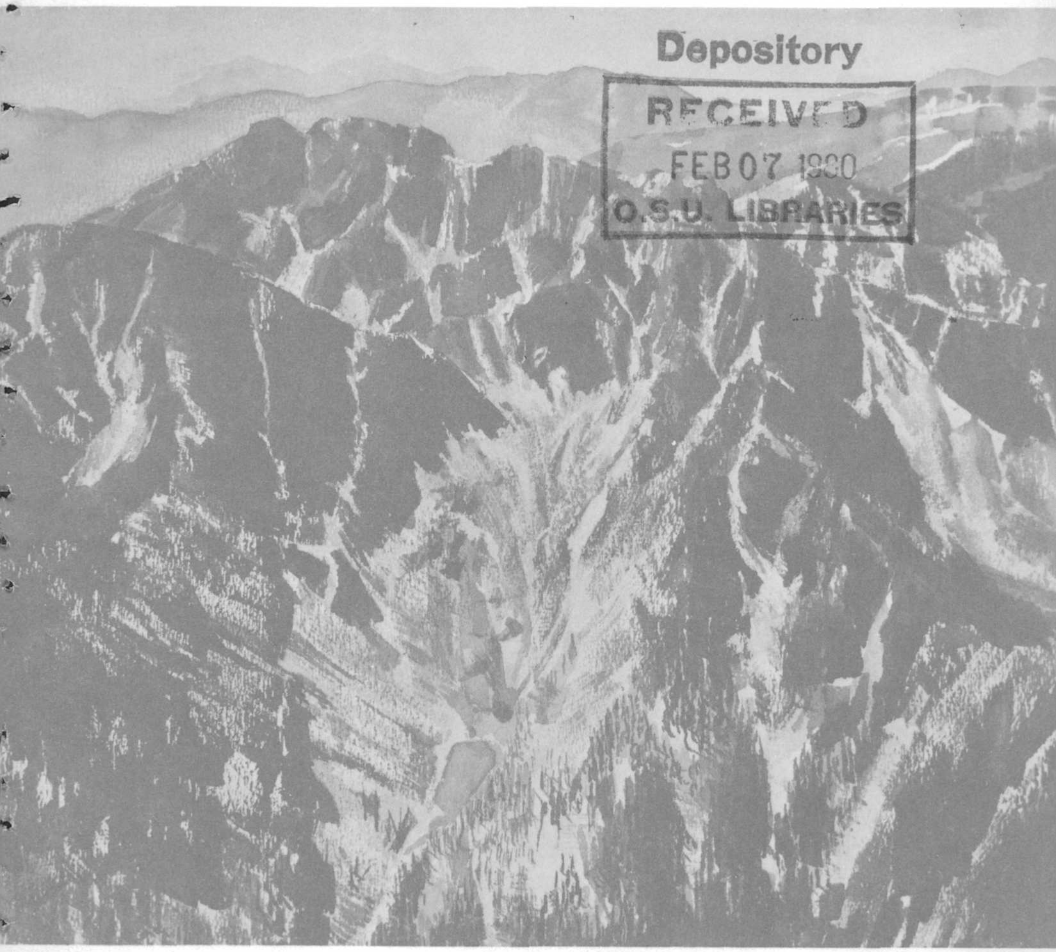
STUDIES RELATED TO WILDERNESS

STUDY AREAS



STURGEON RIVER WILDERNESS STUDY AREA, MICHIGAN

GEOLOGICAL SURVEY BULLETIN 1465

Mineral Resources of the Sturgeon River Wilderness Study Area, Houghton and Baraga Counties, Michigan

By W. F. CANNON *and* ELIZABETH R. KING, U.S. GEOLOGICAL SURVEY,
and by JAMES J. HILL *and* PETER C. MORY, U.S. BUREAU OF MINES

STUDIES RELATED TO WILDERNESS—STUDY AREAS

GEOLOGICAL SURVEY BULLETIN 1465

An evaluation of the mineral potential of the area

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, *Secretary*

GEOLOGICAL SURVEY

H. William Menard *Director*

Library of Congress catalog-card No. 80-600000

For sale by Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 024-001-03259-7

STUDIES RELATED TO WILDERNESS STUDY AREAS

In accordance with the provisions of the Wilderness Act (P.L. 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, and as specifically designated by P.L. 93-622, January 3, 1975, the U.S. Geological Survey and 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 Sturgeon River Wilderness study area, Michigan, that is being considered for wilderness designation (P.L. 93-622, January 3, 1975). The area studied is in the Ottawa National Forest in Houghton and Baraga Counties in the Upper Peninsula of Michigan.

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CONVERSION FACTORS

Metric unit		Inch-Pound equivalent	
Length			
millimeter (mm)	=	0.03937	inch (in)
meter (m)	=	3.28	feet (ft)
kilometer (km)	=	.62	mile (mi)
Area			
square meter (m^2)	=	10.76	square feet (ft^2)
square kilometer (km^2)	=	.386	square mile (mi^2)
hectare (ha)	=	2.47	acres
Volume			
cubic centimeter (cm^3)	=	0.061	cubic inch (in^3)
liter (L)	=	61.03	cubic inches
cubic meter (m^3)	=	35.31	cubic feet (ft^3)
cubic meter	=	.00081	acre-foot (acre-ft)
cubic hectometer (hm^3)	=	810.7	acre-feet
liter	=	2.113	pints (pt)
liter	=	1.06	quarts (qt)
liter	=	.26	gallon (gal)
cubic meter	=	.00026	million gallons (Mgal or 10^6 gal)
cubic meter	=	6.290	barrels (bbl) (1 bbl=42 gal)
Weight			
gram (g)	=	0.035	ounce, avoirdupois (oz avdp)
gram	=	.0022	pound, avoirdupois (lb avdp)
metric tons (t)	=	1.102	tons, short (2,000 lb)
metric tons	=	0.9842	ton, long (2,240 lb)
Specific combinations			
kilogram per square centimeter (kg/cm^2)	=	0.96	atmosphere (atm)
kilogram per square centimeter	=	.98	bar (0.9869 atm)
cubic meter per second (m^3/s)	=	35.3	cubic feet per second (ft^3/s)

Metric unit		Inch-Pound equivalent	
Specific combinations—Continued			
liter per second (L/s)	=	.0353	cubic foot per second
cubic meter per second per square kilometer [$(m^3/s)/km^2$]	=	91.47	cubic feet per second per square mile [$(ft^3/s)/mi^2$]
meter per day (m/d)	=	3.28	feet per day (hydraulic conductivity) (ft/d)
meter per kilometer (m/km)	=	5.28	feet per mile (ft/mi)
kilometer per hour (km/h)	=	.9113	foot per second (ft/s)
meter per second (m/s)	=	3.28	feet per second
meter squared per day (m^2/d)	=	10.764	feet squared per day (ft^2/d) (transmissivity)
cubic meter per second (m^3/s)	=	22.826	million gallons per day (Mgal/d)
cubic meter per minute (m^3/min)	=	264.2	gallons per minute (gal/min)
liter per second (L/s)	=	15.85	gallons per minute
liter per second per meter [(L/s)/m]	=	4.83	gallons per minute per foot [(gal/min)/ft]
kilometer per hour (km/h)	=	.62	mile per hour (mi/h)
meter per second (m/s)	=	2.237	miles per hour
gram per cubic centimeter (g/cm^3)	=	62.43	pounds per cubic foot (lb/ft^3)
gram per square centimeter (g/cm^2)	=	2.048	pounds per square foot (lb/ft^2)
gram per square centimeter	=	.0142	pound per square inch (lb/in^2)
Temperature			
degree Celsius (°C)	=	1.8	degrees Fahrenheit (°F)
degrees Celsius (temperature)	=	[(1.8×°C)+32]	degrees Fahrenheit

MINERAL RESOURCES OF THE STURGEON RIVER WILDERNESS STUDY AREA, HOUGHTON AND BARAGA COUNTIES, MICHIGAN

By W. F. Cannon and Elizabeth R. King,
U.S. Geological Survey
and James J. Hill and Peter C. Mory,
U.S. Bureau of Mines

SUMMARY

The mineral-resource potential of the Sturgeon River Wilderness Study Area is low, despite the fact that the area is in the prolific mineral-producing Upper Peninsula of Michigan. Within 50 km of the area lie major iron and copper districts, and uranium exploration is currently underway to the east of the area.

This study did not disclose any mineral deposits that could be mined economically. Minor resources of stone, sand and gravel, clay, and peat exist in the area but warrant little attention because they lie far from present markets.

A complete lack of favorable signs of mineralization in the study area and immediate surroundings indicates a very low potential for the existence of undiscovered mineral deposits. The graywacke and slate turbidite sequence of the Michigamme Formation, which underlies about two-thirds of the area, does not contain any known economically attractive minerals anywhere in the Upper Peninsula. Lower Keweenawan basalt and related diabase dikes, which are in some respects similar to middle Keweenawan native copper-bearing basalts elsewhere, underlie about one-third of the area. They are barren of mineralization both within the area and at all other localities where they have been studied. The Jacobsville Sandstone, the youngest bedrock unit in the area, is similarly barren of significant mineralization in all its numerous exposures in the Upper Peninsula.

Pleistocene glacial deposits, and the alluvial deposits derived from them, contain small quantities of heavy minerals, including titanium and zirconium-bearing minerals, but not in concentrations approaching economic grade and size.

INTRODUCTION

By W. F. Cannon, James J. Hill, and Peter C. Mory

The mineral-resource potential of the Sturgeon River Wilderness Study Area (fig. 1) was studied by personnel of the U.S. Geological Survey and U.S. Bureau of Mines in 1975. The survey revealed no deposits of current economic value and a very low possibility that undiscovered deposits of potential economic value are in the area.

AREA DESCRIPTION

The Sturgeon River Wilderness Study Area comprises approximately 53 km^2 and lies wholly within

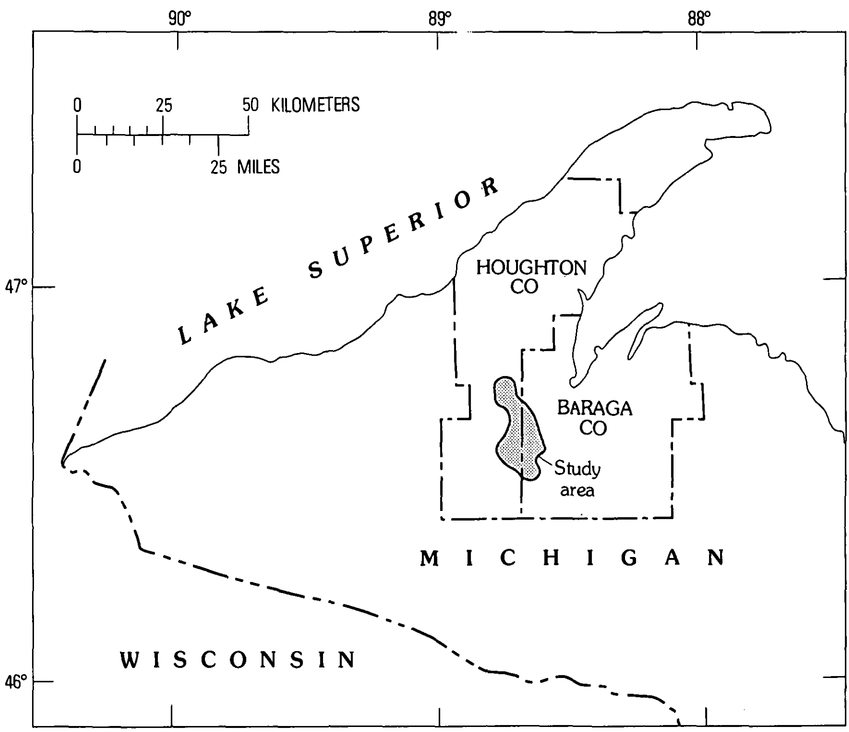


Figure 1.--Index map of part of Michigan showing the location of the Sturgeon River Wilderness Study Area.

Ottawa National Forest in Houghton and Baraga Counties in the northern peninsula of Michigan.

The area is easily reached by traveling about 5 km north on Forest Service road 191, which joins Michigan Highway 28 immediately east of the town of

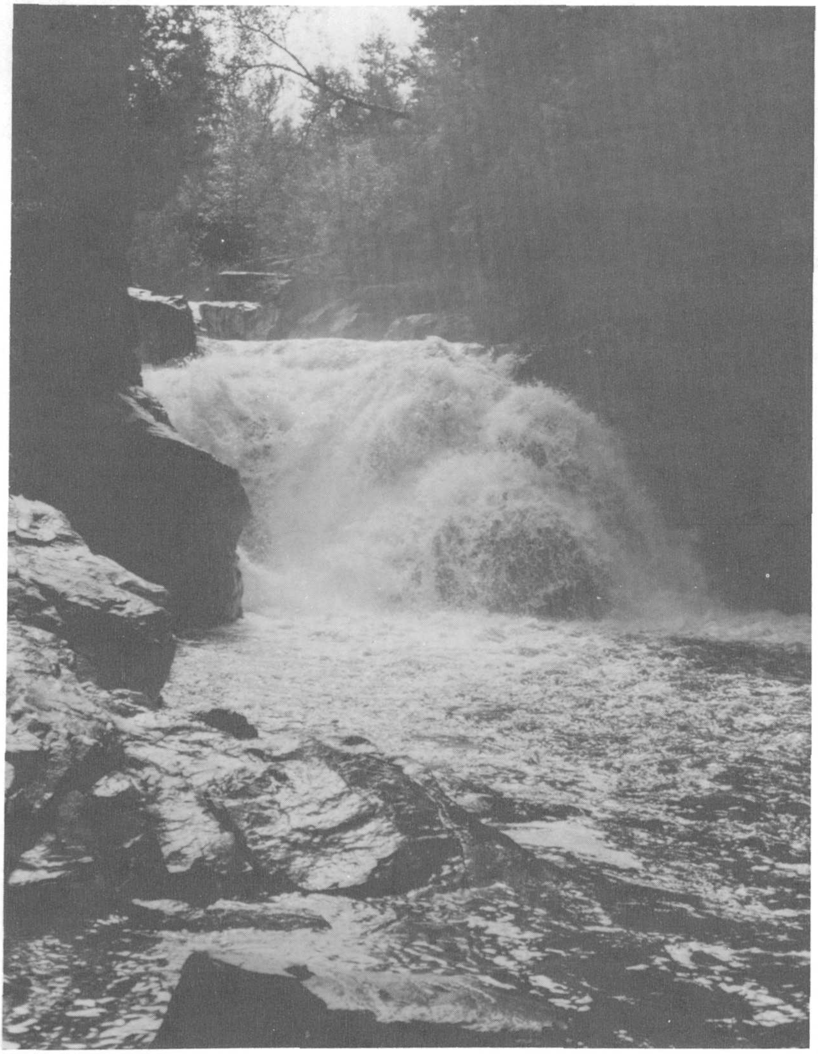


Figure 2.--Waterfalls on the Sturgeon River. Bedrock is basalt flows of the Siemens Creek Formation that dip gently in a downstream direction.

Sidnaw, Mich., or by traveling about 15 km south on Forest Service road 191 from Michigan Highway 35 from near Alston, Mich. Forest Service roads 191, 192, and 193 provide access to much of the study area's perimeter. Access to the interior is by foot over logging trails, now closed to motor vehicle traffic. Railroad tracks of the Soo Line pass within 3 km of the southern boundary of the area.

The northwest-flowing Sturgeon River and its tributaries have incised deep valleys, mostly through unconsolidated glacial deposits. Elevations range from about 244 m in the north to 427 m in the south. The most scenic attractions are Sturgeon Falls (fig. 2), caused by basalt flows, and the gorge carved through basalt and overlying sandstone immediately downstream from the falls (fig. 3).

Trees include birch, aspen, maple, red pine, white pine, jack pine, balsam fir, cedar, and hemlock. Although the area has been logged extensively, several mature stands of timber remain.

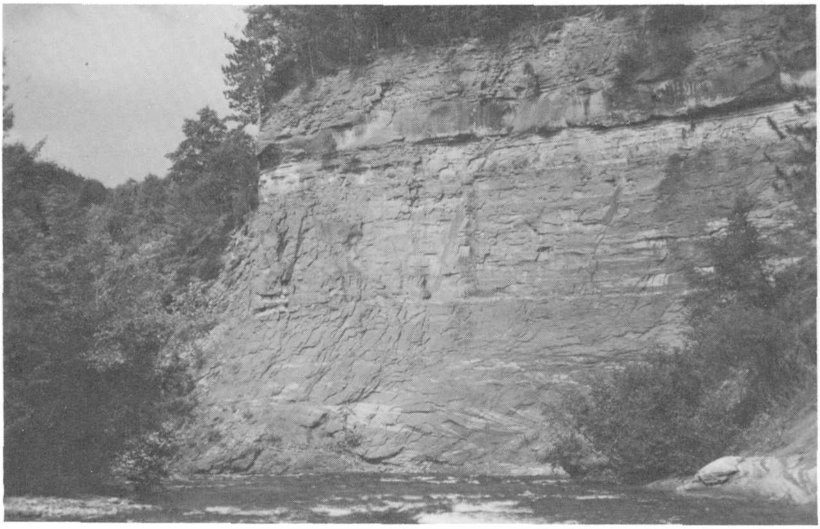


Figure 3.--Gorge downstream from waterfalls. The gorge is cut through horizontally layered Jacobsville Sandstone and basalt of the Siemens Creek Formation at lower left of exposure.

The area has been used especially for timbering and recreation. Ownership records indicate that the area may have been considered as a site for hydroelectric power.

PRESENT INVESTIGATION

The mineral-resource potential of the area was evaluated by several means. Previously collected geologic and geophysical data from many sources were compiled to give a geologic framework on which to base field studies and by which a preliminary assessment could be made.

Fieldwork included examining known outcrops of bedrock for favorable signs of mineralization and sampling the bedrock for laboratory tests. All previously reported exposures of bedrock were located, and their positions were plotted on a topographic base map. No additional exposures were found. Because of the very limited number of outcrops in the area, rock units known or inferred to be present in the area were examined and sampled at their nearest known exposures outside the area. Clay beds in Pleistocene glacial deposits were also sampled to test their suitability for ceramic uses. We collected samples of soil and stream sediments throughout the area that were analyzed in the laboratory for metal content. Stream sediments were collected at several places along the Sturgeon River and from each major tributary. Because these streams derive their sedimentary load almost totally from the Pleistocene deposits, metal concentrations in these deposits will be detected in stream sediment samples more so than in soils. The location of sample sites is shown in figure 4.

Samples collected by the U.S. Bureau of Mines were analyzed spectrographically for 43 elements by the Reno Metallurgy Research Center of the U.S. Bureau of Mines, Reno, Nev. Selected samples were analyzed by fire assay methods for gold and silver. Copper content was determined by atomic absorption. Uranium scans were performed on all sandstone samples. The Tuscaloosa Metallurgy Research Center of the U.S. Bureau of Mines, Tuscaloosa, Ala., evaluated ceramic properties of glacial clays.

Samples collected by the U.S. Geological Survey were tested for 65 elements by semiquantitative spectrographic analysis, and selected samples were analyzed for gold by combined fire assay-atomic absorption procedure at the U.S. Geological Survey analytical laboratories, Reston, Va. All exposures of bedrock were tested in the field for uranium by using a portable scintillometer.

Data on mineral-right ownerships were obtained from the U.S. Forest Service and were updated by examining records at the Baraga and Houghton County courthouses. Bureau of Land Management records were checked for leasing activity.

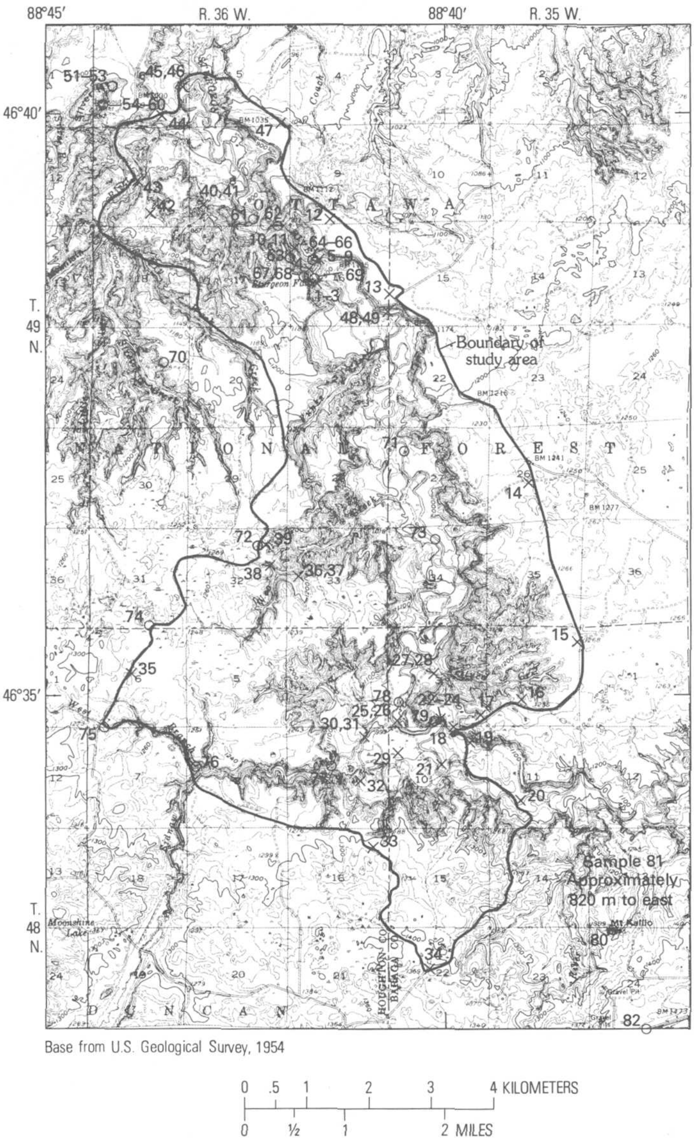
Representatives of the mining industry, as well as State and Federal agencies, were asked to give their views on the mineral resource potential of the area.

GEOLOGY AND GEOPHYSICAL INTERPRETATION

By W. F. Cannon and Elizabeth R. King

INTRODUCTION

The Sturgeon River Wilderness Study Area is astride a major geologic contact between Precambrian rocks of two different ages, types, and geologic histories. About two-thirds of the area is underlain by middle Precambrian (Precambrian X) graywacke and slate deposited in a deep ancient sea about 2 billion years ago. These rocks have subsequently been deformed and recrystallized, uplifted, and then deeply eroded. The northern third of the area is underlain by much younger basalt, about 1 billion years old, that was extruded in a continental environment. The basalt flows were later tilted and eroded and then covered by younger sandstone. As recently as 10,000 years ago, continental glaciers covered the area. When the last of these melted, the area was covered with a thick blanket of sediments deposited from the glacial meltwaters.



EXPLANATION

× Samples collected by U.S. Geological Survey

○ Samples collected by U.S. Bureau of Mines

Figure 4.--The Sturgeon River Wilderness Study Area showing the locations of sample sites.

Only locally, near Sturgeon Falls, has erosion removed the glacial deposits to expose the underlying bedrock. Consequently, little is known directly of the bedrock in the area. Aeromagnetic and gravity surveys, however, along with projection of information from outcrops outside the wilderness, provide a means of inferring the general geologic relationships.

An airborne magnetometer survey of the Sturgeon River Wilderness Study Area was made by the U.S. Geological Survey in 1947 as part of a larger program to investigate the Upper Peninsula of Michigan for mineral resources, primarily iron and copper (Balsley and others, 1949). The survey was made by using a continuously recording fluxgate magnetometer along north-south flight lines spaced 0.25 mi (0.40 km) apart and 500 ft (150 m) above the ground surface. The data were published as magnetic profiles and an accompanying map showing the flight lines and locations of the magnetic peaks and troughs (Balsley and others, 1949). These data were later compiled as a contour map with a contour interval of 50 gammas (50 nT) (Balsley and Smith, 1967). A part of this map is shown in figure 5.

The entire Upper Peninsula has now been covered by similar surveys by the U.S. Geological Survey. The data were recompiled as a single contour map after the gradient of the Earth's magnetic field was removed, so that only the anomalies caused by the rocks of the Earth's crust remain (Zietz and Kirby, 1971). Figure 6 shows part of this map, including the area of the Sturgeon River Wilderness Study Area.

Aeromagnetic surveys record variations in the Earth's total magnetic field, which are caused primarily by differences in the magnetic mineral content of the rocks beneath the surveying aircraft. Although several minerals are magnetic, the most important and common one is magnetite. Small amounts of magnetite are disseminated through many types of igneous rocks and give the rocks characteristic magnetic expressions. The resulting magnetic patterns are used by geologists to map these

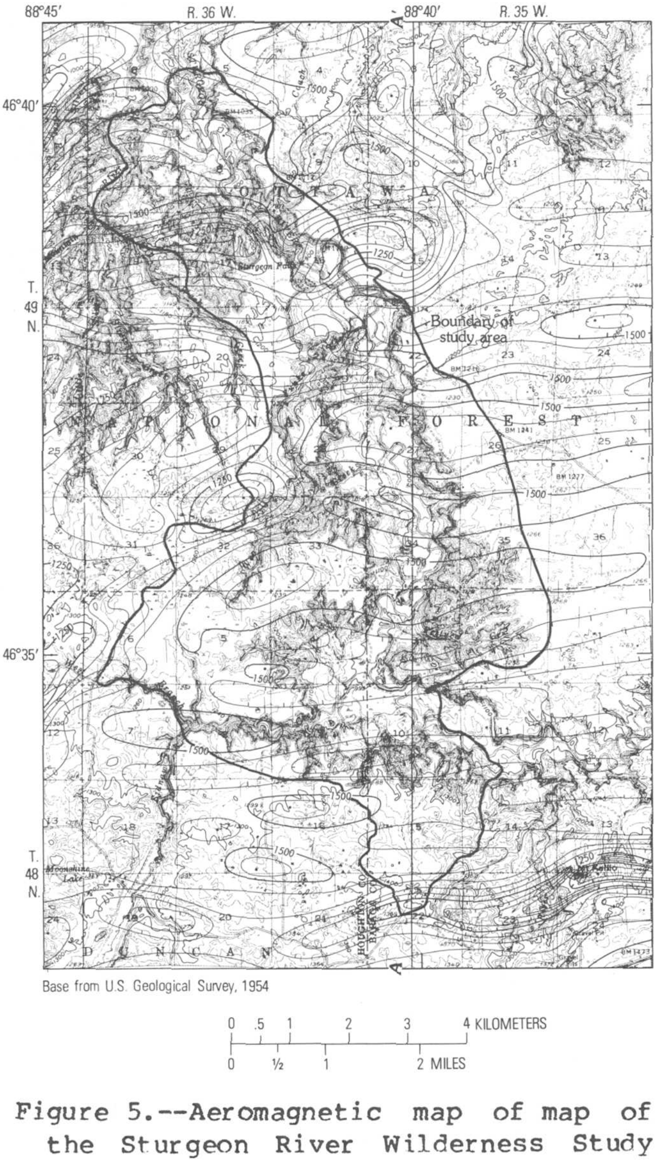


Figure 5.--Aeromagnetic map of map of the Sturgeon River Wilderness Study area (part of a map by Balsley and Smith, 1967). Contour interval is 50 gammas (50 nT). Profile along line A-A' is shown in figure 12. Flight lines trend N-S at 0.4-km intervals.

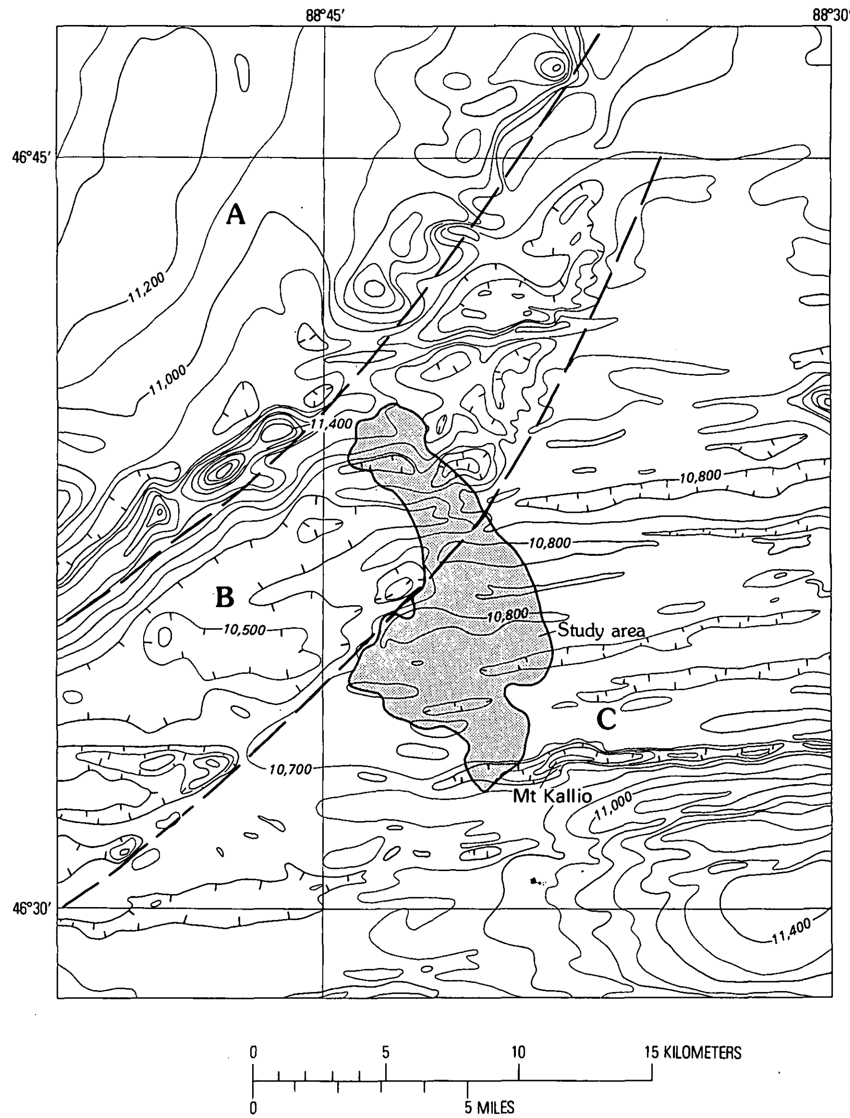


Figure 6.--Regional aeromagnetic expression of three geologic terranes in the vicinity of the Sturgeon River Wilderness Study Area (part of a map by Zietz and Kirby, 1971). Contour interval is 100 gammas (100 nT). Dashed lines separate zones of different magnetic character. Zones A, B, and C are discussed in the text.

rocks, even where they are covered by soil, glacial drift, or sedimentary rocks (which are commonly much less magnetic). Magnetite also occurs in metamorphic rocks, such as the iron-formation of the iron districts of Michigan, Minnesota, and Wisconsin.

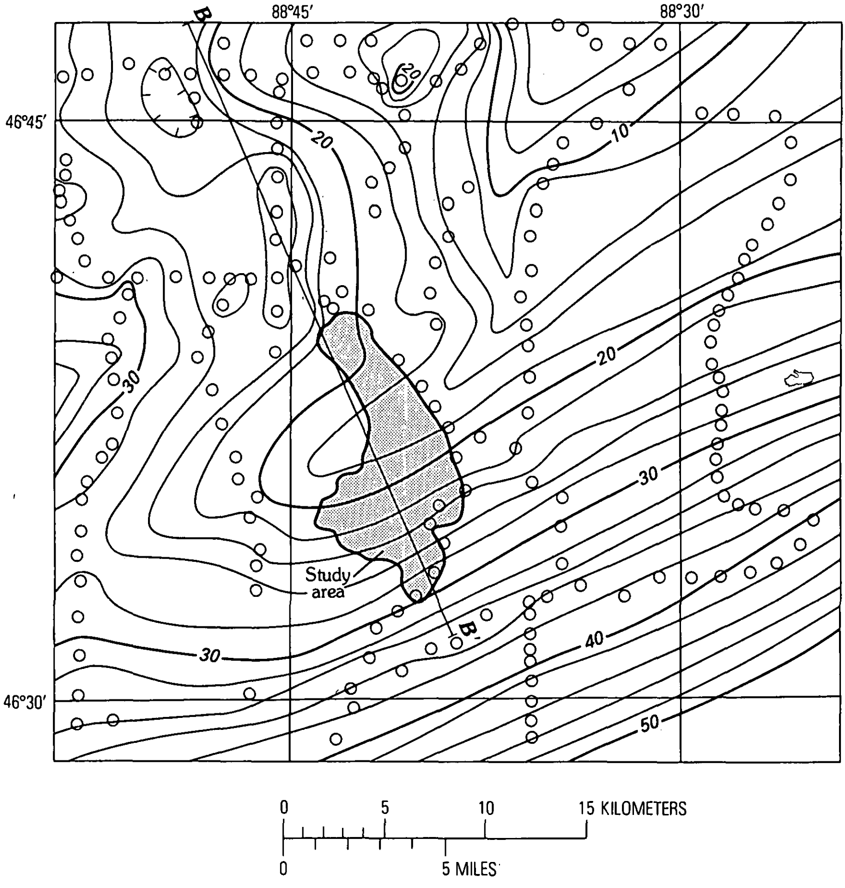


Figure 7.--Regional Bouguer anomaly gravity map of the Sturgeon River Wilderness Study Area and surrounding area (modified from a map by Bacon, 1966). Contour interval is 2 mgal (2×10^5 m/s^2). Circles indicate locations of gravity stations. Profile along line B-B' is shown in figure 13.

Another geophysical method that is useful in this region is the measurement of variations in gravity (Bacon, 1966). Dense rocks, such as basalt, have a higher gravitational attraction than the granitic and metamorphic rocks typical of much of the region. Sedimentary rocks, such as sandstone and arkose, have relatively low density and produce lower gravitational attraction.

A large number of gravity measurements have been made in the Upper Peninsula and have been compiled and contoured as a regional map by Bacon (1966). The measurements in the Sturgeon River area were made by Campbell (1952) along road traverses separated by approximately 10 mi (16 km) with stations spaced about every mile. The gravity anomalies of this map, part of which are shown in figure 7, show a good correlation with the regional magnetic patterns. Thus, it is possible to infer the distribution of dense, magnetic units of rocks. In some places, the gravity data can be used to calculate the approximate thickness of buried rock units.

PHYSIOGRAPHY

The Sturgeon River Wilderness Study Area lies near the west edge of the Baraga Plains, a gently rolling upland underlain by thick Pleistocene glacial deposits. The study area contains deep (as much as 100 m) steep-sided gorges cut into the Baraga plains by the north-flowing Sturgeon River and its tributaries. Flat uplands, remnants of the once more extensive Baraga Plains, lie between the gorges. The steep topography of the area is in striking contrast to the gently rolling topography of much of the surrounding area (fig. 8).

The Sturgeon River is largely a graded meandering stream that has a narrow flood plain. Lateral cutting against steep valley sides locally forms oversteepened slopes and results in prominent slumping and landsliding.

Only at Sturgeon Falls in sec. 16, T. 49 N., R. 35 W., and for a few hundred meters downstream from the falls, does the river flow on bedrock. There, the river is fast moving with short reaches of white water. Elsewhere, it is slow moving and flows on unconsolidated Pleistocene deposits (or river sand and gravel derived from the deposits).

LITHOLOGY

Five stratigraphic units are present in the Sturgeon River Wilderness Study Area. The stratigraphic relationships are shown in figure 9, and their areal distribution is shown in figure 10.

Only three of the units, Pleistocene glacial deposits, Jacobsville Sandstone, and basalt of the Siemens Creek Formation, are exposed in the wilderness. Diabase dikes of Keweenawan age and graywacke and slate of the Michigamme Formation are inferred to be present because a distinctive magnetic pattern produced by these exposed rocks in nearby areas extends into the Wilderness Study Area.

Figure 8.--View from Silver Mountain looking southeastward. The Sturgeon River Wilderness Study Area is in the foreground. Steep-sided stream valleys in the study area are cut into the Baraga Plains, which form the flat upland surface in the distance. Higher hills on the horizon are underlain by graywacke and slate of the Michigamme Formation.

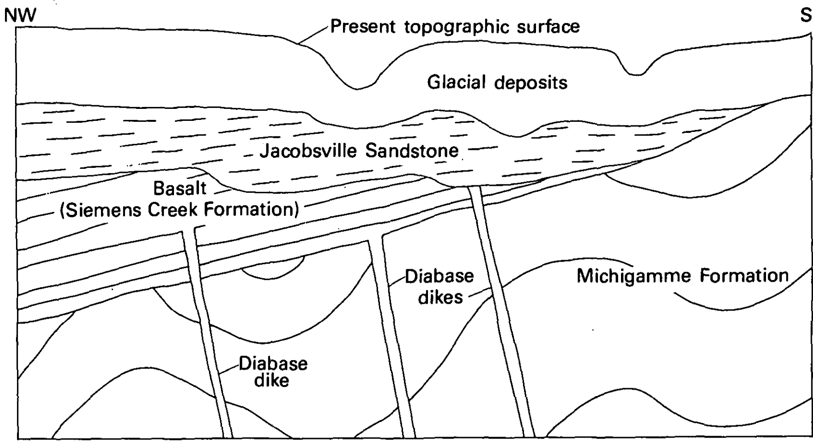


Figure 9.--Schematic cross section of the Sturgeon River Wilderness Study Area showing the stratigraphic, intrusive, and structural relationships of the rock units in the area.

PLEISTOCENE GLACIAL DEPOSITS

Pleistocene glacial deposits form a thick blanket of unconsolidated material over most of the area. The steep stream gorges are cut mostly through this material, but, because it slumps rapidly, exposures of undisturbed material are rare and confined to areas where streams are actively cutting laterally into valley sides (fig. 11). Most of the material is light-brown, rather well-sorted sand composed mostly of quartz and lesser amounts of feldspar. Heavy minerals generally form less than 1 percent of the sand. The sand is well bedded (fig. 11, top), and crossbedding is common. Locally, gravel beds as much as 1 m thick are interbedded with the sand.

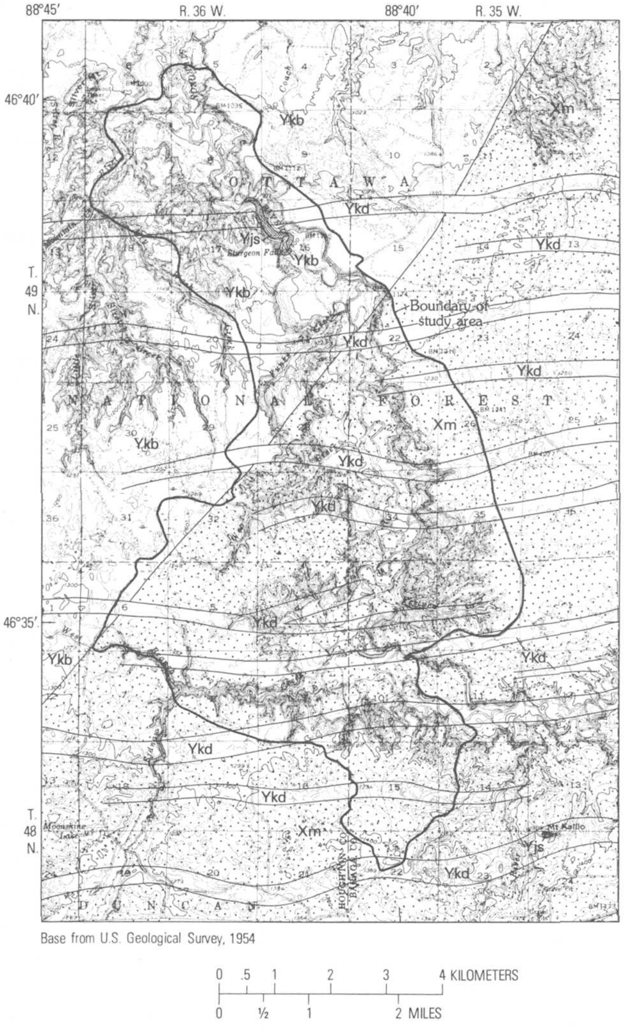
Units of silt-and clay-size particles, generally well intermixed, also make up a part of the Pleistocene deposits. They are reddish-brown to tan and generally massive with no discernible internal bedding (fig. 11, center). Units as much as 6 m thick are exposed along the Sturgeon River, but the lateral continuity of such beds is not known.

JACOBSVILLE SANDSTONE

The Jacobsville Sandstone is exposed in nearly vertical valley walls along the Sturgeon River near Sturgeon Falls (fig. 3). It is well bedded in nearly horizontal units. Crossbedding and ripple marks are common. Owing to alternate zones in which small amounts of iron are in reduced and oxidized form, the color varies on a small scale from very light tan to red brown. In places, such zones follow bedding planes, making the bedding very easily visible (fig. 3). According to Roberts (1940), grain size varies from conglomeritic beds having 1-cm pebbles to beds of very fine sandstone. Average grain size is about 1 mm. The sand grains are generally well rounded and in well-sorted beds. The average mineral composition near Sturgeon Falls is 50 percent quartz, 30 percent potassium feldspar, 10 percent muscovite, and 2 percent plagioclase. The remainder is mostly heavy minerals. The heavy-mineral suite consists of about 10 percent garnet, 3 percent leucoxene, 1-2 percent zircon, and the remainder is opaque minerals, mostly magnetite and ilmenite (Denning, 1949).

DIABASE DIKES

No diabase dikes are exposed in the area, but their presence is inferred from very distinctive west-trending linear negative magnetic anomalies that are invariably associated with diabase dikes to the east, where bedrock is better exposed. There, the rock ranges from coarse- to fine-grained massive diabase consisting of plagioclase, clinopyroxene, and rarely olivine, as well as small amounts of magnetite and other opaque minerals. Large boulders of diabase are found along the bed of the Sturgeon River near the falls and may be locally derived. The nearest exposure of diabase is at Mt. Kallio, about 2 km east of the area (fig. 10).



Base from U.S. Geological Survey, 1954

Figure 10.--(See caption on facing page.)

BASALT

Basalt is exposed at Sturgeon Falls and at several other places for a short distance downstream (northward) from the falls. These rocks were assigned by Hubbard (1975) to the Siemens Creek Formation that he named for rocks near Bessemer, Mich., about 100 km to the west. Basalt of the Siemens Creek Formation is also exposed on Silver Mountain immediately north of the study area. These rocks

EXPLANATION

Yjs	Jacobsville Sandstone—Reddish sandstone containing minor conglomerate and shale interbeds. Variably bleached to very light brown giving mottled appearance in outcrop
Ykb	Siemens Creek Formation—Thick flows of basalt consisting of fine-grained andesine and pyroxene. In places metamorphosed amphibolite. Commonly vesicular near flow margins
Ykd	Diabase dikes—Inferred from aeromagnetic pattern
Xm	Michigamme Formation—Inferred from aeromagnetic pattern to be interbedded graywacke and slate
	Outcrop area
———	Contact—Approximately located

Figure 10.--Bedrock geologic map of the Sturgeon River Wilderness Study Area based on magnetic patterns and showing the inferred distribution of Michigamme Formation, diabase dikes, and lower Keweenawan basalt. The extent of the Jacobsville Sandstone away from its only exposures along the Sturgeon River is not known. A thin blanket of Jacobsville probably overlies much of the area, though it is not shown in this map. The thickness of dikes shown on the map is the maximum thickness consistent with the shape of aeromagnetic anomalies, but, because of uncertainties in interpretation, they may be thinner than shown.

were studied in detail by Roberts (1940). At Sturgeon Falls he recognized three separate flows by identifying amygdaloidal zones that formed near the top and bottom contact of each flow. The flows are fine-grained (~1 mm) black massive basalt. The average mineral content is 45 percent andesine, 25 percent chlorite, 20 percent augite, 5 percent magnetite and other opaque minerals, and 2 percent epidote. Amygdules are filled with combinations of quartz, calcite, epidote, potassium feldspar, and ankerite.

On Silver Mountain, Roberts found at least 14 flows, each from 1 to 6 m thick. There, the basalt is metamorphosed, and original augite was converted to hornblende (which makes up about 40 percent of the rock). Andesine (40 percent), calcite (10 percent), and leucoxene (5 percent) are other important constituents.

At an exposure about 300 m downstream from Sturgeon Falls, the basalt is overlain unconformably by the Jacobsville Sandstone. Weathering prior to

Figure 11.--Exposure of Pleistocene glacial deposits in a stream bank along the Sturgeon River. Crossbedded sand (lighter colored material near top) overlies a bed of clay (darker colored massive-appearing material near center), which is underlain by stratified sand mostly covered by slumped material near the bottom of the exposure.

deposition of the Jacobsville has produced a reddish-brown color in the basalt and a partially disaggregated rubbly texture. As much as 2 m of this soft, rubbly weathered rock is preserved beneath the Jacobsville.

MICHIGAMME FORMATION

The Michigamme Formation is not exposed in the wilderness study area. Large areas to the south and east of the study area are underlain by a monotonous sequence of graywacke and slate. The nearest outcrops are about 3 km southeast of the study area. These rocks are commonly in graded beds 0.5 to 1 m thick that range from coarse-grained graywacke at their base to fine-grained dark-gray to black slate near their top. The rocks are folded about west-northwest-trending axes, and cleavage is generally well developed, especially in the tops of graded beds. Areas known to be underlain by the Michigamme Formation produce a characteristic uniformly low magnetic field. The extension of that magnetic pattern from areas where the Michigamme is exposed into parts of the wilderness study area indicates that much of the area is underlain by similar graywacke and slate.

STRATIGRAPHY AND STRUCTURE

In spite of sparse exposures of bedrock in the study area, the stratigraphic and structural relationships can be inferred with confidence because of abundant geophysical data. The geologic map of the area (fig. 10) is drawn from aeromagnetic data. Figure 6 shows that the wilderness study area and surroundings can be divided into three zones, each having a characteristic magnetic signature. Zone C is characterized by uniform and relatively low magnetic attraction. Southeast of the study area, we know this magnetic low correlates with thick graywacke and slate of the Michigamme Formation. We infer, therefore, that the southern part of the study area is also underlain by Michigamme Formation because it has the same magnetic signature. Zone B is characterized by very low magnetic attraction. The exposures of the Siemens Creek Formation at Sturgeon Falls and Silver Mountain are in zone B and have been extensively sampled by Kenneth Books, of the U.S. Geological Survey, for magnetic property studies. He found that they have a strong remanent magnetization acquired when the flows cooled. This magnetization is alined with the direction of the Earth's magnetic field at the time of cooling, slightly more than a billion years ago. The direction of magnetization in the Sturgeon River area is nearly opposite the direction measured in the much thicker series of volcanic rocks of the middle Keweenawan on the Keweenawan Peninsula to the north, so that the flows near Sturgeon River produce magnetic lows instead of highs. Books (1968, 1972) found this same reversed magnetization in lower Keweenawan flows near Ironwood, Mich. and at other areas around Lake Superior, so the flows in the Sturgeon River area must also be lower Keweenawan.

Zone A, entirely outside the study area, is marked by a prominent series of magnetic highs that form an arcuate belt that strikes westward without interruption into the exposed Keweenawan basalt near Ironwood, Mich. (King, 1975). At a depth of 730 m, basalt was found in a drill hole 40 km west of the Sturgeon River on the crest of this anomaly (Bacon, 1966). The Jacobsville Sandstone covers the area of this magnetic high, which is inferred to mark the southern edge of a thick series of Keweenawan basalt flows that get progressively deeper to the northwest. This deepening is indicated by the magnetic contours that are widely spaced and have lower values in that direction. The gravity data show a broad high in that area, indicating the presence of a large mass of dense rock, such as basalt.

Both zones B and C have a prominent pattern of west-trending negative linear anomalies superimposed on them. These can be seen on the contoured maps (figs. 5 and 6) but are even more evident on the original profiles, one of which is shown in figure 12. The sharp distinction between zones B and C is also well shown on this profile. These anomalies in other areas are known to be caused by diabase dikes that, like the basalt of the Siemens Creek Formation, have reversed magnetic polarity. The diabase and the basalt presumably crystallized during the same period of magnetic reversal. Because they do not cut anomalies formed by the younger basalts of zone A, they are believed to be feeder dikes for the lower Keweenawan basalt flows.

Figure 9 shows the stratigraphic and structural relationships of the area in schematic form. The oldest rocks are the Michigamme Formation, which is probably a thick, folded unit of graywacke and slate. Volcanic rocks underlying the Michigamme Formation well southeast of the area have been dated radiometrically at about 2.0 billion years (Banks and Van Schmus, 1971). Metamorphism, which was approximately synchronous with deformation, took place about 1.9 billion years ago. Although the Michigamme is a highly varied formation in many parts of

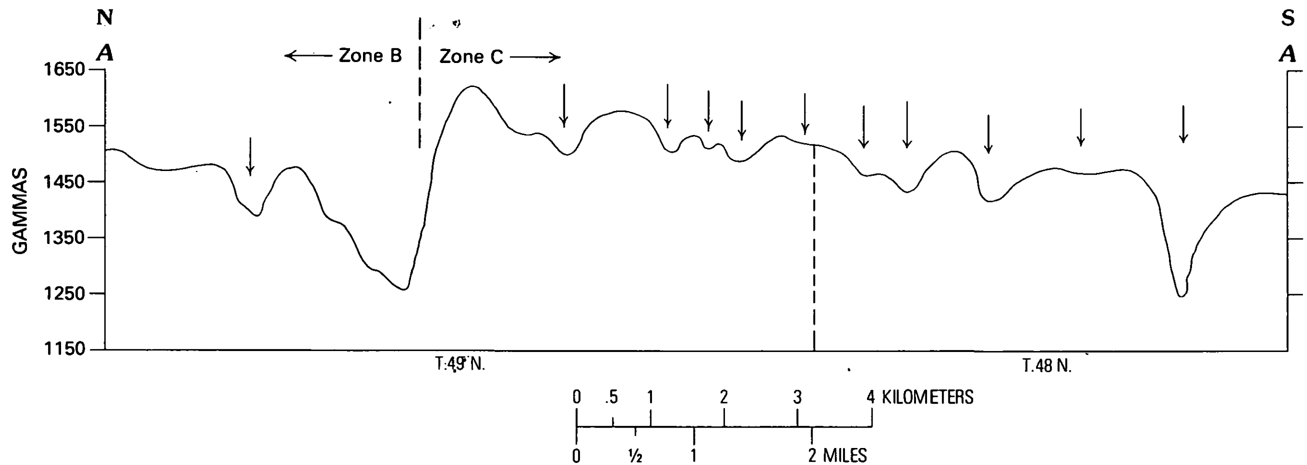


Figure 12.—A typical aeromagnetic profile from which the magnetic contour maps were drawn. See figure 5 for the location of the profile. Arrows indicate areas of low magnetic attraction inferred to be caused by lower Keweenawan diabase dikes.

the Upper Peninsula, the exposures nearest to the study area are composed uniformly of graywacke and slate that were deposited by turbidity currents, probably in deep water.

A long gap in the geologic history of the region is represented by the unconformity between the Michigamme Formation and the Siemens Creek Formation. The basalt flows of the Siemens Creek spread over the erosion surface on the Michigamme. Gravity data indicate that the basalts are only a thin sheet in the study area and that the Michigamme is present in the shallow subsurface (see fig. 13). This is consistent with the observed low dips of flows at Sturgeon Falls and Silver Mountain and the position of the area near the southeasternmost edge of the basalt flows.

During eruption of the basalt, nearly vertical feeder dikes, the Baraga dikes, brought lava to the surface along east-west fractures. These dikes have been described by Graham (1953), Balsley and others (1949), and DuBois (1962). They were evidently emplaced during an early phase of rifting of the Lake Superior and midcontinent regions coincident with eruption of lower Keweenawan basalt. Shortly afterward, much thicker basalt, forming the middle Keweenawan rocks, accumulated to a thickness as great as 15 km. Although these rocks once probably covered the Sturgeon River Area, they have since been eroded. The rift in which the Keweenawan rocks accumulated may have been similar to the present African rift system and may have extended from Lake Superior to Kansas. The area invaded by the Baraga dikes was one of crustal extension associated with the opening of the rift.

After the flows cooled, they were tilted toward the northwest, and an erosion surface developed on them prior to deposition of the Jacobsville Sandstone. Exposures near Sturgeon Falls indicate that local relief was 25 m or more when the area was covered by the Jacobsville. Regional studies by Hamblin (1958) show that the Jacobsville was deposited by generally north- or northwest-flowing streams and occupied a basin nearly coincident with the present Lake Superior drainage basin.

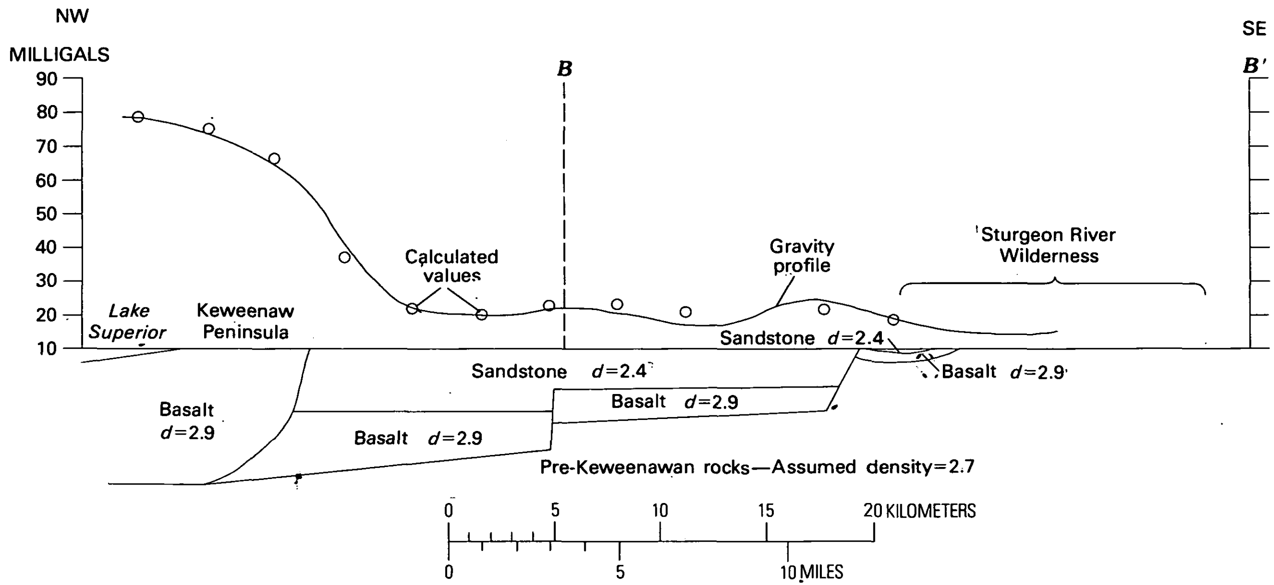


Figure 13.—A generalized density model of the Sturgeon River Wilderness Study Area and surrounding area (from Bacon, 1966), derived by calculating a theoretical gravity anomaly to coincide with the observed Bouguer anomaly. The model indicates that Keweenawan rocks in the study area are thin and are underlain at a relatively shallow depth by rocks of lower density, presumably part of the Michigamme Formation. The location of line B-B' is shown in figure 7. This model does not reflect the additional data and slight recontouring in figure 7.

Fig. 13

The exact age of the Jacobsville is not known. Unconformable relationships with the underlying lower Keweenawan basalt and overlying Munising Sandstone (Upper Cambrian) place only widely spaced limits on the possible age (Hamblin, 1958). It is considered provisionally to be late Precambrian (Precambrian Y).

A long period having no geologic record separates the Jacobsville and Pleistocene deposits. Outliers of Ordovician sedimentary rocks at Limestone Mountain, a short distance north of the area, suggest that the entire area was once covered with Ordovician and possibly other Paleozoic rocks, which have since been removed by erosion.

The Pleistocene deposits are mostly fluvial sand and gravel deposited south of a retreating continental glacier. The fine-grained clayey beds were probably deposited in standing water, perhaps small lakes or channels on the fluvial plain.

MINERAL-RESOURCE POTENTIAL OF KNOWN DEPOSITS

By James J. Hill and Peter C. Mory

An investigation of the mineral-resource potential of known deposits was undertaken by the U.S. Bureau of Mines in 1975. Evaluations were made for deposits of stone, sand and gravel, clay, and peat, as well as for two prospects on Silver Mountain just outside the study area. The study disclosed no metallic mineral deposits that can be mined economically. Minor resources of stone, sand and gravel, clay, and peat exist in the area, but, because they lie far from major demand centers, they are of little economic interest.

LAND STATUS

Investigations of mineral potential in wilderness areas are based in part on evaluations of historical activities and data. Consideration is given to the past availability (accessibility) of land to individuals and (or) industry engaged in mineral exploration. This information can give some insight to the thoroughness with which a particular area might have been evaluated during times of continually evolving exploration concepts and methods.

SURFACE OWNERSHIP

U.S. Forest Service and courthouse records indicate that before 1934, when the Federal government began to purchase national forest land in the area, most of the land was in private ownership. Although not open to prospecting and location under the General Mining Law of 1872, it is possible that some of the area was accessible for exploration either through lease option or by actual ownership of surface and mineral rights.

As of July 1975, U.S. Forest Service and courthouse records show that approximately 25 percent of the land surface (fig. 14) is still privately owned.

MINERAL OWNERSHIP

After Federal purchase of lands within the national forest boundary, mineral rights were severed from most tracts and remain outstanding. Figure 15 depicts Federal mineral ownership as of July 1975. Mineral rights on all other tracts remain in private ownership (table 1). After Federal purchase of these lands, the President's Reorganization Plan No. 3 of 1946, Section 402, provided for the Bureau of Land Management to accept applications for prospecting and mining permits on acquired lands having federally owned mineral interests. Although representing a small part of the total acreage involved in the wilderness proposal, these Federal mineral lands have been accessible for exploration.

MINING ACTIVITY

No active mines are within the Sturgeon River Wilderness Study Area, and no record of past mineral production has been found. In a few places, minor amounts of sand and gravel from within the area have been used in the construction of logging roads. The

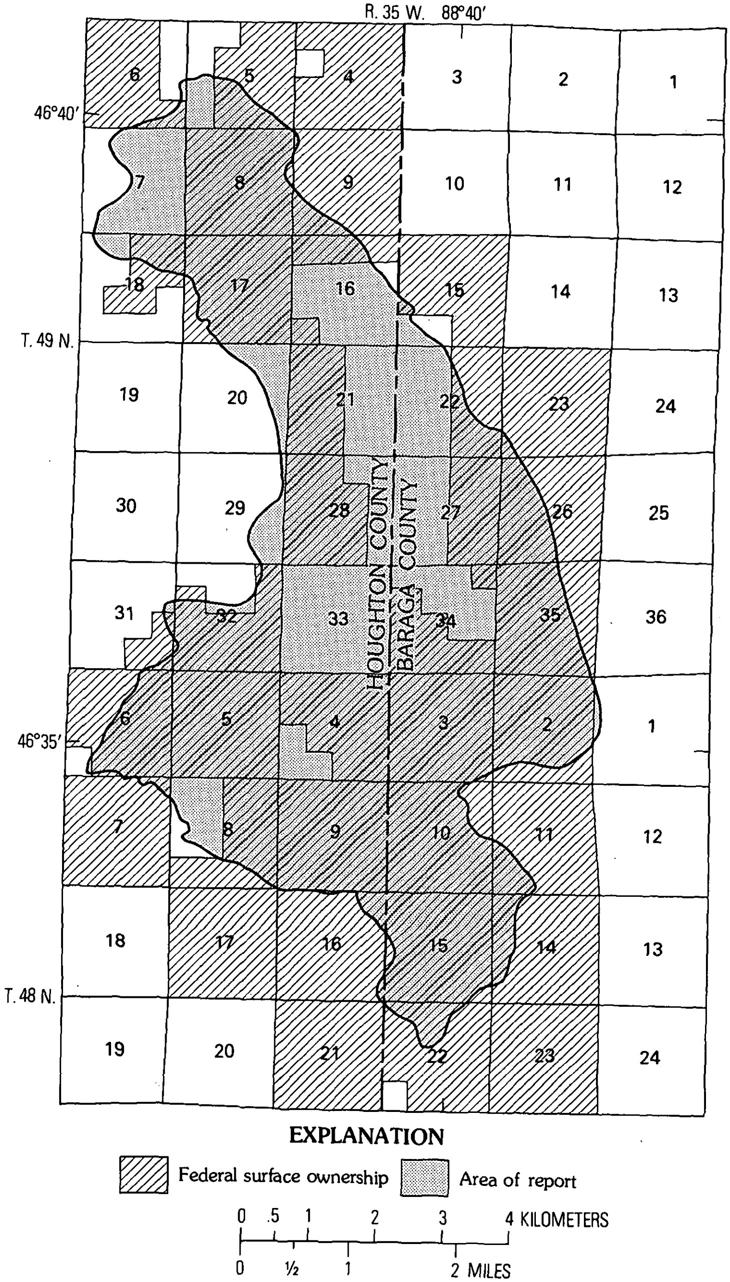


Figure 14.--Federal surface ownership within the Sturgeon River Wilderness Study Area. Not all Federal ownership outside the area is shown.

nearest mineral operations in recent times are small sand and gravel pits located in secs. 24 and 25, T. 48 N., R. 35 W., approximately 2.4 km southeast of the study area. These pits appear to be worked intermittently to supply local needs.

PROSPECTING ACTIVITY

WITHIN THE AREA

No tangible evidence or record of exploration drilling and test pitting exists within the present study area. Several outcrops of basalt along Sturgeon River have been cored to a depth of several centimeters to obtain rock samples for paleomagnetic studies that will aid in regional stratigraphic correlation. The only other drilling of record is a water well drilled by the U.S. Forest Service in 1964 at the Sturgeon River Campground (sec. 11, T. 48 N., R. 35 W.). This well penetrated 10.3 m of gravel and boulders and 9.8 m of hard-rock ledge (Doonan and Byerlay, 1973). To our knowledge, a geologic description of the bedrock found in the water well is not available.

SILVER MOUNTAIN

The only physical evidence of prospecting activity in the immediate vicinity of the proposed wilderness is an adit and a trench located on Silver Mountain (fig. 16). The prospects warrant mention because they are found in rock lithologically and stratigraphically similar to the basalt flows exposed along the Sturgeon River.

Attention may have first been directed to the study area by Burt (1849, p. 849), who described Silver Mountain (approximately 1.2 km west of the proposed wilderness boundary, on the east boundary of T. 49 N., R. 36 W., on the line between secs. 1 and 6) as follows:

> This mountain-like mass of greenstone trap is, to some extent, metalliferous; in nearly every part, traces of the gray

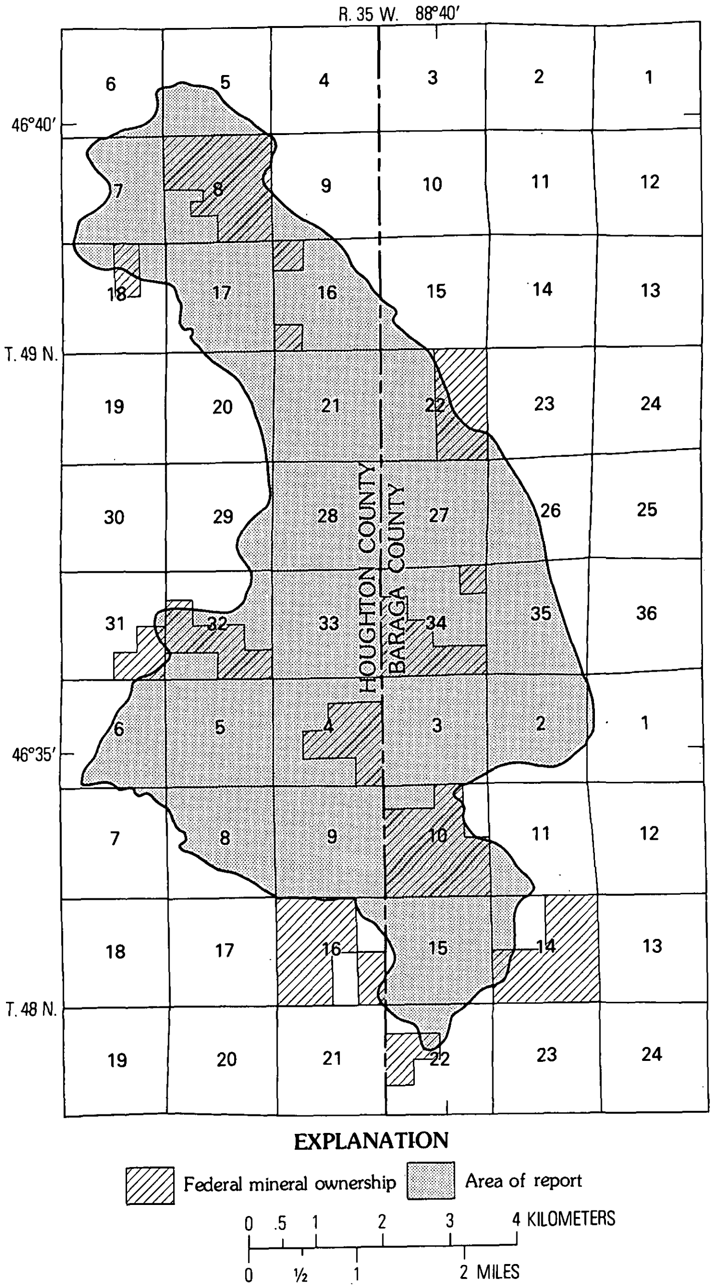


Figure 15.--Federal mineral ownership within the Sturgeon River Wilderness Study Area. Not all Federal ownership outside the area is shown.

TABLE 1.—*Mineral ownership within and adjacent to the Sturgeon River Wilderness Study Area*

T. 49 N., R. 35 W.		
Section	Subdivision	Owner
5	Entire	Ford Motor Co.
6	W½ NE; W½; W½ SE; SE SE	Worcester Lumber Co.
6	E½ NE; NE SE	Ford Motor Co.
7	Entire	Ford Motor Co.
8	W½ SW; SE SW; NW NE SW	Worcester Lumber Co.
8	N½; SE¼; NE NE SW; S½ NE SW	Federal
9	Entire	Ford Motor Co.
15	N½; SE¼; N½ SW	Michigan Iron and Land Co.
15	S½ SW	Unknown party
16	N½ NE; NE NW	State of Michigan
16	NW NW; SW SW	Federal
16	SE¼; S½ NE; S½ NW; E½ SW; NW SW	Unknown party
17	Entire	Ford Motor Co.
18	E½ NE; NW SE; NE SW	State of Michigan
18	W½ NE	Federal
18	NW¼; W½ SW; SE SW; S½ SE; NE SE	Ford Motor Co.
20	Entire	Ford Motor Co.
21	Entire	Ford Motor Co.
22	E½	Federal
22	W½	Michigan Iron and Land Co.
23	Entire	Michigan Iron and Land Co.
26	Entire	State of Michigan
27	Entire	Michigan Iron and Land Co.
28	W½ SE; W½; SW NE	Worcester Lumber Co.
28	E½ SE; E½ NE; NW NE	Unknown party
29	Entire	Ford Motor Co.
31	N½; SW¼; NW SE	Ford Motor Co.
31	E½ SE; SW SE	Federal
32	E½ NE; NE SE	State of Michigan
32	W½ NE; E½ NW; NW NW	Ford Motor Co.
32	S½ SW	J. Van Evera
32	SW NW; N½ SW; NW SE; S½ SE	Federal
33	Entire	Ford Motor Co.
34	NE NE; S½ SE; SW NW; SW¼	Federal
34	N½ NW; SE NW; S½ NE; NW NE; N½ SE	Michigan Iron and Land Co.
35	Entire	Michigan Iron and Land Co.

TABLE 1.—*Mineral ownership within and adjacent to the Sturgeon River Wilderness Study Area*—Continued

T. 48 N., R. 35 W.		
Section	Subdivision	Owner
2	Entire	State of Michigan
3	Entire	Michigan Iron and Land Co.
4	NE SW; N½ SE; SE SE; S½ NE	Federal
4	N½ NE; NW¼	State of Michigan
4	SW SE	Mary N. Bourke, and others
4	S½ SW; NW SW	Von Platen
5	Entire	Ford Motor Co.
6	SW NE; S½ NW; NW SW	Joshua Stark, and others
6	SW SW	Unknown party
6	SE NE; NE SW	Nester Lumber Co., and others
6	N½ NW; N½ NE; SE¼; SE SW	State of Michigan
7	Entire	Ford Motor Co.
8	N½; N½ SW	Nester Lumber Co., and others
8	S½ SW; N½ SE; SW SE	State of Michigan
8	SE SE	Joshua Stark, and others
9	Entire	Ford Motor Co.
10	N½ NW; E½ NE	Mary N. Bourke, and others
10	S½; S½ NW; W½ NE	Federal
11	Entire	Michigan Iron and Land Co.
14	NW NW	Oliver Iron Mining Co.
14	S½ NW; NE NW	State of Michigan
14	E½; SW¼	Federal
15	Entire	Ford Motor Co.
16	W½; W½ NE; E½ SE	Federal
16	E½ NE	Mayme Sanborn
16	W½ SE	State of Michigan
22	N½ NW	Sage Land and Improvement Co.
22	S½ NW; NW SW	Federal
22	E½ SW; SE¼; SW NE; NE NE	State of Michigan
22	NW NE; SE NE	Oliver Iron Mining Co.
22	SW SW	Unknown party

> sulphuret of copper were seen, but no well-defined and productive vein was found. On its southeasterly side two or three imperfectly formed veins of quartz and calcareous spar were seen associated with the gray sulphuret of copper; and in some places, with slight traces of green carbonate of steatite.

He then noted that the Sturgeon River passed over traprock in falls and rapids about 3 miles (5 km) south-southeast of Silver Mountain in T. 49 N., R. 35 W.

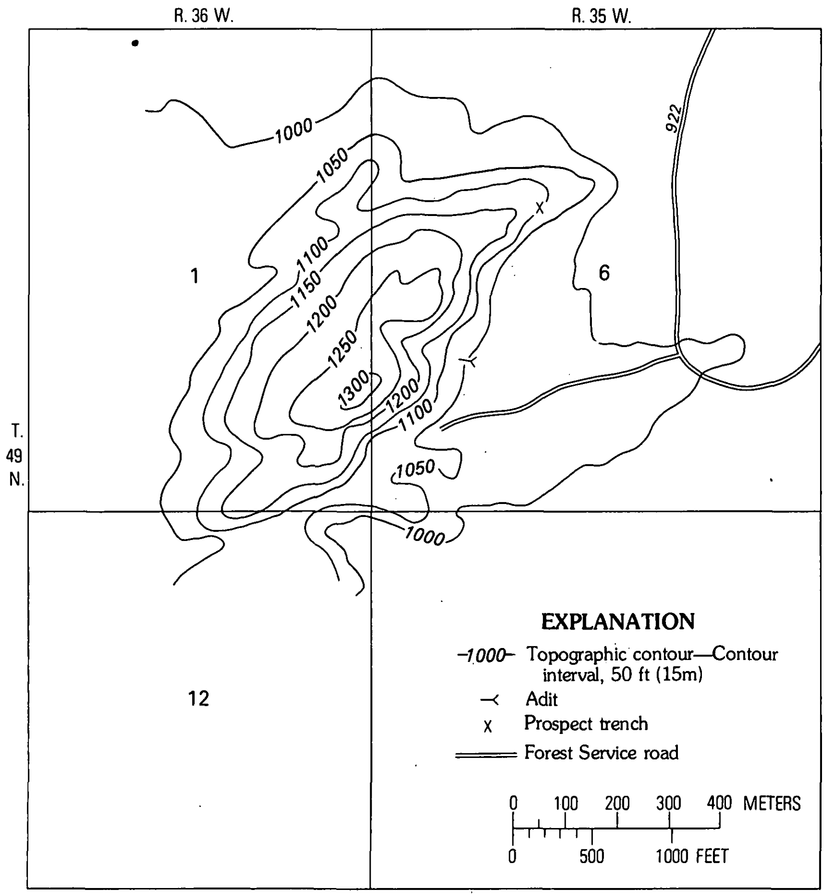


Figure 16.--Location of the prospect adit and trench on Silver Mountain.

Several other early investigators--Foster and Whitney (1850), Wadsworth (1891), and Irving (1883)--reported on the geology of Silver Mountain. Roberts (1940), in his study of the Alston district, investigated Silver Mountain and, of more importance, described the rock outcrops along the Sturgeon River, the focal point of the present study.

Silver Mountain, formerly the site of a U.S. Forest Service lookout tower, is a dome-shaped mass of rock rising approximately 300 feet (91 m) above the surrounding terrain. Now designated on national forest maps as a "scenic view," it is reached by a gravel road leading off Forest Service Road 922. Just off the trail leading from a parking lot is the adit (fig. 16). A Forest Service plaque notes that mining was carried on here by the National Co. prior to 1850.

The adit penetrates basalt for about 43 m along a fault plane, which has a bearing of about N. 70° W. and dips 60° to the north. Fault breccia in fragments 2 to 30 cm in diameter (covered with talc) is visible in the trace exposed in the back. No significant mineralization was noted during this investigation, although Roberts (1940, p. 11) mentioned amygdules that carried traces of bornite and chalcopyrite. Foster and Whitney (1850, p. 68, 69) noted no metallic mineralization in the rock dump at the time of their investigation.

Sites of samples taken within the adit (nos. 54-60) are shown in figure 17. The samples represent random chips taken every 5-10 cm through the fault zone in the roof and along the ribs over intervals indicated on figure 17. Sample analyses are tabulated in table 2. Very sparse mineralization is indicated by the results of the analyses; the highest copper value is 60 parts per million (ppm), and a trace of silver was found in the same sample. The water impounded in the rear of the adit precluded reaching the face for observation or sampling.

A small prospect trench is about 305 m northeast of the adit at an elevation of 329 m. First noted by Roberts (1940), it is presumed to have been opened by the same people who worked the adit. The trench lies within the same rock unit as the adit

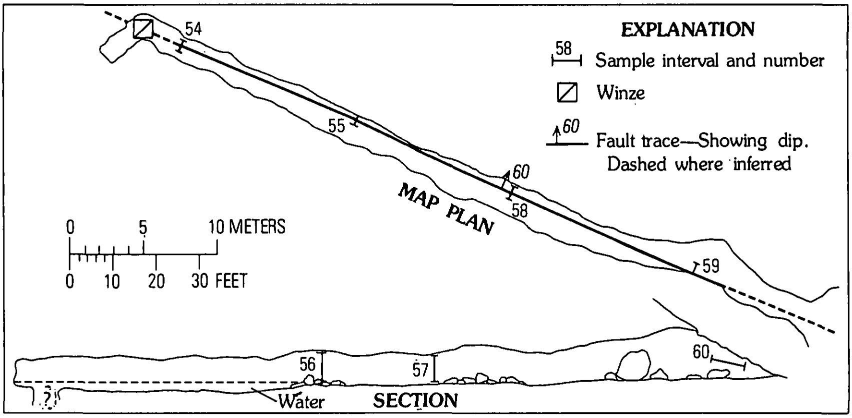


Figure 17.--Map and section of the Silver Mountain adit showing sample locations.

and has been excavated on a fault zone near the head of a narrow ravine that reflects the fault's trace. The workings are about 6.7 m long, 1.2 m wide, and 1.8 m deep. Exposed in the face of the trench, the fault zone is about 1 m wide and has a strike of N. 46° W. and a dip of 80° NE.

A chip sample of fault gouge and brecciated country rock was taken across the face. Assay results indicate a trace of silver and 90 ppm copper. Random chip samples from the ribs have lower copper values. The sparse mineralization indicated by the assay data negates the possibility of any economic value for the prospect.

HIGH-SILICA SAND

Evaluation of analyses for the Jacobsville Sandstone (table 2) indicates that high aluminum, iron, magnesium, and titanium negate the possibility of this sandstone being considered a source of high-silica sand. Whether or not more pure sandstone underlies the glacial material in the area could not be determined, but examination of the few outcrops suggests that it does not. Because they lack maturity, glacial deposits in the area are not considered likely sources of high-silica sand.

TABLE 2.—*Partial chemical analyses of samples from the Sturgeon River Wilderness Study Area*

[Results in parts per million, except as indicated; N.a., not analyzed; N.d., not detected; Tr, detected in trace amounts but below limit of quantitative determination. Samples 1-49 were analyzed at U.S. Geological Survey analytical laboratories, Reston, Va. Au was determined by combined fire assay-atomic absorption technique. Remaining reported elements were determined by semiquantitative spectrographic technique for which the standard deviation of any single answer should be taken as +50 and −33 percent. Si, Al, Fe, Mg, Ca, Na, K, Ti, P, B, Ba, Bi, Cd, Ce, Dy, Er, Eu, Ga, Gd, Ge, Ho, In, Lu, Nb, Nd, Os, Pd, Pr, Pt, Re, Rh, Ru, Sb, Sc, Sm, Sr, Ta, Tb, Te, Th, Tl, Tm, W, Y, and Yb were analyzed but either not detected or detected in nonanomalous amounts. Samples 51-82 were analyzed by U.S. Bureau of Mines, Reno Metallurgical Research Center, Reno, Nev. Co, Cr, Sc, Mo, Ni, Pb, V, Zr analyzed by general spectrographic technique. Cu also by general spectrographic technique except for samples 51, 54-57, 59, 80, 81, 71, 73, 78, which were analyzed by atomic absorption technique. Elements tested for, but not detected, are As, Au, Ba, Be, Bi, Cd, Ga, Hf, In, Li, La, Y, Nb, P, Pt, Re, Sb, Sn, Sr, Ta, Te, Tl, W, Zn]

	Number	Ag[1]	Au	Co	Cr	Cu	Hf	Mn	Mo	Ni	Pb	Sn	U	V	Zn	Zr
Soil samples	12	0.12	0.05	4.3	16	14	<100	260	<2.2	8.8	12	<6.8	<320	34	<22	330
	13	<.10	<.05	4.3	15	9.4	<100	350	<2.2	9.4	17	<6.8	<320	26	<22	220
	14	<.10	<.05	5.6	26	14	<100	370	<2.2	12	15	<6.8	<320	61	<22	770
	15	<.10	<.05	4.7	19	9.5	<100	330	<2.2	8.3	24	<6.8	<320	34	<22	110
	16	.12	<.05	[2] 3.7	15	8.2	<100	220	<2.2	6.7	12	<6.8	<320	42	<22	340
	17	.35	<.05	320	15	8.4	<100	290	<2.2	7.5	31	<6.8	<320	28	<22	92
	18	<.10	<.05	11	48	26	<100	420	<2.2	25	17	<6.8	<320	58	<22	570
	19	<.10	<.05	6.5	24	17	<100	470	<2.4	14	18	<6.8	<320	55	<22	270
	33	<.10	<.05	4.7	19	11	<100	340	<2.2	8.3	14	<6.8	<320	38	<22	440
	34	<.10	<.05	4.5	15	47	<100	340	<2.2	8.9	11	<6.8	<320	42	<22	220
	35	<.10	<.05	8.0	27	9.8	<100	260	<2.2	11	15	<6.8	<320	37	<22	540
	39	.14	<.05	3.9	20	9.6	<100	250	<2.2	7.6	12	<6.8	<320	29	<22	660
	42	<.10	<.05	6.8	26	19	<100	360	<2.2	15	15	<6.8	<320	43	<22	520
	44	<.10	<.05	5.1	43	17	<100	410	<2.2	9.5	17	<6.8	<320	47	<22	620
	47	<.10	<.05	4.9	23	11	<100	340	<2.2	7.6	16	<6.8	<320	40	<22	560
Stream sediment samples	26	<.46	<.05	3.6	32	6.9	<21	540	<2.2	9.4	14	<15	<150	67	<15	380
	28	<.46	<.05	3.7	29	4.0	<21	360	<2.2	7.8	15	<15	<150	68	<15	220
	29	<.46	<.05	5.5	67	6.4	<21	670	<2.2	13	15	<15	<150	110	<15	480

	31	<.46	<.05	3.0	41	3.5	< 46	320	< 2.2	8.6	15	<15	< 150	57	<15	200
	37	<.46	<.05	1.6	30	1.6	< 22	170	< 2.2	3.6	9.9	<15	< 150	21	<15	120
	40	<.46	<.05	2.4	24	2.9	< 22	270	< 2.2	4.5	11	<15	< 150	44	<15	200
	46	<.46	<.05	4.2	35	5.6	< 22	330	< 2.2	8.9	13	<15	< 150	55	<15	360
	49	<.46	<.05	3.4	35	4.7	< 22	340	< 2.2	9.4	14	<15	< 150	43	<15	200
Pan concentrate samples	3	<.46	<.05	15	96	9.1	<100	2,500	<2.2	35	17	<15	<150	250	85	200
	4	<.46	<.05	16	170	14	<22	4,400	<3.2	34	37	<15	<150	390	110	>2,100
	20	<.46	<.05	19	130	30	<22	1,500	<2.2	51	16	45	<150	210	87	140
	25	<.46	<.05	4.9	25	2.3	<22	530	<2.2	8.7	12	<15	<150	100	<15	250
	27	.54	<.05	27	450	21	220	5,300	3.0	50	66	<22	<150	550	160	>2,100
	30	.58	<.05	22	380	14	<22	5,600	<4.6	44	110	<15	<150	610	240	>2,100
	36	<.46	<.05	4.6	44	1.2	<46	1,000	<2.2	7.4	8.5	<15	<150	94	<15	480
	41	<.46	<.05	2.2	62	<1.0	<22	470	<2.2	2.7	9.2	<15	<150	74	<15	700
	43	<.46	<.05	20	240	17	<22	8,200	<2.2	34	54	<15	<210	510	120	>2,100
	45	.51	<.05	16	170	11	<22	2,300	<3.2	36	29	<15	<150	300	100	>2,100
	48	1.1	<.05	31	530	22	<22	5,800	<4.6	59	100	<52	<150	870	270	>2,100
	71	Tr	N.d.	N.d.	70	40	N.d.	2,000	<20	N.d.	<100	N.d.	N.a.	100	N.d.	600
	73	N.d.	N.d.	N.d.	70	30	N.d.	2,000	<20	N.d.	<100	N.d.	N.a.	100	N.d.	300
	78	N.d.	N.d.	N.d.	100	30	N.d.	2,000	<20	N.d.	<100	N.d.	N.a.	100	N.d.	400
Rock samples: Basalt	2	<.10	<.05	31	280	92	<100	1,800	<3.2	65	15	<6.8	<320	180	63	100
	8	.28	<.05	25	200	130	<100	1,500	<2.2	93	18	<6.8	<320	49	73	95
	9	<.10	<.05	37	140	92	<100	2,500	<3.2	66	17	<6.8	<320	23	24	150
	51	Tr	N.d.	<10	<30	90	N.d.	300	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	52	N.d.	N.a.	<10	<30	40	N.d.	300	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	53	N.d.	N.a.	<10	60	40	N.d.	600	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	54	.1	N.d.	<10	<30	40	N.d.	600	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	55	N.d.	N.d.	<10	<30	40	N.d.	600	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	56	Tr	N.d.	<10	30	60	N.d.	600	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	57	N.d.	N.d.	<10	<30	40	N.d.	300	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	58	N.d.	N.a.	<10	<30	<20	N.d.	300	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	59	N.d.	N.d.	<10	<30	40	N.d.	300	N.d.	<20	N.d.	N.d.	N.a.	<60	N.a.	<70
	60	N.d.	N.a.	<10	<30	40	N.d.	14,000	N.d.	<20	<100	N.d.	N.a.	<60	N.a.	<70

TABLE 2.—*Partial chemical analyses of samples from the Sturgeon River Wilderness Study Area*—Continued

	Number	Ag[1]	Au	Co	Cr	Cu	Hf	Mn	Mo	Ni	Pb	Sn	U	V	Zn	Zr
Rock samples:																
Basalt	64	N.d.	N.a.	< 10	< 30	40	N.d.	600	N.d.	< 20	N.d.	N.d.	N.a.	< 60	N.a.	< 70
	66	N.d.	N.a.	< 10	< 30	40	N.d.	600	N.d.	< 20	N.d.	N.d.	N.a.	< 60	N.a.	< 70
	69	N.d.	N.a.	< 10	60	N.a.	N.d.	14,000	N.d.	< 20	N.d.	N.d.	N.a.	< 60	N.a.	< 70
Diabase	80	N.d.	N.a.	< 10	< 30	460	N.a.	14,000	N.d.	< 20	N.d.	N.a.	N.a.	100	N.a.	< 70
	81	<.10	N.a.	< 10	< 30	490	N.a.	14,000	N.d.	20	N.d.	N.a.	N.a.	< 60	N.a.	< 70
Sandstone	1	<.10	<.05	3.8	5.6	8.3	<100	1,400	<2.2	4.8	<10	<6.8	< 320	15	< 22	88
	5	<.10	<.05	5.6	29	16	<100	200	<2.2.	11	15	<6.8	< 320	67	< 22	190
	10	<.10	<.05	4.6	22	12	<100	330	<2.2	10	17	<6.8	< 320	23	24	150
	11	<.10	<.05	6.2	19	11	<100	280	<2.2	13	19	<6.8	< 320	34	< 22	170
	23	<.10	<.05	6.2	19	11	<100	280	<2.2	13	13	<6.8	< 320	27	< 22	180
	61	N.d.	N.a.	< 10	< 30	30	N.a.	300	N.d.	< 20	N.d.	N.a.	< 20	100	N.a.	< 70
	62	N.d.	N.a.	< 10	< 30	30	N.a.	300	N.d.	N.d.	N.d.	N.a.	< 20	< 60	N.a.	< 70
	63	N.d.	N.a.	< 10	< 30	30	N.a.	300	N.d.	< 20	N.d.	N.a.	< 20	< 60	N.a.	< 70
	65	N.d.	N.a.	< 10	< 30	20	N.a.	300	N.d.	< 20	N.d.	N.a.	< 20	< 60	N.a.	< 70
	67	N.d.	N.a.	< 10	< 30	20	N.a.	140	N.d.	< 20	< 100	N.a.	< 20	< 60	N.a.	< 70
	68	< 10	N.a.	< 10	< 30	< 20	N.a.	140	N.d.	< 20	< 100	N.a.	< 20	< 60	N.a.	< 70
	70	N.d.	N.a.	< 10	< 30	20	N.a.	60	N.d.	N.d.	N.d.	N.a.	< 20	< 60	N.a.	< 70
Quartzite	82	N.d.	N.a.	< 10	30	40	N.a.	140	N.d.	< 20	N.d.	N.a.	N.a.	60	N.d.	< 70

[1]Values for numbers 51 to end of table are given to oz/ton.
[2]High value due to contamination during sample preparation.

STONE

Before the turn of the century, the Jacobsville Sandstone was quarried as dimension stone at the town of L'Anse, approximately 23 km northeast of the Sturgeon River area, and at several other localities near the Lake Superior shore (Kirby, 1964).

Jacobsville Sandstone in the study area would not be suited to quarry development even if there were sufficient market demand. The distance to major market areas, the vast quantities of overburden, as well as the lack of electrical power and access roads, preclude economic development and limit the potential of the sandstone.

Basalt of the Siemens Creek Formation within the study area is a minor resource of crushed stone and riprap. The distance to markets, the limited areal extent of the outcrops, and extensive overburden, plus the lack of electrical power and access roads, limit the possibility of economic development. The basalt at nearby Silver Mountain represents a more likely source of a very large quantity of stone, and a developed access road is nearby.

SAND AND GRAVEL

Sand and gravel is found in the extensive glacial deposits that blanket the study area. Deposits range from 0 to about 30 m in thickness in cutbanks along the Sturgeon River. On the basis of topographic mapping, sand and gravel in thicknesses of more than 61 m is estimated to be present in some areas.

Moraine deposits of till, lake-plain and stream-bench deposits of sand and clay, and outwash deposits of stratified sand and gravel are present (Doonan and Byerlay, 1973). In this heavily vegetated area, characteristics of individual deposits are visible mainly in stream drainages. Observations indicate that many deposits are composed of fine sand with interbedded silt and clay, which are a deterrent to commercial development.

Coarse water-washed gravel and sand and numerous boulders are found in the Sturgeon River channel and along bars from a point where the river enters the study area in sec. 11 to the south line of sec. 3, T. 48 N., R. 35 W. The distance from major demand centers and the high transportation costs effectively limit commercial utilization of these deposits. Because most of the surrounding area is national forest land, local demand is unlikely.

CLAY

Deposits of clay within the study area are mainly visible in stream drainages (fig. 18). The areal extent of most exposures is only a few meters. In several instances, deposits are overlain by glacial sand and gravel in excess of 15 m. The clay is red or tan, somewhat gritty, and locally interspersed with small pebbles.

Samples were collected during this investigation to evaluate the ceramic properties of the clay (table 3). Only clay sample No. 72 (table 3) shows any potential for use as a moderate-weather building brick. All other samples were found not suitable for use in vitreous clay products.

Limited areal extent of the deposits, poor quality, thickness of overburden, distance to markets, and lack of accessibility negate the possibility of their economic development.

PEAT

Minor resources of peat are found in swampy lowlands within the study area, for the most part in the SW¼ sec. 32, T. 49 N., R. 35 W., and the NE¼ sec. 6, T. 48 N., R. 35 W. Because of the lack of local demand and distance to major markets, it is unlikely that the deposits will be commercially significant.

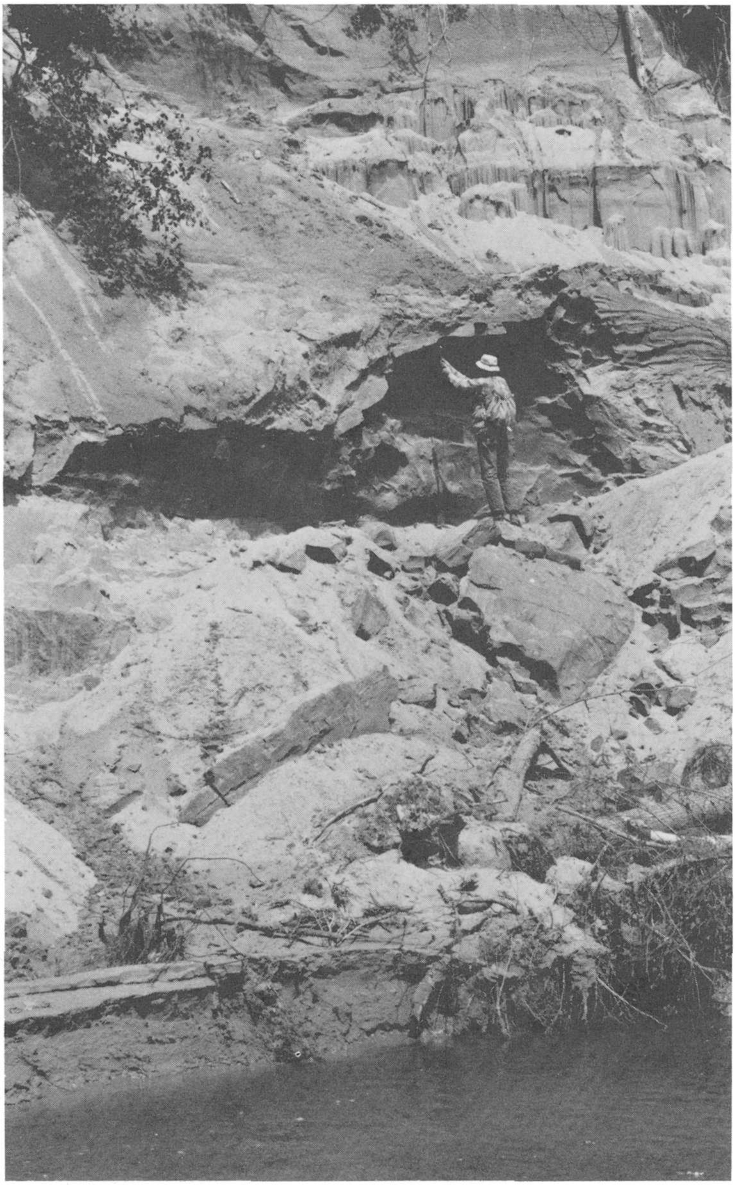


Figure 18.--Exposure of Pleistocene glacial deposits in a stream bank along Sidnaw Creek in southwestern part of study area. A clay bed (darker massive-appearing material near center) is overlain and underlain by stratified sand.

TABLE 3.—*Evaluation of glacial clay samples*

[All data presented here are based on laboratory tests that are preliminary in nature and will not suffice for plant or process design]

Sample Number	Sample interval (feet)	Raw properties[2]	Slow firing test: Temperature[3] (°F)	Munsell color	Moh's hardness	Total shrinkage (percent)	Absorption (percent)	Apparent porosity (percent)	Bulk density (g/cm)	Potential use
72	2.5	Water of plasticity: 20.8 percent	1800	5 YR 7/6	2	5.0	20.8	34.5	1.70	Grade MW building brick
		Working properties: short	1900	5 YR 7/6	2	5.0	20.4	34.2	1.67	
		Drying shrinkage: 5.0 percent	2000	2.5 YR 6/8	3	5.0	19.1	32.7	1.71	
		pH: 7.3	2100	2.5 YR 5/6	4	5.0	13.8	25.5	1.85	
		No effervescence with HCl	2200*	2.5 YR 3/2	7	12.5	1.9	4.1	2.14	
			2300	---	-	Melted	---	---	---	
74	6.0	Water of plasticity: 20.5 percent	1800	5 YR 8/2	3	5.0	19.4	33.6	1.73	Not suitable for use in vitreous clay products, too soft
		Working properties: plastic	1900	5 YR 8/2	3	5.0	19.2	33.5	1.74	
		Drying shrinkage: 5.0 percent	2000	7.5 YR 8/4	3	5.0	17.0	30.8	1.81	
		pH: 7.7	2100*	7.5 YR 6/4	8	10.0	3.3	7.5	2.25	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
75	4.0	Water of plasticity: 22.2 percent	1800	5 YR 8/4	2	5.0	20.9	35.1	1.68	Not suitable for use in vitreous clay products, too soft
		Working properties: plastic	1900	5 YR 8/4	2	5.0	20.7	34.9	1.69	
		Drying shrinkage: 2.5 percent	2000	2.5 YR 7/4	3	5.0	15.4	28.3	1.84	
		pH: 8.0	2100*	5 YR 4/2	6	12.5	0.9	2.2	2.30	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	

76	7.5	Water of plasticity: 21.0 percent	1800	5 YR 8/4	2	5.0	20.8	34.7	1.67	Not suitable for use in vitreous clay products, too soft
		Working properties: plastic	1900	5 YR 8/4	2	5.0	20.4	34.6	1.69	
		Drying shrinkage: 5.0 percent	2000	2.5 YR 7/4	3	5.0	18.0	31.7	1.78	
		pH: 7.8	2100*	5 YR 5/4	7	10.0	2.7	6.1	2.28	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
77	6.3	Water of plasticity: 20.4 percent	1800	2.5 YR 7/6	3	5.0	15.9	29.4	1.84	Not suitable for use in vitreous clay products, too soft
		Working properties: plastic	1900	2.5 YR 7/6	3	5.0	15.1	28.3	1.87	
		Drying shrinkage: 5.0 percent	2000	2.5 YR 6/6	3	5.0	11.9	23.5	1.97	
		pH: 8.1	2100*	2.5 YR 4/2	7	10.0	2.4	5.5	2.26	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
79	4.0	Water of plasticity: 17.2 percent	1800	2.5 YR 7/6	2	5.0	14.9	28.0	1.88	Not suitable for use in vitreous clay products
		Working properties: plastic	1900	2.5 YR 7/6	2	5.0	14.6	27.6	1.89	
		Drying shrinkage: 5.0 percent	2000	2.5 YR 6/8	3	5.0	12.5	24.6	1.97	
		pH: 8.2	2100*	5 YR 4/4	6	5.0	7.0	15.2	2.17	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	

[1] To convert sample interval to meters, multiply footage by 0.3048.
[2] Tests indicate the following for all samples: Drying defects - none; Dry strength - good; Bloating test - negative.
[3] Asterisk indicates abrupt vitrification prior to reaching temperature noted.

POTENTIAL FOR UNDISCOVERED MINERAL DEPOSITS

By W. F. Cannon, James J. Hill, and Peter C. Mory

The probability that undiscovered mineral deposits exist in the study area was evaluated in two ways: by geologic environment and by geochemical surveys. Ore deposits are commonly associated with a characteristic geologic environment. By comparing the geologic environments in the study area with those containing known mineral deposits elsewhere, it was possible to estimate what, if any, types of ore deposits could occur in the area. The potential for mineral deposits can sometimes be assessed more directly by geochemical surveys. Ore deposits, even though buried, commonly cause anomalous metal content in soil developed over them, in bedrock in a halo around them, or in sediments in streams flowing across the mineralized area.

On the basis of these methods of evaluation, the area has a low probability for undiscovered mineral deposits.

ASSESSMENT BY GEOLOGIC ENVIRONMENT

Mineral commodities that have been produced in major quantities in nearby areas include iron from middle Precambrian iron-formations, copper from middle Keweenawan basalt and interbedded sedimentary rocks and from upper Keweenawan shale, and lesser amounts of gold from gold-bearing quartz veins. Also, several small deposits of uranium-rich rocks have been found east of the area, and uranium exploration is currently very active in much of the Upper Peninsula.

MICHIGAMME FORMATION

If the Michigamme Formation in the study area is a graywacke-slate sequence, as inferred from aeromagnetic data, the potential for mineral deposits in it is very low. Such sequences, which accumulate rapidly in deep marine basins, are generally barren of metal concentrations. This is certainly true in the Upper Peninsula. The graywacke-slate sequence of the Michigamme is extensively exposed south and east of the study area and is virtually devoid of mineralization. The stratigraphically lower part of the Michigamme Formation, east of the study area, contains iron-formation from which iron was produced in the past. That iron-formation, along with surrounding pyritic black slate, is the site of considerable uranium exploration activity. If these units underlie the study area, they are probably so deep below the graywacke-slate sequence that exploration is not feasible. Outcrops of the Michigamme Formation nearest the study area have been field checked with a scintillometer and checked in the laboratory by a uranium scan. They are not anomalously uraniferous.

BASALT AND DIBASE DIKES

Basalt and diabase, in general, are not favorable host rocks for ore deposits, but the Keweenawan basalts of Michigan are an exception. Extensive deposits of native copper and associated silver have been mined from middle Keweenawan basalt and interbedded sedimentary rocks north and west of the study area. In spite of this, the basalt in the study area is not considered favorable for copper deposits. All economic copper deposits are in middle Keweenawan rocks, whereas the basalt in the study area is undoubtedly lower Keweenawan as indicated by magnetic studies. Important copper mineralization is unknown in lower Keweenawan basalt or related diabase.

JACOBSVILLE SANDSTONE

The Jacobsville Sandstone has been studied widely in the Upper Peninsula (for instance, Hamblin, 1958), and no mineralization has been reported. Its barren nature elsewhere indicates little likelihood that it would contain mineralization in the study area.

GLACIAL DEPOSITS

The only possible occurrence of metallic minerals in the glacial deposits is as heavy mineral placer concentrates. The stratified, probably fluvial, nature of much of the glacial material indicates that placer concentration is possible, but the geochemical data discussed next show no indication that such deposits exist in the wilderness study area.

Deposits of nonmetallic materials, such as clay, peat, and sand and gravel, are abundant and have not been thoroughly explored or measured in this study. The poor ceramic quality of the known clay beds suggests that undiscovered clay beds are likewise of poor quality. Peat is likely to occur in marshy areas, particulary in the southwest part of the study area. Most marshes, however, are small and far from potential markets, suggesting that no important undiscovered peat resources are in the area. The area contains vast quantities of sand and gravel, but the abundance of similar material throughout the region, much of it closer to points of use, negates any large economic potential for sand and gravel in the study area.

ASSESSMENT BY GEOCHEMICAL SURVEY

A geochemical survey of the study area used three sample media: bedrock, soil developed on glacial deposits, and stream sediments consisting of both pan concentrates and grab samples. None of these showed highly anomalous compositions, and no suggestion of buried ore deposits was found. A partial listing of analyses is in table 2.

SOIL SAMPLES

Soil samples were collected from 15 localities, mostly on uplands near the margin of the study area. All samples were taken from soils developed on thick glacial deposits where the soil profile consisted of 1-2 cm of organic material at the surface and 10-20 cm of light-gray sandy soil over reddish-brown sand. Most samples were taken from depths 30-40 cm below the surface.

Because of the porous nature of the glacial deposits and their great thickness, it is unlikely that a mineral deposit beneath the deposits or in the deposits themselves would be detected in the soil. Except in areas of clay beds, ground water percolates freely downward, and there is no mechanism by which metals in anomalous concentrations could diffuse upward to the soil zone. The soil samples were intended to provide background values against which stream sediment samples could be compared. The results of the analyses are shown in table 2. No anomalously high values were found.

STREAM SEDIMENTS

Eight grab samples of stream sediments and 11 heavy-mineral concentrates panned from the sediments were collected and analyzed. Sample sites were chosen along the Sturgeon River and on all major tributaries so that each individual drainage system was sampled. The stream sediments of tributaries are derived totally from glacial deposits, whereas those in the Sturgeon River, although derived principally from glacial deposits, also have a component introduced from upstream parts of the river outside of the study area. Any concentration of metals in the glacial deposits should cause higher concentrations in the stream sediments than were measured in soil from the adjacent uplands.

Certain elements, such as Cu, Hf, Pb, Zn, Zr, and Ti, showed predictably higher concentrations in heavy-mineral concentrates than in either grab samples of stream sediments or soil samples (see table 4). This reflects only that these elements are contained in heavy minerals. According to visual estimates, heavy minerals generally are less than 1 percent of the stream sediments. Comparison of analyses of pan concentrates with those of grab samples

TABLE 4.—*Comparison of analyses of some stream sediments and heavy-mineral pan concentrates*

[N.d., not detected]

Element	Range (ppm)	Median (ppm)
	Pan concentrates (11 samples)	
Cu	<1-30	14
Hf	<21-220	< 21
Pb	8.5-100	29
Zn	<15-270	110
Zr	136- >2,100	>2,100
TiO_2	13,000-87,000	37,000
	Stream sediments (8 samples)	
Cu	1.5-6.9	4
Hf	<21-<47	<21
Pb	1.5- 9.9	14
Zn	all <15	<15
Zr	120-480	210
TiO_2	5,000-13,000	8,000
	Soil (15 samples)	
Cu	3.2-13.1	5
Hf	N.d.	N.d.
Pb	4.8-15	10
Zn	<15-21	<15
Zr	81-634	230
TiO_2	4,400-10,000	7,000

collected at the same site shows no anomalous values in the sediments for those elements having very high values in the pan concentrates.

Thus, no evidence of metal concentrates that approach economic grade or size was found in the glacial deposits.

Two pan concentrates had slightly anomalous tin content (45 and 52 ppm). One of the samples (20) was collected from the point where the Sturgeon River enters the study area; thus, small amounts of tin are apparently being carried into the area from some point upstream. The other sample (49), collected from the Sturgeon River near the mouth of Funks Creek, also had slightly anomalous silver (1.5 ppm) and arsenic (210 ppm) values, for which there is no obvious source in the study area.

BEDROCK

Seven samples of basalt from the Siemens Creek Formation and 13 samples of the Jacobsville Sandstone were analyzed for anomalous metal content. In addition, two samples of lower Keweenawan diabase dikes and one sample of graywacke from the Michigamme Formation outside the study area were analyzed.

No unusual concentrations of metals were found in any samples except for the diabase dikes (80 and 81 in table 2), which contain 460 and 490 ppm copper. In outcrops, these rocks show no unusual concentrations of minerals that are likely to bear copper, and no explanation for the high copper content is apparent. Although these values are considerably higher than the typical copper content of diabase (150 ppm), they are not economic concentrations. Because no higher grade copper concentrations have been found here or in any other similar diabase throughout a large surrounding region, these values are probably not associated with economically important mineralization.

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