), along a tributary to the Anchor River in sec. 22, R. 14 W., T. 5 S. (1.8 ppm), and from another tributary to the Anchor River along the east side of the Sterling highway about 1.5 km north of the Anchor River campground (2.8 ppm). No other anomalous metals were found consistently in stream-sediment samples containing anomalous gold. Silver concentrations for all 75 stream-sediment samples were at background levels, ranging from not detected at the 0.045-ppm lower determination limit to 0.080 ppm. A few samples with anomalous gold values contained 30 to 40 ppm As, but most arsenic values were below 20 ppm.

Sixteen of 71 heavy-mineral-concentrate samples contained anomalous gold concentrations ranging from 20 ppm to 700 ppm. In addition, three other samples had detectable gold but at levels below the 20 ppm lower determination level. Small flakes of gold were commonly visible in these samples when viewed with a 10X hand lens in the field. The majority of these samples were from sites that lacked anomalous gold concentrations in corresponding stream sediments. Similarly, most sites with anomalous gold concentrations in stream-sediment samples yielded heavy-mineral-concentrate samples that lacked anomalous gold. The lack of correlation suggests that (1) gold grains are relatively fine and easily lost during the panning process, and (2) gold grains likely occur in many other heavy-mineral-concentrate samples but in concentrations below the 20-ppm lower determination level. Anomalous silver values of 1 to 20 ppm in heavy-mineral-concentrate samples characterize most of the sites with gold anomalies in stream-sediment or heavy-mineral-concentrate samples. Molybdenum, tin, and tungsten are commonly found at anomalous levels in many of the heavy-mineral-concentrate samples from throughout the Kenai lowland. Most of these samples contain microscopically visible scheelite; molybdenite was identified in one sample (Richard Tripp, unpub. data). Whereas these metals show no distinct correlation with the gold and silver anomalies, they do suggest a strong igneous component within the Tertiary sedimentary rocks that are the source for much of the stream sediment.

The regional geochemical data indicate a widespread distribution of gold grains in the Kenai lowland. The distribution, as well as the commonly delicate morphology of gold flakes viewed with a hand lens, suggest an extensive, locally derived source. Brooks (1911) speculated that the gold was derived either from rocks of the Tertiary Kenai Group or from overlying glaciofluvial gravels; our data allow both possibilities.

FOLLOWUP INVESTIGATION

Sediments

Three stream channel localities that contained samples with anomalous gold collected during the regional investigation were revisited for more detailed study of the placer material. Bulk samples were collected at Mutnaia Gulch (site S2), on Chakok River (site S3), and on Twitter Creek (site S4). These sites (fig.1) had yielded samples with anomalous concentrations of gold in sediment only, both concentrate and sediment, and concentrate only, respectively.

In an effort to better estimate the amount of gold at the three sites, sixteen 14-in.-diameter gold pans of alluvium were sluiced at each site. The sixteen pans approximately equal one-sixteenth of a cubic yard of alluvium. This quantity is sufficient to remove the "nugget effect" from analyses (S. Fechner, oral commun., 1991). The alluvium was sieved using a 10-mesh (2.0-mm) stainless-steel screen prior to being placed into the sluice. The sluice was arranged in each stream so that water velocity carried a 1-in.-diameter pebble through at a slow, steady rate. Material that did not wash away was saved for analysis. A thorough cleaning of the sluice between samples ensured minimal contamination.

Table 1. Concentrations of gold in nonmagnetic fractions of sluice concentrates from selected stream sample sites in the Kenai lowland, Alaska

[Values in parts per million]

Sample	S2	S3	S4
Mesh size:			
−10 to +18	<0.002	<0.002	<0.002
−18 to +35	<0.002	<0.002	<0.002
−35 to +80	920	120	700
−80 to +230	840	520	380
−230[a]	8.6	5.2	160

[a]Values include combination of magnetic, semimagnetic, and nonmagnetic fractions because −230-mesh fraction was too small for effective use of the magnetic separator.

Site S2, S3, and S4 samples were air dried in the laboratory before being sieved into five size fractions (−10-mesh to +18-mesh, −18-mesh to +35-mesh, −35-mesh to +80-mesh, −80-mesh to +230-mesh, and −230-mesh). Lightweight material from each fraction was separated by floatation in bromoform (specific gravity 2.86), and the resulting heavy-mineral fraction was split into magnetic, semimagnetic, and nonmagnetic fractions using a Frantz Isodynamic Separator. Semimagnetic and magnetic fractions were analyzed for gold by emission spectrography using the method outlined by Grimes and Marranzino (1968). The nonmagnetic fraction was analyzed for gold using flame atomic absorption (Thompson and others, 1968). The lower determination limits for the two are 20 and 0.050 ppm, respectively.

The semimagnetic and magnetic fractions contained no detectable gold at any site in any of the five sieve catagories. The nonmagnetic fraction, however, contained gold in three of the size fractions for sites S2, S3, and S4: −35-mesh to +80-mesh, −80-mesh to +230-mesh, and −230-mesh (table 1). The −35-mesh to +80-mesh and the −80-mesh to +230-mesh fractions contained the bulk of the gold, whereas no gold was found in the −10-mesh to +18-mesh and the −18-mesh to +35-mesh fractions. Sample site S2 had the greatest concentrations of gold with 920, 840, and 8.6 ppm in the −35-mesh to +80-mesh, −80-mesh to +230-mesh, and −230-mesh fractions, respectively. All of the sluice samples contained visible gold when viewed with a 10X hand lens in the field.

Site S2 is located at the mouth of Mutnaia Gulch on the shore of Cook Inlet. It is a small, steplike stream

(<2 m across) of moderate gradient with water depth never exceeding 0.3 m in the sampling area. The sample was obtained from the drainage above possible tidal influence. The Beluga Formation crops out at the beach and on both sides of the gulch. Site S3 on Chakok River predominantly drains Quaternary sediments. However, within its drainage basin to the east is Epperson Knob, which consists of the Sterling Formation. The sampled stream is 3 to 4 m across, with depths to 1.5 m on some cutbanks. It has a low gradient, meanders, and has alluvium ranging in size from silt to cobble. Site S4 is located on Twitter Creek just north of Homer. It mainly drains the Sterling Formation of Ohlson Mountain, Crossman Ridge, and Lookout Mountain, but the Beluga Formation is present on some of the lower stretches near the Anchor River. It is of low to moderate gradient, 1.5 to 3 m across, and 0.3 to 1 m deep.

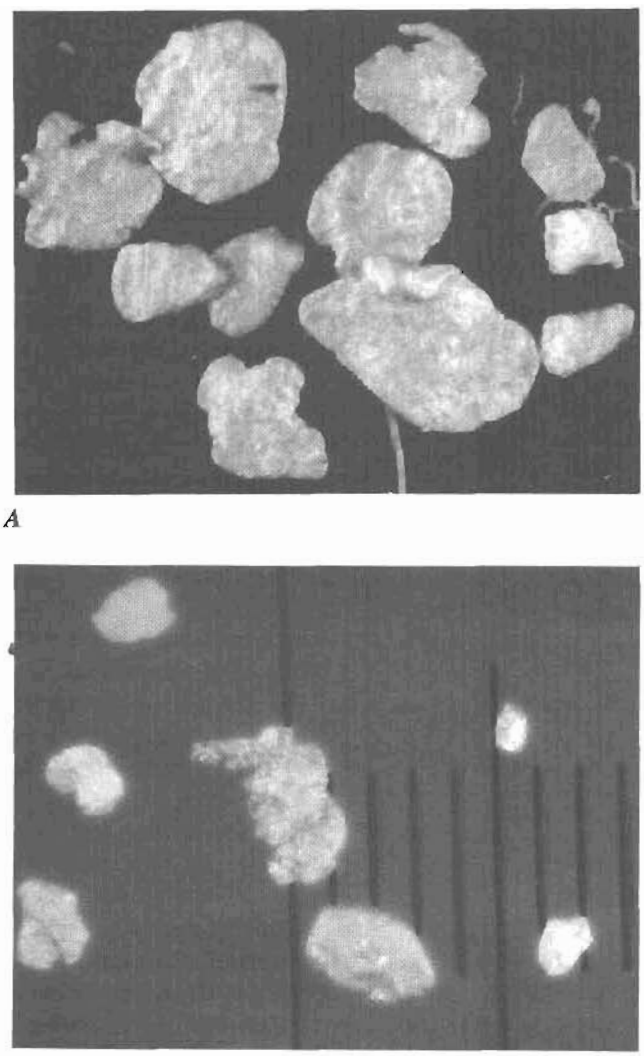

Figure 2. Gold grains from two sluice-concentrate sites within Kenai lowland. A, Grains from sample site S2. Longest gold grain is approximately 1 mm across. *B*, Grains from sample site S1.

Table 2. Concentrations of gold of rock samples from the Kenai lowland, Alaska

[Values in parts per million. N, not detected at indicated lower determination limit; L, detected but below indicated lower determination limit; Do., ditto]

Sample	Concentration	Location	Source
R1-1 --------	L(.002)	T.3 S., R. 9 W.,	conglomerate
R1-2 --------	L(.002)	sec. 16, SE¼	cong. matrix
R1-3 --------	L(.002)		Do.
R1-4 --------	L(.002)		Do.
R1-5 --------	L(.002)		Do.
R2B-1 -------	.004	T. 2 S., R. 9 W.,	conglomerate
R2B-2 -------	.004	sec. 24, NW¼	cong. matrix
R2B-3 -------	.004		Do.
R2B-4 -------	.006		Do.
R2B-5 -------	.004		Do.
R2A-1 -------	.004		Do.
R2A-2 -------	.002		Do.
R2A-3 -------	.002		Do.
R3-1 --------	.014	T. 5 S., R. 14 W.,	claystone
R3-2 --------	N(.002)	sec. 26, NW¼	coaly coarse ss
R3-3 --------	N(.002)		coal
R3-4 --------	L(.002)		< 2 mm clactics
R3-5 --------	L(.002)		< 2 mm clastics

Prior to analysis the gold grains from site S2 were hand picked (fig. 2*A*) for examinations of gold morphology; the gold was returned to the sample before chemical analysis. Site S2 grains are generally flat and rounded to irregular, with the largest grain being 0.95 mm at its longest dimension. With increasing distance of mechanical transport, gold-grain morphology changes from delicate, through irregular and abraded, to rounded, while grain size is progressively diminished (Grant and others, 1991). The studied gold grains in all likelihood have undergone at least secondary fluvial and possibly glacial transport. The range in shape from round to irregular suggests either that the gold has weathered out at different locations along the flowpath of the stream, or that morphologic differences among gold grains are inherited from prior fluvial histories, or both.

Rocks

The only available background gold values for the Kenai Group are from three conglomerates analyzed in the present study (table 2). Owing to relatively weak lithification, we were able to remove coarse material (cobbles to boulders) by hand. The samples then were sieved and the +35-mesh fraction was discarded.

Sample R1 is from the Sterling Formation along the Fox River. The outcrop consists of conglomerate with a coarse sandstone matrix and interlayered siltstones and claystones. The −35-mesh fraction was crushed, ground, and analyzed for low-level gold by graphite furnace atomic absorption spectrophotometry (Meier, 1980). None of the five splits from site R1 measured above the lower determination limit.

Sample R3 is from the Beluga Formation about 10 km northwest of Homer along the south bank of the Anchor River. The outcrop consists of conglomerate, claystone, coaly iron-stained coarse sandstone, and coal. The conglomerate matrix contained detectable gold below the determination limit. The claystone contained 0.014 ppm gold, the highest value for any rock sample. No gold was detected in the sandstone or coal.

Sample R2 is from the undifferentiated (Tertiary or Quaternary) gravel and coglomerate along the upper Fox River (fig. 3). Eight splits of the sample were analyzed for gold; values ranged from 0.002 to 0.006 ppm. Sample S1 was taken from the same location and was crushed prior to being sieved, sluiced, prepared, and analyzed in similar fashion to the sediment samples S2, S3, and S4 mentioned previously. For sample S1, the semimagnetic and magnetic fractions from all sieve categories were barren of detectable gold at the 20-ppm determination limit using an optical emission spectrograph according to the method outlined by Grimes and Marranzino (1968). Also barren were the −10-mesh to +18-mesh, −18-mesh to +35-mesh, and −35-mesh to +80-mesh sieve sizes of the nonmagnetic fraction. The −80-mesh to +230-mesh size fraction contained 5.6-ppm gold, while the −230-mesh size fraction contained 0.3-ppm gold.

Gold from the sluice concentrate from site S1 was hand picked (fig. 2*B*) to examine morphology. Gold grains are smaller and more delicate than those from site S2. The largest grain is approximately 0.45 mm on its longest dimension. Since the sample at site S1 was taken directly from outcrop, the gold has not undergone reworking by present fluvial activity. Therefore, barring chemical transport and reprecipitation of gold, it appears likely that the lack of present-day mechanical transport is responsible for the more delicate nature of gold grains at site S1.

DISCUSSION AND CONCLUSIONS

Placer gold is extensive throughout the Kenai lowland. Of 75 sampled drainages, 27 were anomalous for gold in stream sediment and 16 were anomalous for gold in heavy-mineral concentrates from stream sediment. A sluice box was used to assess the placer-gold potential of three streams. Of the three stream locations (sites S2, S3, and S4) where the sluice was used to concentrate larger volumes of material, none contained significant gold quantities. The fine size (generally <0.2 mm) and lack of concentration of the gold deflate any hope of a minable resource at this time.

Whether the gold has been reworked from the Quaternary deposits or the Tertiary Kenai Group, or both, remains unresolved. The two bedrock sites in unequivocal Sterling and Beluga Formations lack significant gold,

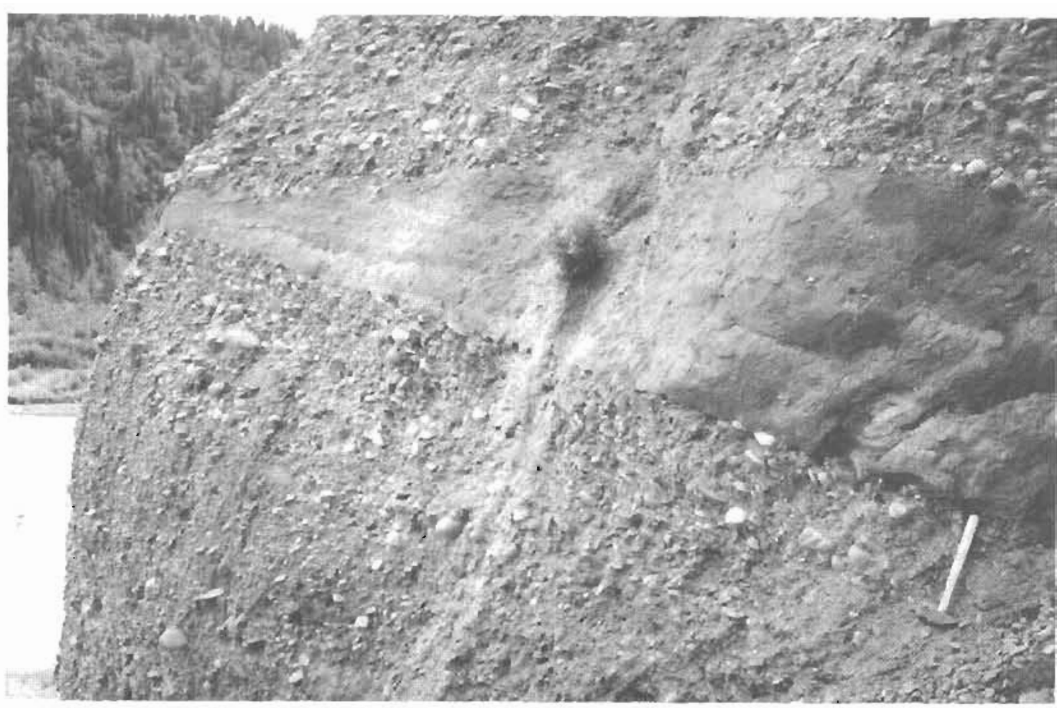

Figure 3. Outcrop of Tertiary or Quaternary conglomerate and gravel along upper Fox River where sluice sample S1 and rock sample R2 were taken.

but more sampling would likely be necessary to locate significant quantities. In addition, it is possible that the placer gold was derived from the coarser fraction of conglomerates-the fraction that was discarded prior to chemical analysis. Although gold was recovered from bluffs of gravel and conglomerate along the upper Fox River (samples R2, S1), the stratigraphic position is ambiguous. Regardless of whether the strata are Tertiary or Quaternary, the occurrence of paleoplacer gold in alluvium derived from the Kenai Mountains does indicate that at least some of the placer gold was ultimately derived from the east.

An analagous situation to the gold in the Kenai lowland may be the placer deposits along the Gulf of Alaska coastline from Cape Yakataga to Icy Bay. There, the Yakataga Formation is the principal source of gold, which is being reworked and concentrated by recent fluvial systems and by longshore currents (Reimnitz and Plafker, 1976; Eyles, 1990). Eyles (1990) cited glaciers as playing a major role in transporting detrital gold over such large areas and noted that postglacial shallow-marine and fluvial activity concentrated the gold. Eyles (1990) also pointed out that gold shows a noticeable size reduction as it moves away from its source river along the beach.

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