STUDIES RELATED TO WILDERNESS

MINERAL RESOURCES OF THE RAINBOW LAKE WILDERNESS AREA AND THE FLYNN LAKE WILDERNESS STUDY AREA, BAYFIELD COUNTY, WISCONSIN

GEOLOGICAL SURVEY BULLETIN 1511

Mineral Resources of the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area, Bayfield County, Wisconsin

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U.S. BUREAU OF MINES

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An evaluation of the mineral potential of the area

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of national forest land in the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area, Wisconsin, that is being considered for wilderness designation (Public Law 93-622, January 3, 1975). The area studied is in Chequamegon National Forest in Bayfield County.

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SUMMARY

The Rainbow Lake Wilderness Area contains a low-grade identified resource of copper in thin sedimentary beds that are no more than 1.5 feet thick and that contain grades no higher than 0.5 percent. The beds are restricted to a single stratigraphic horizon, dip 5° to 30° N., and are present only at great depth in much of the area. The area also contains about 210,000 short tons of commercial-quality peat and a great amount of sand and gravel (fig. 1). An abundance of similar material in the region closer to transportation and consumption centers makes these deposits unimportant.

The Flynn Lake Wilderness Study Area contains about 300,000 short tons of commercial-quality peat and large amounts of sand and gravel, but these, like similar deposits in the Rainbow Lake Wilderness Area, are not economically important.

Basalt and andesite lava flows are bedrock beneath the glacial drift in the southern part of the area and dip northward 30°. Consequently, the lava flows are present in the subsurface of both the Flynn Lake and the Rainbow Lake areas. Little is known of these rocks because of the lack of exposures, but, on the basis of regional geologic relationships and a theory of how native-copper ores were formed, they are believed to be favorable for such deposits. Because native-copper ores in Michigan are presently uneconomic to mine, little interest in exploration for native copper is found in Wisconsin. The study area could prove promising, however, if copper prices increase.

INTRODUCTION

A study of mineral-resource potential in the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area was conducted by personnel of the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) in accordance with provisions of the Wilderness Act (Public Law 85-577, September 3, 1964, and Public Law 93-622, January 3, 1975). Because the two areas are adjacent, they are treated as a single study area in this report.

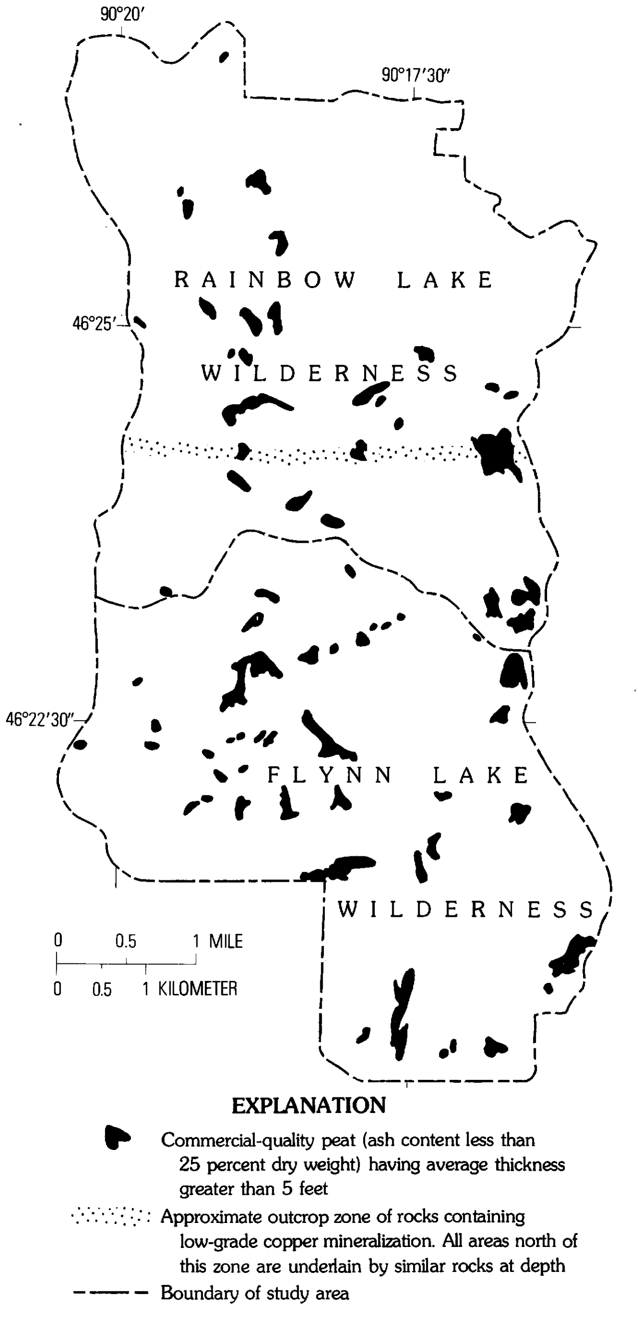

FIGURE 1.—Mineral resources in the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area.

The USGS investigation consisted of field reconnaissance and sampling in 1976 followed by detailed investigations of peat deposits in 1977. Using aerial photographs as an aid, USGS personnel made pace and compass traverses. Depths and stratagraphic units were determined by means of a Davis peat sampler.[1] Thirty-six core samples, S.101 to S.136, were selected for American Society for Testing and Materials (ASTM) ash analyses. The ash fraction, in turn, was examined for trace elements in the USGS analytical laboratories at Reston, Va., by means of a semiquantitative spectrograph technique for analyzing 65 elements.

The USBM field reconnaissance was conducted in the spring of 1976. Several copper prospects and a small abandoned mine outside the study area were examined. Some nearby outcrops of formations, which can be projected into the area, were reported to contain copper and were sampled because bedrock is not exposed in the study area.

Nine rock samples were submitted to the USBM Reno Metallurgy Research Center, Reno, Nev., where they were analyzed spectrographically for 42 elements. On selected samples, fire assays for gold and silver, atomic-absorption tests for copper, and radiometric tests for uranium were performed. Physical-property determinations of 13 peat samples were conducted by the USBM Pittsburgh Coal Preparation and Analysis Group, Pittsburgh, Pa. Ash from these samples was submitted to the Reno Metallurgy Research Center for spectrographic analysis to determine the copper content. A clay sample was tested for its ceramic properties by the USBM Tuscaloosa Metallurgy Research Center, Tuscaloosa, Ala.

Appreciation is extended to personnel of the Wisconsin Geological and Natural History Survey for sharing their knowledge of the area and for their assistance in searching their files for published geologic reports. The U.S. Forest Service provided information concerning surface and mineral rights, maps, and aerial photographs. Drill-hole data for the region were contributed by the Bear Creek Mining Co. Walter S. White of the USGS provided much useful information and advice on the interpretation of the copper-resource potential of the area.

LOCATION AND PHYSIOGRAPHY

The Rainbow Lake Wilderness Area, 6,580 acres in Tps. 45 and 46 N., Rs. 7 and 8 W., and Flynn Lake Wilderness Study Area, 6,320 acres in T. 45 N. and Rs. 7 and 8 W., are in Chequamegon National Forest, Bayfield County, Wis. The Flynn Lake Wilderness Study Area is south of the Rainbow Lake Wilderness Area and shares a common boundary (fig. 2).

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[1] Any trade names in this publication are used for descriptive purposes only and do not constitute endorsement by the U.S. Geological Survey.

Ashland, the nearest major town, is about 30 miles northeast of the study area. The village of Drummond, at the southeast corner of the Flynn Lake area, is connected with Ashland and cities to the southwest by the Chicago and North Western Railroad and by U.S. Highway 63. Forest Service roads surround the Rainbow Lake area and most of the Flynn Lake area. The North Country hiking trail, maintained by the Forest Service, enters the Flynn Lake Wilderness Study Area at its northeast corner and bisects the Rainbow Lake Wilderness Area. Old logging trails, some of which are overgrown, provide access by foot to much of the interior. Because the woods are open, areas beyond the trails are also easily accessible.

The topography is controlled by glacial drift, which is mostly stratified sand and gravel. Most of the surface is gently rolling, but several deep depressions and steep-sided hills provide a maximum relief of about 300 feet; the lowest altitudes of the area are in the north, and the highest are in the south.

Distinctive physical features of the area are the many small lakes, the peat bogs, and the steep-sided undrained depressions. Surface drainage is poor. Two intermittent creeks drain some of the northern parts of the Rainbow Lake Wilderness Area, but most precipitation is dissipated by percolation through the glacial drift or by transpiration.

LAND STATUS

The U.S. Forest Service owns all surface rights except for six private tracts that constitute approximately 2 percent of the area (fig. 3). Mineral ownership is more complex (fig. 4). As of May 1976, the Forest Service did not own the mineral rights for about 75 percent of its surface ownership nor for any of the six privately held tracts of land. Mineral rights in private possession fall into three categories:

1. Rights retained through either 1984 or 1985—about 59 percent of the study area.
2. Unlimited rights—12 percent of the study area.
3. Rights retained until 2033 with consecutive 5-year extensions if commercial operations have been active for 234 days each year for 5 years—4 percent of the study area.

Mineral ownership for private land is recorded at the Bayfield County Courthouse in Washburn. Mineral ownership records for Forest Service land are available at the Forest Service Regional Office in Milwaukee.

GEOLOGY

The regional map (fig. 5) shows that the study area is within a belt of volcanic and sedimentary rocks that extends for many hundreds of miles in the upper midwest region of the United States. Commonly

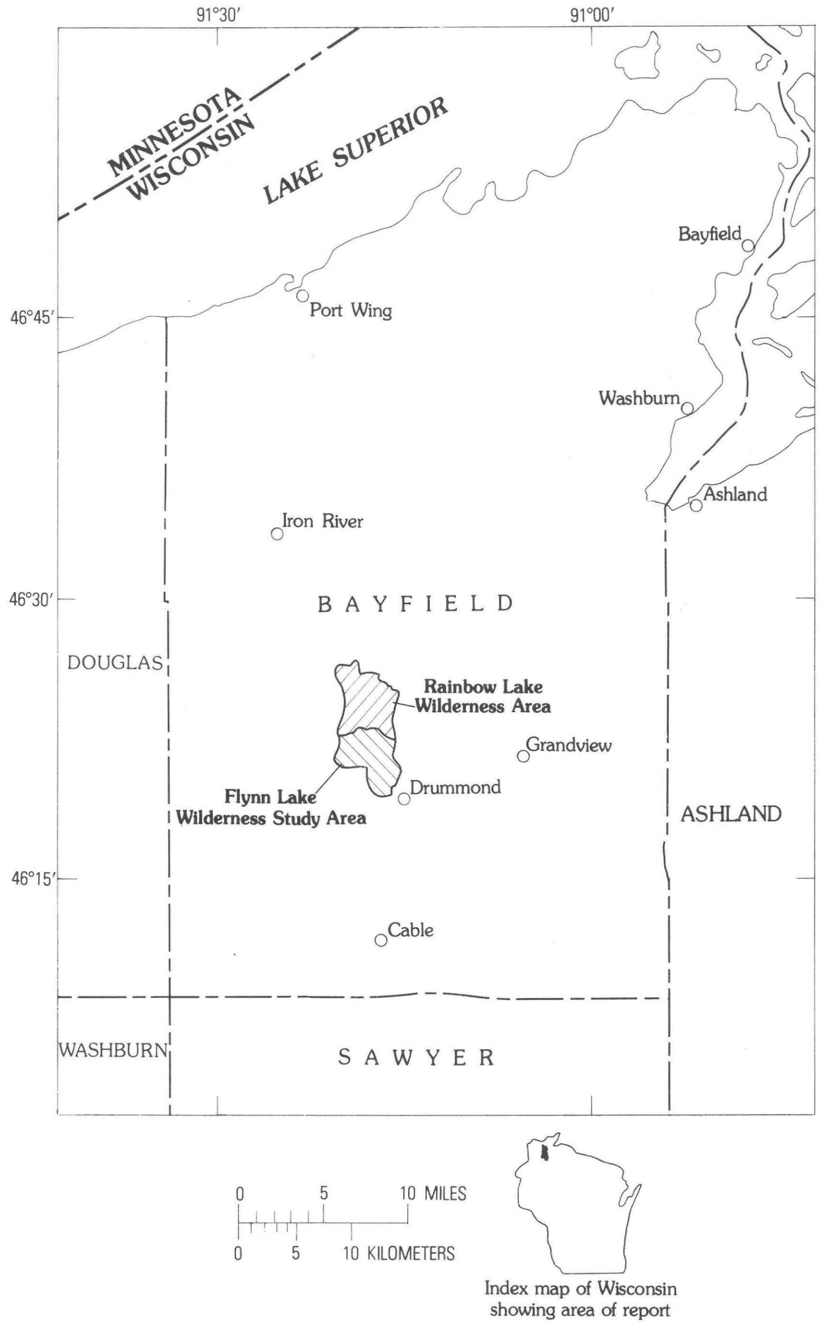

FIGURE 2.—Location of the study area.

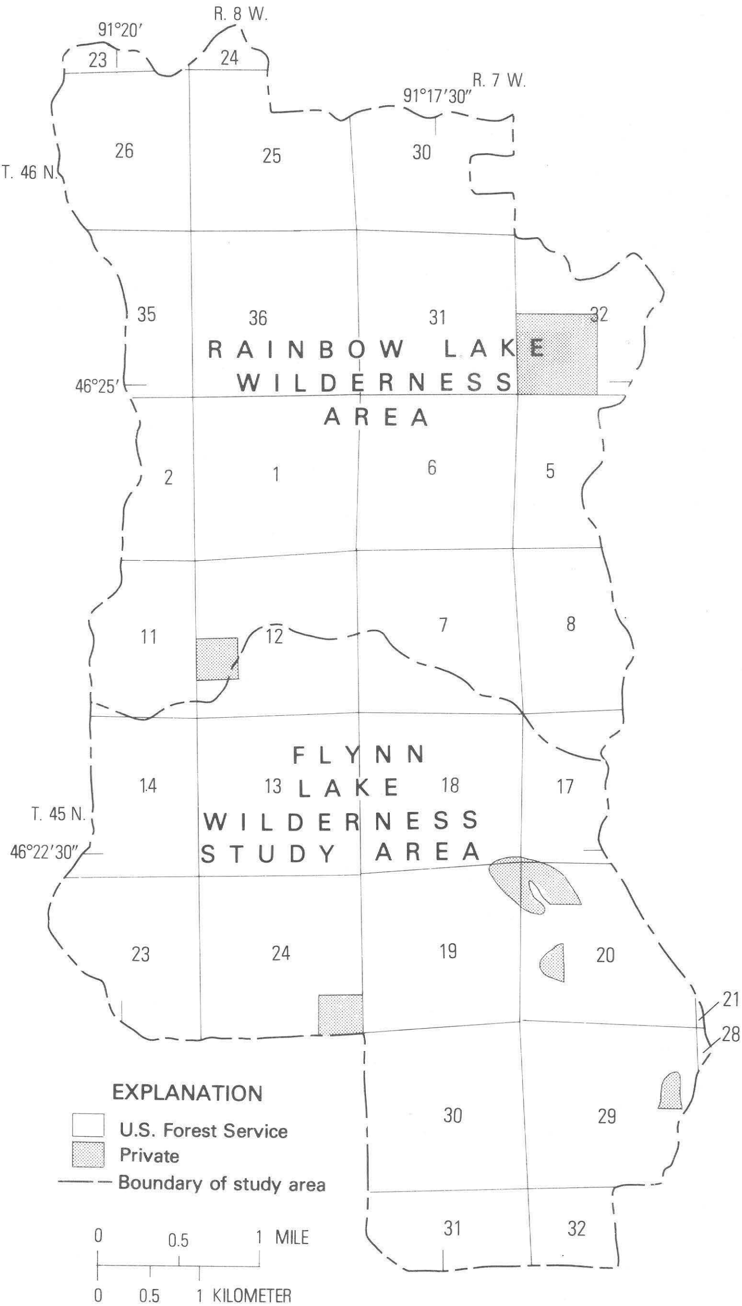

FIGURE 3.—Surface ownership.

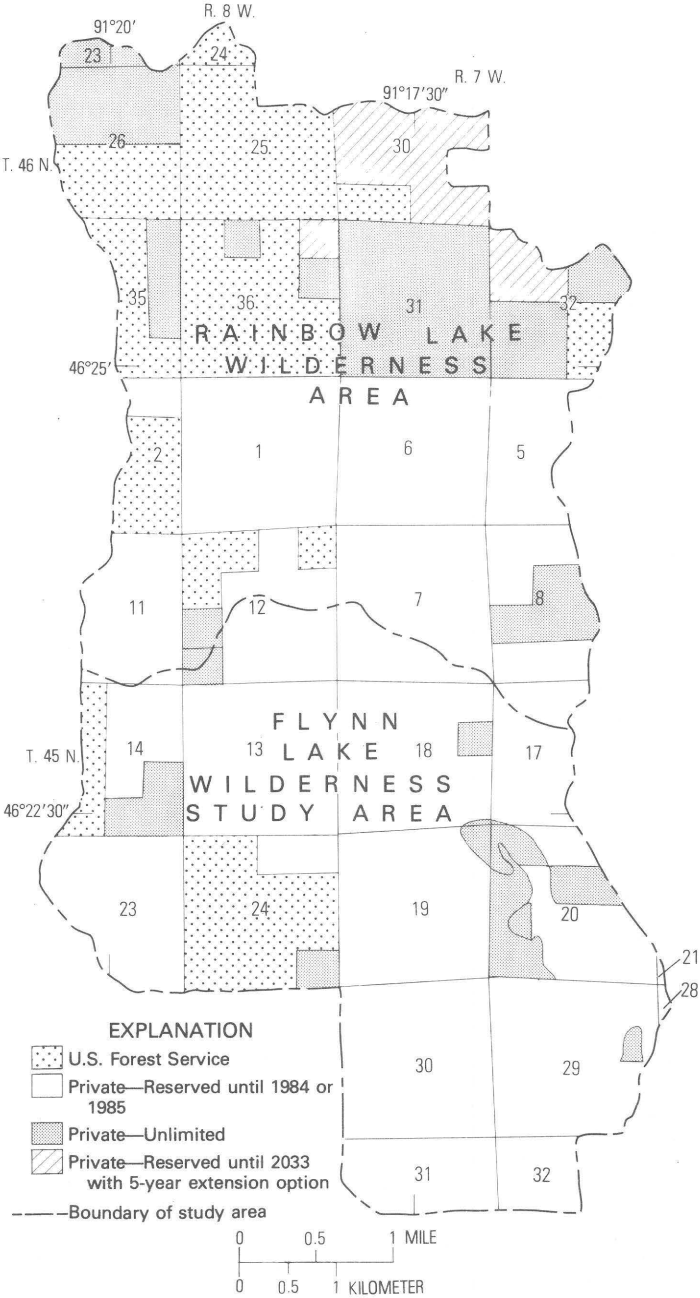

FIGURE 4.—Ownership of mineral rights.

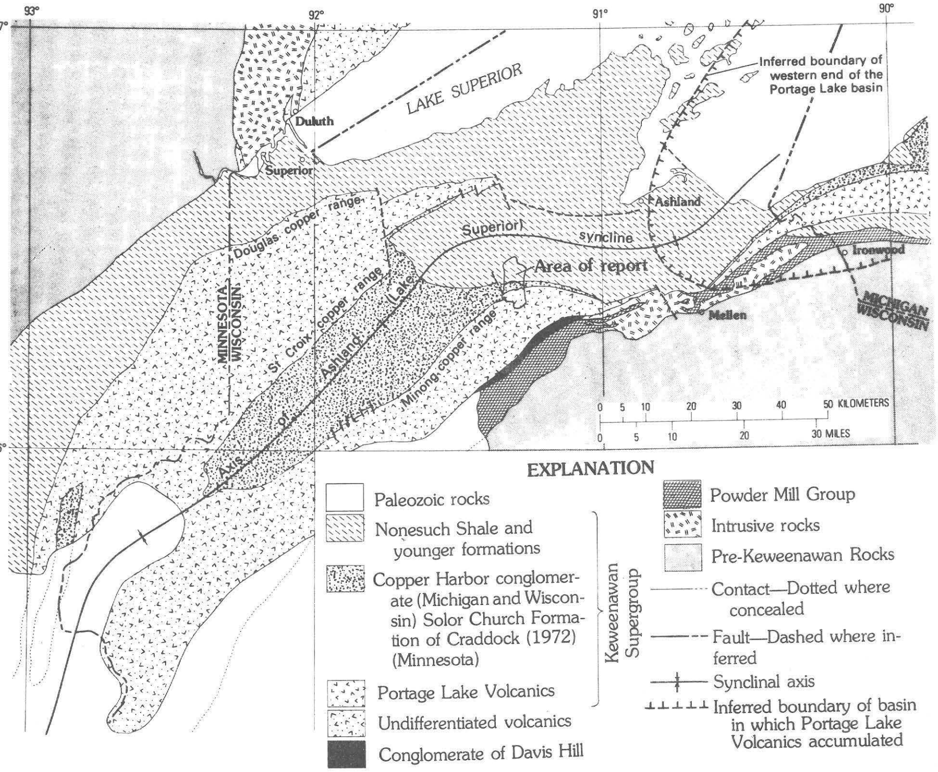

FIGURE 5.—Regional geologic map (from White, 1978).

called "Keweenawan rocks" because of their extensive exposures on the Keweenaw Peninsula in Michigan, these 1-billion-year-old rocks are preserved in a downfold known as the Ashland syncline. The study area is on the south limb of the syncline.

The entire study area is blanketed by unconsolidated drift deposits of sand and gravel formed during Pleistocene glaciation; peat deposits have formed in many of the depressions on the surface of the glacial drift. The glacial deposits are probably thin toward the southern edge of the area because bedrock is exposed near the southern boundary, but these deposits are progressively thicker toward the north. Some information about their thickness is available from five drill holes (see pl. 1*A*), one of which is within the area and four of which are within 2 miles of the area. Drill hole WC–9, near the center of the Rainbow Lake Wilderness Area, penetrated 596 feet of drift.

The bedrock geology has been interpreted from the five drill holes, from projections of bedrock exposures at considerable distances from the area, and from magnetic surveys performed many years ago by the Wisconsin Geological Survey and shown on a map by Dutton and Bradley (1970).

In the bedrock beneath the study area are four stratigraphic units. Contacts shown on plate 1*A* are projections updip from drill holes to the bedrock surface. Because of uncertainties of the continuity of dip angles and of the configuration of the bedrock surface, the projections may be in considerable error.

Four of the stratigraphic units are composed of sedimentary rocks. They underlie most of the area and overlie a thick sequence of basalt and andesite lava flows. The youngest unit, the Freda Sandstone, consists of red to brown fine- to coarse-grained sandstone and siltstone and minor red shale. The Freda is a thick unit, but only its lowest 2,000 to 3,000 feet is in the study area. The Nonesuch Shale, underlying the Freda, is mostly gray siltstone and minor gray sandstone and shale and is about 400 feet thick in the study area. The Copper Harbor Conglomerate, 4,000 feet thick, underlies the Nonesuch and is composed of brown medium- to coarse-grained sandstone and conglomerate. Underlying the sedimentary rocks is a great thickness of slightly metamorphosed basalt and andesite flows.

The structure of the area is simple, as shown by the geologic cross profile (fig. 6). The rock units dip 5° to 30°N.; dips are progressively less toward the north as the axis of the Ashland syncline is approached. The extent to which the rocks may be faulted is unknown because of the wide spacing of drill holes used to construct the section.

IDENTIFIED MINERAL RESOURCES

Copper, peat, and sand and gravel are the only identified resources in the study area. All have low economic potential.

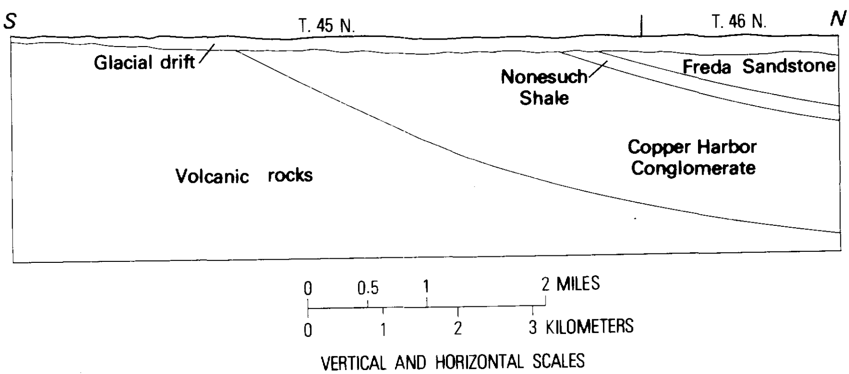

FIGURE 6.—Geologic profile of the study area. Line of profile is the north-south boundary of Rs. 7 and 8 W.

COPPER IN THE NONESUCH SHALE AND COPPER HARBOR CONGLOMERATE

In Ontonagon County, Mich., native copper and copper sulfides are present near the base of the Nonesuch Shale. This shale was recognized as a large low-grade copper deposit in 1942, and, in 1953, the White Pine Mine was opened (Ensign and others, 1968). These events and the known extension of the Nonesuch into Wisconsin prompted the Bear Creek Mining Co. to drill into the Ashland syncline seeking copper-bearing Nonesuch Shale.

Between 1955 and 1960, the Bear Creek Mining Co. drilled about 50 holes in Ashland, Bayfield, Douglas, Washburn, and Burnett Counties. Field mapping, magnetic and gravity surveys, and refraction seismic techniques were also used in the exploration (Moerlein, 1963). Eleven holes were drilled on land owned by Bayfield County. Drill logs, analyses, an exploration report, and a geologic map of Bayfield County are on file at the Bayfield County Courthouse. According to the final exploration report, the Bear Creek Mining Co. concluded that further exploration on county lands was not justified. Additional data provided to the USBM by the Bear Creek Mining Co. for the five holes in and near the study area (pl. 1*A*) are summarized in table 1.

Interpretation of drill cores by the Bear Creek Mining Co.[2] indicates that the Nonesuch Shale is present in the subsurface in the northern part of the study area. About 80 percent of the Rainbow Lake Wilderness Area is underlain by the Nonesuch Shale. Copper determinations by the Bear Creek Mining Co. were made on parts of three

[2] "Final exploration report on lands covered by easement with option to lease with Bayfield County, Wisconsin." Unpublished report, May 1, 1959, on file at Bayfield County Courthouse, Washburn, Wis. (map, logs, and analyses of 11 holes on county-owned lands).

TABLE 1.—*Drill-hole data—Rainbow Lake*

[Data from the Bear Creek Mining Co., Salt Lake City, Utah. —, not

Drill hole No.	Location	Formation intercepts	
		Glacial drift	Freda Sandstone
WC-5	100 feet S., 300 feet W. of NE cor. SW¼NW¼ sec. 14, T. 45 N., R. 8 W.	0 [363]	not present
WC-90	SE corner, sec. 36, T. 46 N., R. 8 W.	0 [596]	596 [629]
WC-17[2]	South shore Cranberry Lake, SE cor. sec. 3, T. 45 N., R. 7 W.	0 [250]	256 [696]
WC-19	800 feet W., 200 feet S. of NE cor. sec. 9, T. 45 N., R. 8 W.	0 [500]	not present
WC-22	500 feet E., 100 feet S. of NW cor. sec. 3, T. 45 N., R. 8 W.	0 [746]	746 [867]

[1] Copper determinations were made on intervals of 1,235 to 1,260 feet and 1,610 to 1,625 feet; however, most were negative. Intervals shown are those in which copper was found.

drill cores (table 1) that intersected the Nonesuch. Analyses revealed that here, as in Ontonagon County, Mich., copper values are highest in the basal part of the Nonesuch and the top of the subjacent Copper Harbor Conglomerate. However, concentrations are much lower than those in Michigan, where ore grades average 1.2 percent copper (Ensign and others, 1968, p. 464). For these three holes (WC–9, 17, and 22), maximum copper content for 1-foot intervals did not exceed 0.17 percent for the Nonesuch (1,723–1,724-foot intervals of WC–9) and 0.45 percent for the Copper Harbor (1,335–1,336-foot intervals of WC–17). The depth of the Nonesuch Shale in the study area and the low copper content preclude mining in the foreseeable future.

PEAT

Peat is broadly classified by the USBM as moss and reed-sedge, according to the type of plant material from which it formed; humus, the third type, is so decomposed that identities of the plants composing it are lost. According to the American Society for Testing and Materials (1969) (D–29, ASTM D 2607–69) the term "peat" may be used only if the material has an ash content that does not exceed 25 percent of its dry weight because it is the organic part that makes peat valuable.

Virtually all peat presently sold in the United States is for agricultural purposes. In 1976, 86 percent was sold for general soil improvement, and the remaining 14 percent for use in potting soils (Mickelsen, 1976). To estimate tonnage of the resource for these purposes, we make the assumption that 200 short tons of air-dried peat can be obtained from 1 acre-foot of in-place material. Sheridan and De Carlo (1957) estimated that in Wisconsin, about 1 million acres of peat

Wilderness Area and nearby areas

sampled. Thickness shown in brackets. Locations shown on pl. 1 A]

and thickness (feet)					
Nonesuch Formation	Copper Harbor Conglomerate	Total depth (feet)	Dip (degrees)	Interval sampled (feet)	Average copper (percent)
not present	363 [273+]	637	25–30 NW.		
1,225 [500]	1,725 [16+]	1,741	<5–18 NW.	1,241–1,248	0.012
				1,619–1,625	.023
				1,723–1,726	.107
946 [338]	1,334 [77+]	1,441	10–35 N.	1,335–1,344	.132
not present	500 [166+]	696	13 NW.	—	—
1,613 [439]	2,052 [24+]	2,078	0– 9 NW.	2,046–2,051	.093

[2] Contradictory location.

lands were present that could yield at least 1 billion short tons of air-dried commercial quality peat, assuming deposits average 5 feet in thickness.

The growing shortage of fossil fuel has aroused interest in the use of peat as an alternative source of energy. Peat is found in many parts of Wisconsin on the poorly drained surface of glacial drift within the generalized areas shown in figure 7. According to R. S. Farnham, Professor of Soils Science, University of Minnesota, peat lands in Wisconsin mapped by the U.S. Soil Conservation Service for the Conservation Needs Inventory Committee cover about 4,500 square miles. Although much of this peat is not of present commercial quality, it might be burned and could yield as much as 77 quadrillion Btu's (R. S. Farnham, written commun., 1977).

In the Rainbow Lake Wilderness Area, the amount of air-dried agricultural-quality peat, calculated from the amount in the USGS cored deposits, is 210,000 short tons (pl. 1). This peat is 5 to 25 feet thick and is in deposits 2 to 48 acres in extent. An additional 86 acres of untested deposits that are assumed to have an average thickness of 5 feet is estimated to contain about 140,000 short tons of air-dried peat. Similarly, in the Flynn Lake Wilderness Study Area, the amount of commercial-quality peat in measured deposits is determined to be 300,000 short tons of air-dried peat (see tables on pl. 1); approximately 11,000 short tons of air-dried peat is estimated in a total of 75 acres of untested deposits assumed to average 5 feet in thickness. All resources are essentially the moss and reed-sedge type. Because of the large amount of peat available elsewhere in Wisconsin, this resource is not important.

Peat may be considered a potential energy source, and table 2 indicates that most of the sampled bogs in the study area have low ash content, and several samples have superior values in British thermal units. On the basis of heating value alone, this peat meets the requirements for gasification; however, interest in development is improbable because of the small size of the bogs. Large volumes of peat are required to support a gasification plant. Boffey (1976, p. 1068) estimated that about 100,000 acres of peat bog are required to produce 80 million cubic feet of synthetic natural gas per day for 20 years. Because the total area of peat deposits is less than 400 acres and because individual bogs are isolated, little foreseeable need is apparent for the area's peat resources. Many larger bogs are present in this region that could more adequately satisfy future demands.

SAND AND GRAVEL

Large quantities of sand and gravel are in the thick Pleistocene glacial deposits that cover the whole area. Similar material is also very

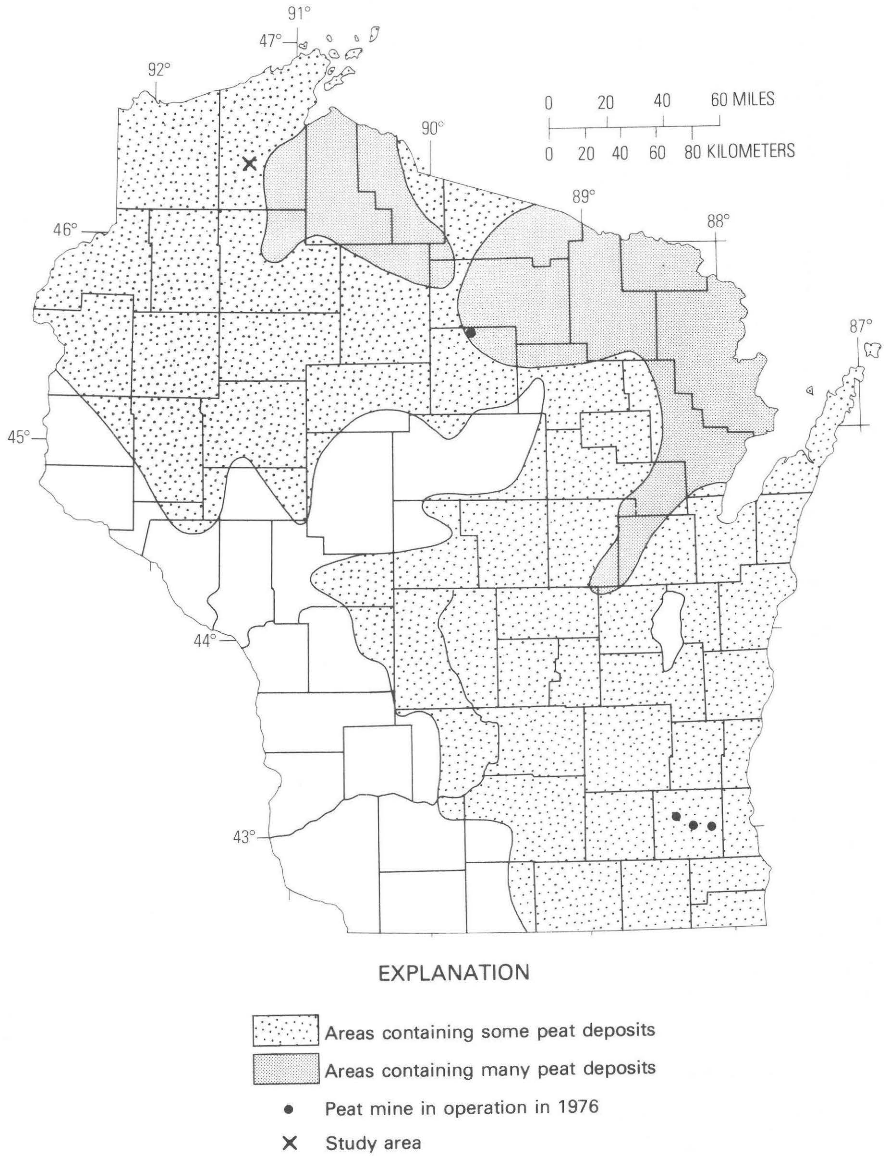

FIGURE 7.—Location of the study area in relation to the distribution and density of peat deposits in Wisconsin and the locations of peat mines in operation in 1976 (modified from map by Cameron, 1976).

abundant throughout the region and is much closer to points of consumption. Sand and gravel deposits in the study area, therefore, are of no foreseeable commercial importance.

TABLE 2.—*Analyses of peat samples, Rainbow Lake Wilderness Area and Flynn Lake Wilderness Study Area*

[Analyses by U.S. Bureau of Mines; Coal Preparation and Analysis Group, Pittsburgh, Pa. Location of bogs shown on pl. 1*B*].

		Proximate analysis (percent)			Ultimate analysis (percent)						
Bag No.	Condition of sample[1]	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Sulfur	Oxygen	Ash	Heating value (Btu/lb)[2]
B.36	MF	45.8	18.2	36.0	4.4	38.1	2.5	0.3	18.8	36.0	6,856
	MAF	71.5	28.5	---	6.9	59.5	3.9	.5	29.3	---	10,713
B.37	MF	63.1	27.6	9.3	5.5	54.1	2.1	.3	28.7	9.3	9,429
	MAF	69.6	30.4	---	6.1	59.6	2.3	.3	31.6	---	10,391
B.38	MF	65.7	28.7	5.6	5.7	54.0	2.0	.3	32.5	5.6	9,306
	MAF	69.6	30.4	---	6.0	57.1	2.1	.3	34.4	---	9,854
B.39	MF	70.9	24.0	5.1	5.6	50.8	1.4	.3	36.7	5.1	8,677
	MAF	74.8	25.2	---	5.9	53.6	1.5	.4	38.7	---	9,147
B.40	MF	66.0	27.9	6.1	5.7	51.2	1.3	.3	35.7	6.1	8,652
	MAF	70.4	29.6	---	6.1	54.5	1.4	.3	37.7	---	9,218
B.41	MF	69.2	25.7	5.1	5.6	51.2	1.3	.3	36.6	5.1	8,704
	MAF	72.9	27.1	---	5.9	53.9	1.4	.3	38.5	---	9,167
B.42	MF	66.8	27.7	5.5	5.7	54.8	2.0	.3	31.6	5.5	9,378
	MAF	70.7	29.3	---	6.0	58.0	2.1	.3	33.5	---	9,925
B.43	MF	67.3	27.0	5.7	5.8	53.8	2.1	.3	32.3	5.7	9,374
	MAF	71.3	28.7	---	6.2	57.0	2.2	.3	34.2	---	9,940
B.44	MF	48.7	16.8	34.5	4.3	37.7	2.0	.4	21.1	34.5	6,697
	MAF	74.4	25.6	---	6.6	57.5	3.0	.6	32.2	---	10,232
B.45	MF	63.7	28.2	8.1	5.6	54.8	2.0	.3	29.2	8.1	9,591
	MAF	69.3	30.7	---	6.1	59.6	2.2	.3	31.7	---	10,437
B.46	MF	67.7	26.0	6.3	5.7	52.0	1.8	.3	33.9	6.3	9,048
	MAF	72.3	27.7	---	6.1	55.5	1.9	.3	36.2	---	9,660
B.47	MF	66.0	27.6	6.4	5.6	50.6	1.4	.3	35.6	6.4	8,619
	MAF	70.6	29.4	---	6.0	54.1	1.5	.3	38.1	---	9,212
B.48	MF	58.2	28.0	13.8	5.1	51.1	2.2	.4	27.3	13.8	8,791
	MAF	67.6	32.4	---	5.9	59.3	2.5	.5	31.7	---	10,203

[1] Symbols: MF, moisture free; MAF, moisture and ash free.
[2] To convert Btu/lb to kg-cal/kg, multiply by 0.5556.

SPECULATIVE MINERAL RESOURCES

In the study area, lake-bed clay and copper minerals in volcanic rocks are properly classed as speculative mineral resources. Because of marginal value or limited information, neither can be accurately evaluated. The clays probably will never be of value; theoretically, however, copper deposits similar to those of Michigan's Keweenaw Peninsula might be present.

POTENTIAL FOR UNDISCOVERED NATIVE-COPPER DEPOSITS

Volcanic rocks of the Keweenawan Supergroup contain large deposits of native copper in northern Michigan, where they have been mined for many years. In Wisconsin, these rocks have been intensively explored in areas where they crop out. Although numerous copper shows and small deposits have been found, mostly in the late 1800's (fig. 8), no large economic deposits have been discovered. Grant (1901) described most of these occurrences and placed them into three "copper ranges," the Douglas, St. Croix, and Minong. The study area is approximately along the geologic trend of the Minong Copper Range (fig. 5). Exploration and copper discoveries have been limited largely to areas of abundant outcrops; therefore, the distribution of known occurrences may reflect only the degree of bedrock exposure rather than the true distribution of copper.

A theoretical basis for the exploration for native copper in Wisconsin outlined by White (1978) indicates that the study area is in one of the

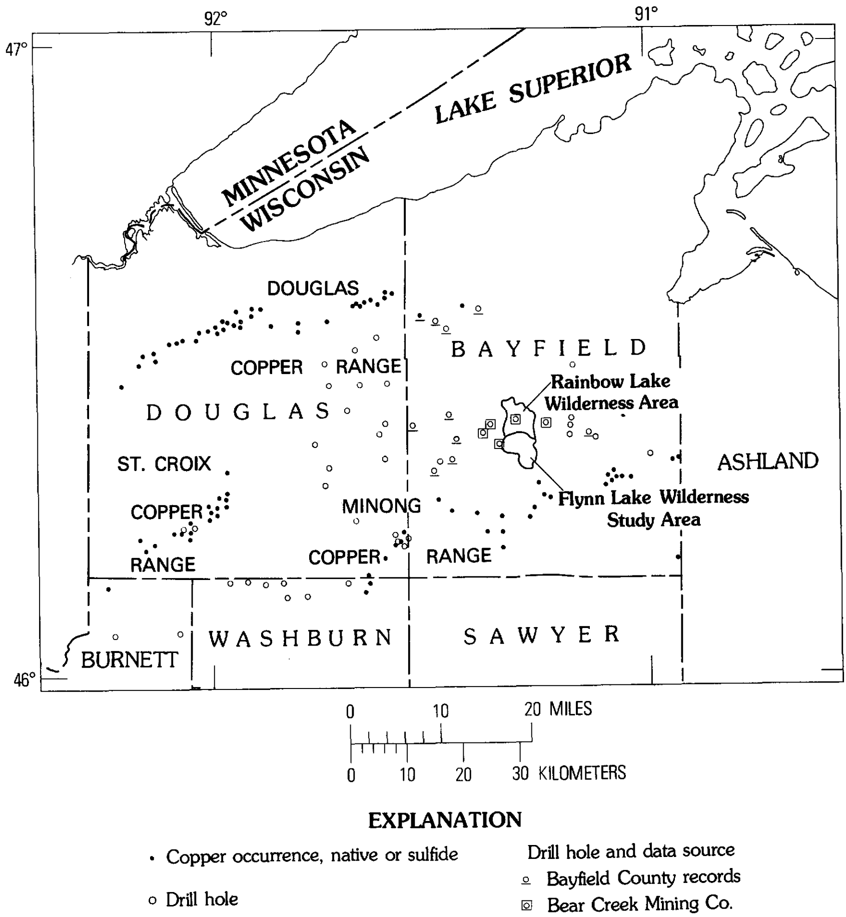

FIGURE 8.—Occurrences of copper in volcanic rocks of the Keweenawan Supergroup and location of drill holes in northwestern Wisconsin (from Dutton and Bradley, 1970).

most promising exploration regions in the State. White's evaluation is based on a genetic model for the formation of the native copper ores in Michigan, where the results of many years of study and the extraordinarily complete geologic information have led to a well-documented theory of origin. The native copper ores in Michigan, and, by inference, any that might be found in Wisconsin, were formed by secondary copper enrichment, in which the copper was deposited in voids in the flows and interlayered conglomerate from heated copper-bearing solutions migrating updip through the rocks. According to White's theory, the localization of ore deposits was controlled by the shape of the original volcanic basin, by later folding of the basin, and by the degree of metamorphic recrystallization of the volcanic rocks. In particular, the most favorable areas are believed to be areas updip from points where the margins of original lava basins cross the keel of the Ashland syncline and where the volcanic rocks were heated sufficiently to form pumpellyite by recrystallization and almost enough to form epidote. The study area satisfies all these criteria.

White's reconstruction of the original configuration of volcanic rocks in the region (White, 1978, fig. 5) indicates that the volcanic rocks in Wisconsin were deposited in a separate basin, which is not part of the basins in Michigan, and that the basin margin intersected the axis of the Ashland syncline north (downdip) of the study area.

The metamorphic grade of the area might also be favorable for native copper mineralization. Microscopic examination of rocks that crop out south of the study area (see pl. 1*A*) indicates that the southernmost and stratigraphically lowest exposure (WRFL–57-58 on pl. 1*A*) is relatively highly metamorphosed; epidote is abundant. All other samples (WRFL–52-56) contain no detectable epidote. Alteration in these samples is limited to formation of minor amounts of chlorite and sericite. Therefore, the southernmost and originally more deeply buried parts of the volcanic rocks apparently were heated sufficiently to produce considerable alteration and recrystallization, whereas the

TABLE 3.—*Analyses of rock and clay samples—Rainbow Lake*

[Analyses performed by U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nevada. Elements tested for (0.002), As (0.08), Au (0.002), B (0.01), Ba (0.07), Be (0.001), Bi (0.005), Cd (0.04), La (0.02), Li (1.0), Mo (0.001), Nb noted. Si occurs in all samples in amounts greater than the upper detection limit (10 percent). Symbols used: >,

Sample No.	General spectrographic analyses									
	Al	Ca	Co	Cr	Cu	Fe	Ga	K	Mg	Mn
WRFL–51[1]	7.6	0.2	<0.004	0.008	<0.004	2	<0.002	2.4	0.9	0.05
WRFL–52[2]	10	7.4	< .004	.01	.005	>10	.002	<1.1	3.4	.2
WRFL–53	>10	8.6	< .004	.02	.009	>10	< .002	<1.1	3.5	.2
WRFL–54	>10	>10	.005	.02	.008	>10	.003	<1.1	3.3	.2
WRFL–55	>10	7.1	< .004	.01	.009	>10	.003	1.2	3.9	.2
WRFL–56	>10	10	< .004	.02	.007	>10	< .002	<1.1	3.8	.2
WRFL–57	>10	6.7	< .004	.02	.01	>10	.002	<1.1	2.3	.2
WRFL–58[3]	>10	9	.005	.02	.007	>10	.003	<1.1	4.3	.2

[1] Clay sample. [2] Contains 0.002 percent Mo. [3] Contains 0.008 percent Y.

more northerly and originally less deeply buried parts were not heated as much and underwent less alteration. Thus, the critical boundary between epidote- and pumpellyite-bearing rocks may lie somewhere near or within the study area.

In Wisconsin, a favorable sign indicating the past existence of fluids in which copper could be mobilized and concentrated is the occurrence of native copper and copper sulfides wherever the volcanic rocks are exposed. Such widespread mineralization is known only in Wisconsin and in the mining district of Michigan, not in other areas of Keweenawan volcanic rocks in the Lake Superior region (White, 1978). The fact that the rocks of the Minong Range are epidote-bearing may be significant, and the small deposits there may be the margins of a more enriched district that may have existed updip in long since eroded parts of the volcanic rocks, or the deposits may still exist along the trend of the district if the metamorphic grade decreases laterally away from the Minong Range.

Keweenawan volcanic rocks of the study area are considered to be some of the most favorable rocks in Wisconsin for the occurrence of native copper ores. This judgement is based entirely on theoretical grounds; we have no direct evidence for native copper in volcanic rocks of the study area. However, native copper was noted in rocks of locality WRFL–57-58 and chalcopyrite was found at locality WRFL–53. Both localities are within 2 miles of the southeasternmost corner of the Flynn Lake area boundary (see pl. 1*A*). The copper minerals were seen as minute specks in hand specimens, and analysis did not reveal significant concentrations (table 3).

The native copper district in Michigan currently is not being mined, but some exploration is continuing. If White's theory stimulates interest or if the price of copper increases substantially in the future, the study area and surroundings could become a promising area for exploration.

Wilderness Area and Flynn Lake Wilderness Study Area

but not listed may occur only in concentrations below the lower level of determination (in parentheses) and include: Ag (0.08), Pd (0.002), Pt (0.002), Sb (0.05), Se (0.03), Sn (0.006), Ta (0.03), W (0.02), and Y (0.007). Exceptions are foot-greater than; <, less than; N.T., not tested for. All values in percent.]

General spectrographic analyses											Atomic absorption analyses
Na	Ni	P	Pb	Sc	Sr	Te	Ti	V	Zn	Zr	Cu
1.2	0.004	<0.08	<0.008	0.001	0.003	<0.02	0.2	<0.004	0.001	0.007	N.T.
2.1	.01	< .08	< .008	.001	.006	.02	.2	.007	.01	.003	0.008
1.3	.01	< .08	< .008	.001	.006	< .02	.3	.008	.009	< .002	.01
2.8	.02	.1	.01	.002	.008	.03	.3	.01	.01	.004	.008
>3	.01	.08	< .008	.001	.007	.02	.3	.009	.01	.005	.01
1.8	.01	< .08	< .008	.002	.007	< .02	.3	.01	.009	< .002	.008
2.5	.009	.1	< .008	.002	.005	.02	.3	.009	.01	.003	.01
2.3	.01	< .08	< .008	.002	.009	< .02	.4	.01	.02	.007	.01

GEOCHEMICAL ANOMALIES IN PEAT

Because the organic matter in peat can be a potent concentrator of elements of economic interest, samples from bogs throughout the area were analyzed in the hope that anomalous metal concentrations in buried bedrock might be reflected by similar anomalies in overlying peat. Several peat samples were found to have very high zinc and copper content and somewhat anomalous nickel values (see table 4 and pl. 1).

TABLE 4.—*Spectrographic analyses of peat ash—Rainbow Lake Wilderness Area and Flynn Lake Wilderness Study Area*

[Analyses performed by U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nevada. Elements tested for but not listed may occur only in concentrations below the lower level of determination (in parentheses) and include: Ag (0.002), As (0.08), Au (0.002), B (0.01), Ba (0.07), Be (0.001), Bi (0.005), Cd (0.04), La (0.02), Li (1.0), Mo (0.001), Nb (0.08), Pd (0.002), Pt (0.002), Sb (0.05), Se (0.03), Sn (0.006), Ta (0.03), W (0.02), and Y (0.007). Exceptions are footnoted. Si occurs in all samples in amounts greate than the upper detection limit (10 percent). Symbols used: >, greater than; <, less than; --, not detected. Results in percent. Location of bogs shown on pl. 1B]

Bog No. of Sample	Ca	Cu	Fe	Mg	Mn	Na	Ni	Pb	Sn	Zn
B.36	0.5	0.02	>4	0.6	0.03	1	0.002	<0.01	0.02	--
B.37	1	.01	>4	.6	.01	.5	.004	< .01	--	0.2
B.38	2	.01	>4	.6	.03	1	.01	.02	.004	.3
B.39	1	.01	>4	.6	.2	1	.02	.03	.08	.2
B.40	2	.004	1	.6	.06	1	.008	.02	.04	.1
B.41[1]	2	.08	>4	.6	.2	2	.04	.03	.08	.4
B.42	2	.02	>4	.6	.06	1	.01	.01	.03	.2
B.43	.1	.004	1	.3	.02	.5	.01	.01	.04	.2
B.44	.4	.006	>4	.6	.03	1	.004	< .01	.004	--
B.45	>2	.02	>4	.8	.06	.5	.01	.01	<.002	<.1
B.46	2	.01	>4	.6	.03	1	.01	.02	.03	<.1
B.47	2	.004	>4	.6	.1	1	.02	.02	.03	.2
B.48[2]	>2	.01	>4	.6	.03	1	.004	.01	.002	--

[1] Contains 0.07 percent Cr. [2] Contains 0.002 percent Ag.

These high values probably are not related directly to anomalous metal content in underlying bedrock. The drift is very thick and, in places, contains impermeable clay beds; therefore, direct chemical exchange between bedrock and peat is improbable. The anomalous samples are widely scattered throughout the study area and are underlain by various types of bedrock. The anomalies were probably caused by concentrations of metals released from copper-, zinc-, and nickel-bearing minerals, perhaps sulfides, in the drift, but the bedrock source of these minerals is unknown

Six soil samples from near the southern margin of the study area (see pl. 1*A*) contained no anomalous amounts of copper, zinc, or nickel.

CLAY

Some shallow lakes and peat bogs in the Rainbow Lake and the Flynn Lake areas are floored with clay that is too sandy to warrant serious consideration as raw material for ceramic uses. Near the eastern boundary of the Rainbow Lake Wilderness Area, however, Flakefjord Lake and its accompanying peat bogs are underlain by at least 2.5 feet of pink and gray clay that contains little sand.

A sample of this clay, WRFL-51, was submitted to the USBM Tuscaloosa Metallurgy Research Center for a preliminary ceramic evaluation. During slow-firing tests, the clay melted at 1,150°C and showed a short-firing characteristic by undergoing abrupt vitrification between 1,000° and 1,050°C. Because of this property, it is unsuitable for structural clay products. Preliminary bloating tests were negative also.

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