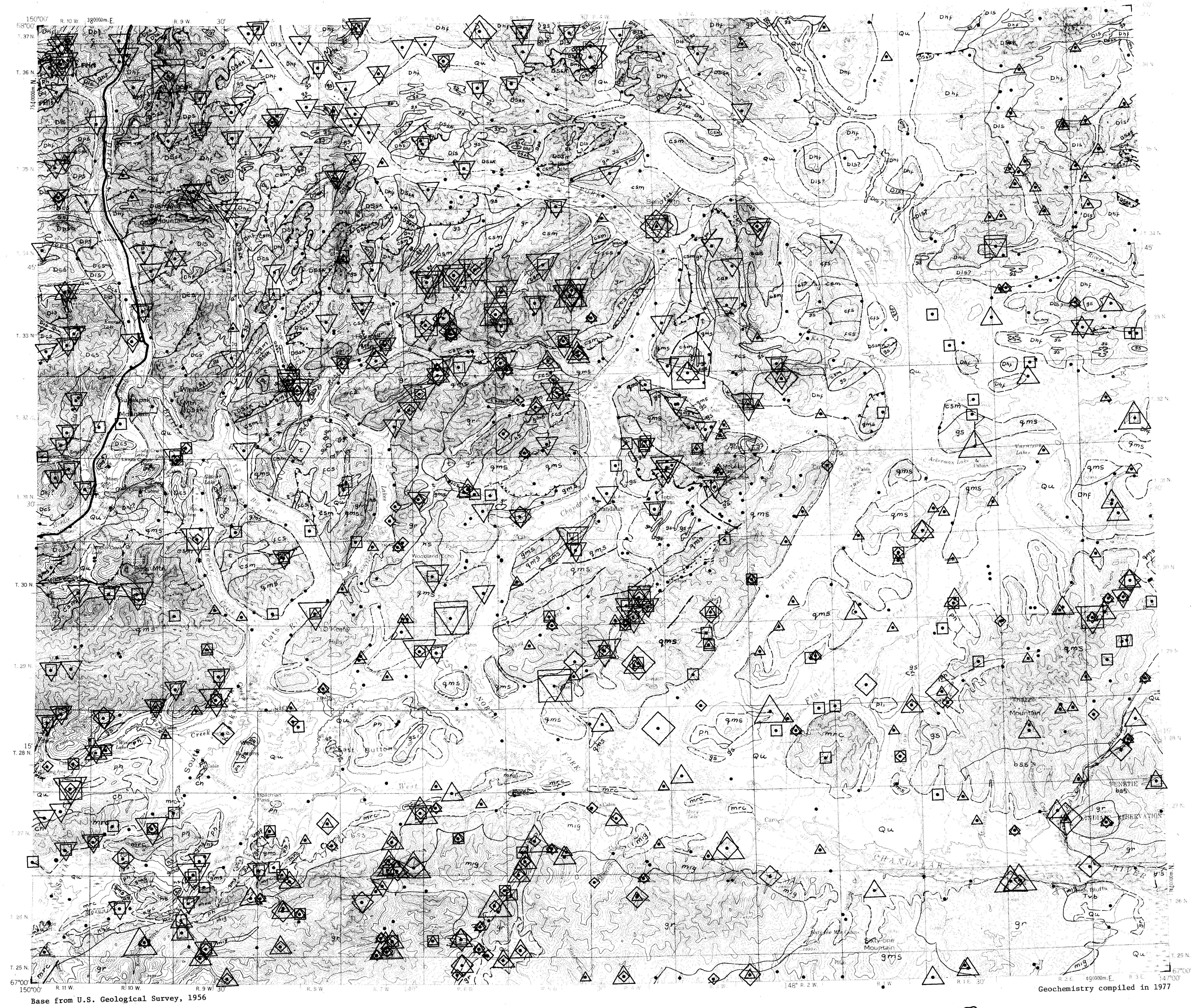
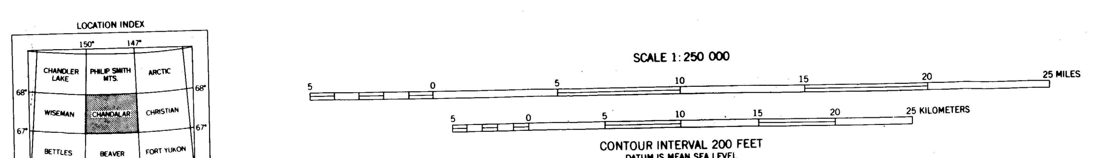
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

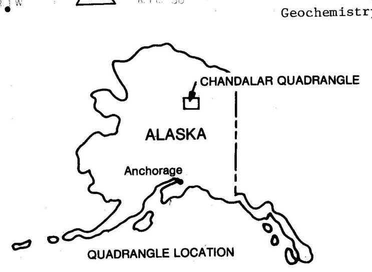
MISCELLANEOUS FIELD STUDIES
MAP MF-878F
FOLIO OF THE CHANDALAR QUAD., ALASKA
GEOCHEMICAL MAP; Ni, Co, La, Y



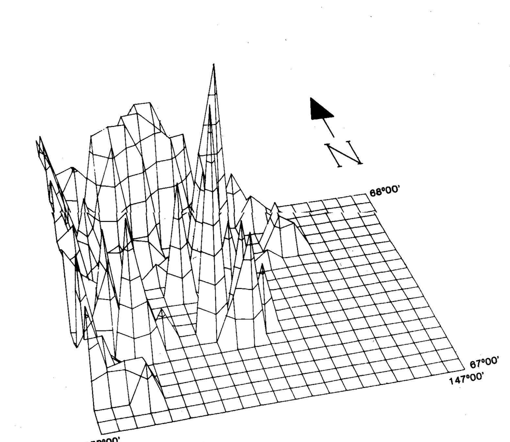
Base from U.S. Geological Survey, 1956

Geochemistry compiled in 1977

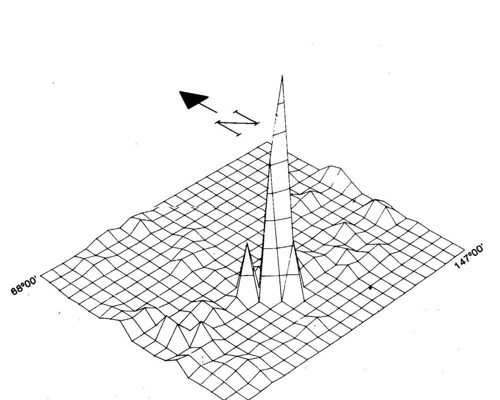




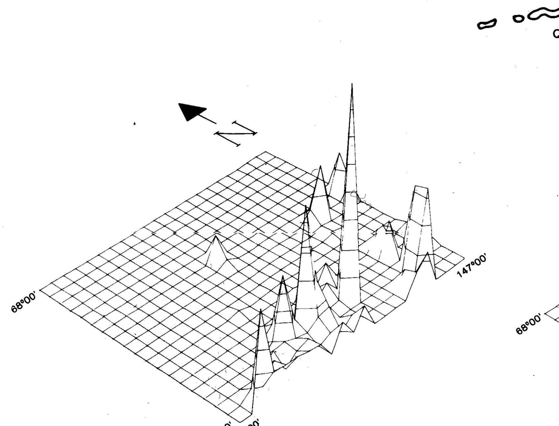
QUADRANGLE LOCATION



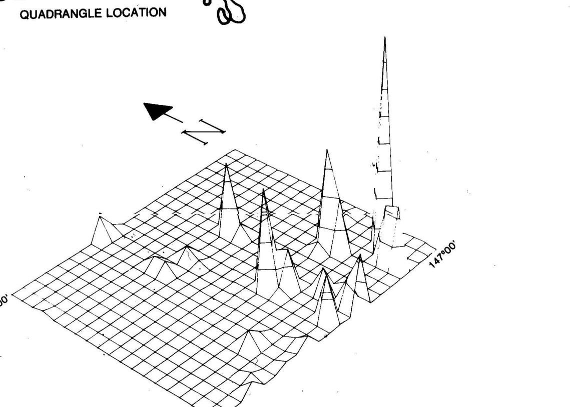
PERSPECTIVE PLOT OF NICKEL IN STREAM-SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA



PERSPECTIVE PLOT OF COBALT IN STREAM-SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA



PERSPECTIVE PLOT OF LANTHANUM IN STREAM-SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA



PERSPECTIVE PLOT OF YTTRIUM IN STREAM-SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA

GEOCHEMICAL AND GENERALIZED GEOLOGIC MAP SHOWING DISTRIBUTION AND ABUNDANCE OF NICKEL, COBALT, LANTHANUM AND YTTRIUM IN STREAM SEDIMENTS, CHANDALAR 1° X 3° QUADRANGLE, ALASKA

By

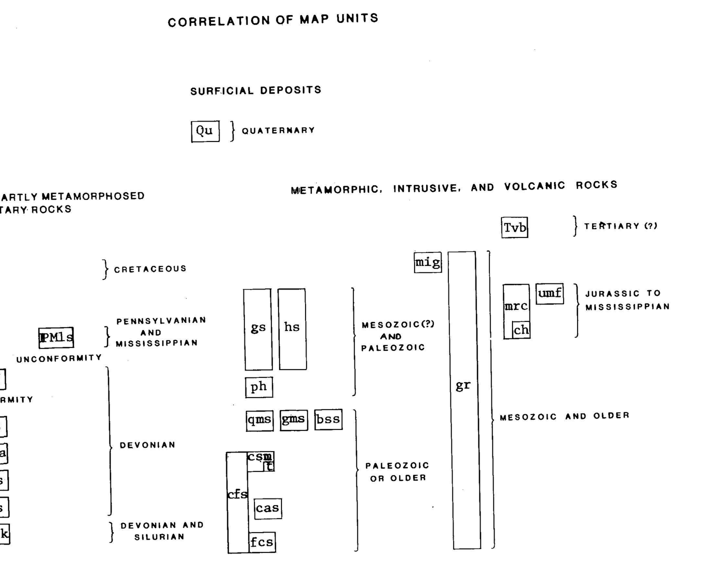
S.P. Marsh, D. E. Detra, and S. C. Smith

1979

EXPLANATION

GEOLOGY GENERALIZED AND REVISED FROM BROSGE AND REISER, 1964, AND CHIPP, 1970

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

This map is generalized from Brosgé and Reiser (1964). Many of these map units are combinations of units shown separately on the older map. The Devonian and Devonian(?) age that was assigned to the metamorphic rocks by Brosgé and Reiser (1964) is herein revised to early Paleozoic or older.

SURFICIAL DEPOSITS

- Qu — Unconsolidated sedimentary deposits (Quaternary)

FOSSILIFEROUS PARTLY METAMORPHOSED SEDIMENTARY ROCKS

- Kqc — Quartz pebble conglomerate (Cretaceous)
- PM1s — Lisburne Group (Pennsylvanian and Mississippian) and Kayak Shale (Mississippian)--Limestone, dolomite, shale and conglomerate
- Dhf — Hunt Fork Shale (Upper Devonian)--Slate and phyllite
- Dps — Purple and green slate and phyllite (Devonian)
- Dpsa — Purple and green andesitic volcanic sheared conglomerate (Devonian)
- Dcs — Chloritic siltstone and grit (Devonian)--Schistose; in part graywacke
- Dls — Limestone and siltstone (Upper Devonian)--Schistose; includes some green slate locally
- DSsk — Skajit Limestone (Upper and Middle Devonian, Upper Silurian)--Limestone, dolomite, and marble

METAMORPHIC, INTRUSIVE AND VOLCANIC ROCKS

- Tvb — Vesicular olivine basalt flows (Tertiary?)
- mig — Migmatite (Mesozoic and older)--Intercalated mica schist and granite; granite with mafic inclusions
- gr — Granitic rocks (Mesozoic and older)--K/Ar dates of biotite are 101 m.y. and 125 m.y. (Brosgé and Reiser, 1964); of hornblende, 486 m.y. (M. L. Silberman and D. L. Turner, written commun., 1977)

JURASSIC TO MISSISSIPPIAN

- mrc / ch — Mafic rocks and chert--Pillow basalt, andesite, minor chert; diorite; diabase and gabbro. Chert (ch) differentiated where abundant
- umf — Ultramafic rocks

MESOZOIC(?) AND PALEOZOIC

- gs — Greenstone and greenschist--Includes pillowed flows in Hunt Fork Shale (Dhf) in northeast part of the quadrangle
- hs — Hornblende schist--Mostly hornfels facies
- ph — Phyllite and schistose wacke

PALEOZOIC OR OLDER

- qms — Quartz muscovite schist
- gms — Garnet mica schist--Mostly hornfels facies
- bss — Biotite staurolite schist--Hornfels facies
- cfs — Undifferentiated calcareous schist (csm) and feldspathic chloritic schist (fcs)
- csm / t — Calcareous schist, marble and tactite (t) locally
- cas — Chloritized amphibole schist--Local remnant glaucophane
- fcs — Feldspathic chloritic schist--Includes metadiorite sills and pyritic quartzite

GEOLOGIC SYMBOLS

- CONTACT--Dashed where approximate; dotted where concealed
- U/D NORMAL FAULT--Dashed where inferred, queried where doubtful; dotted where concealed; U, upthrown side; D, downthrown side
- THRUST FAULT--Queried where doubtful; dotted where concealed. Sawteeth on upper plate

GEOCHEMICAL SYMBOLS

- Sample localities
- Anomalous values of nickel[1]
- Anomalous values of cobalt[1]
- Anomalous values of lanthanum[1]
- Anomalous values of yttrium[1]

[1]Histograms show metal values for symbols

DISCUSSION

This geochemical map shows the distribution and abundance of nickel (Ni), cobalt (Co), lanthanum (La), and yttrium (Y) in -80 mesh (177 micrometers) stream sediment samples in the Chandalar quadrangle, Alaska. The map is part of a series of geochemical maps that together with the background information circular (Reiser and others, 1979) comprises the folio on the Chandalar quadrangle, Alaska. The data are plotted on a base map showing the generalized geology, topography, and sample localities. Map symbols showing the ranges of metal values are indicated on the accompanying histograms and all values shown are considered anomalous. An explanation of sampling, preparation, and analytical procedures, and geochemical raw data for all samples are discussed by O'Leary and others (1976). The -80 mesh (177 micrometers) stream-sediment medium was used in this study because, given the rather restrictive time and manpower constraints, this medium combined with panned concentrates was considered to be the most economical and adequate medium in this area of the north-central Brooks Range where clastic sediments are derived from local bedrock.

The study area is one of generally high relief with short, fast-moving streams and broad glacial valleys. All samples were taken from active streams, as close to the center channel as possible. All sediments were considered to be locally derived. Care was taken, when sampling an obviously glaciated terrain, to sample above or upstream from morainal material, wherever possible. Most samples were taken in areas where bedrock was within 30 m of the sample site.

GEOCHEMISTRY OF NICKEL, COBALT, LANTHANUM, AND YTTRIUM

Nickel-Cobalt

Nickel and cobalt are siderophile elements, but may become oxyphyle in the upper lithosphere. Although nickel and cobalt are found in the main stages of magmatic crystallization in sulfide ores, most is incorporated in structures of silicate minerals (Rankama and Sahama, 1955). Nickel and cobalt tend to be enriched in the ultrabasic and basic rocks in the magnesium and ferromagnesium minerals. Nickel and cobalt behave differently in the weathering cycle; nickel remains in the solid products and deposits in the hydrolyzate sediments, while cobalt, being more soluble, remains in the weathering solutions to form oxidates. Nickel and cobalt form sulfide ores in basic and ultrabasic rocks as massive sulfides, sulfide veins, and as residual (supergene) deposits from weathered basic rocks. Cobalt is commonly associated with base metal sulfide deposits and with bedded copper (Boyle, 1974).

Lanthanum and Yttrium

The rare earths lanthanum and yttrium consistently occur together in nature. They have a marked affinity for fluorine and phosphorous and become concentrated in residual solutions during crystallization. They are common in granites and nepheline syenites and are also found in pegmatites (Rankama and Sahama, 1955). Both lanthanum and yttrium form hydrolyzates upon weathering and are carried in carbonate solutions. Lanthanum- and yttrium-bearing minerals from deposits in pegmatites, skarns, rare earth carbonate veins, and in carbonatite (Boyle, 1974). Lanthanum and yttrium are also minor constituents of some minerals, notably euxenite, monazite, allanite, sphene, and apatite.

STATISTICAL DATA

There are four sections of statistical data included with this map: (1) Four histograms show frequency (number of samples) plotted against concentration in ppm (parts per million). Analytical values qualified by an N indicate that an element was not detected at an established lower limit of detection (5 ppm for Ni, 5 ppm for Co, 20 ppm for La, and 10 ppm (5 ppm for some of the older data) for Y). Analytical values qualified by an L indicate that the element was detected, but at a concentration below the lower limit of determination. A short tabulation of statistical information is included with each histogram. (2) A correlation diagram shows correlation coefficients in the upper part (in decimal fraction of 1) and the number of sample pairs used in the correlation in the lower part. The correlation coefficients and number of sample pairs for Ni, Co, La, and Y are shaded on the diagram. A coefficient of 1 indicates a perfect direct proportional relation, -1 an inverse relation. The significance of a coefficient is directly proportional to the number of sample pairs used in determining that coefficient. (3) A cumulative frequency plot shows cumulative frequency plotted against concentration in ppm for Ni, Co, La, and Y. (4) Four perspective plots show a three-dimensional representation of anomalous Ni, Co, La, and Y in the Chandalar quadrangle. A grid was arbitrarily applied to the quadrangle to give the best representation of the values, and the metal values of samples in each grid square were averaged. The peaks shown reflect this average. The plateaus in the perspective plots represent an arbitrary anomalous value (shown on the histograms as a line pattern), usually the 95th percentile or two standard deviations above the median. Because N and L values were used only in the histograms and cumulative plots and not in the computation of other statistical information, the results may be somewhat biased.

OCCURRENCES

Nickel

The highest concentration of nickel occurrences in the Chandalar quadrangle is in the north and northwest, where it is, for the most part, derived from the Hunt Fork Shale (Dhf). This is not an uncommon occurrence as shales may contain as much as 150 ppm nickel (Rankama and Sahama, 1955). A second area of anomalous nickel, associated with cobalt, surrounds the Geroe Creek altered zone in the west-central part of the map (T. 33 N., R. 5 W.). This area contains numerous samples where nickel is 100 ppm or greater and also has anomalous tin (Sn) and tungsten (W) in non-magnetic panned concentrates (Detra and others, 1977). This area is also anomalous in molybdenum and other base metals (Marsh and others, 1978a, b) and is a possible porphyry molybdenum system.

Nickel-cobalt anomalies occur in quartz-muscovite schist (qms) along Big Creek in the south-central part of the quadrangle. This area is associated with geochemical anomalies in base metals, rare earths, and boron (B) in the stream sediments and with anomalies in Sn, Be, and W in non-magnetic panned concentrates (Detra and others, 1977; Marsh and others, 1978a, b). An aeromagnetic high is also associated with the area (Cady, 1978) and may represent buried, mineralized intrusive rocks. Abundant low-level nickel-cobalt anomalies occur along the southwest side of the quadrangle. These occur mostly in quartz-muscovite schist and are probably due to mafic minerals in the stream sediments. The numerous anomalies in the southwest corner occur in mafic rocks and chert (mrc) and are probably normal abundances for these rocks. Indeed, the only occurrence of ultramafic rocks (umf) in the quadrangle is in this area, just south of Bostman Pass.

One nickel anomaly occurs south of Chekhechunnjik Creek on the east edge of the quadrangle associated with base metal anomalies in stream sediment (Marsh and others, 1978a, b) and anomalies in panned concentrates (Detra and others, 1977) and may represent mineralization along a fault in quartz-muscovite-schist (qms) (Brosgé, oral commun., 1976).

COBALT

Cobalt, being less resistate than nickel, forms less scattered anomalies over the quadrangle indicating relative proximity to the source areas. Cobalt is also associated with nickel in most of the samples; consequently anomalous areas are often the same for both elements. Cobalt is not nearly so ubiquitous in the Hunt Fork Shale (Dhf) as nickel and tends to concentrate in more restricted areas. Two prominent areas stand out; one, north of the North Fork Chandalar River in Tps. 35, 36 N., Rs. 5, 6 W. may be related to the lead-silver veins at the northeast end of a prominent skarn zone (Marsh and others, 1978a), and the second, a clustering of nickel-cobalt anomalies on the west edge of the quadrangle in Tps. 31-33 N. This group of samples comes from streams draining areas of chloritic siltstone and grit (Dcs) and possibly some Hunt Fork Shale (Dhf) and may represent a more mafic character of the sediments in this area.

As previously mentioned, cobalt anomalies occur with nickel surrounding the Geroe Creek altered zone. Some of the highest cobalt anomalies, associated with nickel, are along Big Creek, described above.

Cobalt and nickel anomalies are fairly abundant in the southwest corner of the map and are associated with the mafic rock and chert unit (mrc) that outcrops in this area. Some scattered anomalies occur in the quartz-mica schist (qms) trending southwest from the Geroe Creek area and, along with scattered Sn, W, and Nb in non-magnetic panned concentrates (Detra and others, 1977), may represent additional concealed granitic rocks with potential mineralization (Marsh and others, 1978a). Cobalt also occurs, associated with other metal anomalies, in the potential mineralized fault zone south of Chekhechunnjik Creek along the eastern edge of the quadrangle (Marsh and others, 1978a, b, c, d).

LANTHANUM

The rare earths lanthanum and yttrium are commonly associated with granitic rocks and in the Chandalar quadrangle most of the major anomalies can be related to outcrops of granite. As with most other metals, lanthanum is anomalous in stream sediment samples taken from the area surrounding the Geroe Creek altered zone. Although this is in an area of granitic terrane, it also is a potential porphyry molybdenum system. Scattered low-level lanthanum anomalies occur southwest from the Geroe Creek area, and with other metal anomalies (Marsh and others, 1978a, b, c, d; Detra and others, 1977), may represent concealed granitic rocks with potential for mineralization.

By far, most lanthanum anomalies occur in the granitic rocks along the southern border of the map. Although lanthanum is pervasive throughout the area, it is more abundant in the western half of the granite than in the eastern half. This is even more strongly emphasized in the panned concentrates from the area (Detra and others, 1977), with high values almost exclusively in the western half of the granitic rocks. Rocks have been migmatized in the western part and the highest lanthanum concentrations are in the areas of most migmatization which is also anomalous in Sn and Mo in non-magnetic panned concentrates (Detra and others, 1977). This western area also contains an abundance of the mafic rocks and chert unit (mrc) mixed with basaltic and andesitic volcanic adjacent to the granitic rocks. This could lead to some mineralization along the contact zone, and indeed, a number of anomalies are in areas where the granitic rocks are in contact with the mafic rocks. A large concentration of lanthanum anomalies also occurs along Trail Creek, Tps. 25-27 N., Rs. 5 and 6 W. This area also contains base metals (Marsh and others, 1978a) and many Sn anomalies in non-magnetic panned concentrates (Detra and others, 1977). This is also the largest area of migmatization. These anomalies may indicate a potential for mineralized veins in this area.

Scattered lanthanum anomalies occur in the southeast part of the quadrangle around and east of Thazzik Mountain. Some of these anomalies are associated with the potentially mineralized fault zone south of Chekhechunnjik Creek, but most seem to be in quartz-mica schist (qms) and biotite-staurolite schist (bss). There are also high boron, niobium, and zinc, anomalies in this area (Marsh and others, 1978b, c, d), the boron anomalies being the highest in the quadrangle. These anomalies combined with W and some Sn anomalies in non-magnetic panned concentrates (Detra and others, 1977) may indicate a potential for rare-earth pegmatites, although none are known to exist. This potential mineralization may possibly extend westward to the area of quartz-mica schist between Flat Creek and Middle Fork Chandalar River where low-level anomalies in lanthanum in the stream sediment samples become greatly enhanced in the non-magnetic panned concentrates.

In the northeast corner of the quadrangle low-level lanthanum anomalies occur in streams draining areas of Hunt Fork Shale (Dhf) and limestone and siltstone (Dls), and are associated with weak boron, copper, zinc, and scattered molybdenum anomalies. A broad subdued aeromagnetic high is also present in this area and may reflect mineralization from a deeply buried pluton (Cady, 1978).

YTTRIUM AND URANIUM

Yttrium consistently occurs with lanthanum although it is less abundant. All of the localities mentioned above in which lanthanum is anomalous also contain anomalous amounts of yttrium.

Seventy-five samples from the southeast part of the quadrangle, mostly from granitic rocks (gr), were separately analyzed for uranium. Most yielded no values in uranium, but those with values are listed in Table 1. Microscopic examination of selected panned concentrate samples from this area gave the mineralogic information listed in Table 2. The uranium found in these samples is most probably contained in the structures of sphene, allanite, monazite, and euxenite (S. Rosenblum, oral commun.). Virtually all of the samples with reported uranium values come from drainages around a granitic mass just east of Sixty One Mountain in the southeast corner of the quadrangle. This pluton forms a large aeromagnetic high (Cady, 1978), and stream sediments and panned concentrates from this area are anomalous in rare-earths and niobium (Marsh and others, 1978d).

THIS MAP IS ONE OF A SERIES, ALL BEARING THE NUMBER MF-878
BACKGROUND INFORMATION RELATING TO THIS MAP IS PUBLISHED
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Table 1.--*Fluorimetric analyses of uranium in selected stream sediment samples,[1] Chandalar 1° x 3° quadrangle, Alaska*

Sample Number	U (ppm)
CH600	0.24
CH601	0.58
CH602	0.19
CH605	0.24
CH608	0.14
CH613	0.22
CH614	0.78
CH615	0.34
CH616	0.34
CH617	0.30
CH618	0.20
CH619	0.42
CH620	0.25
CH621	0.26
CH622	0.25
CH623	0.24

[1]Map showing sample localities and sample numbers is in O'Leary and others (1976).

REFERENCES

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____1978b, Geochemical and generalized geologic map showing distribution and abundance of zinc in stream sediments in the Chandalar quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-878-E.
____1978c, Geochemical and generalized geologic map showing distribution and abundance of barium, arsenic, boron, and vanadium in stream sediments in the Chandalar quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-878-G.
____1978d, Geochemical and generalized geologic map showing distribution and abundance of antimony and niobium in the Chandalar quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-878-H.
O'Leary, R. M., McDanal, S. K., McDougal, C. M., Day, G. W., and Marsh, S. P., 1976, Chemical analyses and statistical data for stream sediment samples from the Chandalar quadrangle, Alaska: U.S. Geological Survey Open-File Report 76-492, 120 p.
Rankama, K., and Sahama, T. H. G., 1955, Geochemistry: The University of Chicago Press, 912 p.
Reiser, H. N., Brosgé, W. P., DeYoung, J. H., Cady, J. W., Hamilton, T. D., Marsh, S. P., and Albert, N. D., 1979, The Alaskan Mineral Resource Assessment Program: Guide to Information contained in the Folio of Geologic and Mineral Resource Maps of the Chandalar Quadrangle, Alaska: U.S. Geological Survey Circular 758.

CORRELATION COEFFICIENT

[Upper half of table contains correlation coefficients; lower half is the number of pairs of values used to compute coefficients. Where number of pairs is less than the total number of samples analyzed the bivariate frequency distribution was censored owing to the limitations of the method of analysis (L, N, and G values were not used in the correlation)]

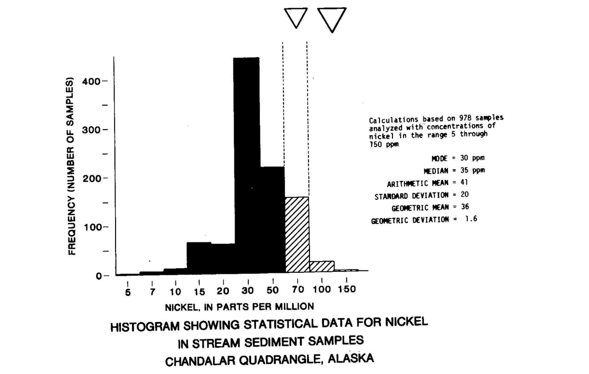
	Six-step semiquantitative spectrographic analysis											Atomic absorption analysis		Colorimetric analysis
	B	BA	CO	CU	LA	MO	NB	NI	PB	V	Y	ZN	SB	AS
B		-.05	.24	.21	.04	.07	-.11	.26	-.02	.14	.09	.40	.17	-.06
BA	962		.29	.12	.11	-.30	.17	.06	.27	.51	.14	.25	.08	.21
CO	897	909		.27	.08	.07	.07	.51	.22	.35	.22	.42	.09	-.17
CU	962	975	909		.12	.29	.01	.47	.31	.27	.14	.35	.20	-.08
LA	750	759	716	759		.20	.16	.10	.22	.14	.40	.05	-.04	-.02
MO	44	45	37	39	39		-.38	.43	.003	.25	.34	.25	.22	.04
NB	411	417	416	416	414	14		.01	.13	.19	.38	-.19	-.01	.28
NI	963	976	909	977	760	41	418		.23	.40	.29	.43	.20	-.23
PB	889	900	872	902	707	41	412	902		.19	.27	.24	.15	.20
V	963	976	909	977	760	46	417	978	902		.32	.24	.11	-.05
Y	921	932	881	932	731	41	413	933	873	933		.002	-.03	-.10
ZN	950	963	897	964	752	46	413	965	890	965	929		.36	.01
SB	797	808	805	807	631	29	389	808	802	808	792	801		.14
AS	229	229	171	231	181	21	27	231	163	231	196	228	112	

Row groups: B–Y, Six-step semiquantitative spectrographic analysis; ZN, SB, Atomic absorption analysis; AS, Color. anal.

NUMBER OF SAMPLE PAIRS

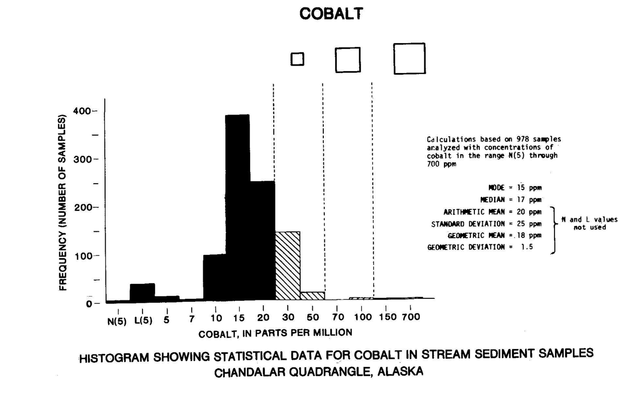
CORRELATION DIAGRAM FOR NICKEL, COBALT, LANTHANUM, AND YTTRIUM IN STREAM SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA

NICKEL



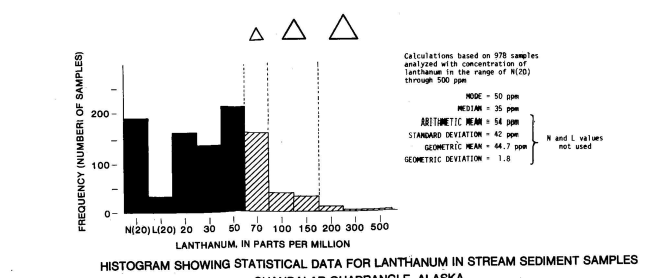
HISTOGRAM SHOWING STATISTICAL DATA FOR NICKEL IN STREAM SEDIMENT SAMPLES CHANDALAR QUADRANGLE, ALASKA

COBALT



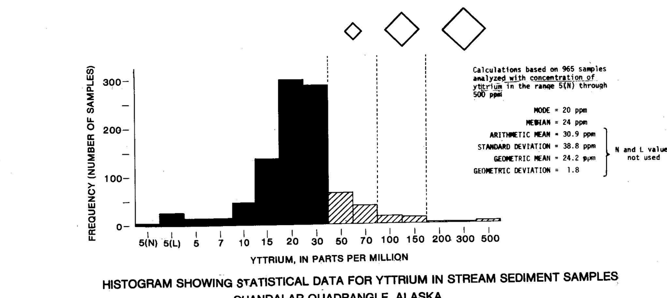
HISTOGRAM SHOWING STATISTICAL DATA FOR COBALT IN STREAM SEDIMENT SAMPLES CHANDALAR QUADRANGLE, ALASKA

LANTHANUM

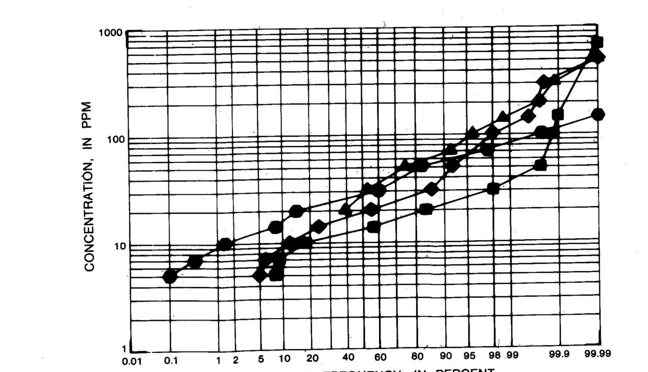


HISTOGRAM SHOWING STATISTICAL DATA FOR LANTHANUM IN STREAM SEDIMENT SAMPLES CHANDALAR QUADRANGLE, ALASKA

YTTRIUM



HISTOGRAM SHOWING STATISTICAL DATA FOR YTTRIUM IN STREAM SEDIMENT SAMPLES CHANDALAR QUADRANGLE, ALASKA



CUMULATIVE FREQUENCY PLOT FOR NICKEL (●), COBALT (■), LANTHANUM (▲), AND YTTRIUM (◆) IN STREAM SEDIMENT SAMPLES, CHANDALAR QUADRANGLE, ALASKA

Table 2.--Mineral content of selected panned concentrates[1]

[X -- indicates major constituent; 0 -- indicates minor constituent. All samples also contained minor amounts of country rock, mostly schist. Mineral examination by S. Rosenblum (written commun.)]

Field Number	Magnetic Fraction	hornblende	garnet	epidote	tourmaline	sphene	rutile	anatase	zircon	andalusite	sillimanite	staurolite	actionlite	biotite	muscovite	pyrite	limonite hematite	ilmenite	apatite	scheelite	allanite	monazite	euxenite	zoisite	spinel
CH600	0.6 amp	X	X	0	0	X						0	0		0		0				0				
CH601	0.6 amp	X	X	X		0								0	0			0	0						
CH602	0.6 amp	X	0	0	0	X	0			0							0				0				0
CH602	non-mag		0		0	X	0	0		0										0 (2 grains)					0
CH603	0.6 amp	X	0	X	0	0											0					0			
CH604	0.6 amp	X	0	X		0											0								
CH604	non-mag			0		X		0	0											0 (1 grain)					
CH613	0.6 amp	X	0	X	0										0										
CH613	non-mag			X		0	0												0	0			0		
CH614	0.6 amp	X	X	X													0	0			X			0	
CH616	0.6 amp	X	0	0	0						0		X	X		0						0			
CH616	non-mag				0	0	0		0	X	X				0					0 (4 grains)					
CH619	0.6 amp	X	X	0								0					0	0			0			0	
CH619	non-mag			0		0	0	0	X	0					0				0	0 (?)				0	0
CH620	0.6 amp	0	0	0	X	0			0 (red)			0	0									0			
CH620	non-mag				X	X	0		0	X					0				0	0					

[1]Map showing sample localities and sample numbers in O'Leary and others (1976).

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