GJBX-20(83)

National Uranium Resource Evaluation

USE OF NURE AND OTHER DATA SETS TO CHARACTERIZE MINERALIZED ENVIRONMENTS IN THE WALLACE AND CHOTEAU NTMS QUADRANGLES, MONTANA AND IDAHO

Bendix Field Engineering Corporation
Grand Junction, Colorado

September 1983

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Nuclear Energy
Grand Junction Area Office, Colorado

This report is a result of work performed by Bendix Field Engineering Corporation, Operating Contractor for the U.S. Department of Energy, as part of the National Uranium Resource Evaluation. NURE was a program of the U.S. Department of Energy's Grand Junction, Colorado, Office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

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USE OF NURE AND OTHER DATA SETS TO CHARACTERIZE MINERALIZED ENVIRONMENTS IN THE WALLACE AND CHOTEAU NTMS QUADRANGLES, MONTANA AND IDAHO

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PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION AREA OFFICE
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CONTENTS

CONTENTS (continued)

ILLUSTRATIONS

ILLUSTRATIONS (continued)

Plates 1-84 are on microfiche in pocket inside back cover.

ABSTRACT

Reconnaissance-scale National Uranium Resource Evaluation (NURE) data were used to recognize, characterize, and delineate mineralized environments in the Wallace and Choteau 1° x 2° Quadrangles of Idaho and Montana. Data interpretation methods developed during the NURE program for the recognition of areas with potential for uranium deposits were used in this study to delineate localities representative of several different mineralized environments. The delineations were based on anomalous concentrations of elements in stream sediments and waters, and anomalous values of aerial radiometric potassium, equivalent uranium, equivalent thorium, and radioelement ratios. Aeromagnetic characteristics of the delineated localities were also derived from NURE data. Characteristics of NURE data were compared with known geology, structure, mineralization, and mining history of the project area.

Recognition criteria were developed from NURE data for several mineralized environments in the project area. The most discrete criteria are for Coeur d'Alene-type deposits; less discrete criteria are also described for porphyry-type deposits, strata-bound deposits, and vein-type deposits related to intrusive and extrusive rocks.

A total of 24 mineralized localities were delineated in this study. The localities were categorized as reference localities, representative of a particular mineralized environment; as marginal localities; or as follow-up localities, with NURE data characteristics that warrant further study. Three localities delineated in the study are follow-up localities and are considered by the authors to have potential for new or additional mineral resources. The Vermillion Peak-Moose Peak and Echo Mountain localities may host uranium-bearing, base- or precious-metal vein-type deposits. The Trout Creek locality has potential for additional gold-bearing placer deposits.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this study is twofold. The first purpose is to determine to what extent mineralized environments, and localities representing them, in the Wallace and Choteau Quadrangles can be recognized and characterized by National Uranium Resource Evaluation (NURE) hydrogeochemical and stream sediment, aerial radiometric, and aeromagnetic reconnaissance data. Recognition of mineralized localities is an important first step in mineral exploration programs. The second objective is to demonstrate the methodology of applying NURE data to the recognition and delineation of localities within a project area that have potential for mineral resources.

The scope of the project is limited to rapid delineation of those localities in the project area that have anomalous characteristics shown by the NURE reconnaissance data. Recognition of specific deposits or mining districts is not intended; detailed investigations of local geology, geochemistry, and geophysics in delineated localities are beyond the scope of the project. Localities delineated in this study are ranked according to their respective NURE data characteristics. This subjective ranking is intended to identify mineralized localities sufficiently interesting for further investigation (follow-up localities) and those that are less interesting (marginal localities). The follow-up localities are considered legitimate targets for additional work.

LOCATION AND GENERAL INFORMATION

The Wallace and Choteau Quadrangles are situated between long 112° and 116° W. and lat 47° and 48° N. in northwestern Montana and northern Idaho (Fig. 1). The eastern part of the Choteau Quadrangle is within the Great Plains physiographic province. The remainder of the project area is in the Northern Rocky Mountains Province. The Continental Divide trends northerly through the middle of the Choteau Quadrangle. The eastern watershed is tributary to the Missouri River system, and the western watershed is tributary to the Columbia River system. Topographic relief in the area is as much as 2000 m. Most of the project area west of the Continental Divide consists of mountains and hills formed by folding, faulting, and deep dissection by streams and glaciers. Approximately one-third of the Choteau Quadrangle consists of lands in the National Wilderness Preservation System, including all or part of the Great Bear, Bob Marshall, Scapegoat, and Mission Mountains Wilderness areas. No wilderness areas have been set aside in the Wallace Quadrangle. Towns and villages are widely scattered; most settlements serve mining, lumbering, railroad, tourist, sheep, cattle, and farming activities. The Burlington Northern Railroad and its branch lines provide rail freight transportation. Interstate 90 and U.S. Highways 89, 93, and 2 are major thoroughfares. State, county, and unimproved roads provide reasonable access to much of the area.

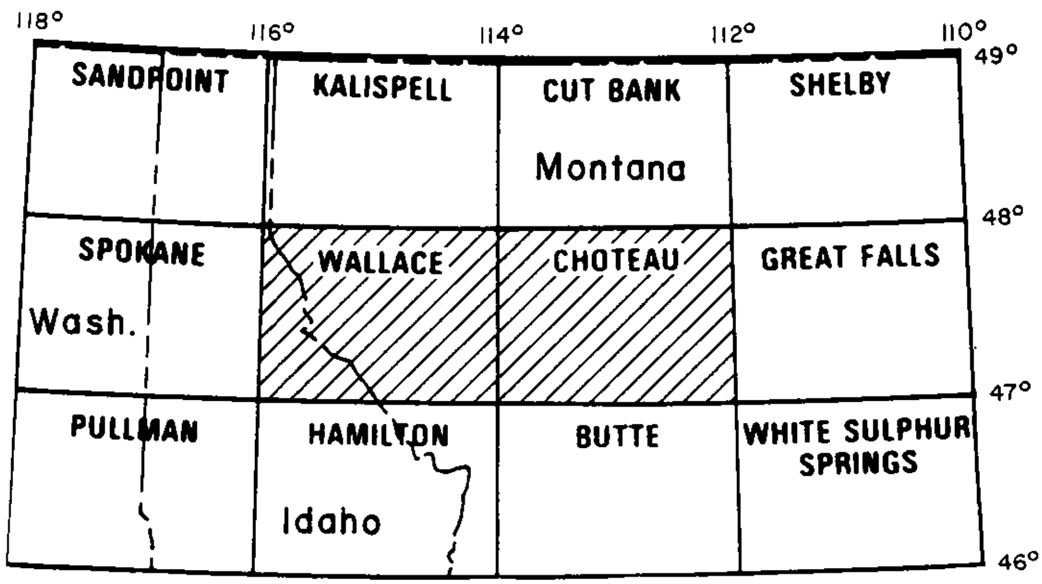

Figure 1. Location of the Wallace-Choteau study area.

GEOLOGIC AND TECTONIC SETTING

General Geology

Rocks in the Wallace and Choteau Quadrangles are mostly of sedimentary origin and range from Proterozoic to Quaternary in age. Many of the Proterozoic rocks are regionally metamorphosed to chlorite-grade and locally metamorphosed to sillimanite- or kyanite-grade. Glacial deposits of Pleistocene age are prominent along river valleys and the flanks of the higher mountain ranges.

The eastern one-third of the Choteau Quadrangle is underlain by Mesozoic and Cenozoic mudstones, shales, and sandstones that have a widespread cover of glacial deposits and alluvium. Except near the tectonic front of the Lewis and associated thrust faults these rocks of the High Great Plains are only gently deformed.

West of the tectonic front, the Wallace and Choteau Quadrangles exhibit structurally complex terranes composed chiefly of Paleozoic and Proterozoic carbonate and clastic sedimentary rocks. Intrusive and extrusive igneous rocks occur in both quadrangles; they range in age from Proterozoic to Cenozoic and are abundant in the southeastern part of the Choteau Quadrangle and in the western part of the Wallace Quadrangle. Several prominent sills intrude rocks of the Belt Supergroup in both quadrangles.

Stratigraphy

Rocks of the Belt Supergroup (Proterozoic) crop out in many parts of the Wallace and Choteau Quadrangles. Figure 2 (from Elston and Bressler, 1980) shows a generalized cross section of the Belt Supergroup across northwestern Montana, northern Idaho, and northeastern Washington. These rocks are known by a host of stratigraphic names, many of which are given in Figure 2. The location of the cross section is shown in Figure 3. Several features of the Belt rocks are noteworthy:

1. This pile of shallow-water rocks of flood-plain, tidal-flat, and delta origin is as much as 19 km thick.

2. Rocks change facies across the basin, yet the several facies are in themselves remarkably uniform across large areas.

3. The geologic time spanned by deposition of the Belt rocks (1,470 to 850 m.y.) is more than 600 m.y. which is equivalent to the time span represented by all of the Phanerozoic.

4. A large volume of sediments was derived not only from rather mature source areas mainly to the east, but also from less mature source areas to the south and southwest.

5. Some features of the rocks indicate continuous sedimentation, yet some geologists have suggested that Belt rocks should be thicker if sedimentation had been continuous.

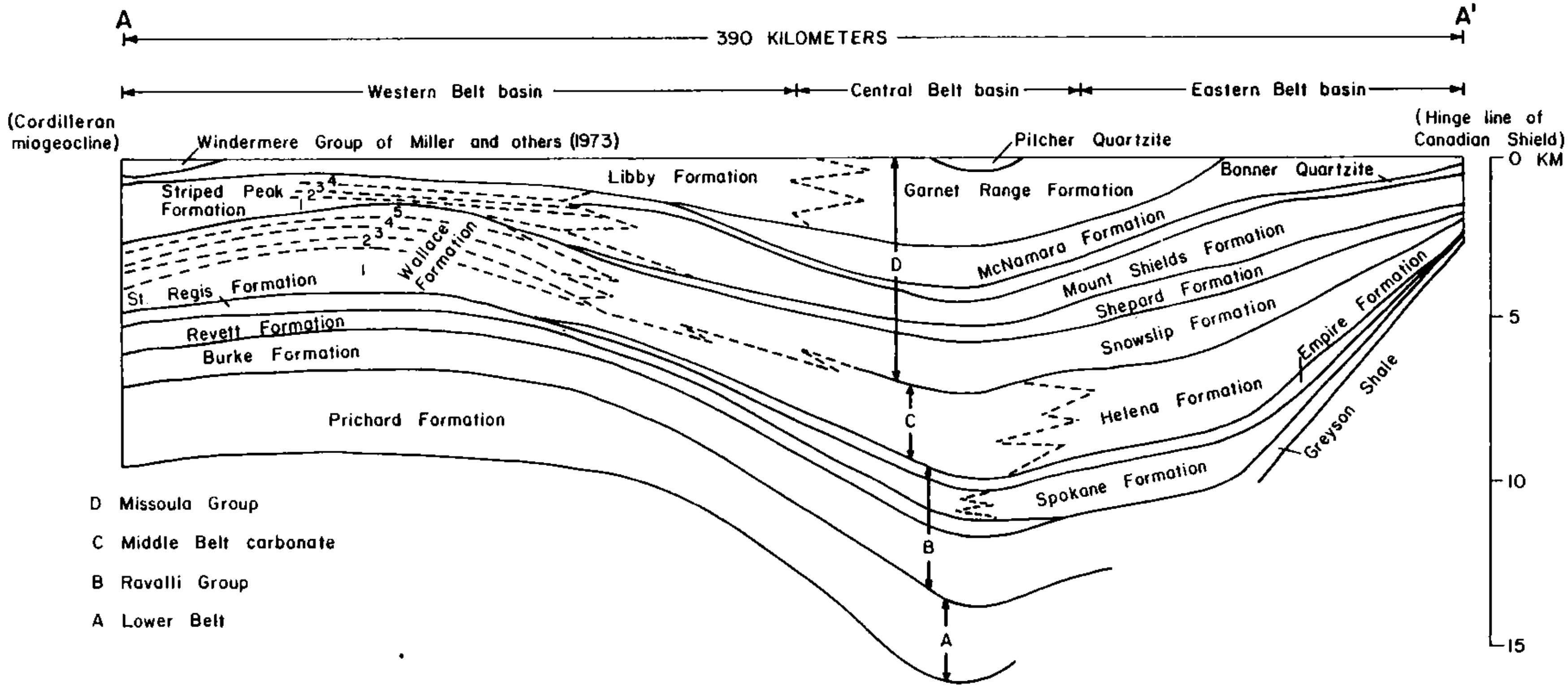

Figure 2. Cross section of the Belt Supergroup across the Belt Basin (modified from Elston and Bressler, 1980).

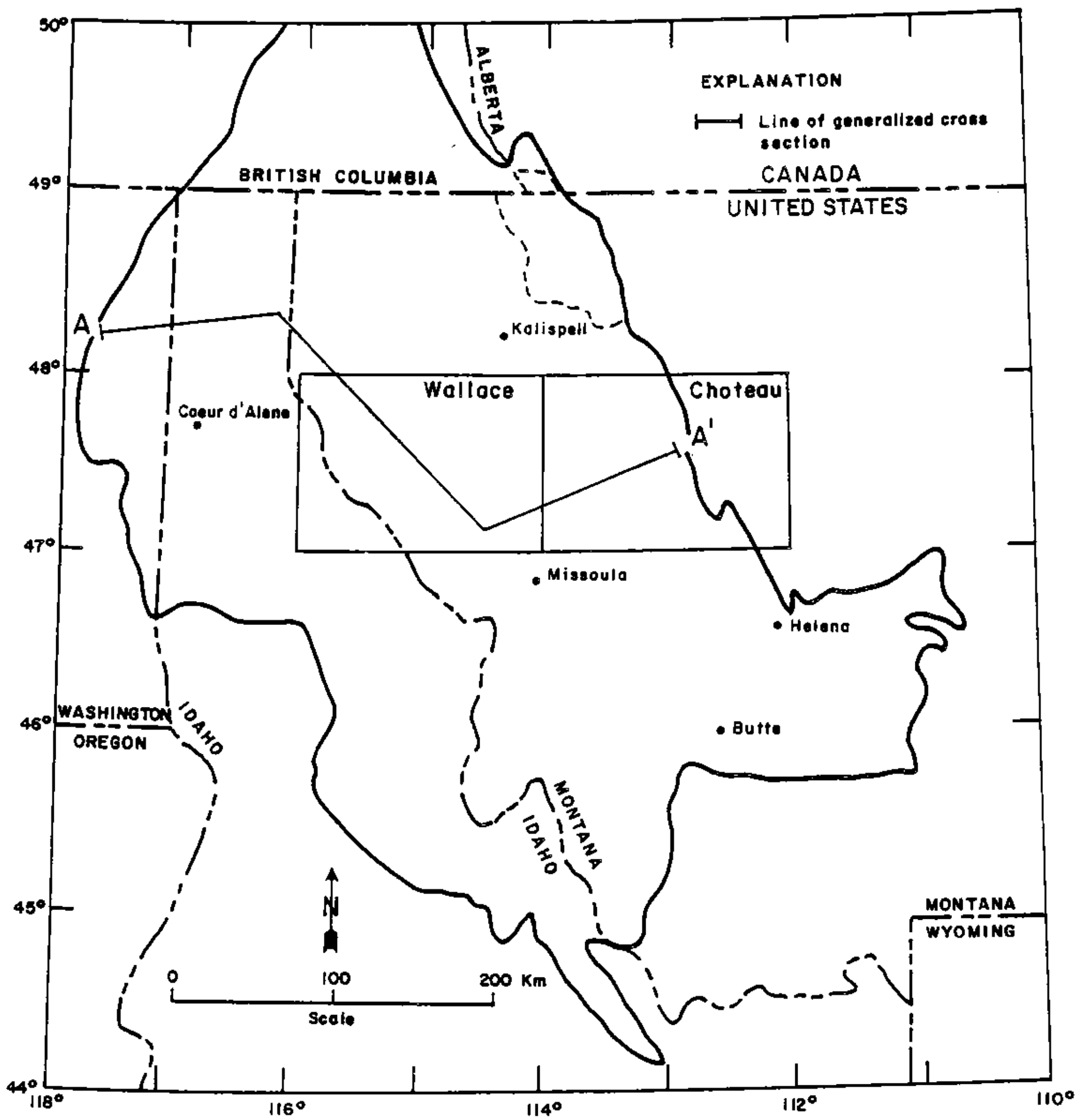

Figure 3. Index map showing area of outcrop of the Belt Supergroup and location of cross section shown on Figure 2.

6. Most replacement ore deposits in the Belt rocks are in the clastic or siliceous facies, in contrast to many replacement ore deposits elsewhere in the world in carbonate rocks.

Hobbs and others (1965) provided a general description of the Belt Supergroup in the Coeur d'Alene District (Table 1). Belt rocks across the Choteau and Wallace Quadrangles generally fit their description.

Structure

There are four major structural elements in the Wallace and Choteau Quadrangles (Fig. 4): 1) listric thrust faults, 2) trenches and high-angle faults, 3) Purcell anticlinorium, and 4) shear zones related to the Lewis and Clark lineament.

1. Harrison and others (1980) described the thrust faults: 'Newly identified listric thrust faults show eastward translation north of the Lewis and Clark line across all 800 km of Belt terrane from Spokane, Washington, on the west to Glacier National Park on the east. Right-lateral slippage on the line was accompanied by clockwise rotation on the thrusts. These movements were probably in response to the complex plate interactions that began about 200 m.y. ago along the western continental margin. Gravity and magnetic data suggest that basement rock is involved in the thrusting. West of the Rocky Mountain Trench, Phanerozoic strata that elsewhere have oil and gas potential may have been stepped up by the thrusting, and eroded, rather than extending beneath most of the thrust belt.'

2. The Rocky Mountain Trench lies along the eastern margin of the Wallace Quadrangle, and Swan Valley is along the western margin of the Choteau Quadrangle; both die out to the south along the St. Mary's fault, which is a part of the Lewis and Clark lineament. Harrison and others (1980) stated that the Rocky Mountain Trench and Swan Valley form horst and graben systems composed of zones of closely spaced high-angle faults. Similar, but less pronounced, closely spaced, north-trending, high-angle faults cut thrust blocks near the Lewis and El Dorado thrusts.

3. The Purcell anticlinorium occupies part of the eastern half of the Wallace Quadrangle. The anticlinorium trends north, is cut in turn by numerous high- and low-angle faults, and terminates to the south against the lateral faults of the Lewis and Clark lineament.

4. The Lewis and Clark lineament strikes N. 70° W. across the southern part of the Wallace and Choteau Quadrangles. This lineament is as much as 40 km wide and consists of numerous faults and shear zones, some of which have vertical displacement, but in the aggregate show major right-lateral movement. The amount of offset is difficult to determine along the lineament. Two other lateral fault zones in the Wallace Quadrangle complement the Lewis and Clark lineament: the Hope fault strikes northwesterly across the northwestern part of the Wallace Quadrangle, and the Big Draw fault trends easterly across the northern part of the Wallace Quadrangle.

TABLE 1. CHARACTERISTICS OF BELT SUPERGROUP, COEUR D'ALENE DISTRICT (stratigraphic data from Hobbs and others, 1965)

Group	Formation		Lithology	Thickness (ft)	Thickness (m)	Ore-bearing
Missoula	Striped Peak Formation		Interbedded quartzite and argillite with some arenaceous dolomitic beds; purplish gray and pink to greenish gray; ripple marks and mud cracks common. Top is eroded.	1,500+	457+	No.
	Wallace Formation	Upper part	Mostly medium to greenish-gray,finely-laminated argillite; some arenaceous dolomite and impure quartzite, and minor gray dolomite and limestone in the middle part.	4,500-6,500	1,372-1,981	Yes, but limited.
	Wallace Formation	Lower part	Light-gray,more or less dolomitic quartzite interbedded with greenish-gray argillite. Ripple marks and mud cracks are abundant.			
Ravalli	St. Regis Formation	Upper part	Light greenish-yellow to light green-gray argillite; thinly laminated; some carbonate-bearing beds.	1,400-2,000	427-610	Yes.
Ravalli	St. Regis Formation	Lower Part	Gradational from interbedded argillite and impure quartzite at top to thick-bedded pure quartzite at base. Red-purple color is characteristic; has some green-gray argillite and some carbonate-bearing beds. Ripple marks, mud cracks, and mud-chip are breccia common.			
Ravalli	Revett Formation		Thick-bedded,vitreous,light yellowish-grey to nearly white pure quartzite. Grades into nearly pure and impure quartzite at top and bottom. Cross-stratification is common.	1,200-3,400	366-1,036	Yes.
Ravalli	Burke Formation		Light greenish-gray impure quartzite; has some pale red and light yellowish-gray pure-to nearly-pure quartzite; has ripple marks, swash marks and pseudoconglomerate.	2,200-3,000	571-914	Yes.
	Prichard Formation	Upper part	Interbedded medium-gray argillite and quartzose argillite and light-gray impure-to pure-quartzite; has some mud cracks and ripples marks.	12,000+	3,658+	Yes
	Prichard Formation	Lower part	Thin-to thick-bedded, medium gray argillite and quartzose argillite; laminated in part; pyrite is abundant. Contains discontinuous quartzite zones. Base is buried.			

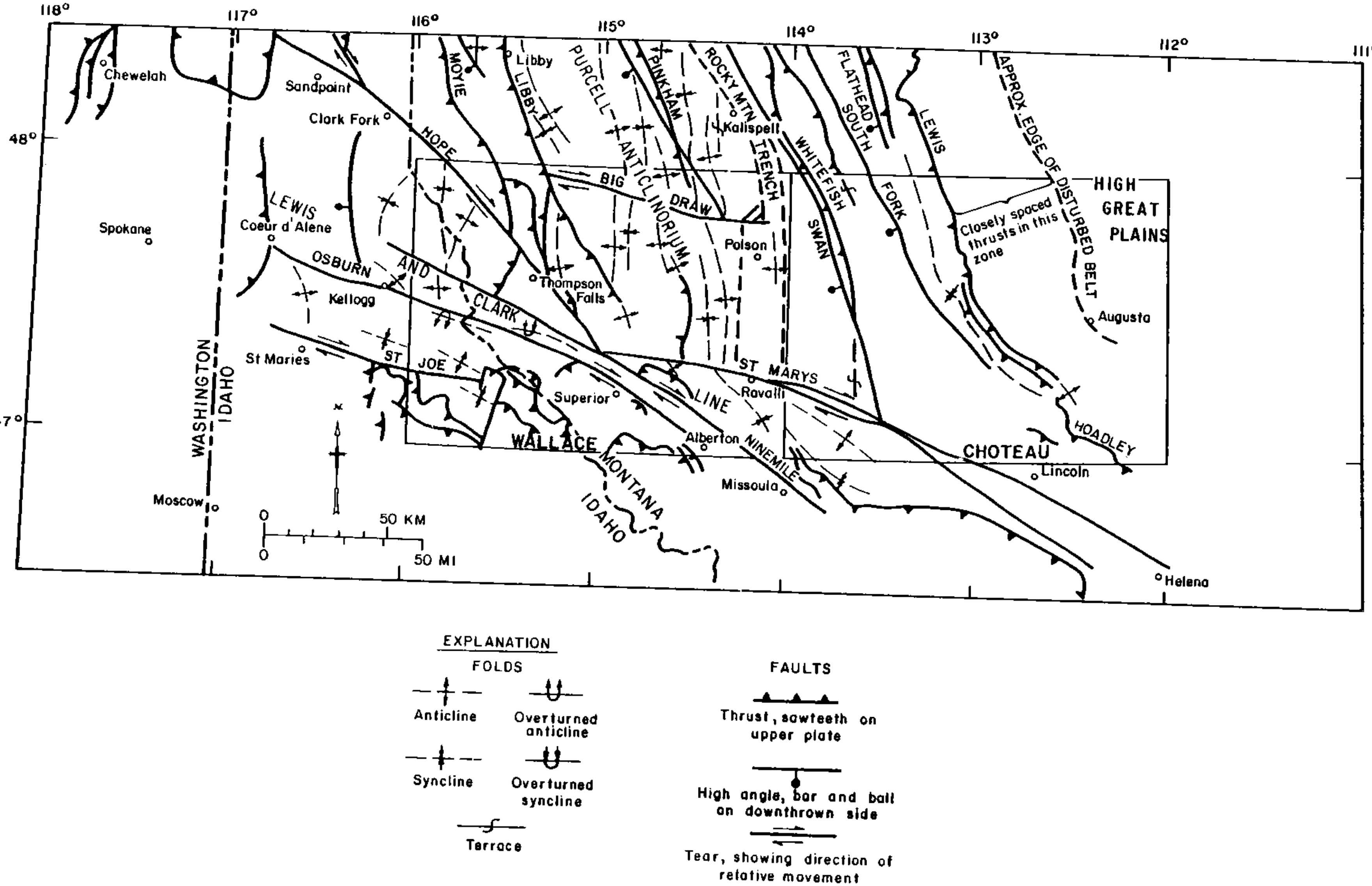

Figure 4. Major structural features in the Wallace and Choteau Quadrangles.

EXISTING DATA

Data collected during the NURE program were used extensively in this study. Analytical data were available for 3,530 stream-sediment samples and 1,903 stream-water samples collected in the two-quadrangle project area. (See Arendt and others, 1981a, b; Shettel and others, 1982; and Zinkl and others, 1982.) Analytical results for 44 elements in stream-sediment samples and five elements in stream-water samples were used to recognize and describe mineralized localities. Aerial radiometric and aeromagnetic data (Geodata International, Inc., 1981; and Texas Instruments, Inc., 1979) for the two quadrangles were also used to describe characteristics of mineralized localities in the project area.

Other data were used in conjunction with the NURE data sets. The U.S. Geological Survey (USGS) Computerized Resource Information Bank (CRIB) was an important source of information on mineral occurrences for the project area. These data are included in Appendix A.

Both the Wallace and Choteau Quadrangles are included in the USGS Conterminous U.S. Mineral Assessment Program (CUSMAP) effort (Earhart and others, 1981). Most of the CUSMAP work in the Choteau Quadrangle has been published, whereas the data for the Wallace Quadrangle are currently in various states of preparation for publication. USGS CUSMAP stream-sediment and rock analyses were used in addition to NURE hydrogeochemical and stream-sediment analytical data for the Choteau Quadrangle.

The Coeur d'Alene Mining District in the Wallace Quadrangle has several interesting geologic features. Numerous studies and several interpretations have been published on the rich lead, zinc, silver, and copper deposits of that and adjacent mining districts (for example, see Ransome and Calkins, 1908; Umpleby and Jones, 1923; Fryklund, 1964; Gott and Cathrall, 1979a). Several wildcat oil and gas wells have been recently drilled in the eastern part of the Choteau Quadrangle in the overthrust belt. Information from these boreholes and from previous drilling in the foothills has advanced geologic understanding of this complexly faulted area. The selected bibliography accompanying this report provides a good introduction to the geologic literature pertaining to the Wallace and Choteau Quadrangles.

KNOWN MINERALIZED ENVIRONMENTS

For more than a century, northwestern Montana and northern Idaho have produced large amounts of silver, copper, lead, zinc, and smaller amounts of gold. The Coeur d'Alene District, part of which is included in the Wallace Quadrangle, has produced more than $2 billion worth of metals and is one of the world's important silver-producing districts. Other mining districts in the Wallace and Choteau Quadrangles have had intermittent metal production over the last century, the aggregate value of which is far less than that of the Coeur d'Alene District.

Several types of mineralized environments are known in the project area.

- Replacement veins of sulfide and some oxide minerals occur in Precambrian quartzitic, phyllitic, and carbonate host rocks that have been extensively sheared and faulted. This type dominates the Coeur d'Alene District.

- Low-grade, strata-bound, disseminated sulfide minerals (chiefly copper, zinc, and silver) of early diagenetic origin occur in Precambrian quartzitic sandstones. These are the so-called 'green bed' deposits (Earhart and others, 1981). Such currently uneconomic deposits are most common in the central part of the Choteau Quadrangle.

- Quartz-carbonate copper-bearing veins in 'green beds' are common in the central part of the Choteau Quadrangle. None are currently producing ore (Earhart and others, 1981).

- Lead, zinc, silver, and copper sulfide replacement ores occur at the contacts of Tertiary volcanic rocks with Precambrian metasedimentary rocks. Similar sulfide minerals accompany the fumaroles, vents, and solution tubes of the volcanic rocks. Supergene enrichment has followed primary mineral deposition. Such deposits typify the Hog Heaven Mining District (Johns, 1970).

- Sulfide-bearing replacement veins occur in felsic to intermediate stocks, plugs, and dikes. These mineralized areas differ considerably in size and distribution. None have been major producers, but deposits having potential resources in excess of 1 million tons of copper are known (Mudge and others, 1974).

- Porphyry copper-molybdenum deposits in quartz monzonites are found in the Heddleston District. They are marginally economic (Earhart and others, 1981). Vein deposits that contain lead, zinc, copper, silver, and gold are also associated with the quartz monzonites in the Heddleston District.

- Titaniferous magnetite placer deposits occur in the Virgelle Sandstone (Cretaceous) in the northeastern part of the Choteau Quadrangle. These deposits were in part derived from the intermediate to mafic sills of Proterozoic age (Earhart and others, 1981), and have reserves that amount to 90 million tons of ore containing up to 30 percent iron.

- Gold-bearing placers initiated interest in prospecting and mining in this part of Idaho and Montana, but production peaked early. Both morainal and alluvial placer deposits have been developed and worked in the project area.

In 1949, uraninite was found in the lower workings of the Sunshine and Coeur d'Alene Mines in the Coeur d'Alene District and has since been discovered in three other mines of the district. Most of the uranium-bearing veinlets are found in the quartzite wall rock of the major silver orebodies, which contain argentiferous tetrahedrite, pyrite, arsenopyrite, chalcopyrite, siderite, and quartz. The uranium veinlets are bordered by red, hematite-stained, sericitized quartzite of the Precambrian St. Regis Formation. In the Coeur d'Alene Mine, the uraniferous material is found in highly silicified zones, associated with the cobalt mineral erythrite. The width of the uranium-bearing veins in the Sunshine Mine ranges from paper-thin seams to 18 in.; these veins lie parallel to the strike of the bedding and are controlled by fracture cleavage, in contrast to the major veins of the district which are localized along faults and shear zones. The uranium in the Sunshine Mine occurs from the 2,900- to the 3,700-ft levels (see Cook, 1955).

The age of the Sunshine uraninite has been determined as approximately 750 m.y. (Kerr and Robinson, 1952, p. 124). It may be much older than the silver-bearing siderite-tetrahedrite veins that, according to Robinson (1950, p. 818), cut the uranium stringers.

Pitchblende associated with red alteration has been found in the Crescent Mine in this same district; two channel samples taken in this mine by the USGS assay 0.026 percent uranium and 0.048 percent uranium (Armstrong, 1953, p. 219). Radioactive zones have also been reported from the 2,800-ft level of the Galena Mine (Armstrong, 1954, p. 184).

METHODS

DATA DISPLAY

Automated methods for processing and plotting NURE data developed by Bendix Field Engineering Corporation (BFEC) as part of the NURE program were used to provide many of the graphic displays in this study. Mineral-occurrence data (Pl. 1 through 3) were plotted by the LABPLT computer program (Zinkl and others, 1982b). These plates are accompanied by a tabulation of mineral-occurrence data for the project area (App. A).

NURE aerial radiometric data (Pl. 4 through 9) were displayed by the CALFLT computer program (LaBonte and Zinkl, 1982). NURE aeromagnetic data (Pl. 10 and 11) were displayed using the same software as used in the NURE Aeromagnetic Mapping Project. Aeromagnetic-map-preparation procedures are discussed in detail in Zinkl and others (1983, in press).

NURE data displays using Canadian symbols in this project (Pl. 12 through 84) were generated by the PLTSYM computer program (Zinkl and others, 1982a). Details of the automated methods used in processing NURE data for the characterization of mineralized environments were also presented in Madson and others (1983).

STATISTICAL METHODS

Preprocessing of Data for Statistical Analysis

Stream-sediment analytical data for the Wallace and Choteau Quadrangles were processed by the FACEDT computer program (Shettel and others, 1980). In this preprocessing, a sample that has more than 20 percent of its elemental analyses missing or below detection limit is eliminated from the data set; any single element missing or below detection limit in more than 60 percent of the samples is also eliminated. Any remaining value below detection limit is converted to one-half of the absolute value of the detection limit for that particular element. The result of this preprocessing is a data matrix in which no missing values for the stream-sediment samples are retained. The 20- and 60-percent levels used in the FACEDT procedure are chosen empirically by the investigator to retain a practical level of samples and variables for additional statistical procedures. Conversion of too many values below detection limit to an absolute value can introduce an artificial skewness to the distribution pattern of an element in the data set. Tables 2 and 3 show the statistics for the combined Wallace and Choteau stream-sediment data before and after FACEDT preprocessing, respectively. Elements eliminated in this preprocessing were not eliminated from consideration in the characterization of mineralized localities, but were plotted on individual element maps and used for geochemical interpretation. Stream-water and ground-water data for the project area did not contain appropriate trace element analyses and, consequently, were not used extensively in this study.

Simple Statistics

Histograms and probability graphs (App. B) were constructed for each element in the Wallace-Choteau combined stream-sediment data set. The probability graphs were of value in selecting anomaly thresholds for indicator elements discussed later in this report. The mean, standard deviation, skewness, and kurtosis values for each element in the stream-sediment data set are shown in Table 4. The stream-sediment data were free from significant differences in detection limits or analytical sensitivities between the two quadrangles.

Aerial radiometric data required adjustment along the boundary between the two quadrangles. The adjustment was necessary because the data were collected by two different contractors, did not conform to published calibration factors, and did not provide acceptable matches of radioelement concentration values across the quadrangle borders. These data were standardized by the same methods discussed by Madson and others (1983).

Multivariate Statistics

Stepwise multiple regression, using uranium as the dependent variable, was conducted on the Wallace-Choteau combined stream-sediment data. This procedure attempts to identify the relationships between uranium and other elements in the data set and serves to determine the level of independent occurrence of uranium in the stream sediments analyzed. Uranium is a natural component of primary resistate-mineral grains such as monazite, zircon, and other rare-earth-bearing minerals eroded from crystalline rocks and is, therefore, expected to correlate with elements contained in those grains (thorium, yttrium, hafnium, and lanthanides). Uranium in stream sediments that is not intimately associated with resistate-mineral grains may be present as a result of some other type of mineralization or geochemical process. The results of multiple regression analysis presented in Table 5 indicate that a portion of the variance of uranium content in the stream sediments can be

TABLE 2. WALLACE-CHOTEAU STREAM-SEDIMENT DATA BEFORE EDITING

VAR		# MISSING	%	# BDL	%	MEAN	STD DEV
1	U	1	.03	0	0.00	4.90	4.27
2	AG	12	.34	3507	99.35	2.57	2.23
3	BI	12	.34	2481	70.28	3.69	2.42
4	CD	12	.34	3480	98.58	2.56	.80
5	CU	12	.34	195	5.52	33.49	57.62
6	NB	12	.34	3518	99.66	10.00	0.00
7	NI	12	.34	2096	59.38	13.61	9.17
8	PB	12	.34	349	9.89	32.82	248.35
9	SN	12	.34	3483	98.67	5.26	7.08
10	W	12	.34	3280	92.92	8.43	4.13
11	AS	12	.34	1033	29.26	9.39	21.36
12	SE	12	.34	3516	99.60	2.51	.45
13	ZR	12	.34	0	0.00	241.99	100.70
14	MO	3530	100.00	0	0.00	0.00	0.00
15	BE	3530	100.00	0	0.00	0.00	0.00
16	LI	3530	100.00	0	0.00	0.00	0.00
17	AL	2	.06	1	.03	56994.79	11898.43
18	AU	2	.06	3514	99.55	.04	.18
19	BA	3	.08	112	3.17	701.78	519.47
20	CA	2	.06	138	3.91	20245.35	34342.52
21	CE	2	.06	40	1.13	75.63	27.76
22	CL	2	.06	2435	68.98	103.97	121.81
23	CO	2	.06	45	1.27	13.73	9.93
24	CR	2	.06	314	8.90	37.73	18.07
25	CS	2	.06	253	7.17	5.96	15.72
26	DY	3	.08	60	1.70	6.05	2.66
27	EU	3	.08	92	2.61	1.28	.53
28	FE	2	.06	36	1.02	23844.09	11659.25
29	HF	2	.06	59	1.67	8.58	4.15
30	K	3	.08	49	1.39	18794.55	5808.17
31	LA	2	.06	272	7.71	37.01	16.15
32	LU	4	.11	243	6.88	.42	.19
33	MG	2	.06	71	2.01	10456.95	8430.73
34	MN	2	.06	0	0.00	662.32	1035.29
35	NA	2	.06	2	.06	9432.85	4217.31
36	RB	2	.06	1458	41.30	63.60	40.53
37	SB	4	.11	3413	96.69	2.12	24.61
38	SC	2	.06	4	.11	8.46	2.65
39	SM	2	.06	161	4.56	6.04	3.05
40	SR	9	.25	3433	97.25	126.64	73.10
41	TA	10	.28	3475	98.44	.83	.52
42	TB	147	4.16	2983	84.50	.62	.39
43	TH	2	.06	27	.76	9.85	3.37
44	TI	73	2.07	0	0.00	3299.79	1790.04
45	V	3	.08	23	.65	58.84	34.87
46	YB	2	.06	757	21.44	4.39	2.28
47	ZN	2	.06	1864	52.80	82.51	156.86

TOTAL NUMBER OF SAMPLES = 3530

VAR= VARIABLE #= NUMBER OF SAMPLES %= PERCENT OF TOTAL SAMPLES

MISSING= ANALYSES NOT AVAILABLE BDL= BELOW DETECTION LIMIT

STD DEV= ONE STANDARD DEVIATION

TABLE 3. WALLACE-CHOTEAU STREAM-SEDIMENT DATA AFTER EDITING

VAR		# MISSING	%	# BDL	%	MEAN	STD DEV
1	U	0	0.00	0	0.00	4.90	4.26
2	CU	0	0.00	194	5.63	32.53	41.71
3	NI	0	0.00	2045	59.33	13.64	9.15
4	PB	0	0.00	327	9.49	31.39	240.93
5	AS	0	0.00	1002	29.07	9.03	13.63
6	ZR	0	0.00	0	0.00	244.10	99.68
7	AL	0	0.00	0	0.00	57392.58	11191.19
8	BA	0	0.00	72	2.09	705.19	518.59
9	CA	0	0.00	127	3.68	18924.88	29161.53
10	CE	0	0.00	26	.75	76.31	27.22
11	CO	0	0.00	36	1.04	13.67	9.67
12	CR	0	0.00	276	8.01	38.04	17.65
13	CS	0	0.00	217	6.30	5.65	3.51
14	DY	0	0.00	24	.70	6.11	2.61
15	EU	0	0.00	72	2.09	1.29	.52
16	FE	0	0.00	32	.93	23851.90	10887.16
17	HF	0	0.00	34	.99	8.64	3.81
18	K	0	0.00	20	.58	18975.27	5611.98
19	LA	0	0.00	237	6.88	37.35	15.95
20	LU	0	0.00	208	6.03	.43	.19
21	MG	0	0.00	51	1.48	10454.89	8194.03
22	MN	0	0.00	0	0.00	621.83	371.72
23	NA	0	0.00	1	.03	9503.63	4134.26
24	RB	0	0.00	1393	40.41	64.14	40.56
25	SC	0	0.00	3	.09	8.52	2.61
26	SM	0	0.00	138	4.00	6.09	3.03
27	TH	0	0.00	13	.38	9.94	3.30
28	TI	0	0.00	0	0.00	3299.86	1790.02
29	V	0	0.00	2	.06	59.37	34.83
30	YB	0	0.00	701	20.34	4.43	2.26
31	ZN	0	0.00	1813	52.60	81.49	154.41

TOTAL NUMBER OF SAMPLES = 3447

VAR= VARIABLE #= NUMBER OF SAMPLES %= PERCENT OF TOTAL SAMPLES

MISSING= ANALYSES NOT AVAILABLE BDL= BELOW DETECTION LIMIT

STD DEV= ONE STANDARD DEVIATION

TABLE 4. STATISTICAL DATA FOR THE WALLACE-CHOTEAU COMBINED STREAM-SEDIMENT DATA SET

WALLACE-CHOTEAU STREAM SEDIMENTS

VAR		TOTAL	NADL	NBDL	MISS	FOR TOTAL ANALYSES: MEAN	STD.DEV.	SKEWNESS	KURTOSIS	FOR ABOVE DETECTION LIMIT ANALYSES: MEAN	STD.DEV.	SKEWNESS	KURTOSIS	MAXIMUM	MIN(ADL)
1	U	3529	3529	0	1	4.90	4.27	5.58	58.41	4.90	4.27	5.58	58.41	80.45	.39
2	AG	3518	11	3507	12	2.57	2.23	41.19	1797.77	24.64	33.30	1.70	4.32	109.00	5.00
3	BI	3518	1037	2481	12	3.69	2.42	6.62	115.99	6.53	2.90	9.33	147.19	62.00	5.00
4	CD	3518	38	3480	12	2.56	.80	19.89	463.69	8.05	5.34	1.98	5.84	25.00	5.00
5	CU	3518	3323	195	12	33.49	57.62	20.69	619.63	35.16	58.66	20.47	600.30	2154.00	10.00
6	NB	3518	0	3518	12	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	10.00
7	NI	3518	1422	2096	12	13.61	9.17	2.18	11.99	22.63	8.47	3.02	19.50	101.00	15.00
8	PB	3518	3169	349	12	32.82	248.35	21.36	544.13	36.16	261.46	20.29	490.72	7953.00	5.00
9	SN	3518	35	3483	12	5.26	7.08	53.03	3001.22	31.29	66.03	5.34	30.59	409.00	10.00
10	W	3518	238	3280	12	8.43	4.13	6.67	70.25	21.24	8.75	3.19	15.58	70.00	15.00
11	AS	3518	2485	1033	12	9.39	21.36	29.79	1177.96	12.25	24.85	26.41	896.71	955.00	5.00
12	SE	3518	2	3516	12	2.51	.45	57.90	3397.49	17.50	11.50	0.00	1.00	29.00	6.00
13	ZR	3518	3518	0	12	241.99	100.70	2.49	20.01	241.99	100.70	2.49	20.01	1558.00	20.00
14	MO	0	0	0	3530	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	BE	0	0	0	3530	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	LI	0	0	0	3530	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	AL	3528	3527	1	2	56994.79	11898.43	-.41	5.06	57009.91	11866.20	-.40	5.01	108700.00	4449.00
18	AU	3528	14	3514	2	.04	.18	41.91	1803.67	1.28	2.62	2.10	5.55	6.54	.10
19	BA	3527	3415	112	3	701.78	519.47	35.08	1724.17	720.66	516.45	36.81	1817.25	26490.00	129.00
20	CA	3528	3390	138	2	20245.35	34342.52	4.27	26.00	21042.78	34800.84	4.21	25.27	368400.00	1406.00
21	CE	3528	3488	40	2	75.63	27.76	.94	7.36	76.44	26.85	1.17	7.80	287.00	4.00
22	CL	3528	1093	2435	2	103.97	121.81	4.98	50.47	226.90	156.58	4.64	39.89	2120.00	52.00
23	CO	3528	3483	45	2	13.73	9.93	1.92	7.52	13.89	9.86	1.95	7.58	85.00	1.30
24	CR	3528	3214	314	2	37.73	18.07	1.38	11.91	40.76	15.97	2.34	18.02	243.00	6.00
25	CS	3528	3275	253	2	5.96	15.72	46.23	2362.30	6.34	16.25	45.00	2223.28	844.10	1.10
26	DY	3527	3467	60	3	6.05	2.66	2.43	17.43	6.14	2.59	2.70	18.93	34.00	1.00
27	EU	3527	3435	92	3	1.28	.53	2.08	14.73	1.31	.50	2.55	17.05	6.50	.20
28	FE	3528	3492	36	2	23844.09	11659.25	10.85	292.46	24085.61	11472.27	11.53	314.06	387100.00	1682.00
29	HF	3528	3469	59	2	8.58	4.15	4.94	83.52	8.71	4.06	5.39	91.89	101.10	.80
30	K	3527	3478	49	3	18794.55	5806.17	.49	4.17	18999.81	5557.25	.75	4.05	46540.00	2273.00
31	LA	3528	3256	272	2	37.01	16.15	.97	7.73	39.44	14.26	1.77	10.68	153.00	3.00
32	LU	3526	3283	243	4	.42	.19	1.10	6.75	.45	.18	1.76	11.76	2.00	.10
33	MG	3528	3457	71	2	10456.95	8430.73	3.98	24.02	10634.21	8417.14	4.05	24.30	88790.00	1545.00
34	MN	3528	3528	0	2	662.32	1035.29	30.53	1254.69	662.32	1035.29	30.53	1254.69	47480.00	45.00
35	NA	3528	3526	2	2	9432.85	4217.31	1.44	8.20	9438.15	4212.63	1.45	8.22	38530.00	419.00
36	RB	3528	2070	1458	2	63.60	40.53	.42	2.23	92.67	26.91	.69	3.72	208.00	24.00
37	SB	3526	113	3413	4	2.12	24.61	40.12	1790.42	30.58	134.34	7.05	56.63	1209.00	2.00
38	SC	3528	3524	4	2	8.46	2.65	.73	6.58	8.47	2.65	.74	6.60	27.90	.70
39	SM	3528	3367	161	2	6.04	3.05	2.36	16.13	6.28	2.91	2.86	18.93	36.10	.50
40	SR	3521	88	3433	9	126.64	73.10	4.95	40.02	465.25	177.57	.87	3.65	1043.00	171.00
41	TA	3520	45	3475	10	.83	.52	5.26	52.72	3.42	2.01	.60	2.06	8.00	1.00
42	TB	3383	400	2983	147	.62	.39	5.56	49.17	1.42	.73	2.61	14.11	7.00	1.00
43	TH	3528	3501	27	2	9.85	3.37	1.61	22.25	9.92	3.29	1.84	24.12	62.30	.80
44	TI	3457	3457	0	73	3299.79	1790.04	7.05	82.87	3299.79	1790.04	7.05	82.87	32410.00	456.00
45	V	3527	3504	23	3	58.84	34.87	6.73	87.05	59.15	34.77	6.83	88.42	728.00	9.00
46	YB	3528	2771	757	2	4.39	2.28	.53	4.73	5.24	1.79	1.39	9.10	19.10	1.10
47	ZN	3528	1664	1864	2	82.51	156.66	13.82	286.70	137.25	195.63	12.19	214.30	4587.00	26.00

NUMBER OF SAMPLES = 3530

VAR= VARIABLE   NADL= NUMBER ABOVE DETECTION LIMIT   NBDL= NUMBER BELOW DETECTION LIMIT   MISS= NUMBER MISSING

TABLE 5. RESULTS OF MULTIPLE REGRESSION ANALYSIS OF THE WALLACE-CHOTEAU COMBINED STREAM-SEDIMENT DATA SET

3447 Samples, 18 steps

Step No. 18

Enter Variable 6 (Niobium)

F-Level	6.54983
Standard Error of Y	3.46872
Multiple Correlation	.58378
R-Squared	.34080
Degrees of Freedom	3428
Constant Term	3.76413

ORDER OF ENTRY	VARIABLE	BETA PRIME	BETA	SE(BETA)
17	Cu	.43444E-01	.44380E-02	.15612E-02
18	Zr	-.42301E-01	-.18080E-02	.70647E-03
9	Ba	.82438E-01	.67728E-03	.12070E-03
16	Ca	-.76838E-01	-.11226E-04	.35283E-05
6	Ce	-.15485E+00	-.24235E-01	.45182E-02
14	Co	.52161E-01	.22992E-01	.77386E-02
3	Cs	.97661E-01	.11865E+00	.19551E-01
8	Dy	.17828E+00	.29071E+00	.45088E-01
7	Eu	-.27135E+00	-.22175E+01	.26906E+00
15	Fe	-.65039E-01	-.25452E-04	.63230E-05
10	K	-.10919E-01	-.82895E-04	.14566E-04
4	La	.24883E+00	.66465E-01	.67359E-02
5	Mg	-.76987E-01	-.40030E-04	.11610E-04
13	Na	-.65483E-01	-.67483E-04	.16968E-04
2	Rb	-.11120E+00	-.11680E-01	.18547E-02
1	Sm	.48340E+00	.68059E+00	.44104E-01
12	Th	.91779E-01	.11859E+00	.31751E-01
11	Yb	-.84992E-01	-.16026E+00	.41583E-01

Analysis of Variance

Term	SS	DF	MS
Total	.62570E+05	3446	
Reg	.21324E+05	18	.11847E+04
Err	.41246E+05	3428	.12032E+02

accounted for by association with 18 other elements. Uranium residual values from this regression (Pl. 12) were mapped and used to indicate loci of uranium concentration in stream sediments unrelated to resistate minerals.

R-mode factor analyses (principal component type) were conducted on the Wallace-Choteau stream-sediment data sets singly and in combination. This analytical method can resolve a large number of elements into a smaller number of new combinations of elements (factors). These factors may represent the operation of geologic or geochemical processes unique to the data set being analyzed. The factor analysis program used in this study calculates both unrotated and Varimax orthogonally rotated factors. The unrotated factors accounted for 2 to 3 percent less variance in the data than rotated factors but were used because they allowed a simpler empirical interpretation of the factor components. The relations between variables in factor analyses performed in this study are expressed in tables of factor loadings. Factor loadings shown in Tables 6, 7, and 8 represent the Wallace-Choteau combined data set, the Choteau data subset, and the Wallace data subset, respectively. Correlation coefficients between variables of each data set are also included in each of the tables. Eigenvalues and cumulative proportion of total variance (CPTV) for each factor are shown at the head of the factor-loadings columns. Factor loadings represent the contribution of a variable to a particular factor; similar sign and level (large absolute value) of loading for variables in a factor are used to determine elemental association groups in the stream sediments. Only the first five factors of each data set were used in this study because of the dubious statistical validity of factors 6 through 15. Variables loading into the three factor analyses are summarized in Table 9.

In all three factor analyses, factor 1 is interpreted to represent resistate mineral (rare-earth-bearing) components in the stream sediments; factor 2 is interpreted to represent minerals such as magnesium-iron silicates, magnetite, and ilmenite in the stream sediments.

Subsequent factors in the Wallace and Choteau Quadrangles can also be explained geologically. In the Choteau Quadrangle, factor 3 may represent vein-type barium occurrences, factor 4 is interpreted to represent limestones and dolomites, and factor 5 is interpreted to represent sediments enriched in zircon. In the Wallace Quadrangle, factor 3 is interpreted to represent lead-zinc-copper mineralization, factor 4 is interpreted to represent granitic source rocks, and factor 5 is interpreted to represent a mixed provenance of sodic and alkalic crystalline rocks.

The factor analysis of the combined stream-sediment data for Wallace and Choteau does not discriminate associated groups of elements as clearly as the factor analyses of the individual quadrangles. Consequently, later discussions of geochemically anomalous localities deal only with factors present in the quadrangle containing the locality.

TABLE 6. R-MODE FACTOR ANALYSIS OF THE WALLACE-CHOTEAU COMBINED STREAM-SEDIMENT DATA SET

NUMBER OF SAMPLES 3447
NUMBER OF VARIABLES 31

CORRELATION COEFFICIENTS

	U	CU	NI	PB	AS	ZR	AL	BA	CA	CE	CO	CR	CS	DY	EU
U	1.000														
CU	.129	1.000													
NI	.126	.179	1.000												
PB	.012	.321	.069	1.000											
AS	.073	.341	.097	.029	1.000										
ZR	.027	-.036	-.105	.019	.016	1.000									
AL	.144	.123	.277	.009	.086	-.083	1.000								
BA	.116	.055	-.020	.029	.023	.044	.149	1.000							
CA	-.207	-.076	-.063	-.034	-.059	-.296	-.471	-.149	1.000						
CE	.363	.085	.220	.039	.072	.128	.376	.053	-.371	1.000					
CO	.140	.132	.271	.058	.048	-.204	.375	-.008	-.196	.323	1.000				
CR	.075	.069	.362	-.010	.063	.025	.229	.029	-.005	.223	.059	1.000			
CS	.224	.230	.164	.140	.241	-.008	.277	.180	-.209	.273	.155	.230	1.000		
DY	.441	.171	.289	.023	.057	.028	.335	.067	-.378	.673	.319	.050	.231	1.000	
EU	.419	.174	.280	.046	.042	.051	.365	.161	-.332	.716	.409	.205	.279	.862	1.000
FE	.052	.335	.277	.149	.234	-.061	.351	.036	-.164	.274	.291	.319	.238	.146	.242
HF	.106	-.063	-.088	-.000	-.009	.869	-.038	.049	-.327	.345	-.041	.093	.070	.132	.247
K	-.043	-.375	-.004	-.012	.042	.330	.236	.101	-.282	.117	-.069	.191	.203	.045	.008
LA	.440	.091	.204	.039	.053	.133	.284	.052	-.300	.731	.237	.215	.216	.646	.722
LU	.369	.138	.222	.024	.057	.165	.285	.063	-.398	.643	.315	.166	.308	.767	.764
MG	-.213	-.074	-.063	-.054	-.019	-.240	-.375	-.151	.757	-.312	-.206	.069	-.127	-.352	-.341
MN	.125	.336	.273	.241	.143	-.175	.284	.138	-.172	.201	.337	.077	.209	.194	.247
NA	.004	-.021	-.004	-.022	.001	-.052	.403	.020	-.251	.173	.196	-.162	-.139	.062	.096
RB	-.001	.020	.042	.035	.080	.162	.229	.081	-.245	.256	-.059	.211	.264	.140	.115
SC	.172	.305	.356	.021	.163	-.113	.591	.071	-.273	.462	.415	.493	.422	.373	.485
SM	.506	.135	.213	.002	.061	.140	.228	.082	-.268	.749	.178	.231	.296	.747	.826
TH	.303	.068	.155	.045	.080	.275	.393	.086	-.352	.746	.241	.334	.342	.468	.567
TI	.048	.309	.188	.032	.146	.072	.237	-.005	-.191	.179	.241	.139	.124	.149	.142
V	-.029	.282	.215	-.006	.135	-.036	.238	.005	-.012	.011	.145	.343	.092	-.055	.009
YB	.311	.130	.188	.032	.058	.152	.260	.041	-.382	.616	.210	.122	.254	.716	.654
ZN	.033	.211	.087	.557	.026	-.013	.057	.027	-.032	.057	.109	.056	.166	.042	.098

	FE	HF	K	LA	LU	MG	MN	NA	RB	SC	SM	TH	TI	V	YB
FE	1.000														
HF	.021	1.000													
K	.023	.273	1.000												
LA	.232	.309	.092	1.000											
LU	.225	.361	.106	.63[illegible]	1.000										
MG	-.110	-.295	-.076	-.268	-.334	1.000									
MN	.388	-.125	-.140	.135	.194	-.198	1.000								
NA	.079	.037	-.293	.131	.070	-.279	.071	1.000							
RB	.183	.222	.520	.226	.238	-.108	.001	-.139	1.000						
SC	.671	.035	.121	.365	.463	-.148	.376	.067	.254	1.000					
SM	.170	.292	.080	.753	.712	-.229	.147	-.001	.200	.398	1.000				
TH	.267	.460	.351	.642	.612	-.251	.129	.028	.401	.477	.614	1.000			
TI	.555	.063	-.017	.114	.166	-.144	.308	.136	.046	.565	.110	.109	1.000		
V	.571	-.084	-.063	-.021	-.039	.024	.244	.068	-.019	.597	-.003	-.013	.794	1.000	
YB	.198	.317	.120	.597	.731	-.329	.181	.071	.274	.381	.640	.562	.135	-.061	1.000
ZN	.145	-.008	-.008	.070	.071	-.045	.235	-.004	.000	.078	.060	.103	.048	.041	.052

	ZN
ZN	1.000

TABLE 6. R-MODE FACTOR ANALYSIS OF THE WALLACE-CHOTEAU COMBINED STREAM-SEDIMENT DATA SET (continued)

	FACTOR 1	2	3	4	5
EIGENVALUES	8.18132	3.47973	2.36760	1.96846	1.79238
CPTV	.26391	.37616	.45254	.51604	.57385
ELEMENTS		UNROTATED	FACTOR	LOADINGS	
U	-.46361	-.14291	-.27562	.10104	.06755
CU	-.27607	.45829	.00820	.04273	.42184
NI	-.36566	.31749	-.09211	.19716	-.07026
PB	-.10042	.18638	.09221	.01891	.77984
AS	-.16278	.29045	.13361	.06297	.17674
ZR	-.17097	-.52261	.57844	-.23472	.11604
AL	-.55969	.31369	.06264	-.32149	-.16171
BA	-.15116	-.05431	.08175	-.11943	.16620
CA	.54695	.12227	-.18709	.59511	-.07165
CE	-.82085	-.23979	-.10702	.06280	-.08688
CO	-.43390	.28426	-.28510	-.16815	-.06172
CR	-.33705	.24953	.33926	.42328	-.21469
CS	-.44760	.20607	.19216	.20893	.24939
DY	-.77364	-.13423	-.35423	.06289	-.01518
EU	-.83807	-.12237	-.30496	.10279	-.02444
FE	-.46736	.58730	.22830	-.00513	-.05564
HF	-.35972	-.49519	.48095	-.18773	.06012
K	-.20198	-.25651	.65852	.12119	.02222
LA	-.77136	-.22609	-.17034	.13902	-.05964
LU	-.81364	-.21556	-.14191	.07268	-.01123
MG	.46789	.15310	-.01924	.65818	-.11966
MN	-.36327	.45748	-.16042	-.11725	.27999
NA	-.14284	.10441	-.28056	-.64423	-.16843
RB	-.34034	-.10253	.52391	.17173	.01685
SC	-.69779	.50854	.17706	.08594	-.22175
SM	-.79371	-.30877	-.20185	.26171	-.04310
TH	-.76295	-.27591	.20595	.13461	-.02293
TI	-.36051	.54745	.24399	-.21863	-.18067
V	-.19497	.71982	.29551	-.05843	-.26699
YB	-.74705	-.25035	-.12041	.05706	.00555
ZN	-.14398	.22666	-.01979	.04788	.69633

TABLE 7. R-MODE FACTOR ANALYSIS OF THE CHOTEAU STREAM-SEDIMENT DATA SET

NUMBER OF SAMPLES 1512
NUMBER OF VARIABLES 30

CORRELATION COEFFICIENTS

	U	CU	PB	AS	ZR	AL	BA	CA	CE	CO	CR	CS	DY	EU	FE
U	1.000														
CU	.171	1.000													
PB	.091	.343	1.000												
AS	.224	.357	.084	1.000											
ZR	.116	-.073	-.013	-.020	1.000										
AL	.175	.153	.080	.174	.049	1.000									
BA	.428	.161	.075	.248	.124	.439	1.000								
CA	-.239	-.102	-.093	-.179	-.508	-.556	-.438	1.000							
CE	.210	.072	.069	.117	.361	.469	.296	-.499	1.000						
CO	.078	.469	.127	.274	-.098	.455	.119	-.134	.320	1.000					
CR	-.026	.102	.031	.005	-.049	.458	.055	-.068	.269	.477	1.000				
CS	.347	.240	.132	.454	-.007	.368	.390	-.306	.361	.267	.153	1.000			
DY	.452	.215	.089	.181	.357	.408	.498	-.532	.489	.165	.039	.426	1.000		
EU	.365	.222	.095	.129	.297	.450	.505	-.488	.600	.316	.283	.390	.685	1.000	
FE	.033	.440	.174	.388	-.045	.294	.071	-.153	.179	.562	.319	.168	.064	.188	1.000
HF	.130	-.077	-.009	-.029	.914	.056	.134	-.481	.498	-.044	.025	.062	.372	.435	-.016
K	.060	-.106	-.001	.025	.461	.360	.180	-.408	.375	.037	.130	.169	.335	.229	.004
LA	.320	.073	.064	.104	.342	.396	.271	-.417	.628	.207	.255	.269	.433	.502	.195
LU	.325	.172	.068	.136	.398	.301	.321	-.478	.522	.192	.123	.396	.699	.688	.132
NG	-.232	-.081	-.077	-.094	-.442	-.446	-.420	.782	-.350	-.067	-.045	-.193	-.392	-.406	-.115
MN	.157	.508	.221	.296	-.160	.248	.232	-.135	.155	.579	.118	.227	[illegible]	.233	.354
NA	.004	.005	-.001	.072	-.015	.402	.288	-.297	.217	.134	-.026	-.004	.024	.150	.163
RB	.092	-.003	.014	.078	.291	.330	.191	-.332	.408	.092	.157	.243	.334	.264	.117
SC	.205	.469	.148	.310	-.059	.628	.270	-.324	.460	.815	.553	.451	.401	.520	.613
SM	.466	.170	.095	.131	.321	.350	.367	-.446	.717	.236	.193	.401	.709	.751	.121
TH	.191	.050	.061	.114	.441	.498	.293	-.470	.728	.253	.320	.346	.536	.598	.160
TI	.097	.467	.058	.286	.097	.237	.110	-.202	.193	.642	.167	.170	.181	.197	.552
V	.012	.430	.058	.245	-.103	.319	.054	-.077	.077	.691	.394	.107	-.002	.106	.599
YB	.259	.155	.019	.141	.429	.261	.301	-.456	.526	.137	.075	.327	.649	.547	.111
ZN	.038	.131	.173	.052	-.044	.083	.059	-.049	.034	.133	.096	.084	.088	.125	.084

	HF	K	LA	LU	MG	MN	NA	RB	SC	SM	TH	TI	V	YB	ZN
HF	1.000														
K	.424	1.000													
LA	.427	.366	1.000												
LU	.504	.306	.470	1.000											
MG	-.420	-.223	-.296	-.333	1.000										
MN	-.142	-.179	.074	.137	-.146	1.000									
NA	-.004	-.210	.148	.045	-.322	.180	1.000								
RB	.330	.589	.399	.339	-.198	-.081	-.085	1.000							
SC	.033	.127	.335	.399	-.200	.490	.115	.211	1.000						
SM	.450	.276	.583	.676	-.330	.190	.055	.378	.423	1.000					
TH	.562	.551	.625	.598	-.316	.062	.049	.323	.416	.661	1.000				
TI	.074	.011	.101	.181	-.149	.400	.165	.038	.641	.143	.098	1.000			
V	-.123	-.140	.033	.001	-.084	.400	.181	-.059	.691	.005	-.019	.856	1.000		
YB	.501	.341	.416	.636	-.318	.100	.009	.411	.319	.617	.568	.147	-.023	1.000	
ZN	-.027	-.030	.083	.103	-.038	.152	.051	-.032	.100	.095	.130	.067	.065	.070	1.000

TABLE 7. R-MODE FACTOR ANALYSIS OF THE CHOTEAU STREAM-SEDIMENT DATA SET (continued)

	FACTOR 1	2	3	4	5
EIGENVALUES	9.02376	4.49366	1.98921	1.72710	1.57204
CPTV	.30079	.45058	.51689	.57446	.62686
ELEMENTS		UNROTATED	FACTOR LOADINGS		
U	-.42632	.05366	-.50893	.16331	.02665
CU	-.33121	-.55851	-.20862	.14963	.36312
PB	-.15442	-.18280	-.20019	.12796	.15100
AS	-.31338	-.33989	-.27827	.09884	.16188
ZR	-.44465	.54257	.21867	-.29496	.49268
AL	-.65953	-.20029	.09003	-.24344	-.52184
BA	-.53680	.02391	-.46684	-.16112	-.24363
CA	.70727	-.20824	.11504	.45842	-.00866
CE	-.76398	.16504	.15227	.01744	-.13259
CO	-.49289	-.69705	.24297	.04915	-.00550
CR	-.34700	-.31773	.48270	.13174	-.38789
CS	-.53791	-.12655	-.30372	.30544	-.15501
DY	-.75270	.20858	-.27800	.15940	.06643
EU	-.79670	.08433	-.14448	.09131	-.06753
FE	-.38232	-.60367	.21752	-.03337	.17796
HF	-.52841	.54710	.24406	-.18893	.42856
K	-.45237	.41029	.39569	.08459	-.05046
LA	-.66477	.19551	.12798	.06366	-.13746
LU	-.73795	.22575	-.09857	.17872	.14341
MG	.55460	-.17103	.18269	.59271	-.01878
MN	-.33053	-.58646	-.26464	-.00925	.09018
NA	-.19692	-.15921	-.21750	-.66721	-.31000
RB	-.49059	.28491	.32394	.17712	-.11083
SC	-.69832	-.59641	.17783	.09821	-.09179
SM	-.78687	.20581	-.12701	.25058	-.01427
TH	-.77188	.27689	.25550	.14919	-.12766
TI	-.41323	-.62065	.18307	-.19455	.38877
V	-.28494	-.78522	.26260	-.20899	.16449
YB	-.68300	.27514	-.03449	.16025	.19022
ZN	-.13290	-.13267	-.12069	.11237	-.03726

TABLE 8. R-MODE FACTOR ANALYSIS OF THE WALLACE STREAM-SEDIMENT DATA SET

NUMBER OF SAMPLES 1935
NUMBER OF VARIABLES 31
CORRELATION COEFFICIENTS

	U	CU	NI	PB	AS	ZR	AL	BA	CA	CE	CO	CR	CS	DY	EU
U	1.000														
CU	.102	1.000													
NI	.143	.168	1.000												
PB	-.003	.407	.065	1.000											
AS	.045	.363	.120	.032	1.000										
ZR	.063	.029	-.042	.067	.018	1.000									
AL	.050	.083	.227	-.025	.088	-.043	1.000								
BA	.043	.019	-.017	.032	-.023	-.009	.064	1.000							
CA	-.075	-.008	-.055	-.020	-.034	-.229	-.150	-.003	1.000						
CE	.378	.080	.245	.021	.084	.149	.215	.001	-.167	1.000					
CO	.058	.054	.205	.025	.059	-.083	.237	-.004	.017	.192	1.000				
CR	.203	.059	.440	.003	.084	-.008	.170	.010	-.122	.342	.140	1.000			
CS	.165	.223	.245	.204	.173	-.009	.207	.098	-.019	.252	.195	.333	1.000		
DY	.399	.151	.309	-.010	.059	.047	.142	-.012	-.111	.606	.129	.219	.165	1.000	
EU	.400	.146	.296	.027	.041	.059	.218	.095	-.086	.720	.315	.302	.215	.810	1.000
FE	.040	.215	.356	.242	.161	-.003	.415	.030	-.081	.374	.262	.416	.372	.158	.297
HF	.135	-.042	-.054	.011	-.009	.835	-.073	.008	-.203	.349	.039	.131	.032	.096	.227
K	-.088	-.028	.036	-.004	.053	.015	.230	.069	-.201	.008	-.005	.228	.267	-.038	-.076
LA	.451	.091	.229	.025	.056	.148	.133	.007	-.143	.819	.126	.303	.211	.681	.771
LU	.348	.102	.265	-.002	.058	.171	.114	-.009	-.140	.655	.195	.360	.275	.769	.779
MG	-.170	-.049	-.003	-.076	-.013	-.304	.051	-.047	.280	-.156	.040	.101	.003	-.157	-.206
MN	.047	.222	.282	.281	.124	-.055	.186	.133	-.037	.113	.171	.162	.218	.059	.151
NA	-.077	-.063	-.053	-.056	-.004	.092	.293	-.085	-.002	.028	.014	-.177	-.276	-.118	-.063
RB	-.060	.040	.072	.047	.090	.023	.144	.040	-.141	.181	-.144	.281	.289	.048	.041
SC	.129	.145	.345	.007	.129	-.109	.538	-.009	-.090	.462	.361	.515	.394	.350	.475
SM	.517	.112	.280	-.008	.046	.051	.138	.002	-.104	.785	.160	.298	.221	.924	.886
TH	.339	.073	.175	.043	.083	.229	.267	.020	-.163	.763	.205	.412	.354	.427	.547
TI	-.010	.122	.215	.042	.107	.099	.218	-.072	-.113	.165	.156	.147	.061	.115	.090
V	-.017	.117	.257	.002	.099	-.046	.334	-.046	-.034	.066	.212	.222	.073	.036	.037
YB	.282	.101	.226	.011	.061	.137	.090	-.029	-.139	.599	.015	.318	.227	.691	.652
ZN	.029	.265	.097	.686	.019	.023	.038	.018	-.010	.067	.127	.034	.244	.021	.069

	FE	HF	K	LA	LU	MG	MN	NA	RB	SC	SM	TH	TI	V	YB
FE	1.000														
HF	.118	1.000													
K	.117	.012	1.000												
LA	.275	.322	-.038	1.000											
LU	.311	.351	.008	.687	1.000										
MG	.096	-.313	.142	-.188	-.141	1.000									
MN	.446	-.067	-.036	.072	.096	-.062	1.000								
NA	-.010	.081	-.348	.025	-.083	-.001	-.131	1.000							
RB	.292	.108	.460	.142	.170	.090	.055	-.204	1.000						
SC	.779	.070	.170	.378	.499	.150	.253	-.043	.301	1.000					
SM	.236	.210	-.065	.830	.769	-.176	.104	-.062	.090	.394	1.000				
TH	.402	.458	.205	.649	.610	-.094	.114	-.098	.307	.520	.591	1.000			
TI	.552	.069	-.042	.117	.126	-.052	.221	.084	.057	.452	.085	.111	1.000		
V	.613	-.070	.042	.010	.041	.177	.243	.074	.059	.576	.014	.057	.737	1.000	
YB	.264	.280	.024	.640	.738	-.148	.086	-.068	.192	.403	.685	.542	.094	.020	1.000
ZN	.234	.008	.018	.065	.053	-.084	.293	-.040	.024	.061	.042	.066	.033	.024	.040

	ZN
ZN	1.000

TABLE 8. R-MODE FACTOR ANALYSIS OF THE WALLACE STREAM-SEDIMENT DATA SET (continued)

	FACTOR 1	2	3	4	5
EIGENVALUES	7.72159	3.42010	2.16756	2.06546	2.02296
CPTV	.24908	.35941	.42933	.49596	.56122
ELEMENTS		UNROTATED	FACTOR LOADINGS		
U	.45036	.27906	-.00968	-.19309	-.04468
CU	.22120	-.24958	.41147	-.35872	.01464
NI	.43399	-.30039	-.07452	-.15851	-.03579
PB	.10233	-.24613	.70445	-.36999	.01708
AS	.15278	-.20702	.14717	-.06087	.00064
ZR	.16114	.30986	.46175	.46527	.48219
AL	.34456	-.42869	-.20415	.12655	.13932
BA	.02893	-.02266	.12975	-.01326	-.13917
CA	-.20838	-.05004	-.20645	-.35835	-.15012
CE	.83395	.21479	-.04937	.02690	.04171
CO	.29618	-.25293	-.13377	-.18778	.12915
CR	.52547	-.26033	-.05730	.21524	-.24141
CS	.43860	-.29513	.28827	.04139	-.35969
DY	.75268	.30892	-.16542	-.24245	-.08783
EU	.84470	.25648	-.11361	-.23757	-.02706
FE	.58037	-.64550	.03454	.07582	.16997
HF	.34491	.35633	.38363	.50703	.40444
K	.09815	-.25895	.14605	.54061	-.50456
LA	.81565	.32830	-.05407	-.06642	.01809
LU	.83078	.25605	-.06055	-.01893	-.04471
MG	-.15597	-.36319	-.36676	.01473	-.31509
MN	.26796	-.43214	.26050	-.27819	.05490
NA	-.08638	.04943	-.21650	-.05136	.60929
RB	.26733	-.22696	.16293	.50361	-.40451
SC	.70181	-.51361	-.24204	.12659	.01923
SM	.84281	.34399	-.13941	-.20221	-.06963
TH	.77144	.09544	.08255	.26478	-.05401
TI	.30533	-.49423	-.12561	.08637	.51321
V	.25499	-.67489	-.25893	.07045	.38266
YB	.74194	.26453	-.03514	.00151	-.07968
ZN	.15594	-.24427	.62641	-.37455	.00357

TABLE 9. VARIABLES LOADING INTO FACTOR ANALYSES

Factor	Wallace-Choteau Combined Data Set	Choteau Data Subset	Wallace Data Subset
1	Eu, Ce, Lu, Sm, Dy, Ta, Th, Yb, Sc	Eu, Sm, Th, Ce, Dy, Lu, Sc, Yb, La, Al	Eu, Sm, Ce, Lu, La Th, Dy, Yb, Sc
2	V, Fe, Ti, Sc, Cu, Mn	V, Co, Ti, Fe, Sc, Mn, Cu	V, Fe, Sc, Ti, Mn Al
3	K, Sr, Rb, Hf	U, Ba	Pb, Zn, Cu
4	Mg, Ca	Mg, Ca	K, Hf, Rb, Zr
5	Pb, Zn, Cu	Zr, Hf	Na, Ti, Zr, Hf, V

INTERPRETATION OF DATA

Methods of interpreting the data available to this project are extensions of methods developed during the NURE program. The integration and interpretation of NURE and other data sets are accomplished by a contingency approach wherein the project geologist selectively applies data characteristics (e.g., HSSR, ARMS, occurrence data) to localities within the project area in order to arrive at a description of the mineralized environment(s) in those localities.

Hydrogeochemical and Stream-Sediment Data

NURE HSSR data interpretations in this study are based primarily on the spatial distribution of elements, the observed associations of geochemically related elements, and the relationship of associated elements with the geology of the area. Threshold values (Table 10) for elements in the stream-sediment data were selected arbitrarily by a combination of methods and are considered by the authors to represent anomalous local concentrations. Probability curves and histograms (App. B) for the analyzed elements were most commonly used to determine threshold values. Partitioning of the probability curves to recognize local and regional thresholds was done according to the method of Sinclair (1974). Histograms were used to confirm or adjust thresholds selected from the probability curves. Symbol maps of stream-sediment factors (Pl. 13 through 27), trace elements in stream waters (Pl. 28 through 43), rare-earth content in stream sediments (Pl. 44 through 53), and other single-element distribution maps (Pl. 54 through 84) were used to recognize coinciding geochemical anomalies, elemental association groups, and localities suspected to be mineralized.

TABLE 10. THRESHOLD VALUES

Element	Value	Element	Value	Element	Value
U	20 ppm	Mo	no data	La	100 ppm
Ag	10 ppm	Be	no data	Lu	1 ppm
Bi	20 ppm	Li	no data	Mg	not determined
Cd	10 ppm	Al	100000 ppm	Mn	2000 ppm
Cu	200 ppm	Au	0.1 ppm	Na	not determined
Nb	no data	Ba	2000 ppm	Rb	200 ppm
Ni	50 ppm	Ca	not determined	Sb	10 ppm
Pb	200 ppm	Ce	200 ppm	Sc	20 ppm
Sn	20 ppm	Cl	500 ppm	Sm	20 ppm
W	20 ppm	Co	20 ppm	Sr	500 ppm
As	50 ppm	Cr	100 ppm	Ta	5 ppm
Se	20 ppm	Cs	20 ppm	Tb	5 ppm
Zr	500 ppm	Dy	20 ppm	Th	20 ppm
Eu	5 ppm	Hf	20 ppm	Ti	1%
Fe	5%	K	not determined	V	100 ppm
Yb	10 ppm	Zn	200 ppm		

Trace-element concentrations in stream waters were used cautiously in this study. The relationships between conductivity and total dissolved solids in waters have been demonstrated for uranium; however, stream-discharge rates, temporal variations in input of trace elements to stream waters, and the nature of dissolved solids in stream waters all affect concentrations of trace elements. NURE hydrogeochemical data available for this project area were not sufficiently detailed to be used extensively.

Rare-earth-element concentrations in stream sediments (Pl. 46 through 53) were investigated in order to discriminate crystalline-rock environments. Total rare-earth contents and ratios of light to heavy rare-earth elements (Pl. 44 and 45) were computed for the Wallace and Choteau Quadrangles. These computations were performed according to the method reported by Madson and others (1983).

Aerial Radiometric and Aeromagnetic Data

Maps of aerial radiometric data (Pl. 4 through 9) were used to detect radioelement patterns in geochemically anomalous areas. These data were helpful in locating or confirming uncertain geologic contacts and in ascertaining host-rock types within geochemically anomalous areas.

Aeromagnetic data (Pl. 10 and 11) were used to depict the regional tectonic features of the project area as well as to describe structural elements in geochemically anomalous areas. These data were particularly useful in recognizing intrusive crystalline rocks and shallow buried intrusive rocks.

DATA APPLICATION

NURE data were used in this study to recognize and delineate geochemically anomalous localities, as well as to describe the radiometric and aeromagnetic features of the mineralized environments represented by them. Many of these localities encompass parts of known mining districts. Within the scope of this study, neither mining districts nor economic deposits are intended to be delineated; rather, any locality exhibiting an anomalous signature in NURE data is identified, and the nature of the suspected mineralized environment is described. Nearly all of the previously discussed mineralized environments in the project area were detected by the NURE HSSR data.

Several localities discussed in the following sections are termed 'reference localities.' A reference locality is considered by the authors to:

- Be representative of, or the only example of, a particular mineralized environment.
- Have a concentration of known mines or prospects within its borders.
- Have abundant geologic information.
- Exhibit anomalous geochemical or geophysical features or both.
- Be moderately to extensively explored or developed for mineral resources.

Because these reference localities often include well-known and unique mineralized environments, their geochemical, geophysical, and radiometric features are distinctive. These distinctive characteristics are used in this study to recognize other localities with similar characteristics and, possibly, similar types of mineral deposits.

Because of the high level of human intrusion and development in reference localities, interpretation of HSSR data can be affected by contamination. Contamination of stream sediments by mining activity cannot be separated from local mineral concentrations in the NURE HSSR data. Because of this and previously mentioned factors, reference localities are not considered targets for further investigation, although it is recognized that extensions of known deposits may exist within their borders.

Other anomalous localities that have characteristics similar to the reference localities are placed in one of two categories in this study. First, follow-up localities exhibit obvious similarity to an appropriate reference locality, generally lack high levels of human intrusion, and are considered to be favorable for exploration for new or additional mineral resources. Second, marginal localities are those that have some positive NURE data characteristics and are worthy of consideration, in contrast to the remainder of the project area. The marginal localities exhibit low-level regional, and some local, elemental concentrations in the HSSR data, have no unusual radiometric features for the rocks in that locale, and show insignificant or predictable magnetic characteristics. Anomalous HSSR features in marginal localities may be explained, in most cases, by proximity to known mines and prospects. In other cases, marginal localities may exhibit a paucity of NURE data that precludes complete evaluation.

RESULTS

In this study, 24 mineralized localities have been recognized and delineated. Of these, five are reference localities, three are follow-up localities, and the remaining 16 are marginal localities. The localities are shown on Plate 85; specific information for each locality can be found in the Anomaly Reports (App. C). Other parts of this project area are considered, on the basis of available data and interpretations, to have low potential for mineral resources. Mineral-deposit areas may certainly exist outside of the localities delineated in this study; however, the wide spacing of NURE data may have precluded their recognition.

The following sections briefly describe characteristics of reference localities, follow-up localities, and marginal localities recognized in the project area. The sections are organized according to the geologic environment represented by the various mineralized localities.

REPLACEMENT VEINS IN SHEARED AND FAULTED PRECAMBRIAN QUARTZITE AND CARBONATE HOST ROCKS

Three reference localities, one follow-up locality, and six marginal localities representing this environment were delineated in this study.

The Wallace-Mullan reference locality (App. C, Anomaly Report WC-1, Pl. 85) exhibits anomalous zinc, lead, silver, cadmium, copper, antimony, tungsten, uranium, tin, manganese, iron, cobalt, barium, cesium, and bismuth in stream sediments. Factor 3 (lead, zinc, and copper) and Factor 2 (vanadium, iron, scandium, titanium, and manganese) coincide in many drainages of the area. Much of the area north of Wallace is underlain by a pronounced magnetic high that apparently coincides with Cretaceous intrusive rocks. The origin of mineral deposits in the Coeur d'Alene District, which this reference locality represents, is controversial. Proposed origins range from strata-bound/syngenetic to magmatic-hydrothermal. Some models propose a hydrothermal remobilization of strata-bound orebodies related to tectonism and magmatism. (See Bennett and Venkatakrishnan, 1982.) The area is cut by several, right-lateral faults that trend east-southeast and intersect north-trending faults.

The Murray reference locality (App. C, Anomaly Report WC-2) appears to be a northern extension of the Wallace-Mullan reference locality. Stream sediments from the area contain anomalous lead, zinc, copper, antimony, cobalt, and silver. Factor 2 (vanadium, iron, scandium, titanium, and manganese) and Factor 3 (lead, zinc, and copper) are strong in the area. A magnetic high extends into the area from the Wallace-Mullan reference locality and suggests the continuation of a buried intrusive body. Faulting in the area is similar to the Wallace-Mullan reference locality. The Vermillion Peak, Dixie Peak, Twenty Peak, and Bend Ranger Station localities resemble the Murray and Wallace-Mullan reference localities.

The Vermillion Peak-Moose Peak locality (App. C, Anomaly Report WC-5) exhibits highly anomalous uranium (20 to 100 ppm) and high uranium residuals (up to 50 ppm) in stream sediments derived from Ravalli Group and Wallace Formation rocks. The stream sediments are also anomalous in zinc, tungsten, cobalt, and chromium. The uranium-to-conductivity ratio is high in stream waters. The area is on the flank of two magnetic highs to the west and south. Mines and prospects are not well developed in the area. The locality is recommended for follow-up on the basis of the strong uranium geochemical anomalies.

The Dixie Peak locality (App. C, Anomaly Report WC-3) exhibits anomalous zinc, uranium, tungsten, copper, bismuth, and antimony in stream sediments; a strong magnetic high underlies most of the area. The locality contains parts of the White Pine and Prospect Creek Mining Districts, as well as the Jack Waite Mine. The stream-sediment anomalies in the locality are suspected to be contaminant related and, consequently, the locality is categorized as marginal.

The Twenty Peak locality (App. C, Anomaly Report WC-4) contains anomalous zinc, tungsten, uranium, chromium, and arsenic in stream sediments. The area is underlain by a strong magnetic high, which may be related to a syenite intrusive exposed in the Clark Fork river valley. Five mines in the Vermillion River (Silver Butte) District operated sporadically in the area, and the stream-sediment anomalies are suspected to be related to these activities. The locality is considered marginal.

The Bend Ranger Station locality (App. C, Anomaly Report WC-6) contains anomalous uranium and zinc, and has no significant radiometric or magnetic features in the NURE data. A large part of the area is covered by glacial sediments, and the provenance of the anomalous stream sediments is not known. The locality is considered marginal.

The Keystone reference locality (App. C, Anomaly Report WC-10) is on the Lewis and Clark trend and is east-southeast of the Wallace-Mullan and Murray reference localities (See Pl. 85). This locality exhibits anomalous zinc, lead, copper, cadmium, bismuth, arsenic, antimony, uranium, tungsten, silver, and cesium in stream sediments. Factor 3 (lead, zinc, and copper) and Factor 4 (potassium, hafnium, rubidium, and strontium) are moderate to strong in the area. Two low-intensity magnetic highs occur in the western part of the area. Major east-southeast-trending faults cut Belt rocks in the area. Host rocks of vein-type deposits in the area are the Piegan and Ravalli groups. The area covers the Keystone, Iron Mountain, and part of the Nine-Mile Creek Mining Districts. Stream-sediment anomalies are suspected to be related to the several known mineral occurrences in the area.

The following localities resemble the Keystone reference locality; all are considered marginal.

The Boyd Mountain-Newman Peak area (App. C, Anomaly Report WC-8) exhibits anomalous zinc, uranium, tungsten, and nickel in stream sediments and has weak factor scores; it is underlain by a magnetic low. The Camels Hump area (App. C, Anomaly Report WC-9) exhibits anomalous zinc, uranium, and nickel and weak factor scores; it is underlain by a magnetic low. The Tarkio area (App. C, Anomaly Report WC-14) exhibits anomalous uranium, tungsten, gold, chromium, and chlorine in stream sediments; has weak to moderate factor 2 scores; and is on the flank of a moderate magnetic high.

Delineated anomalous localities for this environment that are known to contain hydrothermal base-metal (copper, lead, and zinc) and precious-metal (gold, silver, arsenic, antimony, and tungsten) deposits appear to meet common recognition criteria in the NURE data. The Wallace-Mullan, Murray, and Keystone reference localities all contain anomalous levels of zinc, lead, copper, silver, and antimony. These localities are also characterized by the presence of magnetic highs, either coinciding with intrusive crystalline rocks or suspected to be related to shallow intrusive rocks. These localities are all extensively faulted. Coincidence of these characteristics in a locality may represent a favorable setting for mineral resources. The absence of one or more of these characteristics is assumed to represent less potential for mineral resources. The Vermillion Peak-Moose Peak locality is categorized as a follow-up locality on the basis of its unusually anomalous uranium signature. The other localities delineated for this environment are considered marginal for the occurrence of deposits like those in the reference localities.

STRATA-BOUND DISSEMINATED SULFIDE DEPOSITS

Eight marginal localities representing this environment were delineated in the project area. Collectively, but not individually, these localities may represent not only the strata-bound disseminated sulfide deposits but also, in some instances, quartz-carbonate, copper-bearing, vein-type deposits in green beds. On the basis of NURE HSSR data, these two types of deposits are essentially indistinguishable in this project area. Stream sediments collected from provenances containing both types of deposits are somewhat homogeneous and may represent mineral enrichment from either or both deposit types.

The central part of the Choteau Quadrangle and areas bordering the Wallace and Choteau Quadrangles are known to contain strata-bound copper deposits and copper-bearing, vein-type deposits. (See Earhart and others, 1981.) NURE data recognition criteria for these deposit areas are not discrete. Stream sediments collected from the eight delineated localities contain anomalous zinc concentrations of 100 to 500 ppm. Anomalous uranium concentrations were not always present in stream sediments; anomalous copper concentrations were not detected. No significant aerial radiometric or aeromagnetic signatures are associated with these localities.

Localities delineated for this environment include Ronan, Swan Lake, Gyp Mountain, Lookout Mountain, Sheep Mountain, Burn Top Mountain, Blanchard Creek, and Omar Mountain. The areas are shown on Plate 85, and their characteristics are described in Anomaly Reports WC-12, WC-15, WC-16, WC-17, WC-18, WC-19, WC-20, and WC-21, respectively (App. C). These localities are designated marginal because they lack strong NURE signatures; however, Gyp Mountain and Sheep Mountain are noteworthy.

The Gyp Mountain locality (App. C, Anomaly Report WC-16) exhibits interesting geochemical features. Stream waters in this area contain 2 to 20 ppb molybdenum and moderate to high molybdenum-to-conductivity ratios. Stream sediments contain 20 to 50 ppm uranium, 5 to 23 ppm residual uranium, 200 to 500 ppm zinc, and 2,000 to 5,000 ppm barium. Stream-sediment factor 4 (manganese and calcium) is strong in drainages of the area. This locality has potential for not only strata-bound sulfides, but also quartz-carbonate-barite vein deposits. The source of the uranium in this locality is unknown.

The Sheep Mountain locality (App. C, Anomaly Report WC-18) contains 2 to 10 ppb uranium, moderate to high uranium-to-conductivity ratios, and 2 to 20 ppb molybdenum in stream waters. Stream sediments contain 5 to 20 ppm chromium and 200 to 500 ppm zinc. Aerial radiometric and aeromagnetic features of this locality are nondescript. The source of molybdenum and uranium is unknown. Chromium may be a natural component of the green beds in this locality.

LEAD, ZINC, SILVER, AND COPPER SULFIDE REPLACEMENT ORES AT THE CONTACTS OF TERTIARY VOLCANIC ROCKS

One reference locality was delineated for this environment. The Hubbart Reservoir reference locality (App. C, Anomaly Report WC-7) contains anomalous zinc, tungsten, strontium, nickel, copper, cobalt, bismuth, arsenic, and antimony in stream sediments. Aerial radiometric potassium is high over the volcanic latites, and the area is underlain by a broad magnetic low that may indicate altered intrusive rocks. Strontium, cobalt, and nickel in stream sediments may represent the latites; tin, copper, bismuth, arsenic, and antimony in stream sediments may represent vein-type deposits of sulfide minerals. The locality contains the Hog Heaven Mining District. Mines in this locality are in flows, dikes, and plugs of latite, as well as in argillites of the Ravalli Group. No other similar localities were recognized in this study.

PORPHYRY DEPOSITS AND ASSOCIATED VEIN DEPOSITS

The Rogers Pass reference locality (App. C, Anomaly Report WC-23) is known to contain copper and molybdenum associated with igneous intrusive rocks (porphyritic monzonites). The area also is known to contain hydrothermal base-metal (lead, zinc, and copper) and precious-metal (silver, gold, arsenic, antimony, and tungsten) vein-type deposits. Some diorite sills in this area are also mineralized with copper and may represent the quartz-carbonate, copper-bearing, vein-type deposits of Mudge and others (1974).

This complexly mineralized area exhibits complex geochemical characteristics and meets the following recognition criteria. Stream sediments contain anomalous lead, copper, zinc, cadmium, arsenic, tungsten, as well as iron, titanium, cobalt, and vanadium. Stream-sediment factors 1 through 5 are particularly strong in the area. The coincidence of these factors along the Blackfoot River suggests conditions favorable for gold-bearing and heavy-mineral placers. Aerial radiometric equivalent uranium values of 2 to 7 ppm occur near the contacts of intrusive granodiorite dikes and Precambrian rocks of the Spokane Formation in the western part of the locality. Aeromagnetic data show the center of this locality to be underlain by a magnetic low and the northeastern quarter of the area to be on a steep magnetic gradient. The Wolf Creek Thrust cuts the northeastern corner of the area. The portion of the area south and west of this thrust is heavily faulted.

The complex geochemical signature of the Rogers Pass reference locality is similar in many respects to the Pipestone Pass region and the North Boulder, Treasure Mountain, Lincoln, and Marysville localities delineated by Madson and others (1983) in the Butte Quadrangle; these localities also contain complex deposit types related to mineralized Precambrian metasedimentary rocks and crystalline intrusive rocks. The Rogers Pass reference locality is on a structural trend that strikes east-southeast into the Lincoln and Marysville areas of the Butte Quadrangle.

The Echo Mountain follow-up locality (App. C, Anomaly Report WC-22) is similar in many respects to the Rogers Pass reference locality. Stream sediments in this area contain anomalous copper, zinc, barium, arsenic and antimony, cobalt, iron, titanium, selenium, and vanadium and highly anomalous uranium (20 to 100 ppm). Residual uranium up to 35 ppm also occurs in stream sediments. Stream waters in the north-central part of the area contain anomalous molybdenum (20 to 50 ppb) and high molybdenum-to-conductivity ratios. Molybdenum, copper, and uranium anomalies in stream sediments coincide with, and are spatially related to, Cretaceous intrusive dikes. Sediment samples from Meadow Creek exhibit coincident factor 2 (vanadium, cobalt, and titanium), factor 3 (uranium and barium), factor 4 (manganese and calcium), and factor 5 (hafnium and zirconium). This coincidence suggests a favorable environment for the occurrence of placer deposits.

Aerial radiometric equivalent uranium values of 2 to 6 ppm were detected over the contact of Cretaceous dikes with the metasedimentary rocks of the Spokane Formation. These radiometric values are spatially related to uranium anomalies in stream sediments. Aeromagnetic features show the area to be on the south flank of a moderately intense magnetic high and suggest the presence of buried intrusive rocks. The magnetic features are continuous into the Rogers Pass reference locality.

Many inactive base- and precious-metal mines and prospects are known in this area. None, however, are known to contain uranium.

The Echo Mountain locality is recommended for follow-up work on the basis of the highly anomalous uranium that may be concentrated in polymetallic vein-type deposits in Precambrian metasedimentary rocks near the margins of Cretaceous intrusive dikes.

TITANIFEROUS MAGNETITE DEPOSITS

Titaniferous magnetite-bearing placers of Cretaceous age occur as fossil placers in the northeastern part of the Choteau Quadrangle. These deposits could not be identified or delineated by NURE data used in this study. Failure to detect the deposits during the HSSR study may be a result of the narrow outcrop pattern of the Virgelle Sandstone and the wide spacing of HSSR sample sites. Contoured magnetic data show large features that probably represent basement rock in the area and not the thinly bedded fossil placers.

In some cases, radioelement values show slight increases over background values along flight lines that cross mapped outcrops of the Virgelle Sandstone; however, the significance of these slight increases is unknown.

GOLD-BEARING PLACERS

Several reference localities and other localities that have been discussed earlier in this report have potential for gold-bearing placer deposits. Low concentrations of gold have been detected in the NURE stream-sediment analytical data for the Echo Mountain, Sheep Mountain, Boyd Mountain-Newman Peak, and Tarkio areas. A single point anomaly in the western part of the Lookout Mountain area is also anomalous. Gold in placers along Nine-Mile Creek in the Keystone reference locality was not detected in the NURE data, nor was gold detected in suspected placers along the Blackfoot River in the Rogers Pass reference locality.

Within the NURE HSSR data, placer-deposit areas show concentrations of elements that indicate resistate minerals. Anomalous concentrations of rare-earth elements and anomalous niobium, tantalum, hafnium, iron, magnesium, vanadium, scandium, and titanium in stream sediments have been demonstrated as a practical guide to the recognition of placer deposits in the Elk City, Idaho, area by Madson and others (1983). The presence of precious metals in sediments recovered from placer-deposit areas is commonly indicated in the NURE data; however, absence of these metals in sediments collected may not imply less favorability. Gold analyses of sediments recovered from resistate-bearing placers are subject to error because of nuggeting effects and should be interpreted cautiously. Of the localities in this study area considered to have potential for gold-bearing placers, the Trout Creek locality has the highest confidence. Paucity of data for other areas previously mentioned does not allow their evaluation for this deposit type.

Three stream-sediment samples from the Trout Creek locality (App. C, Anomaly Report WC-24) contain anomalous gold. The gold content of these samples ranges from 0.1 ppm to more than 5 ppm. Aerial radiometric and aeromagnetic features of the area are nondescript and the area is structurally simple. The Amador Mine, Cedar Creek placers, and Trout Creek placers have all produced gold (see Pl. 1 and 3). The Amador Mine contains lead, zinc, copper, and gold in quartz veins cutting Precambrian argillites of the Wallace Formation. The lead, zinc, and copper content of stream sediments in upper Trout Creek and upper Cedar Creek indicates that the sediments may have been at least partially derived from a similar source. The presence of anomalous gold and accumulations of rare-earth-element resistates and mafic resistates in these sediments suggest that additional placer deposits may exist; consequently, the area is recommended for follow-up work.

OTHER ENVIRONMENTS

Two unusual mineralized environments were also delineated in this study. Both the Perma (App. C, Anomaly Report WC-11) and the Little North Fork localities (App. C, Anomaly Report WC-13) are categorized as marginal localities.

The Perma locality is mostly in the Seepay Creek Mining District. Mineral deposits (copper, lead, and zinc) in this inactive district are essentially restricted to quartz-filled veins and fissures cutting massive gabbro sills of Precambrian age. These sills are emplaced in metasedimentary argillites of the Prichard Formation. Stream sediments from the area contain anomalous levels of zinc, uranium, nickel, and total rare earths. The nickel may be derived from the gabbroic rocks, and the zinc and uranium may be inherent in strata-bound deposits in the Prichard Formation or in the quartz veins in the area. The rare earths have no nearby source and may represent detrital accumulations related to Pleistocene glaciation or fossil placers.

The Little North Fork locality contains granitic intrusive rocks of Cretaceous age, a large syenite body, and metasediments of the Prichard Formation. Stream sediments from this area contain anomalous calcium (2 to 5 percent), sodium (0.5 to 5 percent), and strontium (500 to 1,000 ppm), all of which are interpreted to be related to the syenite body. The granitic intrusive rocks are represented in stream sediments by elevated zirconium and hafnium. Low levels of zinc, uranium, vanadium, cobalt, tungsten, and bismuth may be related either to background of the Prichard Formation or vein-type occurrences near the margins of intrusive rocks, or both. The calcium-sodium-strontium signature in stream sediments of this locality justifies consideration of this elemental association as an indicator of syenitic rocks.

CONCLUSIONS

NURE data were used successfully in this study to recognize and delineate 24 localities containing specific mineralized environments in the Wallace and Choteau Quadrangles. The methods of data analysis and interpretation developed during the NURE program for the recognition of uranium resources are also applicable to other metallic commodities.

The NURE data set most useful in this study was the reconnaissance-scale stream-sediment analytical data. Anomalous concentrations of elements and elemental associations in stream sediments from certain localities are direct indicators of local mineralized environments. Several of the localities delineated in this study are, or have been, active mining areas. In these areas, the separation of mining-related contaminants from natural ore contaminants in stream sediments cannot be performed by NURE stream-sediment data. Nearly all known mining districts in the project area are indicated by anomalous stream-sediment characteristics.

Aerial radiometric and aeromagnetic data were used in conjunction with stream-sediment data to describe the geologic setting and characteristics of mineralized environments in delineated localities.

Recognition criteria were developed from NURE data for several mineralized environments in the project area. The most discrete criteria are those described in this report for the Coeur d'Alene type deposits in the Wallace-Mullan, Murray, and Keystone reference localities. Those criteria can be used to recognize other localities with potential for similar deposits. Less discrete criteria were also described for porphyry-type, strata-bound, and vein-type deposits related to intrusive and extrusive rocks.

Three of the 24 localities delineated in this study are considered by the authors to have potential for new or additional mineral resources. The geochemical and geophysical characteristics of the Vermillion Peak-Moose Peak and Echo Mountain localities suggest they are favorable for uranium-bearing, base- or precious-metal, vein-type deposits. The Trout Creek locality has potential for additional gold-bearing placer deposits. The NURE data characteristics of these three areas are sufficiently interesting to warrant further investigation.

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Plate 85. Index to Reference Localities and Anomalous Areas