Geochemical and Geologic Reconnaissance of a Part of the Fortymile Area, Alaska

By HELEN L. FOSTER and SANDRA H. B. CLARK

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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GEOCHEMICAL AND GEOLOGIC RECONNAISSANCE OF A PART OF THE FORTYMILE AREA, ALASKA

By Helen L. Foster and Sandra H. B. Clark

Abstract

Analyses of stream-sediment and rock samples from the Fortymile area, Eagle quadrangle, Alaska, indicate that several localities have weak geochemical anomalies. In most places, the source of the anomaly is not known and more geological information is needed. Chromium and nickel in amounts above normal background in stream sediments probably came in large part from ultramafic intrusions and greenstone. Some weak anomalies may be due to scattered sulfide minerals in low-grade metamorphic rocks and are not necessarily indicative of mineral deposits.

The weak anomaly in the Champion Creek area is one of the most promising for prospecting, because galena has also been found in float. In the Alder Creek area, silver was detected in two-thirds of the stream-sediment samples. In the Gold Run, Joseph, and Hutchinson Creek areas there is evidence of mineralization associated with probable Tertiary igneous activity. The abundance of small igneous intrusions, favorable host rocks, the occurrence of placer gold, and the presence of some bedrock prospects suggest that these and several other parts of the Fortymile area warrant further sampling and geological exploration.

INTRODUCTION

A geochemical and geologic reconnaissance of parts of the Fortymile River drainage area, Alaska (fig. 1), was conducted in the summer of 1968 as a part of the U.S. Geological Survey's Heavy Metals program. A helicopter was used for 2 weeks in early June to make geologic observations and to collect stream-sediment and rock samples for geochemical analysis. Later in the summer, several long traverses on foot were made to obtain additional geologic data. (Analyses from a few samples which were collected in 1967 are also incorporated in this report.) Work in 1968 was concentrated

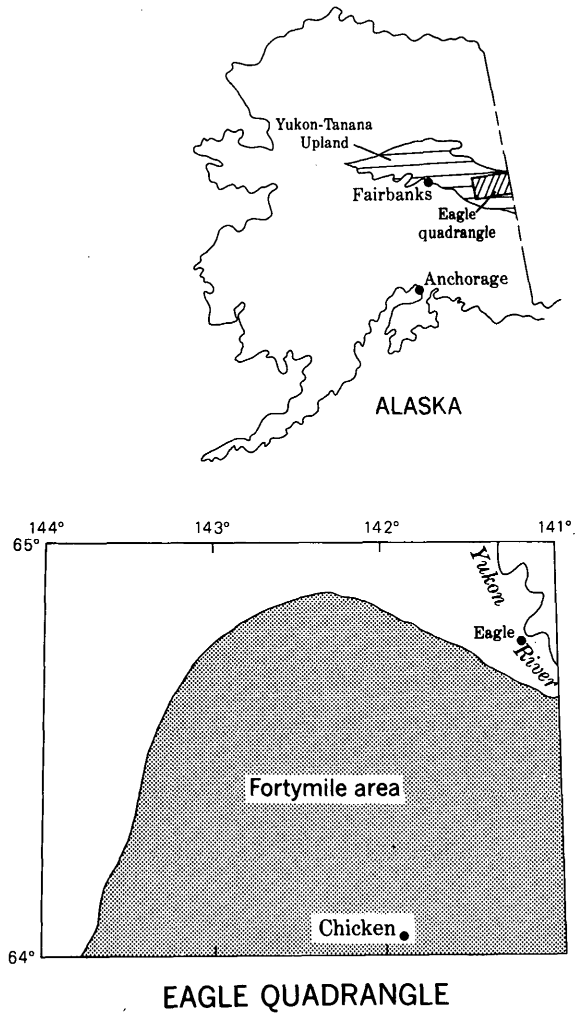


FIGURE 1.—Location of the Yukon-Tanana Upland, Eagle quadrangle, and the part of the Fortymile area included in this report.

in parts of the Fortymile area not included in recent geologic studies by the senior author (Foster and Keith, 1968; Foster, 1969b) or in geochemical investigations by the Division of Mines and Minerals, State of Alaska (Saunders, 1966 and 1967; Burand, 1968; and Smith, 1968). Several geochemical anomalies were located which deserve further exploration and checking, but no areas were found which have a large number of strongly anomalous samples.

LOCATION OF AREA

The Fortymile area, known locally as The Fortymile or the Fortymile country, is the drainage area of the Fortymile River, a tributary to the Yukon River. The area is included in the physiographic province known as the Yukon-Tanana Upland (Wahrhaftig, 1965), the maturely dissected mountainous terrain lying between the Tanana and Yukon Rivers. The Taylor Highway extends from Tetlin Junction on the Alaska Highway to Eagle on the Yukon River and crosses the eastern part of the Yukon-Tanana Upland. The part of the Fortymile area included in this report is in the southern and central parts of the Eagle quadrangle (fig. 1).

ACKNOWLEDGMENTS

Florence R. Weber, geologist, assisted the senior author for several days in early June and field assistant Ronald Warbelow collected most of the stream-sediment samples. The field party was also assisted for a short time by Sharleen McDonald and Katherine Nichols.

Mr. and Mrs. Robert McCombe at South Fork Lodge provided a comfortable base of operations during the helicopter work and the Marvin Warbelow family at Cathedral Bluffs Lodge gave assistance and furnished a base of operations during July and August. The hospitality of Carl Sorenson, Suzanne Gilbert, and Gordon Miller at Joseph is also appreciated.

PREVIOUS GEOLOGIC WORK

Placer gold was discovered on the Fortymile River in 1886 (Prindle, 1909, p. 9), and within a few years gold was being produced from many creeks in the Fortymile drainage area. A U.S. Geological Survey party consisting of J. E. Spurr, H. B. Goodrich, and F. C. Schrader investigated the placers of the Fortymile area in 1896 (Mertie, 1937, p. 5); during the fall of 1899 the area was traversed by the W. J. Peters and A. H. Brooks party on their trip from Pyramid Harbor to Eagle (Prindle, 1909, p. 8). In 1903 L. M. Prindle visited all of the gold-producing creeks and during the course of his work in the Yukon-Tanana region from 1904 to 1911 he traversed parts of the Fortymile area (Prindle, 1909, p. 8). J. B. Mertie, Jr., carried on geologic studies in the Yukon-Tanana region from 1911 to 1931. The work of Prindle and Mertie provides the background for our present geologic knowledge of the area. More recently, The Division of Mines and Minerals of the State of Alaska has carried on geochemical investigations in parts of the Fortymile area (Saunders, 1966; Burand, 1968; and Smith, 1968), and the U.S. Geological Survey has done reconnaissance geologic mapping (Foster, 1967, 1969b; and Foster and Keith, 1968). Much of the area in this report is not covered by recent geologic maps.

GEOLOGIC SETTING

The Fortymile area is underlain primarily by metamorphic rocks which have been intruded by a wide variety of igneous rocks. Locally, sedimentary rocks rest unconformably on the metamorphic and igneous rocks and are associated with lava and tuff. The Fortymile River and its major tributaries are entrenched, and high-level terrace remnants border many of the streams. Rubble covers many ridge tops, and colluvium covers most of the slopes. Good exposures of bedrock are scarce.

The metamorphic rocks can be divided into several groups on the basis of lithology and metamorphic grade. In the southern part of the area quartz-biotite gneiss and schist, amphibolite, quartzite, and marble of the amphibolite facies predominate. In the northern part of the area, quartz-graphite schist, quartz- muscovite schist, quartzite, marble, greenschist, and greenstone of the greenschist facies are most abundant. All of the metamorphic rocks are highly deformed and faulted. Some rocks of the greenschist facies are known to be of Paleozoic age; the other metamorphic rocks are of unknown age and could be Precambrian and (or) Paleozoic.

The igneous rocks occur in lava flows and in large and small instrusive bodies, such as batholiths, stocks, dikes, and sills. The rocks range in composition from granite, pegmatite, and rhyolite to gabbro and basalt. Most of the large intrusive bodies consist of granodiorite, and margins of quartz diorite or diorite occur locally. The Taylor Mountain batholith crops out on both sides of Mosquito Fork (fig. 4) and is the largest granodiorite intrusive in the area; some rocks of the Charley River batholith are found in the northwestern part of the area, and intrusive rocks of the Mount Harper batholith extend into the southwestern part of the area. At least one syenite intrusion is known in the vicinity of Mount Veta. Many small intrusive bodies consisting of quartz monzonite, diorite, or gabbro are found throughout the Eagle quadrangle. In several places, particularly south of Joseph, near Gold Run, and in the Hutchinson Creek area, granitic hypabyssal-type rocks occur in small masses and dikes. Basalts, some of which were probably formed as flows, crop out north of Bullion Creek. Rhyolitic and dacitic lavas have been found, mostly in small patches, in the central and western parts of the area. Small ultramafic masses and dikes, most of which have been serpentized, occur in no recognizable pattern through the Fortymile area. They are most numerous in the eastern part, but this may be partly because mapping there is more detailed.

The age of the granodiorite of the Taylor Mountain batholith has been determined by isotopic methods to be about 180 million years (Wasserburg and others, 1963, p. 258), and most of the other granodiorite intrusions are probably about the same age. At least some of the other igneous rocks, including some of the basalt and probably the hypabyssal rocks, are Tertiary in age, but few data are available concerning the age of most of these rocks.

Only a few small widely scattered areas of sedimentary rocks are known. The rocks in these areas consist of conglomerate, sandstone, shale, and coal; in places they are tuffaceous. Plant remains and pollen indicate that most of these deposits are of Tertiary age.

MINERAL DEPOSITS

Gold is the only metallic mineral of economic significance presently known in the Fortymile area. Nearly all the gold has been derived from placer deposits, and placer gold mining still continues on a small scale in a few creeks—notably Chicken, Lost Chicken, Wade, and Canyon Creeks, and Fortyfive Pup. Lode gold has not been found in sufficient quantity to mine, except for small deposits in quartz and calcite veins on the ridge between Myers Fork and Stonehouse Creek near Chicken. A rich vein and veinlets were mined here by Fred and Arthur Purdy, but promising extensions of these deposits have not been located. No other metals are presently mined in the area, although there are some silver, copper, iron, and antimony prospects (Saunders, 1967, p. 24–28).

At one time a small amount of coal was mined at Chicken for local use (Mertie, 1937, p. 262). An occurrence of asbestos has been discovered near Gold Run, and the possibility of finding deposits of potentially commercial size and quality does exist (Foster, 1969a).

GEOCHEMICAL STUDIES

The extent of geochemical studies in the Fortymile area on this project is shown in figure 2. The 448 stream-sediment samples were anlyzed for gold by the atomic absorption method and for 29 other elements by six-step semiquantitative spectographic anal-

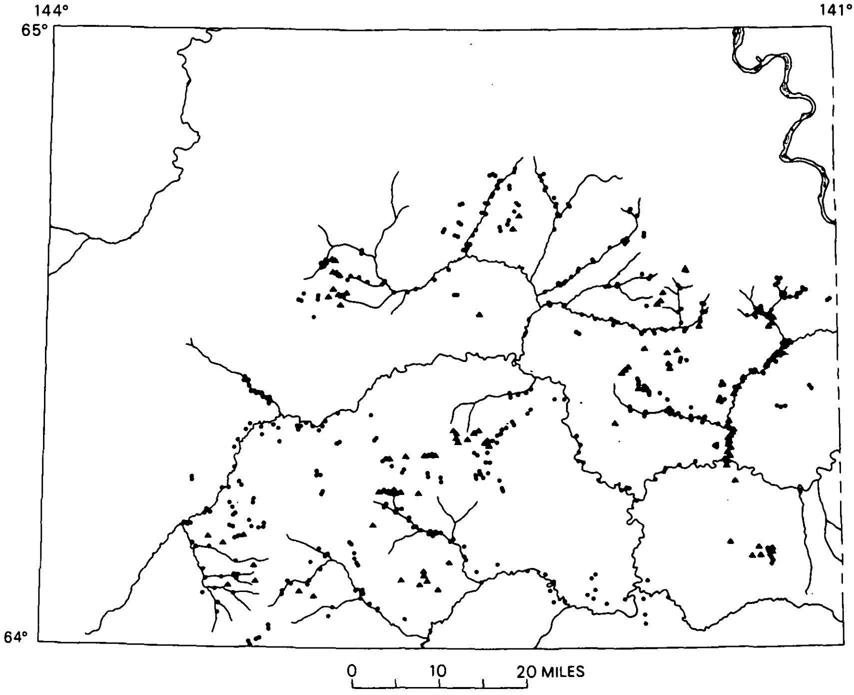


FIGURE 2.—Density and general location of analyzed stream-sediment samples (dots), and analyzed rock samples (triangles) in the Fortymile area. Area included on map is the Eagle quadrangle.

ysis in which the results are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.15, 0.1 and so forth. The rock samples, 199 in number, were similiarly analyzed. The complete analyses of these samples with histograms, computed means, and other statistical data are available in an open-file report (Foster and Clark, 1969). All sample numbers used in this report correspond to those in the open-file report.

Most of the stream-sediment sampling was done in June when the streams were high. A resampling in some streams later in the summer when streamflow was near normal did not show a significant difference in the concentration of metals. The majority of stream-sediment samples were collected in the active channel of small tributaries, some of which are too small to show on the map (fig. 2). Where the tributary is not shown the dot or the center of the symbol showing the sample location is offset from the main stream. Where possible fine sand and silt were collected. The samples were dried, sieved, and the minus 80 mesh fractions were analyzed.

The upper limits of background for the indicator elements of the following discussion are based on the element distribution in several hundred stream-sediment samples collected in the Fortymile area over the past few years. The limits are subjective, however, and must be evaluated in terms of the geology of any given part of the area. Histograms derived from computer analysis (fig. 3) are used to infer probable normal values and to help determine anomalous values. The upper limit for background is arbitrarily chosen as 50 ppm (parts per million) for lead, 100 ppm for copper, 100 ppm for nickel, and 200 ppm for chromium. The local background values of chromium and nickel are probably higher in areas of greenstone, greenschists, and ultramafic rocks. In most of the Fortymile area these rocks are only a small part of a wide variety of rocks which crop out, and until the geology is known in sufficient detail to establish local background limits the figures given above are used. In many places, values for nickel and chromium which are near the threshold values (upper limit of background) indicate a local abundance of greenstone or a somewhat more distant ultramafic rock, whereas a value of 500 ppm or above for chromium may indicate the presence of nearby ultramafic rock.

The limit of determination for silver by the semiquantitative spectographic method used is 0.5 ppm. Only 15 of 448 stream-sediment samples had 0.5 ppm or more of silver; in 75 samples silver was detected but was below the limit of determination (table 1). Most of the samples in which silver was detected in amounts below 0.5 ppm were collected from only a few streams, and silver occurred rather consistently in the samples from these streams. In contrast, silver was not detected in most of the streams in the Fortymile area. Thus, the presence of silver, even in such small amounts may have significance, and is shown on the distribution maps.

Only 11 samples contained 0.02 ppm or more of gold, so even values reported as 0.02 ppm are indicated on the maps. However, the accuracy of the instrumental reading for gold at this low value is not reliable and values reported as 0.02 ppm should be used with caution. The limit of determination for molybdenum is 5 ppm and only 16 of 448 samples had 5 ppm or more molybdenum. Because molybdenum was detected (but below 5 ppm) in only 50 samples, detected molybdenum is considered sufficiently uncommon to show on some of the distribution maps, particularly where it is in association with other metals which are present in amounts above background values.

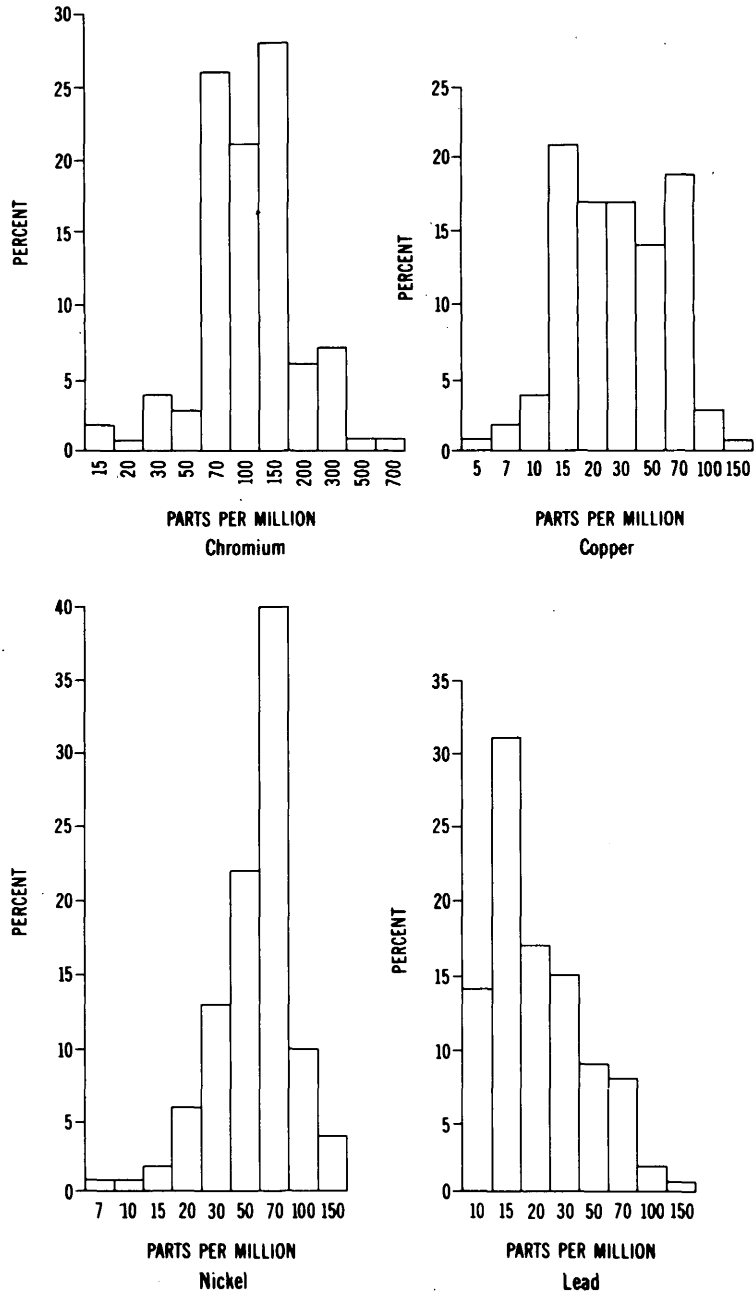


FIGURE 3.—Percentage frequency distribution of chromium, copper, nickel, and lead for 448 stream-sediment samples from the Fortymile area. Histograms plotted by computer. Percentage frequency is rounded to the nearest 1 percent.

TABLE 1.—*Selected statistical data for 448 stream-sediment samples from the Fortymile area*

Element	Value, in parts per million			Percentage of samples in which element was found[1]
	Min	Max	Geometric mean	
Silver	[2]0.5	1.5	--------	20
Arsenic	[2]200	<200	--------	7
Gold	[2]0.02	0.3	--------	[3]3
Bismuth	[2]5	5	--------	1
Antimony	[2]100	<100	--------	1
Chromium	7	2000	108	100
Copper	5	150	29	100
Molybdenum	[2]5	7	--------	15
Nickel	5	200	54	100
Lead	10	150	22	100
Tungsten	[2]70	200	--------	2
Tin	10	10	--------	<1
Zinc	[2]200	700	--------	39

[1]Includes samples in which value is below limit of determination, except gold. See footnote 3.
[2]Limit of determination.
[3]Samples containing 0.02 ppm or more.

Because of the high limit of determination for zinc (200 ppm) and arsenic (200 ppm) any detectable zinc and arsenic are considered anomalous. Because of the rarity of detection of tungsten at 50 ppm or above, bismuth at 10 ppm or above, tin at 10 ppm or above, and antimony at 100 ppm or above, their detection in any amount is considered anomalous.

Rock samples which were analyzed include mineralized specimens such as those high in visible sulfides, vein quartz without visible mineralization, rock from sheared, oxidized, and hydrothermally altered zones, and specimens of representative rock types (to help determine background values). Because of the wide variety of rock types analyzed, it is not practicable to set overall threshold limits. However, for simplicity on the distribution maps the same limits are applied to both rock and stream-sediment samples.

No localities with an abundance of strongly anomalous samples were discovered in the Fortymile area, but there are several localities with weak anomalies. Nine areas have been selected and studied—these areas cover most parts of the Fortymile drainage area (see fig. 4)—and the pertinent geology and analytical results are discussed for each area. If more complete numerical informa-

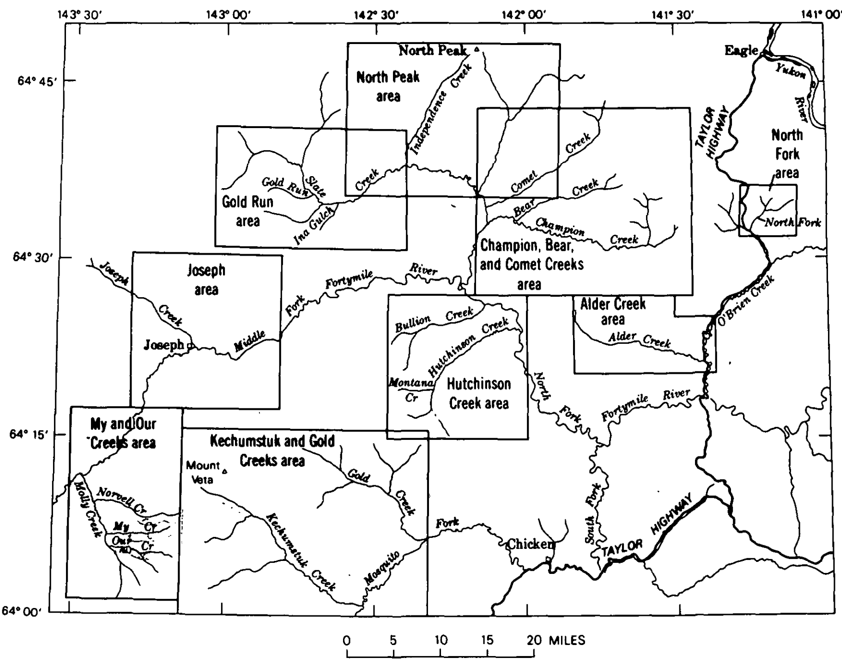


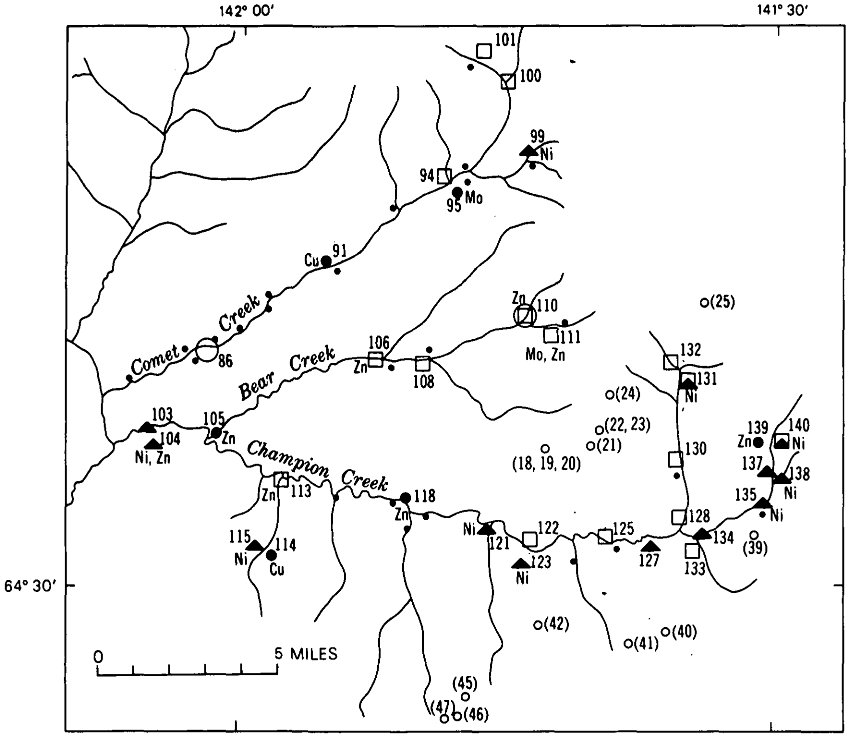
FIGURE 4.—Location of areas discussed in text. Outlines of areas correspond with maps showing the location of stream-sediment and rock samples (figs. 5–13).

tion is desired for any particular sample it can be obtained from the complete analysis in the open-file report (Foster and Clark, 1969).

CHAMPION, BEAR, AND COMET CREEKS AREA

In the drainage area of Champion, Bear, and Comet Creeks, 57 stream-sediment samples were collected (fig. 5). Values for lead in these samples range from 10 to 150 ppm and 16 samples (28 percent) have 50 ppm or more. Zinc is found in about 14 percent of the samples. Chromium and nickel values are fairly high in about 22 percent of the samples, but copper and silver occur in anomalous amounts in less than 4 percent of the samples.

Eight rock samples collected north of Champion Creek (fig. 5) were analyzed. Three samples of diorite (samples 22, 23, and 24) containing visible sulfides do not have unusual concentrations of metals, but a limonite-stained zone near the margin of the diorite intrusion (sample 21), in which the rock has visible sulfide minerals, has 200 ppm bismuth. Marble rubble containing patches of an unidentified dark-gray mineral was present in several prospect pits. Analyses (samples 19 and 20) show high con-



EXPLANATION

○ Silver (less than 0.5-0.7 ppm)

▲ Chromium (200-700 ppm)

□ Lead (50-150 ppm)

● Sample containing element(s) in anomalous amounts not shown by symbols at left. Element(s) contained indicated by chemical symbol:
- Cu, copper (100-150 ppm)
- Mo, molybdenum (5-7 ppm)
- Ni, nickel (100-150 ppm)
- Zn, zinc (200-300 ppm)

• Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

o Rock sample (discussed in text)

FIGURE 5.—Location of stream-sediment and rock samples collected from the Champion, Bear, and Comet Creeks area. Anomalous amounts of selected metals in the stream-sediment samples are shown by symbol. Rock sample numbers are in parentheses.

centrations of lead (>20,000 ppm), zinc (>10,000 ppm), copper (150 ppm), iron (>20 percent), and silver (0.7 ppm). A sample of serpentinized ultramafic rock (sample 25) had 1,500 ppm of both nickel and chromium.

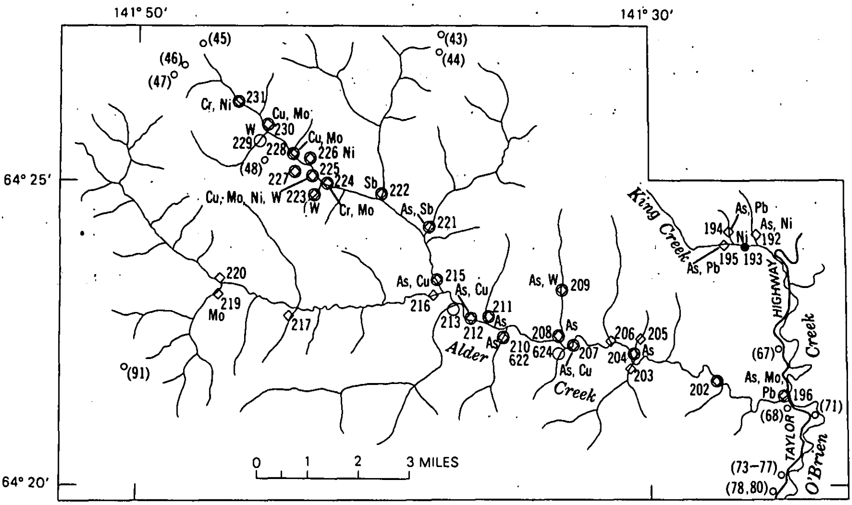
Galena was found as float on a ridge south of Champion Creek (fig. 5). The sample (39) contains >20,000 ppm lead, >10,000 ppm zinc, 30 ppm silver, 150 ppm cadmium, 700 ppm copper, and >20 percent iron. Four samples of schist collected south of Champion Creek were analyzed. A graphite schist (sample 45) contains 1 ppm silver, 20 ppm molybdenum, and zinc is detected but is <200 ppm. Another graphite schist (sample 47) has 100 ppm copper and zinc is detected but is below 200 ppm. In a chlorite schist (sample 46), silver and zinc are detected in amounts below the limits of determination. A sample of greenstone (sample 41) contains more nickel (200 ppm) and chromium (700 ppm) than other metamorphic rock types in the area; ultramafic rock (sample 42) associated with greenstone has 1,000 ppm nickel and 1,500 ppm chromium. A quartz vein (sample 40) is barren.

Only the general geology of this area is known. Drainage of Bear and Comet Creeks is primarily from igneous intrusive rocks of granitic to dioritic composition. Narrow zones, a few feet wide, of oxidized and possibly hydrothermally altered rocks occur. The contact of the intrusive rocks with the metamorphic country rocks is very irregular and complex. Small patches of intrusive rock rubble are surrounded by metamorphic rock rubble and small patches of metamorphic rocks are in the igneous terrane. Southern tributaries to Champion Creek primarily drain metamorphic rocks, including quartz-graphite schist, chlorite schist, quartz-muscovite schist, marble, quartzite, and some greenstone. At the locality of sample 39 (fig. 5), south of Champion Creek, galena float is believed to be near its place of origin, and this suggests the presence of a mineralized vein or veins in the metamorphic rocks. Some of the higher metal values found in the stream sediment from Champion Creek could be due to such veins, and also, to the occurrence of small masses and dikes of ultramafic rock.

Further exploration of this area is recommended because it is a contact zone of several igneous intrusions, it has favorable host rocks such as marble, it has ultramafic rock, and there are indications of some mineralized veins.

ALDER CREEK AREA

Analyses of stream-sediment samples from Alder Creek suggest that this area might be considered for further exploration. Silver is detected in two-thirds of the samples, zinc is detected in more than three-fourths of the samples, and a few samples contain slightly anomalous amounts of other metals. Alder Creek is ex-



EXPLANATION

Silver (0.5 ppm or less)

Zinc (less than 200-700 ppm)

Rock sample

Sample containing element(s) in anomalous amounts not shown by symbols at left. Element(s) contained are indicated by chemical symbol:
- As, arsenic (200 ppm or less)
- Cr, chromium (200-1,000 ppm)
- Cu, copper (100 ppm)
- Mo, molybdenum (less than 5-7 ppm)
- Ni, nickel (100-150 ppm)
- Pb, lead (50-150 ppm)
- Sb, antimony detected
- W, tungsten detected

FIGURE 6.—Location of stream-sediment and rock samples collected from the Alder Creek area. Anomalous amounts of selected metals in the stream-sediment samples are shown by symbol. Rock samples (numbers in parentheses) containing one or more elements in possibly anomalous amounts:

43. Graphitic phyllite; lead (50 ppm) and silver and zinc detected.
44. Graphitic schist; silver and zinc detected.
45. Graphitic schist; silver (1 ppm), molybdenum (20 ppm), and lead (150 ppm).
46. Chlorite schist; silver and zinc detected.
47. Graphitic quartzite; copper (100 ppm) and zinc detected.
48. Garnetiferous greenstone; chromium (300 ppm), nickel (150 ppm), and silver detected.
67. Serpentinized ultramafic; chromium (2,000 ppm), nickel (1,000 ppm), and silver and arsenic detected.
68. Quartz-mica schist with sulfides; silver (0.7 ppm) and gold (5 ppm).
71. Diorite or metadiorite; zinc detected.
73. Sheared quartzite; molybdenum (5 ppm) and silver and zinc detected.
74. Sheared and crushed rock; silver (0.5 ppm).
75. Sheared quartzite; silver, molybdenum, and zinc detected.
76. Gouge; silver, molybdenum, and zinc detected.
77. Sheared rock; zinc (300 ppm).
78. Quartzite; zinc detected.
80. Sheared marble and quartzite; silver (0.7 ppm) and zinc detected.
91. Mafic dike rock; chromium (700 ppm), silver and zinc detected.

ceptional in the consistency with which silver is detected in the samples. Sample locations and the distribution of anomalous amounts of metals are shown in figure 6.

Alder Creek drains an area that consists primarily of metamorphic rocks, of which marble is the most abundant rock type exposed along the creek. The south branch of Alder Creek heads in metamorphic terrane consisting mostly of marble, quartzite, quartz-mica gneiss and schist, and quartz-graphite schist. A few granitic dikes cut the metamorphic rocks, and a granitic intrusion crops out on the ridge south of the stream for a distance of about 3 miles. The tributaries from which samples 217 and 219 were taken drain the area of contact between the intrusion and meta-

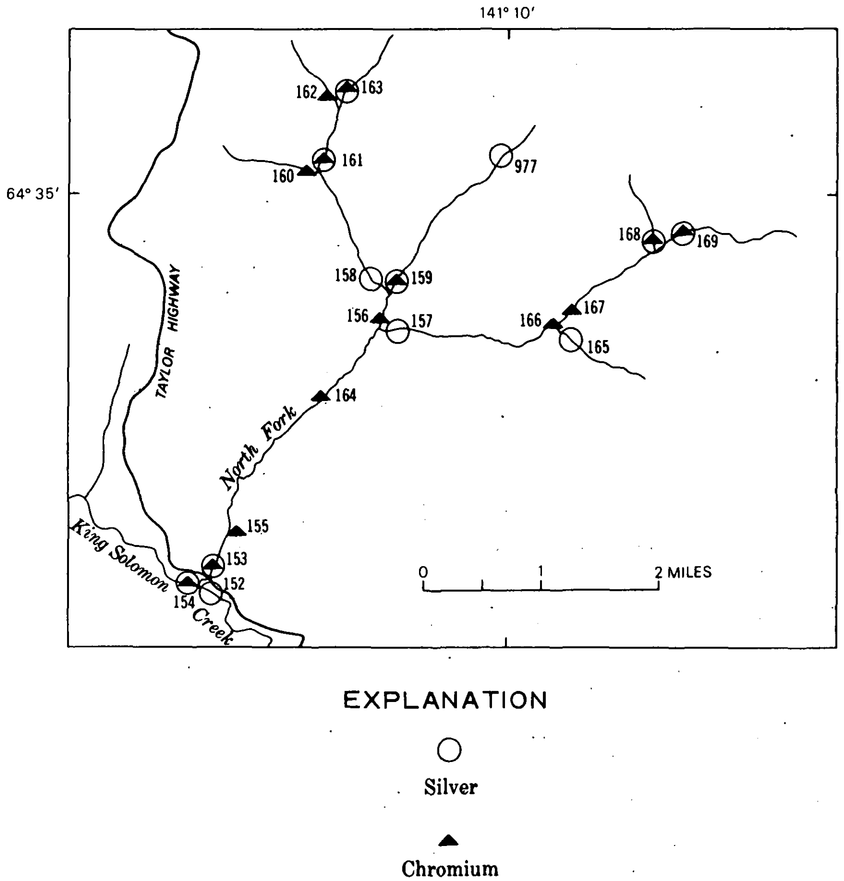


FIGURE 7.—Location of stream-sediment samples collected from North Fork showing anomalous amounts of chromium and silver. Some symbols are combined to show both metals. Other elements for these samples are given in table 2.

morphic rocks. The tributary from which sample 203 was obtained (fig. 6) heads near a small mass of serpentinized ultramafic rock which crops out on the ridge above (Foster, 1969a).

Marble is the most abundant rock type between the two main branches of Alder Creek. The north branch of Alder Creek heads primarily in quartz-graphite schist, quartzite, mica-schist, and chlorite schist, and no intrusions are presently known in its drainage area. Further geological and geochemical work is needed to learn the source of the anomalous values in the stream sediments and to determine whether or not the Alder Creek area has economic mineral protential.

NORTH FORK AREA

Stream-sediment samples from the North Fork drainage area all contain amounts of several metals which are slightly above threshold values (fig. 7). Twelve out of 19 samples (63 percent) have detectable silver, 14 samples (73 percent) have detectable zinc, and 13 samples (68 percent) have detectable molybdenum as compared with 20, 26, and 17 percent, respectively, for these metals in all Fortymile area stream-sediment samples. Gold is found in two samples, and chromium, nickel, and lead have values slightly above threshold values in many. Table 2 gives analyses for these samples and figure 7 shows the location of the samples.

The North Fork drains an area of greenschist facies metamorphic rocks consisting primarily of quartz-graphite and carbonaceous schists, quartz-muscovite schist, and quartzite. Some greenstone and at least one ultramafic mass crop out. No intrusions other than the ultramafic one are known. There are several small zones of crushed and possibly hydrothermally altered rock. Much of the area is covered by colluvium and vegetation, and the geology is not well known. The 2,000 ppm of chromium in sample 159 may be from ultramafic rock known to crop out about 1 mile upstream. Other values for chromium and nickel which are slightly above background may be due to greenstones or ultramafic rocks. The source of other metals which are in amounts slightly greater than background is not known, but it could be from the altered rock along shear zones.

NORTH PEAK AREA

Independence Creek and an unnamed stream drain southward from the vicinity of North Peak to the North Fork of the Fortymile River (fig. 8). In the sediments of the unnamed stream, silver was detected in eight of 13 samples; gold (0.04 ppm) was detected in one; molybdenum, in two; zinc, in three; and 11 contained 50

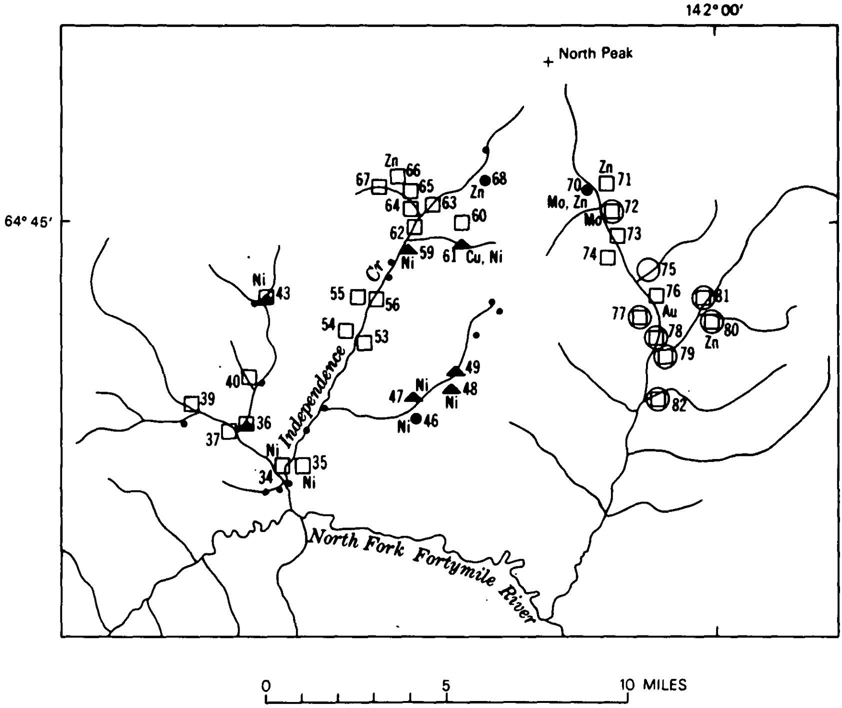
TABLE 2.—*Semiquantative spectrographic analyses and gold analyses of stream-sediment samples from the North Fork drainage area*

[Results are given in parts per million. N, element not detected; L, below limit of determination. Limits of determination: Ag, 0.5; As, 200; Au, 0.02; Mo, 5; and Zn, 200. Analysts: Elizabeth Martinez and K. J. Curry, spectrographic; R. L. Miller and A. L. Meier, gold by atomic absorption. Results of analyses of samples (except 977) for 29 elements in Foster and Clark (1969)]

Sample No.	Ag	As	Au	Cr	Cu	Mo	Ni	Pb	Zn
152	L	N	L	150	50	N	100	20	L
153	L	N	.3	200	70	N	100	15	N
154	L	N	L	300	70	N	150	20	N
155	N	L	L	200	50	L	100	50	500
156	N	L	L	300	50	L	70	50	L
157	L	N	L	150	50	N	100	50	L
158	L	L	L	150	70	5	70	50	L
159	.5	N	L	2,000	70	L	100	70	200
160	N	N	L	200	50	L	100	15	L
161	L	N	L	200	70	5	100	50	L
162	N	N	L	200	50	L	70	30	N
163	L	N	L	200	50	5	70	15	L
164	N	N	L	200	30	5	100	50	L
165	L	N	L	150	50	N	70	50	L
166	N	N	L	200	50	5	100	30	200
167	N	L	L	200	70	L	100	50	200
168	L	L	L	200	50	L	70	150	N
169	L	N	.04	200	70	L	100	20	N
977	L	L	L	150	100	N	50	30	L

ppm or more lead. None of the sediments from Independence Creek, which more or less parallels the unnamed stream, contain silver, gold, or molybdenum, but some contain chromium, nickel, lead, and zinc in amounts slightly above background values. The distribution of anomalous values for some of the metals is shown in figure 8.

The streams of this area primarily drain metamorphic rocks which include amphibolite, quartz-mica schist, quartzite, quartz-graphite schist, and greenschist. The metamorphic rocks are intruded by granodiorite and diorite and possibly more mafic rocks. Locally, the diorite is epidotized. Specks of sulfide minerals are abundant locally in the diorite and adjacent metamorphic rocks. Felsic rock with euhedral quartz phenocrysts also intrudes the metamorphic rocks.



EXPLANATION

○ Silver (0.5 ppm or less)

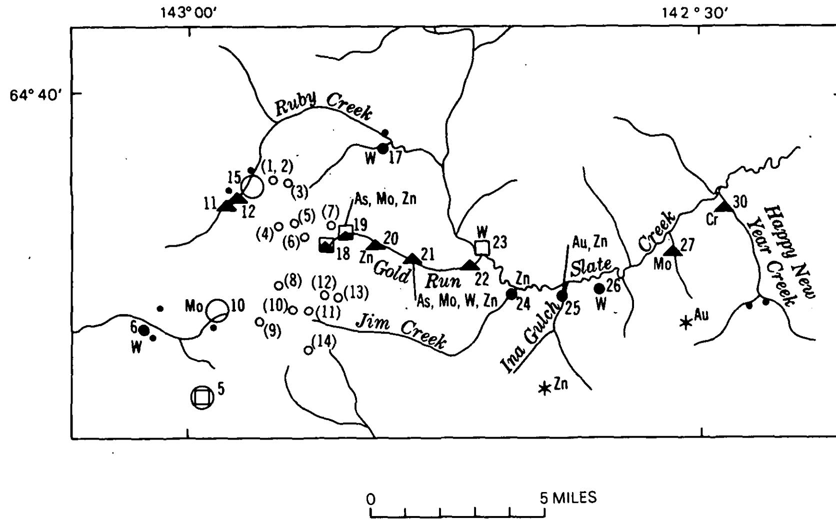
▲ Chromium (200-700 ppm)

□ Lead (50-100 ppm)

● Sample containing element(s) in anomalous amounts not shown by symbols at left. Element(s) contained are indicated by chemical symbol:
- Au, gold (0.04 ppm)
- Cu, copper (100 ppm)
- Mo, molybdenum detected
- Ni, nickel (100-200 ppm)
- Zn, zinc detected

• Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

FIGURE 8.—Location of stream-sediment samples collected from the North Peak area. Anomalous amounts of selected metals in the samples are shown by symbols.



EXPLANATION

Silver detected

Nickel
(100-150 ppm)

Lead
(50-70 ppm)

Sediment sample from spring containing gold (0.02 ppm) or zinc detected

Rock sample

Sample containing element(s) in anomalous amounts not shown by symbols at left. Element(s) contained are indicated by chemical symbol:
As, arsenic detected
Au, gold (0.02 ppm)
Cr, chromium (300 ppm)
Mo, molybdenun (5 ppm or less)
W, tungsten detected
Zn, zinc detected

Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

FIGURE 9.—Location of stream-sediment, spring-sediment, and rock samples collected from the Gold Run area. Anomalous amounts of selected metals in the samples are shown by symbol. No numbers are given for spring-sediment samples; rock samples (numbers in parentheses) containing one or more elements in possibly anomalous amounts:

1, 2. Hypabyssal type granitic rock; molybdenum (5 ppm), lead (50 ppm), and silver detected.
3. Hypabyssal type granitic rock; molybdenum (10 ppm) and arsenic detected.
4. Conglomerate; gold (0.02 ppm) and arsenic detected.
5. Basalt; chromium (700 ppm), nickel (150 ppm), and arsenic and zinc detected.
6. Basalt; gold (1.6 ppm), chromium (1,500 ppm), copper (100 ppm), nickel (500 ppm), and silver and molybdenum detected.
7. Quartzite; arsenic detected.

These streams drain a considerable area that crosses contacts, possibly mineralized, between the various igneous and metamorphic rocks. The nickel and chromium values which are above background may be related to greenstone and (or) ultramafic rock. Some other anomalous values in other metals may come from small amounts of sulfide minerals scattered throughout the metamorphic rocks.

GOLD RUN AREA

The Gold Run area has some weakly anomalous amounts of silver, gold, tungsten, and other metals in both stream sediments and rocks (fig. 9). The anomalous values are both small and inconsistent, but Gold Run has produced considerable placer gold and the geology of the area indicates a possibility of Tertiary(?) mineralization. The area is a dominantly metamorphic terrane intruded by granitic rocks, but locally both fine-grained felsic and malfic hypabyssal and volcanic rocks occur. Between the head of Gold Run and Ruby Creek a small area of basalt is in contact with Tertiary(?) conglomerate on both its eastern and western sides. A random sample of the fairly fresh basalt (sample 6) collected about 500 feet from its eastern contact contains 1.6 ppm gold. Conglomerate (sample 4) adjacent to the basalt on the west contains 0.02 ppm gold. Gold is also present (0.02 ppm) in a stream-sediment sample taken near the mouth of Ina Gulch (sample 25) and from a hillside spring sediment (0.02 ppm) above Slate Creek. Arsenic is detected but is below 200 ppm in eight of 14 bedrock samples and is 3,000 ppm in sample 13 (fig. 9). Silver is detected but in amounts below 0.5 ppm in three bedrock samples and in one soil sample, and sample 9 (fig. 9) contains 3 ppm of silver.

Stream-sediment samples from Gold Run contain amounts of lead, nickel, tungsten, zinc, molybdenum, and arsenic slightly above threshold values. Samples from other streams in the vicinity contain fewer metals in anomalous amounts (fig. 9). Slightly anomalous values for chromium (300 ppm) and nickel (150 ppm) in a sample (30) collected near the mouth of Happy New Year Creek may be due to ultramafic rock known to occur upstream. Further

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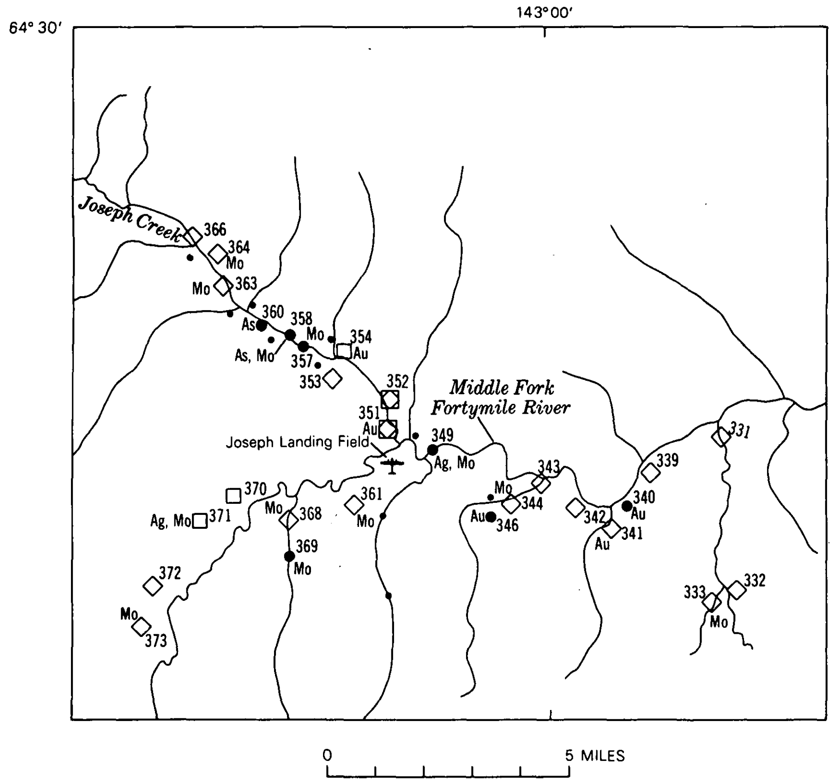
8. Quartz vein; molybdenum (20 ppm).
9. Quartzite; silver (3 ppm), zinc (300 ppm), and arsenic and molybdenum detected.
10, 11. Quartz vein; arsenic and tungsten detected.
12. Dike rock with visible sulfides; chromium (700 ppm).
13. Quartz vein; arsenic (3,000 ppm) and silver and molybdenum detected.
14. Quartz vein; copper (100 ppm) and arsenic detected.



EXPLANATION

□ Lead (50 ppm)

◇ Zinc detected

● Sample containing element(s) in anomalous amounts not shown by above symbols. Elements(s) contained are indicated by chemical symbol:
- Ag, silver detected
- As, arsenic detected
- Au, gold (0.02 to 0.08 ppm)
- Mo, molybdenum (less than 5-50 ppm)

• Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

FIGURE 10.—Location of stream-sediment samples collected from the Joseph area. Anomalous amounts of selected metals in the samples are shown by symbol.

investigation of the relation between the mineralization and the shallow mafic and felsic intrusions and volcanic rocks is needed.

JOSEPH AREA

On the Joseph Creek drainage and on the Middle Fork above and below Joseph about two-thirds of the stream-sediment samples have one or more metals in amounts slightly above background values (fig. 10). Gold is found in five stream-sediment samples, and although it occurs in small amounts (0.02 to 0.08 ppm) it is found in more samples here than in any other drainage area sampled in the Fortymile area. The significance of the gold is not evident.

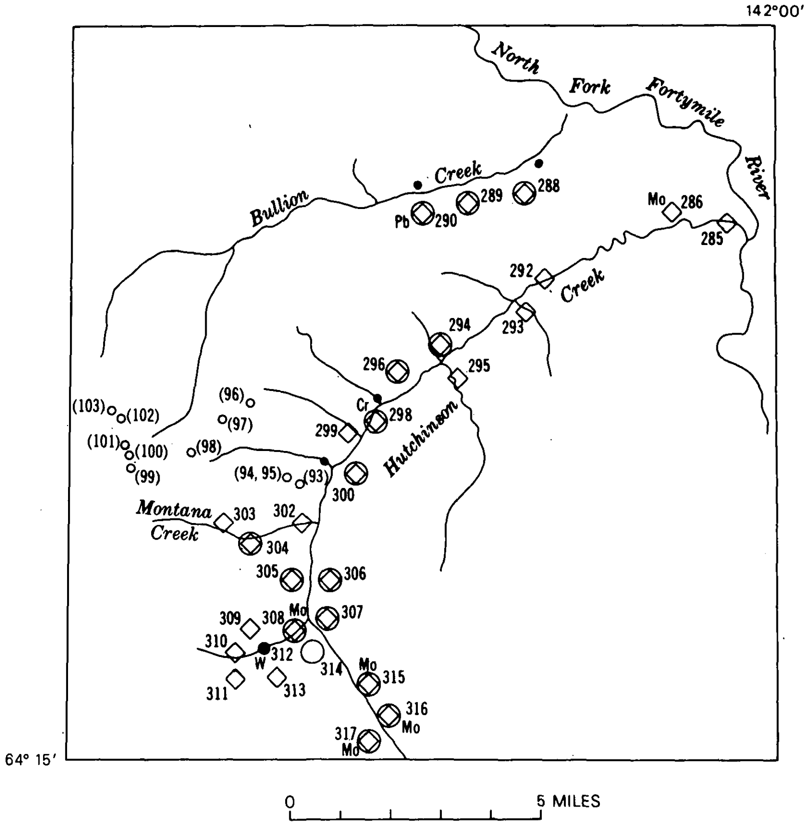
Joseph Creek primarily drains metamorphic terrane but some tributaries to Joseph Creek entering from the west cross contacts between Mesozoic(?) granitic rocks and the metamorphic rocks. In a single traverse crossing this intrusive contact no favorable indications for mineral deposits were observed.

Tributaries entering the Middle Fork from the south near Joseph cross contacts between metamorphic rocks and silicic igneous rocks which are shallow intrusive rocks and (or) volcanic rocks. They are similar to rocks in the Gold Run area and may be of Tertiary age.

HUTCHINSON CREEK AREA

On Hutchinson Creek drainage, including Montana Creek, and on Bullion Creek, silver is detected in 16 samples and zinc is detected in 27 samples of 32 stream-sediment samples (fig. 11). Although the amounts of silver and zinc found in the samples are low, they are detected much more consistently than in sediment samples from most other Fortymile streams. The only other streams in which silver is so consistently detected are Alder Creek and North Fork. The Hutchinson Creek area has produced placer gold in the past.

Hutchinson Creek heads in an area of metamorphic rocks cut by a few small Mesozoic(?) granitic intrusive masses and dikes. Montana Creek and other tributaries to the north are in an area of metamorphic rocks which are intruded by both felsic and mafic dikes and other small intrusions. Most of these intrusions are fine grained or porphyritic and may be shallow intrusives; some of the rocks may be volcanic. Bullion Creek flows across a complex of felsic and mafic rocks, probably mostly of volcanic origin. They are younger than the granitic intrusions of the type more common near the head of Hutchinson Creek. Many of the igneous rocks resemble those of the Gold Run area and may be Tertiary



EXPLANATION

Silver detected

Zinc detected

Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

Sample containing element(s) in anomalous amounts not shown by symbols at left. Element(s) contained are indicated by chemical symbol:
Cr, chromium (200 ppm)
Mo, molybdenum detected
Pb, lead (50 ppm)
W, tungsten (200 ppm)

Rock sample

FIGURE 11.—Location of stream-sediment and rock samples collected from the Hutchinson Creek area. Anomalous amounts of selected metals in the samples are shown by symbol. Rock samples (numbers in parentheses) containing one or more elements in possibly anomalous amounts:

93. Quartz-biotite schist; zinc detected.

94. Quartz porphyry; arsenic (1,000 ppm), lead (100 ppm), tin (50 ppm), and molybdenum and silver detected.

95. Quartz porphyry; lead (150 ppm), molybdenum (7 ppm), tin (30 ppm), and arsenic, silver, and zinc detected.

in age. The distribution of metals in the sediments suggests that the mineralization may be associated with these younger igneous rocks. A quartz porphyry in a saddle about 30 feet wide on the ridge north of Montana Creek (samples 94 and 95, fig. 11) is unique in having 30 to 50 ppm tin; the rock also contains lead (100 to 150 ppm), detectable arsenic ($<$200 ppm to 1,000 ppm), silver ($<$0.5 ppm), and molybdenum ($<$5 to 7 ppm). The quartz porphyry may be intruded along a fault. Although this area was rather thoroughly prospected in the early 1900's, more detailed stream-sediment sampling coupled with further geologic reconnaissance may be warranted to determine the significance of the silver and zinc distribution.

MY AND OUR CREEKS AREA

Several bedrock prospects for silver and one for antimony in the vicinity of My and Our Creeks in the Eagle A–5 quadrangle have been previously checked by several investigators (Saunders, 1967, p. 24–25, 57). Because this remote area is largely covered by timber and brush and is difficult to prospect, it was hoped that geochemical studies of stream sediment might give some indication of the degree and extent of mineralization. Fortyfive stream-sediment samples were collected and analyzed, and about half of them contain amounts of one or more metals which are slightly above background values. The location and metal content of these samples are shown in figure 12.

My Creek, Our Creek, and Norvell Creek all head in and drain an area of metamorphic rocks consisting primarily of quartz-biotite gneiss and schist, quartz-graphite schist, quartzite, marble, amphibolite, greenstone, and greenschist. The metamorphic rocks are in contact with a large granitic intrusive along the west side of a ridge near the head of these streams. The intrusive is epidotized and has local altered zones near the contact. A few dikes and small granitic masses (probably mostly diorite and syenite) and quartz veins were noted in the metamorphic country rock west of the contact.

The stream-sediment samples do not seem to indicate particularly promising or extensive mineralization of the area. However,

96. Biotite schist; copper (300 ppm) and silver and zinc detected.
97. Felsic hypabyssal rock; lead (70 ppm) and silver detected.
98. Felsite; molybdenum (5 ppm), lead (100 ppm), and tin detected.
99. Gabbro dike; lead (150 ppm) and zinc detected.
100. Diorite (?); zinc detected.
101. Diorite; lead (100 ppm) and zinc detected.
102. Diorite porphyry; lead (150 ppm) and arsenic detected.
103. Quartz vein; arsenic detected.

the stream-sediment samples were collected in early June when water was high and snow and ice still bordered the streams, so they may not be as representative as samples collected under better conditions. Nevertheless, there are a few samples containing metals in high enough amounts to suggest places where further sampling and exploration might be desirable such as the lower part of the unnamed creek north of Norvell Creek (sample 382).

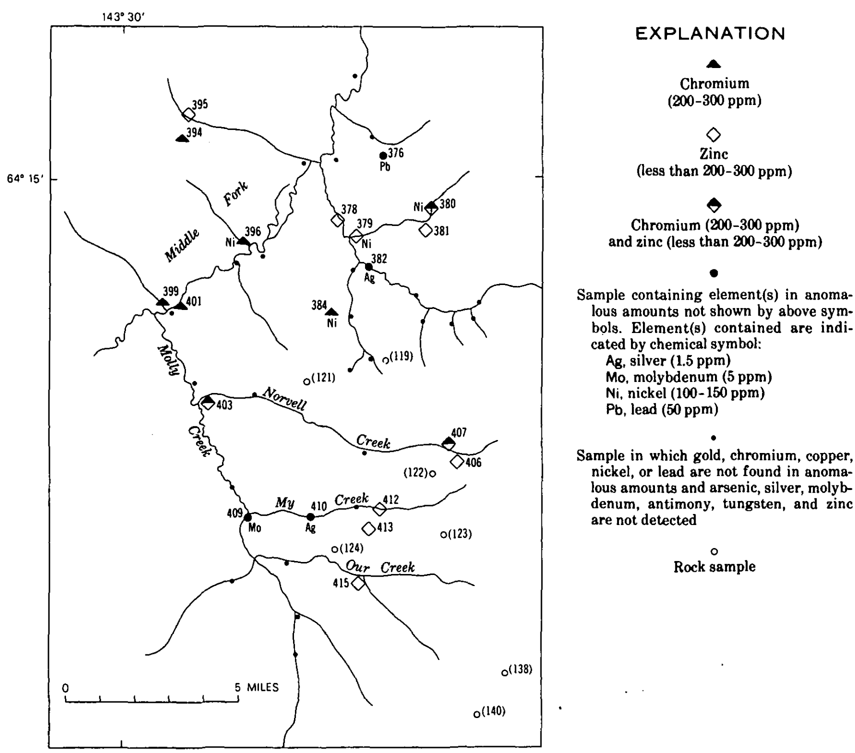


FIGURE 12.—Location of stream-sediment and rock samples collected from the My and Our Creeks area. Anomalous amounts of selected metals in the samples are shown by symbol. Rock samples (numbers in parentheses) containing one or more elements in possibly anomalous amounts:

119. Quartzite breccia; silver (1.5 ppm), copper (100 ppm), lead (1,000 ppm), zinc (3,000 ppm), and arsenic detected.
121. Quartz vein; silver (0.7 ppm) and lead (150 ppm).
122. Galena and quartz from vein material of prospect pit; silver (300 ppm), gold (0.04 ppm), copper (1,500 ppm), lead(>20,000 ppm), cadmium (>500 ppm), zinc (>10,000 ppm), and arsenic and tungsten detected.
123. Galena and gangue from vein material in prospect pit; arsenic (200 ppm), silver (1,000 ppm), gold (0.04 ppm), copper (1,500 ppm), and cadmium (500 ppm).
124. Stibnite from quartz vein in prospect pit; antimony (>10,000 ppm) and silver (<0.2 ppm) detected, and gold possibly detected.
138. Gabbro with specks of sulfide minerals; silver (0.7 ppm), lead (300 ppm), and zinc (500 ppm).
140. Greenstone; lead (150 ppm), zinc (300 ppm), and arsenic detected.

Mineralization appears to be primarily in quartz veins cutting the metamorphic rocks. The presence of minor amounts of gold, silver, and copper and considerable lead and zinc is confirmed in selected samples from the silver prospects (samples 122, 123; fig. 12). One sample (122) also contains cadmium. One quartz vein (sample 121) north of Norvell Creek contains minor amounts of silver (0.7 ppm) and lead (150 ppm). Other quartz veins sampled in the area are barren.

Some of the metallic values in the stream-sediment samples may be coming from scattered specks of sulfide minerals in greenschists and greenstone. The chromium and nickel may be from greenstone and greenschist possibly from ultramafic dikes, although ultramafic rocks have not yet been observed nearby.

KECHUMSTUK AND GOLD CREEKS AREA

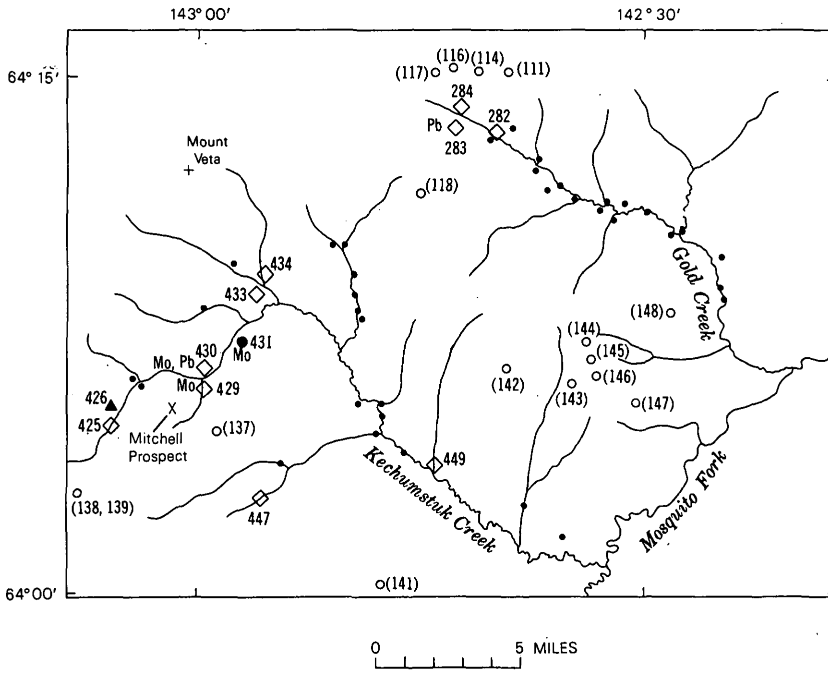
Geochemical studies were undertaken in the Kechumstuk and Gold Creeks drainage area because this area is favorably located in regard to igneous intrusions, has some placer gold, has favorable host rocks, and there are several prospects in the area (Saunders, 1967, p. 25). Of 27 stream-sediment samples collected from the Kechumstuk Creek drainage area (fig. 13) only nine have metal values slightly above background. Zinc (<200 ppm) is detected in seven samples and molybdenum (<5 ppm) is detected in three. The content of chromium is 300 ppm in one sample.

Of 20 samples from the Gold Creek drainage area three have detectable zinc (<200 ppm) and one has 70 ppm lead. Near the head of Gold Creek, silver is detected in samples of quartz monzonite (sample 114), diorite porphyry (sample 111), and greenschist (sample 116). On a ridge near the mouth of Gold Creek, greenstone (sample 147) interlayered with marble and apparently intruded by a gabbroic rock has detectable silver and 200 to 700 ppm copper.

The stream-sediment sampling gives little indication of significant mineralization in the Kechumstuk and Gold Creeks area. However, favorable geology and known small mineralized areas (Brooks and others, 1912, p. 213; Saunders, 1967, p. 25, 26) including the Mitchell Prospect (Saunders, 1967, p. 25) (see table 3), suggest that some further checking should be done to determine if stream-sediment sampling truly reflects the mineral potential of the area.

CONCLUSIONS

A study of analyses of 448 stream-sediment samples from the Fortymile area suggests several areas which have not been care-



EXPLANATION

▲ Chromium (300 ppm)

◇ Zinc detected

● Sample containing element(s) in anomalous amounts not shown by above symbols. Element(s) contained are indicated by chemical symbol:
Mo, molybdenum (less than 5-7 ppm)
Pb, lead (50-70 ppm)

• Sample in which gold, chromium, copper, nickel, or lead are not found in anomalous amounts and arsenic, silver, molybdenum, antimony, tungsten, and zinc are not detected

○ Rock sample

FIGURE 13.—Location of stream-sediment and rock samples collected from the Kechumstuk and Gold Creeks area. Anomalous amounts of selected metals are shown by symbol. Rock samples (numbers in parentheses) containing one or more elements in possibly anomalous amounts:

111. Diorite porphyry; silver detected.

fully prospected recently that may be worthy of further sampling and geologic exploration; the Champion Creek and Alder Creek areas are two of the most promising. The Champion Creek area not only has anomalous values in stream-sediment samples, but it also has known mineralized bedrock. This preliminary sampling suggests that although lead and zinc are present, the minerals may not contain much silver.

The large number of samples from Alder Creek that contain silver as well as other metals slightly above background suggests that this area should receive further consideration. The geology of the Alder Creek area is not well known and little recent prospecting has been done there. Because the area is mostly tree and brush covered, additional geochemical sampling might be helpful.

The drainage area of North Fork and drainage from North Peak have weak unexplained anomalies. They may be due, at least in part, to widely scattered specks of sulfide minerals occurring in the metamorphic rocks but which are not necessarily associated with mineral deposits. The Gold Run, Joseph, and Hutchinson Creek areas, formerly mined for placer gold, have minor indications of Tertiary(?) mineralization which have not been thoroughly checked. No new encouraging indications of mineralization were found in the My Creek, Kechumstuk, or Gold Creek areas, but geochemical and geologic work and prospecting is still not sufficient for a final evaluation of these areas.

The present geochemical studies in the Fortymile area have not conclusively indicated either the presence or the absence of undiscovered gold placer deposits. Gold can commonly be panned from streams in which it is not found in the fine-grained stream-sediment samples.

It is likely that the anomalies in some areas are due to sulfide minerals in greenschist and greenstones and are not indications

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114. Quartz monzonite; silver detected.
116. Greenschist; silver detected.
117. Greenschist; chromium (500 ppm).
137. Quartz vein; silver (3 ppm), gold (0.06 ppm), molybdenum (50 ppm), and lead (150 ppm).
138. Gabbro; silver (0.7 ppm), lead (300 ppm), and zinc (500 ppm).
139. Greenstone; (silver 0.7), lead (300 ppm), and zinc (500 ppm).
141. Greenstone; chromium (200 ppm) and copper (100 ppm).
142. Greenstone; arsenic detected.
143. Greenstone; chromium (700 ppm), copper (100 ppm), and nickel (100 ppm).
144. Greenstone; arsenic detected.
145. Greenstone; molybdenum (7 ppm) and zinc detected.
146. Greenstone; tin (10 ppm).
147. Greenstone; copper (200 to 700 ppm) and silver detected.
148. Greenstone; chromium (500 ppm) and nickel (150 ppm).

TABLE 3.—*Analyses of selected samples from the Mitchell Prospect*

[Analyses reported in parts per million. N, element not detected; L, detected but less than the limit of determination. Limits of determination: As, 200; Au, 0.02; Mo, 5; Sn, 10; and Zn, 200. Analysts: K. J. Curry, spectrographic; R. L. Miller and A. L. Meier, gold by atomic absorption]

Sample description	Sample No.	Ag	As	Au	Cr	Cu	Mo	Ni	Pb	Sn	Zn
Quartzite	125	5	N	L	70	500	N	70	700	N	300
Calcareous vein	126	30	N	0.4	70	>20,000	L	20	300	L	1,000
Calcareous vein	127	30	N	0.02	30	15,000	L	50	1,500	L	500
Marble	128	150	N	0.08	70	>20,000	N	70	70	N	300
Quartzite	129	N	N	L	70	500	N	70	150	N	300
Marble	130	50	N	0.08	70	20,000	N	50	300	N	1,500
Quartzite	131	15	700	0.04	30	700	50	70	300	N	7,000
Felsite	132	0.7	N	L	15	30	N	7	300	N	500
Felsite	133	0.5	N	L	10	7	N	7	300	L	L
Malachite and vein material	134	7	N	L	70	15,000	N	70	500	N	>10,000
Malachite and vein material	135	1.5	N	L	15	>20,000	N	70	300	N	3,000
Limonite and vein material	136	7	N	L	15	1,500	15	10	150	N	>10,000

of mineral deposits. Some other metamorphic rocks such as quartzites also have locally abundant scattered specks of sulfide minerals. The distribution of chromium and nickel in the stream sediments may be helpful in locating ultramafic rocks. Although these rocks may not contain commercial quantities of nickel or other metals they should be checked as soon as possible sources of asbestos.

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