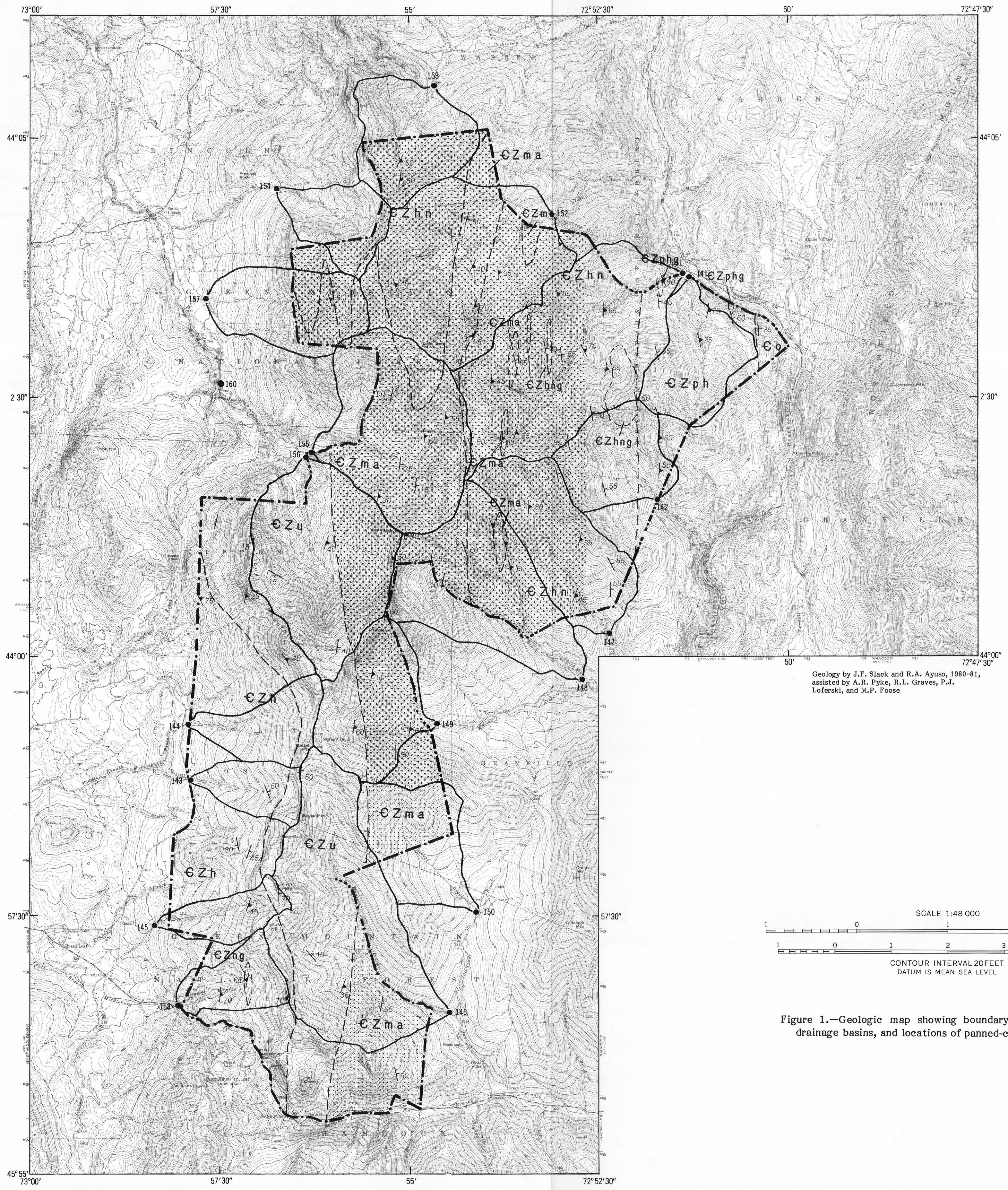

Geology by J.F. Slack and R.A. Ayuso, 1980-81, assisted by A.R. Pyke, R.L. Graves, P.J. Loferski, and M.F. Fouse

Base from U.S. Geological Survey, 1:24,000 Bread Loaf, 1970; Lincoln, 1970; and Warren, 1970

SCALE 1:48 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Figure 1.—Geologic map showing boundary of the study area, drainage basins, and locations of panned-concentrate samples.

DESCRIPTION OF MAP UNITS

€o — **Ottauquechee Formation (Middle and Late Cambrian)**—Quartz-muscovite phyllite and interbedded quartzite (locally carbonaceous)

€Zph, €Zphg — **Pinney Hollow Formation (Late Proterozoic and (or) Early Cambrian)**—Noncarbonaceous quartzose schist and quartz-muscovite-albite-chlorite schist. Locally interbedded are thin lenses of greenstone (€Zphg)

€Zhng, €Zhn, €Zhnm — **Hazens Notch Formation (Late Proterozoic and (or) Early Cambrian)**—Carbonaceous quartz-muscovite schist and interbedded noncarbonaceous albitic schist. Disseminated sulfides are common in the noncarbonaceous schist. Small lenses of greenstone (€Zhng) and one large body of metagabbro (€Zhnm) are present locally

€Zma — **Mount Abraham Schist (Late Proterozoic and (or) Early Cambrian)**—Silvery micaceous schist characterized by abundant white mica (chiefly paragonite), minor chlorite, and tiny, greenish-black grains (smaller than 0.1 in.) of chloritoid. Coarse (1-in.) porphyroblasts of magnetite are common in some outcrops

€Zu — **Underhill Formation (Late Proterozoic and (or) Early Cambrian)**—Quartz-mica schist and gneiss locally containing abundant albite and chlorite

€Zhg, €Zh — **Hoosac Formation (Late Proterozoic and (or) Early Cambrian)**—Quartz-mica-albite-chlorite schist containing distinctive albite porphyroblasts. Interbedded greenstone (€Zhg) present in one area

EXPLANATION OF MAP SYMBOLS

Area having low to moderate mineral-resource potential for volcanogenic massive-sulfide deposits of copper, lead, and zinc

Area having low mineral-resource potential for volcanogenic massive-sulfide deposits of copper, lead, and zinc

Contact—Dashed where approximate, queried where uncertain

149 Outline of stream drainage basin—Shows sample locality (dot) and sample number

Boundary of Bread Loaf Roadless Area

15 Strike and dip of inclined bedding

Strike and dip of vertical bedding

55 Strike and dip of inclined foliation

Studies Related To Wilderness

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. 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. This report presents the results of a geochemical survey of the Bread Loaf Roadless Area, Addison and Washington Counties, Vermont.

Introduction

A geochemical survey of bedrock samples in the Bread Loaf Roadless Area (index map; fig. 1) was conducted by the U.S. Geological Survey (USGS) during October, 1981 in order to outline areas that may contain undiscovered mineral deposits. This report describes the results of a geochemical analysis of panned concentrates collected from stream sediments, and complements other geologic and geochemical investigations of the area (Slack and Bitar, 1983). The present study has offered us a chance to identify sampling media and a technique most appropriate for the enhancement of certain metallic elements in samples of panned concentrate. This study is important to the resource evaluation of the Bread Loaf Roadless Area because it reveals that geochemical anomalies produced by this technique are not evident in the standard magnetic and nonmagnetic fractions of panned concentrates.

Field and Laboratory Methods

Approximately 2-3 gallons of stream deposits were panned from each of 18 streams and from one outcrop of glacial outwash (sample 160) (fig. 1). These large amounts of material were panned to provide sufficient quantities of heavy minerals for a series of geochemical analyses of multiple fractions. The panning procedure consisted of screening 2-3 gallons of sediment with a no. 14 stainless-steel U.S. Standard Sieve to remove oversized material, removal by washing of the clay-sized particles, and panning of the remaining fraction to obtain a 60 to 70 percent heavy-mineral concentrate.

Panned-concentrate samples were processed by sieving, heavy-liquid separation, and use of a Frantz[1] isodynamic magnetic separator. The separation procedure is shown schematically in figure 2. The first laboratory treatment step was to remove coarse-grained material using a no. 16 stainless steel U.S. Standard Sieve. The >16-mesh fraction from this screening, consisting of larger rock fragments and of smaller polymineralic grains was not analyzed. The remaining <16-mesh fraction of each sample was then treated with bromoform to separate the >2.85 specific gravity (sp gr) fraction from the <2.85 fraction. A split of the heavy fraction was taken following the bromoform separation and separated at 0.5 ampere into magnetic and nonmagnetic fractions. The magnetic, nonmagnetic, and light <16 mesh (sp gr <2.85) fractions were submitted for analysis; the results are presented in table 1 as fractions 1, 2, and 3, respectively. The remaining split of the <16-mesh heavy-mineral fraction with >2.85 sp gr was treated to remove its highly magnetic subfraction with a hand-held magnet (fraction 5, table 1). The less magnetic fraction of the heavy minerals was screened with a no. 60 stainless-steel sieve. The >60-mesh fraction was submitted for analysis (fraction 4, table 1). The <60-mesh fraction was further separated into magnetic subfractions (0.0-0.5 ampere, 0.5-1.0 ampere, and 1.0 ampere). In order to reduce the number of mineral species in the heavy-mineral subfractions, the 0.0-0.5 ampere magnetic subfraction was further separated in methylene iodide (sp gr >3.25) and the resulting separates were also submitted for analysis. In table 1, the 0.0-0.5 ampere (sp gr <3.25) fraction is labeled 6, the 0.0-0.5 ampere (sp gr >3.25) fraction is 7, the 0.5-1.0 ampere (sp gr >2.85) fraction is 8, and the >1.0 ampere (sp gr >2.85) is 9.

The minerals of the panned concentrates are basically the same; geochemical variation between sample sites is mostly a function of the relative amounts of different minerals at each site. The heavy-mineral fraction from all the sample sites is dominated by chlorite minerals and by weathered magnetite. Other minerals, constituting variable percentages of the assemblage, include tourmaline, garnet, epidote, sillimanite, leucoxene, apatite, zircon, rutile, limonite, ilmenite, amphibole-group minerals, monazite, muscovite, and polymineralic grains. The presence of sillimanite in the heavy-mineral assemblages is anomalous in the study area. Inasmuch as the metamorphic grade of the rocks in this area is such that sillimanite is precluded, it is certain that the mineral was introduced into the area, probably by glacial processes.

Analytical Techniques

Each sample was analyzed semiquantitatively for 31 elements by a visual six-step direct-current-arc, optical-emission spectrographic method (Grimes and Marranzino, 1968) by S.J. Sutley and B.M. Adrian (USGS). Analyses for gold, copper, lead, zinc, and uranium were performed by quantitative atomic-absorption techniques (Ward and others, 1969), by B. Kelley, R. Martin, A. Mantei, D. Galland, and R.B. Vaughn (USGS). The semiquantitative spectrographic values are reported as six steps per order of magnitude (0.1, 0.15, 0.2, 0.3, 0.5, 0.7, or multiples of 10 of these numbers) and are approximately geometric midpoints of the concentration ranges. The precision is shown to be within one adjoining reporting interval on each side of the reported value 83 percent of the time and within two adjoining intervals 96 percent of the time (Motooka and Grimes, 1976).

The chemical analyses of the samples are shown in table 1. The geographic location of each sample site is given by X and Y coordinates of the Universal Transverse Mercator (UTM) grid, zone 18. The X coordinate is the easting value; the Y is the northing (the last number, 0, of the northing values was deleted for computer-programming convenience). Symbols used include: <, less than lower limit of determination; >, greater than the upper limit of determination; aa, atomic absorption analysis; N, not detected at limit of detection; and —, not analyzed. The limits apply under ideal conditions; in some cases, interferences narrow the limits. All data are in parts per million (ppm) except where indicated in percent (pct). Note that, in table 1, the lower limits of determination are greater for magnetic fractions 1 and 2 than they are for fractions 3 through 9. Elements looked for spectrographically but not found and their lower limit of determination (in parentheses) are: arsenic (500); gold (20); bismuth (20); cadmium (50); molybdenum (10), except sample splits 157-7, 141-8, 152-8, and 160-8 reported to contain detectable molybdenum but less than 5 ppm the limit of determination, and 151-9 reported to contain 7 ppm molybdenum; antimony (100); and tungsten (50).

The semiquantitative spectrographic values for zinc in the magnetic fraction (1 in table 1) are substantially higher (up to 10 times) than the atomic absorption (AA) values. The reason for this is the inability of routine acid digestion to attack the magnetite matrix; therefore, if zinc is not detectable spectrographically in a panned-concentrate sample, it more than likely is not present at meaningful levels (R.W. Leinz, USGS, written commun., 1982). In addition, strontium, beryllium, and scandium values at detection limit are subject to question due to high background.

Geochemical Evaluation

To evaluate the geochemical data, several methods of approach were used. First, the data were visually inspected for isolated occurrences, high values, and correlations between other elements or samples. Second, histograms constructed for selected chemical elements (fig. 3) were examined for outliers in the distribution. To test for the occurrence of geochemical patterns for an element or group of elements, a threshold corresponding to two standard deviations above the mean (Lepeltier, 1969) was arbitrarily chosen. The mean and standard deviation were calculated for only those values that were not qualified by "<", ">", or by "N".

Values of individual analytical fractions for barium, boron, copper, cobalt, chromium, zinc, uranium, nickel, gold, thorium, and tin were plotted in the appropriate drainage basins for all samples (fig. 4). These elements were selected because their presence in stream sediments may be related to undiscovered mineral deposits, based on known deposits in rocks similar in type and age to those exposed in the study area. Visual examination of the plots for barium, copper, lead, zinc, and nickel reveals a distribution possibly indicative of anomalous mineralization; high values for these elements are systematically clustered in adjoining drainage basins in the northern part of the study area as shown in figure 5 (fig. 5 is derived from fig. 4). High values for other elements are scattered and probably are not associated with significant mineralizing processes. For comparison, cumulative statistics for 66 stream-sediment samples taken from the drainage basins are given in table 1.

This study has demonstrated that the use of density and magnetically produced separates for enhancement of metal anomalies is at least partially successful. Several magnetic subfractions (table 1) show enhanced concentrations, especially fraction 3 (gold); fraction 5 (iron and vanadium); fraction 6 (copper, lead, zinc, and nickel); fraction 7 (lead, molybdenum, and copper); fraction 8 (boron, barium, beryllium, cobalt, copper, lanthanum, niobium, lead, strontium, yttrium, thorium, zinc, and uranium); and fraction 9 (boron, barium, cobalt, chromium, tin, zirconium, AA copper, and AA lead). Most element concentrations in the various magnetic and density subfractions are accounted for by the heavy minerals present in each subfraction (e.g., magnetite in fraction 5, monazite in fraction 8, cassiterite in fraction 9). The presence of gold in fraction 3 (bromoform float) is more difficult to explain, however; it is possible that the gold is very fine grained and included in grains of quartz but it is more likely that these values which are at the lower limit of analytical detection for the method are due to interference or operator bias.

High concentrations of most analyzed elements are also present in the concentrate from the glacial outwash sediment. This raises the possibility of contamination by glacially derived material. No method exists which distinguishes glacial sediment from stream sediment. To resolve the nature and extent of such contamination, a suite of concentrates from the area to the north of the study area and surrounding the path of the advancing glacier should be taken. Another possible means for evaluating this potential contamination is to sample major drainage basins at higher elevations, where glacially derived detritus has not been deposited, or has been removed by erosion.

The pattern of anomalies in the drainage basins at the northern end of the study area is in general agreement with anomalies defined by rock, soil, and stream-sediment samples (Slack and Bitar, 1983).

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Motooka, J.M., and Grimes, D.J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analysis: U.S. Geological Survey Circular 738, 25 p.

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[1]The use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

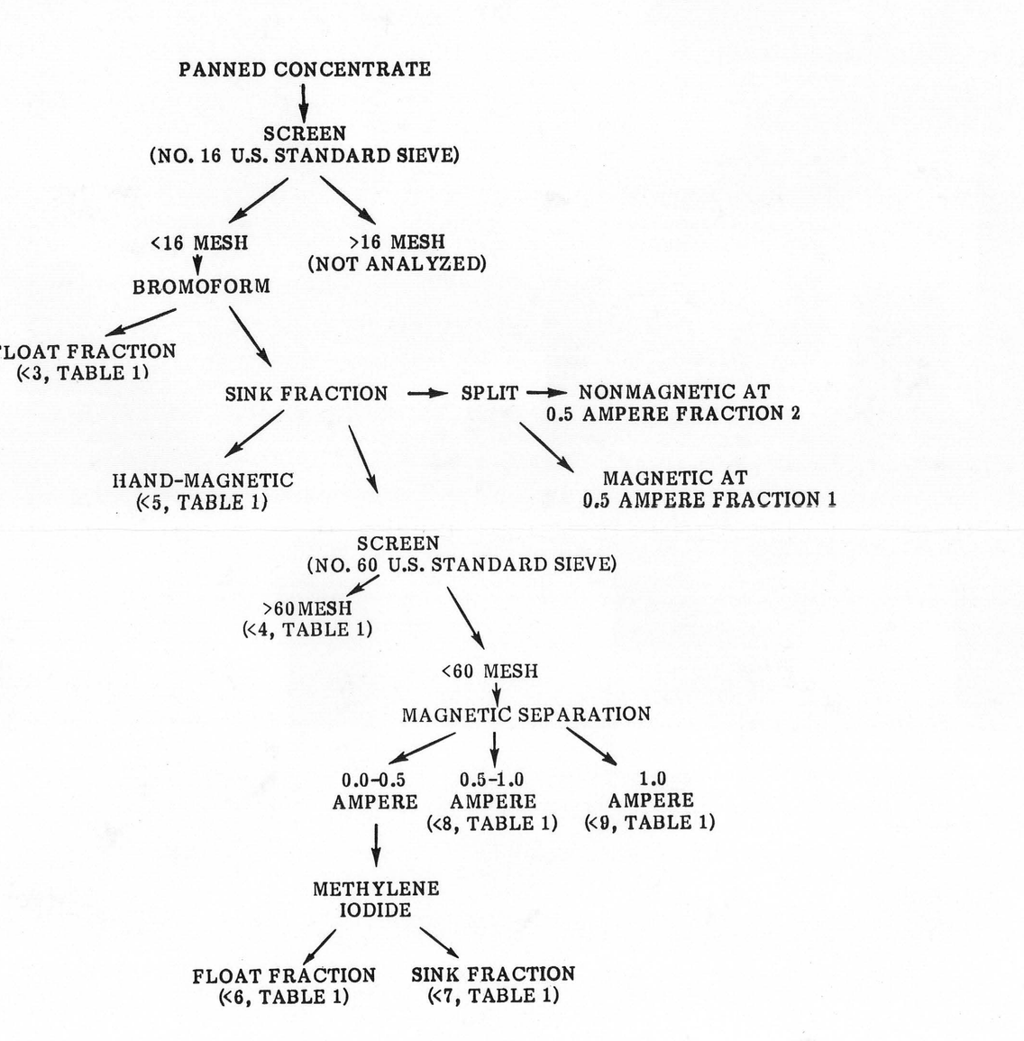


Figure 2.—Schematic diagram showing heavy-mineral separation procedure.

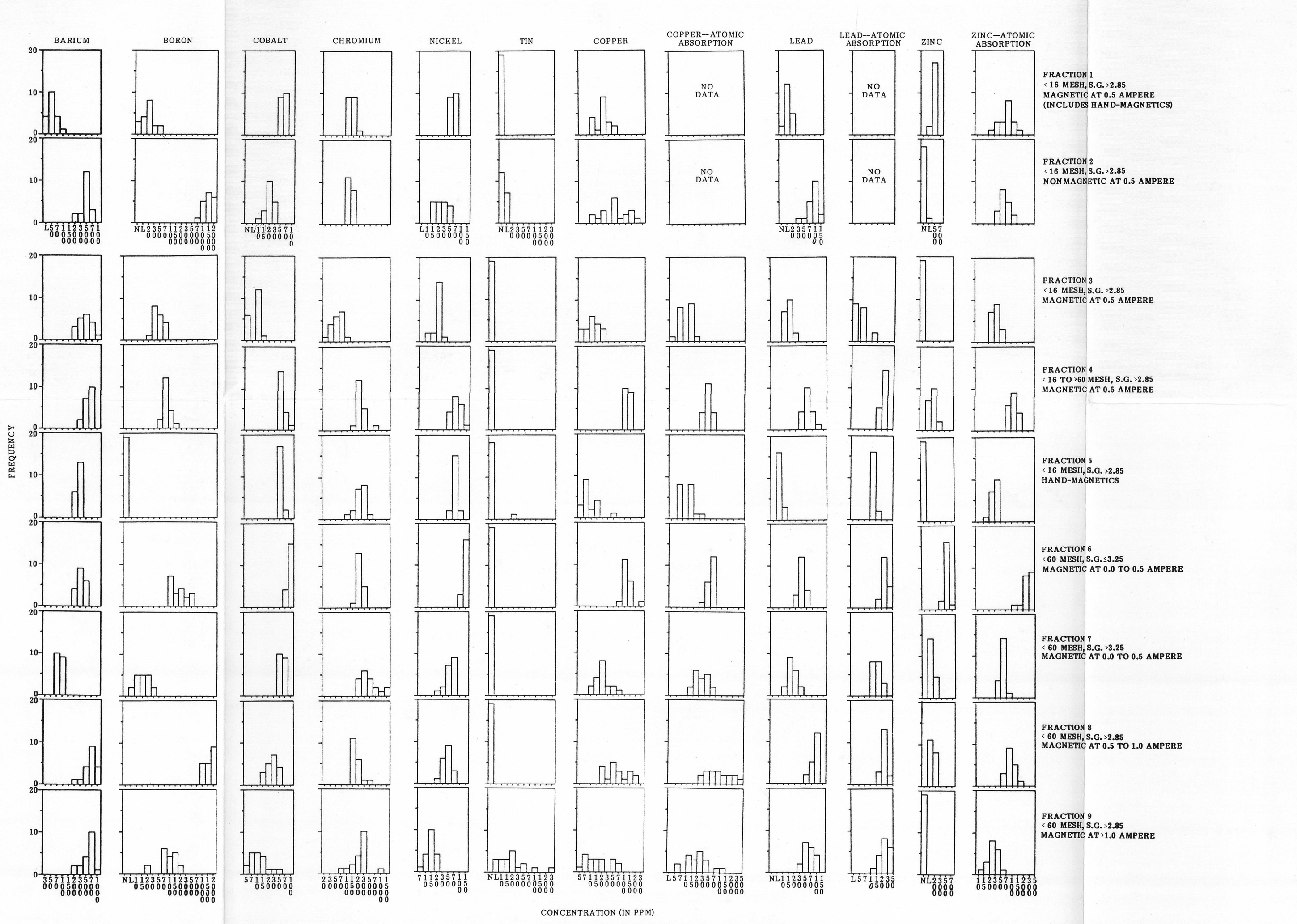


Figure 3.—Histograms showing the distribution of selected elements in 19 panned-concentrate samples.

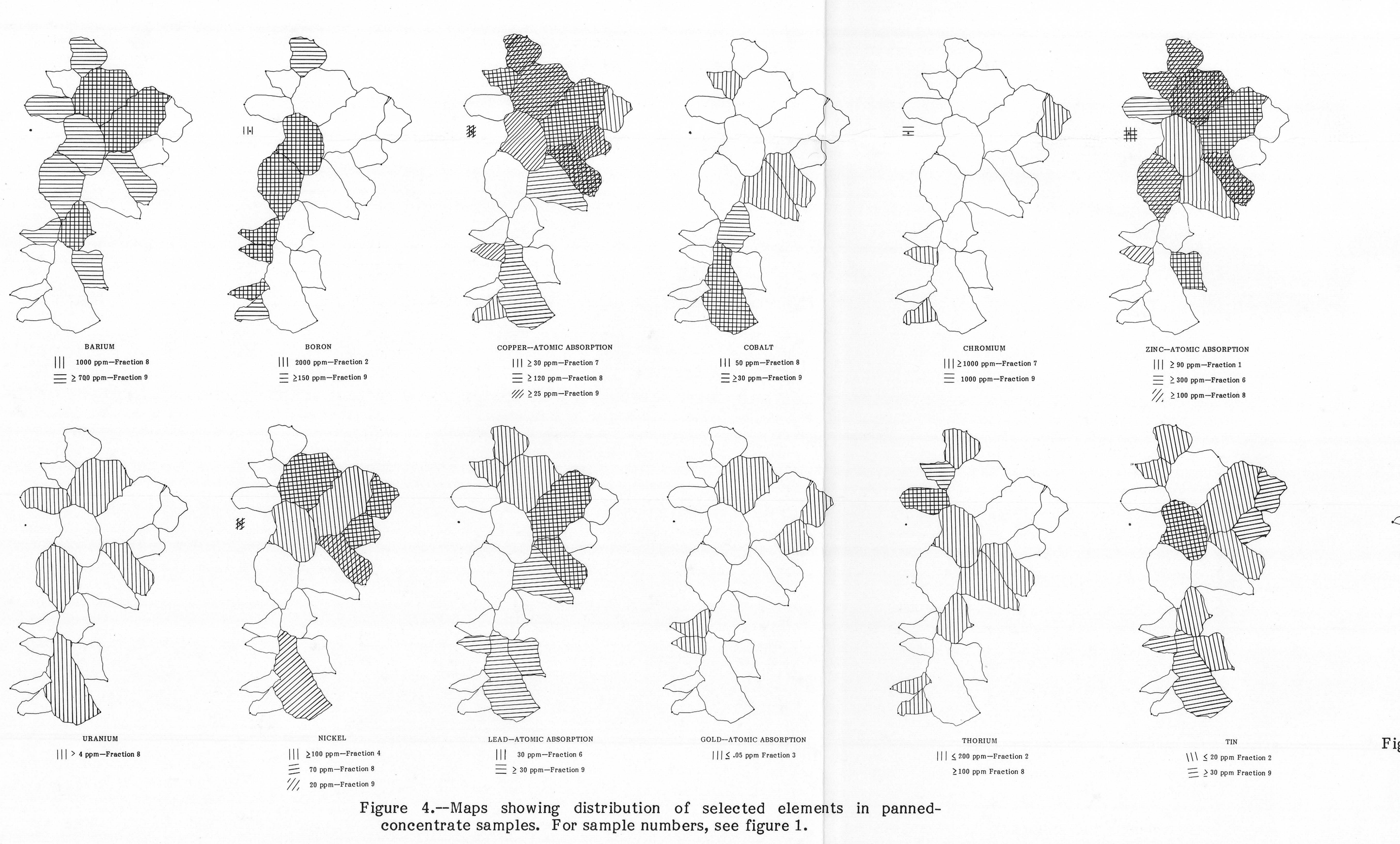


Figure 4.—Maps showing distribution of selected elements in panned-concentrate samples. For sample numbers, see figure 1.

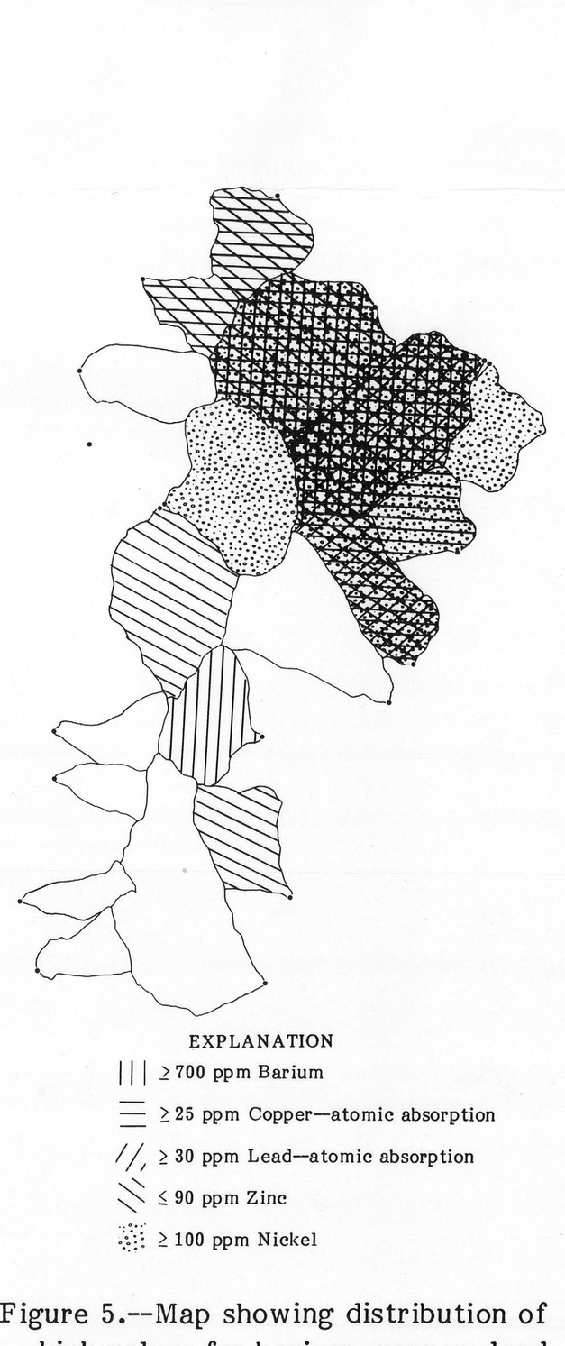
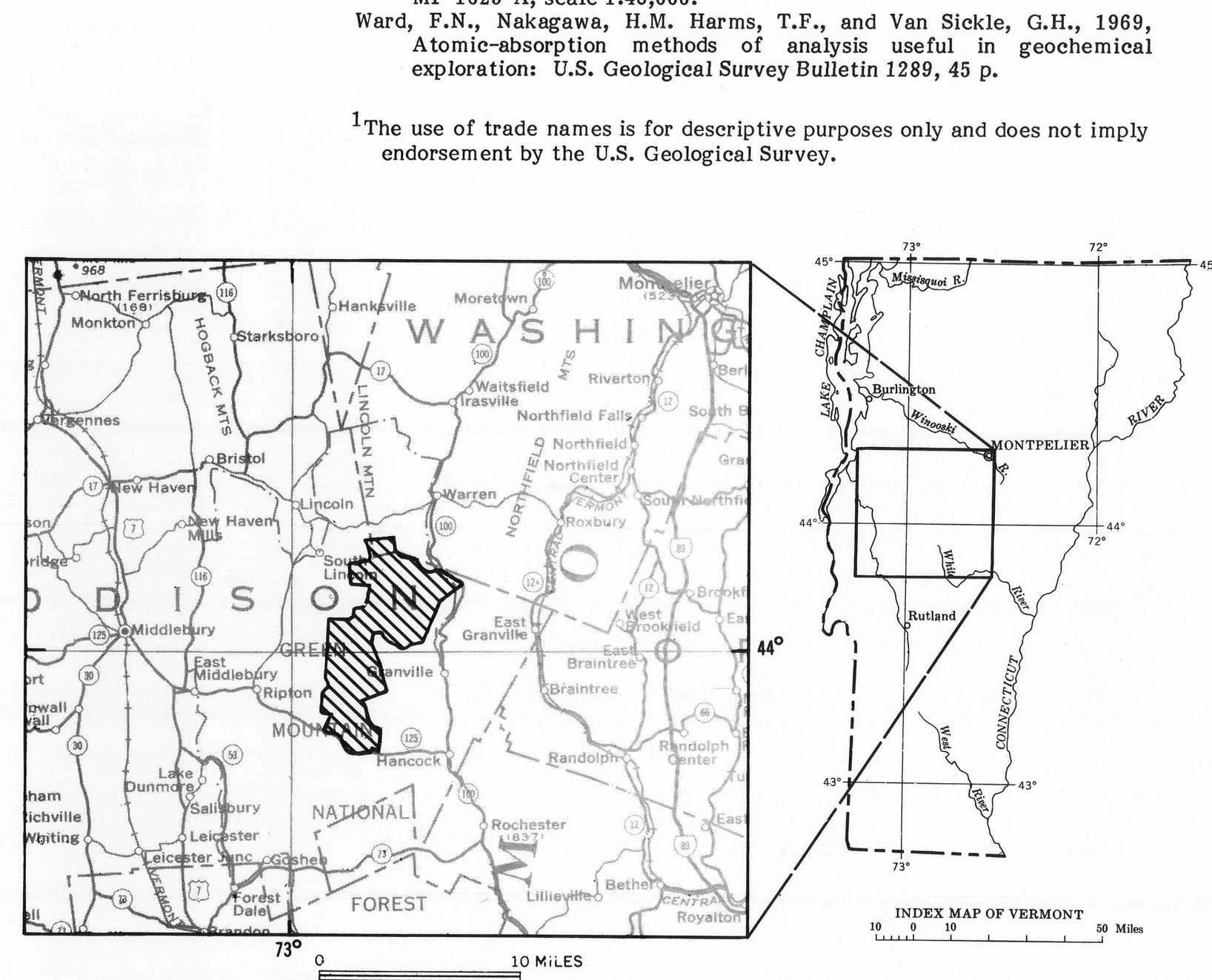


Figure 5.—Map showing distribution of high values for barium, copper, lead, zinc, and nickel. For sample numbers, see figure 1.



Index map showing location of Bread Loaf Roadless Area.

Table 1.—*Analyses of panned-concentrate samples. All analyses were by semiquantitative spectrographic analysis (s)[1] except for gold, copper, lead, and zinc which were analyzed by atomic absorption methods (aa), or uranium which was analyzed by instrumental methods (INST).*

FRACTION 1 <16 MESH, S.G.>2.85 MAGNETIC AT 0.5 AMPERE (INCLUDES HAND-MAGNETICS)

Sample	X coordinate	Y coordinate	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Cu-ppm aa	Pb-ppm aa	Zn-ppm aa	U-INST
141-1	671,790	880,720	50	.2	.10	1	1,500	N	N	<50	N	50	200	20	N	N	50	<20	10	N	N	500	30	500	50	N	--	--	--	20	--
142-1	671,320	876,680	>50	.2	.10	1	1,500	N	N	<50	N	70	100	15	N	N	70	N	15	N	N	700	30	500	50	N	--	--	--	35	--
143-1	663,230	871,460	>50	.2	<.10	2	2,000	N	<20	<50	N	50	100	10	N	<50	50	<20	15	N	N	300	30	<500	70	N	--	--	--	45	--
144-1	663,110	872,460	50	.3	.10	>2	3,000	N	20	50	N	50	100	20	N	50	50	N	15	N	N	200	100	500	70	N	--	--	--	55	--
145-1	662,680	868,770	50	.3	.15	>2	2,000	N	<20	50	N	50	150	10	N	50	50	<20	15	N	N	200	150	500	50	N	--	--	--	50	--
146-1	667,750	867,390	50	.3	.10	2	2,000	N	20	50	N	50	100	10	N	50	50	<20	15	N	N	200	100	500	70	N	--	--	--	65	--
147-1	670,550	874,290	50	.5	.10	>2	5,000	N	20	70	N	70	100	20	N	50	70	<20	20	N	N	200	100	500	50	N	--	--	--	90	--
148-1	670,080	873,420	50	1.0	.10	2	5,000	N	20	100	N	70	100	30	N	50	70	<20	20	N	N	200	150	500	70	N	--	--	--	95	--
149-1	667,510	872,560	50	1.0	.10	>2	5,000	N	<20	70	N	50	150	20	N	50	70	<20	20	N	N	200	150	500	70	N	--	--	--	95	--
150-1	668,280	869,250	50	.5	.15	>2	3,000	N	20	50	N	50	100	20	N	50	50	20	15	N	N	200	70	500	70	N	--	--	--	110	--
151-1	671,670	880,730	30	1.0	.10	>2	5,000	N	30	70	N	50	150	30	N	50	50	20	15	N	N	150	100	500	100	N	--	--	--	100	--
152-1	669,360	881,730	50	.7	<.10	2	5,000	N	20	50	N	50	150	20	N	<50	70	20	15	N	N	150	70	500	70	N	--	--	--	115	--
153-1	667,170	883,940	50	.7	.10	>2	7,000	N	20	50	N	70	100	20	N	50	70	20	15	N	N	200	100	500	100	N	--	--	--	95	--
154-1	664,460	882,060	50	1.0	.15	>2	7,000	N	20	50	N	70	150	50	N	50	70	<20	15	N	N	150	200	500	70	N	--	--	--	85	--
155-1	665,190	877,360	30	1.0	.20	>2	5,000	N	50	50	N	70	150	30	N	50	70	<20	15	N	N	150	100	500	70	N	--	--	--	95	--
156-1	665,100	877,270	50	.7	.15	>2	7,000	N	30	50	N	70	150	20	N	50	50	<20	15	N	N	200	100	500	70	N	--	--	--	85	--
157-1	663,280	880,060	>50	.2	<.10	2	2,000	N	N	<50	N	70	100	10	N	<50	70	20	10	N	N	500	50	500	50	N	--	--	--	40	--
158-1	663,110	867,410	30	1.0	.50	>2	5,000	N	<20	50	N	70	150	20	N	50	50	<20	20	N	<200	200	150	500	100	N	--	--	--	70	--
160-1	663,560	878,490	30	2.0	.15	>2	7,000	N	50	70	N	70	150	50	50	50	70	<20	15	N	N	150	100	<500	100	N	--	--	--	180	--
MINIMUM			30	.2	<.10	1	1,500	N	N	<50	N	50	100	10	N	N	50	N	10	N	N	150	30	<500	50	N	N	--	--	20	--
MEDIAN			50	.7	.10	>2	5,000	N	20	50	N	70	150	20	N	50	70	<20	15	N	N	200	100	500	70	N	N	--	--	85	--
MAXIMUM			>50	2.0	.50	>2	7,000	N	50	100	N	70	200	50	50	50	70	20	20	N	<200	700	200	500	100	N	N	--	--	180	--

FRACTION 2 <16 MESH, S.G.>2.85 NONMAGNETIC AT 0.5 AMPERE

Sample	X coordinate	Y coordinate	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Th-ppm s	Au-ppm aa	Cu-ppm aa	Pb-ppm aa	Zn-ppm aa	U-INST
141-2	671,790	887,200	2	.7	2.0	2	1,000	N	1,000	500	<2	20	100	20	50	50	30	30	30	N	200	150	100	N	>2,000	N	--	--	--	40	--
142-2	671,320	876,680	3	1.0	2.0	2	1,000	2	700	300	<2	20	150	20	70	50	50	50	50	N	200	200	100	N	>2,000	N	N	--	--	50	--
143-2	663,230	871,460	3	.5	2.0	>2	1,000	N	2,000	300	N	20	150	15	300	50	20	70	30	N	200	100	200	N	>2,000	N	--	--	--	65	--
144-2	663,110	872,460	2	.5	1.0	>2	700	N	2,000	500	<2	10	100	10	200	50	20	70	30	N	200	150	150	N	>2,000	N	--	--	--	65	--
145-2	662,680	868,770	3	.7	2.0	>2	1,000	N	2,000	200	N	20	150	10	500	50	20	100	30	N	500	150	200	N	>2,000	<200	--	--	--	65	--
146-2	667,750	867,390	3	.5	2.0	>2	700	N	1,500	500	<2	30	100	50	500	50	15	100	30	N	200	150	200	N	>2,000	N	--	--	--	70	--
147-2	670,550	874,290	5	.7	2.0	>2	1,000	<1	1,500	500	<2	30	150	150	500	70	20	100	20	<20	300	150	200	N	>2,000	<200	--	--	--	85	--
148-2	--	--	3	.5	1.5	>2	1,000	N	1,000	700	2	30	100	100	500	50	50	150	20	N	<200	100	150	N	>2,000	<200	--	--	--	--	--
149-2	667,510	872,560	3	.5	2.0	>2	1,000	N	1,500	500	<2	30	100	50	500	70	20	150	30	<20	200	150	200	N	>2,000	<200	--	--	--	115	--
150-2	668,280	869,250	2	.5	3.0	>2	1,000	N	1,500	500	<2	20	150	150	500	50	30	100	20	20	200	150	200	N	>2,000	N	--	--	--	95	--
151-2	671,670	880,730	3	.5	1.0	>2	1,000	<1	1,000	700	2	30	150	200	500	50	50	100	20	<20	<200	150	150	<500	500	N	--	--	--	65	--
152-2	669,360	881,730	2	.3	2.0	>2	500	N	1,500	500	<2	15	100	150	500	50	15	70	15	N	<200	150	150	N	>2,000	N	--	--	--	100	--
153-2	667,170	883,940	3	.5	1.0	>2	700	N	1,500	500	<2	20	150	100	500	50	15	100	15	<20	N	100	150	N	>2,000	<200	--	--	--	60	--
154-2	664,460	882,060	3	.5	1.5	>2	700	N	1,500	500	<2	20	100	70	500	50	15	100	20	<20	200	150	200	N	>2,000	N	--	--	--	35	--
155-2	665,190	877,360	3	.5	2.0	>2	700	N	2,000	500	<2	20	100	50	500	50	15	100	20	<20	200	150	200	N	>2,000	<200	--	--	--	60	--
156-2	665,100	877,270	[illegible]																												
[illegible]																															

CUMULATIVE STATISTICS FOR 66 STREAM-SEDIMENT SAMPLES WITHIN DRAINAGE BASINS SAMPLED BY PANNED CONCENTRATES

[illegible]		

MAP SHOWING GEOCHEMICAL DATA FOR PANNED STREAM SEDIMENTS FROM THE BREAD LOAF FURTHER PLANNING AREA, ADDISON AND WASHINGTON COUNTIES, VERMONT

By
Andrew E. Grosz, Paul G. Schruben, and Paul J. Atelsek

1987

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1987

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