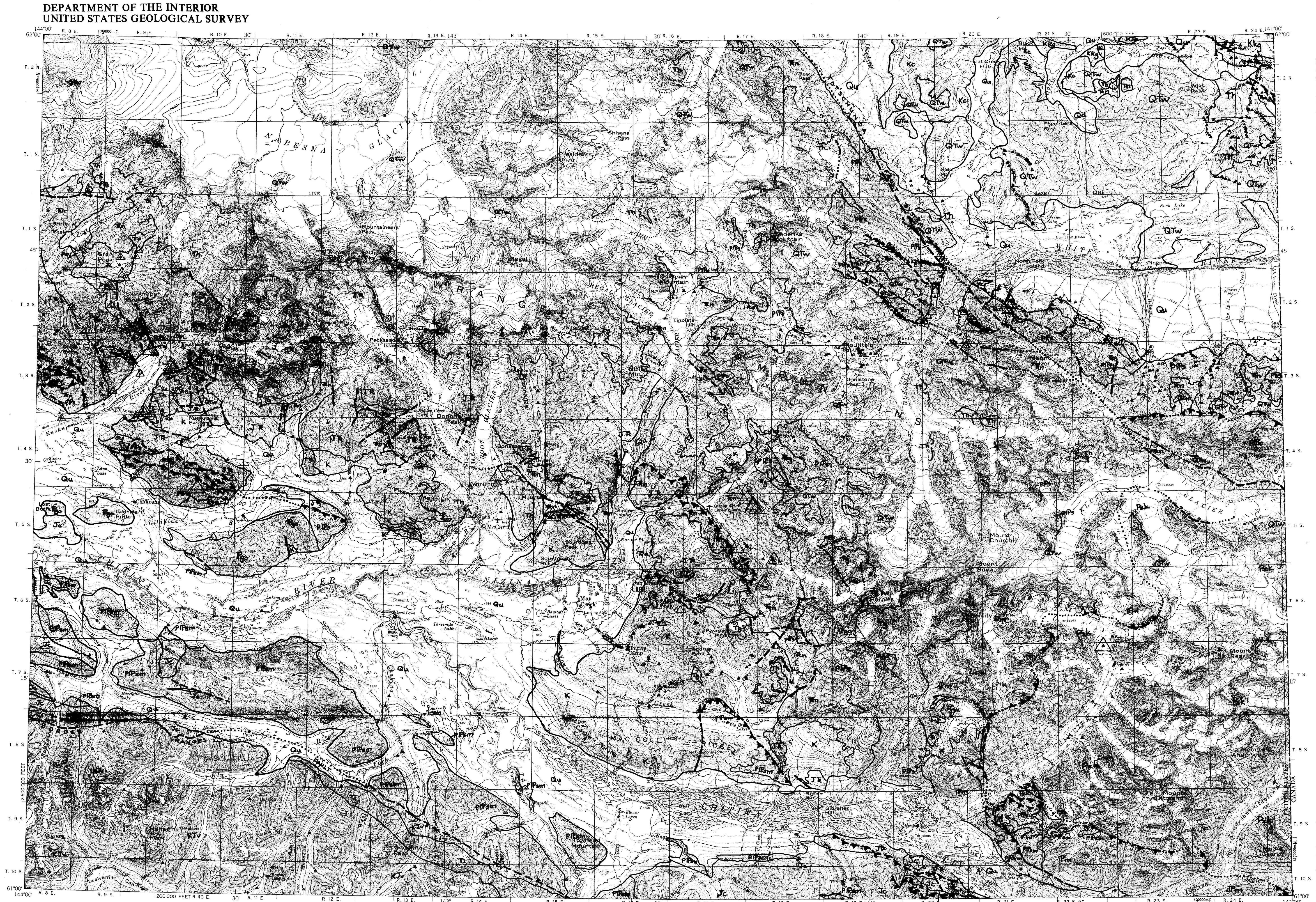

Base from U.S. Geological Survey, 1965
Geology generalized by MacKevett, 1976

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL
1960 MAGNETIC DECLINATION AT SOUTH EDGE OF SHEET VARIES FROM 28°30′ TO 29° EAST

Background information for this folio is published as U.S. Geological Survey Circular 739, available free of charge from the U.S. Geological Survey, Reston, Va. 22092.

Table showing linear correlation coefficients between logarithmic values of the concentration of selected elements versus copper, McCarthy quadrangle, Alaska. [Leaders(---)indicate insufficient data.]

Analytical method	Six-step semiquantitative spectrographic analyses																					Atomic absorption and colorimetric 1/					
Element	Fe	Mg	Ca	Ti	Mn	Ag	B	Ba	Be	Co	Cr	Cu	Mo	Nb	Ni	Pb	Sc	Sr	V	Y	Zn	Zr	Au	Cu	Pb	Zn	Hg	As
Correlation Coefficient (X100)	51	36	10	34	35	-29	-2	-11	7	51	31		12	-3	50	4	52	-35	51	16	26	-5	-20	83	22	33	20	12
Number of pairs	1449	1449	1425	1414	1448	46	1217	1431	483	1429	1422		715	874	1447	1127	1437	1446	1448	1434	683	1436	54	1083	1048	1086	358	311

1/ Au, Cu, Pb, and Zn by atomic absorption analysis
Hg by flameless atomic absorption analysis
As by colorimetric analysis

DISTRIBUTION AND ABUNDANCE OF COPPER IN STREAM SEDIMENTS AND MORAINE DEBRIS, McCARTHY QUADRANGLE, ALASKA

By

Keith Robinson, C. M. McDougal, G. W. Day, and Theodore Billings

1976

DISCUSSION

A geochemical survey was conducted in the McCarthy quadrangle, Alaska, to identify areas containing anomalous concentrations of various metallic and nonmetallic elements. This study incorporates the results of analyses for copper, from 1,454 stream sediment and glacial moraine debris samples collected in the quadrangle, and analyzed by the U.S. Geological Survey between 1961 and 1976 using semiquantitative emission spectrophotometry. In addition, the study includes most of the analytical results of the samples of stream sediment from the White River area, located in the northeastern part of the quadrangle, which were collected and analyzed by the Alaskan Division of Mines and Geology (Knaebel, 1970).

The accompanying map shows the distribution and relative abundance of copper in stream sediment and glacial moraine debris samples collected. Geochemical analyses have been grouped and are represented by symbols on a base map, which includes topography and generalized geology. The range of analytical values and the symbol that represents it are shown on the histogram. Graphical representation of analytical values on the map permits easy observation of any large variation resulting from separate or duplicate samples collected at the same or nearby localities

In general, the stream sediment samples were obtained from active streams as close to the channel center as was practical, however in some cases, only dry stream beds could be sampled. The glacial debris was collected from medial and lateral moraines on active glaciers. Samples of both stream sediments and glacial moraine debris were air dried and sieved to obtain material that would pass through a 180 micron opening sieve for analysis. When a fine sediment sample could not be obtained, a representative fraction of the smallest available rock fragments in the streams or on the glacial moraines was collected and ground so that it would pass through the same sieve opening for analysis. The copper analyses may help to locate potential occurrences of concealed mineral deposits, particularly large buried porphyry copper an molybdenum deposits.

The arithmetic and geometric mean values of copper in stream sediments and glacial debris from the McCarthy quadrangle are 72 and 47 ppm, respectively. These values are well below the average of copper in the Middle and (or) Upper Triassic Nikolai Greenstone, which is 160 ppm in the McCarthy quadrangle. Based on an evaluation of the statistical data given in the accompanying histogram, copper values ranging from N(5) to 100 ppm are classified as background values. Those values between 150 and 200 ppm are classified as threshold to weakly anomalous, and values greater than 200 ppm copper are considered to be significantly anomalous. These class boundaries seem to be satisfactory to minimize the influence of the Nikolai Greenstone. While classified as weakly anomalous relative to overall concentrations, those samples with values in the range of 100 to 200 ppm copper may indicate porphyry-type copper deposits in areas not unduly influenced by the Nikolai Greenstone. Samples with values greater than 200 ppm copper may be related to porphyry and other type copper deposits in all areas regardless of influence by the Nikolai Greenstone.

A geochemical interpretation of the distribution and abundance of copper in samples of stream sediment and glacial moraine debris collected in the McCarthy quadrangle is complicated and influenced by metals derived from the Nikolai Greenstone, which crops out in a wide northwest-southeast trending belt through the central part of the quadrangle on both flanks of the Wrangell Mountains. A large proportion of the creeks, streams, rivers, and some glaciers in the McCarthy quadrangle either originate on or cross outcrops of the greenstone, which may contaminate stream sediments. An initial study of the geographical distribution of copper anomalies suggests that most of the copper is related to and associated with the Nikolai Greenstone. Undoubtedly, amygdaloidal basalt flows of the Nikolai Greenstone exert considerable local influence on copper values found in samples of stream sediment and glacial moraine debris. Statistically significant positive correlation coefficients occur between copper and the following elements: iron, magnesium, calcium, titanium, cobalt, chromium, nickel, and vanadium, all of which are similarly enriched in the Nikolai Greenstone. Copper has been extensively mined in the McCarthy quadrangle and the stream sediments in such areas are contaminated by old mine dumps. Copper occurs in Kennecott-type deposits, and in veins and lodes as native copper and copper sulfides associated with other economic metals in the Nikolai Greenstone, resulting in numerous small mines and prospects throughout the quadrangle. The high regional background levels are influenced by these factors which could conceivably mask weak copper anomalies associated with buried or concealed copper deposits.

Because erratic, biased, and in many cases widely separated sample localities were used in this project, undue emphasis may be placed on anomalous copper values occuring in only one or two samples in a given area. In all cases, geochemical interpretation has been made utilizing associated elements in combination with geological, structural, and geophysical data. More detailed geological, analytical, and statistical data for geochemical studies of specific areas in the McCarthy quadrangle can be found in reports by MacKevett and Smith (1968), Winkler and MacKevett (1970), Knaebel (1970), and Winkler, MacKevett, and Smith (1971).

Copper is an important pathfinder element that can be used in the search for porphyry, telethermal, and stratiform-type deposits. Copper appears to be enriched around some molybdenum centers and is its own indicator of copper deposits. The distributions of gold, molybdenum, silver, and arsenic in rocks, together with the distributions of copper, gold, lead, arsenic, and mercury in stream sediments and glacial debris, may reveal zoning patterns that are related to undiscovered mineral deposits.

Samples of stream sediment in the area of the McCarthy quadrangle south of the Chitina River show no evidence to indicate strong or extensive copper mineralization. Only two stream sediment samples not influenced by the Nikolai Greenstone contain anomalous amounts of copper. Copper enrichment in one sample appears to be related to an association of the Jurassic Chitina Valley batholith with rocks of the Jurassic(?) and Cretaceous Valdez Group (T. 8 S., R. 10 E.), and in the other sample to an association of Tertiary intrusive rocks with rocks of the Valdez Group (T. 9 S., R. 14 E.). Both occurrences are in juxtaposition with the Border Ranges fault. Although the general area has no apparent known major copper potential, the occurrence of scattered gold, silver, arsenic, and mercury anomalies suggest that more detailed geochemical studies should be conducted.

Highly anomalous copper values were detected in stream sediment samples from National Creek, which drains the west slope of Bonanza Ridge, and from Nikolai Creek (T. 5 S., R. 15 E.). The anomalous values however, are probably the result of contamination from mining at the Kennecott group of mines and at the Nikolai mine, respectively. It is interesting to note that stream sediment samples collected in McCarthy Creek, including some collected below its confluence with the Nikolai Creek, contain no anomalous copper values. McCarthy Creek drains an extensive area containing Nikolai Greenstone outcrops in addition to having numerous tributary streams draining mines and prospects. The fact that these mines were not detected indicates a severe limitation of standard stream sediment sampling to detect copper anomalies in an acidic and active erosional environment such as exists in the McCarthy quadrangle. In this environment the chemical solubility and mobility of copper is probably high. The physico-chemical weathering of minerals is fast and results in the rapid dispersion and dilution of copper a short distance from the source area. Thus, the high relief of the area, in combination with acidic conditions and the low organic content of the streams, promotes the transportation of the copper ion in solution for considerable distances. The copper is finally removed from solution in the less acidic, sluggish rivers and swamps present in the valley bottoms where vegetation is abundant. Here, it is absorbed by organic material, clays, and iron-manganese oxides. Therefore, in a region of high background copper values, copper anomalies could be easily masked and go undetected unless the sample is obtained close to its source.

Several highly anomalous copper values were detected in stream sediments collected adjacent to the Totschunda fault system (T. 3 S., R. 21 E.), and to the northeast, in the White River area; these samples were collected and analyzed by the Alaska Division of Mines and Geology. In general, the anomalies are probably associated with the Nikolai Greenstone and local vein occurrences of native copper and copper sulfides. A more detailed interpretation is made by Knaebel (1970). It is possible that some of the anomalies indicate mineralization associated with the Cretaceous Klein Creek plutons of mainly granodioritic composition. The plutons occur in the extreme northeast corner of the quadrangle and south of the White River on the north flank of Mount Sulzer (T. 3 S., R. 21 E.). Both positive and negative aeromagnetic anomalies (Case and MacKevett, 1976), occur in this area but support for major mineralization from associated geochemical anomalies is not strong. There are a few weak lead anomalies in stream sediments, some minor occurrences of silver in panned concentrates, and a few arsenic anomalies in stream sediment samples in this same general area. The evidence for the occurrence of a major porphyry mineral system in the area does not appear conclusive. The Klein Creek plutons require more detailed investigation, especially in view of their association with porphyry copper deposits in the Nabesna quadrangle (Richter and others, 1975).

East of the University Peak (T. 6 S., R. 20 E.), a highly anomalous copper value was detected in a sample of glacial moraine debris derived from an east-west trending outcrop of a Pennsylvanian monzonitic-granitic complex (T. 6 S., R. 22 E.), located in the upper reaches of the Barnard Glacier. This anomaly is associated with gold, arsenic, and minor concentrations of mercury in samples of sediment from the same general area. Outcrops covering several square kilometers show evidence of strong hydrothermal alteration associated with locally occurring positive aeromagnetic anomalies (Case and MacKevett, 1976). A highly anomalous copper value was also detected in a sediment sample derived from a stream draining a continuation of the monzonitic-granitic complex located in the southern part of the quadrangle (T. 9 S., R. 22 E.). Anomalous amounts of gold, silver, arsenic, mercury, and lead were detected in samples of stream sediment and rock collected from this area. The intrusive complex also contains anomalous amounts of molybdenum in several places and tin in two places. The presence in anomalous amounts of all these elements suggests that this area might contain undiscovered porphyry-type copper and molybdenum deposits related to the intrusive complex.

Highly anomalous copper values were detected in samples of glacial debris collected in an area of Tertiary granodiorite and tonalite intrusions located in the vicinity of The TWA Harpies (T. 6 S., R. 19 E.). Other anomalous copper values in samples of stream sediment from the TWA Harpies Glacier valley (T. 5 S., R. 18 E.) and Toby Creek (T. 4 S., R. 17 E.), may also reflect mineralization related to the exposed Tertiary granodiorite and tonalite. Zones of intense hydrothermal alteration are visible in the outcrop. The intrusives may be inferred to extend northwest under the central part of the University Range (T. 5 S., R. 18 E.). This inference is also supported by aeromagnetic data (Case and MacKevett, 1976). Anomalous concentrations of gold, arsenic, mercury, silver, and molybdenum are also present in samples of rocks and stream sediments collected in the same general area. While the possibility of contamination from metals eroded from the Nikolai Greenstone cannot be discounted especially in Toby Creek and the TWA Harpies Glacier valley (T. 5 S., R. 17 E.), The TWA Harpies area is considered promising for the discovery of porphyry-type copper or possibly molybdenum deposits.

Several weakly anomalous copper values were detected in samples of stream sediment from the Dan Creek, Nikolai Butte, Williams Peak, Pyramid Peak, Andrus Peak, and Mount Holmes area (T. 6 S., R. 16 E.), all located in the south-central part of the quadrangle. The anomalous values are considered to be extremely significant. An intrusive complex of Tertiary granodiorite and tonalite, which forms small outcropping plutons, is inferred to underlie much of the area. This complex is probably related to the Tertiary intrusives exposed in the University Range (T. 5 S., R. 18 E.) to the northeast. In addition to copper, anomalous concentrations of gold, silver, arsenic, mercury, antimony, lead, and molybdenum detected in samples of rock and stream sediment suggest that relatively intense mineralization probably occurs in this area. Strong positive magnetic anomalies are present (Case and MacKevett, 1976) and hydrothermally altered rocks are visible in outcrops. The area has been extensively placer mined for gold and is known to contain veins of gold-arsenic-antimony, and gold-copper-molybdenum. These element associations suggest a strong possibility for concealed porphyry-type copper, molybdenum, or other types of deposits.

Extremely high copper anomalies were detected in samples of stream sediments collected from Nugget Creek (T. 2 S., R. 9 E.) and the general area of the Kuskulana River south of Skyscraper Peak (T. 2 S., R. 9 E.). The anomalies may be related to veins of sulfides in the Nikolai Greenstone. Contamination from mine dumps, especially in Nugget Creek, may account for some of the anomalies. However, the close proximity of monzodiorite, granodiorite, and tonalite intrusives of the Jurassic Chitina Valley batholith suggests that the mineralized rocks may be related to the intrusives in the area (Moffit and Mertie, 1923). The copper anomalies are associated with gold, arsenic, silver, and molybdenum anomalies.

Anomalous amounts of copper were detected in samples of stream sediment collected from Surprise Creek and the Kotsina River valley, both of which drain the south slope of Granite Peak (T. 1 S., R. 9 E.), and from Roaring Creek, which drains the north face of Skyscraper Peak (T. 2 S., R. 9 E.). Anamalous concentrations of molybdenum, gold, arsenic, and mercury were also detected in some samples of stream sediment and rock collected in the same general locality. The Jurassic Chitina Valley batholith of monzodiorite, granodiorite, and tonalite underlies much of Granite Peak and intrudes the Nikolai Greenstone. Positive aeromagnetic highs occur locally (Case and MacKevett, 1976) and strongly altered rocks are visible in the area. As in the Nugget Creek area, some geochemical anomalies may be related to veins of sulfide in the Nikolai Greenstone, however, many of the anomalous samples may be related to undiscovered porphyry-type copper and possibly molybdenum deposits.

Copper anomalies occurring in a few samples of stream sediment collected south of the Kuskulana River (T. 3 S., R. 9 E.) suggest the possibility of mineralization in a skarn environment. Anomalous concentrations of gold, silver, arsenic, and molybdenum were detected in samples of rock and stream sediment collected in this area.

Anomalous amounts of copper detected in a few samples of stream sediment collected from the Crystalline Hills area (T. 4-5 S., R. 10 E.), appear related to mineralization associated with Pennsylvanian gabbroic intrusives. These intrusives crop out in the Crystalline Hills and also in the adjacent hills to the north. Gold and silver anomalies, together with associated peripheral mercury and arsenic anomalies detected in samples of stream sediment from the area, suggest a potential for concealed mineralization. The area contains a strong positive magnetic anomaly (Case and MacKevett, 1976).

A complete set of coordinates for sample sites, as well as statistical and analytical data, obtained 1974-1976 for copper in stream sediments and glacial moraine debris collected in the McCarthy quadrangle is available, together with details of sample collection, preparation, analysis, data storage and retrieval, in U.S. Geological Survey Open-File Report 76-824 (O'Leary and others, 1976) and on a computer tape (VanTrump and others, 1977).

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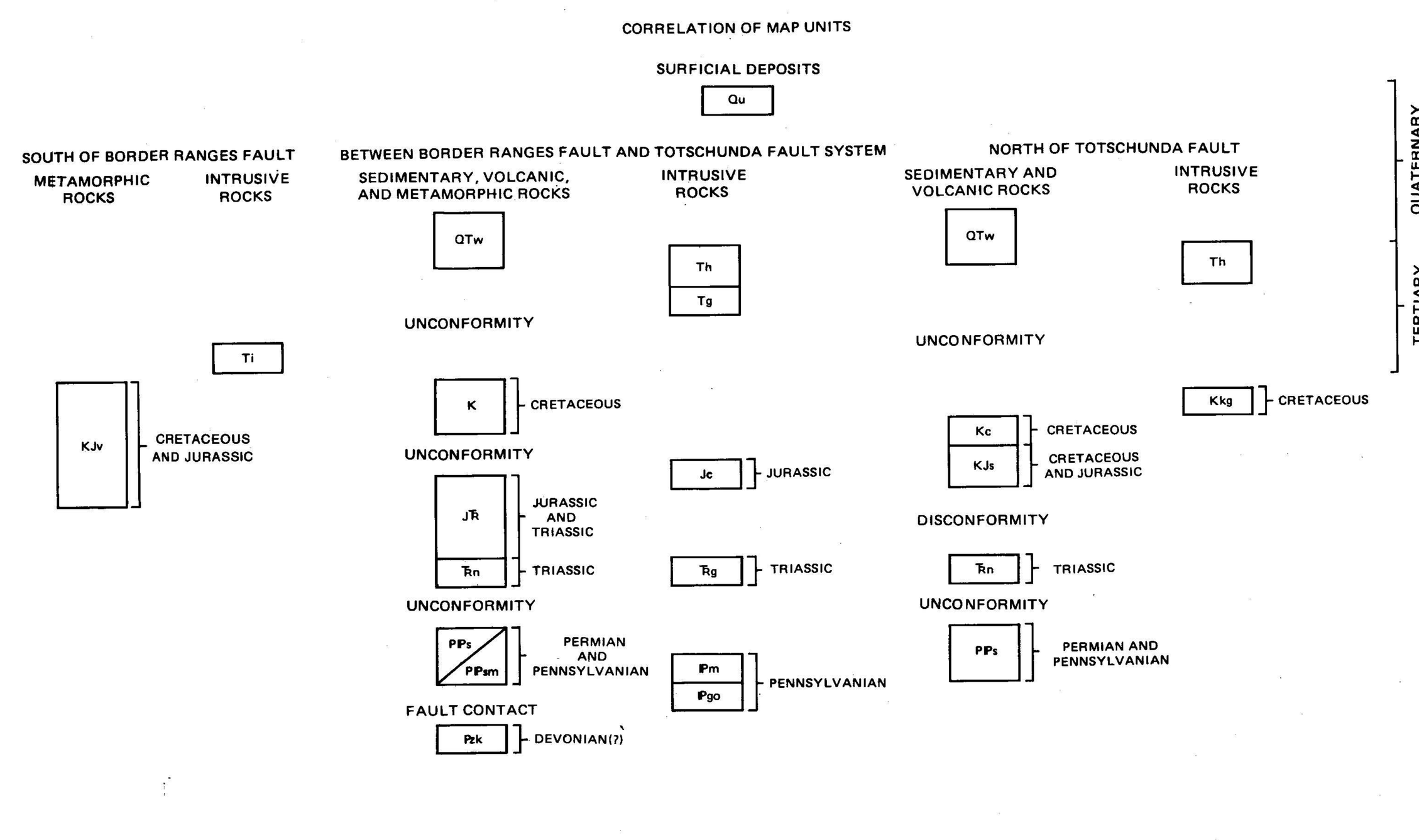
EXPLANATION FOR GENERALIZED GEOLOGIC MAP
(GEOLOGY GENERALIZED BY MacKEVETT, 1976)



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qu — UNCONSOLIDATED SEDIMENTARY DEPOSITS (Quaternary)

SOUTH OF BORDER RANGES FAULT

METAMORPHIC ROCKS

KJv — VALDEZ GROUP (Cretaceous and Jurassic?)

INTRUSIVE ROCKS

Ti — INTRUSIVE ROCKS (Eocene?) Typically, foliated granodiorite and tonalite

BETWEEN BORDER RANGES FAULT AND TOTSCHUNDA FAULT SYSTEM

SEDIMENTARY, VOLCANIC, AND METAMORPHIC ROCKS

QTw — WRANGELL LAVA (Quaternary and Tertiary) Chiefly subaerial andesitic lava flows and tephra; includes local subaerial sedimentary rocks of the Frederika Formation

K — MARINE SEDIMENTARY ROCKS (Upper and Lower Cretaceous) Includes MacColl Ridge, Chititu, Moonshine Creek, Schulze, and Kennicott Formations, and unnamed Lower Cretaceous rocks

JTr — MARINE SEDIMENTARY ROCKS (Jurassic and Triassic) Includes Root Glacier, Nizina Mountain, Lubbe Creek, and McCarthy Formations, Kotsina Conglomerate, and Nizina and Chitistone Limestones

Trn — NIKOLAI GREENSTONE (Upper and (or) Middle Triassic) Mainly subaerial tholeiitic basalt; includes subordinate Chitistone Limestone north of Totschunda fault system

PPs — SKOLAI GROUP (Permian and Pennsylvanian) As mapped includes a few scattered remnants of Middle Triassic sedimentary rocks in northeastern part of quadrangle.

PPsm — METAMORPHOSED SKOLAI GROUP (Permian and Pennsylvanian) Includes a few small outcrops of serpentinized ultramafic rocks near Border Ranges fault

Pzk — KASKAWULSH GROUP OF KINDLE (1953) (Devonian?)

INTRUSIVE ROCKS

Th — FELSIC HYPABYSSAL ROCKS (Pliocene) Mainly porphyritic dacite

Tg — GRANODIORITE (Pliocene) Unfoliated granodiorite with local mafic border facies

Jc — CHITINA VALLEY BATHOLITH (Jurassic) Mainly foliated quartz monzodiorite, granodiorite, and tonalite

Trg — GABBRO

Pm — MONZONITIC-GRANITIC COMPLEX (Pennsylvanian) Mainly nonfoliated quartz monzonite and granite, local mafic border facies

Pgo — GABBRO AND ORTHOGNEISS (Pennsylvanian)

NORTH OF TOTSCHUNDA FAULT SYSTEM

SEDIMENTARY AND VOLCANIC ROCKS

QTw — WRANGELL LAVA See above

Kc — CHISANA FORMATION (Lower Cretaceous) Marine and subaerial volcaniclastic and volcanic rocks

KJs — NUTZOTIN MOUNTAINS SEQUENCE (Lower Cretaceous and Upper Jurassic)

Trn — NIKOLAI GREENSTONE See above

PPs — SKOLAI GROUP See above

INTRUSIVE ROCKS

Th — FELSIC HYPABYSSAL ROCKS See above

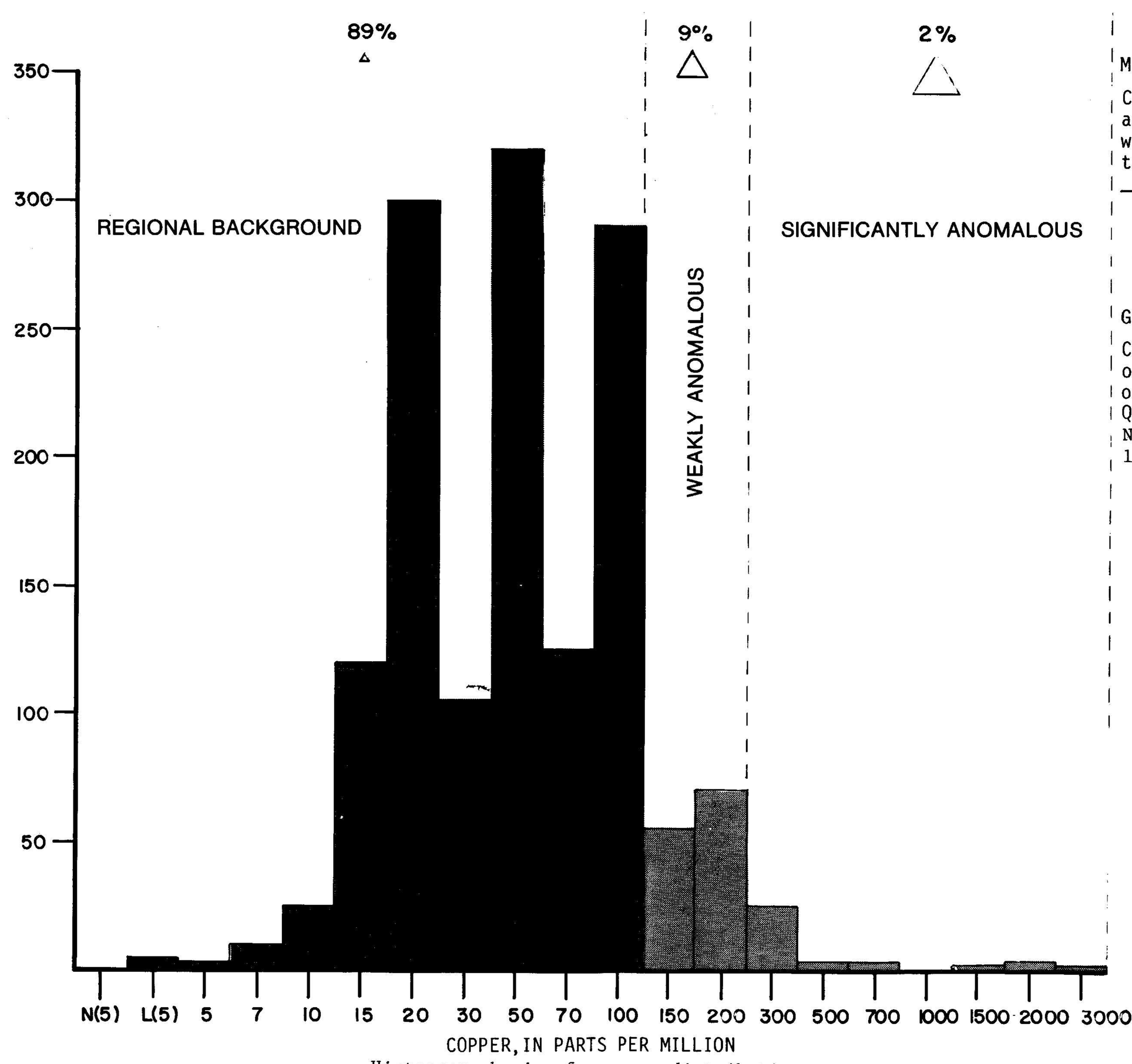
Kkg — KLEIN CREEK PLUTON (Cretaceous) Chiefly granodiorite

Contact; dotted where concealed

High-angle fault; dotted where concealed

Thrust fault; sawteeth on upper plate. Dotted where concealed

NOTE: Areas without letter symbols are glaciers and snowfields



Histogram showing frequency distribution, analytical range, and map symbols for copper in stream sediments and glacial debris, McCarthy quadrangle, Alaska

MODE = 50 ppm
MEDIAN = 50 ppm
Calculation based on analysis of 1454 samples with concentrations of Cu in the range N(5) through 3000 ppm

ARITHMETIC MEAN = 72 ppm
STANDARD DEVIATION = 127
GEOMETRIC MEAN = 47 ppm
GEOMETRIC DEVIATION = 2.4
Calculation based on analysis of 1449 samples with concentrations of Cu in the range 5 through 3000 ppm. Qualified N and L values not included. N, not detected; L, detected but below limit of determination (5).

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1976

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