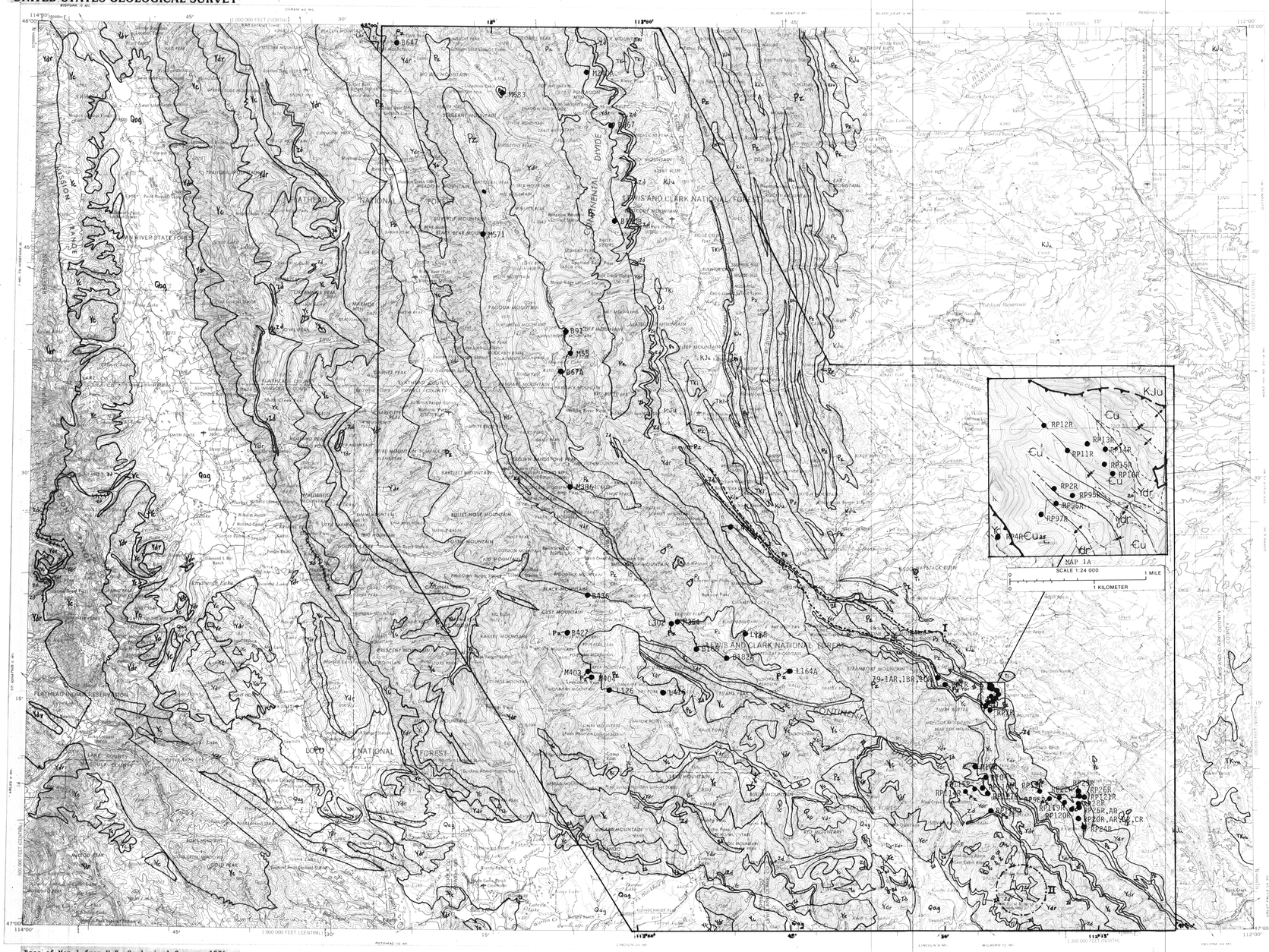
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN-FILE REPORT
81-475
SHEET 1 OF 4



Base of Map 1 from U.S. Geological Survey, 1976.
Base of Map 1A, from U.S. Geological Survey, 1963

Geology of Map 1 generalized from Mudge and others, 1980; geology of Map 1A by James W. Whipple

MAPS 1 AND 1A-FLATHEAD SANDSTONE SAMPLE LOCALITIES

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS

Qag — QUATERNARY

SEDIMENTARY ROCKS

Kju — CRETACEOUS

Pz, Cu — PALEOZOIC

Ydr

Yc — PROTEROZOIC Y

IGNEOUS ROCKS

Ti — TERTIARY

Tki — TERTIARY OR CRETACEOUS

Zd — PROTEROZOIC Z

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qag — UNCONSOLIDATED DEPOSITS (QUATERNARY)--Chiefly of aluvial origins. Locally includes sedimentary and pyroclastic rocks of Tertiary age in southern part of map area

SEDIMENTARY ROCKS

Kju — SEDIMENTARY ROCKS (CRETACEOUS AND JURASSIC)--Chiefly mudstone and sandstone

Pz — UNDIFFERENTIATED, MISSISSIPPIAN, DEVONIAN, CAMBRIAN SANDSTONE, LIMESTONE, AND DOLOMITE (PALEOZOIC)--Locally includes shale, siltstone, and quartzite; basal formation is Flathead Sandstone

Cu — DEARBORN LIMESTONE, DAMNATION LIMESTONE, GORDON SHALE, AND FLATHEAD SANDSTONE (CAMBRIAN)--Fine- to coarse-grained sandstone and quartzite, shale, and limestone

Ydr — ARGILLITE, SILTITE, AND QUARTZITE (PROTEROZOIC Y)--Includes dolomite and dolomitic limestone in easternmost exposures

Yc — DOLOMITE, DOLOMITIC LIMESTONE, AND LIMESTONE (PROTEROZOIC Y)--Locally includes dolomitic and calcareous argillite, siltite, and quartzite

IGNEOUS ROCKS

Ti — INTRUSIVE ROCKS (TERTIARY)--Chiefly quartz monzonite stocks and dacite plugs, locally porphyritic

Tki — TRACHYANDESITE SILL (TERTIARY OR CRETACEOUS)

Zd — DIORITE AND GABBRO SILLS (PROTEROZOIC Z)

MAP SYMBOLS

CONTACT--Dashed where approximately located

THRUST FAULT--BARBS ON UPPER PLATE

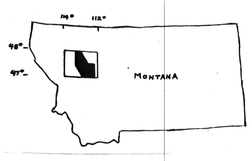
SYNCLINAL AND ANTICLINAL FOLDS

STRIKE AND DIP OF BEDS

AREA OF LEAD-ZINC MINERALIZATION

HEDDLESTON DISTRICT

RP1R SAMPLE LOCATION



INDEX SHOWING LOCATION OF THE CHOTEAU 1° X 2° QUADRANGLE AND MAP AREA, MONTANA

Table 1.--Concentrations of selected elements in 62 untreated samples of Flathead Sandstone, and their concentrations in the oxalic acid-soluble iron and manganese oxide fractions of the samples, Choteau quadrangle, Montana.
[All values reported in parts per million except Pb for sample 79-1BR which is greater (G) than 2%. Lower limits of determination given in parentheses (5) at the top of table. N, not detected at lower limit; L, detected but less than lower limit; R, concentrations in the untreated rock samples; Ox, concentrations in oxide fractions. Samples analyzed spectrographically by D. J. Grimes.]

Sample no.	Elements																			
	Cu (5)		Pb (10)		Zn (200)		Ag (.5)		As (200)		Sb (100)		Cd (20)		Mo (5)		W (50)		Th (100)	
	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox	R	Ox
RP 1R	7	1000	L	300	N	500	N	5	N	N	N	N	N	N	N	30	N	N	N	N
RP 2R	15	700	30	500	N	1000	N	N	N	N	N	N	N	N	N	N	N	70	N	N
RP 4R	15	10000	20	15000	N	3000	N	15	N	3000	N	1500	N	70	N	70	N	N	N	150
RP 7R	10	7000	70	20000	N	5000	N	2	N	1000	N	700	N	100	N	20	N	50	N	100
RP 11R	L	300	L	200	N	2000	N	N	N	N	N	N	N	N	N	N	N	50	N	N
RP 12R	L	300	L	500	N	2000	N	N	N	N	N	N	N	N	N	7	N	N	N	N
RP 13R	7	1500	L	2000	N	1500	N	1	N	N	N	N	N	N	N	15	N	70	N	150
RP 14R	20	5000	100	15000	N	2000	N	7	N	2000	N	N	N	N	N	70	N	N	N	500
RP 15R	10	700	200	20000	N	5000	N	1	N	300	N	N	N	N	N	N	N	50	N	150
RP 16R	7	500	150	1000	N	2000	N	5	N	300	N	N	N	N	N	30	N	N	N	N
RP 19R	5	2000	L	1000	N	700	N	5	N	300	N	N	N	N	N	20	N	N	N	700
RP 20R	7	300	L	500	N	1500	N	N	N	N	N	N	N	N	N	N	N	70	N	N
RP 20AR	5	300	L	700	N	1000	N	N	N	N	N	N	N	N	N	N	N	50	N	N
RP 20BR	5	1500	N	1000	N	2000	N	2	N	N	N	N	N	N	N	N	N	N	N	N
RP 20CR	7	1000	L	700	N	1500	N	2	N	N	N	N	N	N	N	15	N	N	N	N
RP 22R	10	1500	L	700	N	1500	N	2	N	N	N	N	N	N	N	15	N	N	N	N
RP 24R	30	7000	N	500	N	1500	N	5	N	300	N	N	N	N	N	50	N	N	N	150
RP 25R	10	3000	L	500	N	700	N	5	N	1000	N	N	N	N	N	150	N	N	N	N
RP 25AR	L	300	N	150	N	2000	N	N	N	N	N	N	N	N	N	N	N	N	N	N
RP 26R	10	1000	L	1000	N	2000	N	1	N	N	N	N	N	N	N	N	N	N	N	N
RP 28R	L	500	L	700	N	1500	N	N	N	N	N	N	N	N	N	N	N	N	N	700
RP 29R	10	1500	N	1000	N	2000	N	1	N	200	N	N	N	N	N	15	N	N	N	N
RP 95R	50	5000	1000	15000	N	10000	2	50	N	2000	N	150	N	N	N	30	N	50	N	500
RP 96R	15	2000	300	20000	N	10000	N	15	N	700	N	150	N	N	N	20	N	50	N	200
RP 97R	20	2000	L	700	N	3000	N	1	N	300	N	200	N	N	N	15	N	70	N	100
RP 98R	10	500	L	100	N	2000	N	1.5	N	N	N	N	N	N	N	15	N	50	N	N
RP114R	10	700	N	70	N	500	N	10	N	500	N	N	N	N	N	5	N	N	N	N
RP115R	10	150	20	50	N	300	N	N	N	N	N	N	N	N	N	5	N	N	N	N
RP116R	15	150	20	70	N	1500	N	2	N	N	N	N	N	N	N	N	N	N	N	N
RP117R	20	500	L	70	N	1000	.5	1.5	N	N	N	N	N	N	N	N	N	N	N	N
RP118R	15	1500	50	1000	N	5000	N	2	N	500	N	N	N	N	N	70	N	N	N	N
RP119R	15	1500	30	700	N	500	N	2	N	200	N	N	N	N	N	20	N	N	N	N
RP120R	15	150	20	100	N	N	N	N	N	N	N	N	N	N	N	7	N	L	N	100
RP121R	7	500	L	300	N	500	N	1	N	N	N	N	N	N	N	15	N	N	N	N
79-1AR	100	5000	L	200	N	200	N	N	N	N	N	N	N	N	N	15	N	N	N	N
79-1BR	300	500	G(2%)	30000	N	200	10	7	N	N	N	100	N	N	N	15	N	N	N	N
79-1CR	10	500	70	3000	N	300	1	3	N	1500	N	N	N	N	N	70	N	N	N	100
M 55	10	1000	15	500	N	500	L	.7	N	N	N	N	N	N	N	N	N	N	N	150
M240A	L	150	L	100	N	700	N	N	N	N	N	N	N	N	N	N	N	N	N	N
M354	L	500	N	300	N	500	N	N	N	N	N	N	N	N	N	30	N	N	N	N
M386	5	300	L	200	N	700	1.5	2	N	N	N	N	N	N	N	N	N	N	N	N
M403	5	500	L	300	N	200	N	N	N	N	N	N	N	N	N	N	N	N	N	N
M404	L	150	15	50	N	1000	N	N	N	N	N	N	N	N	N	N	N	N	N	N
M571	L	300	10	500	N	500	N	N	N	N	N	N	N	N	N	30	N	N	N	N
M683	7	1000	N	1000	N	200	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B67A	5	700	10	500	N	700	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B 91	N	500	L	1000	L	N	1.5	N	N	N	N	N	N	N	N	7	N	N	N	N
B150B	L	1000	10	1500	N	500	N	N	1500	N	N	N	N	N	N	50	N	N	N	N
B267	L	700	L	700	N	200	N	1	N	N	N	N	N	N	N	5	N	N	N	N
B427	15	1500	N	500	N	500	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B436	L	300	L	1000	N	500	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B647	L	500	N	500	N	500	N	N	N	N	N	N	N	N	N	L	N	N	N	N
B168	L	200	L	300	N	700	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B182A	L	300	L	200	N	500	N	N	N	N	N	N	N	N	N	N	N	N	N	N
L126	7	150	15	200	N	1000	N	N	N	N	N	N	N	N	N	N	N	N	N	N
L164A	7	1000	N	300	N	300	N	N	N	N	N	N	N	N	N	N	N	N	N	N
L188	L	300	100	10000	N	700	N	2	N	500	N	N	N	N	N	7	N	N	N	N
L302	7	200	N	150	N	L	N	N	N	N	N	N	N	N	N	7	N	N	N	N
L416	20	3000	10	700	N	500	L	150	N	700	N	N	N	N	N	7	N	N	N	N
L431	N	150	20	300	N	1000	N	N	N	N	N	N	N	N	N	N	N	N	N	N
R100	7	150	N	150	N	700	N	N	N	N	N	N	N	N	N	N	N	N	N	N
R104	15	1000	15	700	N	700	N	1	N	700	N	150	N	N	N	15	N	N	N	N

OXALIC ACID-SOLUBLE IRON AND MANGANESE OXIDES IN THE CAMBRIAN FLATHEAD SANDSTONE, CHOTEAU QUADRANGLE, MONTANA--A SAMPLE MEDIUM FOR MINERAL EXPLORATION

By

Reinhard W. Leinz and James W. Whipple

1981

INTRODUCTION

This report discusses the use of the iron-manganese oxide minerals in the Cambrian Flathead Sandstone as a sample medium for mineral exploration. The Fe-Mn oxide fractions of 62 sandstone samples were analyzed to determine their trace element content and distribution. The study is confined to the Flathead, which is exposed in the central and southeastern parts of the Choteau 1° x 2° quadrangle in northwestern Montana. The Flathead Sandstone was chosen for the investigation because the occurrence of Fe-Mn oxide minerals is a characteristic feature of the unit, and its exposures in the quadrangle transect both mineralized and apparently unmineralized areas.

Chao and Theobald (1976) noted that hydrous iron and manganese oxides are ubiquitously present in stream sediments and soils as coatings, stains, and concretions or as discrete particles of colloidal dimensions and that the oxides are, through one or more of several mechanisms, scavengers for many heavy metals released in the weathering processes. Scavenging may proceed by coprecipitation, adsorption, surface complex formation, ion exchange and penetration of the crystal lattice, or more likely, a combination of these mechanisms. Carpenter and others (1979) reported on the use of metal analysis of Fe-Mn oxide joint coatings in igneous and sedimentary rocks as a possible exploration tool. They conclude that metal relationships in the coatings appear to reflect certain types of mineralization in the Pinos Altos district of New Mexico.

The purpose of this study is to determine if the trace element concentrations in the iron-manganese oxides hosted by the Flathead Sandstone and the distribution of these elements reflect mineralized zones in the Choteau quadrangle.

DESCRIPTION AND GEOLOGIC SETTING

The Flathead Sandstone, of Middle Cambrian age, ranges in thickness from 20 to 35 meters and consists of 80 to 90 percent fine to coarse, white quartz grains in a grain-supported fabric with minor amounts of feldspar, mica, and opaque accessory minerals (Mudge, 1972). Most grains are stained with hematite or limonite, giving outcrops a pale maroon to orange cast. Fracture surfaces are commonly coated with iron and manganese oxides. Fresh surfaces are buff to yellow-gray. The sandstone in most exposures, though poorly indurated, is resistant to weathering in comparison to the enclosing strata. In places, gray to maroon shales are interbedded with the sandstone.

Within the study area, the Flathead Sandstone rests unconformably upon middle Proterozoic Belt Supergroup metasedimentary rocks. The unconformity, which represents a pre-Middle Cambrian erosion surface, occurs at different stratigraphic levels within the Belt Supergroup depending on the location of exposures relative to thrust faults (Mudge and others, 1979).

SAMPLING AND ANALYTICAL METHODS

Of the 62 samples analyzed for this study, 25 were collected during the period 1969-1976 by Mudge and Earhart in their mineral resource evaluation of the Bob Marshall and Scapegoat Wilderness areas and proposed additions (Mudge and others, 1974; Earhart, 1978; Earhart and others, 1977). The exposures of the Flathead in the mineralized southeastern section of the quadrangle were sampled more extensively by D. J. Grimes, R. W. Leinz, and R. L. Earhart during the field seasons of 1977-1979.

Hydrous iron and manganese oxides in geologic materials are dissolved by aqueous solutions of oxalic acid (Alminas and Mosier, 1976). In this study, 5 grams of the finely ground sample were boiled for ten minutes in 50 milliliters of a 5-percent aqueous solution of oxalic acid. The hot solution was then filtered and the filtrate evaporated to dryness, care being taken to avoid splattering. Excess crystalline oxalic acid was sublimed by continued heating. The residual oxalates were scraped into porcelain crucibles and heated in a muffle furance at 450°C for 4 hours. Five milligrams of the resulting anhydrous oxides were mixed with 5 milligrams of spectrographically-pure quartz and 20 mg of graphite powder containing 5 percent lithium carbonate. The mixture was packed into a graphite electrode and analyzed for 31 elements by a semiquantitative direct-current arc spectrographic method (Grimes and Marranzino, 1968). For comparison, untreated rock samples were also analyzed spectrographically.

RESULTS

Table 1 lists the concentrations of selected elements in the untreated sandstone samples and in their oxalic acid-soluble oxide fractions. Of the 31 elements determined, those selected are associated with the known types of mineral occurrences in the quadrangle. These include metal-enriched carbonate vein systems, stratabound copper and associated metals, and the copper-molybdenum porphyry deposit and related mines of the Heddleston district east of Lincoln, Montana, described by Miller and others (1973).

Usable trace metal data on the untreated samples listed on the table are minimal, the range of values are narrow, and their interpretation is difficult. The number of metals found over wide concentration ranges is markedly increased in the oxide fractions. Concentrations of copper and lead are enhanced to as much as two orders of magnitude. Zinc is present in abundant amounts and significant concentrations of the other metals appear. Consequently, only the geographic distribution and abundances of the elements in the oxide fractions are presented on maps 2-8 and 2A-8A.

Concentrations of twice the background are defined as the thresholds at which values are considered anomalous. Background values of Cu, Pb, and Zn were chosen as those concentrations at the 50th percentile cumulative frequency. These values are 500, 500, and 700 parts per million, respectively. For the other elements, background levels were selected by inspection to be at or below the analytical limit of determination (given in "()" next to the element symbol at the top of table 1).

Maps 2-8 and 2A-8A show two principal areas of anomalous metal concentrations. The more pronounced is at Cuniff Basin, the area indicated by the enlarged inset on each of the maps (maps 2A-8A). Base metal content is 20 to 30 times threshold. Silver, molybdenum, tungsten, thorium, arsenic, and antimony are also anomalous. This locality is near the southern edge of a lead-zinc belt, outlined on the maps, described by Mudge and others (1968), and the anomaly may indicate an extension of that belt.

The second area lies to the south-southeast of Cuniff Basin. The occurrence of anomalous copper and molybdenum along with other trace metals at this locality is suggestive of the porphyry system in the Heddleston district to the south, indicated on each of the maps.

Samples 79-1AR, 1BR, and 1CR, from or near a lead prospect at Beaver Meadows (map 1), contain anomalous amounts of several metals. These results reflect a part of the lead-zinc belt referred to above. To the north, sample B150B is from an area where veins associated with a Precambrian diorite sill contain copper, lead, zinc, and silver minerals (Earhart, 1978). Spatial relationships of other anomalous samples to mineralized zones are unknown but may warrant further investigation.

CONCLUSIONS

The possible sources of anomalous trace metals determined in the oxalic acid-soluble Fe-Mn oxide fraction of the Flathead Sandstone may include any combination of the following: trace metals associated with oxidation products of primary sulfide minerals disseminated in the sandstone; trace metals scavenged by oxides from groundwater solutions permeating the sandstone, especially those moving through mineralized zones; trace metals scavenged by the oxides from hydrothermal fluids. The magnitude of the concentrations and the suites of elements present in the two anomalous regions suggest mineralized sources.

The results of this study indicate that analysis of iron-manganese oxides prevalent in specific rock units may be an effective tool for delineating hidden mineral deposits.

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