UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Lithology and geologic setting of Lower Proterozoic iron-formations in parts of northern Wisconsin

by

Carl E. Dutton

Open-File Report 84-76

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

1983

INTRODUCTION

The geology of Precambrian rocks in northern Wisconsin has long been only generally known, largely because exposures of bedrock through the mantling glacial drift are so few. With the advent of modern geophysics, particularly comprehensive magnetic surveys, the general pattern of geologic structures is reasonably clear and by understanding the nature of rocks that create certain types of anomalies, a bedrock geologic map can be drawn. Particularly important are magnetic sedimentary units, mostly lean magnetic iron-formations, that can be traced for long distances on magnetic maps and are thus the key to interpreting the overall map pattern of the region. These units are seldom seen at the surface but have been widely drilled in the first half of the 1900's in exploration for iron ores. Although no exploitable orebodies have been found, the drilling has provided much useful information on the nature of these marker beds. At various times over several decades I have had the opportunity to examine much of this drill core and acquire drill logs and other information which has not been readily available in the public record. This report presents and discusses much of that information so that future workers in the area will be assured access to that useful body of data.

Interest in exploring for iron ore in the project area during 1910-1914 led to geologic field examinations, magnetic dip-needle surveying, map compilation of the data at 4 inches per mile, geologic interpretation, subsequent drilling, and report preparation by Allen and Barrett (1915, figure 1 and p. 65-129). Copies of the maps for Wisconsin and the adjacent areas of Michigan as well as field notes, have been available and have aided in this study. Based on data from the exploration of magnetic trends and areas, Allen and Barrett (1915, figure 1 and p. 21-64) proposed interpretations concerning stratigraphy and correlation of Precambrian rocks in Wisconsin and Michigan. A summary and interpretation of the geologic and magnetic surveys and subsequent drilling, which was mainly in Wisconsin, are presented in this report.

Two parts of the project area contain many data and are designated as the Turtle and Manitowish "ranges,"; two parts have fewer data and are designated the Vieux Desert and Conover "districts"; undesignated tracts have very sparse or no data (Figure 1). The term "range" implies possible or inferred geologic and magnetic similarity to the major iron-bearing areas of the Lake Superior region.

The location and kinds of exposed or inferred Precambrian bedrock, location of drill holes and kinds of rock penetrated, and the inferred areal geology in the project area were represented on maps at 1:500,000 scale by Dutton and Bradley (1970).

Appreciation is expressed to mining companies and other interested persons for access to drill cores and records, also for data of magnetic surveys and discussion of geologic interpretations.

General Geology

Recent geologic compilations of the area include those of Cannon (in press) Morey and others (1982) and Mudrey and others (1982). They show the area to include lower Proterozoic sedimentary and volcanic units and Archean gneiss. The map pattern is inferred mostly from magnetic surveys with the iron-formations, the subject of this report, being the key magnetic markers. The general distribution of the iron ranges and districts as originally defined by Allan and Barrett (1915) is shown in figure 1. It should be pointed out that the continuity of some of these "ranges" inferred by Allan and Barrett is not totally supported by more recent interpretations. The recent aeromagnetic data allow the inference of a more complex fold structure. However, a continuity is still inferred to exist in that most, if not all, iron-formations discussed here are believed to be the same stratigraphic unit.

Most, if not all, of the iron-formations appear to be near the base of the middle Proterozoic section and are likely to be approximately correlative with each other as well as with the better known iron ranges to the north such as the Gogebic Range.

Cherty iron-formation in the several areas contains various amounts of magnetite, hematite, and some siderite but at present are not of commercial value.

Iron ore was formerly mined in commercial quantities at the communities of Iron River and Crystal Falls in Michigan (James and others, 1968), also from the Florence, Wisconsin area (T. 41 N., R. 17 and 18 E.) (Dutton, 1971).

The sedimentary and associated volcanic rocks in outcrops and penetrated by drilling are commonly steeply to vertically inclined.

The directional extent of magnetic anomalies and of exploratory data indicate a general northeasterly trend of iron formations in the two northwestern units of the area in Wisconsin and easterly trend in the two southeastern ones. Visible and inferred structure and the distribution of stratigraphic units in the project area indicate that deformation was mainly of early Proterozoic age.

Discussion of the geology in the project area will in general proceed southeasterly. The designations of the subdivisions are those used by Allen and Barrett (1915).

GEOLOGY OF MARENISCO RANGE

General Features

The Marenisco Range of Allen and Barrett (1915) refers to sparse outcrops and related magnetic anomalies determined by dip-needle surveys, and later aeromagnetic surveys, that trend southwesterly in Michigan for 12 miles from the village of Marenisco (Sec. 16, T. 46 N., R. 43 W.). The group of anomalies ranges from 1/4 mile to 2 miles wide and continues prominently southwestward in Wisconsin for 27 miles to Sec. 36, T. 43 N.,

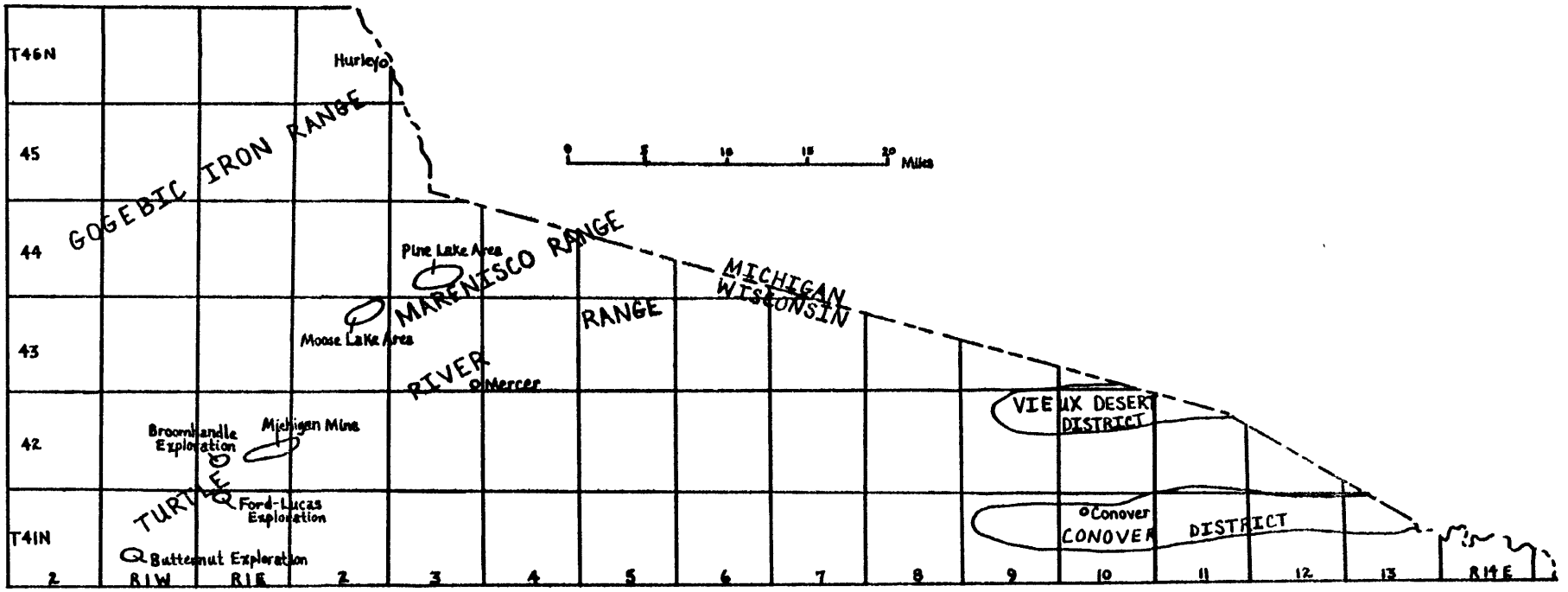

Figure 1.--Map of part of northern Wisconsin showing the location of districts and explorations discussed below.

R. 1 W. and includes the Moose Lake area and Pine Lake area of this report. The trend and extent of the anomalies in Michigan and in Wisconsin, first detected by dip needle surveys, are well corroborated by more recent aeromagnetic surveys.

Southwestward continuation of the anomalies in Wisconsin (figure 2) is verified by unpublished mining company data from dip-needle surveying that corroborated magnetic trends as far west as Sec. 9, T. 43 N., R. 2 E.

Pine Lake Area

The Pine Lake area in Iron County, Wisconsin, is about 12 to 14 miles south of the iron-bearing sequence in the Gogebic district and extends through parts of sections 26, 27, and 28, T. 44 N., R. 3 E. Outcrops of greenstone and granite are common in the northern third of the interval separating the Gogebic and Pine Lake areas, but no bedrock is exposed in the Pine Lake area.

Interest in the possibilities of direct-shipping iron ore from northern Wisconsin led to a magnetic dip-needle survey of the Pine Lake area in T. 44 N., R. 3 E. in 1912[1]. Parallel positive anomalies of

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[1]Allen and Barrett, 1915, p. 15 and 65. Field notebooks of Barrett in files of Michigan Geological Survey. Township maps showing magnetic data in files of Wisconsin Geological Survey.

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northeast trend were mapped. Fragments of old drill core were present in the SW 1/4, NE 1/4, Sec. 28, T. 44 N., R. 3 E. (Allen and Barrett, 1915, p. 65); but no record of the location or depth of that exploration has been found. Insofar as is known, the area had little or no attention for about 35 years.

However, the later possibility of beneficiating magnetic iron-formation renewed interest in the area, and exploration by diamond drilling was started in July 1954 by the Jones and Laughlin Steel Corporation[2]. Nineteen holes (see figure 2) were drilled during a three-year period and fourteen more in 1963, but no exploration for further information has been made. Most holes were in sections 27 and 28 in order to get information about the cause of a magnetic anomaly that had high dip-needle values and a general relief of 15,000 gammas according to a survey by Askania magnetometer. The total explored area was about 3 miles long and 600 to 800 feet wide. The average iron content was probably about 30 to 35 percent.

Drilling records and drill cores of the Pine Lake area indicate that chlorite schist or phyllite lies to the south of and thus above the iron-formation. The rock locally contains thin lenses and knots of calcite or less commonly some quartz. Foliation and lenses range from relatively planar to much contorted. Figure 2 shows the location of schist penetrated by drill holes and of the inferred approximate contact of schist and iron-formation at the bedrock surface. Drill hole 2601 penetrated schist in the uppermost 100 feet and also from 1400 to the end at 1421 feet.

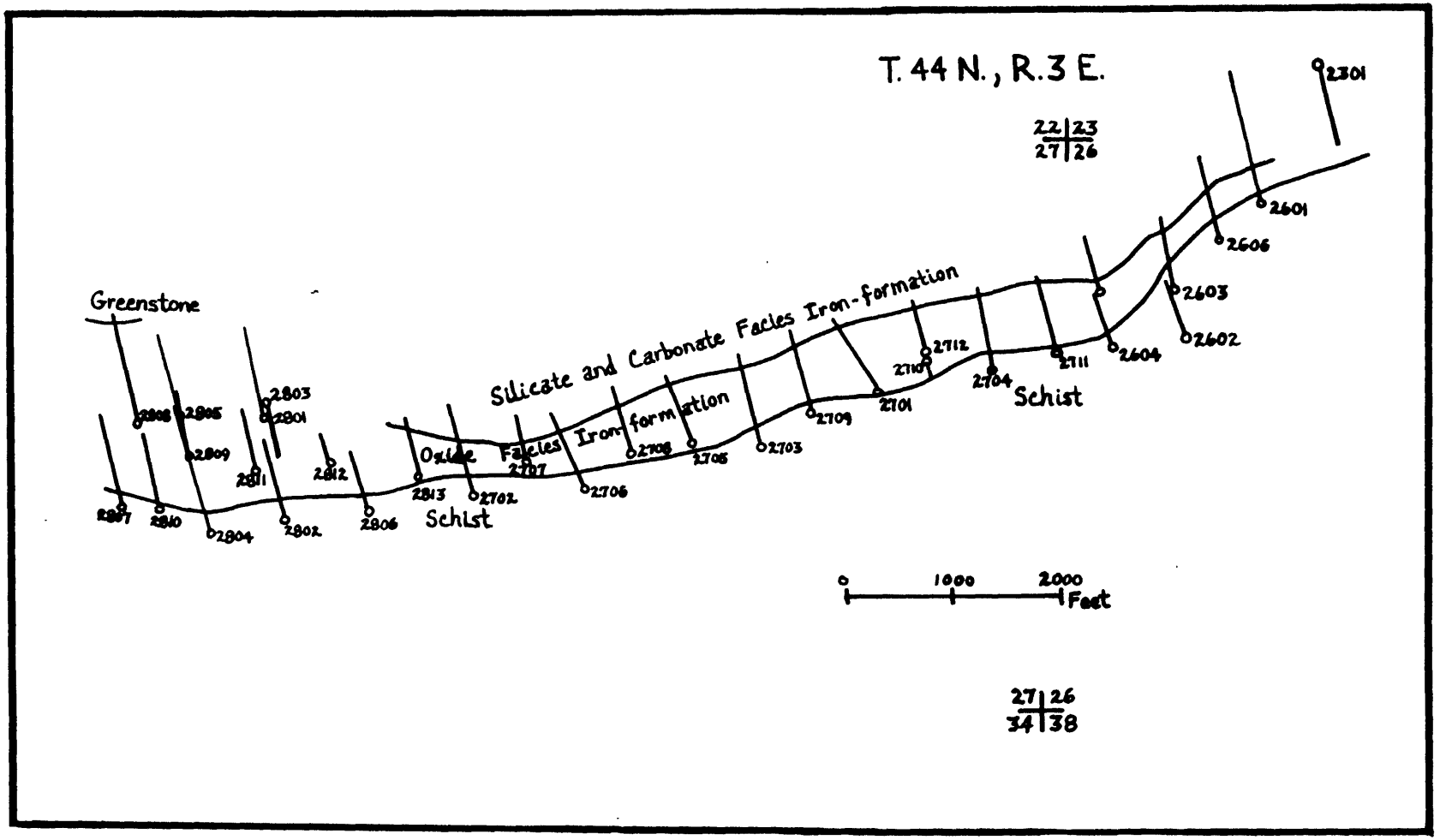

Figure 2.--Map of the Pine Lake area showing location and surface projection of drill holes and inferred geology.

The upper part of the iron-formation is mainly gray to bluish gray, very fine-grained magnetite and hematite with a wide range in the amount of interbedded, lenticular, or irregular dark gray to black chert. Drill-core samples commonly range from 23 to 33 percent soluble iron and from 20 to 25 percent magnetic iron.

A striking local difference in the lithology of this part of the iron-formation is that some magnetite-hematite layers contain few to many rounded grains of transparent quartz that are about one millimeter in diameter, and broken grains have brilliantly reflecting glassy fractures. The outer surface of cores that contain such quartz grains have a general minutely mottled appearance or the mottling may accompany a larger pattern of small tabular to lenticular fragments and irregularly discontinuous layers of chert. The dots along the drill holes indicated in Figure 2 show the location of quartz grains.

Of the 33 holes drilled, 20 ended in green to greenish gray, moderately to well-bedded iron-formation that contains fine-grained chlorite, siderite, and magnetite. Stilpnomelane and minnesotaite may also be present, but no petrographic identifications have been made. This second type of iron-formation represents a combination of oxide, carbonate, and silicate facies that underlies the oxide facies mentioned previously. Analyses of drill cores of the oxide-carbonate-silicate facies commonly range from 22 to 26 percent soluble iron and 11 to 15 percent magnetic iron; some local segments contain as much as 22 percent soluble iron but only 1.35 percent magnetic iron.

A comparison of some additional features in the Pine Lake area and in the Gogebic range is interesting.

(1) The iron-formation in both localities is composed of three sedimentary facies--oxide (magnetite and hematite), carbonate (siderite), and silicate (chlorite and minor stilpnomelane). Each facies commonly has minor to much interbedded chert. Bedding of the iron-formation in both localities is either regular and thin or irregular and thick. The Gogebic range has three stratigraphic units of thick wavy-bedded cherty iron-formation separated by units of thin-bedded cherty carbonate iron-formation. Similar lithologies are in the Pine Lake area, but the five-fold succession does not appear to be present or is less well developed.

(2) Iron-formation and underlying strata in the Gogebic range dip north. The underlying Archean complex is a mafic volcanic sequence intruded by granite. The iron-formation in the Pine Lake area dips southward; the rock north of and presumably older than the iron-formation was penetrated by only one drill hole, which passed through a gouge zone and ended in brecciated fine-grained chloritic rock intruded by granite.

(3) The iron-formation and associated rocks in both the Pine Lake area and Gogebic range are at low grade metamorphism as minor biotite is present locally.

(4) Iron-formation in the western part of the Gogebic range in Michigan dips about 15 degrees less steeply than the overlying Keweenawan sandstone and lavas. Thus, the iron-formation in pre-Keweenawan time dipped gently southward and may have extended to the Pine Lake area, or correlative iron-formation may have accumulated separately in the Pine Lake area. Post-Keweenawan rise of the crystalline Archean rocks probably draped the overlying strata causing reversal of dip along the north (Gogebic) flank and steepening of the normal dip along the south (Pine Lake) flank.

The two northern magnetic anomalies in the Pine Lake area continue westward for only 3 miles beyond the part explored by drilling and are probably terminated by a northeasterly trending fault.

Moose Lake Area

The two southern anomalies in the Pine Lake area trend progressively more southwesterly through sections 1, 2, 10, and 9, T. 43 N., R. 2 E. Drill explorations of the American Can Company by two holes in section 9 penetrated rock composed mainly of magnetite and quartz with associated amphibole, garnet, and chlorite in various local quantities and combinations. The iron content for 5-foot intervals ranged from 20 to 31 percent and for a 150-foot interval was 24.5 percent.

The magnetic anomalies extend only about 2 miles west of the drill holes, and the pattern of the magnetic contours suggests the probability of termination at a northeastern trending limit that is probably a fault.

Geology south of Pine Lake area

A few small outcrops, about one mile south of the southernmost magnetic anomaly in the Pine Lake area, are in the southwest part of section 4 and the north central part of section 5, T. 43 N., R. 3 E. The predominant rock is fine grained amphibolite, and the outcrops at the west edge of the exposures are intruded by granite. Another small area of granite is near the southeast limit of the amphibolite, but the contact relations of these rocks are not exposed.

GEOLOGY OF TURTLE RANGE

The Turtle Range (Figure 1) trends nearly parallel to the Marenisco Range for almost 40 miles in Wisconsin and for about 12 miles in Michigan. The name refers to its principal stream.

The area is characterized by discontinuous, or discontinuously magnetic, iron-formations with various associated (1) volcanic rocks near the town of Mercer (T. 43 W., R. 3 E.) and southwestward through part of T. 42 N., R. 1 W., (2) metasedimentary rocks in the more southwestern part (T. 41 N., Rs. 1 and 2 W.) near the town of Butternut, and (3) representatives of both rock classes in the northeastern part (T. 44 N., R. 6 E.) at the Wisconsin-Michigan border. The nature of the boundaries of the area and those of the principal lithologic associations in it are not known but probably are major faults.

Occurrences of banded iron-formation in the northern part of the Turtle River area accompany local exposures of younger southward facing pillowed or graded fragmental volcanic rocks west-southwest from the town of Mercer. Farther southwest in areas of magnetic anomalies but no bedrock exposure, drilling penetrated iron-formation underlain by greenstone. Drilling in T. 42 N., R. 1 W. went into bedrock that was described as "tuffaceous" for 13 feet and then continued in low grade iron-formation.

The same or similar volcanic associations probably also extend unexposed northeastward from Mercer to the Winegar site in T. 44 N., R. 6 E. according to magnetic trends in the intervening area and drilled penetration of iron-formation, altered slate, and tuff as indicated in Figure 7 of this report, which is shown on page 100 of Allen and Barrett, 1915.

Michigan Mine Area

In 1954, H. L. James of the U.S. Geological Survey examined and described core from six holes (2201-2206) (see figure 3) in section 22, T. 42 N., R. 1 E. and from four holes (2301-2304) in section 23. Nineteen thin sections were prepared from selected pieces of core. James' descriptions of representative core and of the thin sections have been examined, corroborated, and are described briefly in Table 1 on following pages 27 and 28.

Drill cores and crushed core were not available for examination by the writer.

Prints from the Ashland Mining Company are in the files of the Wisconsin Geological and Natural History Survey. Data shown include (1) general description of the kinds of materials cored, (2) related partial chemical analyses of iron content, (3) geologic cross-sections along the drill holes, and (4) related magnetic profiles based on dip-needle surveying.

This area was examined in the field by the writer in 1971, and the geologic information in Barrett's notes was corroborated. Furthermore, the ellipsoidal greenstone indicated in the cross-section in Figure 6 of the report by Allen and Barrett was verified by two areas of outcrop; one is 700 feet south of and the other is 1200 feet south-southwest of the outcrop of iron-formation. Poorly developed ellipsoids in each area indicate that the tops of the flows are southward. The iron-formation is thus overlain by greenstone, and probably underlain by phyllite and the westward continuation of the greenstone exposed along County road F (SW/4 section 9, T. 42 N., R. 2 E.) near the center of the east limit of T. 42 N., R. 2 E.

A test pit about 0.9 mile south of the greenstone penetrated garnetiferous greenschist and magnetic iron-formation.

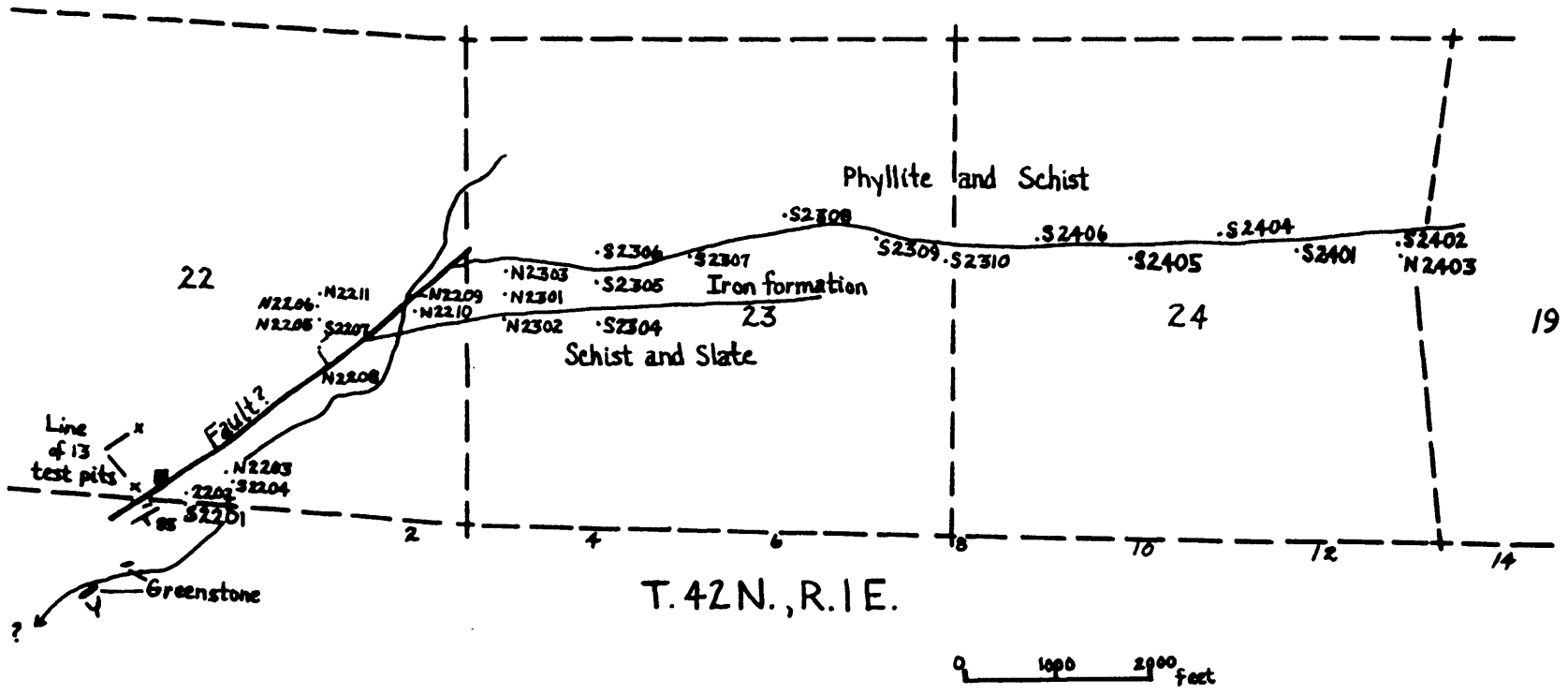

Figure 3.--Map of the Michigan Mine area showing location of drill holes, outcrops, and inferred geology.

Descriptions of iron-formation as given on the log sheets of 24 drill holes report magnetite in cores from 20 holes, specularite in 10, hematite in 8, chlorite in 12, jasper in 13 and chert in 2, phyllite in 3, and garnets in iron-formation in 10 (2208 to 2211 and 2308 to 2310 inclusive, also 2401, 2404, and 2406).

The crude iron content commonly ranged from about 25 to 30 percent and the magnetic crude iron from 15 to 25 percent.

Formations north of the iron-formation. Rock north of the iron-formation in the drilled areas, and presumably older than the iron-formation according to the dip in the single outcrop, was penetrated by six holes (see table 1).

Iron-formation.--Iron-formation in the outcrop, in dumps at the shaft and test pits, and in drill cores is dark gray, cherty, magnetitic and specularitic; it is characteristically an alternation of ferruginous and siliceous layers that differ greatly in thickness. The ferruginous layers range widely in proportions of magnetite, hematite, and specularite; they also range from laminated to massive. The siliceous layers are mainly jasper that locally have a slight to pronounced rounded or granular texture similar to oolites, but no concentric or radial patterns are present. The jasper is predominantly a fine-grained (0.05-1.0 mm) quartz mosaic in which hematite grains less than 0.01 mm or hematite blades to 0.1 mm are in circular or oval areas. H. L. James mentions the presence of grunerite in some pieces of core, but none was identified by the writer. Biotite is common in some thin sections of iron-formation, and carbonate was present in several other sections.

Drill data indicate that a phyllite and schist unit is about 50 feet thick at hole 2202 and 120 feet thick at hole 2403, but data elsewhere are insufficient for even an estimate. The thickness of the underlying amphibolite, "greenstone porphyry," and "porphyritic green schist" is unknown but was penetrated more than 25 feet at hole 2202 and more than 65 feet at hole 2403. These materials are similar to and probably part of a unit that may include the exposed porphyritic amphibolite in the northwest part of section 23, T. 42 N., R. 1 E., as mentioned previously.

Rocks south of the iron-formation.--Rock south of the iron-formation was penetrated by five drill holes (fig. 3). Core from hole 2204 near the west end of the exploration is designated on the prints as chlorite schist, and chlorite schist with calcite. Chlorite schist with calcite beds is also recorded on prints pertaining to holes 2204 and 2302, and 2406. James' description of core from holes 2204 and 2302 shows comparable amphibolite and coarse carbonate.

The fifth hole south of the iron-formation was 2304. The bedrock was penetrated for only 73 feet and, according to the description on the prints, was probably a quartzose and micaceous part of the iron-formation.

Table 1.--Rocks north of the iron-formation at Michigan mine area

Sec. 22, T. 42 N., R. 1 E. (Wisconsin)

Hole	Length and direction	Drilled interval in feet	Rock description	
			Drilling record	James' record
2202	570N	500-570	Phyllite.	Laminated phyllite. Some quartzose layers in lower part.
	625N	570-625	Greenstone porphyry.	Light greenish amphibolite with original porphyritic texture (white feldspar phenocrysts).
2205	140N	26-140	Phyllite and chlorite schist.	Amphibolite, fine- to medium-grained; streaked feldspars. Strong fabric; actually a schist.
2211	350N	265-285	Light gray phyllite.	No data.
		285-305	Light green porphyry.	
		305-325	Phyllite with iron-formation bands.	
		325-350	Fine-grained graywacke and pegmatite.	
2303	300N	215-300	Chlorite phyllite.	Laminated phyllite, perfect cleavage with lustrous mica, parallel to lamination.
2306	517S	19-97	Phyllite with pegmatite.	No data.

continued.

Table 1 continued.

Hole	Length and direction	Drilled interval in feet	Rock description: Drilling record	Rock description: James' record
2403	386N	105-249	Mainly gray mica schist.	No data.
		249-286	Porphyritic green schist.	No data.

The eastward continuation of the iron-formation for about 2 miles to hole 2401 appears not to be folded. The marked decrease in thickness from more than 1100 feet at hole 2401 to 11 and 12 feet of iron-formation separated by 7 feet of mica schist cut by hole 2402 may be due to faulting or to decrease in original thickness during deposition. The magnetic intensity also decreases rapidly, and a weak anomaly does not continue more than one mile.

A cross-section representation that includes the two drill holes near the shaft shows one hole to be vertical and the other to be inclined 45 degrees northward. The indicated dip of stratification is 80 degrees southward and quite comparable to that in the outcrop. All other cross-sections, however, show prevalent dips to range from vertical to 80 degrees northward, but no pair of drill holes cut the same limit of any stratigraphic unit and thus permit determination of the dip. Similarly, a dike shown in a vertical section near the shaft was cut by one hole and is also shown as dipping 80 degrees northward; and the dip of dikes in all other sections is shown to range from vertical to 77 degrees northward. Neither edge of any dike was cut by two drill holes in the same cross-section.

As mentioned previously, ellipsoids in greenstone south and southwest of the shaft indicate a southward facing sequence.

Exploration in sections 32 and 31, T. 42 N., R. 1 E.

A magnetic anomaly through the south half of sections 32 and 31, T. 42 N., R. 1 E. was the basis for drilling exploration by the Snyder Mining Company. The anomaly is about 4500 feet long and is 1000 to 1200 feet wide. The crest of the anomaly 100 feet north of drill hole 1 has a value of 75 dip-needle scale divisions but 47 divisions at 1000 feet west of that hole. The anomaly has a value of 50 scale divisions north of hole 7, 60 divisions north of hole 3, then 30 divisions 1000 feet east of hole 3, and 15 divisions 1500 feet east of hole 3. The decrease in values eastward probably indicates decrease in magnetite content or in thickness of the iron-formation or combined changes.

Bedrock exposed during excavation for road gravel about 700 feet east of the center of section 3 is greenish gray sericitic schist with small garnets and little to much fine-grained magnetite. Associated material is light gray to dark brown layers of fine-grained quartz (recrystallized chert) that contain little to much fine-grained magnetite. The strike is eastward and dip is vertical. These rocks are probably at the north limit of a shear zone between the Turtle River area and the Manitowish area to the south.

No outcrops, test pits, drill holes, or prominent magnetic anomalies are known to be present for about 35 miles along the south side of the Turtle range from the east side of T. 41 N., R. 1 E. to the Winegar exploration near Presque Isle, Wisconsin, in the south-central part of T. 44 N., R. 6 E.

Very different bedrock is exposed along County Road F at the southeast edge of section 3 and adjacent section 10. The most abundant materials are well foliated assemblages of quartz, biotite, almost white feldspar, and elongate hornblende that locally are amphibolite, gneiss, or schist in various proportions. Outcrops of those rocks in the western part of this area are cut by coarse-grained pink granite, and both are cut by very fine-grained mafic rocks.

Ford-Lucas Exploration

The early Ford-Lucas exploration was a series of 9 test pits near the center of the NE 1/4 sec. 5, T. 41 N., R. 1 E. as shown by Figure 4 of Allen and Barrett (1915, page 91). The rocks at the pits are indicated in ascending order to the south as quartzite and mica schist, iron-formation, and black slate.

According to Allen and Barrett, a width of about 600 feet of gruneritic and magnetitic iron-formation with associated chert was indicated by the tests pits. No data are given as to strike or dip, and no rocks are exposed at present. Material north of the iron-formation was penetrated by two of three test pits and was reported to be "grading into quartzite," but the material now available appears to be recrystallized chert with some associated magnetite and amphibole (grunerite ?). There are no test pits for about 350 feet beyond the probable south limit of the iron-formation. One fragment of black slate presumably from a pit 500 feet south was reported by Allen and Barrett, but bedrock was not penetrated by an adjacent pit 70 feet to the north or another one 20 feet to the south.

The Ford-Lucas area was also explored in 1957 by diamond drill hole 502 of the Ashland Mining Company, an exploratory cooperative of Pickands-Mather and McClouth companies. The approximate location of the hole was 3,850 feet north along the road through the center of section 5 and then 1,100 feet east of that point. The hole was inclined northward at about 65 degrees and was 922 feet long. Core was not available for examination in this study because it had been crushed and ground for concentration tests. A description of the core given on prints by

Pickands-Mather & Co. in the files of the Wisconsin Geological and Natural History Survey is summarized as follows. The iron-formation is overlain by the downward succession of chlorite schist (26-117 feet), sericitic slate (117-140 feet), carbonate iron-formation (140-354 feet), a thin brecciated zone, and a thinly sheared and crumpled zone (354-501 feet). Magnetic iron-formation was penetrated from 501 to 861 feet, and associated pyrrhotite was locally present from 745 to 874 feet.

Approximately 450 feet south and 250 feet east of the probable location of drill hole 502 is a very local area of small angular fragments of thinly bedded chert-grunerite rock that is slightly magnetic.

Drill hole 501 of the Ashland Mining Company was 1,920 feet northward along the west side of the road through the center of section 5. This location is 350 feet south of an anomaly of 50 gammas and of N. 70 W. trend. The hole was inclined northward and was 1,003 feet long. The company record of core classification indicates that iron-formation penetrated from 165 to 1,003 was moderately to highly magnetic, cherty to slaty, and had associated zones of graphitic slate with "scattered sulphides."

T. 41 N., R. 1 W., and 1 E.

Iron-formations in the southwest part of T. 41 N., R. 1 W. and the northern part of T. 41 N., R. 1 E. are metamorphosed, composed of layers that are mainly granular magnetite, locally with grunerite and garnets, separated by layers that are dominantly granular quartz (recrystallized chert). Strata associated with the iron-formation vary from fine-grained graphitic to phyllitic and quartzose rocks to medium-grained garnet-biotite schists. The iron-formations and associated rocks strike east-northeast and are steeply southeastward to vertically inclined.

The projected trend of occurrences of iron-formation and associated metasedimentary rocks in the northern part of T. 41 N., R. 1 E. is less than one mile south of the iron-formation underlain by greenstone at the Snyder Mining Company exploration in sec. 31, T. 42 N., R. 1 E. The iron-formation in section 31 was reported to be overlain by "schist and slate," and further information has not been found.

Butternut Exploration

The crest of a magnetic anomaly about 1 1/2 miles long extends east-northeasterly from the SW 1/4, NW 1/4, section 29 to the SE 1/4, SW 1/4, section 21, T. 41 N., R. 1 W. The maximum dip-needle value is 85 scale divisions above the norm and is near the center of the NE 1/4 of section 29. Values decline to 40 scale divisions within one mile northeast and southwest.

Information from the drilling indicates that the explored area is underlain mainly by steeply southward dipping cherty iron-formation that locally contains masses of infolded or infaulted schist and intrusive or infaulted granite. Schist south of iron-formation was penetrated by one or more drill holes in each of the 12 drilled sections, and the contact

of these rocks generally dips 85 degrees northwest but at the west end is locally southeast. Six drill holes passed through one or more areas of schist with iron-formation on each side, but it is not known whether the contacts were of stratigraphic or structural origin. Twenty-one drill holes passed through iron-formation and one or more occurrences of granite. Rocks north of the iron-formation were penetrated by seven drill holes; two were in granite only, two in schist only, and three were in granite and schist.

The iron-formation is fine-grained magnetite and specular hematite with locally to commonly associated gray chert or jasper as layers, lenses, or fragments. Some parts of the iron-formation contain rounded glassy quartz grains as much as 0.5 mm in diameter.

Rocks between areas of iron-formation are mainly quartz-garnet-biotite schist. Locally garnets are as much as 2 cm in maximum dimension. The rocks range from non-magnetic to moderately magnetic. Irregular lenses of serpentine with minor calcite and quartz are in moderately foliated biotite with minor hornblende. Poorly layered to massive fine-grained hornblende-garnet-quartz rock is slightly magnetic and locally contains disseminated fine-grained iron- or copper-bearing sulphides, or both (Dutton, 1972).

Two kinds of rocks are prevalent north of the iron-formation. Fine-grained nonfoliated muscovite-biotite-quartz is locally somewhat magnetitic. Fine to very fine-grained hornblende has various associations of biotite, quartz, and feldspar.

The most common rocks south of the iron-formation are well foliated and are composed mainly of biotite and quartz. Less well foliated varieties in this general type result from lenticular to irregularly distributed biotite and quartz and also from different ratios of minor to moderate amounts of chlorite, hornblende, and serpentine. Calcite is locally sparse to abundant as veinlets, irregular lenses, and layers. Non-foliated rocks are layered or not layered. One type of layered rock is composed of hornblende, quartz, garnet, calcite, magnetite, pyrite, and minor chalcopyrite; an associated type contains hornblende, biotite, and quartz. A third variety is composed mainly of serpentine(?), hornblende, calcite, and accessory magnetite. Rocks that are not foliated or layered contain (1) hornblende, serpentine, red or white feldspar, and quartz, (2) hornblende and gray feldspar with small granitic pods, (3) finely granular quartz and biotite, and (4) biotite, muscovite, and anhedral garnets to 1 by 2 cm.

T. 41 N., R. 1 W.

North Butternut Exploration.--Allen and Barrett do not mention T. 41 N., R. 1 W., but a later magnetic survey led to diamond drilling in section 9.

Zones of low-grade magnetic iron-formation and much garnetiferous chlorite schist were penetrated in 1956 by diamond drill hole 901 in section 9, T. 41 N., R. 1 W.

Section 3, T. 41 N., R. 1 E.

The Whiteside exploration by 12 test pits in the northwest quarter of the section was examined in 1912 by L. P. Barrett (Allen and Barrett, 1915, p. 93-94) and in 1972 by the writer.

The trend of anomalous magnetic values extends east-southeastward across the northwest quarter of the section, and the two southern pits were presumably located with reference to a magnetic anomaly of as much as 60 dip-needle scale divisions. The material now available in the dumps is, however, mainly very fine-grained recrystallized chert that is light to dark gray or yellow to brown; maroon and bluish gray chert are also present but not common. Only a very few specimens attract a magnet even slightly. Barrett's field notes state that "...taken as whole, dump is pretty cherty." Barrett also noted that the northern two pits did not reach bedrock, as was confirmed during examination in 1972.

Another area of high magnetic values trends eastward across the northern part of the south half of section 3. The dip-needle readings along a line north from the center of the section rise to an anomaly of 33 scale divisions in a distance of 775 feet, and 9 of the 11 test pits along or near this line penetrated bedrock. Most of the magnetic attraction is caused by magnetite-bearing recrystallized chert that is interlayered with chert that contains little or no magnetite. Magnetite-bearing very fine sericitic (?) schist is locally present, and bladed pyrrhotite is with magnetite at the southernmost pit of this group. Magnetite and recrystallized chert are also in the dump of the test pit about 100 feet south of the center of section 3. Five of six other test pits farther south did not reach bedrock and magnetic values are low. The probable total width of the known magnetite-bearing unit is about 750 feet.

Three pits over a distance of 190 feet north of the magnetite-bearing unit were in locally foliated but mainly massive graphitic slate that contains 1/16-inch flakes of muscovite. Many quartz-filled fractures and cavities are present. Dip-needle readings in this part of the area were five scale divisions higher than those related to the magnetite-recrystallized chert unit about 350 feet south. No magnetite or pyrrhotite was seen, and the cause of the magnetism is not known.

Mercer Area

Magnetic anomalies in an area of exposed mafic extrusives and intrusives about a mile to a mile and a half northwest of Mercer, Wisconsin, were the basis for drilling six holes in section 26, T. 43 N., R. 3 E. (fig. 4). The reported results were summarized by Allen and Barrett, 1915, p. 97-99 as follows.

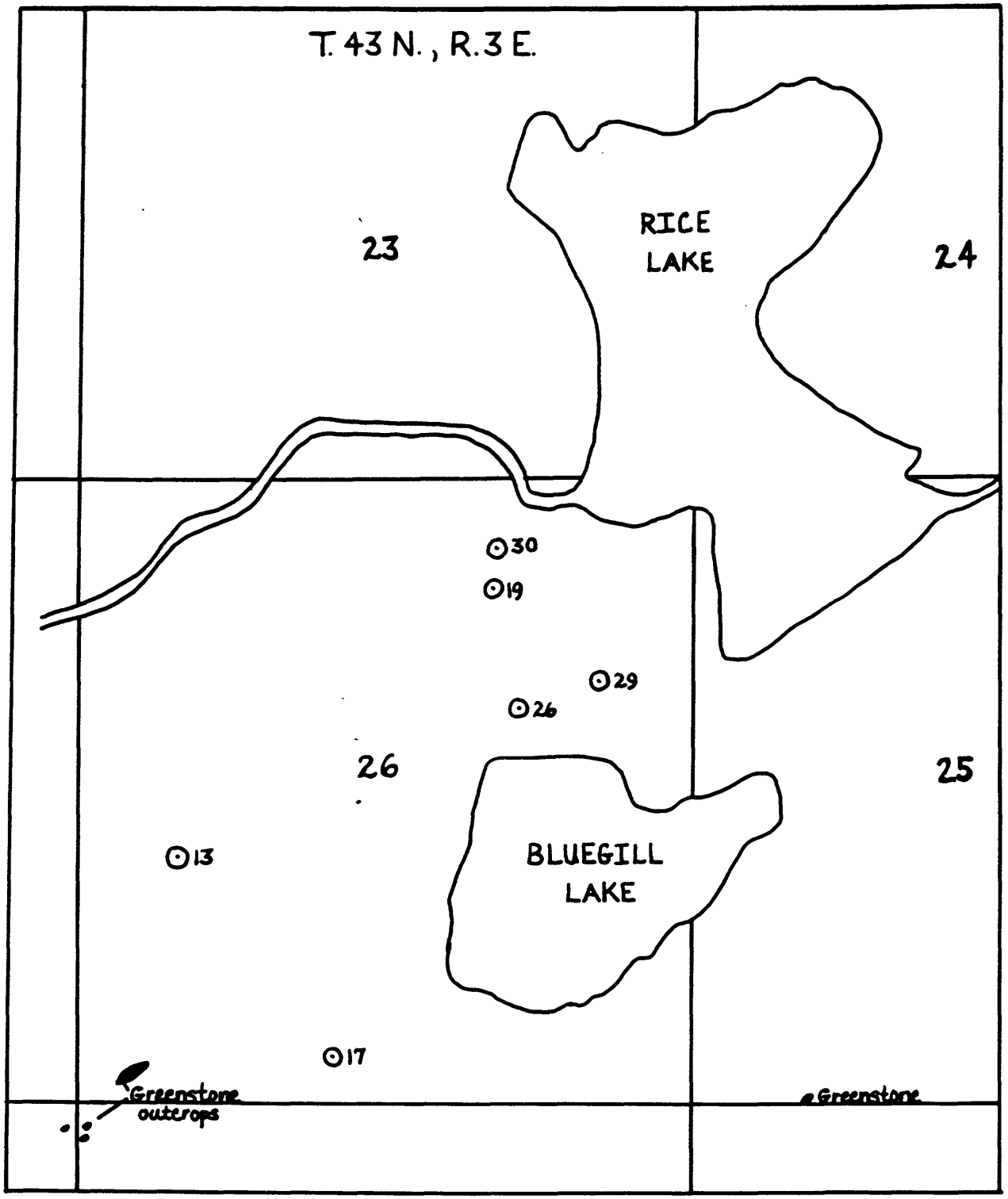

Figure 4.--Map of the Mercer area showing the location of drill holes and outcrops.

Table 2
Exploration near Mercer, Wisconsin

Drill Hole Number	Depth	Description of bedrock
13	115-138	Diabase
17	174-190	Thick layers of gray quartz (recrystallized chert?) alternating with less thick bands of light brown amphibole (grunerite) and others nearly black containing magnetite. Metamorphosed iron-formation.
	190-217	Magnetic black rock at 208 feet contained 29.1 percent iron.
19	79-101	Interlayered black chert and cherty bands containing amphibole (green hornblende and grunerite?) and garnet; scattered biotite and pyrite; fine-grained magnetite in amphibole and garnet. The rock is metamorphosed iron formation.
26	26-51	Coarse-grained amphibolite
29	25-40	Coarse-grained greenstone
30	152-172	Greenstone

VIEUX DESERT DISTRICT

The Vieux Desert district extends eastward from the northwest corner of T. 42 N., R. 9 E., through T. 42 N., R. 12 E.; it is mainly about 3 to 4 miles wide, is 15 miles long in Wisconsin, and possibly extends about 6 miles into Michigan. There are no outcrops in the district, but magnetic surveying with dip needle indicated several linear positive anomalies, and subsequent drilling of 10 holes revealed that the glacial drift is from 106 to 211 feet thick. The thickness of bedrock penetrated ranged from 5 to 100 feet, and no iron-formation was found. Four holes were reported to be in quartz-mica schist and gneiss with associated pegmatite and granite dikes; some schist and gneiss contained garnet or kyanite, and others were characterized by pyrite and graphite. Two holes were in granite only. The stratigraphy, structure, and cause of the magnetic anomalies are not known.

CONOVER DISTRICT

The Conover district is about 3 miles wide and 25 miles long, extending from the middle of T. 41 N., R. 9 E., to the middle of T. 41 N., R. 13 E. Bedrock is not exposed in the area, but dip-needle magnetic

surveying indicated several linear positive anomalies of about 5 to 10 scale divisions, and 17 holes were drilled as part of the exploration by the Carpenter Syndicate. The overburden ranges from 84 to 220 feet in thickness, and bedrock was penetrated for depths from 14 to 160 feet. No material penetrated contained sufficient iron to warrant designation as iron-formation, and the cause of the anomalies was not positively determined. Magnetite reported to be present at three sites was in chlorite schist, gray slate, and serpentine but was only a subordinate constituent; the only analysis given was 7.5 percent iron for a 4-foot thickness. Ferruginous slate was most common and was reported at seven sites, but analyses given were only 11 and 32 percent iron for a 3-foot thickness in two holes. Oxidation extended as much as 75 feet locally and material containing 40 percent iron was penetrated by several holes. Two holes were in granite and two in schist and granite. The stratigraphic and structural relations have not been deciphered, but Allen and Barrett (p. 124) suggested that the sedimentary and metasedimentary rocks might be continuous with those in the Iron River area of Michigan about 10 miles eastward.

References

Allan, R. C., and Barrett, L. P., 1915, Contributions to the Precambrian geology of northern Michigan and Wisconsin: Michigan Geological and Biological Survey Publication 18, Geological Series 15, p. 13-164.

Cannon, W. F., in press, Bedrock geologic map of the Iron River 1° x 2° quadrangle, Michigan and Wisconsin: U.S. Geological Survey Miscellaneous Investigations Map I-1360b, scale 1:250,000.

Dutton, Carl E., 1971, Geology of the Florence area, Wisconsin and Michigan: U.S. Geological Survey Professional Paper 633, 54 p.

James, H. L., Dutton, Carl E., Pettijohn, F. J., and Wier, K. L., 1968, Geology and ore deposits of the Iron River-Crystal Falls District, Iron County, Michigan: U.S. Geological Survey Professional Paper 570, 134 p.

Morey, G. B., Sims, P. K., Cannon, W. F., Mudrey, M. G., Jr., and Southwick, D. L., 1982, Geologic map of the Lake Superior region, Minnesota, Wisconsin and northern Michigan: Minnesota Geological Survey State Map Series S-13, scale 1:1,000,000.

Mudrey, M. G., Jr., Brown, B. A., and Greenberg, J. K., 1982, Bedrock geologic map of Wisconsin: University of Wisconsin Extension, Geological and Natural History Survey, scale 1:1,000,000.