Geochemical and Geophysical Reconnaissance of Parts of the Yakutat and Mount Saint Elias Quadrangles, Alaska

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CONTRIBUTIONS TO ECONOMIC GEOLOGY

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By E. M. MACKEVETT, JR., and GEORGE PLAFKER

ABSTRACT

Geochemical analyses of rock, vein, altered-zone, and stream-sediment samples from parts of the Yakutat and Mount Saint Elais quadrangles show numerous weakly anomalous concentrations of several metals, but none that appear to have any immediate economic significance. Anomalies detected by an airborne magnetic survey of beach deposits on the Yakutat Foreland are believed to represent buried rocks of the Yakutat Group that are magnetic rather than concentrations of magnetic minerals in the beach deposits.

INTRODUCTION

Geochemical sampling and mapping of parts of the Yakutat and Mount Saint Elias quadrangles, Alaska, were undertaken by the U.S. Geological Survey as part of its Heavy Metals program. This report describes the most significant results of geochemical sampling and an airborne magnetometer survey and attempts to relate anomalous concentrations of metals to their geologic settings. More extensive analytical data on all the geochemical samples that were collected during the investigation are given in an open-file report (MacKevett and Plafker, 1969). The region investigated includes most of the Yakutat 1:250,000 quadrangle east of Yakutat Bay and the adjacent southern part of the Mount Saint Elias quadrangle (fig. 1). This area, which lies between the Canadian boundary line and the Gulf of Alaska, includes some of the lofty peaks of the Saint Elias Mountains and several spectacular glaciers and fiords.

The geochemical sampling was done in conjunction with helicopter-supported geologic mapping under the direction of

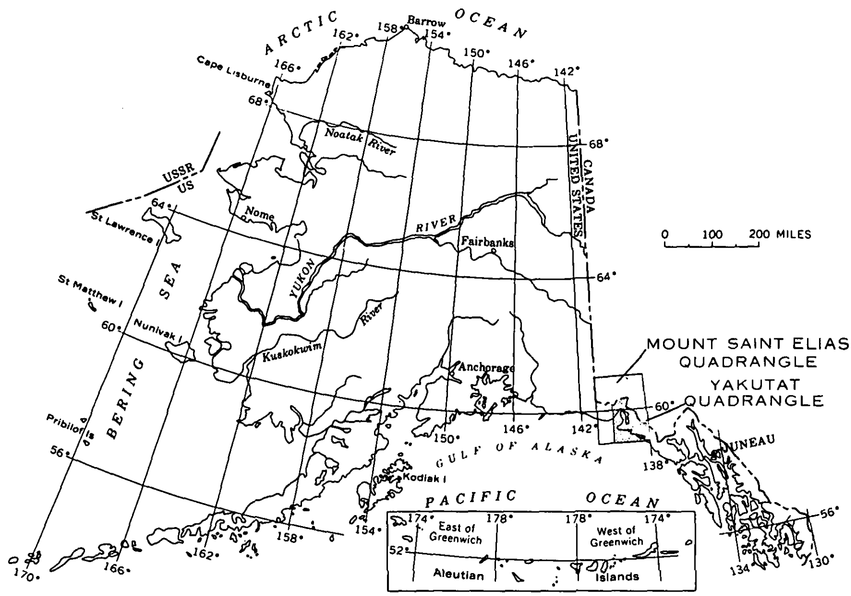

FIGURE 1.—Location of the Yakutat and Mount Saint Elias quadrangles. Stippling indicates area of investigation.

Plafker. The samples were collected by Plafker in 1967 and by Plafker, MacKevett, and M. E. Perkins in 1968. The lack of stream-sediment samples throughout much of the higher terrain reflects poor stream development and the prevalence of glacial drainage in a rigorous alpine environment. Analyses were made for 217 samples that included country rocks, mineralized rocks, material from hydrothermally altered zones, and material from veins; 101 samples of stream sediments and one of beach sand. The sediment samples represent the finest grained material available at the sample site. The other samples were mainly random or composite grab samples that reflect the general composition of the material sampled. Chip or channel samples were taken of some local strongly mineralized concentrations. Most individual grab samples were about the size of an ordinary hand specimen or its fragmented equivalent.

The samples were analyzed for 30 elements by a standard semiquantitative spectrographic method; in addition, most samples were analyzed for gold by atomic absorption methods. All analyses were made in laboratories of the U.S. Geological Survey.

The geochemical fieldwork focused on sampling material of possible economic significance, such as hydrothermally altered zones, veins, and mineralized rocks, and on reconnaissance stream-sediment sampling. Numerous samples were collected of the diverse rocks in the quadrangles to provide background geochemical data and to aid in the geologic studies. Only the magnetometer survey was used to obtain information on the black beach sands and their related beach terrace placers; the deposits themselves were investigated only in a cursory fashion. Some of these deposits were studied by Blackwelder (1907) and by Thomas and Berryhill (1962). The airborne magnetometer survey covered about 2,500 square miles in an area of beach deposits on the Yakutat Foreland between Yakutat and the Alsek River.

The only known mining in the region consists of intermittent small-scale attempts to exploit the beach placers for gold. The only previously reported lode deposits in the region consist of copper-stained rocks along the Alsek River and a copper-bearing vein along Russell Fiord. These deposits, briefly mentioned by Blackwelder (1907, p. 87), whose source of information was prospectors, could not be located during this investigation. Although no ore deposits were found during our investigations, the analytical results indicate numerous minor anomalous concentrations of metals whose distributions and magnitudes should be of value in future prospecting. The analytical results should also be of use in provenance and similar regional geologic studies.

GEOLOGIC SETTING

The geology of the region investigated is dominated by the Fairweather fault and by other major steeply dipping, northwest-striking faults (pl. 1). These faults form important structural boundaries between broadly distinctive geologic terranes. The terrane east of the Art Lewis lineament consists of abundant marble, metavolcanic rocks, and mica schist, and these rocks are intruded by granitic rocks and locally abundant aplitic dikes and sills. The terrane between the Fairweather fault and the Art Lewis lineament consists of diverse metamorphic rocks (amphibolite to a high-grade assemblage in the greenschist facies), large granitic plutons, and extensive aureoles of migmatite. A thick amphibolite unit borders the Fairweather fault on the east for a distance of more than 100 miles. Between the Fairweather and Boundary faults, the rocks consist mainly of semischist, slate, local migmatite, and granitic plutons, as well as minor metavolcanics and marble; in contrast to the higher grade metamorphic rocks in terranes farther east, these rocks are mainly in

TABLE 1.—*Partial analyses of samples from Yakutat and Mount Saint Elias*

[Analyses by semiquantitative spectrographic methods except for Au, which was analyzed by atomic absorption methods. All elements reported in parts per million, except Ti, which is reported in percent. Except for gold, results are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1 *** . Analysts: W. L. Campbell, K. J. Curry, J. C. Hamilton, E. E. Martinez, R. L. Miller, J. M. Motooka, M. S. Rickard, R. B. Tripp, and J. G. Viets. Remarks: All samples are grab samples unless otherwise indicated under Description. G=

Sample	Au	Ti	Ag	Co	Cr	Cu	Mo	Ni	V
67APr—34A	0.08	0.1	N	200	7	300	10	100	150
46D−1	N	G (1)	N	70	200	200	N	100	700
46D−2	.02	.2	N	15	10	5	N	20	200
57A−1		.3	N	30	150	700	L	50	300
58C	N	.7	N	30	300	15	N	50	500
63A−1		.3	N	15	50	30	5	30	150
63A−2		.3	N	30	30	20	3	30	300
63A−3	N	.5	0.5	100	50	500	5	50	500
65C−1		.3	N	15	70	50	3	30	150
65C−2		.7	N	30	3	70	L	15	300
65C−3		.3	N	7	70	30	5	15	150
74C	N	.7	N	20	200	70	N	50	500
74D−2	N	.2	.7	10	150	100	10	50	500
76C	.5	1.5	N	15	300	50	N	70	1,000
83C	N	.7	N	50	30	100	N	20	500
84C	N	.7	N	30	150	30	L	70	500
87C−1		.3	N	30	150	300	L	70	200
87C−3		.15	N	50	2,000	1.5	N	700	150
87C−5		.15	N	30	1,000	N	N	300	150
94A−1	N	.5	N	10	5	20	7	5	100
68APr—68A−1	L	1	N	70	200	500	L	100	300
68A−2	L	.3	N	10	5	15	N	L	30
72C	L	1	.7	30	15	200	5	30	300
85E	.08	.3	N	15	100	200	N	70	100
88C	L	1	N	70	200	200	L	100	500
89D	L	.2	N	20	700	200	10	500	150
68AMK—2A	L	.7	N	20	150	150	L	100	200
2B	L	G (1)	N	100	30	150	5	70	200
19	L	.7	N	15	100	150	L	70	200
20	.04	.5	N	15	150	70	L	50	150
46	L	.7	N	100	700	100	N	200	500
94	L	1	N	50	7	500	L	15	300
101	L	.5	.7	10	500	150	15	100	300
102	L	.2	N	15	150	150	7	70	200
103A	L	.2	L	7	150	100	10	50	150
103C	L	.2	L	20	500	30	L	150	150
104	L	.2	N	10	50	50	70	20	150
105	L	.3	L	100	150	200	L	70	150
126	L	.3	.7	10	150	200	10	70	200
127	L	.5	N	15	70	150	5	70	150
128	L	.7	N	50	150	300	L	50	500
130	L	.5	.7	7	70	50	30	30	150
134	L	.5	L	500	200	150	L	100	200
135	L	1	N	50	150	150	L	50	500
137	L	G (1)	N	15	100	150	7	50	150
138	L	.7	N	7	N	10	5	L	30
139	L	.3	N	20	70	150	15	50	150
145	L	.05	N	50	150	200	L	100	500
146	L	G (1)	N	N	50	30	10	N	150
68APs—42B	L	1	N	15	150	30	5	30	150
Limit of determination.	0.02	0.001	0.5	5	5	5	3 or 5	2	10

quadrangles that contain the principal anomalous concentrations of metals

greater than 10 percent or greater than the value shown. N=not detected at limit of detection or at value shown. L=detected but below limit of determination or below value shown. Limit of determination given at bottom of table. (......)=not looked for. A few weakly anomalous samples collected at or near the sites of the principal anomalous samples, are included in this table. "Selected" means that sample was taken from richest-appearing material at sample site. Sample locations are shown in plate 1]

Zr	Zn	Description
20	N	Sulfide-bearing quartz veins a few inches wide.
200	N	Iron-stained amphibolite with quartz veinlets.
30	N	Quartz vein about 2 inches wide.
30	N	Amphibolite with copper-stained fractures.
70	N	Sulfide-bearing metavolcanic rock with quartz veinlets.
150	N	Metavolcanic rock.
70	N	Do.
50	N	Metavolcanic rock with disseminated sulfides.
150	N	Metasedimentary rock.
N	N	Metavolcanic rock or dike.
70	N	Metasedimentary rock.
150	N	Metagraywacke.
100	L	Metasiltstone
1,500	N	Selected sample of black beach sand.
70	N	Granodiorite.
150	N	Phyllite.
30	N	Schistose serpentinite in fault zone.
15	N	Do.
15	N	Do.
100	N	Siltstone and chert.
30	1,500	Sulfide-bearing amphibolite.
300	N	Amphibolite.
70	200	Greenstone with disseminated pyrite.
200	N	Altered zone about 100 feet wide in quartz diorite.
200	L	Stream sediment.
50	L	Thin sulfide-bearing altered zones.
70	N	Altered aplite.
30	200	Amphibolite.
200	L	Stream sediment.
150	L	Do.
200	L	Do.
10	200	Hornblende gneiss.
50	L	Altered zone about 200 feet wide; selected grab sample.
70	L	Altered zone about 200 feet wide; grab sample near northeast wall.
70	L	Altered zone about 200 feet wide; composite grab sample across easternmost 50 feet of zone.
30	L	Altered zone about 200 feet wide; composite grab sample across westernmost 100 feet of zone.
30	L	Altered zone about 200 feet wide; selected grab sample.
50	L	Altered zone about 200 feet wide; selected grab sample from pyrite-rich zone about 2 feet wide.
200	L	Altered zone about 20 feet wide; chip sample across 2-foot-wide pyrite-rich subzone.
150	L	Altered zone about 20 feet wide; composite grab sample across zone.
70	L	Altered zone about 20 feet wide; selected sample.
150	L	Altered zone about 4 feet wide in metasedimentary rocks; chip sample.
70	L	Altered zone about 12 feet wide; selected grab sample.
150	L	Altered zone about 12 feet wide; composite grab sample across zone.
100	L	Irregular altered zone several hundred feet wide; composite grab sample.
100	L	Irregular altered zone several hundred feet wide; selected grab sample.
70	L	Altered zone several hundred feet wide; composite grab sample.
300	L	Altered zone about 50 feet wide; composite grab sample.
300	N	Pyrite-rich lenses in schist.
700	N	Stream sediment.
20	200	

the greenschist facies, except where contact metamorphosed. The foothills belt lying between the Boundary fault and Yakutat Foreland is underlain mainly by the Yakutat Group, a eugeosynclinal sequence of bedded sedimentary and volcanic rocks of Jurassic(?) and Cretaceous age characterized by chaotic structure and tectonically intermixed fragments or blocks of competent rocks of widely diverse origins and ages. In the southeastern part of the Yakutat quadrangle, the foothills belt is underlain by low-grade metamorphic rocks of the greenschist facies and a granitic pluton. The Yakutat Foreland is made up of Quaternary deposits that consist largely of unconsolidated glacial, alluvial, and shallow marine sediments. Tertiary sedimentary rocks crop out west of Yakutat Bay in the Mount Saint Elias quadrangle, and their correlatives have been penetrated by exploratory wells drilled for oil on the Yakutat Foreland.

The ages of the metamorphic rocks are not known. Regional relations suggest that the sequence east of the Art Lewis lineament is of late Paleozoic(?) and Mesozoic(?) age and that the sequences to the west are probably largely, if not entirely, of Mesozoic age. The Yakutat Group is of Jurassic(?) and Cretaceous age, and the Tertiary bedded rocks that underlie the Yakutat Foreland range in age from Eocene through Pliocene (Plafker, 1967). These are overlain by Quaternary surficial deposits.

The main intrusive rocks range from diorite to leucograndiorite, as exemplified by the Mount Draper pluton. Numerous small aplite and pegmatite dikes are associated with some of the intrusives. Widely scattered lamprophyre dikes cut rocks as young as those of the Yakutat Group. The ages of the intrusive rocks are not known, although isotopic age data are pending for some of them. A comparison with similar intrusive rocks in Glacier Bay National Monument, south of the Yakutat quadrangle, indicates that the dioritic rocks are probably Mesozoic and that the leucograndiorites and possibly most granodiorites are probably Tertiary (Brew, D. A., unpub. data, 1969).

The potential lode deposits are chiefly hydrothermally altered zones and metamorphic rocks that contain disseminated sulfides. The hydrothermally altered zones are locally abundant and are generally localized along faults. They range in width from about a foot to several hundred feet and are as much as several miles long. Disseminated sufides, chiefly pyrite, are widespread in some of the amphibolites and schists. Most of the quartz veins in the region appear to have formed by metamorphic processes. Most of them do not appear promising for ore deposits.

DISTRIBUTION OF METALS

Only the more significant of the anomalous concentrations are described herein, although all the samples with anomalous metal contents and locations of the samples not considered to be anomalous are shown on plate 1. The reader is referred to MacKevett and Plafker (1969) for more complete analytical data on all the samples collected during th Heavy Metals investigation.

No major metal concentrations were found during the investigation, but the samples reveal numerous weakly anomalous concentrations of many metals. The samples shown in table 1 represent the main anomalous concentration of 11 metals, including those believed to have the best potential economic significance in the region. These metals, which include gold, titanium, silver, cobalt, chromium, molybdenum, nickel, vanadium, zinc, and zirconium, were selected after evaluating the analytical data. The content of these metals in a sample forms the sole basis for the anomaly symbols shown on plate 1. Most of the rock samples represent large extensive masses; some size indications of the other material sampled are given in table 1.

To ascertain the lowest metal content required for an anomalous concentration is difficult, and the definition of the lower limit is somewhat subjective. Lower limits chosen for anomalous metal concentrations (pl. 1) are based on analyses of unmineralized rocks of the region (MacKevett and Plafker, 1969) and on comparison of the values with the geochemical data of Turekian and Wedepohl (1961).

PRECIOUS METALS

Gold and silver are sparsely distributed in the parts of the quadrangles investigated. The highest gold concentration detected, 0.5 ppm (parts per million), was in a sample of black beach sand (67APr–76C). (Locations for the samples referred to by number in the parentheses are shown on plate 1, and their analyses are given in table 1 and (or) by MacKevett and Plafker, 1969.) This sample is representative of the richer parts of the beach sands, and the bulk of the black beach sands and their related beach terrace sands are probably considerably leaner (Thomas and Berryhill, 1962, p. 26–33). Minor amounts of gold were found in two sediment samples from streams draining the Yakutat Group terrane of the Brabazon Range (68AMK–20,33). Small amounts of gold were detected in a few samples of quartz veins and hydrothermally altered zones. The richest of these contained 0.08 ppm gold and are from narrow quartz veins that cut metamorphic rocks near the Fairweather fault (67APr–34A) and from an altered zone in quartz diorite (67APr–85E).

Concentrations of 0.5 or 0.7 ppm silver were found in the several samples, mostly samples from amphibolite-facies metamorphic rocks between the Art Lewis lineament and the Fairweather fault. The anomalous silver concentrations are mainly in hydrothermally altered zones and less commonly in sulfide-bearing metamorphic rocks. One of the anomalous samples (68AMK–126) is from an extensive altered zone along the Fairweather fault. Sample 68APr–72C represents a large exotic block of pyritiferous greenstone in the Yakutat Group. No analyses were made for the platinum-group elements.

BASE METALS

The only base metals that form anomalous concentrations of any significance in the region are copper and zinc. Minor anomalous concentrations of copper are widespread and were detected in many of the samples (pl. 1; table 1). Most of these were from amphibolites and similar metamorphic rocks that contain disseminated sulfides, but a few reflect other rock types. The highest copper content (700 ppm) was from an amphibolite with disseminated sulfides and local copper-stained fractures (67APr–57A–1). Copper in quantities of 500 ppm was found at two localities (67APr–63A–3 and 68APr–68A–1) in amphibolite and metavolcanic rocks; both localities are characterized by disseminated sulfides. Copper is a common trace element in many of the amphibolites and metavolcanic rocks and is particularly common in the rocks of the amphibolite belt east of the Fairweather fault. Many of the stream sediments collected near Nunatak Fiord and from the southern part of the area contained minor anomalous amounts of copper.

Zinc was found in quantities of 1,500 ppm in the sulfide-bearing amphibolite represented by sample 68APr–68A–1 and in amounts of 200 or 300 ppm in several other samples of rocks, altered zones and stream sediments (pl. 1; table 1, MacKevett and Plafker, 1969).

No significant concentrations of lead were found in any of the samples, although weakly anomalous concentrations of 30 ppm were revealed in several of the rock samples and in two of the stream sediments (MacKevett and Plafker, 1969). Tin is a rare metal in the region but was detected in amounts of 20 ppm in two sediment samples and in amounts of 15 ppm in a few other samples. Neither antimony nor bismuth was found in any of the samples.

IRON AND FERROALLOY METALS

The iron and ferroalloy metals whose distributions are shown on plate 1 include molybdenum, cobalt, nickel, chromium, titanium, and vanadium. Small anomalous concentrations of molybdenum are widely scattered in diverse geologic settings throughout the region (pl. 1). The greatest molybdenum concentration, 70 ppm, was in a selected sample from a large altered zone (68AMK–104); the second largest, 30 ppm molybdenum, was from a 4-foot-wide altered zone cutting metasedimentary rocks (68AMK–130).

Minor anomalous amounts of cobalt were found in many of the rocks and altered zones and in a few stream sediments. The only significant cobalt enrichment, 500 ppm, was in a selected sample from an altered zone (68AMK–130).

No important anomalous amounts of nickel were detected. The nickel analyses of 700 and 300 ppm from small outcrops of schistose serpentinite along the Boundary fault (67APr–87C–3,5) are comparable with those from some ultramafic rocks. Thin sulfide-bearing altered zones in dioritic rocks near the southeast corner of the Yakutat quadrangle contain 500 ppm nickel (68APr–89D).

The largest concentration of chromium, 2,000 and 1,000 ppm (67APr–87C–3,5) were found in the schistose serpentinite along the Boundary fault and are typical of some ultramafic rocks that contain small amounts of chromite. A sample from a sulfide-bearing altered zone (68APr–89D) contained 700 ppm chromium. Chromium was slightly concentrated in several of the stream-sediment samples, particularly those from streams that drain zones of amphibolite.

Amounts greater than 1 percent titanium were detected in several samples, but probably none of these concentrations are of particular economic significance. The titanium-enriched samples respresent several modes of occurrences including amphibolite, hornblende gneiss, altered zones, sulfide-rich lenses, beach sands, and stream sediments. Probably most of the titanium occurs as a constituent of ilmenite, which is a minor accessory in many of the mafic rocks. The investigations of Thomas and Berryhill (1962, p. 26–33) document sporadic concentrations of ilmenite in the beach sands.

Minor anomalous concentrations of vanadium are widespread throughout the quadrangles. They were detected in many of the rocks and altered zones and in a few sediment samples. A selected beach-sand sample (67APr–76C) contained 1,000 ppm vanadium, the largest amount found.

Reconnaissance investigations of the beach sands by Thomas and Berryhill (1962, p. 26–33) disclosed a few erratically distributed concentrations of iron. Iron in amounts greater than 20 percent was found in a selected sample of black beach sand (67APr–76C) (MacKevett and Plafker, 1969). Analyses of one sample from a sulfide-rich vein (67APr–34A) and of samples from a few altered zones and mafic rocks also revealed 20 percent iron (MacKevett and Plafker, 1969), but such concentrations do not appear to be economically significant. Except for some of the beach sands, the region probably does not contain significant iron resources.

Many minor concentrations of manganese were indicated by the analyses (MacKevett and Plafker, 1969). The two largest concentrations, 10,000 ppm (67APr–58B–2) and greater than 5,000 ppm (68APs–42B), were from a manganese-stained vein and from a garnet-rich stream sediment. Some of the manganese anomalies probably were derived from local concentrations of manganese-rich garnet in and near the Mount Draper pluton. Some of the other manganese anomalies are attributable to hydrothermally derived manganese in altered zones. Tungsten was not detected in any of the samples.

OTHER METALS

Small anomalous concentrations of many other metals were detected in the samples. Zirconium in amounts of 1,500 and 700 ppm was found in the one beach-sand sample (67APr–76C) and in a stream-sediment sample (67APs–42B). Lesser anomalous amounts of zirconium were found in some other samples, particularly in stream-sediment samples collected near the Mount Draper pluton (pl. 1). Weakly anomalous concentrations of several other metals are indicated in the tables of the open-file report (MacKevett and Plafker, 1969). These concentrations include 500 ppm arsenic, as much as 500 ppm boron, 3,000 ppm barium, 150 ppm lanthanum, and as much as 200 ppm yttrium. Except for the richest yttrium sample, a garnet-rich stream sediment (68APs–42B), the minor anomalies occur in samples of country rocks and altered zones.

MAGNETOMETER SURVEY

An attempt was made to detect anomalous concentrations of heavy metals in beach deposits on the Yakutat Foreland with an airborne magnetometer survey carried out in 1968. This approach seemed feasible because the precious metals recovered from the beach placers normally occur in association with significant quantities of iron-bearing minerals (Thomas and Berryhill, 1962). The survey included an area of about 2,500 square miles. Magnetometer lines were flown at ¼-mile spacings, at an average altitude of 200 feet with a proton precession total-field magnetometer, flown by the Lockwood, Kessler, and Bartlett Co. of Pasadena, Calif., under contract to the U.S. Geological Survey. The present beaches and a series of older raised beaches on the foreland between Yakutat and the Alsek River within the area outlined on plate 1 were covered by the survey. A map at a scale of 1:63,360 showing the magnetic data contoured at intervals of 5 and 25 gammas and the major geologic units has been prepared by Johnson and Plafker (1969). None of the magnetic anomalies could be directly correlated with beach deposits. Narrow, linear anomalies several miles long, up to 1 mile wide, and with as much as 200 gammas relief occur in the southeastern part of the surveyed area. Their general trend and position relative to rock outcrops suggest that they reflect buried magnetic rocks—possibly greenstone or diorite—within the Yakutat Group, rather than anomalous concentrations of heavy detrital minerals on the foreland. However, these anomalies appear to be large enough to warrant further investigation by ground magnetometer surveys and (or) shallow drilling.

CONCLUSIONS

Analyses of samples from the region disclose numerous small anomalous concentrations of many metals, but none that appear to have any immediate economic significance. The analytical and geologic data resulting from this work should facilitate any systematic prospecting and should focus attention on areas that warrant more detailed investigations. The best-appearing potential resource for several metals is probably the sands of the present beaches and the elevated beach terraces on the Yakutat Foreland, but these deposits need additional exploration work for their economic evaluation.

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