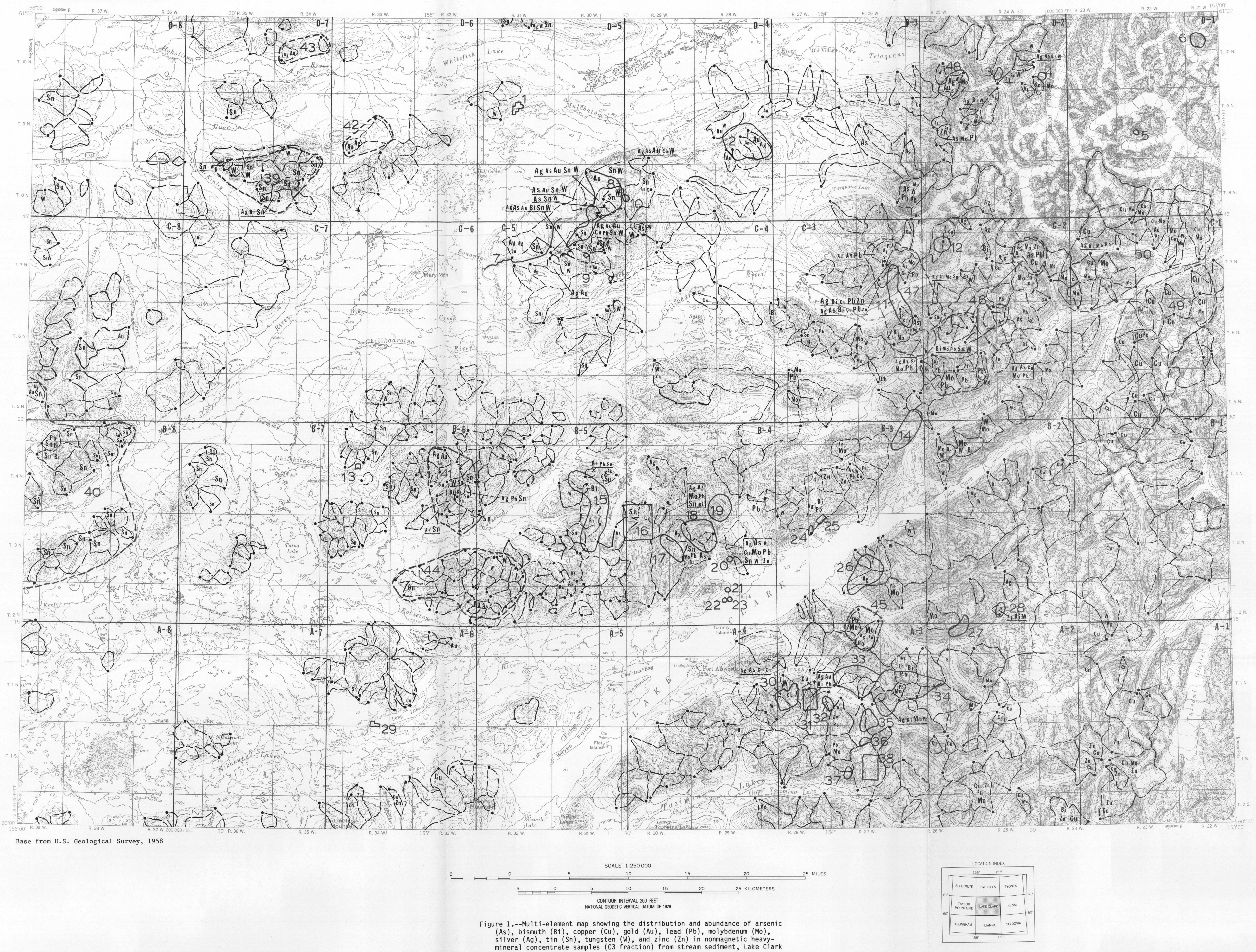
DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1114-C
FOLIO OF THE LAKE CLARK QUADRANGLE, ALASKA
SHEET 1 OF 4



Base from U.S. Geological Survey, 1958

Figure 1.--Multi-element map showing the distribution and abundance of arsenic (As), bismuth (Bi), copper (Cu), gold (Au), lead (Pb), molybdenum (Mo), silver (Ag), tin (Sn), tungsten (W), and zinc (Zn) in nonmagnetic heavy-mineral concentrate samples (C3 fraction) from stream sediment, Lake Clark quadrangle.

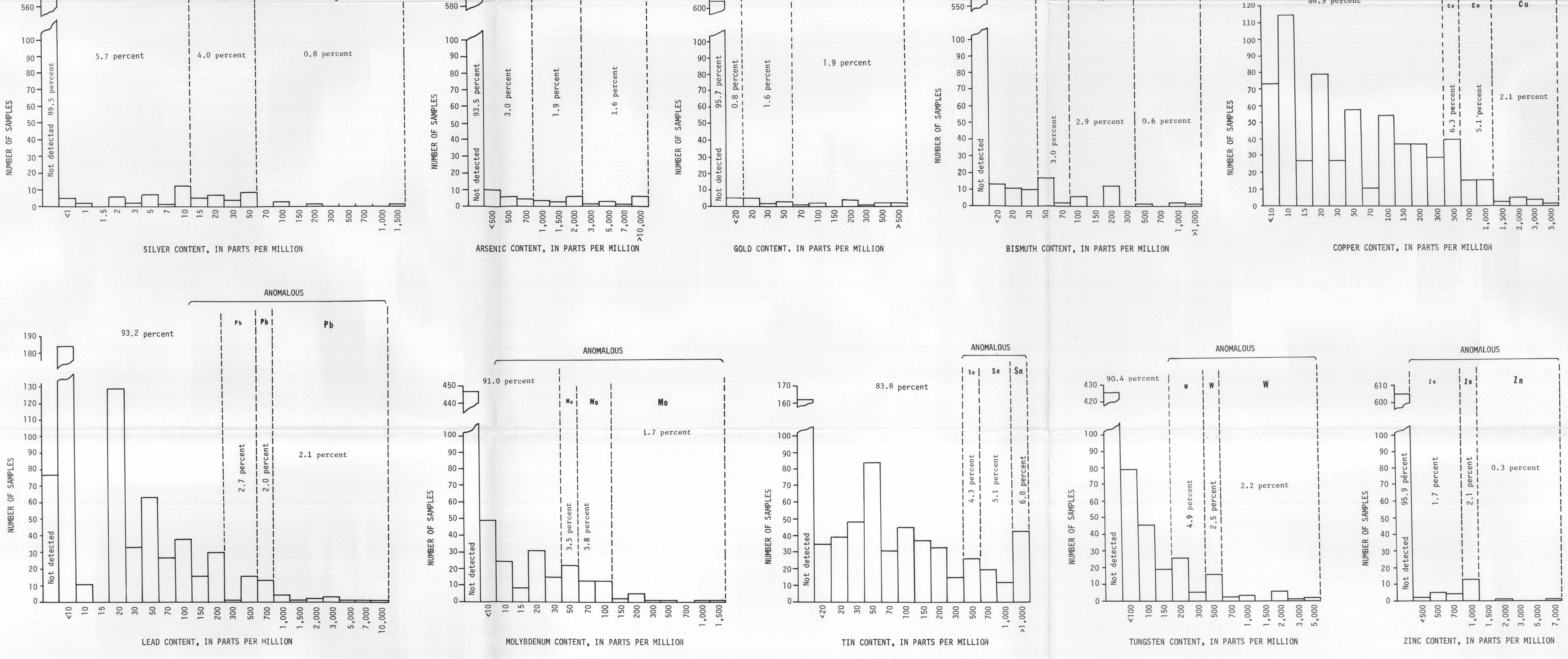


Figure 2.--Histograms showing concentrations of silver (Ag), arsenic (As), gold (Au), bismuth (Bi), copper (Cu), lead (Pb), molybdenum (Mo), tin (Sn), tungsten (W), and zinc (Zn) in 631 nonmagnetic heavy-mineral-concentrate samples (C3 fraction) from stream sediment, concentrations considered anomalous, and percentage of total number of samples represented by each range, Lake Clark quadrangle. Element symbols, which vary in size to denote anomalous concentrations, correspond to symbols used in figure 1. Ranges of concentrations corresponding to the symbols were selected arbitrarily.

MAPS SHOWING THE DISTRIBUTION AND ABUNDANCE OF SELECTED ELEMENTS IN TWO GEOCHEMICAL SAMPLING MEDIA, LAKE CLARK QUADRANGLE, ALASKA

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EXPLANATION

• SAMPLE LOCALITY

---- OUTLINE OF DRAINAGE BASIN

Mo ELEMENT PRESENT IN NONMAGNETIC HEAVY-MINERAL-CONCENTRATE (C3 FRACTION) SAMPLES FROM STREAM SEDIMENT FROM A GIVEN DRAINAGE BASIN--Size of element symbol indicates range, in parts per million, of concentration of element in samples, as shown in figure 2

—— AREA OF MINERAL OCCURRENCE OR GEOCHEMICAL ANOMALY--Solid line (areas 1-38) shows areas of previously known mineral occurrences or geochemical anomalies (references given in table 1); dashed line (areas 39-50) shows areas of anomalies established by the present study

A-7 NUMBER OF TOPOGRAPHIC QUADRANGLE AT 1:63,360--Boundaries of quadrangles shown by grid

INTRODUCTION

These geochemical maps show results of reconnaissance geochemical surveys of the Lake Clark quadrangle, Alaska, carried out during 1977 and 1978 as part of the Alaska Mineral Resource Assessment Program. The multi-element maps (fig. 1, sheet 1 and fig. 3, sheet 2) and histograms (fig. 2, sheet 1 and fig. 4, sheet 2) show the distribution and abundance of arsenic (As), bismuth (Bi), copper (Cu), gold (Au), lead (Pb), molybdenum (Mo), silver (Ag), tin (Sn), tungsten (W), and zinc (Zn) in nonmagnetic heavy-mineral-concentrate (C3 fraction) samples from stream sediments and arsenic, copper, gold, lead, mercury (Hg), molybdenum, silver, and zinc in less-than-0.18-mm stream-sediment samples. The same elements, with the exception of bismuth and mercury, are also shown on single-element maps (fig. 6, sheet 4) and histograms (fig. 7, sheet 4). For most of the elements, lower cut-off values have been chosen for the single-element maps than for the multi-element maps. The single-element maps are presented to aid users primarily interested in a particular element. The chief purpose for the multi-element maps is to show element associations. Element associations are useful in determinations of what type or types of ore deposits may be present in an area. This report discusses geochemical anomalies--departures from normal geochemical patterns--in the Lake Clark quadrangle as indicated by subjective interpretation of the geochemical results.

Most concentrations shown on the multi-element maps are considered anomalous; some lower values may be anomalous in some areas and not in others due to variation in threshold within the quadrangle. Anomalous values for copper, lead, and molybdenum in C3-fraction samples and arsenic in less-than-0.18-mm stream-sediment samples identified in histograms (figs. 2, 4, and 7) but not included in the multi-element maps are shown on the single-element maps for those elements.

Only selected anomalous areas represented by conspicuous anomaly patterns are discussed individually in this report. However, other areas of anomalous values occurring on our element-concentration plots may also be worthy of further investigation. Information given for the described areas may be applicable to other areas of similar element suites not discussed in this report.

The U.S. Geological Survey sampling program was directed by W. D. Crim. Field assistance was provided by D. K. Cohen in 1977 and by J. O. Hampton in 1978. All spectrographic analyses were done by E. F. Cooley. Atomic-absorption and other analyses were done by R. M. O'Leary, A. L. Gruzensky, J. A. Roybal, and Carol Wilson. Ore and ore-related minerals in the C3 fractions were identified by R. B. Tripp.

Geologic information in this report, unless otherwise noted, is from Nelson and others (1983) or from oral and written communications with W. H. Nelson. The geologic map of the Lake Clark quadrangle in figure 5 (sheet 3) is generalized from Nelson and others (1983).

Part of the analytical data used in preparing this report is from samples collected by the Alaska Division of Geological and Geophysical Surveys (DGGS) and analyzed by the U.S. Geological Survey. The samples include 220 less-than-0.18-mm stream sediment samples and 144 heavy-mineral concentrates from stream sediments (C3 fraction) collected during 1977 and 1978 in the central and north-central parts of the Lake Clark quadrangle (1:63,360-scale quadrangles: A-6, B-4, B-5, B-6, C-4, C-5, C-6, D-4, and D-5). In a preliminary report, Eakins and others (1978) described geochemical anomalies and mineral occurrences in the areas of DGGS investigations using this and additional data.

Under contract to the U.S. Bureau of Mines, Resource Associates of Alaska, Inc. (RAA), in 1976, reported results of geological and geochemical investigations in an area of about 6,000 km^2, mainly in the eastern half of the Lake Clark quadrangle. During 1973, 1974, and 1975, more than 3,000 samples of stream sediment, rock, and soil were collected and analyzed. Two prospects and twenty-three geochemical anomalies were delineated.

Routine reconnaissance sampling was done by the U.S. Geological Survey for the present survey in areas of investigations reported by RAA. Some of the anomalies reported by RAA were not indicated or only marginally indicated by our results. This may be due to our relatively low sample density.

SAMPLE MEDIA

The analysis of stream sediment sometimes makes it possible to recognize the presence of mineralized rock in a drainage basin. Whether or not mineralized rock is detected depends on a number of variables, including the degree of erosion and dispersion of the mineralized rock, the sampling procedure, sample preparation methods, and analytical techniques. Evidence of mineralization might not be detected in stream sediment when samples consist of a preponderance of unmineralized particles.

The less-than-0.18-mm stream-sediment samples collected in the Lake Clark quadrangle are predominantly of mechanically disintegrated bedrock, but products of chemically decomposed bedrock, as well as organic matter, are constituents of samples taken in lowland areas or outward from mountain fronts.

Nonmagnetic heavy-mineral concentrates were used in this survey to concentrate ore-related minerals and enhance the possibility of their detection. Identification of specific minerals in the nonmagnetic fraction of the concentrates provided information used in determining the types of deposits or mineralized rock present in the area of this investigation.

Rock samples, many of which showed some evidence of mineralization, were collected from stream-bed alluvium at 42 sites. These samples were analyzed to help define any areas of mineralized rock indicated by the sediment and concentrate data.

SAMPLE COLLECTION AND PREPARATION METHODS

Most of the samples were taken from channels of active first- or second-order streams. Upstream drainage areas range from about 0.65 to 151 km^2; 94 percent of the areas are less than 26 km^2. Several sites are on streams emerging from large glacial systems.

Stream sediments were wet sieved at the sample sites with a stainless-steel screen having 2-mm openings, placed over a 14-in. gold pan. After filling the pan, a sample of the less-than-2-mm sediment was taken from the pan for the stream-sediment sample, and the remaining sediment was panned to obtain a heavy-mineral concentrate.

After drying, the less-than-2-mm stream-sediment samples were sieved with a screen having a 0.18-mm (80 mesh) average opening, and the less-than-0.18-mm fraction was pulverized to less than 0.10 mm in a vertical grinder using ceramic grinding plates. Panned samples were sieved with a screen having a 0.84-mm (20 mesh) average opening. The resulting less-than-0.84-mm fraction was passed through bromoform (specific gravity 2.86) to remove light-mineral grains not removed in the panning process. Each heavy-mineral-concentrate sample was then divided into three fractions on the basis of the magnetic susceptibilities of the mineral grains. A fraction consisting chiefly of magnetite was removed with a hand magnet and a Frantz Isodynamic Magnetic Separator[1] having track settings of 5° forward slope and 10° side slope and current setting of 0.1 ampere. Two additional fractions were obtained from the remaining sample by use of the Frantz separator set at 0.6 ampere. The less magnetic fraction was analyzed and is referred to here as the nonmagnetic, or C3, fraction. Using a microsplitter, a split of the C3 fraction was obtained. One split was used for the determination of the mineralogical composition of the sample by use of a binocular microscope. The other split was pulverized to less than 0.10 mm by hand grinding with a mortar and pestle. The ground portion was used for spectrographic analysis.

The rock samples were prepared by crushing in a chipmunk-jaw crusher, after which they were pulverized to less than 0.10 mm in a vertical grinder.

ANALYTICAL METHODS

The pulverized stream-sediment, rock, and C3-fraction samples were analyzed semiquantitatively for 31 elements using a six-step emission spectrographic method (Grimes and Marranzino, 1968). The method was modified slightly for the concentrate samples to eliminate spectral interferences. The spectrographic results were reported as geometric midpoints, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15 (or appropriate multiples of ten) of geometric brackets having the boundaries 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12 (or appropriate multiples). Stream-sediment samples were also analyzed for gold, copper, mercury, lead, and zinc using atomic-absorption spectrometry (methods described in Ward and others, 1969) and for arsenic using a confined-spot procedure (Almond, 1953; Ward and others, 1963). Selected stream-sediment and concentrate samples were analyzed for uranium by a fluorometric method (modified from Centanni and others, 1956). All of the analytical data have been entered in the U.S. Geological Survey's computerized analysis storage system (RASS). Data for stream-sediment and C3-fraction samples are in two U.S. Geological Survey Open-File Reports (King and others, 1978; Crim and others, 1979). Analytical data for samples collected by the State of Alaska Division of Geological and Geophysical Surveys and analyzed by the U.S. Geological Survey are included in the above reports and also in a DGGS report (Eakins and others, 1978).

DISTRIBUTION AND NATURE OF GEOCHEMICAL ANOMALIES

The results of this survey indicate the presence of a number of geochemical anomalies in the Lake Clark quadrangle. Many of these are related to previously known anomalies and mineral occurrences. Outlines of the previously known occurrences, numbered 1-38, are shown in figure 1 (sheet 1), figure 3 (sheet 2), and figure 5 (sheet 3). Names and principal references to these occurrences are given in table 1 (sheet 1). Generalized outlines of anomalies indicated by data of this survey are shown by dashed lines in figures 1, 3, and 5 and are numbered 39-50. The anomalies known from this survey that coincide with areas of previously known mineral occurrences numbered 15-18 are not additionally outlined.

Anomalies in the northwestern part of the quadrangle are characterized by high values of tin, tungsten, and gold. Anomalous concentrations of silver are also common in this area, particularly in association with gold. Anomalous values of tin, tungsten, and gold in the C3-fraction samples are explained by the presence of cassiterite, scheelite, and gold, respectively, identified in many of the same samples. Where the same samples yield high values of both silver and gold, silver is probably present as an alloy with the gold. Anomalous amounts of several other elements are associated in various areas with this suite, as shown on the maps and discussed below.

The most notable area showing high values of tin, tungsten, and gold is in the Bonanza Hills, in the north-central part of the quadrangle. Other elements noted in anomalous concentrations in the C3-fraction samples from the Bonanza Hills include arsenic, copper, and lead, which are due to the presence of arsenopyrite and chalcopyrite, and of malachite and galena, respectively. The following discussion of the Bonanza Hills area is summarized from Eakins and others (1978). The DGGS discovered significant concentrations of tin and tungsten in a coarse fraction (greater than 0.84 mm) of heavy-mineral concentrates from a placer gold mine on Scenneva Creek (not identified on these maps), a tributary to Bonanza Creek (the Bonanza Creek placer gold mining area is identified as area 7); values are as high as 60 percent cassiterite and 1.36 percent tungsten. In the north-central Bonanza Hills (area 8), anomalous concentrations of tin and tungsten in C3-fraction samples were found to outline border phases of intrusive rocks. Disseminated chalcopyrite and pyrite were also found to occur locally in small plutons in the area. In the central Bonanza Hills, quartz-sulfide vein deposits containing tetrahedrite, arsenopyrite, galena, and chalcopyrite that cut hornfels were reported as the upper Bonanza Creek copper-lead-silver vein deposits (area 9). At least 20,000 tons of low-grade, sulfide-bearing material was inferred. Small zones of veins bearing arsenopyrite and stibnite adjacent to a small quartz monzonite pluton in the east-central Bonanza Hills (area 10) were reported to have yielded 1.25 oz gold per ton.

The area anomalous in gold and silver northeast of the Bonanza Hills and south of Summit Creek was described by Eakins and others (1978, p. 3) as the VABM Trail gold anomaly (area 2). The geologic setting of the anomaly was described as an area of an altered rhyolite or dacite dome complex that locally contains pronounced gossan zones and has undergone sericitic and silicic alteration.

Conspicuous anomalies of tin and tungsten in the C3 fraction are in the area of Halfway Mountain (area 39), in the southern half of the D-7 quadrangle. Cassiterite and scheelite were identified in nearly all of the C3-fraction samples from the area. Sediment samples from the area are anomalous in silver, arsenic, gold, mercury, and zinc. A streambed cobble of fractured argillite containing mineralized veinlets, from a stream on the south slope of Halfway Mountain, was found to contain 100 ppm tin, 20 ppm silver, 2,000 ppm boron, 50 ppm bismuth, 100 ppm copper, and 200 ppm lead. The high boron value suggests tourmaline, a common associate of tin mineralization. Although an igneous intrusive was not mapped in the area, the presence of a buried pluton, a probable source of the mineralization, is considered likely.

Anomalies of tin and gold occur north and south of the Mulchatna River (area 40), at the western border of the Lake Clark quadrangle. The high tin values are from the C3 fraction, but anomalous gold was found in both sediment and concentrate samples. South of the Mulchatna River, in the area of Benchmark Overlook (B-8 quadrangle), sedimentary rocks (KJs) are intruded by monzodiorite (TKi). Two samples of the intrusive rock, taken from streambed alluvium in two streams, each contained 0.3 ppm gold, and one of the samples also contained 5,000 ppm arsenic.

An area (area 41) yielding anomalous values of arsenic, bismuth, gold, lead, silver, tin, and tungsten in the C3 fraction and arsenic, gold, lead, silver, and zinc in the sediments is in the northeastern part of the B-6 quadrangle, between the Koksetna and Chilchitna Rivers (also see Eakins and others, 1978, pl. 2). Cassiterite and scheelite were identified in most C3-fraction samples from the area, and galena was found in two of the samples. Gold was visible in the C3-fraction sample showing the highest gold and silver values. The area is underlain by predominantly Mesozoic sedimentary rocks (KJs), including sandstone and shale. Outcrops of quartz monzonite intrusive bodies of Cretaceous and Tertiary age occur in the area as mapped by Eakins and others (1978, pl. 1). These outcrops were too small to be shown on the generalized geologic map shown in figure 5 (sheet 3).

Several other areas anomalous in gold, silver, and mercury, and in some cases tin, are present in the western half of the Lake Clark quadrangle. One of these areas (area 42) is east of Halfway Mountain, in the D-6 quadrangle; another area (area 43) is in the northeast corner of the D-7 quadrangle. The mercury mineral cinnabar was identified in a C3-fraction sample from this area. A conspicuous cluster of sites showing anomalous amounts of mercury (area 44) is present in the southwest corner of the B-5 quadrangle and the southeast corner of the B-6 quadrangle. Cinnabar was identified in a C3-fraction sample from one of these sites. Anomalous concentrations of gold and arsenic occur in various parts of this area, and gold was noted under the microscope in two C3-fraction samples. Mercury is a common associate of gold and is a useful pathfinder element for precious-metal deposits.

Several anomalies occur in the central part of the quadrangle in areas underlain by primarily Tertiary volcanic rocks (Tv) and Cretaceous and Tertiary intrusive rocks (TKi). Anomalous values of silver, copper, molybdenum, lead, and zinc for sediments and of arsenic and tin for C3-fraction samples were obtained in the vicinity of the Pass copper-silver prospect (area 16) (RAA, 1976, p. 23-24; Eakins and others, 1978, p. 2) in the west-central part of the B-4 quadrangle, about 11 km northwest of Kijik Lake. Minerals in C3-fraction samples include cassiterite, arsenopyrite, and scheelite. In describing the prospect, the RAA report (1976, p. 23) stated that mineralized rock, consisting of stockwork fracture fillings of pyrite and(or) pyrrhotite and variable amounts of associated chalcopyrite, galena, and possible tetrahedrite, occurs in brecciated facies marginal to a dacite porphyry body. The RAA report concluded (1976, p. 24) that, although ore-grade mineralized rock is not present at the surface, higher grade mineralization might occur at shallow depth.

An area showing anomalous concentrations of zinc, lead, molybdenum, and arsenic in sediment samples and arsenic, bismuth, lead, tin, and tungsten in C3-fraction samples, in the eastern half of the B-5 quadrangle, partly coincides with the area of the Pass Lake West copper-silver anomaly (area 15) of RAA (1976, p. 37-38). Cassiterite and scheelite were the only minerals of interest found in C3-fraction samples from this area. The RAA report stated (1976, p. 37) that the Pass Lake West copper-silver anomaly occurs in granites, rhyolites, and rhyodacites and that only weakly mineralized rock was found during one man day of follow-up work (p. 38).

An anomaly of silver, arsenic, bismuth, copper, molybdenum, lead, tin, tungsten, and zinc in the C3 fraction and silver, arsenic, and zinc in sediment samples is located west of the Kijik River and Kijik Mountain and east of the Pass copper-silver prospect in the south-central part of the B-4 quadrangle. Minerals identified in the C3-fraction samples include arsenopyrite, cassiterite, chalcopyrite, fluorite, galena, malachite, scheelite, and wulfenite. The Kijik River West copper-silver anomaly (area 18) of RAA (1976) is in this area. The RAA report described (p. 40-41) the general geologic setting of the anomaly as a granodiorite stock cut by widely spaced quartz-chalcopyrite and quartz-pyrite-arsenopyrite veins, the stock bordered on the north and south by rhyolite that is also mineralized. A silver-lead prospect known as the Thompson claims is in the area (Cobb, 1972); it was described by Moxham and Nelson (1952, p. 4) as an occurrence of arsenopyrite and a little galena, chalcopyrite, and pyrite in a shear zone in granite.

In the eastern half of the Lake Clark quadrangle, numerous anomalies occur within a wide area that extends from near Upper Tazimina Lake and Tazimina River in the south to Telaquana River and Telaquana Pass in the north. The area is bordered on the east by Cretaceous plutonic rocks (Ki) of the Alaska-Aleutian Range batholith. Paleozoic and Mesozoic metamorphic rocks (MzPzm) are exposed in many parts of the area, where they have been intruded by Tertiary plutons (Ti) and are in some places in contact with Tertiary volcanic rocks (Tv).

Ten anomalies and two prospects have been reported to be in the eastern half of the quadrangle south of Lake Clark (areas 26-28, 30-38). Some of these are indicated to various degrees by our data. One of the prospects, the Kasna Creek deposit (area 31), south of Kontrashibuna Lake, is a large contact-metamorphic copper-iron deposit proven by diamond drilling (Detterman and Reed, 1980, p. B76). The deposit is hosted by calcium carbonate beds in Paleozoic and Mesozoic metamorphic rocks (MzPzm). Ore minerals, described by Warfield and Rutledge (1951), are chiefly hematite and associated chalcopyrite. Two sites were sampled on Kasna Creek, both downstream from the known deposit. The sediment samples showed the two highest copper values found in sediment samples for the quadrangle, and were also anomalous in silver, molybdenum, and zinc. The C3-fraction sample from the site on Kasna Creek near Kontrashibuna Lake gave a high value for copper due to chalcopyrite and malachite in the sample. The C3-fraction sample from the upstream site was anomalous in silver, gold, bismuth, and lead; chalcopyrite, galena, gold, powellite, and scheelite were identified in this sample. The sampling was done on Kasna Creek in the area of the known deposit to obtain information useful in the interpretation of results obtained elsewhere in the quadrangle that might have similar geologic settings.

A possible additional area of interest is indicated by our geochemical data for samples from two sites on the north slopes of Copper Mountain (area 45), on tributaries to Currant Creek, an area underlain by Tertiary granodiorite (Ti). C3-fraction samples from both sites are anomalous in lead and molybdenum and contained the lead molybdate wulfenite, a mineral found in the oxidized parts of lead veins. One C3-fraction sample also contained galena. This sample was also moderately anomalous in silver and zinc.

Northeast of Lake Clark, the Otter Lake copper anomaly (area 14), was reported by RAA (1976, p. 35-36) to have geology and rock geochemistry very favorable for massive sulfide deposits. Mineralized rock at this anomaly was described as chalcopyrite occurring as disseminations in massive pyrite associated with chlorite schists west of Otter Lake and with felsic volcanic rocks and breccias northeast of Portage Lake. RAA (1976, p. 35) also reported that limestone and limestone breccia are common host rocks for sulfides west of Otter Lake.

Our data indicate the occurrence of several anomalies (areas identified by No. 46) in the area northeast of the Otter Lake copper anomaly, in the C-2 quadrangle. Those anomalies in the Kijik River drainage basin are in areas where metamorphic rocks (MzPzm) have been intruded by Tertiary granite (Ti). The elements present in anomalous concentrations are silver, arsenic, bismuth, copper, molybdenum, lead, tin, tungsten, and zinc in the C3 fraction and silver, copper, molybdenum, lead, and zinc in sediments. Minerals identified in the C3-fraction samples include arsenopyrite, cassiterite, chalcopyrite, galena, powellite, scheelite, and wulfenite. The powellite and wulfenite probably account for most of the high values of molybdenum and lead shown by the C3-fraction samples.

The Twin Lakes East copper anomaly of RAA (1976, p. 31-32; area 12) is also in the C-2 quadrangle, about 10 km southeast of Turquoise Lake. Our data show anomalous values of copper and molybdenum for the area, and chalcopyrite and wulfenite were identified in the C3-fraction samples. Mineralized rock was described in the RAA report (1976, p. 31) as chalcopyrite associated with pyrrhotite as disseminations and blebs in andesites and bornite occurring as disseminations in andesite porphyry. RAA reported (1976, p. 31) that rock samples contained as much as several percent copper and classified the potential ore deposit as a volcanogenic sulfide deposit. The host for mineralization is volcanic rocks (mapped as unit MzPzm) intruded by Tertiary quartz monzodiorite and peralkaline granite (Ti).

Our data show an anomalous area north of the east lake of Twin Lakes and an anomalous area south of that lake (both areas included in area 47) in an area underlain by chiefly Tertiary volcanic rocks (Tv). These anomalies are in the eastern part of C-3 quadrangle and the west-central part of C-2 quadrangle. The Twin Lakes West lead-zinc anomaly (area 11) of RAA (1976, p. 33-34) is within area 47. Elements present in anomalous concentrations in area 47 are silver, arsenic, bismuth, molybdenum, lead, tin, and zinc in the C3 fraction and the same elements, except bismuth, in sediments. Minerals in the C3-fraction samples include arsenopyrite, chalcopyrite, galena, sphalerite, and wulfenite. The area north of Twin Lakes is underlain by a thick pile of Tertiary andesitic flows and breccias that is adjacent to an arcuate band of rhyolitic ash tuffs and domes south of Twin Lakes, an assemblage that strongly suggests an ash-flow caldera. Mineralized rock of the Twin Lakes West lead-zinc anomaly was described in the RAA report (1976, p. 33) as fine-grained disseminations of pyrite and lesser chalcopyrite, sphalerite, and galena in silicified rhyolite and rhyolite-dacite volcanic rocks, particularly volcanic breccia. The anomaly was classified by RAA (1976, p. 34) as resulting from porphyry-type mineralization related to a volcanic breccia deposit.

High concentrations of silver and gold were detected in a C3-fraction sample (area 48) from a tributary of the Telaquana River, in the northwestern part of the D-2 quadrangle. The sample also showed anomalous values of molybdenum and bismuth. Chalcopyrite and gold were observed under the microscope. Anomalous gold and copper were detected in the sediment sample. The area is underlain by Tertiary tonalite (Ti) in contact with a roof pendant of metamorphic rocks (MzPzm). Anomalous concentrations of gold were detected at few sites east of the Benchmark Trail gold anomaly (Eakins and others, 1978, p. 3), and this site is notable in that it exhibits the highest gold value in the northeastern part of the quadrangle.

An area anomalous in copper in C3-fraction samples (area 49) is south of the Tlikakila and Chokotonk Rivers, mainly in the C-1 quadrangle. The copper values are the result of chalcopyrite in samples from throughout the area and of malachite in samples from sites near the Tlikakila River. The calcium molybdate powellite, a secondary mineral, commonly formed by the alteration of molybdenite, was also found in C3-fraction samples from sites near the Tlikakila River. The C3-fraction samples also contained abundant pyrite. Area 49 is underlain by Cretaceous quartz diorite intrusive rocks (Ki) bounded along the Chokotonk and Tlikakila Rivers by major northeast-trending faults and cut in the southern part by a prominent northeast-trending shear zone. Mineralized rock probably occurs in small veins that apparently are not sufficiently concentrated in surface exposures to have been observed and reported.

A large area anomalous in copper and molybdenum values in C3-fraction samples (area 50) is north of the Tlikakila River, mainly in the C-1 quadrangle. Copper concentrations are, for the most part, lower than those found south of the Tlikakila River. The copper and molybdenum concentrations are mainly the result of chalcopyrite and powellite, respectively, in the samples. The lead molybdate wulfenite was identified in a few samples from the western edge of area 50. Molybdenite was identified in one C3-fraction sample from a glacial outwash tributary to the North Fork of the Tlikakila River. The highest molybdenum value for the area was shown by this sample. Many C3-fraction samples contained scheelite and abundant pyrite. A few samples contained anomalous amounts of gold and silver. Values of 0.05 ppm and 0.1 ppm gold were shown by sediment samples, and 50 ppm gold was detected in a C3-fraction sample from a tributary to the North Fork of the Tlikakila River. A high concentration of mercury in one sediment sample suggests the presence of cinnabar in the sample. The area of this anomaly is underlain chiefly by Cretaceous plutons (Ki) of quartz monzodiorite and granodiorite intruded by Tertiary granite (Ti). Biotite aplite and intermediate dikes common in the quartz monzodiorite pluton northeast of the North Fork of the Tlikakila River suggest that the pluton may be underlain at a relatively shallow depth by younger plutonic rocks. Metamorphic rocks (MzPzm) occur in the area as roof pendants in the intrusive rocks. In general, the minerals noted are probably from thin veins in fractures in the intrusive rocks and in the metamorphic roof pendants. The results suggest a target area for possible copper-molybdenum deposits containing associated gold and silver.

CONCLUSIONS

Results of the reconnaissance survey show a number of local geochemical anomalies in the Lake Clark quadrangle and also indicate regional geochemical patterns. The regional geochemical patterns include the broad area in the western half of the quadrangle where anomalies are characterized by tin, tungsten, and gold; the extensive area in the eastern half where many of the anomalies include high concentrations of copper, molybdenum, lead, silver, bismuth, arsenic, and zinc; and areas along the eastern border of the quadrangle where the anomalies consist of copper, or copper and molybdenum. Identification of minerals in the C3 fraction was of great value in that the sources of most of the highly anomalous analytical values were determined.

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Table 1.--Previously known mineral occurrences and geochemical anomalies, Lake Clark quadrangle, Alaska

[---, name for mineral occurrence or geochemical anomaly not given in reference cited; RAA, Resource Associates of Alaska, Inc.]

No. in figs. 1, 3, and 5	Name	References
1	---.........................	U.S. Bureau of Mines (1973).
2	VABM Trail Au anomaly.............	Eakins and others (1978, p. 3).
3	Telaquana River Mo anomaly.........	RAA (1976, p. 27).
4	Telaquana Pass Mo anomaly..........	RAA (1976, p. 28).
5	Glacier Fork Cu, Au, Ag, Zn........ anomaly.	Nelson and others (1985).
6	Neacola River South Cu-Mo anomaly..	RAA (1976, p. 29).
7	Bonanza Creek gold placer deposit..	Eakins and others (1978, p. 2-3); Jasper (1961, p. 58-64); Smith (1917, p. 136).
8	North-central Bonanza Hills........ Cu-Sn-W anomalies.	Eakins and others (1978, p. 3).
9	Upper Bonanza Creek Cu-Pb-Ag....... vein deposits.	Eakins and others (1978, p. 3).
10	Upper Bonanza Creek............... gold-lode deposit	Eakins and others (1978, p. 3).
11	Twin Lakes West Pb-Zn anomaly......	RAA (1976, p. 33-34).
12	Twin Lakes East Cu anomaly.........	RAA (1976, p. 31-32).
13	---.........................	U.S. Bureau of Mines (1973).
14	Otter Lake Cu anomaly.............	RAA (1976, p. 35-36).
15	Pass Lake West Cu-Ag anomaly.......	RAA (1976, p. 37-38).
16	Pass Cu-Ag prospect...............	RAA (1976, p. 23-24); Eakins and others (1978, p. 2).
17	Kijik Lake Cu anomaly.............	RAA (1976, p. 39); Moxham and Nelson (1952, p. 4).
18	Kijik River West Cu-Ag anomaly.....	RAA (1976, p. 40-41); Moxham and Nelson (1952, p. 4).
19	Kijik Mountain North Zn anomaly....	RAA (1976, p. 42-43).
20	Kijik Mountain prospect............	U.S. Bureau of Mines (1973).
21	---.........................	U.S. Bureau of Mines (1973).
22	---.........................	U.S. Bureau of Mines (1973).
23	---.........................	U.S. Bureau of Mines (1973).
24	Portage Creek placer............... gold deposits.	Capps (1935, p. 94); Bundtzen and Kline (1979).
25	---.........................	U.S. Bureau of Mines (1973).
26	North Currant Creek Cu anomaly.....	RAA (1976, p. 44-45).
27	South Currant Creek Cu anomaly.....	RAA (1976, p. 46-47).
28	Upper South Currant Creek Cu-Mo.... anomaly.	RAA (1976, p. 48).
29	---.........................	U.S. Bureau of Mines (1973).
30	East Takoka Creek Cu anomaly.......	RAA (1976, p. 42-43); Eakins and others (1978, p. 3).
31	Kasna Creek Cu-Fe deposit..........	Warfield and Rutledge (1951); Reed (1967); Eakins (1970).
32	Kontrashibuna Mo anomaly...........	RAA (1976, p. 58-59); Eakins (1970, area 1, p. 18).
33	West Gladiator Zn-Cu-Ag anomaly....	RAA (1976, p. 52-53).
34	East Gladiator Zn-Cu-Pb anomaly....	RAA (1976, p. 49-51); Eakins (1970, area D, p. 17).
35	West Ospook Cu-Pb-Mo anomaly.......	RAA (1976, p. 60-61).
36	Upper Tazimina Cu-Fe anomaly.......	RAA (1976, p. 62-63).
37	Little Tazimina Cu-Pb anomaly......	RAA (1976, p. 64-65).
38	Tazimina Cu prospect...............	RAA (1976, p. 24-26).

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[1] The use of this trade name is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

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