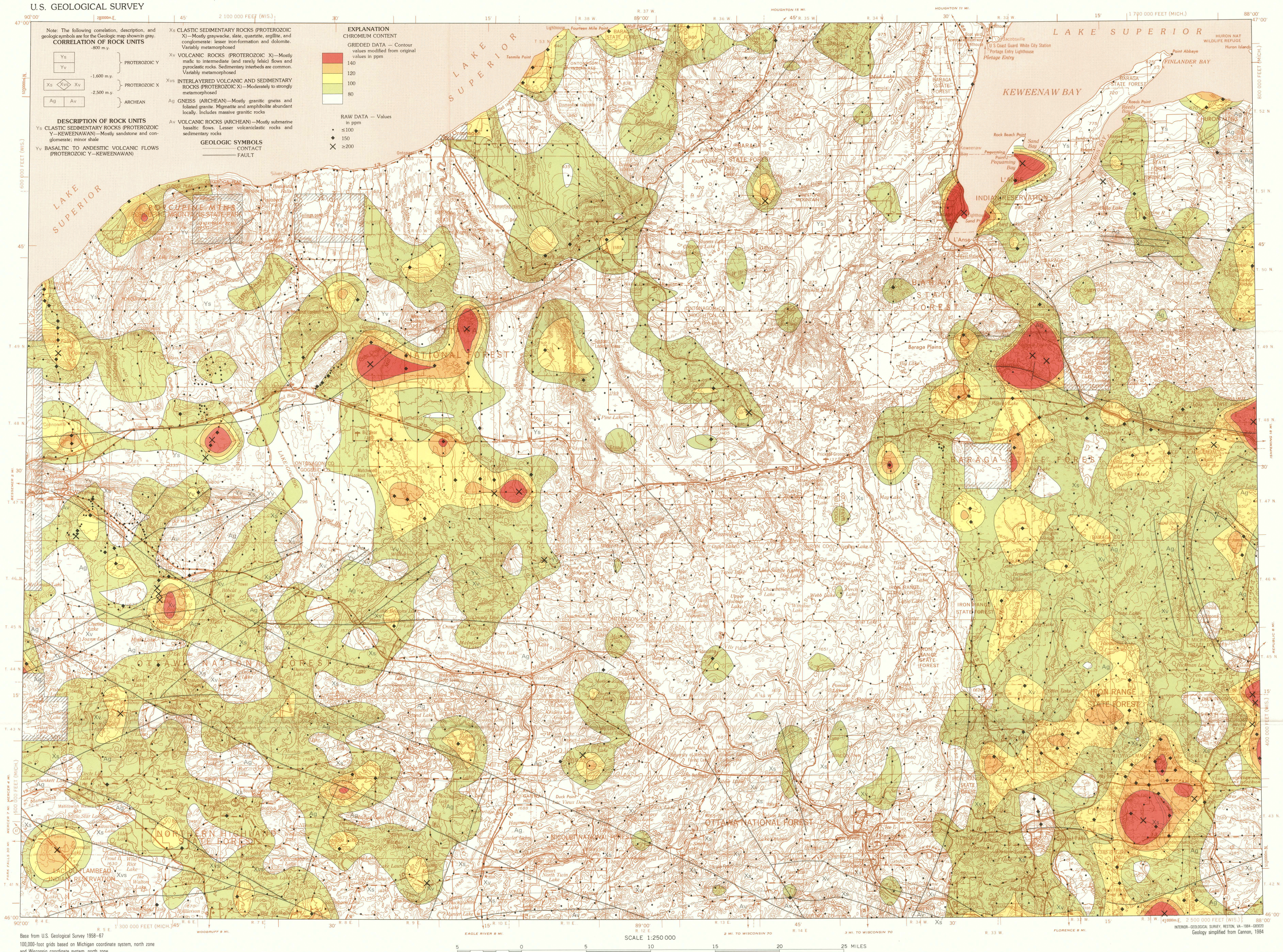


# INTRODUCTION

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 km$^2$ (6,624 mi$^2$) delineated by these boundaries, some 15,454 km$^2$ (5,944 mi$^2$) is land surface; Lake Superior encompasses 1,768 km$^2$ (680 mi$^2$).

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 km$^2$ (2 mi$^2$). 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 | 10 |
| 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

Data on chromium content are presented on the map by symbols and by isopleths, providing the reader with specific information on the chromium content of individual samples (symbols) as well as regional soil chromium content trends (isopleths). Both presentations were computer generated.

Locations of all the sample sites are shown using different symbols to indicate certain chromium content classes (see explanation).

For the isopleth map, the data within the map area were gridded, using a weighted average of circle search. This gridding method is equivalent to a first-order finite difference scheme (Fife, 1981, unpublished computer program). Where data are insufficient for the above method, as along the edges of the sampled area, such techniques as weighted average estimation were used.

For this particular plot, the map area was subdivided into uniform-size square cells with 51 divisions along the longitudinal axis and 37 divisions along the latitudinal axis, giving a total of 1,887 cells. Of these, 1,705 or 90.4 percent were valid, that is they contained sufficient information to continue a contour through the cell. Each cell, therefore, contained about two sample sites. Most of the invalid cells occur in the area occupied by Lake Superior and other large lakes. Areas of invalid cells are shown by hachures.

Gridding of the data tends to reduce variance and generates values that are not equal to the observed spectrographic values. In addition, because calculations are made on a cell basis, isopleth shifts within a cell are possible. The effect of gridding on the chromium data can be seen below:

| | Original data | Gridded data |
|---|---|---|
| Cr minimum | 10 | 7 |
| Cr maximum | 1,000 | 559 |
| Cr mean | 79 | 80 |
| Standard deviation | 35 | 31 |
| Number of points | 3,156 | 1,705 |

Subsequent to gridding, the data were contoured by computer and plotted on a flat bed plotter, using the mapping program STPMAP 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. A comparison of the mean of chromium values from clay-, silt-, and sand-rich soils (87.3 ppm, 63.3 ppm, 72.6 ppm, respectively) from the total map area suggests a soil texture-chromium content relationship, though not a systematic one. However, the difference in the chromium content in sand-rich soils from the eastern and western portions of the map area is equal to that between clay- and sand-rich soils. This indicates that the soil texture-chromium content relationship is more closely linked to underlying rock type, as in the southeastern corner of the map area.

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 shown in figure 2.

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

## STATISTICAL DISTRIBUTION OF CHROMIUM IN SOILS

Chromium contents of the 3,156 B-horizon soils ranges from L (detected but below lowest spectrographic reporting interval at 10 ppm) through 1,000 ppm. A histogram of the chromium concentration (fig. 3) shows a somewhat positively skewed unimodal distribution with a 41.7 percent mode at the 70 ppm class. The geometric mean is 72.3 ppm, and the geometric deviation is 1.5. A list of the 25th through 99th percentiles appears below:

| Percentile | ppm Cu |
|---|---|
| 25 | 57 |
| 50 | 71 |
| 75 | 94 |
| 90 | 114 |
| 95 | 128 |
| 99 | 177 |

The gridded chromium content data represent 1,705 valid cells and have a range of 7–550 ppm. A histogram of these gridded data (fig. 4) shows a strongly positively skewed unimodal distribution with a mode of 62.3 percent at the 66.1-ppm class.

## AREAL DISTRIBUTION OF CHROMIUM CONTENT

Chromium content of ≥ 150 ppm in B-horizon soils in the Iron River 1° x 2° quadrangle is considered to be anomalous. This limit is based on the frequency distribution of the soil chromium values. On this basis, the soils at 181 (5.7 percent) of the 3,156 sample sites within the area contain anomalous concentrations of chromium.

Gridded data cannot be used interchangeably with the original data because gridded data are generated by averaging calculations performed on cell units. As a result, variance is strongly reduced, and the upper end of the value distribution is very compressed. However, gridded data are effective in delineating regional chromium content in these soils. Regional trends are delineated by 80-ppm isopleths; anomalies by 100-ppm isopleths.

Chromium anomalies are distributed about equally in the eastern and western parts of the map area, unlike anomalies of copper (Alminas and others, 1984a), cobalt (Hoffman and others, 1984a), or nickel (Hoffman and others, 1984b), which occur predominantly in the western part of the quadrangle.

Little, if any, association between chromium and rock type can be seen in the west. The major anomaly, in the Matchwood area, occurs over the Proterozoic Y Jacobsville Sandstone of the Keweenawan Supergroup at the Jacobsville-Sandstone-Portage Lake Volcanics (also Proterozoic Y) contact. Several other minor anomalies occur to the northeast and southwest, in a similar geologic setting. Many minor anomalies coincide with the Portage Lake Volcanics-Nonesuch Shale belt; the most intense of these are in the Porcupine Mountains southeast of the Bergland lookout tower.

To the south, several minor anomalies occur over a variety of rock types; the major one of these is at Redboat Lake.

Extensive chromium anomalies occur in the southeastern corner of the map area, probably reflecting the relatively extensive mafic intrusives there.

In the northeast, substantial chromium anomalies occur at Little Summit Lake and in the area of L'Anse. The Little Summit anomaly is probably related to local amphibolities. In addition, a halo-like scatter of moderate values peripheral to the granite outcrop area can be discerned on the chromium symbol plot. The apparent chromium halo is discussed further by Alminas and others (1984b).

## DISCUSSION

The broad regional chromium distribution patterns seen in the Iron River 1° x 2° sheet area are predominantly hydromorphic in origin (see Alminas and others, 1984a).

Some of the areas anomalous in chromium in the western part of the map area, especially those overlying Keweenawan rocks, are also anomalous in copper (Alminas and others, 1984a). This is not, however, reflected by the chromium-copper correlation coefficient ($r = 0.18$) for this area. The chromium-copper association occurs on a regional rather than a site-by-site basis and does not extend to the intermediate and low values for those metals.

In the southwest, however, little evidence of regional anomalous association is seen; the chromium-copper correlation here is relatively high ($r = 0.43$), reflecting a chromium-copper association in the low and intermediate metal value range.

In the southeast, the chromium-copper correlation is intermediate ($r = 0.27$). Although relatively low, this correlation reflects the rock-related chromium-copper association. That is, although the chromium values are some of the highest within the map area the copper values are limited at the upper end by the copper content of the mafic minerals in the rocks in this region.

An overall chromium-copper association does exist, however, within the region as a whole. This is illustrated in figure 5. The implications of this association are discussed by Alminas and others (1984b).

## REFERENCES

Alminas, H. V., 1975, Soil anomalies associated with a Cu-Ni mineralization in the south Kawishiwi area, northern Lake County, Minnesota: U.S. Geological Survey Open–File Report 75–158, 6 p.
Alminas, H. V., Hoffman, J. D., and Hopkins, R. T., 1984a, Copper distribution in B-horizon soils, Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Series Map I–1360–H, scale 1:250,000 [in press].
________1984b, Interpretive geochemical map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Series Map I–1360–N, scale 1:250,000 [in press].
Cannon, W. F., 1984, Mineral resources of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Series Map I–1360–A, scale 1:250,000 [in press].
Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating current spark emission spectrographic field methods for the semiquantitative anlayses of geologic materials: U.S. Geological Survey Circular 591, 6 p.
Hoffman, J. D., Alminas, H. V., and Hopkins, R. T., 1984a, Cobalt distribution in B-horizon soils, Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Series Map I–1360–J, scale 1:250,000 [in press].
________1984b, Nickel distribution in B-horizon soils, Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Series Map I–1360–K, scale 1:250,000 [in press].
Hopkins, R. T., Jr., Hoffman, J. D., Alminas, H. V., 1981, Analyses of outcrops and B-horizon soil samples Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Open–File Report 81–779, 167 p.
Mosier, E. L., 1972, A method for semiquantitative spectrographic analysis of plant ash for use in biogeochemical and environmental studies: Applied Spectroscopy, v. 26, p. 636–641.
Motooka, J. M., Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analysis: U.S. Geological Survey Circular 738, 25 p.
VanTrump, George, Jr., and Miesch, A. T., 1977, U. S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geoscience, v. 3, p. 475–488.

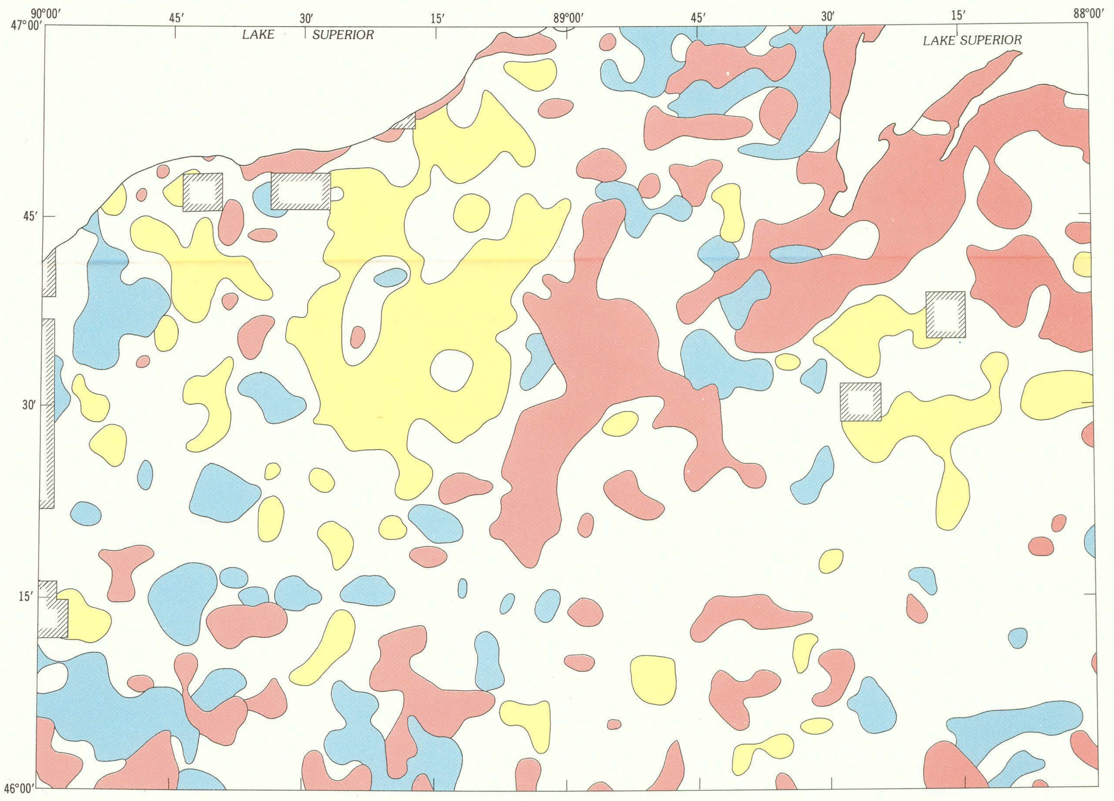

Figure 1.—AREAS OF PREDOMINANTLY SAND (RED), SILT (BLUE), CLAY (YELLOW) AND MIXED SOILS (WHITE). Scale 1:750,000; 1 in. equals approximately 12 mi.

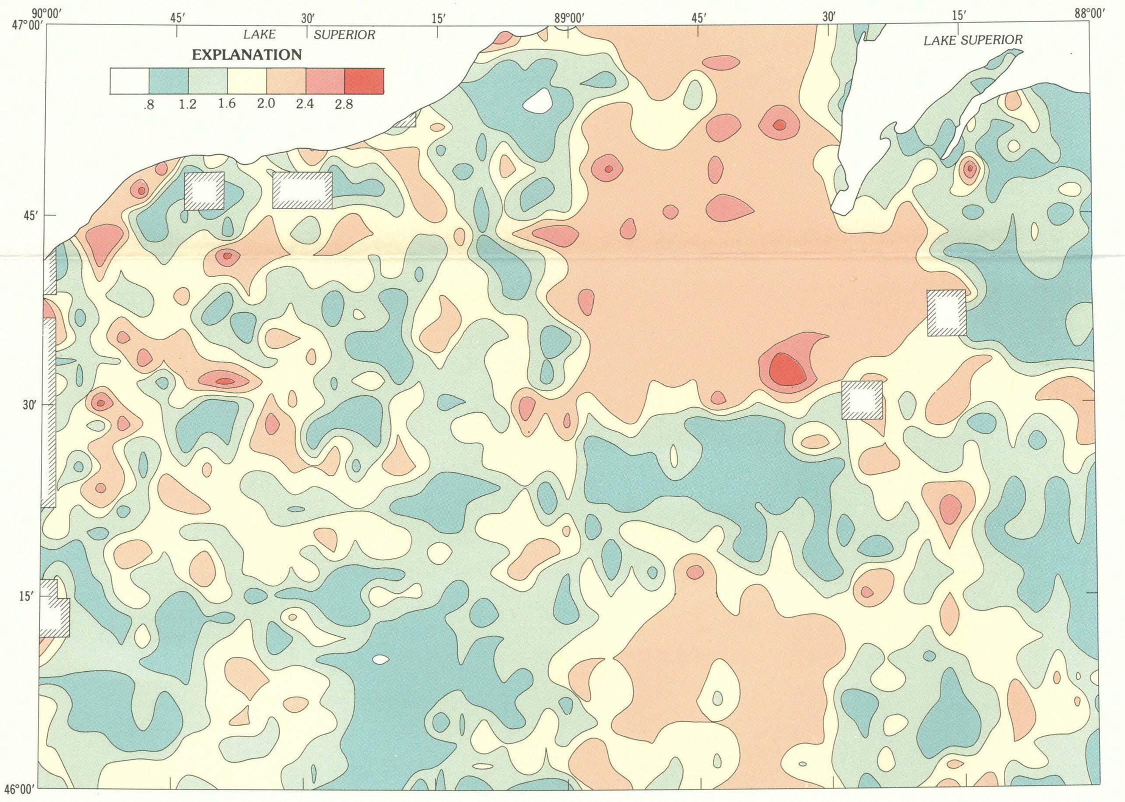

Figure 2.—RELATIVE SOIL MOISTURE CONTENT. High values indicate wetter areas. Scale 1:750,000; 1 in. equals approximately 12 mi.

Figure 3.—DISTRIBUTION OF CHROMIUM VALUES IN B-HORIZON SOILS; RAW DATA. N, not determined; L, determined but below value shown.

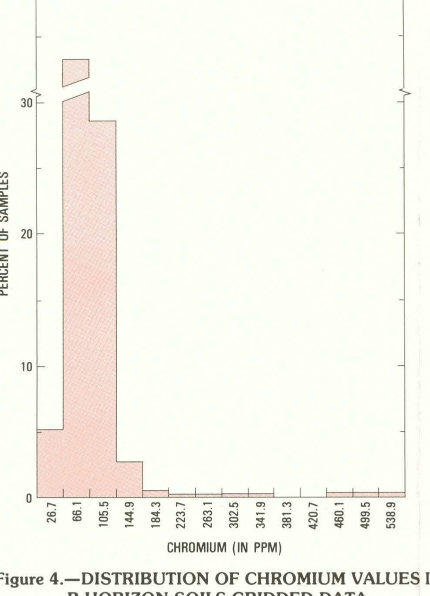

Figure 4.—DISTRIBUTION OF CHROMIUM VALUES IN B-HORIZON SOILS; GRIDDED DATA.

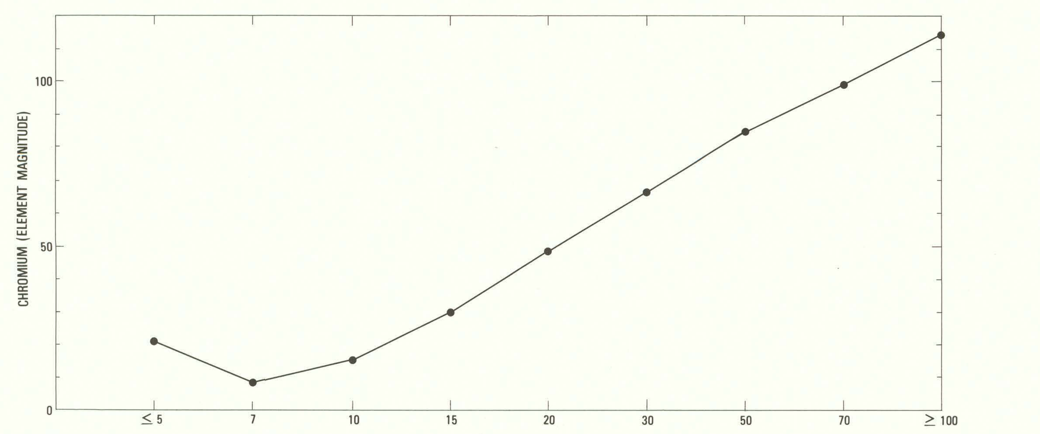

Figure 5.—CHROMIUM-COPPER ASSOCIATION FOR ALL SAMPLES IN THE IRON RIVER 1° x 2° QUADRANGLE.

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

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

1984