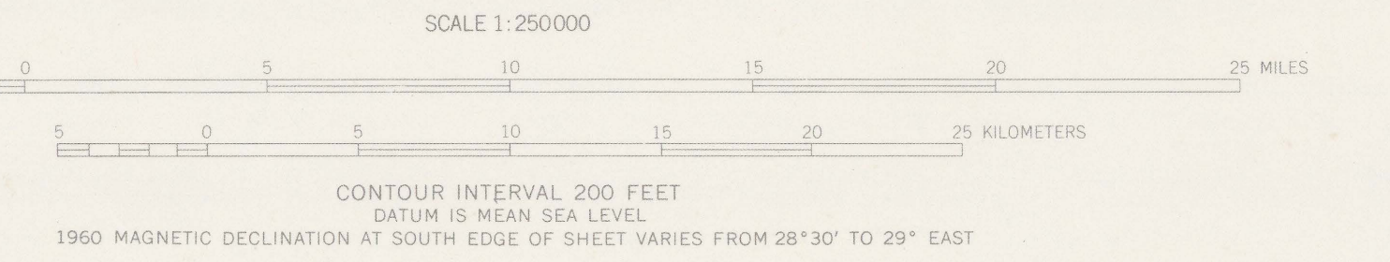
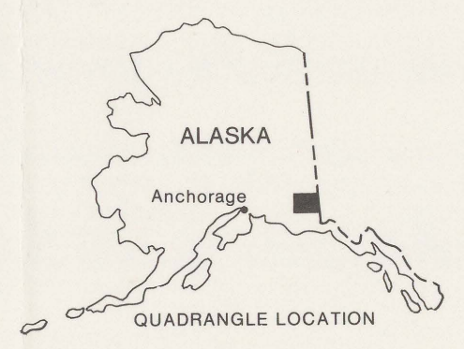
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES MAP MF-773-I
FOLIO OF THE McCARTHY QUADRANGLE, ALASKA

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



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



QUADRANGLE LOCATION

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 arsenic, 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)	0	10	22	-5	-4	--	-7	-18	17	1	-4	12	--	--	5	3	2	12	0	0	--	-12	-32	8	12	-10	30	▨
Number of pairs	212	212	212	210	212	--	187	206	98	204	201	211	--	--	211	142	209	209	211	204	--	208	12	216	209	216	193	▨

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

Table showing linear correlation coefficients between logarithmic values of the concentration of selected elements versus mercury, 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)	8	10	12	0	-6	--	26	-1	24	4	6	20	-7	--	10	28	4	2	9	-7	-11	-14	-23	12	10	3	▨	27
Number of pairs	361	361	358	356	361	--	316	352	136	348	339	358	13	--	357	233	354	358	361	347	10	351	15	360	330	364	▨	193

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

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

By

Keith Robinson, R. M. O'Leary, C. M. McDougal, 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 nometallic elements. This study incorporates the results of analyses for arsenic and mercury from 426 and 424 stream sediment and glacial moraine debris samples collected in the quadrangle, and analyzed by the U.S. Geological Survey between 1961 and 1976 using colorimetric and flameless atomic absorption spectrophotometry respectively. No analytical results for arsenic and mercury are available for stream sediment samples from the White River area, located in the northeastern part of the quadrangle.

The accompanying map shows the distribution and relative abundance of arsenic and mercury in stream sediment and glacial moraine debris samples. 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 histograms. 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, and this fraction was used 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 geographic distribution of samples analyzed for arsenic and mercury in the McCarthy quadrangle is large but irregular. However, the arsenic and mercury analyses may help to locate potential occurrences of concealed mineral deposits, particularly large buried porphyry copper and molybdenum centers, telethermal lead and zinc deposits, or more especially Kennecott-type copper deposits.

The arithmetic and geometric mean values of arsenic in stream sediments and glacial debris from the McCarthy quadrangle are 18 and 16 ppm, respectively. Based on an evaluation of the statistical data given in the accompanying histogram, arsenic values ranging from N(10) to 15 ppm are classified as background values. Values of 20 ppm are classified as threshold to weakly anomalous, and values greater than 20 ppm arsenic are considered to be significantly anomalous.

The arithmetic and geometric mean values of mercury in stream sediments and glacial debris from the McCarthy quadrangle are 0.13 and 0.07 ppm, repectively. Based on an evaluation of the statistical data given in the accompanying histogram, mercury values ranging from N(0.02) to 0.15 ppm are classified as background values. Values of 0.2 ppm are classified as threshold to weakly anomalous, and values greater than 0.2 ppm mercury are considered to be significantly anomalous.

A significant feature in a study of the geographical distribution of arsenic and mercury anomalies is the fact that both elements are closely associated with, or related to, occurrences of the Upper Triassic Chitistone Limestone and Middle and (or) Upper Triassic Nikolai Greenstone in areas of known Kennecott-type copper deposits. Of even greater significance is the fact that higher, even more pronounced anomalies of arsenic and mercury occur in association with the same two rock units to the west and southeast of the known Kennecott-type deposits (T. 4 S., R. 14 E.). Therefore, both arsenic and mercury should be useful pathfinder elements in the search for Kennecott-type deposits. Additionally, both elements are closely associated with areas of potential porphyry copper and molybdenum-type deposits, and with gold and lead mineralization in sedimentary rocks of the Devonian(?) Kaskawulsh, Pennsylvanian and Permian Skolai, and Jurassic(?) and Cretaceous Valdez Groups. The statistically significant positive correlation coefficients such as between arsenic and the elements calcium and mercury and between mercury and the elements calcium, copper, lead, and arsenic, suggest a carbonate rock and sulfide ore association, like that seen for Kennecott-type deposits. The positive correlation of mercury and boron and beryllium suggests mutual entrapment in a host rock as a result of mobilization related to the intrusion of felsic rocks into marine sediments.

Because erratic, biased, and in many cases widely separated sample localities were used in this project, undue emphasis may be placed on anomalous arsenic or mercury values occurring 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).

Arsenic and mercury are important pathfinder elements which can be used in the search for porphyry, telethermal, and stratiform-type deposits. Arsenic and mercury often form halos around zoned porphyry copper and other 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.

A plot of arsenic in stream sediments collected in the area of the McCarthy quadrangle south of the Chitina River shows extensive anomalies that are associated with the gold-producing rocks of the Valdez Group. A cluster of mercury anomalies are related to metamorphosed rocks of the Skolai Group and to rocks of the Jurassic Chitina Valley batholith. These mercury anomalies and one arsenic anomaly are located immediately adjacent to and southwest of the O'Hara prospect (T. 6 S., R. 9 E.). The occurrence of scattered gold, silver, arsenic, and mercury anomalies in this area suggests that more detailed geochemical studies should be conducted.

Highly positive arsenic and mercury anomalies were detected in samples of stream sediments collected from the west slope of Bonanza Ridge (T. 4 S., R. 14 E.), and some weak arsenic and mercury anomalies in sediments from McCarthy and Nikolai Creeks (T. 5 S., R. 15 E.). These anomalies may result from contamination by mining from the Kennecott-type deposits and the Nikolai mines, respectively. It is significant, however, that arsenic and mercury seem to exist in association with rocks containing Kennecott-type copper deposits. Stream sediments collected from the area west of Bonanza Ridge, extending to Castle Peak (T. 3 S., R. 11 E.), and southeast of Bonanza Ridge in the Nikolai Butte area (T. 6 S., R. 17 E.) also have anomalously high arsenic and mercury contents. The Chitistone Limestone crops out in these same areas and all Kennecott-type copper deposits are stratigraphically confined to the lower part of the Chitistone Limestone. Thus, arsenic and mercury may be sensitive pathfinder elements that can be used to locate new deposits of this type, because arsenic and mercury appear to occur in halos adjacent to the deposits. More detailed studies should be conducted in the area, using rock samples, to determine whether arsenic and mercury can be used successfully to predict and detect the occurrence of concealed Kennecott-type copper deposits.

South and southeast of the University Peak (T. 6 S., R. 20 E.) in an area encompassing the Hawkins, Barnard, and Anderson Glaciers, located in the southeastern corner of the quadrangle, a large number of arsenic and a few mercury anomalies were detected in samples of glacial moraine and stream sediment. These samples originate in a region containing rocks of the Kaskawulsh Group and some metamorphosed rocks of the Skolai Group that have been intruded by a monzonitic-granitic complex of Pennsylvanian age. Outcrops covering several square kilometers show evidence of strong hydrothermal alteration and positive aeromagnetic anomalies occur locally (Case and MacKevett, 1976). Anomalous amounts of copper, gold, arsenic, and lead were detected in samples of stream sediments and rock collected in the same area. The intrusive complex also contains several molybdenum anomalies and two small tin anomalies. The presence of anomalies of all these elements suggests that this area might contain undiscovered porphyry-type copper and molybdenum deposits related to the intrusive complex.

Anomalous amounts of arsenic and mercury were detected in two separate samples of glacial debris collected from an area intruded by Tertiary granodiorite and tonalite in the vicinity of The TWA Harpies (T. 6 S., R. 19 E.). One anomalous arsenic value in a sample of stream sediment from Toby Creek (T. 4 S., R. 17 E.) and a series of arsenic anomalies in stream sediment and glacial debris samples from the TWA Harpies Glacier valley (T. 5 S., R. 18 E.), may together reflect mineralization related to the exposed Tertiary granodiorite and tonalite. Zones of intense hydrothermal alteration are visible in the outcrop. The intrusive may be inferred to extend northwest under the central part of the University Range. This inference is supported by aeromagnetic data (Case and MacKevett, 1976). Anomalous concentrations of copper, gold, silver, and molybdenum are also present in samples of rocks and stream sediments collected in this general area. This area may contain porphyry-type copper or molybdenum deposits, however, the possibility of contamination from metals in the Nikolai Greenstone cannot be discounted, especially in Toby Creek and in the TWA Harpies Glacier valley.

Highly anomalous arsenic and mercury 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.), located in the south-central part of the quadrangle. Highly anomalous arsenic values were also detected in rock samples from the same localities and these anomalies 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 intrusive complex exposed in the University Range (T. 5 S., R. 18 E.) to the northeast. In addition to arsenic and mercury, anomalous concentrations of copper, silver, 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.

Two arsenic and mercury anomalies were detected in the very few samples of stream sediments collected in the vicinity of Granite Peak (T. 1 S., R. 9 E.), which were analyzed. Anomalous concentrations of molybdenum, gold, and copper were also detected in some samples of stream sediment and rock collected in the same general locality. The Jurassic Chitina Valley batholith composed 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. 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.

A complete set of coordinates for sample sites, as well as statistical and analytical data, obtained 1974-1976 for arsenic and mercury 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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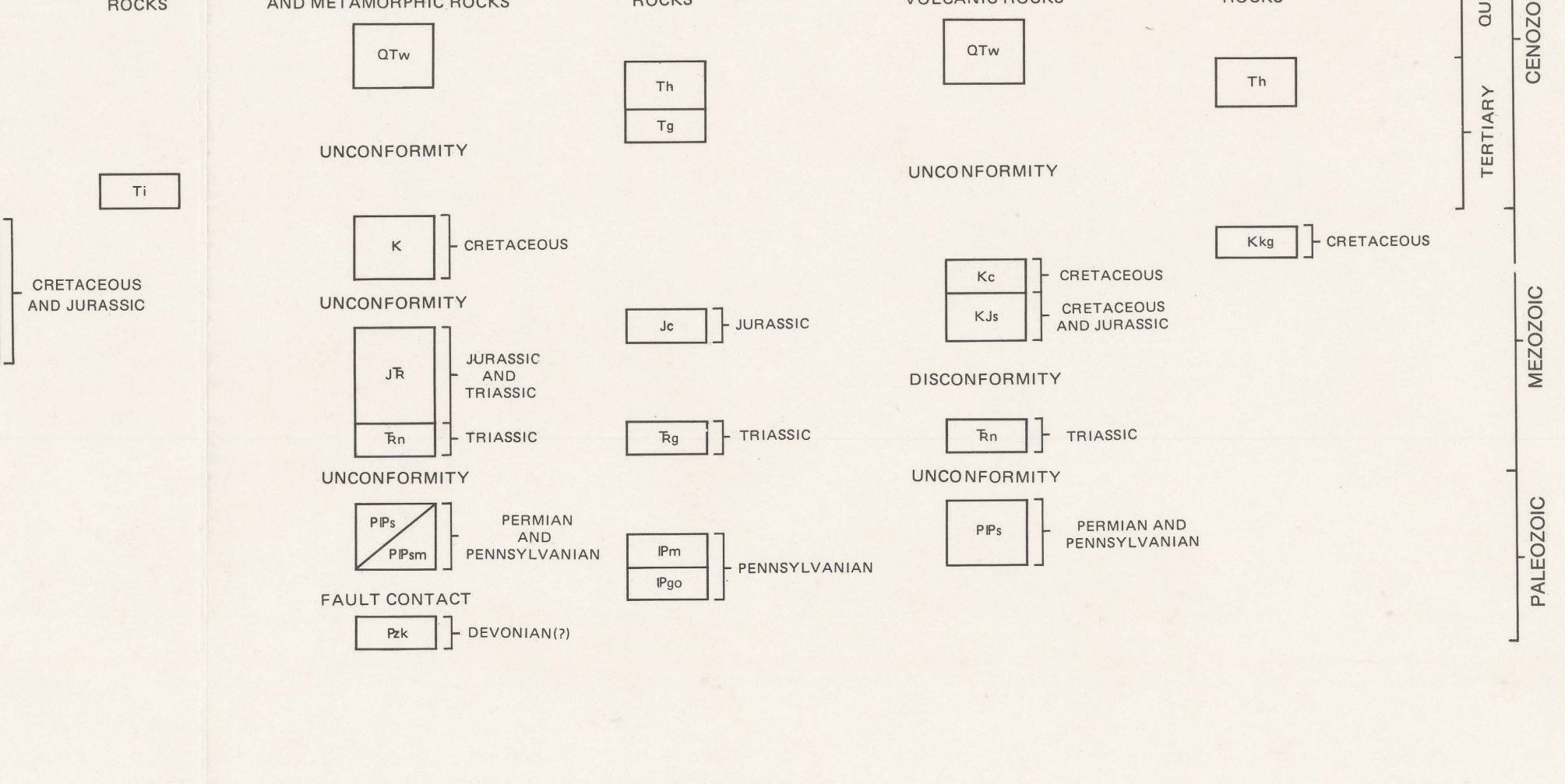
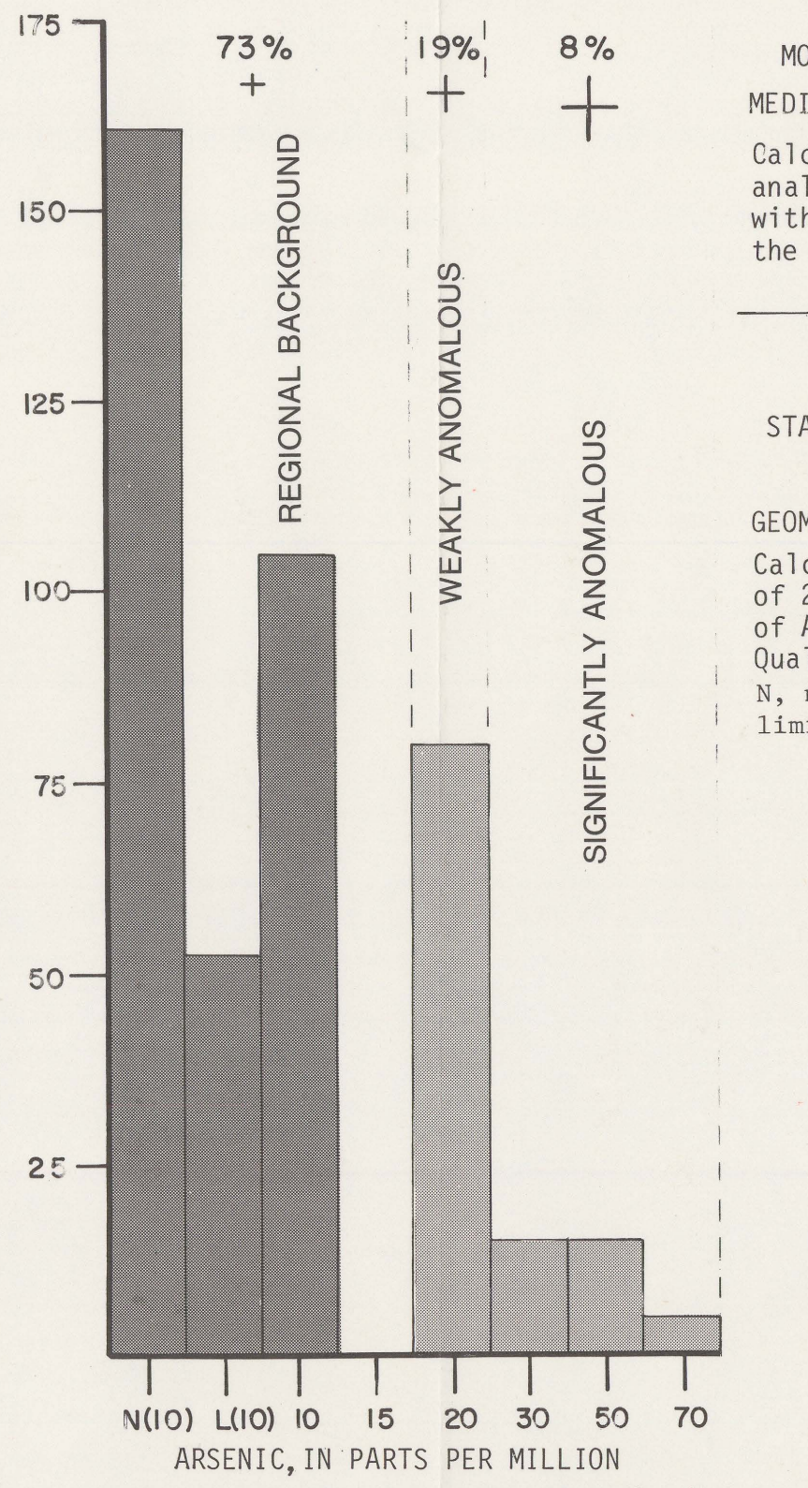
EXPLANATION FOR GENERALIZED GEOLOGIC MAP
(GEOLOGY GENERALIZED BY MacKEVETT, 1976)

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

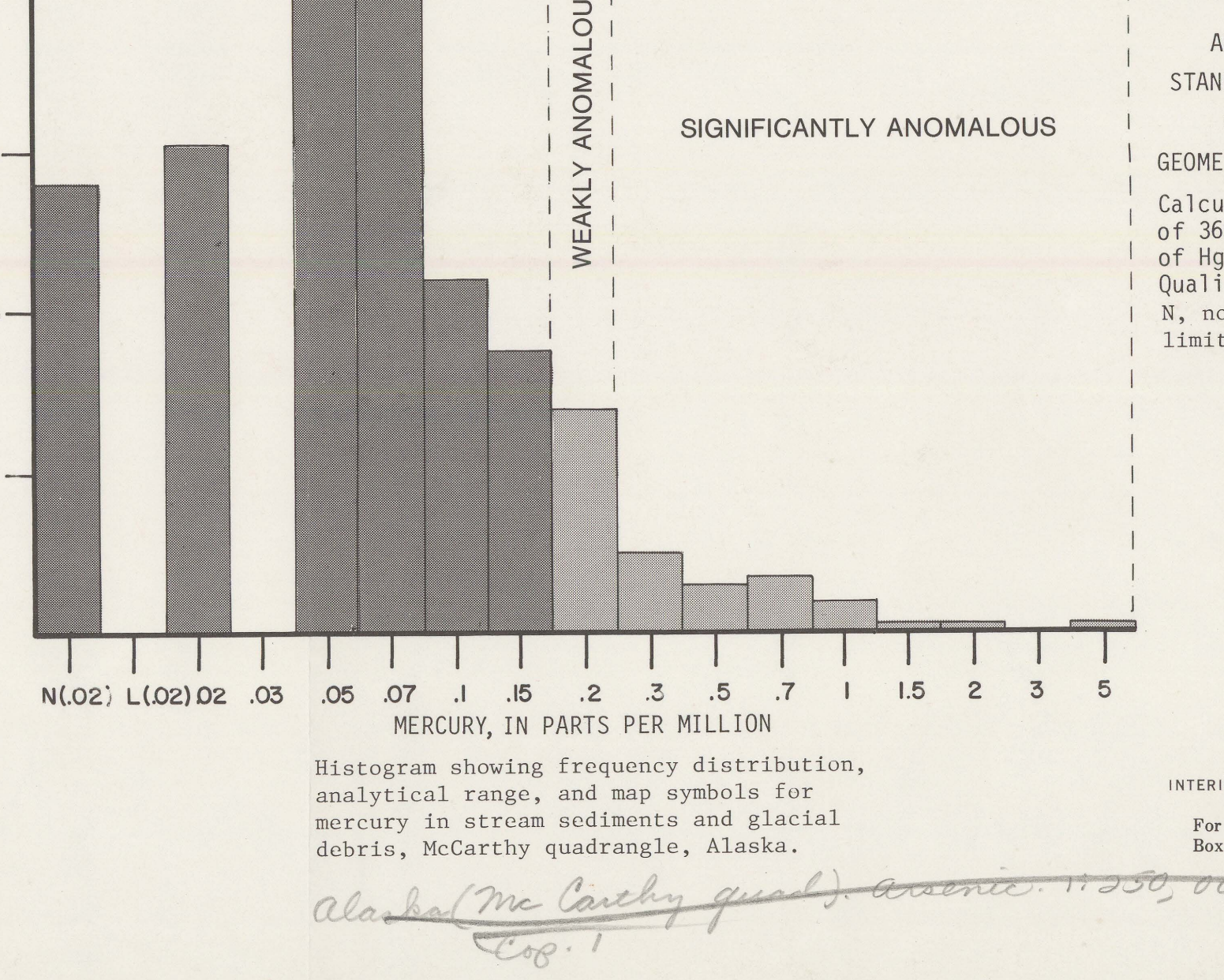
	SURFICIAL DEPOSITS
Qu	UNCONSOLIDATED SEDIMENTARY DEPOSITS (Quaternary)
	SOUTH OF BORDER RANGES FAULT
	METAMORPHIC ROCKS
KJv	VALDEZ GROUP (Cretaceous and Jurassic?)
	INTRUSIVE ROCKS
Ti	INTRUSIVE ROCKS (Eocene?) Typically, foliated granodiorite and tonalite
	BETWEEN BORDER RANGES FAULT AND TOTSCHUNDA FAULT 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
PIPs	SKOLAI GROUP (Permian and Pennsylvanian) As mapped includes a few scattered remnants of Middle Triassic sedimentary rocks in northeastern part of quadrangle
PIPsm	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
IPm	MONZONITIC-GRANITIC COMPLEX (Pennsylvanian) Mainly nonfoliated quartz monzonite and granite, local mafic border facies
IPgo	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
PIPs	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



MODE = N(10) ppm
MEDIAN = 10 ppm
Calculation based on analysis of 426 samples with concentrations of As in the range N(10) through 80 ppm

ARITHMETIC MEAN = 18 ppm
STANDARD DEVIATION = 12
GEOMETRIC MEAN = 16 ppm
GEOMETRIC DEVIATION = 1.7
Calculation based on analysis of 218 samples with concentrations of As in the range 10 through 80 ppm. Qualified N and L values not included. N, not detected; L, detected but below limit of determination (10).

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



MODE = 0.07 ppm
MEDIAN = 0.07 ppm
Calculation based on analysis of 424 samples with concentrations of Hg in the range N(.02) through 4 ppm

ARITHMETIC MEAN = 0.13 ppm
STANDARD DEVIATION = 0.28
GEOMETRIC MEAN = 0.07 ppm
GEOMETRIC DEVIATION = 2.6
Calculation based on analysis of 366 samples with concentration of Hg in the range 0.02 through 4 ppm. Qualified N and L values not included. N, not detected; L, detected but below limit of determination (0.02).

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

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