STUDIES RELATED TO WILDERNESS

MINERAL RESOURCES OF THE ROCK RIVER CANYON WILDERNESS STUDY AREA, ALGER COUNTY, MICHIGAN

GEOLOGICAL SURVEY BULLETIN 1549

Mineral Resources of the Rock River Canyon Wilderness Study Area, Alger County, Michigan

By JESSE W. WHITLOW *and* PHILIP J. GERACI, U.S. GEOLOGICAL SURVEY, *and* PETER C. MORY, U.S. BUREAU OF MINES

With a section on
GEOPHYSICAL-DATA INTERPRETATION

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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, and as specifically designated by PL 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 some national forest land in the Rock River Canyon study area, Michigan, that is being considered for wilderness designation (PL 93-622, January 3, 1975). The area studied is in the Hiawatha National Forest in Alger County in the Upper Peninsula of Michigan.

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MINERAL RESOURCES OF THE ROCK RIVER CANYON WILDERNESS STUDY AREA, ALGER COUNTY, MICHIGAN

By JESSE W. WHITLOW and PHILIP J. GERACI, U.S. Geological Survey, and PETER C. MORY, U.S. Bureau of Mines

SUMMARY

A mineral-resource evaluation of the Rock River Canyon Wilderness Study Area, Alger County, Mich., was completed in 1975 by personnel of the U.S. Geological Survey and the U.S. Bureau of Mines. The area consists of approximately 22 km² in the Hiawatha National Forest.

Rocks exposed in the area include sandstone, shaly sandstone, dolomitic sandstone, sandy dolomite, and a minor amount of conglomerate; these rocks range in age from Proterozoic Y to early Middle Ordovician. A minor amount of unconsolidated glacier-transported debris was deposited during Pleistocene time.

No deposits of either metallic or nonmetallic minerals were found. Although resources of stone, sand, and gravel exist in the study area, they are considered to have small economic potential; similar materials are readily available and easily accessible in the surrounding region.

INTRODUCTION

The U.S. Geological Survey and the U.S. Bureau of Mines completed geologic, mineral, and geochemical surveys of the Rock River Canyon Wilderness Study Area (fig. 1). This bulletin summarizes the results of the surveys and gives an evaluation of the economic potential of the minerals in the area.

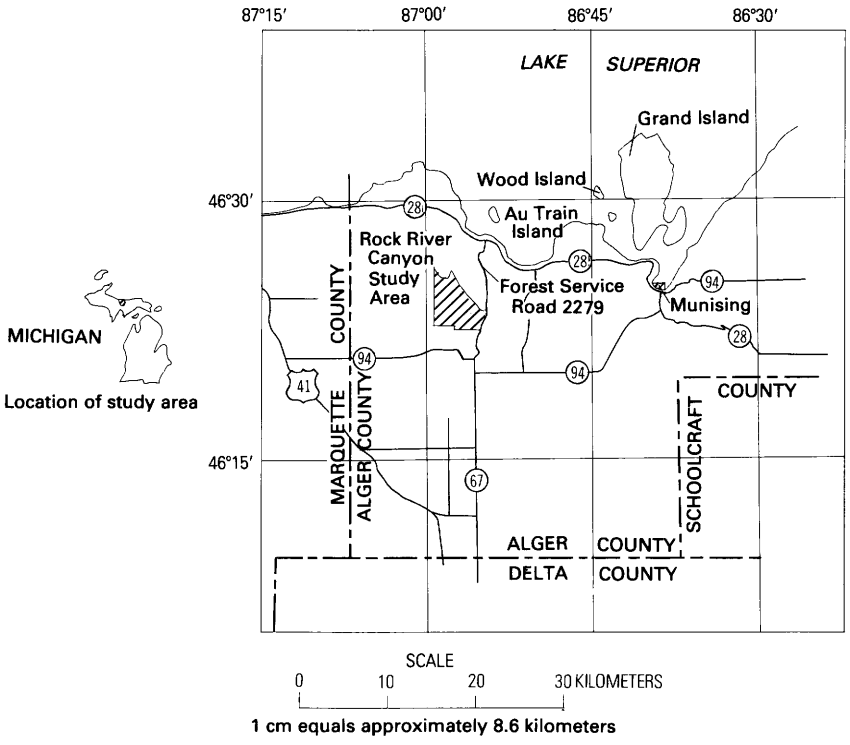


FIGURE 1.—Location of Rock River Canyon Wilderness Study Area.

LOCATION AND ACCESS

The study area consists of approximately 22 km² in the Hiawatha National Forest, Alger County, Mich., 19 km west of Munising (fig. 1). Secs. 6, 7, 8 and 16 and parts of secs. 4, 5, 9, 10, 15, 17, and 18, T. 46 N., R. 21 W., and parts of secs. 31 and 32, T. 47 N., R. 21 W., are within the study area. The area can be reached by traveling south from Michigan State Route 28 or north from Michigan State Route 94 along U.S. Forest Service Road 2279 (fig. 1). Foot trails and logging roads furnish access to the interior of the area.

CLIMATE AND VEGETATION

The cool temperate climate of the study area is reflected in the vegetation. All the native plants can withstand moderately cold weather and a short growing season, but agriculture is restricted to growing forage crops for livestock.

Forest composed of second growth maple, aspen, birch, fir, white pine, hemlock, white cedar, hornbeam, linden, and tulip poplar covers most of the study area; a few open fields are along the south and east sides.

PRESENT STUDY

J. W. Whitlow and P. J. Geraci did reconnaissance geologic mapping and collected geochemical samples. E. R. King made the geophysical interpretation from magnetic and gravity surveys that included the study area. P. C. Mory contacted representatives from industry and Federal and State agencies for information concerning the mineral potential of the area and searched records in the Alger County Courthouse and U.S. Forest Service files to determine ownership of surface and mineral rights and to find records of past prospecting and mining activities in the area. He also collected samples for analyses to aid this study.

PREVIOUS STUDIES

Studies of stratigraphy, structural geology, water resources, Pleistocene glaciation, geophysics, and mineral potential in the Upper Peninsula of Michigan that include the Rock River Wilderness Study Area are by Leverett, 1928; Bergquist, 1930 and 1937; Hamblin, 1958; Vanlier, 1963; Case and Gair, 1965; Gludenzopf, *in* Michigan Basin Geological Society, 1967, p. 58–64; Ostrom and Slaughter, *in* Michigan Basin Geological Society, 1967, p. 1–5; and Zietz and Kirby, 1971. However, no detailed geologic work has been done in the study area.

ACKNOWLEDGMENTS

Personnel of the Geological Survey Division, Michigan Department of Natural Resources, Lansing, Mich., provided geologic information on the region. U.S. Forest Service personnel provided trail maps, access information, and records of surface- and mineral-rights ownership. U.S. Bureau of Land Management personnel examined land-status records. Representatives from Cleveland-Cliffs Iron Company, Ishpeming, Mich., gave their opinions of the area's mineral potential. Local residents gave permission to cross and work on private property in and around the study area.

GEOMORPHOLOGY

The Rock River Canyon area is near the west side of the lake section of the central lowlands physiographic province of Lobeck (1957) and is

in the eastern lowlands of Hamblin (1958, p. 12). Glaciers that crossed the study area during the Pleistocene Epoch were responsible for the general form of the topography, but present relief and drainage are the result of later erosion. Relief in the area ranges from 207 m above sea level in NW¼ sec. 15, T. 46 N., R. 21 W., at the Rock River exit from the study area to 317 m above sea level on a high mound of bedrock and glacial debris in NW¼ sec. 5, T. 46 N., R. 21 W. Most of the upland has relatively low relief and gentle slopes. The small hills in sec. 5, T. 46 N., R. 21 W., range from bedrock with a thin cover of glacial debris to mounds of glacial debris.

The study area is in the late youth stage of the erosional cycle, as shown by the steep-walled narrow valleys, relatively level interfluves, and minor meanderings of the Rock River in its valley. Silver Creek is in the youthful stage of the erosional cycle for its length in the study area. Drainage in the surrounding area was disrupted by glaciation and has not been reestablished. Most of the upland topography is essentially as it was when the last glacier melted away.

GEOLOGY

The Rock River Canyon Wilderness Study Area is near the northwest edge of the Michigan basin (Martin, 1936; Vanlier, 1963; Kelley, 1968). Jacobsville Sandstone, Munising Formation, Au Train Formation (fig. 2), and minor unconsolidated glacial deposits form the exposures in the study area. The indurated rocks range from Proterozoic Y to early Middle Ordovician in age and consist of relatively soft friable sandstone that is locally silty and clayey, hard dolomitic sandstone, sandy dolomite, and minor conglomerate. Unconsolidated Pleistocene glacial debris overlies bedrock in most of the study area.

JACOBSVILLE SANDSTONE

The Jacobsville Sandstone, named by Lane and Seaman (1907, p. 691), is the oldest formation exposed in the area. Thwaites (1943, p. 501) considered its age to be likely Keweenawan. White, Cornwall, and Swanson (1953) considered it late Keweenawan or Early Cambrian. The Michigan Geological Survey (1964) lists it as Early and Middle Cambrian.

The Jacobsville is predominately a maroon sandstone, but some sections contain interlayered reddish and greenish beds. Less than 15 m of the upper part of the formation form the bedrock along 4 km of Rock River from the west edge of the study area to near Ginpole Lake (fig. 2). The best exposure is a 6-m section at Rock River Falls in SE¼ sec. 6, T. 46 N., R. 21 W. (fig. 3). Other erosional pavement type exposures are along the northeast side of the river.

The contact of the Jacobsville Sandstone with the Munising Formation is not exposed in the study area. Exposures on the east side of

Grand Island 29 km N. 65° E. of Rock River Falls show that the Jacobsville Sandstone is overlain unconformably by the Munising Formation; the contact is probably an unconformity in the study area.

MUNISING FORMATION

A series of conglomerate, conglomeratic sandstone, and sandstone is poorly exposed above the Jacobsville Sandstone in the study area. These rocks are the Munising Formation, which was named the Munising Sandstone by Lane and Seaman (1907, p. 692) for exposures near Munising, Mich., 25 km east of Rock River Falls. Hamblin (1958, p. 71) described three distinct members of the formation: a basal unnamed conglomerate member, a middle Chapel Rock Member, and an upper Miners Castle Member.

UNNAMED CONGLOMERATE MEMBER

According to Hamblin (1958, p. 73–76), the unnamed conglomerate member of the Munising Formation ranges in thickness from 0.6 to 4.5 m and is composed of well-rounded pebbles, cobbles, and boulders of vein quartz, quartzite, and chert. A stream-bank exposure of conglomerate 2.2 m high near the middle of S½ N½ SE¼ sec. 8, T. 46 N., R. 21 W., contains diabase, aphanitic volcanic rock, and rhyolite fragments but otherwise resembles Hamblin's description. At all other places in the study area, the basal part of the Munising Formation is covered by colluvial debris. The relation of the unnamed conglomerate member to the overlying Chapel Rock Member cannot be determined in the study area. Exposures on the east side of Grand Island 30 km N. 70° E. of Rock River Falls show the unnamed conglomerate member conformably overlain by the Chapel Rock Member; probably the two members are conformable in the study area.

CHAPEL ROCK MEMBER

Hamblin (1958, p. 71) named the Chapel Rock Member of the Munising Formation for exposures at Chapel Rock on the south shore of Lake Superior east of Munising, Mich. The member is very light gray to yellowish light gray, moderately well sorted quartz sandstone containing well-rounded sand grains. It ranges in thickness from 12 to 18 m in most of Alger County. In the study area, the only good exposure of the Chapel Rock is in a channel, 1.5 m deep, cut by the Rock River east of Ginpole Lake. A bed of sandstone 1 m thick in the channel bank contains quartz pebbles. Elsewhere in the study area, the formation is so poorly exposed that nothing is known of bedding, minor structures, or the contact with the overlying member. Along the south shore of Lake Superior east of Munising, however, the Chapel Rock Member appears to be overlain conformably by the Miners Castle Member.

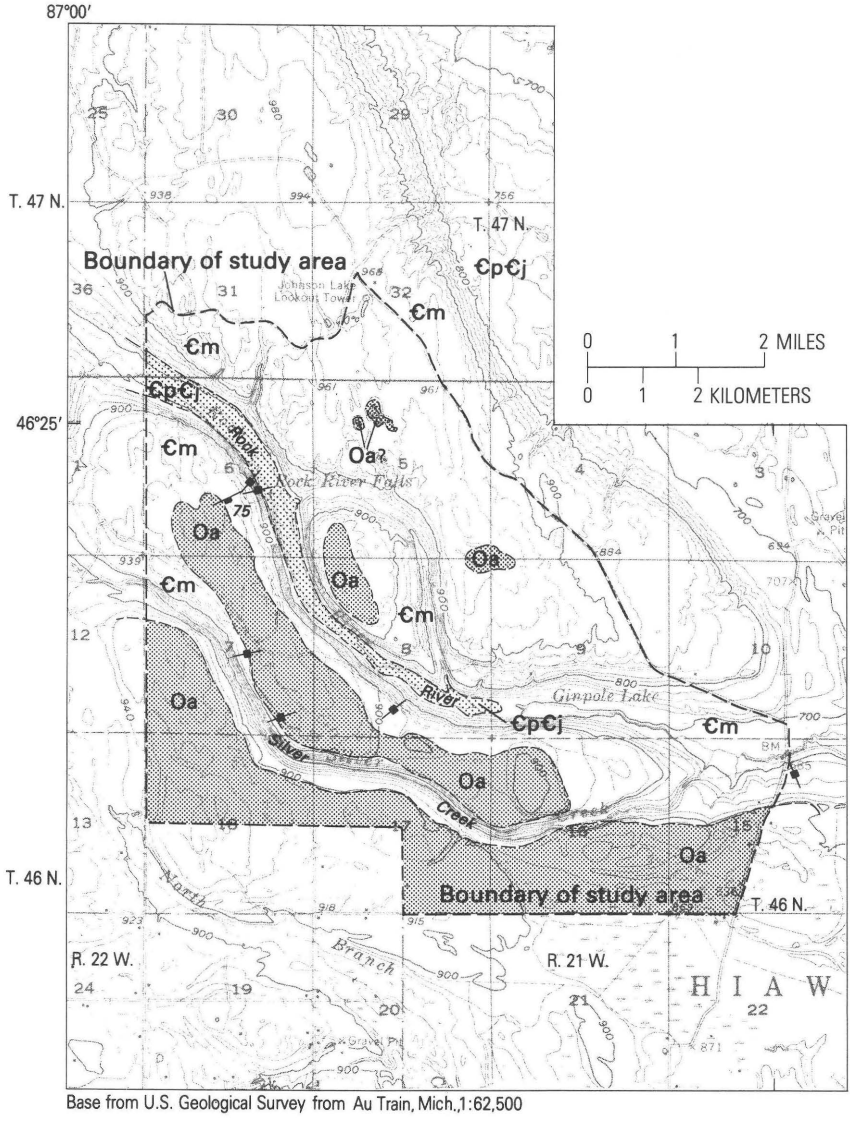


FIGURE 2.—Geology of the Rock River Canyon Wilderness Study Area.

MINERS CASTLE MEMBER

Hamblin (1958, p. 71–95) gave the name Miners Castle Member to the upper approximately 43 m of the Munising Formation exposed at Miner's Castle on the south shore of Lake Superior east of Munising. The lower part of the member is a very light gray to yellowish-gray, poorly sorted sandstone that contains bluish to greenish light-gray silty to clayey lenses and partings and locally quartz-pebble conglomeratic lenses as much as 1.5 m thick. The silty to clayey lenses and partings are abundant in the lower part of the member and decrease in

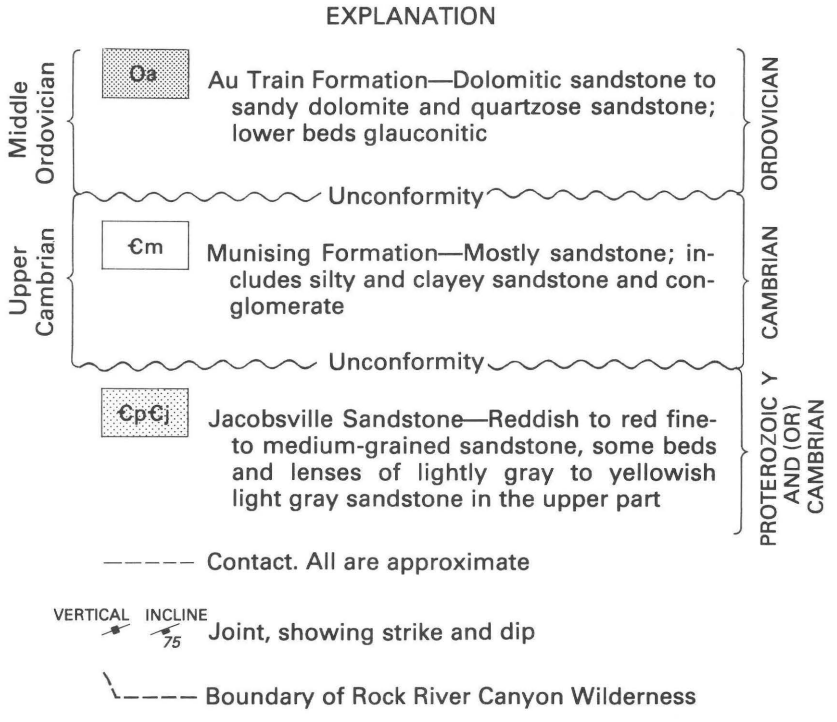


FIGURE 2.—Continued.

number upwards. They commonly form wet mucky slopes that are densely overgrown.

The upper 15 m of the Miners Castle Member is a relatively clean sandstone. Most of the sand grains are rounded and have a high degree of sphericity. The rock ranges from a relatively soft friable sandstone containing little cement to a relatively hard rock that has a silica and, locally, dolomite cement. Caves and reentrants (fig. 4) are formed in the soft beds because of their poor resistance to erosion; the hard beds form ledges. Locally, beds up to 30 cm thick contain considerable iron stain from the breakdown of iron sulfides in the rock; however, most of the section is relatively free of iron stain. The upper part of this member forms the nearly vertical outcrops at and near the top of the valley walls of Rock River and Silver Creek.

A bed of relatively soft sandstone above most of the silty and clayey lenses and partings contain J- and U-shaped markings in a stratigraphic horizon approximately 0.5 m thick. The markings are probably sand-filled worm tubes; no other recognizable fossil-related markings were found.

According to Hamblin (1958, p. 141), no rock of late Late Cambrian or of Early Ordovician age has been recognized in northern Michigan. An unconformity, therefore, separates the Miners Castle Member of

FIGURE 3.—Jacobsville Sandstone at Rock River Falls.

the Munising Formation of early Late Cambrian age from the overlying Au Train Formation, now considered to be of Early and Middle Ordovician age. The lithologic change from the Miners Castle Member to the overlying Au Train Formation described by Hamblin (1958, p. 114) was not found in the study area, and, because of poor exposures, the relation of the two formations cannot be determined. The actual relation of the two formations is probably a disconformity.

AU TRAIN FORMATION

The type locality of the Au Train Formation is the Au Train Falls outcrop, which is approximately 7 km southeast of the southeast corner of the study area. Grabau (1906, p. 583) suggested the name "Aux Trains" for the sequence of rock of early Middle Ordovician age at this outcrop, and Hamblin (1958, p. 115) named the sequence the Au Train Formation, now considered to be of Early and Middle Ordovician age. It is the youngest formation in the study area, and only part of the lower half is present. Total thickness of the unit in the area is unknown because it is mostly overlain by glacial debris.

The Au Train Formation in the study area is composed of thin- to medium-bedded dolomitic sandstone and sandy dolomite that contains

FIGURE 4.—Miners Castle Member of the Munising Formation along Silver Creek.

from a trace to 1 percent or more of glauconite. Bergquist (1930, p. 233) reported that, in the lower part of the formation, as much as 35 percent of the rock is glauconite in samples from outside the study area. The authors considered the lowest glauconitic bed as the base of the forma-

tion because of difficulty in locating a definite contact with the Munising Formation in the map area.

PLEISTOCENE DEPOSITS

Glacial debris of Pleistocene age consisting of sand, silt, gravel, and minor clay overlies most of the bedrock in the study area; its maximum thickness is believed to be less than 30 m. Postglacial erosion has removed an indeterminable amount of this unconsolidated material. Most of the debris originated less than 3 km from its present location although glacial erratics of crystalline rock have been transported many tens of kilometers from the north. The largest erratic of crystalline rock found during this study is 1.5 to 2 m long; a few other erratics are as much as 70 cm long. A few small Holocene alluvial deposits are present along Rock River and Silver Creek.

STRUCTURE

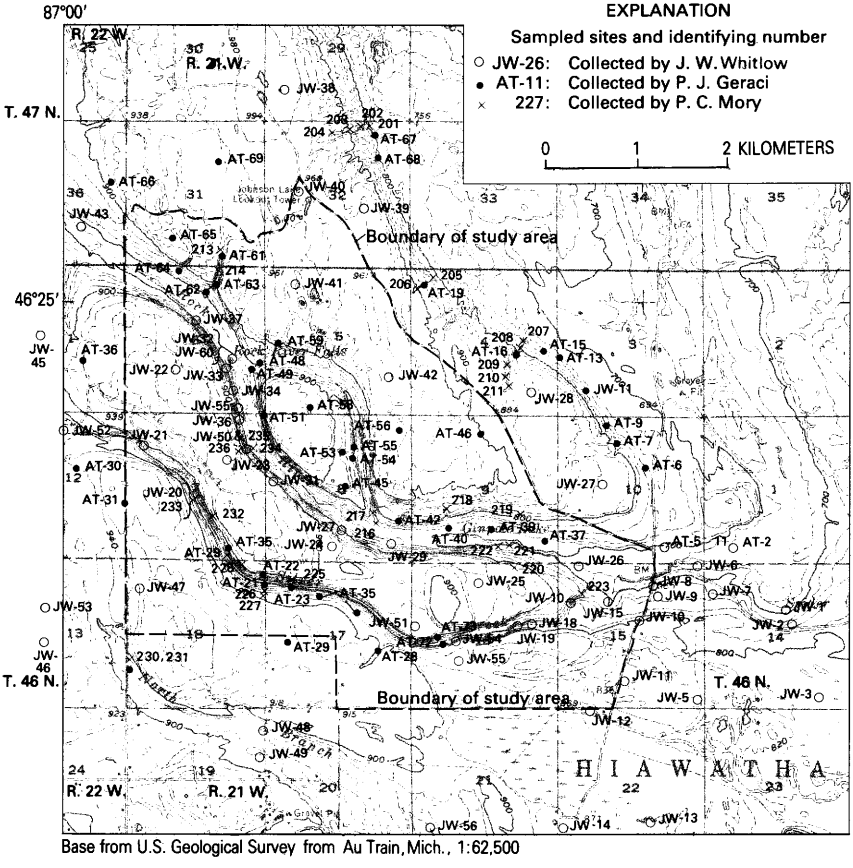
Strata in the study area are nearly flat lying. The Jacobsville Sandstone at Grand Island dips northward 4° to 6° and probably also dips northward here; the beds exposed at Rock River Falls are so nearly level that only joint attitudes were recorded. The younger strata are essentially horizontal but do have a regional dip of 4 to 10 m/km (0.23°–0.57°) to the southeast (Hamblin, 1958, p. 60, 121; Vanlier, 1963, p. 28). This is approximately parallel to the S. 40° E. dip of approximately 7 m/km (0.4°) of the pre-Munising surface shown by Hamblin (1958, p. 66, fig. 35). No faults were seen, and none are mentioned in the literature.

GEOCHEMICAL SURVEY

The geochemical survey consisted of collecting samples for analysis to determine the concentration and distribution of elements that might indicate the mineral resource potential of the study area. Whitlow and Geraci collected 46 stream sediment, 42 forest litter, 41 soil, and 33 rock samples; Mory collected 36 rock samples. Sample localities are shown on figure 5.

All Geological Survey samples were analyzed in the Geological Survey laboratories, Reston, Va., by computerized semiquantitative emission spectrographic methods for 64 elements; the soil samples also were analyzed by atomic absorption methods for zinc. The results are given in table 1 and summarized in tables 2 to 4. The forest litter samples were ashed before analysis, and the percent ash for each sample is reported (table 1).

In addition, all Geological Survey samples were analyzed for gold by combined fire assay—atomic absorption methods by Esma Y. Campbell and Roosevelt Moore in the Geological Survey laboratories, Reston, Va.—but no gold was detected at a detection limit of 0.05 parts per million.



Base from U.S. Geological Survey from Au Train, Mich., 1:62,500

FIGURE 5.—Sample sites in the Rock River Canyon Wilderness Study Area and vicinity, Alger County, Mich.

Samples collected by Mory were analyzed in the Bureau of Mines, Reno Metallurgy Research Center, Reno, Nev., and the results are given in tables 5 and 6.

The analytical results do not suggest the presence of any potential mineral resources. Median values for all elements in the rock samples (table 2) are near the average for sandstone, and the high values are well within the normal range of values found in unmineralized rock. The copper content of six forest litter samples (JW-1, 51, and 55; At-1, 45, and 58), when corrected for percent ash, are a little higher than average (table 1), but other samples nearby have normal copper contents. The one anomalous soil sample (JW-55A, taken from beneath forest litter sample JW-55) also contains greater amounts of Fe, Be, Ce, Co, Er, La, Mn, Mo, Ni, Pb, V, and Y than do the rest of the soil samples. The soils are derived mostly from glacial debris, and the significance of variations in contained elements is unknown.

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*

[Sample localities given in figure 5. X and Y coordinates are Universal Transverse Mercator grid, zone 16. Computerized semiquantitative emission spectrographic analyses (S) on forest litter, stream sediment, and rock samples by Leung Mei; on soil samples by J. L. Harris. Atomic-absorption analyses (AA) for zinc in soil samples by Frederick O. Simon and Angelina C. Vlisidis. Results of the semiquantitative spectrographic analyses are reported to the nearest number in the series 1, 1.5, 2, 3, 5, 7, and 10 that represents approximate midpoints of group data in a geometric scale. Approximately 50 percent of the assigned groups include the quantitative value. The standard deviation of any single value should be taken as plus 50 percent and minus 30 percent. The data should not be quoted without stating these limitations. Letter symbols: L, below the limit of detection; B, not looked for; G, greater than upper limit of determination; P, partial solution. All data in parts per million except where indicated in percent. Elements looked for spectrographically and not found, except where noted, and their lower limit of detection: As (100), except soil sample AT-5 (100), stream sediment sample AT-19 (100); Au (10); Bi (4.6), except forest litter sample AT-55A (7); Dy (6.8), except soil sample JW-55A (70), forest litter samples JW-44 (20), JW-57 (10), AT-66 (15); Gd (6.8), except forest litter samples JW-1, 27, and 37A (15 each), JW-44 (20), AT-1 (15), AT-69 (20), rock sample AT-60A (7); Ge (3.2), except forest litter samples JW-41 and 44 (5 each), JW-49 (3), AT-1 (3), AT-69 (7); Hf (20), except soil sample JW-46A (20); Ho (3.2), except forest litter sample JW-1 (5); In (4.6); Ir (6.8); Nd (50), except forest litter samples JW-1 and 44 (150 each), JW-37A (100), AT-1 (150), stream sediment sample JW-9 (100), rock samples JW-51B (70), AT-60C (50); Os (6.8); Pd (1); Pr (10); Pt (6.8), except soil sample AT-56A (10), forest litter sample JW-12 (7); Re (10); Rh (0.63); Ru (3.2); Sb (63); Sn (6.8), except forest litter samples JW-38 (20), JW-55 (30), AT-66 (15), AT-69 (20), stream sediment samples JW-48 (30), JW-52 (10); Ta (460); Tb (14); Te (460); Tl (4.6), except forest litter sample AT-55 (7); Tm (3.2), except soil samples AT-58A and 69A (3 each); U (147); and W (10)]

Rock samples, (33)

SAMPLE	X-COORD.	Y-COORD.	S-FE%	S-MG%	S-CA%	S-TI%	S-SI%	S-AL%	S-NA%	S-K%
75JW8	137025	506550	0.50	0.30	0.30	0.15	30	3.0	0.020	3.00
75JW10	136640	506375	1.00	10.00	10.00	0.03	10	1.0	0.015	1.00
75JW18	136580	505175	0.15	0.05	0.05	0.02	30	0.3	0.007L	0.10
75JW18A	136580	505175	0.10	0.15	0.20	0.02	30	0.2	0.007L	0.15
75JW20	138000	501500	0.15	0.05	0.30	0.03	30	0.7	0.007L	0.50
75JW20A	138000	501500	0.10	0.05	0.20	0.02	30	0.2	0.007L	0.07
75JW32	139500	501840	0.70	0.20	0.15	0.30	30	3.0	0.030	2.00
75JW50	138550	502000	0.50	0.15	1.50	0.10	30	2.0	0.007	2.00
75JW50A	138550	502000	0.10	0.05	0.50	0.05	30	1.0	0.007	1.50
75JW50B	138550	502000	0.15	0.05	0.15	0.02	30	0.3	0.007L	0.30
75JW51B	136620	503900	0.70	7.00	7.00	0.01	15	0.3	0.007L	0.30
75JW54	136440	504350	0.15	0.05	0.10	0.03	30	0.5	0.007L	0.30
75JW54A	136440	504350	0.15	0.30	1.00	0.02	30	0.3	0.007L	0.15
75JW53	136850	499860	0.50	5.00	7.00	0.10	10	2.0	0.020	3.00
75AT3	137550	507275	1.50	0.50	0.15	0.20	30	5.0	0.050	5.00
75AT16	139625	505025	0.70	0.30	0.20	0.20	30	5.0	0.020	3.00
75AT22	137160	502235	0.07	0.03	0.20	0.05	30	0.7	0.007L	0.50
75AT26	136765	503250	0.07	0.10	0.20	0.02	30	0.2	0.007L	0.10
75AT28	136500	503570	1.50	7.00	7.00	0.10	10	2.0	0.020	3.00
75AT35	137400	501860	0.10	0.05	0.15	0.02	30	0.7	0.007L	0.70
75AT42	137750	503740	0.30	0.20	0.70	0.07	30 G	2.0	0.020	1.50
75AT48	139510	502215	0.20	0.07	0.05	0.05	30	1.0	0.007L	0.20
75AT51	138925	502225	0.15	0.20	0.30	0.03	30	0.7	0.007L	0.30
75AT53	138500	503125	0.30	0.05	0.05	0.10	30	1.5	0.015	2.00
75AT60	139500	502840	0.20	0.10	0.07	0.10	30	2.0	0.050	2.00

75AT60A	139500	502840	1.00	0.20	0.10	0.15	30	5.0	0.070	3.00
75AT60C	139500	502840	0.15	0.10	0.15	0.07	30	2.0	0.050	2.00
75AT60E	139500	502840	1.00	0.50	0.15	0.30	30	5.0	0.050	3.00
75AT61	140660	501740	0.70	0.15	0.10	0.20	30	3.0	0.020	3.00
75AT63	140310	501650	0.30	0.07	0.02	0.37	30	1.0	0.007L	0.20
75AT68A	141700	503450	0.30	0.05	0.05	0.10	30	1.5	0.007L	0.20
75JW50C	138550	501840	0.15	0.05	0.07	0.02	30 G	0.2	0.007L	0.15
75JW52	134400	504100	2.00	1.00	2.00	0.20	30	3.0	0.300	1.50

SAMPLE	S-P%	S-AG	S-B	S-BA	S-BE	S-CD	S-CE	S-CO	S-CR	S-CU
75JW8	0.07	0.10L	100	300	1.0	30 L	30	5	50	20
75JW10	0.15	0.10L	30	100	1.0	30 L	100 L	7	20	10
75JW18	0.07L	0.10	3 L	20	0.7L	30 L	30 L	2	7	3
75JW18A	0.07	0.20	5	50	0.7L	30 L	30 L	1 L	5	5
75JW20	0.07L	0.10	3	70	0.7L	30 L	50	2	15	10
75JW20A	0.07	0.10L	3 L	30	0.7L	30 L	30	1 L	10	7
75JW32	0.07L	0.10L	70	500	1.5	30 L	70	3	20	7
75JW50	0.10	0.10L	50	200	0.7L	30 L	70	7	20	30
75JW50A	0.10	0.10	20	200	0.7L	30 L	30 L	2	15	10
75JW50B	0.07L	0.10L	3 L	70	0.7L	30 L	30 L	2	10	7
75JW51B	0.07L	0.10L	7	50	0.7	30 L	100 L	5	10	7
75JW54	0.07	0.10L	3 L	70	0.7L	30 L	30 L	2	10	3
75JW54A	0.07L	0.15	3 L	50	0.7L	30 L	30	1 L	7	7
75JW53	0.10	0.10L	30	300	0.7L	30 L	100 L	3	30	7
75AT3	0.10	0.10L	100	500	1.5	30 L	70	3	15	10
75AT16	0.07	0.10L	100	500	1.0	30 L	50	5	30	15
75AT22	0.07L	0.15	3	70	0.7L	30 L	30	2	10	3
75AT26	0.07L	0.10L	3	20	0.7L	30 L	30 L	2	7	5
75AT28	0.10	0.10L	50	200	0.7L	30 L	100 L	7	20	10
75AT35	0.07L	0.30	10	70	0.7L	30 L	30 L	3	10	10
75AT42	0.10	0.10L	70	200	0.7L	30 L	30	7	15	15
75AT48	0.07L	0.10L	30	30	0.7L	30 L	70	2	15	3
75AT51	0.07	0.15	3 L	70	0.7L	30 L	30 L	2	10	7
75AT53	0.07	0.20	15	200	0.7L	30 L	70	3	20	20
75AT60	0.07L	0.10L	30	500	0.7L	30 L	70	2	5	5
75AT60A	0.07L	0.10	70	700	0.7	30 L	30	3	5	3
75AT60C	0.07L	0.10	50	500	0.7L	30 L	100	2	7	7
75AT60E	0.07L	0.10	70	500	1.5	30 L	100	3	15	10
75AT61	0.07	0.20	30	300	0.7L	30 L	50	10	30	50
75AT63	0.07L	0.10	30	20	0.7L	30 L	30	2	3	5
75AT68A	0.07L	0.15	30	30	1.0	30 L	30	3	7	5
75JW50C	0.07L	0.20	5	30	0.7L	30 L	30 L	3	5	15
75JW52	0.10	0.10L	20	300	0.7	30 L	70	10	20	20

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	S-ER	S-EU	S-GA	S-LA	S-LU	S-MN	S-MO	S-NB	S-NI	S-PB
75JW8	10 L	1.5L	7	20	20 L	100	2 L	5	20	10
75JW10	10 L	1.5L	2	15	20 L	1500	3	3 L	30	10
75JW18	10 L	1.5L	2 L	10 L	20 L	70	2 L	3 L	5 L	10 L
75JW18A	10 L	1.5L	2 L	10 L	20 L	100	2 L	3 L	5 L	10 L
75JW20	10 L	1.5L	2 L	10 L	20 L	30	2 L	3 L	7	10 L
75JW20A	10 L	1.5L	2 L	10	20 L	30	2 L	3 L	7	10 L
75JW32	10 L	1.5L	5	30	20 L	200	2 L	7	15	10
75JW50	10 L	1.5L	5	15	20 L	500	2 L	5	15	15
75JW50A	10 L	1.5L	2 L	15	20 L	50	2 L	3 L	5	10 L
75JW50B	10 L	1.5L	2 L	10 L	20 L	30	2 L	3 L	5 L	10 L
75JW51B	10 L	1.5L	2 L	10 L	20 L	1500	2 L	3 L	10	10 L
75JW54	10 L	1.5L	2 L	10 L	20 L	50	2 L	3 L	5 L	10 L
75JW54A	10 L	1.5L	2 L	15	20 L	100	2 L	3 L	5 L	10 L
75JW53	10 L	2.0	5	20	20 L	700	2 L	3 L	10	10 L
75AT3	10 L	1.5L	10	20	20 L	300	2 L	3	10	10
75AT16	10 L	1.5L	7	20	20 L	70	2 L	7	15	10
75AT22	10 L	1.5L	2 L	10 L	20 L	30	2 L	3 L	7	10 L
75AT26	10 L	1.5L	2 L	10 L	20 L	50	2 L	3 L	5 L	10 L
75AT28	10 L	1.5L	3	15	20 L	1500	2	3 L	15	20
75AT35	10 L	1.5L	2 L	10 L	20 L	30	2 L	3 L	5 L	10 L
75AT42	10 L	1.5L	3	15	20 L	200	2 L	3 L	10	10 L
75AT48	10 L	1.5L	2 L	30	20 L	150	2	3 L	10	10 L
75AT51	10 L	1.5L	2 L	10 L	20 L	50	2 L	3 L	5 L	10 L
75AT53	10 L	1.5L	3	20	20 L	30	2 L	3 L	5 L	15
75AT60	10 L	1.5L	5	20	20 L	70	2 L	3	5 L	10 L
75AT60A	10 L	1.5L	7	20	20 L	150	2 L	7	5 L	15
75AT60C	10 L	2.0	3	30	20 L	100	2 L	3	7	10 L
75AT60E	10 L	1.5	10	30	20 L	150	2 L	10	10	15
75AT61	10 L	1.5L	7	20	20 L	200	2 L	3	15	20
75AT63	10 L	1.5L	2 L	15	20 L	50	2 L	3 L	5 L	10 L
75AT68A	10 L	1.5L	2	10 L	20 L	300	2 L	10	5 L	10 L
75JW50C	10 L	1.5L	2 L	10	20 L	50	2 L	3 L	5 L	10 L
75JW52	10 L	1.5L	5	20	20 L	1000	2 L	7	15	30

SAMPLE	S-SC	S-SM	S-SR	S-TH	S-V	S-Y	S-YB	S-ZN	S-ZR
75JW8	7.0	50 L	50	20 L	30	10	1.00	20 L	200
75JW10	5.0	50 L	70	20 L	15	10	1.00	20 L	70
75JW18	2.0	50 L	15	20	5	3	0.20	20 L	100
75JW18A	1.5	50 L	30	20 L	5	3	0.20	20 L	100
75JW20	3.0	50 L	50	20 L	7	7	0.30	50	200
75JW20A	2.0	50 L	30	20 L	5	3	0.20	20 L	50
75JW32	5.0	50 L	30	20 L	20	20	2.00	20 L	300
75JW50	5.0	50 L	50	20 L	20	7	0.70	20 L	150
75JW50A	3.0	50 L	50	20 L	15	7	0.50	20 L	300
75JW50B	2.0	50 L	20	30	5	3	0.20	20 L	300
75JW51B	1.0L	50 L	30	20 L	15	7	0.50	20 L	30
75JW54	2.0	50 L	20	30	7	5	0.20	20 L	100
75JW54A	2.0	50 L	20	20 L	7	5	0.20	20 L	100
75JW53	7.0	50 L	70	20 L	30	10	0.70	20 L	200
75AT3	5.0	50 L	50	20 L	20	20	3.00	20 L	150
75AT16	10.0	50 L	70	20 L	30	15	1.50	20 L	300
75AT22	2.0	50 L	20	20 L	10	5	0.20	20 L	150
75AT26	1.0	50 L	15	20 L	5	2	0.15	20 L	50
75AT28	7.0	50 L	70	20 L	20	15	1.00	20 L	300
75AT35	1.0	50 L	30	20 L	7	3	0.20	20 L	100
75AT42	5.0	50 L	50	20 L	20	7	0.70	20 L	150
75AT48	1.5	50 L	15	30	10	10	1.00	20 L	500
75AT51	2.0	50 L	20	20 L	7	5	0.50	20 L	300
75AT53	5.0	50 L	50	20	20	7	0.50	20 L	300
75AT60	2.0	50 L	30	20 L	15	20	2.00	20 L	150
75AT60A	3.0	50 L	50	20 L	15	30	3.00	20 L	200
75AT60C	2.0	50 L	30	20 L	7	10	1.00	20 L	150
75AT60E	7.0	50 L	50	20 L	20	30	3.00	20 L	300
75AT61	7.0	50 L	70	20 L	30	10	1.00	20 L	200
75AT63	2.0	50 L	20	20 L	7	10	1.00	20 L	500
75AT68A	2.0	50 L	20	20 L	10	15	2.00	20 L	500
75JW50C	1.5	50 L	15	20 L	5	3	0.30	20 L	50
75JW52	7.0	50 L	100	20 L	70	20	2.00	30	150

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

Soil samples, (41)

SAMPLE	X-COORD.	Y-COORD.	S-FE%	S-MG%	S-CA%	S-TI%	S-SI%	S-AL%	S-NA%	S-K%
75JW2A	136580	508100	0.7	0.07	0.10	0.30	30 G	3	0.20	3.0
75JW3A	135580	508375	1.0	0.10	0.10	0.20	30 G	5	0.15	3.0
75JW5A	135750	507050	1.5	0.15	0.20	0.50	30 G	5	0.30	5.0
75JW12A	135650	505850	1.5	0.15	0.50	0.30	30 G	5	0.30G	3.0
75JW13B	134450	506480	1.5	0.30	0.70	0.30	30 G	7	0.30G	5.0
75JW14	134400	505550	1.5	0.20	0.50	0.30	30 G	5	0.30G	3.0
75JW22A	139400	501225	1.5	0.15	0.50	0.30	30 G	5	0.30G	3.0
75JW23A	138400	501825	1.5	0.15	0.50	0.30	30 G	5	0.30G	3.0
75JW24A	137475	503000	2.0	0.20	0.50	0.30	30 G	7	0.30G	5.0
75JW25A	137100	504625	2.0	0.30	1.00	0.30	30	7	0.30G	1.5G
75JW27A	138150	505975	1.0	0.10	0.20	0.20	30 G	5	0.30G	3.0
75JW28A	139150	505225	1.5	0.15	0.20	0.30	30 G	5	0.30G	3.0
75JW37B	139940	501480	1.5	0.20	0.15	0.20	30 G	7	0.10	5.0
75JW38A	142380	502500	1.0	0.20	0.30	0.50	30 G	5	0.30G	3.0
75JW39A	141160	503325	2.0	0.15	0.20	0.50	30 G	5	0.30G	3.0
75JW40A	141300	502600	0.7	0.20	0.20	0.30	30 G	7	0.30G	3.0
75JW41A	140340	502580	1.0	0.15	0.30	0.70	30 G	5	0.30G	3.0
75JW42A	139500	503540	1.5	0.15	0.70	0.30	30 G	5	0.30G	3.0
75JW44A	140525	499200	0.7	0.20	0.05	0.20	30 G	5	0.10	5.0
75JW46A	136400	499850	1.0	0.10	0.15	0.20	30 G	5	0.20	3.0
75JW47A	136950	500880	2.0	0.20	0.30	0.50	30 G	7	0.30G	5.0
75JW49A	135090	502200	0.7	0.20	0.50	0.30	30 G	7	0.20	7.0
75JW51A	136620	503900	2.0	0.50	1.50	0.30	30 G	7	0.30G	3.0
75JW55A	136340	504400	15.0	0.50	1.00	0.20	20	7	0.10	0.7G
75JW56A	134400	504100	0.7	0.20	0.50	0.20	30 G	7	0.30G	2.0
75AT2	137450	507400	0.7	0.20	0.50	0.20	30 G	7	0.30G	5.0
75AT5	137450	506660	1.0	0.20	0.70	0.15	30 G	5	0.30G	2.0
75AT25C	136810	502925	2.0	0.15	0.50	0.15	15	2	0.20	1.0
75AT29A	136460	502470	1.5	0.20	0.70	0.50	30 G	7	0.30G	5.0
75AT30A	138260	500150	3.0	0.20	0.70	0.30	30 G	5	0.30G	1.5G
75AT31A	137950	500675	1.0	0.10	0.15	0.50	30 G	5	0.30	3.0
75AT36A	139500	500215	0.7	0.15	0.20	0.15	20	3	0.20	1.5G
75AT45A	138150	503125	1.0	0.10	0.30	0.50	30 G	5	0.30G	2.0
75AT46A	138700	504600	1.5	0.15	0.30	0.30	30 G	7	0.30G	3.0
75AT55B	138540	503275	1.5	0.30	0.50	0.30	30 G	7	0.20	5.0
75AT56A	138775	503700	5.0	0.30	1.00	0.50	50	10	0.20	7.0
75AT58A	139000	502750	1.0	0.05	0.15	0.30	30 G	3	0.30G	2.0
75AT65A	140825	501200	1.5	0.20	0.20	0.30	30 G	5	0.30G	3.0
75AT66A	141450	500525	1.0	0.20	0.30	0.15	30 G	5	0.20	3.0
75AT69A	141730	501725	0.7	0.30	0.30	0.50	30 G	7	0.30G	3.0
75AT70A	141300	498925	2.0	0.30	0.50	0.70	30 G	7	0.30G	3.0

SAMPLE	S-P%	S-AG	S-B	S-BA	S-BE	S-CD	S-CE	S-CO	S-CR	S-CU
75JW2A	0.07L	0.5L	50	700	1.0L	30 L	50 L	1.5	10	2.0
75JW3A	0.07	0.5L	30	700	1.0L	30 L	50 L	2.0	15	2.0
75JW5A	0.10	0.5L	50	1000	1.0L	30 L	50 L	2.0	20	5.0
75JW12A	0.07L	0.5L	50	1000	1.0L	30 L	50 L	1.0L	20	1.5
75JW13B	0.10	0.5L	30	1000	1.0	30 L	70	1.5	30	1.0L
75JW14	0.10	0.5L	50	1000	1.0L	30 L	50	2.0	20	2.0
75JW22A	0.10	0.5L	50	1000	1.0L	30 L	50 L	1.0L	20	1.0L
75JW23A	0.07	0.5L	70	700	1.0L	30 L	50 L	3.0	30	2.0
75JW24A	0.10	0.5L	70	1000	1.5	30 L	50 L	5.0	30	7.0
75JW25A	0.10	0.5L	50	700	1.5	30 L	70	7.0	30	20.0
75JW27A	0.07	0.5L	30	700	1.0L	30 L	50 L	1.0L	20	1.0L
75JW28A	0.10	0.5L	70	700	1.0L	30 L	50 L	1.0L	20	1.0L
75JW37B	0.07	0.5L	70	700	1.0L	30 L	50 L	15.0	50	5.0
75JW38A	0.07L	0.5L	50	1000	1.0L	30 L	50 L	1.0	30	1.0L
75JW39A	0.07L	0.5L	50	700	1.0	30 L	50 L	1.0	15	1.0L
75JW40A	0.07L	0.5L	30	1000	1.5	30 L	50 L	1.0	10	1.0
75JW41A	0.07L	0.5L	2 L	700	1.0L	30 L	50 L	1.0L	15	1.0L
75JW42A	0.10	0.5L	30	1000	1.0L	30 L	50 L	1.0	15	1.0L
75JW44A	0.07L	0.5L	50	500	1.0L	30 L	50 L	1.5	30	1.0L
75JW46A	0.07L	0.5L	20	700	1.0L	30 L	50 L	1.0	15	1.0L
75JW47A	0.15	0.5L	70	1000	1.0	30 L	50 L	2.0	20	2.0
75JW49A	0.10	0.5L	70	1000	1.0L	30 L	50 L	3.0	30	1.0L
75JW51A	0.20	0.5L	50	700	3.0	30 L	50	7.0	30	10.0
75JW55A	0.30	0.5L	70	500	15.0	30 L	500	50.0	50	300.0
75JW56A	0.10	0.5L	30	700	1.5	30 L	50 L	1.0	15	1.5
75AT2	0.07	0.5L	70	1500	1.0L	30 L	50 L	1.5	30	3.0
75AT5	0.10	0.5L	100	700	1.5	30 L	50 L	2.0	15	5.0
75AT25C	0.15	0.5L	20	300	5.0	30 L	70	7.0	15	10.0
75AT29A	0.10	0.5L	70	1000	1.5	30 L	50 L	7.0	70	10.0
75AT30A	0.15	0.5L	70	500	1.5	30 L	70	7.0	30	20.0
75AT31A	0.10	0.5L	50	700	1.0L	30 L	70	1.0L	20	1.0L
75AT36A	0.10	0.5	30	200	1.5	30 L	50 L	2.0	10	3.0
75AT45A	0.07L	0.5L	70	1000	1.0	30 L	50 L	1.0L	30	1.0
75AT46A	0.15	0.5L	50	700	1.0	30 L	50 L	1.0	20	1.0
75AT55B	0.10	0.5L	100	1000	1.0	30 L	50 L	20.0	50	50.0
75AT56A	0.30	0.5L	70	1000	2.0	30 L	200	15.0	100	10.0
75AT58A	0.10	0.5L	50	700	1.0L	30 L	50 L	1.0L	15	1.0L
75AT65A	0.10	0.5L	30	1000	1.0	30 L	50 L	3.0	20	2.0
75AT66A	0.10	0.5L	70	700	1.0L	30 L	50 L	5.0	50	3.0
75AT69A	0.07	0.5L	70	1000	1.5	30 L	50 L	1.0	15	1.0L
75AT70A	0.07L	0.5L	70	700	1.5	30 L	50 L	3.0	30	7.0

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	S-ER	S-EU	S-GA	S-LA	S-LU	S-MN	S-MO	S-NB	S-NI	S-PB
75JW2A	5 L	1.0L	5	15 L	7 L	500	2 L	15 L	2.0	10
75JW3A	5 L	1.0L	7	15 L	7 L	300	2 L	15 L	3.0	15
75JW5A	5 L	1.0	10	20	7 L	300	2 L	15 L	5.0	15
75JW12A	5 L	1.0L	10	20	7 L	200	2 L	15 L	3.0	10
75JW13B	5 L	1.0	10	30	7 L	200	2 L	15 L	5.0	15
75JW14	5 L	1.0L	10	20	7 L	1000	2 L	15 L	5.0	15
75JW22A	5 L	1.0L	10	15 L	7 L	150	2 L	15 L	2.0	15
75JW23A	5 L	1.0L	10	15 L	7 L	200	2 L	15 L	5.0	10
75JW24A	5 L	1.5	10	15 L	7 L	1500	2 L	15 L	10.0	15
75JW25A	5 L	1.0L	10	30	7 L	7000	2 L	15 L	15.0	20
75JW27A	5 L	1.0	7	15 L	7 L	150	2 L	15 L	2.0	7
75JW28A	5 L	1.0L	10	15 L	7 L	150	2 L	15 L	3.0	10
75JW37B	5 L	1.5	10	15 L	7 L	200	2 L	15 L	10.0	15
75JW38A	5 L	1.5	10	15 L	7 L	150	2 L	15 L	3.0	10
75JW39A	5 L	1.0L	7	15 L	7 L	200	2 L	15 L	3.0	10
75JW40A	5 L	1.0L	10	15 L	7 L	150	2 L	15 L	3.0	10
75JW41A	5 L	1.0	10	20	7 L	150	2 L	15 L	2.0	15
75JW42A	5	1.0	10	20	7 L	200	2 L	15 L	3.0	10
75JW44A	5 L	1.0L	7	15 L	7 L	70	2 L	15 L	5.0	2
75JW46A	5 L	1.5	7	15 L	7 L	150	2 L	15 L	2.0	7
75JW47A	5 L	1.0L	15	15 L	7 L	200	2 L	15 L	5.0	15
75JW49A	5 L	1.0L	15	15 L	7 L	300	2 L	15 L	3.0	10
75JW51A	5 L	1.5	10	20	7 L	2000	2 L	15 L	15.0	15
75JW55A	15	5.0	15	70	7 L	15000	10	15 L	70.0	150
75JW56A	5 L	1.0	10	20	7 L	200	2 L	15 L	5.0	10
75AT2	5 L	1.0	10	15 L	7 L	150	2 L	15 L	7.0	10
75AT5	5 L	1.0L	10	15 L	7 L	2000	2 L	15 L	3.0	10
75AT25C	5 L	1.0	5	20	7 L	7000	2 L	15 L	15.0	15
75AT29A	5 L	1.0L	15	15 L	7 L	10000	2 L	15 L	15.0	20
75AT30A	5	1.0L	10	20	7 L	2000	2 L	15 L	10.0	30
75AT31A	5 L	2.0	10	20	7 L	150	2 L	15 L	3.0	15
75AT36A	5 L	1.0L	5	15 L	7 L	150	2 L	15 L	3.0	15
75AT45A	5 L	2.0	10	15 L	7 L	150	2 L	15 L	3.0	15
75AT46A	5 L	1.0L	10	15 L	7 L	150	2 L	15 L	3.0	15
75AT55B	5 L	1.5	10	20	7 L	1500	2 L	15 L	20.0	15
75AT56A	7	1.5	20	50	7 L	3000	2 L	15 L	30.0	50
75AT58A	5 L	1.0L	5	15 L	7 L	150	2 L	15 L	1.5	7
75AT65A	5 L	1.0	10	15 L	7 L	300	2 L	15 L	5.0	15
75AT66A	7	1.0	7	15 L	7 L	700	2 L	15 L	7.0	7
75AT69A	5 L	1.0L	10	15 L	7 L	150	2 L	15 L	3.0	15
75AT70A	5	1.0L	10	15	7 L	300	2 L	15 L	10.0	15

SAMPLE	S-SC	S-SM	S-SR	S-TH	S-V	S-Y	S-YB	S-ZN	S-ZR	AA-ZN-P
75JW2A	2.0	7 L	100	50 L	20	20	2.0	15 L	200	15
75JW3A	2.0	7 L	70	50 L	20	10	1.0	15 L	200	18
75JW5A	3.0	7 L	100	50 L	50	15	2.0	15 L	300	22
75JW12A	2.0	7 L	100	50 L	30	30	5.0	15 L	500	14
75JW13B	5.0	7 L	100	50 L	30	20	3.0	15 L	150	35
75JW14	3.0	7 L	100	50 L	30	15	3.0	15 L	300	26
75JW22A	2.0	7 L	100	50 L	30	15	3.0	15 L	300	12
75JW23A	3.0	7 L	100	50 L	50	20	3.0	15 L	200	25
75JW24A	3.0	7 L	100	50 L	30	15	3.0	15 L	200	20
75JW25A	5.0	7 L	100	50 L	50	20	3.0	30	500	64
75JW27A	1.5	7 L	100	50 L	20	20	3.0	15 L	200	12
75JW28A	2.0	7 L	100	50 L	30	15	2.0	15 L	200	18
75JW37B	7.0	7 L	150	50 L	30	10	2.0	15 L	200	12
75JW38A	3.0	7 L	100	50 L	30	15	2.0	15 L	200	26
75JW39A	2.0	7 L	70	50 L	50	30	5.0	15 L	500	19
75JW40A	2.0	7 L	100	50 L	15	15	3.0	15 L	200	14
75JW41A	2.0	7 L	150	50	30	15	2.0	30	300	14
75JW42A	3.0	7 L	150	50 L	30	15	2.0	15 L	200	19
75JW44A	3.0	7 L	70	50 L	30	7	1.0	15 L	150	14
75JW46A	1.5	7 L	70	50 L	15	10	2.0	15 L	200	14
75JW47A	3.0	7 L	100	50 L	50	20	3.0	15 L	300	19
75JW49A	3.0	7 L	100	50 L	20	15	2.0	15 L	300	10
75JW51A	5.0	7 L	150	50 L	70	20	7.0	15 L	200	24
75JW55A	10.0	20	70	50 L	150	100	7.0	70	700	44
75JW56A	3.0	7 L	100	50 L	20	20	2.0	15 L	200	14
75AT2	5.0	7 L	100	100 L	30	20	2.0	15 L	200	14
75AT5	5.0	7 L	100	50 L	30	15	2.0	15 L	200	41
75AT25C	5.0	7 L	70	50 L	70	20	2.0	70	150	98
75AT29A	3.0	7 L	100	100 L	50	50	3.0	30	300	47
75AT30A	5.0	7 L	100	50 L	100	20	2.0	20	500	39
75AT31A	3.0	7 L	70	100 L	20	20	3.0	15 L	500	14
75AT36A	3.0	7 L	30	50 L	30	15	1.5	15 L	100	38
75AT45A	2.0	7 L	150	50 L	30	30	3.0	15 L	700	12
75AT46A	3.0	7 L	100	50 L	30	20	2.0	15 L	200	14
75AT55B	7.0	7 L	100	50 L	50	20	2.0	15 L	150	25
75AT56A	10.0	10	150	100 L	70	30	3.0	15 L	300	19
75AT58A	1.5	7 L	100	50 L	20	20	2.0	15 L	300	10
75AT65A	3.0	7 L	100	50 L	50	20	3.0	15 L	300	18
75AT66A	5.0	7 L	70	50 L	30	15	2.0	15 L	150	36
75AT69A	2.0	7 L	100	50 L	20	50	5.0	15 L	150	11
75AT70A	3.0	7 L	150	100 L	100	20	3.0	15 L	300	20

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

Mor (Forest Litter) samples, (42)

SAMPLE	X-COORD.	Y-COORD.	S-FE%	S-MG%	S-CA%	S-TI%	S-SI%	S-AL%	S-NA%	S-K%
75JW1	136800	508025	10.0	1.50	5.0	0.30	30	7.0	0.30G	0.7G
75JW2	136580	508100	0.5	0.07	0.1	0.07	30 G	0.7	0.05	0.7
75JW3	135800	508375	0.7	0.10	0.1	0.07	30 G	1.0	0.10	1.0
75JW5	135750	507060	0.7	0.07	0.2	0.10	30 G	1.0	0.15	1.0
75JW6	137250	507000	2.0	0.50	1.0	0.30	30 G	5.0	0.20	5.0
75JW12	135650	505850	0.7	0.07	0.2	0.07	30 G	1.5	0.20	1.5
75JW13A	134450	506480	2.0	1.00	3.0	0.20	30 G	5.0	0.30G	3.0
75JW22	139400	501225	2.0	0.70	2.0	0.20	30 G	3.0	0.30G	1.5G
75JW23	138400	501825	1.5	0.30	1.0	0.20	30 G	3.0	0.30G	1.5G
75JW24	137475	503000	2.0	0.50	2.0	0.20	30 G	3.0	0.30G	3.0
75JW25	137100	504625	2.0	0.50	2.0	0.10	30 G	2.0	0.30	1.0
75JW27	138150	505975	3.0	0.70	1.5	0.30	30 G	3.0	0.30G	1.5G
75JW28	139150	505225	1.0	0.15	0.2	0.20	30 G	2.0	0.30G	1.5G
75JW37A	139940	501480	3.0	1.00	3.0	0.30	30 G	5.0	0.30G	1.5G
75JW38	142380	502500	3.0	1.50	5.0	0.15	30 G	3.0	0.30G	1.5G
75JW39	141160	503325	2.0	0.50	0.7	0.20	30 G	2.0	0.30G	1.5G
75JW40	141300	502600	3.0	0.70	1.5	0.30	30 G	7.0	0.30G	1.5G
75JW41	140340	502580	3.0	0.70	1.5	0.50	30 G	5.0	0.30G	1.5G
75JW42	139500	503540	1.0	0.20	1.0	0.15	30 G	2.0	0.30G	1.5G
75JW44	140525	499200	5.0	0.70	1.5	0.20	30 G	7.0	0.30G	1.5G
75JW46	136400	499850	1.5	0.20	1.0	0.30	30 G	3.0	0.30G	3.0
75JW47	136950	500880	1.0	0.10	0.2	0.20	30 G	2.0	0.30G	3.0
75JW49	135090	502200	5.0	1.50	5.0	0.30	30 G	7.0	0.30G	7.0
75JW51	136620	503900	3.0	1.00	5.0	0.30	30 G	3.0	0.30G	1.5G
75JW55	136340	504400	5.0	1.30	3.0	0.30	30 G	3.0	0.30G	1.5
75AT1	137450	507400	7.0	2.00	5.0	0.30	30	7.0	0.30G	1.5G
75AT4	137450	506660	2.0	1.00	5.0	0.20	30 G	3.0	0.30G	2.0
75AT25B	136860	502925	2.0	1.50	15.0	0.10	30 G	3.0	0.20	1.5G
75AT29	136460	502470	1.5	1.50	15.0	0.10	30	2.0	0.30	2.0
75AT30	138260	500150	2.0	1.00	10.0	0.10	30 G	2.0	0.15	1.5G
75AT31	137950	500675	1.0	1.50	10.0	0.05	20	0.7	0.30	3.0
75AT36	139500	500215	1.0	1.50	7.0	0.05	20	3.0	0.15	1.5G
75AT45	138150	503125	1.5	1.00	10.0	0.10	30	2.0	0.30G	1.5G
75AT46	138700	504600	1.5	1.00	3.0	0.20	30 G	3.0	0.30G	3.0
75AT55A	138540	503275	2.0	1.50	10.0	0.20	30	5.0	0.30G	1.5G
75AT56	138775	503700	5.0	1.00	7.0	0.10	30 G	3.0	0.30G	1.5G
75AT58	139000	502750	3.0	1.50	7.0	0.20	30 G	3.0	0.30G	1.5G
75AT65	140825	501200	2.0	0.70	3.0	0.20	30 G	3.0	0.30G	1.5G
75AT66	141450	500525	2.0	2.00	15.0	0.07	20	3.0	0.30G	1.5G
75AT69	141730	501725	3.0	1.50	7.0	0.30	30 G	5.0	0.30G	1.5G
75AT70	141300	498925	2.0	1.00	2.0	0.50	30 G	5.0	0.30G	1.5G
75JW56	134400	504100	5.0	0.70	3.0	0.50	30 G	10.0	0.30G	10.0

SAMPLE	S-P%	S-AG	S-B	S-BA	S-BE	S-CD	S-CE	S-CO	S-CR	S-CU
75JW1	1.00	2.0	50	1000	7.0	10 L	200	70.0	50	200
75JW2	0.07	0.5L	10	150	1.0L	10 L	50 L	1.5	10	5
75JW3	0.10	0.5L	10	300	1.0L	10 L	50 L	1.5	10	10
75JW5	0.07	0.7	15	300	1.0L	10 L	50 L	1.5	15	5
75JW6	0.15	0.5L	70	700	1.5	10 L	150	70.0	50	50
75JW12	0.10	0.5L	30	300	1.0L	10 L	50 L	1.0	10	7
75JW13A	0.30	0.5L	50	700	1.5	10 L	70	7.0	20	30
75JW22	0.30	0.5	70	1000	1.5	10 L	50 L	7.0	20	100
75JW23	0.15	0.5L	50	700	1.0L	10 L	50 L	5.0	15	50
75JW24	0.20	0.5	50	700	1.5	10 L	50	10.0	30	30
75JW25	0.30	0.7	50	500	1.0L	10 L	50 L	10.0	20	50
75JW27	0.70	3.0	70	1000	2.0	10 L	70	7.0	30	150
75JW28	0.15	0.5L	30	500	1.0L	10 L	50 L	1.5	20	7
75JW37A	0.70	5.0	100	700	2.0	15	100	30.0	50	200
75JW38	1.50	1.5	150	700	2.0	30	70 L	10.0	30	300
75JW39	0.50	7.0	70	700	1.5	20	50 L	5.0	30	100
75JW40	1.00	1.0	50	1000	3.0	15	150	15.0	30	150
75JW41	0.70	1.0	100	1000	3.0	15	70	10.0	50	100
75JW42	0.15	0.5L	50	700	1.0L	10 L	50 L	2.0	20	30
75JW44	1.00	1.5	70	700	5.0	15	300	20.0	30	150
75JW46	0.15	0.5L	50	700	1.0L	10 L	50 L	3.0	20	15
75JW47	0.10	0.5L	20	700	1.0L	10 L	50 L	1.5	15 L	10
75JW49	0.30	1.0	100	700	1.5	10 L	70 L	20.0	70	20
75JW51	0.50	1.5	100	500	2.0	15	70	15.0	30	200
75JW55	0.50	3.0	100	700	5.0	10 L	100	20.0	30	500
75AT1	1.00	3.0	200	1500	5.0	50	700	70.0	100	500
75AT4	0.30	0.5L	100	1000	1.5	10 L	70	7.0	30	30
75AT25B	1.00	1.0	200	300	1.0	15	70 L	7.0	20	70
75AT29	1.50	0.5L	200	700	1.0L	30	70 L	5.0	20	200
75AT30	1.00	0.7	150	300	1.0L	100	70 L	7.0	20	200
75AT31	2.00	2.0	200	1000	1.0L	30	70 L	2.0	15	500
75AT36	2.00	0.5L	200	1500	2.0	70	70 L	15.0	15	300
75AT45	1.00	2.0	150	1000	1.0L	30	70 L	5.0	20	500
75AT46	0.50	1.0	70	1000	1.0L	10 L	70 L	5.0	20	70
75AT55A	1.00	20.0	150	700	1.5	20	70 L	30.0	70	300
75AT56	1.50	0.7	150	1500	7.0	15	100	15.0	30	200
75AT58	1.50	1.5	150	1000	2.0	50	70 L	7.0	50	500
75AT65	0.70	1.5	100	1000	2.0	10	70 L	20.0	30	300
75AT66	1.50	0.7	200	1000	3.0	20	500	7.0	20	200
75AT69	1.00	1.5	150	1500	2.0	30	70	10.0	70	300
75AT70	0.50	1.0	70	1000	1.5	15	70	7.0	30	70
75JW56	0.50	0.5L	100	1000	2.0	10 L	100	20.0	100	30

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	S-ER	S-EU	S-GA	S-LA	S-LU	S-MN	S-MO	S-NB	S-NI	S-PB
75JW1	7	3.0		150	3 L	7000	50.0	20	70	50
75JW2	5 L	1.0L	L	5	3 L	700	1.5L	10 L	5	30
75JW3	5 L	1.0L		7	3 L	1000	1.5L	10 L	5	50
75JW5	5 L	1.0L	3	10	3 L	300	2.0	10 L	7	30
75JW6	5 L	2.0	15	70	3 L	3000	2.0	10 L	50	50
75JW12	5 L	1.0L	5	10	5	500	1.5L	10 L	5	50
75JW13A	5 L	1.0L	10	50	3 L	3000	3.0	10 L	15	200
75JW22	5 L	1.0L	7	20	3 L	5000	2.0	10 L	30	500
75JW23	5 L	1.0L	7	20	3 L	7000	2.0	10 L	15	200
75JW24	5 L	1.0L	10	30	3 L	7000	2.0	10 L	20	200
75JW25	5 L	1.0L	5	20	3 L	5000	2.0	10 L	50	150
75JW27	5 L	1.0L	10	30	3 L	1500	3.0	10	50	500
75JW28	5 L	1.0L	5	15	3 L	500	1.5L	10 L	7	50
75JW37A	5 L	1.0L	15	30	3 L	3000	7.0	10 L	70	700
75JW38	5 L	1.0L	7	30	3 L	15000	7.0	10 L	70	1000 G
75JW39	5 L	1.0L	7	20	3 L	700	5.0	10 L	20	300
75JW40	5 L	1.5	10	100	3 L	700	2.0	10 L	50	700
75JW41	5	1.0L	15	50	5	1000	5.0	15	50	700
75JW42	5 L	1.0	5	15	3 L	3000	1.5L	10 L	10	150
75JW44	7	3.0	15	150	3 L	700	5.0	10	50	700
75JW46	5 L	1.0L	7	20	7	2000	1.5L	10 L	7	70
75JW47	5 L	1.0	5	20	3 L	200	1.5L	10 L	5	70
75JW49	7	1.0L	20	30	7	5000	3.0	10	20	100
75JW51	5 L	1.0L	10	30	3 L	7000	3.0	15	30	200
75JW55	5 L	1.0L	10	50	3	20000	7.0	15	50	500
75AT1	7	5.0	30	150	3 L	15000	10.0	10	70	500
75AT4	5 L	1.0L	10	50	3 L	2000	2.0	10 L	15	70
75AT25B	5 L	1.0L	5	30	3 L	5000	3.0	10 L	20	200
75AT29	5 L	1.0	3	30	3 L	10000	5.0	10 L	20	500
75AT30	5 L	1.0L	3	20	3	5000	5.0	10 L	20	200
75AT31	5 L	1.0L	2	20	3 L	20000	5.0	10 L	20	500
75AT36	5 L	1.0L	3	30	3 L	10000	5.0	10 L	70	500
75AT45	5 L	1.0L	7	20	3 L	15000	5.0	10 L	30	500
75AT46	5 L	1.0L	7	20	5	5000	3.0	10 L	15	300
75AT55A	5 L	1.0L	15	50	3 L	5000	5.0	10 L	70	700
75AT56	5 L	1.0L	7	30	3 L	3000	5.0	10	70	1000
75AT58	5 L	1.0L	10	20	3 L	15000	5.0	10 L	50	1000
75AT65	5 L	1.0L	7	30	3 L	10000	5.0	15	30	500
75AT66	5	5.0	5	200	3 L	5000	7.0	10 L	70	700
75AT69	5 L	1.0L	20	50	5	10000	5.0	15	50	1000
75AT70	5 L	1.0L	10	50	3 L	5000	3.0	15	30	500
75JW56	5 L	1.5	20	50	5	3000	2.0	10 L	50	150

SAMPLE	S-SC	S-SN	S-SR	S-TH	S-V	S-Y	S-YB	S-ZN	S-ZR	ASH%
75JW1	20.0	15	300	100 L	150	70	7.0	100	700	29.8
75JW2	1.0L	5 L	15	20 L	10	5	0.3	30	200	86.9
75JW3	1.5	5 L	30	20 L	10	7	0.7	70	150	78.9
75JW5	1.5	5 L	70	20 L	15	7	0.7	30	300	82.4
75JW6	15.0	10	500	50	100	30	2.0	200	500	79.7
75JW12	1.5	5 L	100	20 L	15	10	1.0	50	300	82.9
75JW13A	10.0	5	200	20 L	50	20	3.0	300	500	36.6
75JW22	5.0	5 L	300	20 L	50	15	2.0	500	500	30.9
75JW23	5.0	5 L	200	50	30	20	2.0	200	300	50.6
75JW24	7.0	5	200	20 L	50	20	2.0	150	500	54.5
75JW25	5.0	5	150	20 L	30	15	1.5	300	200	51.2
75JW27	10.0	5	300	100 L	70	20	2.0	300	500	19.5
75JW28	3.0	5 L	150	20 L	20	15	1.5	15 L	500	77.0
75JW37A	10.0	5	500	100 L	70	20	2.0	700	300	20.7
75JW38	10.0	5 L	700	20 L	70	15	2.0	700	200	9.5
75JW39	7.0	5	300	20 L	50	15	2.0	300	300	20.0
75JW40	10.0	10	300	100 L	50	30	5.0	200	300	15.6
75JW41	10.0	7	300	100 L	70	30	3.0	500	700	24.0
75JW42	2.0	5 L	200	20 L	20	10	1.5	150	300	50.8
75JW44	15.0	20	300	100 L	70	50	3.0	300	500	15.2
75JW46	3.0	5	200	20	30	20	3.0	100	700	72.4
75JW47	3.0	5	150	30	30	10	1.5	15 L	300	77.6
75JW49	10.0	7	200	100 L	70	20	2.0	150	500	54.0
75JW51	10.0	7	200	20 L	70	20	2.0	300	700	42.1
75JW55	10.0	7	200	20 L	100	30	2.0	500	700	32.8
75AT1	20.0	50	500	20 L	200	70	5.0	200	700	18.1
75AT4	10.0	7	300	50	70	30	2.0	150	700	31.9
75AT25B	7.0	5	200	20 L	50	15	1.5	300	300	14.4
75AT29	3.0	7	500	20 L	30	10	1.0	500	200	11.0
75AT30	5.0	5 L	300	20 L	50	10	1.0	300	200	17.6
75AT31	2.0	5 L	500	20 L	15	10	1.0	700	70	8.2
75AT36	2.0	7	700	20 L	20	10	0.7	1000	70	5.7
75AT45	3.0	5 L	700	20 L	30	10	1.0	700	200	13.7
75AT46	3.0	5 L	500	20 L	30	15	2.0	500	500	18.5
75AT55A	10.0	7	500	20 L	70	20	2.0	700	500	13.9
75AT56	7.0	5	1000	20 L	70	20	2.0	700	150	7.6
75AT58	7.0	5 L	700	20 L	70	15	2.0	700	200	13.0
75AT65	7.0	5	500	20 L	70	20	1.5	300	500	18.9
75AT66	10.0	20	700	100	70	70	5.0	500	300	10.0
75AT69	10.0	5 L	500	20 L	100	30	3.0	700	500	9.0
75AT70	7.0	7	1000	20 L	70	20	3.0	500	500	29.2
75JW56	15.0	7	300	70	100	30	5.0	30	500	64.3

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	X-COORD.	Y-COORD.	Stream Sediment samples, (46) S-FE%	S-MG%	S-CA%	S-TI%	S-SI%	S-AL%	S-NA%	S-K%
75JW7	136925	507200	0.5	0.20	0.10	0.15	30	3.0	0.050	3.0
75JW9	136900	506550	1.0	0.10	0.20	0.07	20	1.5	0.070	2.0
75JW11	136000	506225	1.0	0.15	0.20	0.10	30	2.0	0.150	2.0
75JW13	134450	506480	0.7	0.15	0.30	0.15	30	3.0	0.300G	2.0
75JW15	136900	506050	0.7	0.30	0.30	0.10	30	2.0	0.100	3.0
75JW16	136860	505700	0.7	0.15	0.20	0.07	30	2.0	0.070	2.0
75JW19	136540	505040	0.7	0.20	0.15	0.03	30 G	1.0	0.007	0.3
75JW21	138525	500900	0.5	0.30	0.30	0.07	30 G	1.0	0.010	0.5
75JW26	137275	505700	0.5	0.15	0.20	0.10	30 G	1.5	0.010	0.3
75JW29	137480	503620	0.5	0.20	0.20	0.10	30 G	3.0	0.070	1.5G
75JW30	137750	503025	1.5	0.70	0.20	0.30	30 G	5.0	0.050	3.0
75JW31	139100	502590	1.5	0.30	0.70	0.07	30 G	2.0	0.050	3.0
75JW33	139400	501790	1.0	0.20	0.20	0.20	30 G	3.0	0.100	3.0
75JW34	139200	501860	0.7	0.15	0.15	0.15	30	2.0	0.050	2.0
75JW35	139025	501910	1.0	0.30	0.30	0.20	30	3.0	0.070	3.0
75JW36	138850	501950	1.0	0.30	0.70	0.07	30 G	2.0	0.030	1.5G
75JW37	139940	501480	1.5	0.15	0.30	0.10	30	3.0	0.070	1.5G
75JW43	140950	500200	0.5	0.15	0.15	0.10	20	2.0	0.200	2.0
75JW45	139750	499200	0.7	0.10	0.20	0.07	30 G	1.0	0.150	1.0
75JW48	135450	502225	0.7	0.50	1.00	0.07	20	2.0	0.100	3.0
75JW52	138700	500075	0.3	0.10	0.10	0.05	30 G	2.0	0.100	2.0
75AT6	138350	506425	0.7	0.10	0.50	0.15	30	3.0	2.000	2.0
75AT7	138600	506180	0.5	0.10	0.15	0.10	30 G	2.0	0.100	2.0
75AT9	138800	506025	0.7	0.10	0.20	0.05	30	2.0	0.070	1.5G
75AT11	139160	505775	0.5	0.10	0.15	0.15	30	2.0	0.070	2.0
75AT13	139920	505500	0.7	0.15	0.20	0.07	30 G	2.0	0.100	2.0
75AT15	139625	505320	0.7	0.10	0.15	0.07	30 G	2.0	0.100	1.5G
75AT16B	139625	505025	0.5	0.15	0.20	0.07	30 G	2.0	0.100	3.0
75AT19	140360	504000	0.7	0.15	0.30	0.15	30 G	3.0	0.100	3.0
75AT21	137050	502200	0.5	0.20	0.10	0.07	30 G	2.0	0.070	3.0
75AT23	137000	502480	0.7	0.50	1.00	0.07	30	2.0	0.050	3.0
75AT37	137575	505350	0.3	0.07	0.15	0.05	30 G	2.0	0.100	2.0
75AT39	137715	504700	1.0	0.20	0.15	0.07	30	2.0	0.030	1.5G
75AT40	137675	504250	1.0	0.15	0.20	0.10	30 G	3.0	0.150	3.0
75AT47	139850	501900	1.0	0.30	0.30	0.10	30	3.0	0.100	3.0
75AT49	139425	502080	0.7	0.15	0.30	0.10	30	3.0	0.070	1.5G
75AT54	138500	503200	1.0	0.20	0.15	0.10	30 G	2.0	0.070	2.0
75AT55	138540	503275	0.5	0.15	0.20	0.07	30 G	2.0	0.100	2.0
75AT59	139725	502440	0.7	0.15	0.20	0.07	30 G	2.0	0.200	2.0
75AT62	140275	501600	1.0	0.20	0.30	0.10	30	3.0	0.100	5.0
75AT64	140475	501300	0.7	0.10	0.20	0.07	30	2.0	0.050	3.0
75AT67	141975	503425	0.7	0.10	0.20	0.07	30	2.0	0.100	1.5G

SAMPLE	S-P%	S-AG	S-B	S-BA	S-BE	S-CD	S-CE	S-CO	S-CR	S-CU
75JW7	0.07L	0.5L	100	300	1 L	30 L	50 L	3.0	50	15.0
75JW9	0.07L	0.5L	20	500	1 L	30 L	50 L	3.0	15	30.0
75JW11	0.07	0.5L	20	200	1 L	30 L	50 L	1.5	10	30.0
75JW13	0.07L	0.5L	10	700	1 L	30 L	50 L	1.0	7	10.0
75JW15	0.07L	0.5L	50	500	1 L	30 L	50 L	3.0	20	15.0
75JW16	0.07L	0.5L	70	300	1 L	30 L	50 L	5.0	15	10.0
75JW19	0.07L	0.5L	15	100	1 L	30 L	50 L	1.5	15	10.0
75JW21	0.07L	0.5	20	100	1 L	30 L	50 L	2.0	7 L	70.0
75JW26	0.07	0.5L	20	100	1 L	30 L	100	5.0	7	20.0
75JW29	0.07	0.5L	70	500	1 L	30 L	50 L	20.0	20	10.0
75JW30	0.10	0.5L	200	300	3	30 L	50	7.0	30	15.0
75JW31	0.07	0.5L	70	500	1	30 L	50 L	5.0	15	30.0
75JW33	0.07	0.5L	50	300	1 L	30 L	50 L	5.0	7	15.0
75JW34	0.07	0.5L	30	300	1 L	30 L	50 L	3.0	15	7.0
75JW35	0.07	0.5L	70	500	1 L	30 L	100	10.0	15	10.0
75JW36	0.07L	0.5L	20	300	1 L	30 L	50 L	7.0	15	15.0
75JW37	0.10	0.5L	30	700	1 L	30 L	50	20.0	15	10.0L
75JW43	0.07L	0.5L	20	300	1 L	30 L	50	3.0	7	7.0
75JW45	0.07L	0.5L	5	200	1 L	30 L	50 L	1.5	15	1.0L
75JW48	0.07L	0.5L	20	200	1 L	30 L	50 L	3.0	10	10.0
75JW52	0.07L	0.5L	15	300	1 L	30 L	50 L	2.0	20	1.0L
75AT6	0.07L	0.5L	20	700	1 L	30 L	50 L	3.0	7	1.0L
75AT7	0.07L	0.5L	50	500	1 L	30 L	50 L	2.0	20	20.0
75AT9	0.10	0.5L	20	500	1 L	30 L	50 L	10.0	15	10.0
75AT11	0.07L	0.5L	15	300	1 L	30 L	50 L	3.0	20	3.0
75AT13	0.07	0.5L	50	500	1 L	30 L	50 L	15.0	15	20.0
75AT15	0.07L	0.5L	70	500	1 L	30 L	50 L	10.0	15	10.0
75AT16B	0.07L	0.5L	20	500	1 L	30 L	50 L	5.0	15	10.0
75AT19	0.07	0.5L	30	500	1 L	30 L	70	5.0	20	20.0
75AT21	0.07L	0.5L	30	500	1 L	30 L	50 L	10.0	20	10.0
75AT23	0.07	0.5L	30	500	1 L	30 L	70	20.0	15	10.0
75AT37	0.07	0.5L	30	500	1 L	30 L	50 L	2.0	7	2.0
75AT39	0.07L	0.5L	20	300	1 L	30 L	70	10.0	20	10.0
75AT40	0.07L	0.5L	20	700	1 L	30 L	50 L	5.0	30	2.0
75AT47	0.07	0.5L	70	500	1 L	30 L	50 L	7.0	30	20.0
75AT49	0.07L	0.5L	50	500	1 L	30 L	70	7.0	15	10.0
75AT54	0.07	0.5L	50	500	1 L	30 L	70	5.0	30	10.0L
75AT55	0.07L	0.5L	20	500	1 L	30 L	50 L	5.0	20	1.5
75AT59	0.07L	0.5L	50	500	1 L	30 L	50 L	5.0	15	20.0
75AT62	0.07	0.5L	50	700	1 L	30 L	50 L	20.0	30	15.0
75AT64	0.07	0.5L	70	500	1 L	30 L	50 L	10.0	20	5.0
75AT67	0.10	0.5L	20	300	1 L	30 L	50 L	2.0	7	2.0

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	S-ER	S-EU	S-GA	S-LA	S-LU	S-MN	S-MO	S-NB	S-NI	S-PB
75JW7	5 L	1.0L	7	15	7 L	200	2 L	15 L	10.0	5
75JW9	5 L	1.0L	3	15	7 L	200	2 L	15 L	2.0	10
75JW11	5 L	1.0L	5	15 L	7 L	200	5	15 L	2.0	5
75JW13	5 L	1.0L	5	15 L	7 L	200	2 L	15 L	1.0L	5
75JW15	5 L	1.0L	5	15 L	7 L	700	2 L	15 L	10.0	5
75JW16	5 L	1.0L	3	15 L	7 L	200	2 L	15 L	5.0	5
75JW19	5 L	1.5	2	15 L	7 L	200	2 L	15 L	1.0L	2
75JW21	5 L	1.0L	2 L	20	7 L	200	2 L	15 L	3.0	5
75JW26	7	1.0L	2 L	30	7	2000	2 L	15 L	5.0	3
75JW29	7	1.0	5	15	7	700	2 L	15 L	20.0	7
75JW30	5	1.5	10	20	7 L	300	2 L	15 L	15.0	7
75JW31	5 L	1.0L	5	20	7 L	700	2 L	15 L	5.0	15
75JW33	5 L	1.0L	5	15 L	7 L	200	2 L	15 L	7.0	10
75JW34	5 L	1.0L	3	15 L	7 L	300	2 L	15 L	3.0	7
75JW35	5 L	1.0L	5	50	7 L	500	2 L	15 L	10.0	10
75JW36	5 L	1.0L	3	15	7 L	3000	2 L	15 L	7.0	7
75JW37	5 L	1.0L	7	15 L	7 L	1000	2 L	15 L	30.0	15
75JW43	5	1.5	5	20	7 L	300	2 L	15 L	3.0	5
75JW45	5 L	1.0L	2	15 L	7 L	150	2 L	15 L	1.5	5
75JW48	5 L	1.0L	3	15 L	7 L	200	2 L	15 L	5.0	30
75JW52	5 L	1.0L	5	15 L	7 L	150	2 L	15 L	1.5	7
75AT6	5 L	1.0	5	15 L	7 L	700	7	15 L	3.0	10
75AT7	5 L	1.0L	5	15 L	7 L	300	2 L	15 L	5.0	10
75AT9	5 L	1.0L	3	15 L	7 L	2000	2 L	15 L	15.0	10
75AT11	5 L	1.0L	5	15 L	7 L	300	10	15 L	5.0	7
75AT13	5 L	1.0L	5	15 L	7 L	1000	3	15 L	15.0	10
75AT15	5 L	1.0L	5	15 L	7 L	500	2 L	15 L	15.0	10
75AT16B	5 L	1.0	5	15 L	7 L	300	2 L	15 L	7.0	10
75AT19	5 L	1.5	5	15 L	7 L	300	15	15 L	10.0	15
75AT21	5	1.0L	5	15 L	7 L	300	2 L	15 L	10.0	10
75AT23	5 L	1.0L	5	20	7 L	700	15	15 L	30.0	10
75AT37	5 L	1.0	3	15 L	7 L	100	5	15 L	3.0	7
75AT39	5 L	1.0L	3	15 L	7 L	300	15	15 L	7.0	10
75AT40	5 L	1.0L	7	15 L	7 L	300	2 L	15 L	7.0	10
75AT47	5 L	1.0L	7	15 L	7 L	2000	5	15 L	15.0	15
75AT49	5 L	1.0L	5	15 L	7 L	1000	15	15 L	10.0	10
75AT54	5 L	1.0L	5	20	7 L	300	2 L	15 L	5.0	15
75AT55	5 L	1.5	5	15 L	7 L	300	10	15 L	7.0	7
75AT59	5	1.5	5	15 L	7 L	300	7	15 L	10.0	7
75AT62	5 L	1.0	7	15 L	7 L	3000	2 L	15 L	15.0	15
75AT64	5 L	1.0L	3	15 L	7 L	1000	2 L	15 L	10.0	10
75AT67	5 L	1.5	3	15 L	7 L	700	2 L	15 L	7.0	5

SAMPLE	S-SC	S-SM	S-SR	S-TH	S-V	S-Y	S-YB	S-ZN	S-ZR
75JW7	5.0	7 L	70	50 L	30	10	1.0	15 L	150
75JW9	3.0	7 L	50	50 L	15	10	0.7	50	100
75JW11	2.0	7 L	70	50 L	30	10	1.0	50	100
75JW13	2.0	7 L	100	50 L	15	15	1.0	15 L	150
75JW15	5.0	7 L	70	50 L	20	15	1.0	30	150
75JW16	5.0	7 L	70	50 L	20	15	2.0	50	150
75JW19	5.0	7 L	15	50 L	10	10	1.0	50	300
75JW21	3.0	7 L	50	50 L	15	5	0.5	70	70
75JW26	2.0	10	15	50 L	10	20	2.0	15 L	2000
75JW29	5.0	7 L	70	50 L	15	10	2.0	50	200
75JW30	7.0	7 L	70	50 L	30	20	3.0	15 L	700
75JW31	5.0	7 L	70	50 L	15	15	2.0	150	200
75JW33	3.0	7 L	70	50 L	20	15	2.0	15 L	150
75JW34	3.0	7 L	50	50 L	20	15	1.5	15 L	500
75JW35	7.0	7	70	50 L	30	30	5.0	15 L	700
75JW36	7.0	7 L	70	50 L	15	30	3.0	30	200
75JW37	5.0	7 L	100	50 L	20	15	2.0	30	500
75JW43	3.0	7 L	50	50 L	10	20	2.0	15 L	300
75JW45	1.0	7 L	30	50 L	15	5	0.5	20	100
75JW48	5.0	7 L	70	50 L	15	10	0.7	30	150
75JW52	1.5	7 L	50	50 L	10	7	1.0	30	100
75AT6	2.0	7 L	100	50 L	15	15	2.0	15 L	150
75AT7	2.0	7 L	70	50 L	15	10	1.0	15 L	150
75AT9	2.0	7 L	70	50 L	15	10	0.5	50	70
75AT11	5.0	7 L	70	50 L	15	15	1.5	15 L	300
75AT13	7.0	7 L	70	50 L	15	20	3.0	50	200
75AT15	5.0	7 L	70	50 L	20	15	1.5	50	300
75AT16B	3.0	7 L	70	50 L	15	10	1.0	30	150
75AT19	5.0	7 L	70	50 L	20	20	2.0	15 L	300
75AT21	5.0	7 L	70	50 L	15	15	1.0	70	300
75AT23	5.0	7 L	70	50 L	15	20	1.5	30	200
75AT37	1.0	7 L	70	50 L	10	5	0.5	30	70
75AT39	7.0	7 L	70	50 L	20	15	1.5	30	700
75AT40	3.0	7 L	70	50 L	20	10	1.5	50	300
75AT47	3.0	7 L	100	50 L	30	10	0.7	70	100
75AT49	3.0	7 L	70	50 L	20	10	1.0	70	150
75AT54	7.0	7 L	70	50 L	20	20	2.0	15 L	1000
75AT55	3.0	7 L	70	50 L	15	10	1.0	20	150
75AT59	5.0	7 L	70	50 L	20	15	1.5	50	150
75AT62	3.0	7 L	100	50 L	20	10	1.0	15 L	100
75AT64	5.0	7 L	70	50 L	15	15	2.0	50	500
75AT67	3.0	7 L	70	50 L	15	20	3.0	50	100

TABLE 1.—*Analysis of rock, soil, forest litter (mor), and stream sediment samples collected by Whitlow and Geraci from Rock River Canyon and vicinity, Alger County, Mich.*—Continued

SAMPLE	X-COORD.	Y-COORD.	S-FE%	S-MG%	S-CA%	S-TI%	S-SI%	S-AL%	S-NA%	S-K%
75AT68	141700	503450	0.7	0.15	0.15	0.07	30	3.0	0.100	3.0
75AT71	136125	500750	0.5	0.30	0.70	0.05	30	2.0	0.100	3.0
75AT72	136375	504250	0.5	0.10	0.15	0.03	30	1.5	0.050	2.0
75AT73	136450	504215	0.7	0.07	0.15	0.03	20	1.0	0.050	2.0

SAMPLE	S-P%	S-AG	S-B	S-BA	S-BE	S-CD	S-CE	S-CO	S-CR	S-CU
75AT68	0.07	0.5L	30	500	1 L	30 L	50 L	3.0	30	10.0
75AT71	0.10	0.5L	30	500	1 L	30 L	50 L	3.0	7	1.0L
75AT72	0.07L	0.5L	20	500	1 L	30 L	50 L	1.0L	10	2.0
75AT73	0.07L	0.5L	15	500	1 L	30 L	50 L	10.0	5	10.0

SAMPLE	S-ER	S-EU	S-GA	S-LA	S-LU	S-MN	S-MO	S-NB	S-NI	S-PB
75AT68	5 L	1.0	5	15 L	7 L	700	2 L	15 L	5.0	7
75AT71	5 L	1.0L	3	15 L	7 L	300	2 L	15 L	3.0	5
75AT72	5 L	1.0L	2	15 L	7 L	200	2 L	15 L	1.5	2
75AT73	5 L	1.0L	2 L	15 L	7 L	300	2 L	15 L	7.0	2

SAMPLE	S-SC	S-SM	S-SR	S-TH	S-V	S-Y	S-YB	S-ZN	S-ZR
75AT68	5.0	7 L	70	50 L	15	15	3.0	50	300
75AT71	1.5	7 L	100	70	15	5	0.2	15	70
75AT72	5.0	7 L	50	50	10	15	1.0	15	100
75AT73	2.0	7 L	70	50	10	5	0.3	200	70

TABLE 2.—*Range and median values for 35 elements in rock samples from Rock River Canyon and vicinity, Alger County, Mich.*

[Symbols: L, less than value shown; G, greater than upper limit of determination]

	Rock samples					
	Munising Formation 24 samples			Jacobsville Sandstone 6 samples		
Element	High	Low	Median	High	Low	Median
Percent						
Fe	1.0	0.07	0.15	1.0	0.15	0.3
Mg	7	.05	.1	.5	.05	.1
Ca	7	.02	.2	.15	.05	.1
Ti	.3	.01	.05	.3	.07	.1
Si	30G	10	30	30	30	30
Al	5	.15	.7	5	1.5	2
Na	.05	.007L	.007L	.07	.007L	.05
K	5	.07	.7	3	.2	2
P	10	.07L	.07L	.07	.07	.07
Parts per million						
Ag	.03	.1L	.1L	.15	.1L	.1
B	100	3L	10	70	30	50
Ba	500	20	70	700	30	500
Be	1.5	.7L	.7L	1.5	.7L	.7L
Ce	70	30L	30L	100	30L	70
Co	10	1L	3	3	2	3
Cr	50	3	15	20	5	7
Cu	30	3	10	10	3	7
Er	10L	10L	10L	10L	10L	10L
Eu	2	1.5L	1.5L	2	1.5L	1.5L
Ga	1	2L	2L	10	2	5
La	30	10L	10	30	10L	20
Mn	15,000	30	70	300	70	150
Mo	2	2L	2L	2L	2L	2L
Nb	10	3L	3L	10	2L	7
Ni	15	5L	5L	15	5L	7
Pb	30	10L	10L	15	10L	10L
Sc	10	1L	2	7	2	2
Sm	50L	50L	50L	50L	50L	50L
Sr	100	15	30	50	20	30
Th	30	20L	20L	20L	20L	20L
V	70	5	10	20	7	15
Y	20	2	7	30	10	20
Yb	3	.15	.5	3	1	2
Zn	50	20L	20L	20L	20L	20L
Zr	500	30	150	500	150	200

TABLE 3.—*Range and median values for 36 elements in soil samples from Rock River Canyon and vicinity, Alger County, Mich.*

[Samples divided according to stratigraphic unit that is bedrock at sample site. Symbols used: L, less than value shown; G, greater than upper limit of determination]

Element	Soil samples: On the Munising Formation, 24 samples — Content: High	Low	Median	Soil samples: On the Au Train Formation, 17 samples — Content: High	Low	Median
Percent						
Fe	5	0.7	1.5	2	0.7	1.5
Mg	.5	.05	.2	.5	.07	1.5
Ca	1.0		.3	1.0	.1	.5
Ti	.7	.15	.3	.5	.2	.3
Si	30G	15	30G	30G	20	30G
Al	10	2	5	7	3	7
Na	.3G	.1	.3G	.3G	.1	.3G
K	7	1.0	3	7	.7	2
P	.3	.05	.1	.3	.05	.1
Parts per million						
Ag	0.5L	.5L	.5L	.5L	.5L	.5L
B	70	.2L	50	70	20	50
Ba	1,000	200	700	1,000	500	700
Be	3	1.5L	1.5	15	1.5L	1.5
Ce	200	30L	30L	500	30L	30L
Co	20	1L	20	7	1L	2
Cr	100	10	20	70	10	30
Cu	50	1L	1L	300	1L	5
Er	7	5L	5L	15	5L	5L
Eu	2	1L	1L	5	1L	1L
Ga	20	5	10	15	5	10
La	50	10L	10	70	10L	15
Lu	7L	7L	7L	7L	7L	7L
Mn	7,000	70	150	15,000	150	300
Mo	2L	2L	2L	10	2L	2L
Nb	15L	15L	15L	15L	15L	15L
Ni	30	1.5	3	70	2	5
Pb	50	2	15	150	7	15
Sc	10	1.5	3	10	1.5	3
Sm	10	7L	7L	10	7L	7L
Sr	150	30	100	150	70	100
Th	100	50L	50L	100	50L	50L
V	100	15	30	150	15	30
Y	50	7	20	100	10	20
Yb	5	1	2	7	1	3
Zn	70	15L	15L	70	15L	15L
Zr	700	100	200	700	150	300

TABLE 4.—*Range and median values for 36 elements in forest litter samples from Rock River Canyon and vicinity, Alger County, Mich.*

[Samples divided according to stratigraphic unit that is bedrock at sampled site. Symbols used: L, less than value shown; G, greater than upper limit of determination]

	Forest litter					
	On the Munising Formation 27 samples			On the Au Train Formation 15 samples		
Element	High	Low	Median	High	Low	Median
Percent						
Fe	10	1.0	2	5	0.5	1.5
Mg	2	.15	1	1.5	.07	
Ca	15	.2	.5	15	.1	2
Ti	.5	.05	.2	.5	.05	.5
Si	30G	20	30G	30G	20	30G
Al	7	2	3	10	.7	2
Na	.3G	.15	.3G	.3G	.05	.3G
K	5	.7	1.5	10	.7	1.5
P	2	.15	1.0	2	.07	.3
Parts per million						
Ag	20	5L	0.7	3	.5L	.5L
B	200	30	100	200	10	50
Ba	15,000	150	700	1,000	150	700
Be	7	1L	2	5	1L	1L
Cd	100	10L	20	30	10L	10L
Ce	700	50L	70	100	50L	50L
Co	70	1.5	7	20	1	5
Cr	100	10	20	100	10	20
Cu	500	7	150	500	5	30
Er	7	5L	5L	7	5L	5L
Eu	5	1L	1L	1.5	1L	1L
Ga	30	3	7	20	2L	5
La	200	10	30	50	5	20
Mn	15,000	500	5,000	20,000	200	3,000
Mo	50	0.5L	3	7	1.5L	2
Nb	20	10L	10L	15	10L	10L
Ni	70	7	50	50	5	20
Pb	1,000	50	500	500	30	150
Sc	20	2	5	15	1L	3
Sm	50	5L	5L	7	5L	5L
Sr	1,000	100	500	500	15	200
Th	100	20L	20L	70	20L	20L
V	200	15	70	100	10	30
Y	70	10	20	30	5	15
Yb	7	.7	2	5	.3	1.5
Zn	1,000	70	500	700	15L	150
Zr	700	70	300	700	70	300

TABLE 5.—*Analyses of rock samples collected by P. C. Mory from*

[Analyses performed by U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nev. graphically but not detected unless otherwise noted in footnote: Ag, As, Au, Ba, Be, Bi, Cd, greater than 3 percent; Cr content less than 0.003 percent; Cu content less than 0.004 per- Symbols used: >, greater than upper limit of determination; <, detected but less than lower detection limit. Formation designations: Js, Jacobsville Sandstone; Mf, Munising Formation;

Sample number	General spectrographic analyses (percent)							
	Al	B	Ca	Fe	Mg	Mn	Mo	Na
201[1 2]	>3	<0.01	<0.02	0.2	0.09	0.05	—	0.1
202	.4	<.01	—	.4	.02	.03	—	—
203	1	<.01	.04	.5	.2	.009	—	.08
204[3]	1	<.01	.1	.9	.3	.03	—	.1
205	.2	<.01	<.02	.2	.007	.03	—	—
206	.7	<.01	.1	.4	.3	.06	<0.001	—
207[2]	.3	<.01	—	.2	.008	<.003	<.001	—
208	.6	<.01	—	.3	.007	.006	—	—
209[4]	>3	<.01	.04	.4	.08	.005	—	.08
210	.3	<.01	<.02	.4	.01	.003	—	—
211	.07	—	<.02	.1	.003	<.003	—	—
212[2]	.7	<.01	<.02	.3	.04	.003	—	.09
213[3 5]	>3	<.01	<.02	.7	.09	.003	—	.04
214[3]	1	<.01	—	1	.09	.006	—	.08
215[1 2]	.4	<.01	.04	.3	.02	<.003	—	—
216[2]	.7	<.01	.1	1.2	.1	.007	<.001	.09
217	.6	<.01	<.02	.2	.01	<.003	<.001	—
218	.07	—	.1	.7	.01	.006	<.001	—
219	.07	—	—	.4	.01	.007	—	—
220[2]	.08	<.01	—	.3	.5	.03	—	—
221	.1	<.01	.04	.4	.002	<.003	<.001	—
222	.1	<.01	<.02	.3	.003	<.003	<.001	—
223	.8	<.01	<.02	.5	.08	.01	<.001	.09
224[2]	.1	<.01	<.02	.7	.08	.01	<.001	—
225	.1	<.01	.1	.4	.3	.01	—	—
226	.06	<.01	—	.1	.007	<.003	<.001	—
227[6 7]	.3	—	>2	.7	>3	.07	—	—
228[8]	.1	<.01	1	.2	.9	.02	—	—
229[9]	.03	—	—	.4	.009	.007	—	—
230[10]	.3	<.01	>2	>4	1.2	.06	—	<.02
231[11]	>3	<.01	>2	>4	1.2	.06	—	<.02
232[12]	.08	—	>2	.1	>3	.03	<.001	—
233[2]	.07	—	—	.1	.008	<.003	—	—
234	.05	<.01	<.02	.4	.01	<.003	<.001	—
235[2]	.08	<.01	<.02	.3	.007	<.003	—	—
236[8 13]	.07	<.01	>2	.4	>3	.06	<.001	—

[1] Contains 2.9 percent Al by neutron activation analysis.
[2] Contains less than 0.02 percent U_3O_8 by radiometric technique.
[3] Contains less than 0.004 percent Co by spectrographic analysis.
[4] Contains 4.8 percent Al by neutron activation analysis.
[5] Contains 4.6 percent Al by neutron activation analysis.
[6] Contains less than 0.001 percent Ag by spectrographic analysis and 0.02 oz/ton Ag by fire assay.
[7] Contains 6.8 percent Mg by atomic absorption analysis.

the Rock River Canyon Wilderness Study Area, Alger County, Mich.

Samples are random chips every 2 to 10 cm through interval noted. Elements tested for spectro- Co, Ca, Hf, In, La, Li, Nb, P, Pt, Re, Sb, Sc, Sn, Sr, Te, Tl, W, Y, Zn. All samples showed: Si content cent. A possible error of plus 100 percent to minus 50 percent of reported concentration assumed. limit of determination; —, not detected and hence may be present only in amounts below the lower Atf, Au Train Formation]

General spectrographic analyses (percent)						Sample interval (meters)	Formation and sample description
Ni	Pb	Ta	Ti	V	Zr		
—	—	<0.008	0.03	<0.006	<0.004	2.44	Js, sandstone.
—	—	—	.01	—	<.004	3.51	Js, sandstone.
<0.002	<0.01	<.008	.06	<.006	<.004	2.44	Mf, sandstone.
<.002	<.01	<.008	.08	.006	.008	5.49	Mf, sandstone.
—	—	—	.006	—	—	1.07	Js, sandstone.
<.002	<.01	<.008	.03	<.006	.008	3.96	Mf, sandstone.
<.002	—	—	.01	—	.01	1.01	Js, sandstone.
—	—	—	.02	<.006	<.004	2.68	Js, sandstone.
<.002	<.01	<.008	.06	<.006	.007	12.19	Mf, sandstone.
<.002	<.01	<.008	.1	<.006	<.004	2.13	Mf, sandstone.
—	—	—	.006	<.006	—	4.42	Mf, sandstone.
—	<.01	—	.03	<.006	<.004	6.40	Js, sandstone.
<.002	<.01	—	.07	<.006	.01	6.10	Mf, sandstone.
<.002	<.01	—	.07	<.006	.008	5.49	Mf, sandstone.
—	—	—	.02	<.006	<.004	1.68	Js, sandstone.
<.002	<.01	—	.06	<.006	<.004	2.44	Js, sandstone.
—	<.01	—	.03	<.006	<.004	3.66	Mf, sandstone.
<.002	<.01	—	.006	<.006	<.004	3.20	Mf, sandstone.
—	—	—	.006	—	—	3.66	Mf, sandstone.
—	<.01	—	.003	—	—	2.90	Mf, sandstone.
<.002	<.01	—	.006	—	<.004	1.52	Mf, conglomerate.
<.002	—	—	.008	—	<.004	.91	Mf, sandstone.
<.002	.01	<.008	.06	<.006	.007	1.37	Mf, sandstone.
—	—	<.008	.01	<.006	<.004	6.40	Mf, sandstone.
—	<.01	—	.005	<.006	—	2.59	Atf, dolomitic sandstone.
<.002	—	—	.005	—	<.004	5.49	Mf, sandstone.
<.002	<.01	—	.009	<.006	<.004	1.37	Atf, dolomitic sandstone.
—	—	—	.008	<.006	—	1.68	Atf, sandy dolomite with glauconite.
—	<.01	—	.008	<.006	—	4.57	Mf, sandstone.
<.002	—	—	.01	<.006	<.004	—	Atf, glauconite.
—	<.01	—	.06	<.006	.008	2.59	Atf, sandy dolomite with glauconite.
—	—	—	.006	—	—	1.98	Atf, sandy dolomite.
—	—	—	.005	—	—	6.55	Mf, sandstone.
<.002	—	—	.01	<.006	<.004	2.90	Js, sandstone.
—	.01	—	.009	<.006	—	6.71	Mf, sandstone.
<.002	—	—	.003	<.006	—	4.27	Atf, sandy dolomite with glauconite.

[8] Contains approximately 1 percent glauconite by petrographic determination.

[9] Contains less than 0.001 percent Ag by spectrographic analysis and zero Ag by fire assay.

[10] Contains less than 0.001 percent Be by spectrographic analysis and 5 to 7 percent glauconite by petrographic determination.

[11] Contains 3 to 5 percent glauconite by petrographic determination.

[12] Contains 5 percent Mg by atomic absorption analysis.

[13] Contains 5.4 percent Mg by atomic absorption analysis.

TABLE 6.—*Partial chemical analyses of four samples collected by P. C. Mory from the Munising Formation (Miners Castle Member) from Rock River Canyon Wilderness Study Area*

Sample number	Sample interval[1] (meters)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Na_2O	K_2O
211	4.42	96.1	0.76	0.78	0.11	0.013	0.59
218	3.20	94.9	.53	1.72	.22	.010	.34
226	5.49	96.6	.53	1.19	.11	.012	.35
233	6.40	96.0	.45	.83	.11	.015	.28

[1]Samples are random chips taken every 5–10 cm through the interval noted.

GEOPHYSICAL-DATA INTERPRETATION

BY ELIZABETH R. KING, U.S. GEOLOGICAL SURVEY

The Rock River Canyon Wilderness Study Area was included in an aeromagnetic survey by the U.S. Geological Survey in 1961 as part of an extensive program to locate potential mineral resources, particularly iron ore deposits, in northern Michigan (Case and Gair, 1965; Zietz and Kirby, 1971). The magnetic data consist of north-south aeromagnetic profiles spaced 1.6 km apart and recorded at 152 m above the ground. The data have been used to make two contoured magnetic maps (fig. 6), one having a contour interval of 50 gammas and the other having larger contour intervals (fig. 7).

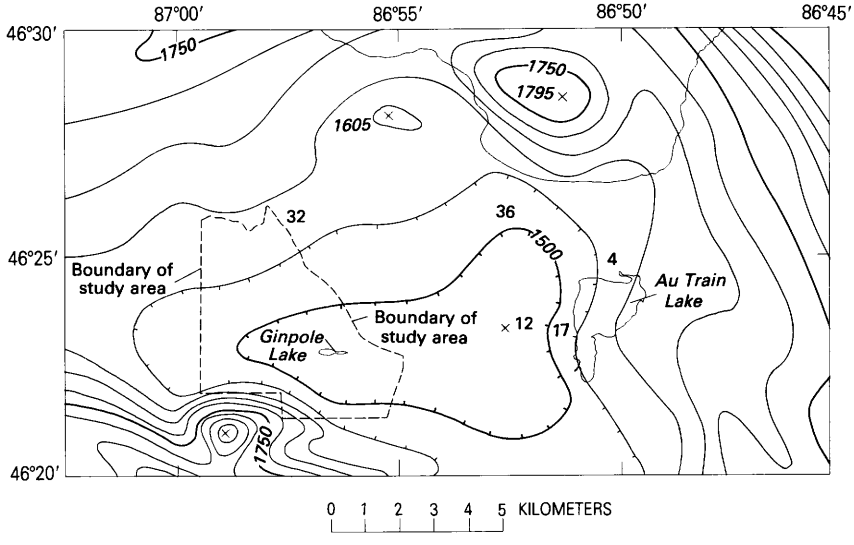


FIGURE 6.—Aeromagnetic map of part of Michigan, which includes the Rock River Canyon Wilderness Study Area (from Case and Gair, 1965).

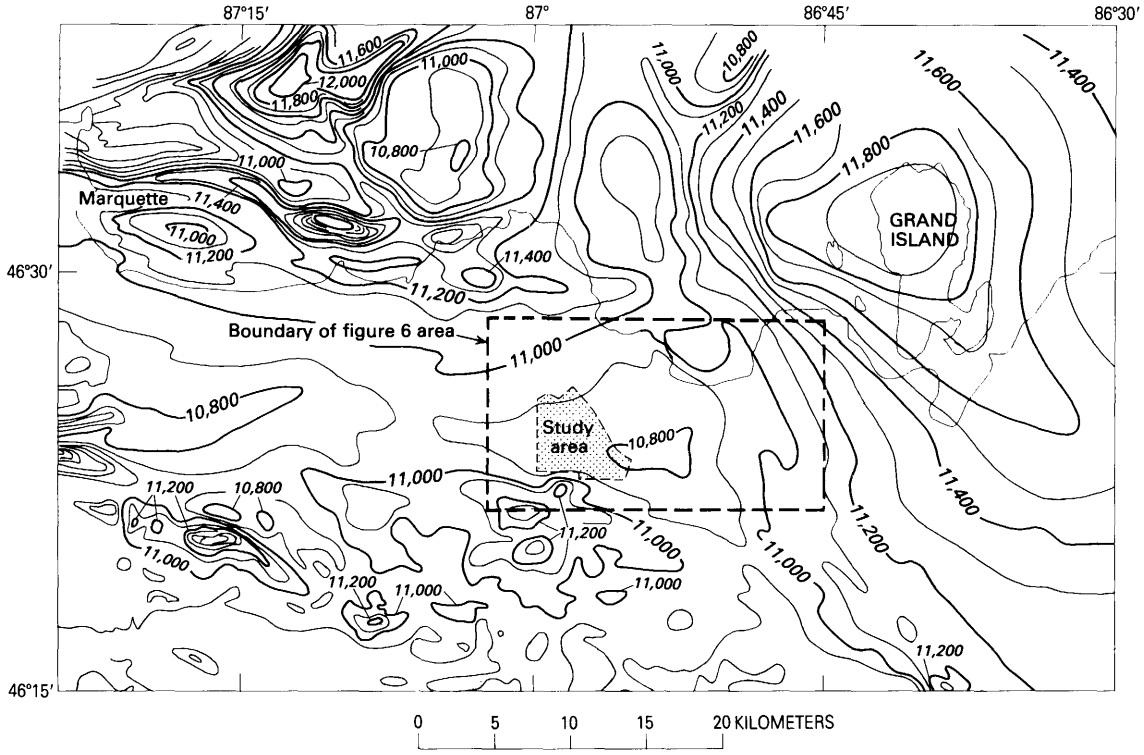


FIGURE 7.—Aeromagnetic map of part of Michigan, which includes the Rock River Canyon Wilderness Study Area (from Zietz and Kirby, 1971).

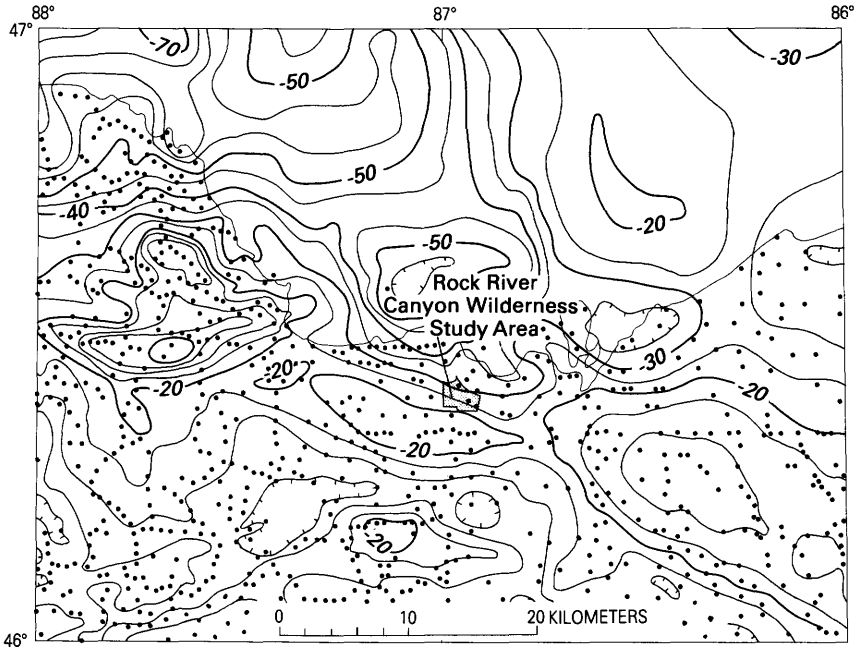


FIGURE 8.—Portion of the Bouguer gravity map of the northern Michigan-Lake Superior area. Contour interval is 5 mGal. Station locations are shown by dots. (Klasner and others, 1978.)

The study area is covered also by regional gravity data (fig. 8) consisting of Bouguer gravity values recorded at stations spaced 1.5 to 6.5 km apart and contoured at 5-mGal intervals (Klasner and others, 1978).

The magnetic data are useful for determining the presence or absence of rocks containing magnetite or other less common magnetic minerals. In the Upper Peninsula of Michigan, several types of Precambrian crystalline basement rocks are associated with magnetic anomalies and quite commonly with gravity anomalies. West of the study area, these rocks are exposed and can be correlated with distinctive magnetic patterns. The study area is underlain entirely by sedimentary rocks that contain little or no magnetite; therefore, the magnetic anomalies reveal information about the crystalline rocks beneath the sedimentary rocks.

The Rock River Canyon Wilderness Study Area is north of a combined magnetic and gravity positive anomaly, the crest of which is about 4 km south-southwest of the center of the study area (figs. 6 and 7). The configuration of magnetic contours north of the positive

anomaly is exceptionally smooth and delineates a broad magnetic low that includes the study area. Gravity intensity decreases northward toward a minimum offshore in Lake Superior.

The magnetic low in which the study area is located is bounded on the east by a large positive magnetic anomaly having a maximum in the vicinity of Grand Island (fig. 7). A partially coincident gravity high trends southeast from the town of Munising on the shore of Lake Superior. This magnetic anomaly is traceable northwestward to the Keweenawan volcanic rocks of the Keweenaw Peninsula, which give rise to very large positive magnetic and gravity anomalies. The Grand Island magnetic anomaly is much smoother and has more gentle gradients than the Keweenaw anomaly because the source rocks are buried under a thick cover of nonmagnetic sedimentary rocks. Basins filled with sedimentary rocks such as the Jacobsville Sandstone typically border and, in many places, overlie the volcanic rocks. These sedimentary basins are marked by magnetic lows or areas of smooth magnetic pattern similar to the broad magnetic low in the area that includes the Rock River Canyon Wilderness Study Area. Because of the broad magnetic low in the study area, it is inferred that a thick section of nonmagnetic sedimentary rock underlies the area. Sedimentary rocks exposed in the study area are composed of the relatively thin section of the Au Train and Munising Formations and less than 15 m of the upper part of the Jacobsville Sandstone that has an unknown thickness in the area. Lane and Seaman (1907, p. 691) report more than 366 m of Jacobsville Sandstone at Grand Marais 80 km N. 70° E. of Rock River Falls.

Most of the Precambrian iron formation in the economic iron districts of the Lake Superior region is delineated by sharp linear magnetic anomalies. No such anomalies are present in the Rock River Canyon Wilderness Study Area; therefore, any significant amounts of iron ore probably are either absent or too deeply buried to be detected.

OWNERSHIP OF SURFACE AND MINERAL RIGHTS

SURFACE-RIGHTS OWNERSHIP

Alger County courthouse and U.S. Forest Service records indicate that all of the study area was in private ownership until 1935. Most of the surface rights were acquired by the Federal Government between 1935 and 1947 under either the Weeks Act (1911) or the Clarke-McNary Act (1924). The Forest Service administers all lands having surface rights owned by the Federal Government, which includes 78 percent of the study area (fig. 9).

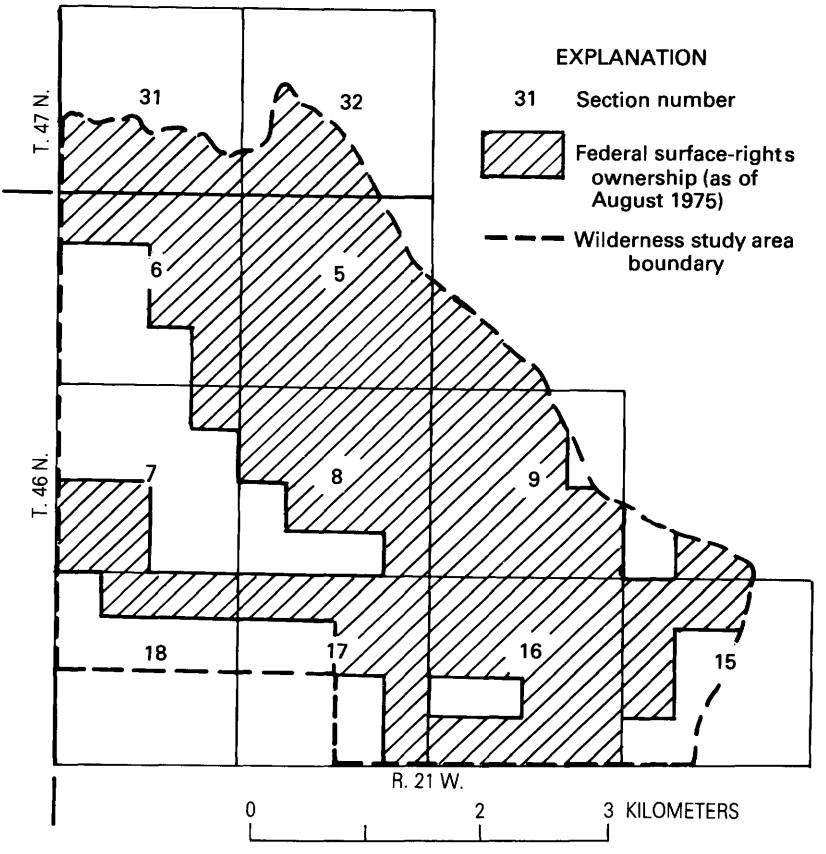


FIGURE 9.—Federal surface-rights ownership, Rock River Canyon Wilderness Study Area.

MINERAL-RIGHTS OWNERSHIP

Although the Federal Government owns 78 percent of the surface rights in the study area, individuals and the State government own 93 percent of the mineral rights (fig. 10; table 7).

Records indicate that prior to 1935 the entire proposed study area was open to mineral exploration; however, no records could be found of exploratory work completed in or near the area. The U.S. Bureau of Land Management, which processes applications for prospecting and mining on lands where mineral rights are owned by the Federal Government, has no record of leasing or exploration permits in the study area.

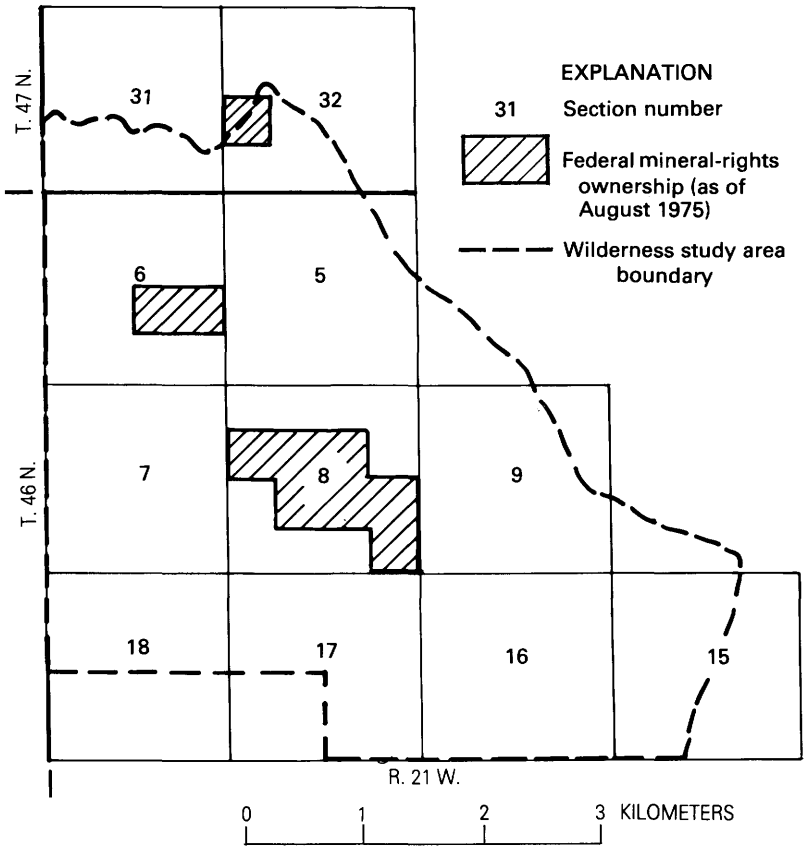


FIGURE 10.—Federal mineral-rights ownership, Rock River Canyon Wilderness Study Area.

MINERAL RESOURCES

No mines or prospects are within the proposed wilderness area. Mining activities near the area have been limited to two stone quarries and many sand and gravel pits (fig. 11) that have supplied local markets. All, except three sand pits, were inactive in 1975. The two quarries are abandoned and filled with water. Jacobsville Sandstone from the quarry in NE¼ sec. 26, T. 47 N., R. 21 W., was used either for dimension stone for local building or possibly for road metal. A quarry in the Au Train Formation in SE¼ sec. 30, T. 46 N., R. 21 W., was operated from about 1916 through 1922 (Michigan Geological and Biological Survey, 1917-20; Michigan Geological Survey, 1921-23); the rock was probably used for road metal.

TABLE 7.—*Mineral-rights ownership, Rock River Canyon Wilderness Study Area, as of August 1975*

Section	Subdivision	Owner of mineral rights
	T. 46 N., R. 21 W.	
4	SW¼	Superior Realty Company.
5	E½; NW¼; NE¼ SW¼	Superior Realty Company.
5	W½ SW¼; SE¼ SW¼	Ford Motor Company.
6	E½ NE¼	Superior Realty Company.
6	W½ NE¼; NW¼; SW¼; S½ SE¼	Ford Motor Company.
6	N½ SE¼	U.S. Forest Service.
7	NE¼; NW¼; SE¼	Ford Motor Company.
7	SW¼	State of Michigan.
8	E½ NE¼; NW¼ NE¼; N½ NW¼ SW¼ SE¼; S½ SW¼; NW¼ SW¼.	Ford Motor Company.
8	SW¼ NE¼; S½ NW¼; E½ SE¼ NW¼ SE¼; NE¼ SW¼.	U.S. Forest Service.
9	NE¼; NW¼; SE¼	Superior Realty Company.
9	SW¼	Unknown party.
10	SE¼ SW¼; SW¼ SE¼	Superior Realty Company.
10	W½ SW¼	Unknown party.
15	NW¼ NE¼; S½ SW¼	The Cleveland-Cliffs Iron Company.
15	SW¼ NE¼	Chicago and Northwestern Railroad Company.
15	N½ NW¼; SW¼ NW¼; NW¼ SW¼	Superior Realty Company.
15	SE¼ NW¼	Northwestern Cooperage and Lumber Company.
15	NE¼ SW¼	Unknown party.
16	E½ NE¼; S½ S½	State of Michigan.
16	W½ NE¼; N½ NW¼; SW¼ NW¼; N½ SE¼.	Superior Realty Company.
16	SE¼ NW¼	The Cleveland-Cliffs Iron Company.
16	NE¼ SW¼	Edward Ylitalo.
16	NW¼ SW¼	Oswald Hautamaki.
17	NE¼; N½ NW¼	Superior Realty Company.
17	SW¼ NW¼; W½ SE¼	Unknown party.
17	SE¼ NW¼; NE¼ SE¼	The Cleveland-Cliffs Iron Company.
17	SE¼ SE¼	State of Michigan.
18	N½	The Cleveland-Cliffs Iron Company.
	T. 47 N., R. 21 W.	
31	S½	Chicago and Northwestern Railroad Company.
32	NW¼; E½ SW¼; SW¼ SW¼	Superior Realty Company.
32	NW¼ SW¼	U.S. Forest Service.
32	SE¼	State of Michigan.

ECONOMIC APPRAISAL

Commodities in the study area that have possible economic potential are high-silica sand, stone, sand, gravel, and glauconite.

High-silica sand.—Both the Jacobsville Sandstone and the Munising Formation are highly siliceous formations. Analyses of the Jacobsville Sandstone and the Munising Formation (table 6) indicate that the combined aluminum, iron, manganese, and titanium contents are too high for use as high-silica sand. Partial chemical analyses of four samples

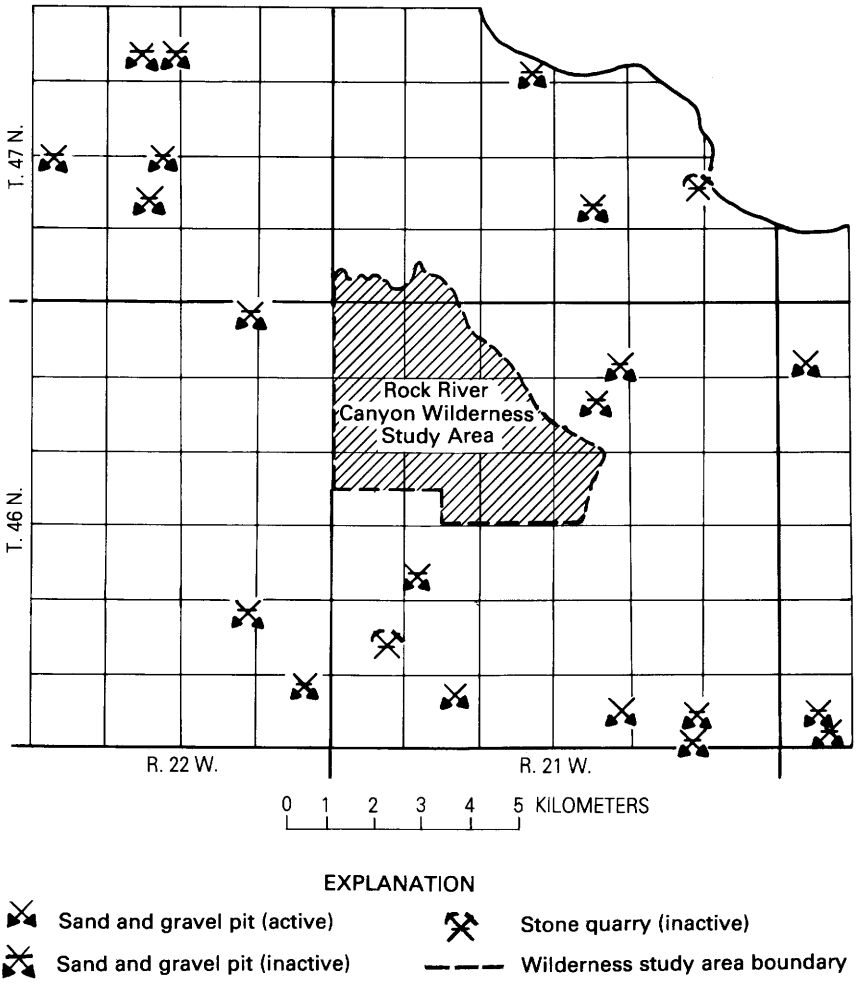


FIGURE 11.—Locations of mining operations near the Rock River Canyon Wilderness Study Area, as of August 1975.

collected by Mory from the Miners Castle Member of the Munising Formation show a silica content ranging from 94.9 to 96.6 percent (table 7); the remainder is combined aluminum, iron, and other impurities that prevent its being used as a high-quality glass sand. Distance from market and transportation routes and competition from favorably located deposits reduce its economic potential.

Stone.—Dimension stone suitable for building purposes is available near the study area and probably in the area (Smith, 1916, p. 171–172); however, competition with similar materials nearer markets and transportation routes reduces its economic potential. No local demand exists for stone except for road metal.

Sand and gravel.—Sand and gravel are present mostly in glacial till and, to a lesser extent, in recent alluvial deposits along Rock River and Silver Creek. The glacial deposits are generally thin; however, substantial reserves of sand and gravel are in the pits examined near the study area (fig. 11). Because local demand is small and is met by active operations close to transportation routes, the sand and gravel deposits in the study area have little or no economic potential.

Glauconite.—The lower unit of the Au Train Formation contains glauconite that reportedly constitutes as much as 25 to 35 percent of the rock in samples from outside the study area (Bergquist, 1930, p. 233). The maximum glauconite content found in the Au Train Formation during this study is 5 to 7 percent (fig. 5, sample 230); glauconite contents of other samples range from 1 to 5 percent. Because of the limited extent of the Au Train Formation (fig. 2) and its low glauconite content, it has no economic potential.

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