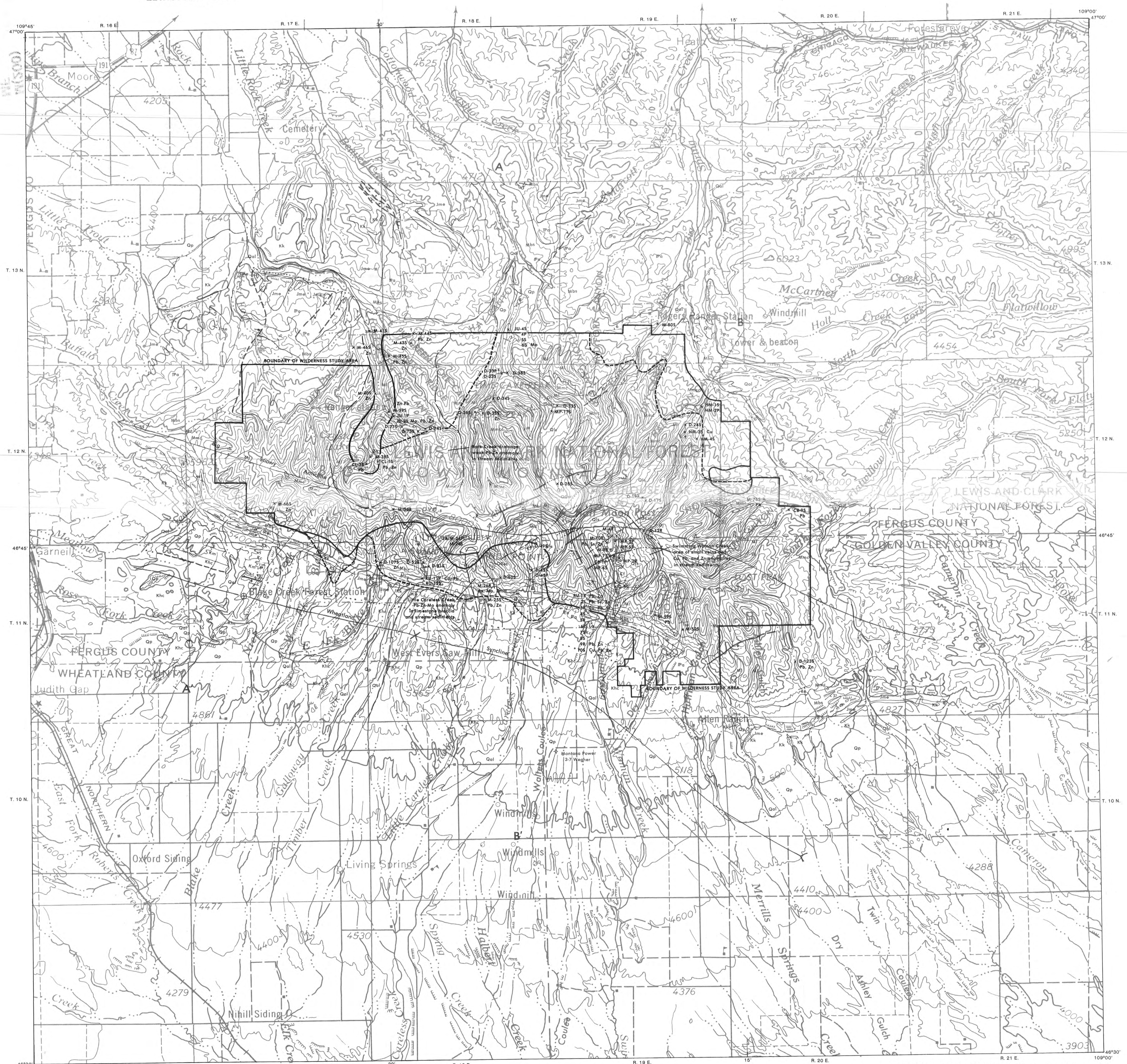

Base from U.S. Geological Survey, Roundup, 1954, scale 1:250,000

SCALE 1:100 000

LOCATION OF AREA

Geology from Lindsey, 1980; sampling by J. C. Antweiler, D. A. Lindsey, C. A. Brannon, and M. R. Pawlowski, 1978; chemical analyses by D. M. Hopkins and E. L. Mosier, 1978.

Studies Related to Wilderness

The Wilderness Act (Public Law 88-577, September 3, 1964) and related Acts, require the Geological Survey and the Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the Administration and the Congress. These maps and reports present the results of a geological and mineral survey of the Big Snowies Wilderness and contiguous RARE II study areas.

RECONNAISSANCE GEOCHEMICAL MAP OF THE BIG SNOWIES WILDERNESS AND CONTIGUOUS RARE II STUDY AREAS, FERGUS, GOLDEN VALLEY, AND WHEATLAND COUNTIES, MONTANA

By
David A. Lindsey, Delmont M. Hopkins,
Elwin L. Mosier, and John C. Antweiler
U.S. Geological Survey
1980

EXPLANATION

LIST OF MAP UNITS

Qal	ALLUVIUM (HOLOCENE)
Qls	LANDSLIDES (QUATERNARY)
Qp	PEDIMENT DEPOSITS (QUATERNARY)
Khc	HELL CREEK FORMATION (UPPER CRETACEOUS)
Km	MONTANA GROUP (UPPER CRETACEOUS)--Exclusive of Hell Creek and Telegraph Formations
Kc	TELEGRAPH CREEK FORMATION (UPPER CRETACEOUS) AND COLORADO GROUP (UPPER AND LOWER CRETACEOUS), UNDIVIDED
Kk	KOOTENAI FORMATION (LOWER CRETACEOUS)
Jme	MORRISON FORMATION (UPPER JURASSIC) AND ELLIS GROUP (UPPER AND MIDDLE JURASSIC)
Pa	AMSDEN GROUP (PENNSYLVANIAN)
Mbs	BIG SNOWY GROUP (UPPER MISSISSIPPIAN)
Mmc	MISSION CANYON LIMESTONE (UPPER AND LOWER MISSISSIPPIAN)
Ml	LODGEPOLE LIMESTONE (LOWER MISSISSIPPIAN)
Dj	JEFFERSON FORMATION (UPPER AND MIDDLE DEVONIAN)
O€sr	UPPER PART SNOWY RANGE FORMATION (LOWER ORDOVICIAN AND UPPER CAMBRIAN?)
€u	UPPER AND MIDDLE CAMBRIAN FORMATIONS, UNDIVIDED
€f	FLATHEAD SANDSTONE (MIDDLE CAMBRIAN)
Ym	NEWLAND FORMATION (PROTEROZOIC Y)

CONTACT

FAULT--dashed where approximately located; dotted where concealed. Ball and bar on downthrown side

STRUCTURE SYMBOLS--Showing plunge. Dashed where approximately located

Anticline

Syncline

10 STRIKE AND DIP OF BEDDING

DRY HOLE

X D-123S Pb, Zn — SAMPLE LOCALITY-- Suffix S indicates sieved stream-sediment sample; P, pan concentrate; R, rock. Symbols for elements denote those present in concentrations considered anomalous (tables 1, 2, and 3). Multiple samples taken at some sites.

OUTLINE OF STREAM DRAINAGE CONSIDERED TO CONTAIN A SIGNIFICANT GEOCHEMICAL ANOMALY

BOUNDARY OF BIG SNOWIES WILDERNESS AREA

BOUNDARY OF CONTIGUOUS RARE II STUDY AREAS

INTRODUCTION

The Big Snowies Wilderness and contiguous study areas contain no known areas of extensive mineralized rock, and only a few prospects which are located mostly in the canyon of Swimming Woman Creek. The prospects explore small calcite veins with traces of sulfide minerals in faults and fractures in the Proterozoic Y Newland Formation. The prospected veinlets along Swimming Woman Creek and ferruginous solution breccia of paleokarst origin in the Upper Mississippian Mission Canyon Limestone contain minor amounts of copper, lead, and zinc; the solution breccias locally extend downward into the Devonian Jefferson Formation. A reconnaissance geochemical survey of the study area was conducted to search for evidence of metals associated with the veins and solution breccias. Although igneous rocks and associated mineralized rocks are not known in the area, the geochemical survey provides an additional indication of their absence.

This report summarizes the results of reconnaissance sampling for trace metals in stream sediments and in a few rocks in the study areas. Reconnaissance geochemical sampling of solution breccias in the Big Snowy Mountains has some limitations. The solution breccias are too voluminous and extensive to sample in the detail that would be required to locate possible metal anomalies or mineralized zones, so stream sediments were selected as a sampling medium to try to define areas that might have metal anomalies. Sampling from some streams was hindered by lack of sediment; conversely, landslides and colluvium choke other streams. Many small streams and some larger streams, such as Rock Creek and Half Moon Creek, are dry during most of the year because their waters enter the solution breccias of the Mission Canyon Limestone. Nevertheless, samples of stream sediments were obtained from all major drainages and many smaller ones, including some dry streams.

METHODS AND DATA ANALYSIS

Samples were collected by J. C. Antweiler and, during geologic mapping of the study area, by D. A. Lindsey, M. R. Pawlowski, and C. A. Brannon. Fifty-five samples of stream sediment (table 1) were prepared by sieving; the sediment finer than 80 mesh (0.157 mm) was analyzed. Eleven panned concentrates of stream sediments (table 2) were prepared in the field, but extensive panning was not done because only traces of heavy minerals could be recovered. Stream sediments and rock samples were analyzed by spectrographic methods (Grimes and Marranzino, 1968) by E. L. Mosier and by atomic absorption spectrometry by D. M. Hopkins. Visibly mineralized and altered rock is scarce in the study area; only eight samples containing possible ore or gangue minerals were selected for chemical analysis (table 3). Conglomeratic sandstone of the Cambrian Flathead Formation along Swimming Woman Creek was tested with a scintillometer and two samples of quartz pebble conglomerate were analyzed for U and Th by the delayed neutron method (Millard, 1976) by H. T. Millard, Jr., J. M. Solt, M. Coughlin, and B. Vaughn.

Statistical analysis of data was directed mainly toward the metal concentrations in sieved stream sediments because this sample set is sufficiently large (55 samples) to define threshold values and to outline anomalous areas in the study areas. For most metals, the threshold value, above which a concentration is considered anomalous, was arbitrarily selected; the selection is based mostly on the author's experience. Lead and zinc, which appeared by this criterion to be slightly anomalous in numerous samples, and which might be expected in stream sediments derived from mineralized carbonate rock terrane, were selected for statistical analysis. The locations of all anomalous concentrations of metals were plotted on the map. Stream drainages were considered to contain trace metal anomalies if more than one sample from a drainage contained anomalous concentrations; these drainages are outlined on the map. Single samples containing anomalous concentrations of metals were not considered as conclusive evidence that a drainage was anomalous because they may reflect analytical or sampling error. Single-sample anomalies occur 1) as the only sample taken from a drainage and 2) as the only anomalous sample among numerous samples found not to be anomalous in the same drainage.

Histograms of Pb and Zn in stream sediments, as analyzed by atomic absorption spectrometry, are skewed to the right, toward low-level anomalous concentrations (figs. 1 and 2). The most typical concentrations (geometric means) of 16 ppm (parts per million) Pb and 43 ppm Zn are quite expectable, but concentrations ranging to as much as 90 ppm Pb and 130 ppm Zn suggest the possibility of weak metal anomalies. The cumulative frequency distributions of Pb and Zn were plotted on log probability paper (Tennant and White, 1959) to examine the data for the presence of more than one population, which may be revealed by breaks in the slope of the cumulative frequency curve. Breaks in the slope of each curve indicate that two or more populations, one of which may represent anomalous values, may be present. The cumulative frequency curves change slope at about 20 ppm Pb and 50 ppm Zn (figs. 1 and 2), and these values were taken as thresholds for anomalous concentrations. Using these thresholds, about 17 percent of stream sediment samples are regarded to contain anomalous traces of Pb and about 25 percent contain anomalous traces of Zn.

METAL ANOMALIES

Anomalous concentrations of trace metals were located in three stream drainages of the Big Snowy Mountains by analysis of stream sediment and rock samples. These are 1) copper, lead and zinc in the canyon of Swimming Woman Creek, 2) lead and zinc in the East Fork of Rock Creek and its tributaries, and 3) lead and zinc in the east branch of Little Careless Creek. The anomalies in stream sediments of Swimming Woman Creek and Little Careless Creek are traceable to anomalies in rocks; the source of the anomaly in Rock Creek has not been located.

Anomalous concentrations of Cu (70 ppm), Pb (90 ppm) and Zn (65 ppm) in stream sediments from Swimming Woman Creek are corroborated by analyses of pan concentrates, which contain as much as 70 ppm Cu and 1,500 ppm Pb. The anomaly is traceable to chalcopyrite, pyrite, and galena that occur sparsely in calcite veins in prospects near stream level. Samples of veinlets and rock from prospects contain as much as 95 ppm Cu, 220 ppm Pb, and 65 ppm Zn (table 3; analyses cited are by atomic absorption, which is more reliable than spectrographic methods).

Low-level anomalies of Pb and Zn in stream sediments are widespread in the Big Snowy Mountains; maximum concentrations are 90 ppm Pb and 130 ppm Zn. The most conspicuous low-level anomaly is in the East Fork of Rock Creek where, of fourteen samples analyzed, nine contained anomalous Zn ($\geq$50 ppm) and six contained anomalous Pb ($\geq$20 ppm). In contrast, of ten samples from Cottonwood Creek (the next major drainage east of Rock Creek and within the same rock formations), only one sample had anomalous Zn and none had anomalous Pb. Maximum concentrations of Pb and Zn in the Rock Creek anomaly are 50 ppm and 110 ppm, respectively. The low levels of anomalous Pb and Zn are probably derived from residual concentrations of these metals in limestone solution breccia of the Mission Canyon, which crops out in the valley walls above Rock Creek.

The small anomaly on the east branch of Little Careless Creek is indicated by anomalous concentrations of metals in two samples, one of stream sediment and one of limestone solution breccia from the Mission Canyon Limestone. The stream-sediment sample contained 35 ppm Pb and 120 ppm Zn; sample M-26R of ferruginous solution breccia from float littering the valley walls upstream contained 170 ppm Zn as well as 200 ppm As, 20 ppm Mo, and 70 ppm Ni. The solution breccia is the most likely source of anomalous metals in stream sediment.

Stream sediments from six small drainages located in the southern and eastern part of the study area contain anomalous Pb and Zn, but in these places the sampling was too limited to determine whether the streams drain a sizable metal anomaly; numerous other low-level Pb and Zn anomalies may be indicated.

The Cambrian Flathead Sandstone along Swimming Woman Creek contains lenses of quartz pebble conglomerate that register as much as twice background radioactivity on a scintillometer. Two samples of quartz pebble conglomerate, analyzed for U and Th by the delayed neutron method (Millard, 1976) contained the following: Sample MP-2R, 8.85 ppm Th, 1.42 ppm U; Sample M-8R (basal conglomerate), 139 ppm Th, 7.61 ppm U. A heavy-mineral separate of sample M-8R contained magnetite, hematite, rutile, zircon, and monazite; thorium is probably in monazite.

Anomalous radioactivity was noted by scintillometer also in the Jurassic Morrison Formation. Steeply dipping beds of Morrison crop out locally for about 11 km (7 mi) within the study areas from Careless Creek to Huffman Gulch, on the south side of the Big Snowy Mountains. The Morrison is poorly exposed and thus was not sampled for U or Th analysis.

REFERENCES CITED

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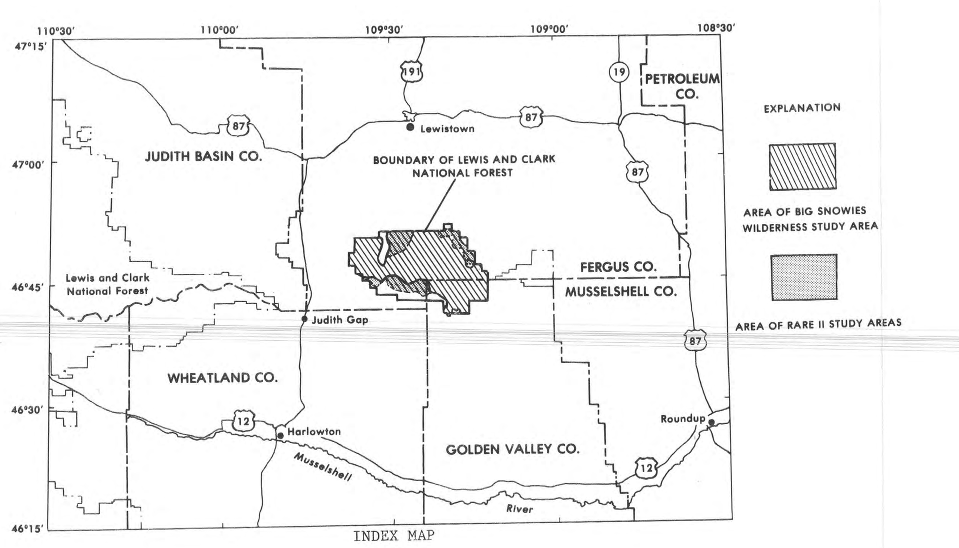
Tennant, C. B., and White, M. L., 1959, Study of the distribution of some geochemical data: Economic Geology, v. 54, no. 7, p. 1281-1290.



INDEX MAP

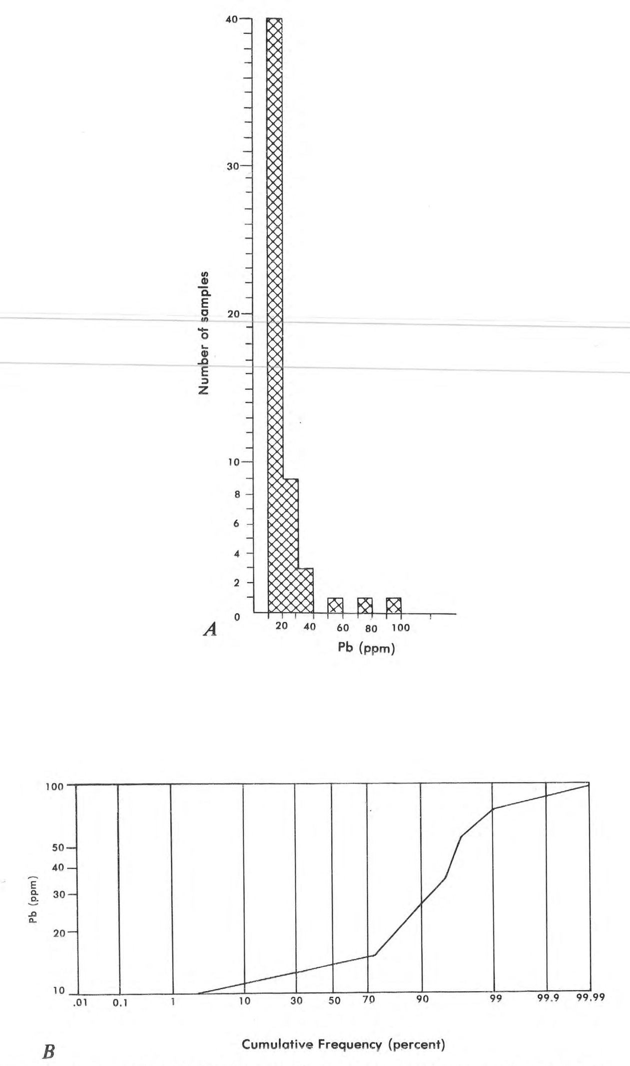


Figure 1.--Frequency distribution of Pb in stream-sediment samples from the Big Snowies Wilderness and contiguous study areas; analysis by atomic absorption spectrometry. A, Histogram; and B, Cumulative frequency on log probability scale.

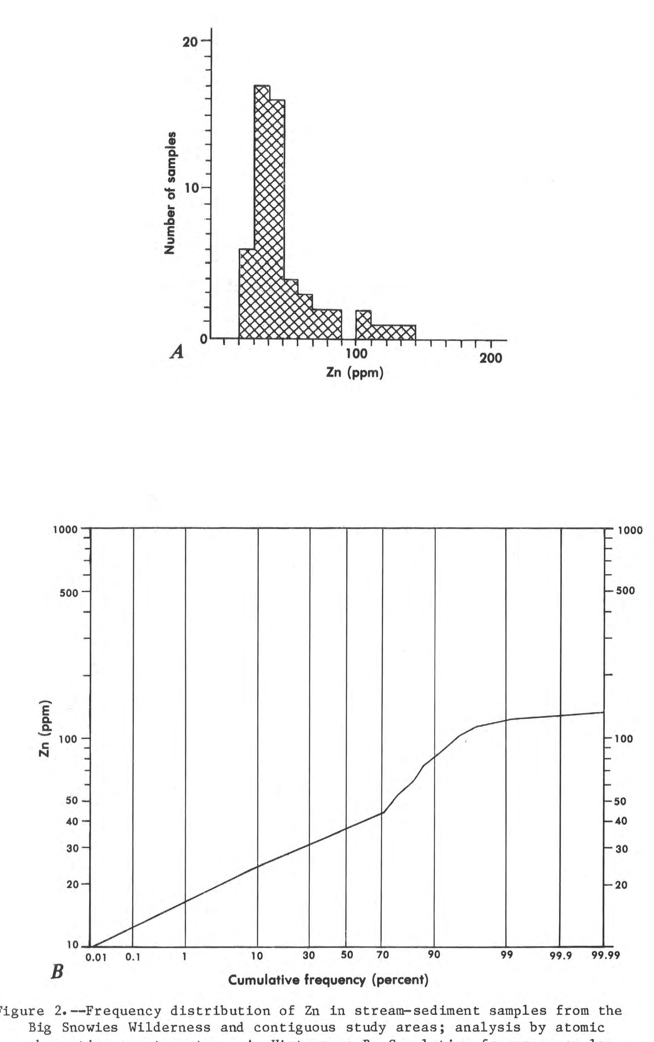


Figure 2.--Frequency distribution of Zn in stream-sediment samples from the Big Snowies Wilderness and contiguous study areas; analysis by atomic absorption spectrometry. A, Histogram; B, Cumulative frequency on log probability scale.

Table 1.--Summary of anomalous concentrations of trace metals in stream-sediment samples from the Big Snowies Wilderness and contiguous study areas

[Analysis by spectrographic methods except where indicated by asterisk (atomic absorption spectrometry). Concentration values in parts per million. Leaders (---) indicate no entry; > indicates greater than or equal to; < indicates less than lower limit of detection; NA indicates not applicable because of insufficient number of values above limit of detection]

Element	Definition of anomalous concentration	Range of concentrations	Geometric mean	Geometric deviation	Sample number and anomalous concentration (in parenthesis)
Ag	≥.5	<.5	NA	NA	---
As	≥200	<200	NA	NA	---
Au*	≥.05	<.05	NA	NA	---
Ba	≥2000	50-500	255	1.73	---
Be	≥5	<1-3	1	1.72	---
Co	≥30	≤20	10	1.83	---
Cr	≥150	20-100	55	1.48	---
Cu	≥50	7-70	15	1.71	HM-3S(50), RU-10S(70)
Cu*	≥50	5-40	11	1.60	---
La	≥100	≤70	25	1.85	---
Mo	≥5	<5-7	NA	NA	JU-2S(7), JU-6S(5)
Ni	≥100	7-50	21	1.49	---
Pb	≥20	10-150	16	1.65	RU-2S(150), RU-7S(20), RU-10S(100), JU-2S(70), HM-4S(20), MP-5S(20), MP-6S(20), M-25S(20), D-18S(20), D-51S(20), D-123S(20)
Pb*	≥20	10-90	16	1.59	CL-1S(50), CL-3S(30), RU-2S(90), RU-10S(70), CB-9S(20), JU-2S(35), HM-4S(20), M-25S(35), M-39S(20), M-44S(20), M-45S(20), M-57S(20), M-66S(20), M-76S(20)
Sr	≥500	<100-500	156	1.51	RU-2S(500)
V	≥150	50-100	67	1.38	---
Y	≥50	10-50	21	1.50	---
Zn*	≥50	20-130	43	1.57	CL-1S(110), JU-2S(100), RU-2S(60), RU-10S(130), M-25S(120), M-38S(60), M-39S(55), M-40S(55), M-43S(85), M-44S(100), M-45S(70), M-46S(70), M-66S(65), D-35S(50), D-107S(50), D-123S(85)

Table 2.--Summary of anomalous concentrations of trace metals in pan concentrates of stream sediments from the Big Snowies Wilderness and contiguous study areas

[Analysis by spectrographic methods except where indicated by asterisk (atomic absorption spectrometry). Concentration values in parts per million. Leaders (---) indicate no entry; > indicates greater than or equal to; < indicates less than lower limit of detection; NA indicates not applicable because of insufficient number of values above limit of detection]

Element	Definition of anomalous concentration	Range of concentrations	Geometric mean	Geometric deviation	Sample number and anomalous concentration (in parenthesis)
Ag	≥1	<1	NA	NA	---
As	≥200	<200	NA	NA	---
Au*	≥0.5	<0.5	NA	NA	---
Ba	≥2000	<20-1000	185	3.82	---
Be	≥5	<1-3	NA	NA	---
Co	≥30	<5-20	10	2.07	---
Cr	≥100	<10-50	21	2.64	---
Cu	≥50	10-70	29	2.23	RU-11P(70), RU-3P(70)
Cu*	≥50	15-20	NA	NA	---
La	≥100	<20-200	NA	NA	RU-6P(200)
Mo	≥5	<5	NA	NA	---
Ni	≥100	15-70	34	1.63	---
Pb	≥100	10-1500	30	4.23	RU-11P(100), RU-3P(1500)
Pb*	≥50	15-30	NA	NA	---
Sr	≥500	<100-500	97	2.98	RU-3P(500)
V	≥150	20-100	43	1.57	---
Y	≥50	<10-30	14	2.30	---
Zn*	100	25-55	NA	NA	---

Table 3.--Trace-metal content of rock samples selected for possible ore or gangue minerals

[Values in parts per million. Analyses by spectrographic methods except where indicated by asterisk (atomic absorbtion spectrometry). < indicates less than the lower limit of detection]

Sample No.	Description	Ag	As	Au*	Ba	Be	Co	Cr	Cu	Cu*	La	Mo	Ni	Pb	Pb*	Sr	V	Y	Zn*
RU-1R	Newland Fm., calcareous argillite with calcite veins; from prospect	<.5	<200	<.05	100	<1	<5	<10	15	5	30	<5	15	70	35	200	50	20	60
RU-5R	Flathead sandstone, conglomerate float below prospect	<.5	<200	<.05	300	<1	<5	<10	5	<5	70	<5	5	<10	<5	<100	20	30	<5
RU-9R	Newland(?) Fm.; from prospect	<.5	<200	<.05	200	1.5	7	20	30	10	<20	<5	30	300	220	300	70	30	65
M-4R	Newland Fm.; 3-cm-thick calcite vein with trace pyrite	<.5	<200	<.05	2000	<1	<5	<10	150	95	<20	<5	<5	<10	10	<100	<10	20	10
M-10R	Newland Fm., calcareous argillite; from prospect	<.5	<200	<.05	150	<1	7	20	7	5	<20	<5	20	30	30	500	50	15	60
M-26R	Mission Canyon Ls., ferruginous breccia; from abundant float	<.5	200	<.05	<20	3	5	15	20	10	<20	20	70	10	5	<100	100	<10	170
M-30R	Mission Canyon Ls., solution breccia; from ice cave	<.5	<200	<.05	30	<1	<5	30	<5	<5	<20	<5	7	<10	10	300	50	10	20
D-12R	Snowy Range Fm., vein of calcite and goethite	<.5	<200	<.05	100	<1	7	10	<5	<5	<20	10	30	<10	10	150	15	15	10

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