Base from U.S. Geological Survey 1958–67
100,000-foot grids based on Michigan coordinate system, north zone and Wisconsin coordinate system, north zone
10,000-meter Universal Transverse mercator grid ticks, zone 16

Geology simplified from Cannon, 1984

INTRODUCTION

This map is part of a folio of 1:250,000-scale maps of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, prepared as a project of the Conterminous United States Mineral Assessment Program. A list of maps (U.S. Geological Survey Miscellaneous Investigations Series Maps I-1360-A–N) for the complete folio follows.

MAP

- I-1360-A Mineral resources of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by W. F. Cannon.
- I-1360-B Bedrock geologic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by W. F. Cannon.
- I-1360-C Surficial geologic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by W. L. Peterson.
- I-1360-D Structural and tectonic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by W. F. Cannon.
- I-1360-E Bouguer gravity anomaly map and geologic interpretation of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by J. S. Klasner and W. J. Jones.
- I-1360-F Aeromagnetic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by E. R. King.
- I-1360-G Metamorphic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by Karen Wier.
- I-1360-H Copper distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by H. V. Alminas, J. D. Hoffman, and R. T. Hopkins.
- I-1360-I Chromium distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by H. V. Alminas, J. D. Hoffman, and R. T. Hopkins.
- I-1360-J Cobalt distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by J. D. Hoffman, H. V. Alminas, and R. T. Hopkins.
- I-1360-K Nickel distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by J. D. Hoffman, H. V. Alminas and R. T. Hopkins.
- I-1360-L Silver distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by R. T. Hopkins, H. V. Alminas, and J. D. Hoffman.
- I-1360-M Molybdenum distribution in B-horizon soils in the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by R. T. Hopkins, H. V. Alminas, and J. D. Hoffman.
- I-1360-N Interpretive geochemical map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin, by H. V. Alminas, J. D. Hoffman, R. T. Hopkins.

The field, analytical, and interpretational work pertaining to this map was conducted in 1978–80. The analytical data were entered and stored in the U.S. Geological Survey computer storage system (RASS), (VanTrump and Miesch, 1977). A table format listing of the data was published in 1981 (Hopkins, 1981).

AREA DESCRIPTION

The Iron River 1° x 2° quadrangle encompasses the area bounded by 46°–47° latitude and 88°–90° longitude. It includes most of the western part of the Michigan Upper Peninsula as well as a segment of northern Wisconsin in its southwestern corner. Of the 17,222 km² (6,624 mi²) delineated by these boundaries, some 15,454 km² (5,944 mi²) is land surface; Lake Superior encompasses 1,768 km² (680 mi²).

The climate within this region is cool and moist. Long severe winters and short summers with moderate temperatures are characteristic. The average annual precipitation is approximately 86 cm (34 in.). Topographically, the region as a whole is a highland and headwater drainage area although locally the topography is quite variable. It has been greatly modified by repeated glacial action, which generally rounded and leveled the high areas and scoured and then filled the valleys.

The entire area is covered by a wide range of glacial materials ranging in thickness from 0 through >90 m (>300 ft), probably averaging in the 20–30 m (70–100 ft) range.

SAMPLING DESIGN

Previous studies (Alminas, 1975) in areas of similar climatic, topographic, and geologic setting have indicated that B-horizon soils can serve as an effective sample medium in an environment exemplified by the Upper Peninsula of Michigan. Also, this sample medium provides operational advantages in that samples can be collected rapidly and easily throughout broad areas with a relatively uniform distribution of sample sites.

For this study, B-horizon soils were collected at 3,156 localities, or at an approximate density of one sample per 5.1 km² (2 mi²). An attempt was made to obtain as uniform a distribution of sample sites as possible, along roads, along rivers and lake shores, and in remote areas (accessible by helicopter). Wherever possible, only seemingly undisturbed soils were sampled. In some agricultural areas, however, it was impossible to avoid sampling in cleared fields.

SAMPLE COLLECTION

Samples were collected in 1978 and 1979 by two sample collectors working a six-week period in May and June and a four-week period in September of each year.

The B-horizon soil samples were collected at a depth range of 7.6 to 71 cm (3–28 in.), although the great majority were collected at a depth between 30.5 cm and 43 cm (12–17 in.). Approximately 1/2 kg (1 lb) of soil was collected at each site, using an impact-type post-hole digger and a small crowbar. The samples were stored in Kraft[1] paper bags. The following information (primarily visually determined) pertaining to the soil and site setting was coded at each location:

1. Slope at sample site
2. Depth at which sample was collected
3. A-horizon thickness
4. Soil color
5. Soil moisture content
6. Soil organic content
7. Soil clay content
8. Soil silt content
9. Soil sand content
10. Angularity of fine fragments
11. Soil pebble content
12. Soil cobble content

Several 5.0-kg (11-lb) B-horizon soil samples were collected at selected sites for heavy-mineral separation.

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

SAMPLE PREPARATION

The soil samples were oven-dried overnight at 100°C in the original paper bags. Extremely clay rich samples were disaggregated in a crusher, using a wide jaw setting. All of the soils were then sieved through an 80-mesh (177-micron opening) sieve, and an 84-g (3-oz) sample of the fine fraction was saved for analysis.

The 5-kg B-horizon samples were washed, panned, and dried. The remaining light-mineral fraction was removed by Bromoform (sp. gr. 2.85) separation.

ANALYTICAL METHODS

Element concentrations were determined by a semi-quantitative spectrographic method described by Grimes and Marranzino (1968). Results of these spectrographic analyses are reported within geometric intervals having the boundaries of 1,200, 830, 560, 380, 260, 180, 120, all in ppm, but are shown in the histograms by approximate geometric midpoints, such as 1,000, 700, 500, 300, 200, 150, and 100 (Mosier, 1972). Precision of a reported value is approximately plus or minus one interval at the 68 percent confidence level, or plus or minus two intervals at the 95 percent confidence level (Motooka, 1976). Table 1 shows the elements analyzed for and individual detection limits.

Table 1.—*Elements analyzed for and limits of detection*

Element	Unit of measure	Limit of detection
Fe	percent	0.5
Mg	percent	.02
Ca	percent	.05
Ti	percent	.002
Mn	ppm	10
Ag	ppm	.5
As	ppm	200
Au	ppm	10
B	ppm	10
Ba	ppm	20
Be	ppm	1
Bi	ppm	10
Cd	ppm	20
Co	ppm	5
Cr	ppm	10
Cu	ppm	5
La	ppm	20
Mo	ppm	5
Nb	ppm	20
Ni	ppm	5
Pb	ppm	10
Sb	ppm	100
Sc	ppm	5
Sn	ppm	10
Sr	ppm	100
V	ppm	10
W	ppm	50
Y	ppm	10
Zn	ppm	200
Zr	ppm	10
Th	ppm	100

DATA PRESENTATION

Molybdenum data are presented on the map by symbols. All of the sample sites within the map area are shown. The symbols used to represent the various silver content classes are shown in the explanation. An isopleth presentation was omitted on this map because of the low number of cells with detectable molybdenum contents. The map was plotted by computer using a mapping program within the STATPAC system (VanTrump and Miesch, 1977).

NATURE AND DISTRIBUTION OF SOILS

Soils are the products of weathering. The nature of a soil is determined by a combination of several factors acting through time within the area of soil formation. Probably the most important of these are:

a. The composition of the parent material
b. The topographic setting (especially slope)
c. The climate
d. The amount of vegetational cover
e. The length of time over which the above factors operated

Within the Iron River 1° x 2° quadrangle, essentially all the parent material was deposited by glaciers or glacial melt water and it ranges in texture from gravel to clay. The soil textures are variable over the map area and could be important in interpreting soil geochemistry. In figure 1, areas of B-horizon soils that are predominantly clay, silt, or sand, are delineated.

Most of the soils with an anomalous molybdenum content are in a predominantly sandy area. They constitute, however, but a small amount of sand-rich samples, nearly all of which show no detectable molybdenum.

Topographic setting ranges from flat to hilly; slopes are as great as 40 percent. Slope determines the position of the sample site relative to the water table, an important factor inasmuch as the geochemical patterns within this area are interpreted as being predominantly hydromorphic. A map of the soil moisture conditions found at each sample site is figure 2.

Factors c, d, and e can be considered to be constant throughout the map area.

STATISTICAL DISTRIBUTION OF MOLYBDENUM IN SOILS

Molybdenum content of the 3,156 B-horizon soils ranges from "not detected" (at 5 ppm) through 70 ppm. The table below shows the frequency and percent frequency distributions of the molybdenum values.

ppm Mo	Frequency	Percent frequency
N[1] (5)	3,044	96.45
L[2] (5)	46	1.46
5	33	1.05
7	25	0.79
10	6	0.19
15	0	0
20	0	0
30	1	0.03
50	0	0
70	1	0.03

[1] Not detected.
[2] Detected but less than 5 ppm.

AREAL DISTRIBUTION OF MOLYBDENUM CONTENT

Any detectable molybdenum (≥ 5 ppm) in B-horizon soils collected within the Iron River 1° x 2° quadrangle is considered to be anomalous. This limit is based on the frequency distribution of the soil molybdenum values. On this basis, 112 (3.5 percent) of the 3,156 sample locations within the map area have anomalous concentrations of molybdenum.

Nearly all of the soil samples having anomalous molybdenum occur in the eastern half of the map area. The greatest concentration is in the northeastern corner. Here, the anomalous sites occur primarily over Michigamme Slate, Jacobsville Sandstone (where it is a thin cover over buried granitic intrusives), and as a halo just outside of the granite margin.

A second cluster of sample sites of soils containing anomalous molybdenum concentrations occurs in the Echo Lake-Prickett Lake area. These sites lie exclusively over Jacobsville Sandstone. To the north, a few scattered anomalous sites can be seen over the Freda Sandstone.

A number of scattered anomalous localities are found in the southeastern corner of the map area. These sites were collected over a great variety of rock types, including granites, mafic intrusives, and Michigamme Formation.

DISCUSSION

The molybdenum distribution patterns in the Iron River 1° x 2° quadrangle are considered to be predominantly hydromorphic in origin (see Alminas and others, 1984a). The high correlations, between molybdenum and manganese (r = 0.78), cobalt (r = 0.57), copper (r = 0.52), nickel (r = 5.2), and iron (r = 0.32) in the northeastern corner of the map area tend to support this conclusion. This association and its implications are discussed more extensively by Alminas and others (1984b).

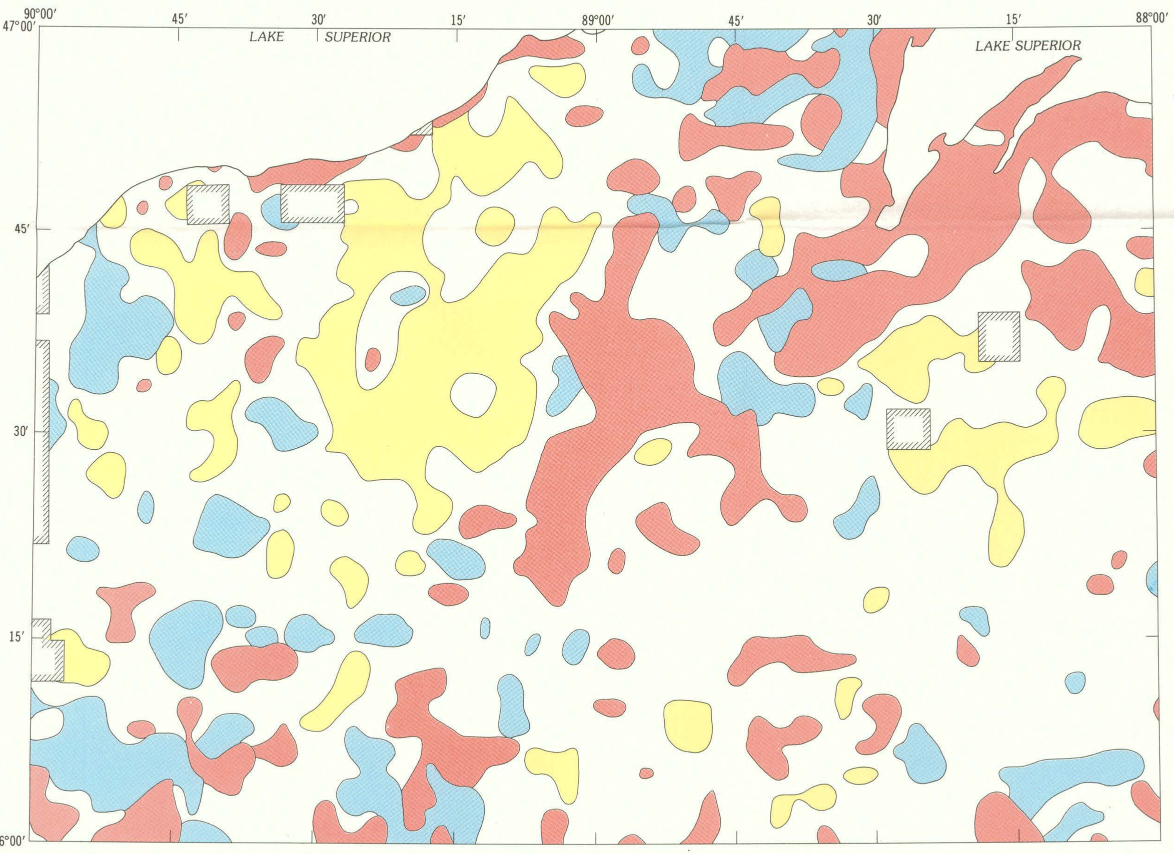

Figure 1.—AREAS OF PREDOMINANTLY SAND (RED), SILT (BLUE), CLAY (YELLOW) AND MIXED SOILS (WHITE). Scale 1:750,000; 1 in. equals approximately 12 mi.

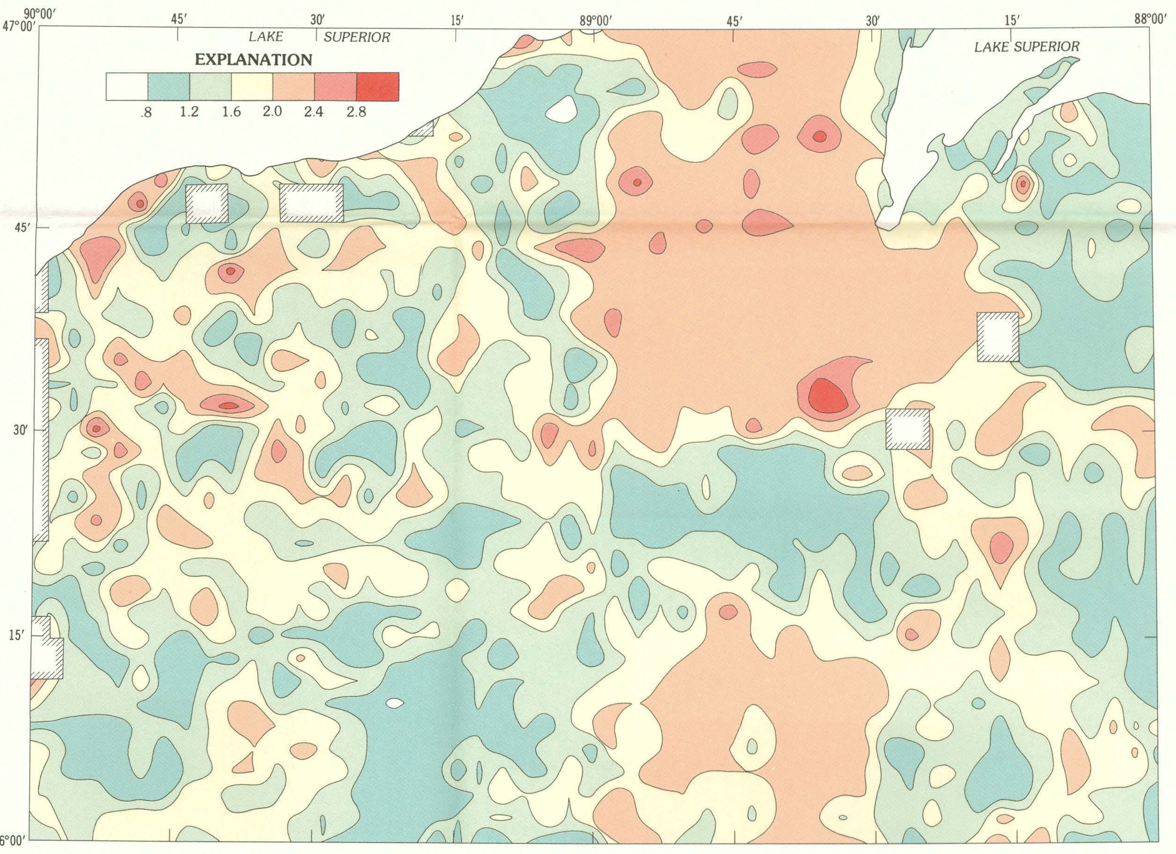

Figure 2.—RELATIVE SOIL MOISTURE CONTENT. Higher values indicate wetter areas. Scale 1:750,000; 1 in. equals approximately 12 mi.

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MOLYBDENUM DISTRIBUTION IN B-HORIZON SOILS, IRON RIVER 1° x 2° QUADRANGLE, MICHIGAN AND WISCONSIN

By
R. T. Hopkins, H. V. Alminas, and J. D. Hoffman

1984

For sale by Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202