UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Metal Distribution in the Battle Lake Area, Grand Encampment Mining District, Carbon County, Wyoming, with Comparisons to Deposits in the New Rambler Mine District, Albany and Carbon Counties, Wyoming

By

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INTRODUCTION

The Grand Encampment Mining District, located in the Sierra Madre Range of southeastern Wyoming, has been a center of considerable exploration and mining activity for a number of decades. Principal production was achieved shortly after the turn of the century; the main product was copper from sulfide ores. Minor amounts of gold also were recovered from some ores (Spencer, 1904). The Battle Lake area of the district (figs. 1 and 2) is traversed by a major shear zone which is considered to be the extension of the Mullen Creek-Nash Fork Shear Zone from the Medicine Bow Mountains, approximately 80 km (50 mi) to the northeast. Geologic setting in the Battle Lake area is somewhat similar to that of the New Rambler Mine area in the Medicine Bow Mountains (fig. 1) where copper-nickel sulfide deposits are enriched in platinoids (Theobald and Thompson, 1968; McCallum and Orback, 1968; McCallum and others, 1976; Loucks, 1976). It has been suggested that ore metals in the New Rambler Mine were derived from associated sheared mafic rocks of the Mullen Creek Mafic Complex by hydrothermal leaching (McCallum and others, 1976). Geologic and geochemical evaluation of the Battle Lake area was initiated to determine the extent of similarity between the two districts, especially with regard to the potential presence of platinum group elements, and to determine if the geochemical model of leaching metals from mafic host rocks might be applicable. The 54 samples collected in the Battle Lake area for geochemical analysis are representative of the rock types present within and adjacent to the shear zone. Sample selection was designed to reflect maximum variability in lithology as well as degree of shearing, alteration, and mineralization (table 1). Sample sites are indicated on figure 3 which shows the locations of the Mullen Creek-Nash Fork Shear Zone and major faults in the area. Principal types of samples may be subdivided as follows: (1) mylonitized metadiabase-metagabbro and mafic phyllonite (some possibly derived from dikes of noritic composition), (2) mylonitized dolomite, (3) gossan, and (4) "high grade" mine dump material composed predominantly of primary chalcopyrite, specular hematite and quartz, with minor secondary chalcocite.

GENERAL GEOLOGY

The Battle Lake area is tectonically dominated by the Mullen Creek-Nash Fork Shear Zone which separates the Sierra Madre Range into distinct time-rock domains (Houston and others, 1975) (figs. 2 and 3). Rocks north of the shear zone comprise the central and northern domains which consist of 1,800 to 2,400 m.y. old metasedimentary units and greater than 2,400 m.y. old basement gneisses respectively. Rocks south of the shear zone comprise the southern domain and include less than 1,800 m.y. old mixed gneisses, metasedimentary, metavolcanic, and granitic units (Houston and others 1975). General reconnaissance investigation to detailed studies of these units in the Battle Lake area have been conducted by Spencer (1904), Divis (1976), Houston and others (1975), Graff and Houston (1977), Graff (1978), and Menzer (1981). Central domain metasedimentary rocks are predominantly interbedded quartzites and phyllites that have been correlated by Graff (1978) with units of the Deep Lake Group in the Medicine Bow Mountains (Houston and others, 1968), and metadolomites and graphistic schists that correlate with the Libby Creek Group (Graff, 1978; Houston and others, 1968). At least two generations of mafic

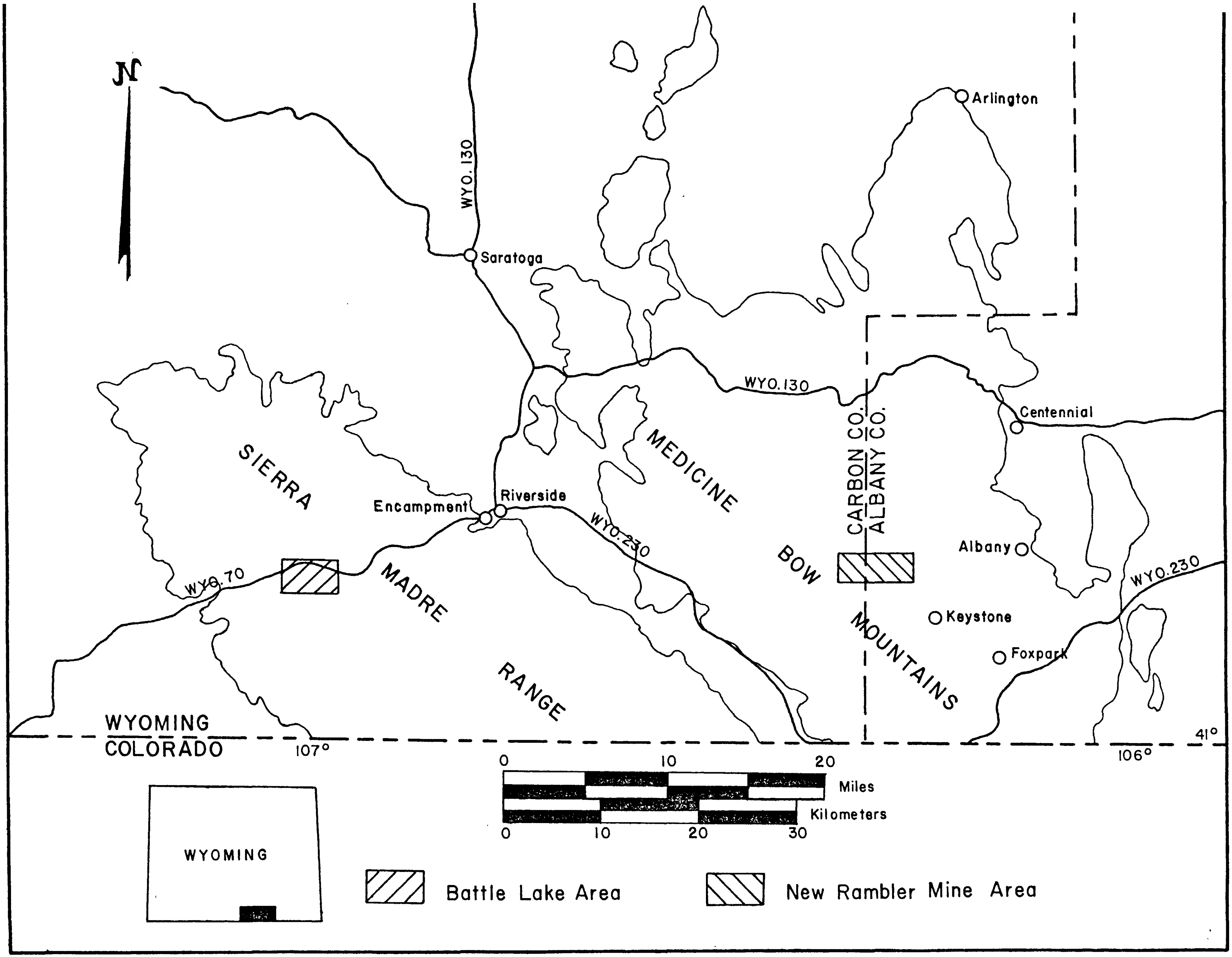


Figure 1. Index map showing locations of the Battle Lake and New Rambler Mine areas.

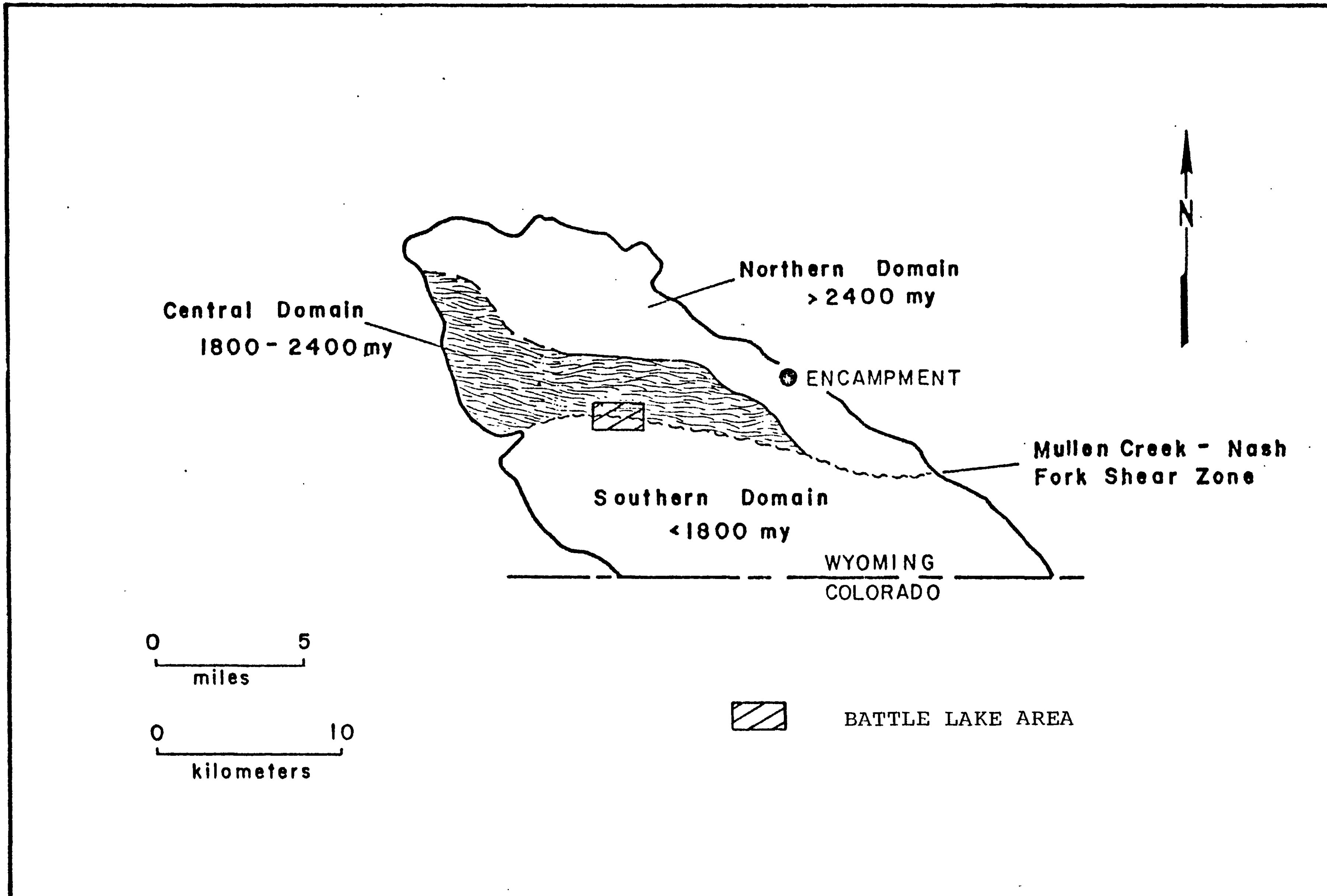


Figure 2. Sketch map showing the geologic subdivisions of the Sierra Madre Range and location of the Battle Lake area (modified from Houston, and others, 1975, p. 8).

Table 1. Descriptions of rock samples collected in the Battle Lake area.

Sample Number	Description
BL-D1	Gossan-like quartzite microbreccia
BL-D2	Copper-stained mylonitized quartzite
BL-D3	Cataclastic quartzite with copper oxide and vein xenotime
BL-D4	Jasperoid cataclasite
BL-D5	Calcite-veined metadiabase
BL-F1	Mylonitized quartzite with interstitial chalcopyrite
BL-H1	Quartz + chalcopyrite vein
BL-H2	Quartz microbreccia with interstitial chalcopyrite
BL-H3	Cataclastic dolomite and mafic mylonite with chalcopyrite
BL-H4	Mafic phyllonite
BL-H5	Mylonitized dolomite
BL-P1	Quartzite microbreccia
BL-P2	Quartzite microbreccia with specularite and pyrite veins and interstitial chalcopyrite
BL-P3	Quartz vein with bornite and pyrite in mafic phyllonite
BL-P4	Quartz vein with specularite and chalcopyrite stringers within mafic mylonite
BL-P5	Quartz cataclasite with chalcopyrite stringers
BL-P6	Mafic phyllonite
BL-P7	Mafic ultramylonite
BL-P8	Mafic phyllonite
BL-P9	Mafic phyllonite
BL-P10	Mafic ultramylonite with calcite veining
BL-PT1	Quartz cataclasite with chalcopyrite and specularite
BL-PT2	Quartz microbreccia with chalcopyrite
BL-PT3	Quartz + dolomite microbreccia with specularite stringers and interstitial chalcopyrite
BL-PT4	Mafic ultramylonite
BL-PT5	Mafic phyllonite
BL-PT6	Mafic ultramylonite
BL-PT7	Cataclastic dolomite
BL-PT8	Quartz microbreccia with interstitial chalcopyrite
BL-PT9	Quartz microbreccia with chalcopyrite

Table 1. (Continued)

Sample Number	Description
BL-R1	Quartz schist
BL-R2	Diabase
BL-R3	Mafic cataclasite
BL-R4	Mafic mylonite
BL-R5	Cataclastic diabase
BL-SD1	Quartz microbreccia with interstitial chalcopyrite
BL-SD2	Cataclastic quartzite with specularite
BL-SD3	Mafic phyllonite
BL-SD4	Mafic phyllonite with calcite veining and chalcopyrite
BL-SD5	Mafic mylonite
BL-SD6	Cataclastic dolomite
BL-104	Mafic mylonite
BL-106	Gabbro
BL-111	Gossan
BL-113	Black siliceous ultramylonite
BL-115b	Cataclastic quartzite
BL-116a	Quartz chlorite schist
BL-129d	Gossan
BL-130b	Gossan
BL-136	Diabase
BL-158	Gabbro
BL-177b	Quartz biotite schist
BL-184	Mafic mylonite with specularite
BL-192	Diabase

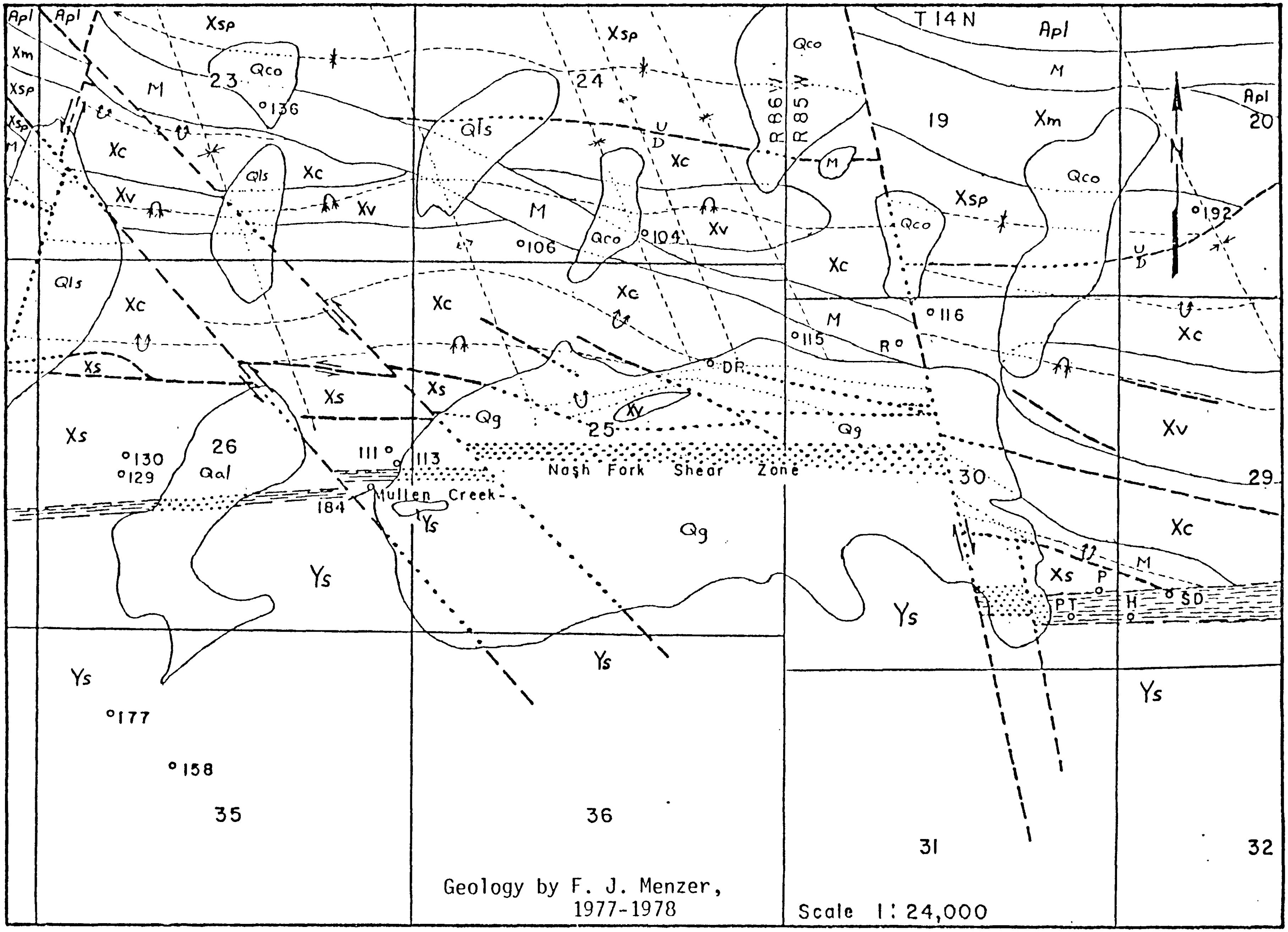


Figure 3. General geologic map of the Battle Lake area with locations of analyzed samples.

EXPLANATION FOR FIGURE 3

Lithologic Units

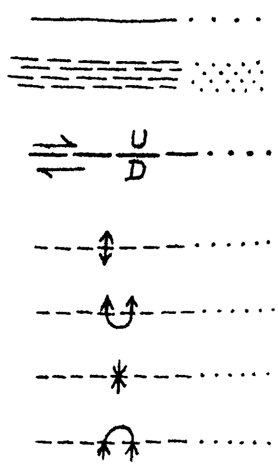
Era	Group	Symbol	Unit
QUATERNARY		Qal	Alluvium
QUATERNARY		Qco	Colluvium
QUATERNARY		Qls	Landslide deposits
QUATERNARY		Qg	Glacial deposits
PRECAMBRIAN		Ys	Sierra Madre Granite - Unit also includes some granodiorite gneiss and amphibolite gneiss. Granite is coarse grained and exhibits cataclastic texture adjacent to major shear zone.
PRECAMBRIAN		M	Metadiabase dikes - At least two generations present.
PRECAMBRIAN	Libby Creek Group	Xs	Slaughterhouse Formation - Black graphite schist and slate, red ferruginous dolomite and dolomitic limestone, and white to tan dolomite.
PRECAMBRIAN	Deep Lake Group	Xv	Vagner Formation[1] - Interbedded quartzite, chlorite schist, calcareous phyllite, limestone, and conglomerate containing rounded and angular granite clasts.
PRECAMBRIAN	Deep Lake Group	Xc	Cascade Quartzite - Thin bedded to massive, locally crossbedded, white quartzite. Brecciated and recrystallized adjacent to major shear zone.
PRECAMBRIAN	Deep Lake Group	Xsp	Singer Peak Formation[2] - Silver-gray phyllite and quartz mica schist.
PRECAMBRIAN	Deep Lake Group	Xm	Magnolia Formation - Thin bedded white quartzite with crossbedding and ripple marks.
PRECAMBRIAN	Phantom Lake Group	Apl	Phantom Lake Group (Undivided) - Comprised of: Silver Lake Conglomerate - a conglomerate with granite, quartzite and metavolcanic rock boulders; Spring Lake Volcanics - garnet and amphibole schist; and Jack Creek Formation - quartzite.

(Stratigraphy after Graff, 1978)

[1]Copperton Quartzite normally overlies the Vagner Formation but has been faulted out in the Battle Lake area.

[2]Campbell Lake Formation normally overlies the Singer Peak Formation but has been faulted out in the Battle Lake area.

Map Symbols for figure 3



- CONTACT, dotted where covered
- SHEAR ZONE, dotted where covered
- FAULT, dotted where covered, sense of movement indicated where evident
- CREST LINE OF ANTICLINE, dotted where covered
- CREST LINE OF OVERTURNED ANTICLINE, dotted where covered.
- TROUGH LINE OF SYNCLINE, dotted where covered
- TROUGH LINE OF OVERTURNED SYNCLINE, dotted where covered
- oR, o115 — ABANDONED MINES AND(OR) SAMPLE LOCATION: DR-Doane Rambler Mine, R-Rambler Mine, P-Portland Mine, PT-Portland Tunnel, H-Hercules Mine.

intrusive rocks (chiefly diabasic dikes and sills) cut the metasedimentary sequence, and evidence for multiple episodes of folding, faulting, and cataclasis is apparent. Southern domain rocks in the Battle Lake area are primarily Sierra Madre Granite and associated felsic igneous and gneissic units (Menzer, 1981; fig. 3). Rocks within the shear zone reflect varying degrees of deformation imparted by multiple episodes of movement. These rocks include a range of microbreccia, mylonitic, ultramylonitic, and blastomylonitic phases as well as host rocks showing only minor amounts of cataclasis and (or) brecciation.

Mineralization in the Battle Lake area appears to be controlled chiefly by the Mullen Creek-Nash Fork Shear Zone and associated fault and fracture systems. Ore-grade concentrations of metal sulfides have been observed in brecciated quartzite and locally in metadolomite. Copper sulfides constitute the predominant ore minerals and, locally, these may contain minor amounts of Au and (or) Ag. The most typical mineralized zone assemblage consists of quartz, specular hematite and chalcopyrite. Local zones of supergene enrichment are characterized by the presence of chalcocite. No other principal ore-metal mineral phases have been recognized to date, but additional polished-section studies are planned.

GEOCHEMISTRY

Fifty-four rock chip samples from the Battle Lake area were analyzed by personnel of the U.S. Geological Survey. Ag, Cu, and Te were analyzed by atomic absorption and As colorimetrically by S. M. Kneipple (table 2). Au was analyzed by fire-assay and the platinum group elements Pt, Pd, Rh, Ru, and Ir by fire-assay, emission spectrographic techniques by R. R. Carlson, S. E. Royse, and E. F. Cooley (table 3). Thirty elements (Fe, Mg, Ca, Ti, Mn, Ag, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cu, La, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, V, W, Y, Zn, and Zr) were analyzed by the dc-arc six-step spectrographic method by R. T. Hopkins (table 4).

Comparisons of precious and base metal concentrations in sulfide ores from the Battle Lake and New Rambler Mine areas (fig. 1) indicate rather significant differences (table 5). Ore samples from the Battle Lake area contain negligible amounts of platinum group elements which are present in New Rambler ores, and levels of Ag and Au are considerably less than New Rambler ores. Furthermore, Battle Lake ores contain significantly lower concentrations of Co and Ni. These differences in metal content suggest either major differences in the genesis of ore solutions in the two districts, or, if an essentially uniform hydrothermal leaching model is viable for both systems, then dissimilarities in original host rock chemistry must have been appreciable. The latter course may be inferred from selected trace element data for mafic rocks in the two districts (table 6). In general, the New Rambler mafic host rocks are significantly more enriched in Ni, Co, and Cr and depleted in Cu than those from the Battle Lake area. These compositional trends suggest a more ultramafic association for the New Rambler metal assemblages, and the earlier mafic differentiates would be expected to contain higher concentrations of platinum group elements. Most of the mafic host rocks in the New Rambler area appear to be related to the Mullen Creek Mafic Complex. Mafic rocks in the Battle Lake area are not related to such a mafic complex, but rather seem to be remnants of minor intrusives of later stage mafic differentiates. Such rocks would not be expected to be appreciably enriched in platinum group elements.

Table 2. Silver, copper, tellurium, and arsenic values of samples collected in the Battle Lake area. [G, greater than value shown; N( ), not detected at limit of detection, or at value shown; L( ), detected, but below limit of determination or below value shown. Methods used for Ag, Cu, Te, atomic absorption; for As, colorimetric. Analyst: S.M. Kneipple, U.S. Geological Survey.]

Sample Number	Element in ppm			
	Ag	Cu	Te	As
BL-104	L(.5)	1,800	0.2	N(10)
BL-106	L(.5)	900	0.4	N(10)
BL-111	L(.5)	130	0.2	10
BL-113	L(.5)	110	0.4	10
BL-115B	L(.5)	510	0.4	N(10)
BL-116A	L(.5)	35	L(.2)	N(10)
BL-129D	L(.5)	35	0.2	40
BL-130B	L(.5)	30	L(.2)	40
BL-136	L(.5)	75	L(.2)	N(10)
BL-158	L(.5)	40	L(.2)	N(10)
BL-177B	L(.5)	40	L(.2)	N(10)
BL-184	L(.5)	150	L(.2)	N(10)
BL-192	L(.5)	70	L(.2)	N(10)
BL-D1	L(.5)	25	L(.2)	30
BL-D2	L(.5)	11,000	L(.2)	80
BL-D3	6.0	21,000	L(.2)	L(10)
BL-D4	6.8	1,900	L(.2)	60
BL-D5	N(.5)	280	L(.2)	N(10)
BL-F1	1.9	20,000	0.2	N(10)
BL-H1	0.9	32,000	0.6	N(10)
BL-H2	0.6	24,000	L(.2)	80
BL-H3	0.7	14,000	L(.2)	N(10)
BL-H4	L(.5)	85	L(.2)	N(10)
BL-H5	L(.5)	100	L(.2)	N(10)

Table 2. (Continued).

Sample Number	Element in ppm			
	Ag	Cu	Te	As
BL-P1	1.9	105,000	0.8	N(10)
BL-P2	0.6	17,000	0.4	N(10)
BL-P3	0.6	5,800	L(.2)	N(10)
BL-P4	L(.5)	8,000	L(.2)	N(10)
BL-P5	0.9	22,000	L(.2)	N(10)
BL-P6	L(.5)	230	L(.2)	N(10)
BL-P7	L(.5)	160	L(.2)	N(10)
BL-P8	L(.5)	25	L(.2)	N(10)
BL-P9	L(.5)	190	L(.2)	N(10)
BL-P10	L(.5)	190	L(.2)	N(10)
BL-PT1	2.3	50,000	0.2	N(10)
BL-PT2	5.0	115,000	1.0	N(10)
BL-PT3	L(.5)	35,000	L(.2)	N(10)
BL-PT4	L(.5)	180	L(.2)	N(10)
BL-PT5	L(.5)	730	L(.2)	N(10)
BL-PT6	L(.5)	340	L(.2)	N(10)
BL-PT7	L(.5)	170	L(.2)	N(10)
BL-PT8	1.4	76,000	0.2	100
BL-PT9	11	74,000	L(.2)	N(10)
BL-R1	L(.5)	270	L(.2)	L(10)
BL-R2	L(.5)	400	L(.2)	N(10)
BL-R3	L(.5)	110	L(.2)	L(10)
BL-R4	L(.5)	250	L(.2)	80
BL-R5	L(.5)	80	L(.2)	10

Table 2. (Continued).

Sample Number	Element in ppm			
	Ag	Cu	Te	As
BL-SD1	1.5	88,000	L(.2)	L(10)
BL-SD2	L(.5)	320	L(.2)	N(10)
BL-SD3	L(.5)	40	L(.2)	N(10)
BL-SD4	0.5	10,000	L(.2)	N(10)
BL-SD5	L(.5)	40	L(.2)	N(10)
BL-SD6	L(.5)	360	L(.2)	N(10)

Table 3. Gold, Platinum, Palladium, Rhodium, Ruthenium, and Iridium values of samples collected in the Battle Lake area. [G, greater than value shown; N( ), not detected at limit of detection, or at value shown; L( ), detected but below limit of determination or below value shown. Analytic method used for Au, fire assay; for Pt, Pd, Rh, Ru, Ir, fire assay - spectrographic. Analysts: R.R. Carlson, S.E. Royse, E.F. Cooley, U.S. Geological Survey.]

Sample Number	Element in ppm					
	Au	Pt	Pd	Rh	Ru	Ir
BL-104	L(0.001)	0.010	0.050	N(0.002)	N(0.200)	N(0.050)
BL-106	0.001	N(0.005)	0.050	N(0.002)	N(0.200)	N(0.050)
BL-111	0.001	N(0.005)	0.010	N(0.002)	N(0.200)	N(0.050)
BL-113	0.050	0.010	0.020	N(0.002)	N(0.200)	N(0.050)
BL-115B	N(0.001)	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-116A	N(0.001)	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-129D	0.020	0.005	0.001	N(0.002)	N(0.200)	N(0.050)
BL-130B	0.001	N(0.005)	0.001	N(0.002)	N(0.200)	N(0.050)
BL-136	0.001	0.005	0.002	N(0.002)	N(0.200)	N(0.050)
BL-158	N(0.001)	0.010	0.005	N(0.002)	N(0.200)	N(0.050)
BL-177B	N(0.001)	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-184	0.003	0.030	0.010	N(0.002)	N(0.200)	N(0.050)
BL-192	0.005	0.030	0.007	N(0.002)	N(0.200)	N(0.050)
BL-D1	N(0.001)	N(0.005)	0.001	N(0.002)	N(0.200)	N(0.050)
BL-D2	N(0.002)	N(0.010)	N(0.002)	N(0.004)	N(0.400)	N(0.100)
BL-D3	0.150	N(0.010)	0.002	N(0.004)	N(0.400)	N(0.100)
BL-D4	0.070	N(0.005)	0.015	N(0.002)	N(0.200)	N(0.050)
BL-D5	0.030	0.050	0.030	N(0.002)	N(0.200)	N(0.050)
BL-F1	0.060	N(0.010)	N(0.002)	N(0.004)	N(0.400)	N(0.100)

Table 3. (Continued)

Sample Number	Element in ppm					
	Au	Pt	Pd	Rh	Ru	Ir
BL-H1	0.150	N(0.010)	0.002	N(0.004)	N(0.400)	N(0.100)
BL-H2	0.150	N(0.010)	0.006	N(0.004)	N(0.400)	N(0.100)
BL-H3	1.0	0.010	0.010	N(0.004)	N(0.400)	N(0.100)
BL-H4	0.001	0.030	0.020	N(0.002)	N(0.200)	N(0.050)
BL-H5	0.200	N(0.005)	0.001	N(0.002)	N(0.200)	N(0.050)
BL-P1	0.300	N(0.015)	0.003	N(0.006)	N(0.600)	N(0.150)
BL-P2	0.400	N(0.010)	0.002	N(0.004)	N(0.400)	N(0.100)
BL-P3	0.200	0.010	0.010	N(0.004)	N(0.400)	N(0.100)
BL-P4	0.030	N(0.010)	0.010	N(0.004)	N(0.400)	N(0.100)
BL-P5	0.060	0.010	0.006	N(0.004)	N(0.400)	N(0.100)
BL-P6	0.010	0.030	0.010	N(0.002)	N(0.200)	N(0.050)
BL-P7	0.005	0.020	0.010	N(0.002)	N(0.200)	N(0.050)
BL-P8	0.005	0.030	0.010	N(0.002)	N(0.200)	N(0.050)
BL-P9	0.005	0.030	0.030	N(0.002)	N(0.200)	N(0.050)
BL-P10	0.005	0.030	0.030	N(0.002)	N(0.200)	N(0.050)
BL-PT1	0.600	N(0.010)	0.006	N(0.004)	N(0.400)	N(0.100)
BL-PT2	9.0	N(0.015)	0.060	N(0.006)	N(0.600)	N(0.150)
BL-PT3	0.400	N(0.010)	0.002	N(0.004)	N(0.400)	N(0.100)
BL-PT4	0.010	0.030	0.010	N(0.002)	N(0.200)	N(0.050)
BL-PT5	0.010	0.030	0.020	N(0.002)	N(0.200)	N(0.050)
BL-PT6	0.005	0.020	0.005	N(0.002)	N(0.200)	N(0.050)

Table 3. (Continued)

Sample Number	Element in ppm					
	Au	Pt	Pd	Rh	Ru	Ir
BL-PT7	0.050	0.010	0.007	N(0.002)	N(0.200)	N(0.050)
BL-PT8	0.600	0.010	0.010	N(0.004)	N(0.400)	N(0.100)
BL-PT9	6.0	N(0.010)	0.020	N(0.004)	N(0.400)	N(0.100)
BL-R1	0.005	N(0.005)	L(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-R2	0.010	0.010	0.010	N(0.002)	N(0.200)	N(0.050)
BL-R3	0.010	0.005	0.003	N(0.002)	N(0.200)	N(0.050)
BL-R4	0.010	0.010	0.010	N(0.002)	N(0.200)	N(0.050)
BL-R5	0.005	0.020	0.070	N(0.002)	N(0.200)	N(0.050)
BL-SD1	0.400	N(0.010)	N(0.002)	N(0.004)	N(0.400)	N(0.100)
BL-SD2	0.050	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-SD3	0.001	0.030	0.030	N(0.002)	N(0.200)	N(0.050)
BL-SD4	0.060	0.040	0.040	N(0.004)	N(0.400)	N(0.100)
BL-SD5	0.001	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)
BL-SD6	0.030	N(0.005)	N(0.001)	N(0.002)	N(0.200)	N(0.050)

Table 4. Semi-quantitative spectrographic analysis of samples collected in the Battle Lake area. Fe, Mg, Ca, and Ti reported in %; all others reported in ppm. ( ), lower limit of detection; N, not detected; L, present but less than measurable amount; G, greater than value shown. As, Au, Bi, Cd, Mo, Nb, Sb, Sn, W, Zn tested but were not detected except as noted. Note: BL-SD6, Mo 5; BL-129d, Mo 5; BL-130b, Mo 5; BL-D2, As 200; BL-D4, As 200; BL-PT5, Mo 7. Analyst: R.T. Hopkins, U.S. Geological Survey, Denver, Colorado.

Sample Number	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	Ag (.5)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	V (10)	Y (10)	Zr (10)
BL-R4	7.0	1.5	5	0.3	1500	N	100	500	1.0	30	15	150	N	70	L	20	N	150	20	30
BL-R5	5.0	1.0	0.3	0.3	700	N	N	30	1.0	30	15	30	20	50	L	20	N	150	20	100
BL-SD1	2.0	0.07	0.15	0.015	700	2.0	N	70	L	15	L	G20000	N	30	L	5	N	15	N	N
BL-SD2	1.5	0.3	5.0	0.05	1500	1.0	N	70	2.0	15	10	500	N	15	L	5	N	30	N	20
BL-SD3	10.0	3.0	2.0	0.7	1500	N	10	100	1.5	30	300	70	N	100	N	30	N	200	20	50
BL-SD4	7.0	1.5	7.0	0.5	1500	1.5	10	100	5.0	20	300	7000	N	50	L	50	N	200	20	30
BL-SD5	2.0	1.5	20.0	0.15	3000	N	50	500	3.0	5	70	30	20	20	L	15	100	50	30	30
BL-SD6	7.0	0.5	10.0	0.15	2000	N	20	150	3.0	30	70	500	N	50	L	15	N	100	15	20
BL-104	10.0	1.5	3.0	0.5	1000	N	N	30	L	30	50	1500	N	50	N	20	150	150	30	100
BL-106	10.0	3.0	10.0	0.5	1500	N	N	200	N	30	100	700	N	70	L	30	300	150	20	100
BL-111	7.0	0.1	0.5	0.05	1500	N	N	300	N	50	10	100	N	70	L	7	N	100	20	20
BL-113	0.7	0.1	0.1	0.7	300	N	100	70	L	N	15	70	100	15	L	5	N	70	50	200
BL-115b	0.7	0.2	0.07	0.1	70	N	N	L	L	5	15	500	N	15	N	N	N	15	N	100
BL-116a	1.5	1.0	0.2	0.2	150	N	N	20	1.0	20	70	30	30	50	10	7	N	50	30	150
BL-129d	15.0	0.3	3.0	0.2	500	N	200	200	N	100	70	50	N	150	L	15	N	300	20	100
BL-130b	7.0	0.2	0.5	0.05	1000	N	50	500	N	15	L	50	N	50	L	10	N	200	30	15
BL-136	7.0	3.0	5.0	0.2	1000	N	N	150	N	30	300	70	N	100	10	30	150	150	20	50
BL-158	7.0	5.0	7.0	0.15	1000	N	N	100	N	30	700	30	N	70	10	50	500	150	10	10
BL-177b	7.0	1.5	2.0	0.3	1000	N	N	500	N	20	L	30	N	15	20	15	500	150	20	70
BL-184	15.0	3.0	10.0	1	1500	N	N	300	N	50	200	150	N	100	10	70	300	300	50	100
BL-192	15.0	5.0	3.0	0.2	700	N	N	50	N	30	1000	30	N	200	L	30	L	150	15	50
BL-D1	10.0	0.3	0.7	0.15	5000	N	500	700	2.0	15	70	30	N	50	N	10	N	100	20	150
BL-D2	3.0	0.07	0.1	0.1	50	N	N	70	2.0	10	50	15000	30	30	10	5	N	70	15	150
BL-D3	0.3	0.1	0.2	0.02	30	15	N	L	200	N	30	20000	200	100	30	20	700	70	G2000	150
BL-D4	15.0	0.05	L	0.015	70	10	150	70	20	20	20	3000	20	70	20	N	N	700	20	20

Table 4.(Continued).

Sample Number	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	Ag (.5)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	V (10)	Y (10)	Zr (10)
BL-D5	10.0	2.0	3.0	0.5	1500	N	100	500	10	30	200	300	N	70	30	30	L	150	50	100
BL-F1	1.5	0.3	0.15	0.1	70	3.0	N	N	N	10	30	15000	N	15	N	N	N	15	N	100
BL-H1	2.0	0.1	3.0	0.05	700	1.5	N	300	2.0	50	L	20000	N	20	N	10	N	30	15	N
BL-H2	3.0	0.5	15.0	0.3	3000	1.5	10	50	2.0	30	100	15000	N	30	L	20	150	150	30	30
BL-H3	5.0	0.5	5.0	0.15	1500	1.5	L	100	1.5	30	70	10000	N	50	L	15	N	100	20	15
BL-H4	10.0	2.0	5.0	0.7	1000	N	N	20	N	30	200	150	N	70	L	50	N	200	30	70
BL-H5	2.0	1.0	20.0	0.03	G 5000	N	10	100	L	15	10	30	30	10	15	15	300	20	30	10
BL-P1	15.0	0.2	5.0	0.15	700	*15	N	70	3.0	30	70	G 20000	N	50	10	15	N	100	30	L
BL-P2	3.0	0.3	2.0	0.15	700	1.5	10	150	3.0	30	70	15000	N	50	L	10	N	100	N	10
BL-P3	7.0	0.5	3.0	0.2	1000	N	30	70	3.0	50	100	7000	N	50	N	20	N	150	20	20
BL-P4	7.0	1.0	3.0	0.5	1500	N	30	150	3.0	150	100	7000	N	70	N	20	N	200	15	50
BL-P5	10.0	0.7	3.0	0.15	1500	1.5	20	70	2.0	100	70	20000	N	70	L	15	N	100	15	15
BL-P6	15.0	3.0	5.0	0.7	1500	N	N	20	N	70	300	300	N	100	N	50	L	200	30	70
BL-P7	15.0	2.0	7.0	0.7	1500	N	N	20	N	70	200	100	N	70	N	50	N	200	30	70
BL-P8	7.0	2.0	10.0	0.5	2000	N	N	50	L	70	200	30	N	70	L	50	N	200	30	70
BL-P9	10.0	1.5	7.0	0.5	1000	N	N	L	N	30	150	100	N	70	L	30	L	200	20	70
BL-P10	7.0	3.0	7.0	0.3	1000	N	N	N	N	30	150	100	N	70	L	30	N	150	20	50
BL-PT1	10.0	0.2	0.1	0.15	100	5.0	10	500	2.0	10	70	G 20000	N	15	L	15	N	100	N	20
BL-PT2	1.5	0.1	0.2	0.1	150	10	10	700	2.0	7	15	G 20000	N	15	10	7	N	100	N	L
BL-PT3	7.0	0.3	1.5	0.1	1000	1.0	10	300	1.5	20	L	20000	N	20	L	7	N	50	N	L
BL-PT4	3.0	2.0	7.0	0.15	1500	N	N	70	N	15	70	150	L	30	L	30	L	150	15	10
BL-PT5	10.0	1.5	3.0	0.5	1000	N	N	N	N	50	20	500	N	70	L	30	L	200	20	30
BL-PT6	7.0	1.5	0.15	0.3	1000	N	N	50	L	30	50	200	N	70	L	20	N	150	15	50
BL-PT7	3.0	0.3	15.0	0.15	3000	N	150	1000	3.0	10	50	100	N	20	N	20	N	150	15	20
BL-PT8	10.0	0.2	0.7	0.15	700	5.0	N	50	2.0	10	30	G 20000	N	30	L	15	N	100	N	15
BL-PT9	5.0	L	0.05	0.02	70	5.0	N	G 5000	N	L	L	G 20000	N	5	10	N	150	10	N	15
BL-R1	7.0	2.0	0.7	0.2	700	N	500	200	5.0	30	70	200	100	70	L	15	N	70	30	150
BL-R2	15.0	3.0	7.0	0.7	1500	N	N	200	N	50	15	500	N	70	20	50	200	150	30	200
BL-R3	15.0	5.0	7.0	0.5	2000	N	15	100	N	70	1500	150	N	300	N	50	N	100	20	70

Table 5. Average concentrations of precious and base metals in Battle Lake and New Rambler sulfide ores. (Values in ppm except as noted; n.d., not detected. Number in parentheses indicates the number of samples analyzed in each group; all samples analyzed by U. S Geological Survey. Au, Pd, Pt, and Rh determined by fire assay-emission spectrography: analysts: R. R. Carlson, E. F. Cooley, and T. A. Doerge. Ag and Cu determined by atomic absorption: analysts - R. B Carten, C. A. Curtis, J. G. Frisken, J. Mitchell, R. M. O'Leary, J. A. Roybol, J. Sharkey, and J. G. Viets. Fe, Co, Ni, Pb and Zn determined by semiquantitative Dc-arc spectroscopy: analysts - R. Babcock, L. B. Breedern, E. F. Cooley, K. J. Curry, G. W. Day, J. Domenico, W. D. Goss, D. J. Grimes, J. Haffty, R. Hopkins, L. B. Riley and D. Siems.)

	New Rambler Hypogene pyritic Cu-Ni sulfide ore (3)	New Rambler Supergene Cu-Ni Sulfide ore (24)	Battle Lake Cu Sulfide ores (15)
Ag	2.3	58.0	1.9
Au	0.44	4.3	1.3
Co	1850.0	160.0	35.0
Cu	0.5%	21.0%	3.9%
Fe	46.0%	27.0%	5.1%
Ni	4000.0	1662.0	33.0
Pb	14.0	12.0	4.7
Pd	24.0	76.0	0.010
Pt	0.98	4.4	0.006
Rh	0.06	0.02	n.d.
Zn	n.d.	453.0	n.d.

Table 6. Average concentrations of selected trace metals in mafic rocks from the Battle Lake and New Rambler Mine areas. [Values listed are in ppm; numbers in parentheses indicate the number of samples analyzed in each group. New Rambler data from McCallum and others, 1976, p. 1555.]

Battle Lake Area	Pt	Pd	Cu	Ni	Co	Cr	V
Diabase (3)	0.015	0.006	182	123	37	438	150
Metadiabase (2)	0.035	0.050	180	60	30	108	150
Gabbro (2)	0.008	0.028	470	70	30	400	150
Mafic phyllonite (7)	0.027	0.019	221	79	44	169	193
Mafic ultramylonite (5)	0.022	0.015	196	51	30	99	144
Mafic mylonite and cataclasite (3)	0.013	0.004	100	140	42	590	150
New Rambler Area							
Metaleucogabbro (5)	0.020	0.020	61	53	23	200	149
Metagabbro (13)	0.008	0.002	46	151	59	428	177
Sheared metagabbro (5)	0.008	0.020	63	268	68	1250	213
Metapyroxenite (5)	0.028	0.026	23	468	81	1175	120
Sheared metapyroxenite (3)	0.120	0.113	68	283	58	150	73

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