Geology of the Rewey and Mifflin Quadrangles, Wisconsin

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By ALFRED R. TAYLOR

GEOLOGY OF PARTS OF THE UPPER MISSISSIPPI VALLEY ZINC-LEAD DISTRICT

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CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

GEOLOGY OF PARTS OF THE UPPER MISSISSIPPI VALLEY ZINC-LEAD DISTRICT

GEOLOGY OF THE REWEY AND MIFFLIN QUADRANGLES, WISCONSIN

By Alfred R. Taylor

ABSTRACT

The Rewey and Mifflin quadrangles comprise 109 square miles in the zinc-lead mining district of southwestern Wisconsin, which is part of the Driftless Area. The main topographic features are mounds or hills, flat divides, wide flood plains bounded by steep banks, and many small V-shaped valleys. In general, the surface of the flat divides dips southward less than 20 feet per mile probably reflecting the gentle southerly dip of the strata. Local relief from the top of the divides to the larger streams is between 180 and 280 feet, but the maximum relief is about 610 feet.

Exposed marine strata aggregate more than 630 feet of dolomite, limestone, shale, and sandstone and range in age from Early Ordovician to Early Silurian. From 5 to 10 feet of loess and alluvium of Quaternary age and soil cover the bedrock in most places. Quartz sandstone boulders of unknown age occur locally.

The marine strata in ascending order are: Prairie du Chien Group of Early Ordovician age; St. Peter Sandstone, Platteville Formation, Decorah Formation, and Galena Dolomite of Middle Ordovician age; Maquoketa Shale of Late Ordovician age; and Edgewood Dolomite and Kankakee Formation of Early Silurian age.

The Prairie du Chien Group is light-gray to yellowish-orange very fine- to coarse-grained cherty dolomite and is separated from the overlying St. Peter Sandstone by an irregular contact.

The St. Peter Sandstone is generally from 40 to 80 feet thick but may be more than 100 feet thick locally where it fills depressions in the underlying Prairie du Chien Group. This formation consists of white to yellowish-brown fine- to coarse-grained quartz sandstone.

The Platteville Formation is 52 to 63 feet thick and is divided into four members, which in ascending order are: Glenwood Shale, Pecatonica Dolomite, McGregor Limestone, and Quimbys Mill Members. The Glenwood Shale Member consists of about 1 foot of moderate olive-brown, grayish-green, and yellowish-green sandy shale. The Pecatonica Dolomite Member is 20 feet thick and is yellowish-gray to olive-gray fine- to medium-grained dolomite. The McGregor Member is about 30 feet thick and is pale-yellowish-brown to light-gray sublithographic to fine-grained limestone and dolomite.

The Quimbys Mill Member thickens from 1 foot in the northwestern part of the mapped area to about 13 feet in the southeastern part. This member

consists of dark-yellowish-brown to pale-yellowish-brown sublithographic to very fine grained limestone and pale-yellowish-brown to dusky-brown very fine to fine-grained dolomite.

The Decorah Formation is 33 to 40 feet thick and is divided into three members, which in ascending order are: Spechts Ferry Shale, Guttenberg Limestone, and Ion Dolomite Members. The Spechts Ferry Member thins from about 8 feet thick in the northwestern part of the mapped area to about 6 inches thick in the southeastern part. This member is pale-yellowish-brown to pale-greenish-yellow sublithographic and very fine to fine-grained limestone and, locally, dolomite. White bentonite is near the base. In the western part of the mapped area grayish-yellow-green shale occurs at the top.

The Guttenberg Member is about 12 feet thick but near sulfide mineral deposits is altered to a dusky-brown shaly residue and is as little as 4 feet thick. This member consists of dark-yellowish-brown to pale-yellowish-brown fine-grained to sublithographic limestone, dolomite, and dusky-brown shale.

The Ion Dolomite Member is about 20 feet thick and is yellowish-gray, olive-gray, and dark-greenish-gray fine- to medium-grained dolomite and, locally, limestone.

The Galena Dolomite is divided into three members which, in ascending order are: Prosser Cherty Member, Stewartville Massive Member, and Dubuque Shaly Member. For mapping purposes, however, the Galena Dolomite is divided into a lower cherty unit and an overlying noncherty unit. The cherty unit averages about 102 feet in thickness and consists of grayish-orange medium- to fine-grained cherty dolomite. The noncherty unit is 120 feet thick and consists of pale-yellowish to grayish-orange very fine to medium-grained dolomite.

The Maquoketa Shale is about 130 feet thick and is olive-gray to dark-yellowish-orange shale and very fine grained dolomite. The base is marked by a zone of phosphatic nodules and small fossils. The top of the Maquoketa Shale is probably an erosional unconformity.

The Edgewood Dolomite is about 145 feet thick and consists of olive-gray, yellowish-gray, and grayish-orange fine- to medium-grained cherty dolomite and some shale. The Kankakee Formation is represented by less than 5 feet of chert.

Regionally the strata dip southward 15 to 20 feet per mile. Superimposed on this regional structure are: broad, gentle asymmetric folds as much as 7 miles long; small folds as much as 2 miles long; joints; and faults having less than 1 foot displacement. The largest fold is an asymmetric anticline which has a south limb that dips less than 1° S. and a north limb that dips an average of 4° N. A syncline about 5 miles long and 1 mile wide parallels the north limb of the anticline and has a closure of about 50 feet.

All the rocks except the Maquoketa Shale and the St. Peter Sandstone have many vertical, and a few inclined, joints. Jointing in the St. Peter Sandstone is poor. The dominant joint set trends N. 75°–85° E. Subordinate joint sets trend northwestward and northeastward.

Mining of lead ore began about 1830 and of zinc ore in 1864. Since the late 1800's most of the lead ore has been a byproduct of zinc mining. The last mining in the mapped area was in 1947. The total amount of lead and zinc ore recovered from the mapped area was about 900,000 tons.

Pitch-and-flat deposits contain mainly zinc ore, and gash-vein deposits contain mainly lead ore. The pitch-and-flat deposits, economically the more important type, are veins of ore and gangue minerals along fractures that are inclined to or parallel to bedding planes in the upper part of the Platteville Formation, the Decorah Formation, and the lower part of the Galena Dolomite. The veins range from a few inches to 2 feet in thickness and average about 4 to 6 inches. Pitches are veins in inclined fractures or fracture zones that commonly dip away from each other. In plan, pitches are arcuate or linear. Flats are horizontal veins along bedding-plane fractures that join pitch fractures. Flats are on the footwall side of the pitch, and some extend to the opposing pitch. Most of the pitch-and-flat deposits are in or on the flanks of synclines, and the dip of the pitches averages 45° away from synclinal axes.

A tectonic theory and a solution-and-collapse theory have been postulated to explain the origin of the fractures that contain pitches and flats. The tectonic theory postulates that the fractures are reverse and bedding-plane faults resulting from compressive forces. The solution-and-collapse theory postulates that the fractures result from slump and sag of beds into voids caused by thinning of limestone where ore-bearing or related solutions came through preexisting tectonic fractures.

The joint-controlled gash-vein deposits consist mainly of galena and are generally in the Galena Dolomite. The gash veins range in width from a fraction of an inch to several feet, but average only a few inches. These veins are along joints that may have been opened through solution by ore fluids and subsequently enlarged by ground water. Deposits of galena occur as thin veins, as coatings on walls of open joints, and as fragments in debris at the bottom of the opening.

Various theories on the origin of the sulphide ores have been postulated; current theory postulates that the ores are of hydrothermal origin.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Rewey and Mifflin quadrangles comprise approximately 109 square miles in the north-central part of the zinc-lead mining district in southwestern Wisconsin (fig. 43). The Mifflin quadrangle is in the northwestern part of Lafayette County and the southwestern part of Iowa County. The Rewey quadrangle is adjacent to and west of the Mifflin quadrangle and is in Grant, Iowa, and Lafayette Counties.

Good roads provide access to all parts of the quadrangles. The main roads are State Highway 80 in the Rewey quadrangle and U.S. Highway 151 in the Mifflin quadrangle (pl. 20). The Chicago and North Western Railway crosses the southwestern part of the Mifflin quadrangle and the northeastern part of the Rewey quadrangle.

The centers of population are the villages of Rewey in the northeastern part of the Rewey quadrangle and Mifflin in the northwestern part of the Mifflin quadrangle. Larger centers nearby are Platteville, population about 5,800, which is 1½ miles south of the Rewey

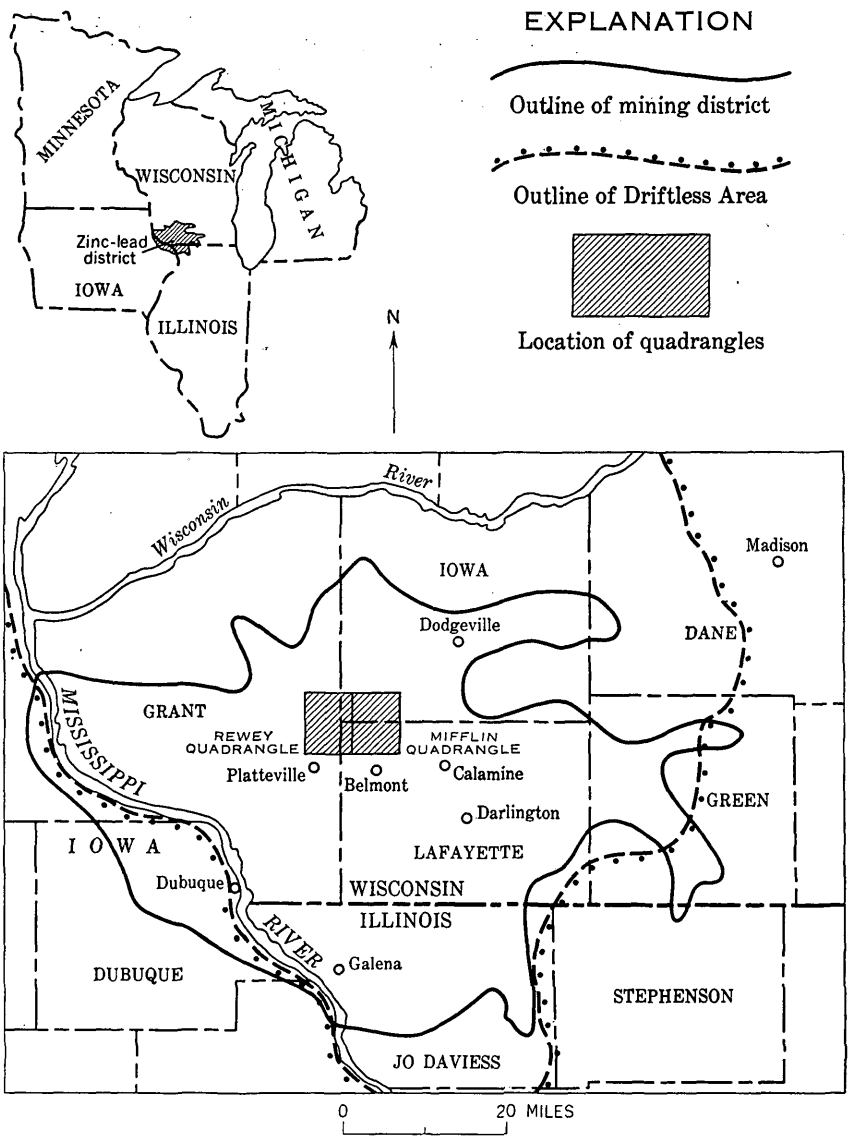

FIGURE 43.—Index map of southwestern Wisconsin, northwestern Illinois, and northeastern Iowa showing the location of the Rewey and Mifflin quadrangles.

quadrangle, and Mineral Point, population about 2,200, which is 5 miles east of the Mifflin quadrangle on U.S. Highway 151.

TOPOGRAPHY AND DRAINAGE

The Rewey and Mifflin quadrangles are in southwestern Wisconsin, which is part of the Driftless Area, the nonglaciated part of the Upper Mississippi Valley. Topographic features in the mapped area are large flat divides, streams with steep banks and wide flood plains, small V-shaped stream valleys, and mounds or hills that stand above the highest divides or uplands. Local relief, as measured from the streams to the tops of the flat divides, generally ranges from 180 to 280 feet, but the maximum relief is about 610 feet. The altitude above sea level ranges from less than 830 feet along the Little Platte River near the southwest corner of the Rewey quadrangle to about 1,440 feet at the north end of Platte Mounds in the SE$\frac{1}{4}$ sec. 31, T. 4 N., R. 1 E. Platte Mounds is the highest topographic feature in the central part of the mining district.

The surfaces of the flat divides commonly slope southward about 20 feet per mile, but the general uniformity is interrupted by three mounds in secs. 3 and 5, T. 3 N., R. 1 E. Grant and Burchard (1907) and Trowbridge (1921) called this southward-sloping surface the Lancaster peneplain. The surface bevels the rocks at the crest of an anticline south of Arthur, Wis., and this fact supports the theory that the surface is a peneplain. On the other hand, the surface at other places apparently reflects the local structure of the rocks, as it closely parallels the regional dip of the strata.

The East Pecatonica River and the Pecatonica River drain the Mifflin quadrangle and carry the water southeastward to the Rock River. The Little Platte River drains most of the Rewey quadrangle and carries the water southward and southwestward to the Platte River. The courses of these streams are controlled by joints in many places.

PURPOSE AND METHODS OF WORK

The U.S. Geological Survey began a study of the Upper Mississippi Valley zinc-lead district in 1942 as a part of a Strategic Minerals Investigation program to determine the relation of lead and zinc mineral deposits to geologic structure and stratigraphy. The work included detailed examination of mines and selected areas in the district, a cooperative prospecting program with the U.S. Bureau of Mines (Heyl and others, 1959, p. 3, 4), and a study of stratigraphy of the rocks exposed in the mining district (Agnew and others, 1956).

In 1951 the U.S. Geological Survey started regional geologic mapping in the district. The purpose of this project was to construct maps of the geologic setting of the central part of the mining district that would be useful in the exploration for new mineral deposits.

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Since 1945 all the geologic work done in southwestern Wisconsin by the U.S. Geological Survey has been in cooperation with the Wisconsin Geological and Natural History Survey.

Field mapping was done in the Rewey and Mifflin quadrangles from 1957 to 1959. Data on outcrops and structural-control points were plotted on 1:17,000-scale aerial photographs and were compiled on 1:20,000-scale topographic base maps.

All control points, such as contacts between formations, key beds, and drill-hole collars, that were used to draw structure contours were surveyed for altitude above sea level with a telescopic alidade and plane table.

Stratigraphic studies were made and structural-control points were determined partly on the basis of information obtained from 28 churn-drill holes drilled by the U.S. Geological Survey during the fall of 1955. These holes were in areas where little information on structure could be obtained from outcrops, and the drill cuttings furnished much information about composition and thickness of the formations in the mapped area. Records of these 28 holes are given in this report. Information furnished by mining companies and drillers of water wells was also of considerable value in determining the structure and stratigraphy in the mapped area.

PREVIOUS GEOLOGICAL WORK

Many geological studies have been made in the Upper Mississippi Valley mining district, and the following list of reports includes some of the most noteworthy contributions: Owen (1840, 1847, 1848), Whitney (1854, 1858, 1862), Hall and Whitney (1862), Daniels (1854), Percival (1855, 1856), Murrish (1863), White (1870), Shaw (1873), Strong (1877), Chamberlin (1877, 1882), Grant (1903, 1906), Bain (1905, 1906), Grant and Burchard (1907), Cox (1911, 1914), Kay (1928, 1929, 1935, 1940), Kay and Atwater (1935), Behre (1935), Behre and others (1937), Bays and Raasch (1935), Bays (1938), Agnew and Heyl (1943), Willman and Reynolds (1947), Agnew and others (1956), Kennedy (1956), Reynolds (1958) and Heyl and others (1959).

Heyl and others (1959) give a comprehensive account of the geology and mine descriptions in the district. The report includes a history of the geological work and a summary of the ideas expressed by individual geologists.

A comprehensive discussion of the stratigraphy of the rocks exposed in the mining district is given by Agnew and others (1956). Recent reports on the district include: Carlson (1961), Agnew (1963), Allingham (1963), Whitlow and Brown (1963), Brown and Whitlow (1960), Mullens (1964), and Klemic and West (1964).

Work that pertains specifically to the Rewey and Mifflin quadrangles is mentioned in several publications: Hall and Whitney (1862, p. 360) and Murrish (1863, p. 11) mentioned lead diggings at Lost Grove and Mifflin in Iowa County; Strong (1877, p. 721–722), Chamberlin (1882, p. 473–475, and pls. 32 and 33), Grant (1906), and Grant and Burchard (1907) described the mines at Mifflin and prepared geologic maps of the area of this report.

Agnew and Heyl (1943) prepared a map that includes some of the northwest corner of the Mifflin and the northeast corner of the Rewey quadrangles. This map shows the areal geology, structure contours, and the mine workings.

ACKNOWLEDGMENTS

J. W. Reddy and J. W. Whitlow assisted the writer in surveying structure-control points in 1957, and R. M. Borcherding and Harry Klemic assisted in 1958. J. E. Carlson surveyed control points along the north border of the mapped area and, with J. W. Allingham, surveyed a strip about 1 mile wide on the east side of the Mifflin quadrangle. A. F. Agnew surveyed control points along the south border of the Rewey quadrangle. The points surveyed in both quadrangles by these geologists were incorporated into the work of the writer. The information furnished by well drillers and mining companies is appreciated.

The map prepared by Agnew and Heyl (1943) was used for locating and outling the mines in the mapped area, and unpublished data by Agnew and Heyl were used for locating some structure-control points. Practically all the information about mines in this report is based on information contained in older reports because the underground workings were not accessible during the period of fieldwork by the writer, 1957 to 1959.

STRATIGRAPHY

GENERAL DISCUSSION

Rocks exposed in the mapped area are marine strata ranging in age from Early Ordovician to Early Silurian, blocks from sandstone dikes that cut Middle Ordovician rocks, and deposits of alluvium and loess of Quaternary age. The marine rocks aggregate more than 630 feet in thickness, and the loess and alluvium average 5 to 10 feet in thickness.

The marine sedimentary rocks include dolomite, limestone, shale, and sandstone, and are from oldest to youngest: Prairie du Chien Group of Early Ordovician age; St. Peter Sandstone, Platteville Formation, Decorah Formation, and Galena Dolomite of Middle

Ordovician age; Maquoketa Shale of Late Ordovician age; and Edgewood Dolomite and Kankakee Formation of Early Silurian age. Formal subdivisions exist for several of the named formations but are too thin to be shown on the geologic map; the Galena Dolomite, however, is shown as a lower cherty unit and an upper noncherty unit.

The location of all outcrops and the areal distribution of the formations are shown on plate 20. A generalized stratigraphic section of the rocks exposed in the mapped area is shown on plate 21.

All formations except the St. Peter Sandstone are fossiliferous in the mapped area. No systematic study of the fossils was made, but the algal reefs in the upper part of the Prairie du Chien Group, *Prasopora* sp. in the top bed of the Decorah Formation, *Receptaculites oweni* Hall in the Galena Dolomite, and a zone of depauperate fossils at the base of the Maquoketa Shale were useful in establishing stratigraphic position. "Depauperate" as used in this report refers to the universally small size of the individual fossils and is being used as a stratigraphic term without genetic implications.

ORDOVICIAN SYSTEM

LOWER ORDOVICIAN SERIES

PRAIRIE DU CHIEN GROUP

The Prairie du Chien Group of Early Ordovician age is the oldest group of rocks exposed in the mapped area. Bain (1906, p. 18) named it for exposures near Prairie du Chien, Wis., about 50 miles northwest of the mapped area. The base is not exposed in the mapped area, but drill holes nearby indicate that it overlies rocks of Cambrian age.

The Prairie du Chien Group commonly consists of three formations, which, in ascending order, are: Oneota Dolomite, New Richmond Sandstone, and Shakopee Dolomite. However, exposures in the mapped area are poor, subdivision is impractical, and the strata are referred to in this report as a group rather than by specific formations.

Only about 40 feet of the Prairie du Chien Group crops out in the mapped area, and the total thickness is not known. Heyl, Lyons, and Agnew (1951, p. 17–22) reported that the thickness ranges from 218 to 255 feet in about 1,000 feet in a locality in the Crow Branch area, which is a mile north of the northwest corner of the Rewey quadrangle.

The range in thickness is explained by some geologists (Grant, 1906; Bain, 1906; Heyl and others, 1951, p. 4; Agnew and others, 1956, p. 273) as an erosional unconformity between the Prairie du

Chien Group and the overlying St. Peter Sandstone. Other geologists believe that the irregularities are due to deposition (Flint, 1956; Carlson, 1961, p. 104). Flint (1956, p. 418) stated that the irregular contact "is due (1) to up-swelled irregular structures called domes and (2) to solution of upper Shakopee beds [upper Prairie du Chien Group] and compaction of residues under the weight of the load of younger sediments."

In the mapped area the Prairie du Chien Group consists of light-gray,[1] olive-gray, and yellowish-orange very fine to coarse-grained[2] thin- to thick-bedded dolomite that contains chert, and interbedded shale and quartz sand lenses. The weathered surface of the dolomite is pale yellowish brown to light gray and vuggy.

Near the top of the Prairie du Chien Group the dolomite contains white fossiliferous chert as much as 5 inches thick and smaller white to gray oolitic chert nodules.

Most of the shale and sand lenses in the upper part of the group are from a fraction of an inch to 3 or 4 inches thick and several inches long. About 6 inches of green shale at the top of the group is exposed in contact with the overlying St. Peter Sandstone about 17 feet above the stream in the west-central part of sec. 11, T. 4 N., R. 1 W., and also about 40 feet west of the stream in a gully in the SW¼ sec. 15, T. 4 N., R. 1 W., near the west section line. Heyl, Lyons, and Agnew (1951, p. 21) reported a green shale, 3 to 10½ feet thick, at the base of the St. Peter Sandstone just north of the mapped area. This writer considers the shale as the top part of the Prairie du Chien Group.

A small outcrop of conglomerate composed of elongate fragments of dolomite is exposed on the slope east of the cemetery in the NE¼ SW¼ sec. 14, T. 4 N., R. 1 E. The writer interprets this rock as slump of partly consolidated rocks near algal reefs that occur at or near the top of the Prairie du Chien Group.

Algal reefs as much as 4 feet in diameter and clusters of two or more algal reefs were observed in a few places near the top of the Prairie du Chien Group. These reefs are in beds of dolomite whose dips are apparently not reflected at the top of the overlying St. Peter Sandstone. For example, in the W½ sec. 15, T. 4 N. R. 1 W., and in the NW¼ sec. 2 and SW¼ NE¼ sec. 11, T. 4 N., R. 1 E., dolomite beds in the Prairie du Chien Group dip as much as 25° where the overlying formations are almost horizontal (pl. 20). These dips are

[1] The colors given in this report are those of wet fresh surfaces, except where weathered surfaces are described. The descriptive adjectives were obtained by comparing the rocks with color chips in the Rock Color Chart, 1948, of the National Research Council, Wash., D.C.

[2] The grain size is in accordance with the Wentworth scale.

probably caused by deposition and differential compaction around large reefs in the top of the group. However, only small reefs were observed; the large reefs could not be identified positively because of poor exposures.

Where the top of the group is at the level of the flood plain, as in sec. 15, T. 4 N., R. 1 E., the area is marshy. This marshy area is probably caused by water that drains from the permeable St. Peter Sandstone onto the relatively impermeable shaly rocks in the upper part of the Prairie du Chien Group.

Although the Prairie du Chien is relatively impermeable, it is a source of a moderate amount of water that is used for farm water supplies. A few water wells have been drilled into this group in the mapped area.

Traces of iron and zinc sulfide minerals have been found in the Prairie du Chien Group just north of the mapped area (Heyl and others, 1951, p. 18–20) but not in the mapped area.

MIDDLE ORDOVICIAN SERIES

ST. PETER SANDSTONE

The St. Peter Sandstone of Middle Ordovician age is exposed along the Little Platte and Pecatonica Rivers and their principal tributaries. The sandstone was named by Owen (1847, p. 170) for exposures along the St. Peter River (now the Minnesota River) near St. Paul, Minn.

In the mapped area the St. Peter Sandstone is in irregular contact with the underlying Prairie du Chien Group and is conformably overlain by the Platteville Formation. The sandstone ranges generally from 40 to 80 feet in thickness but may be more than 100 feet thick where it fills depressions in the underlying Prairie du Chien Group. It is at least 303 feet thick at Belmont, Wis., about 1 mile south of the Mifflin quadrangle.

The St. Peter Sandstone is white to yellowish-brown fine- to coarse-grained quartz sandstone. Most of it is crossbedded, but near the top of the formation sand is in parallel, locally horizontal beds that are 6 inches to 4 feet thick. The quartz grains are clear to frosted, moderately sorted, well rounded, and subspherical. In general, the sandstone is poorly cemented, but locally it is well cemented with silica and iron oxide. A hard ferruginous sandstone, 6 inches thick, is 2 to 3 feet below the top of the St. Peter Sandstone. Above this bed the sand is loose, poorly sorted, fine- to coarse, angular to subrounded, and usually contains limonite concretions, pyrite, and disseminated green clay.

In many exposures of St. Peter Sandstone, a relatively well-cemented bed lies about 6 feet below the St. Peter Sandstone-Platteville Formation contact. The sandstone cliffs in secs. 9 and 10, T. 4 N., R. 1 E., on the south side of Williams Branch and in secs. 10, 11, 22, and 34, T. 4 N., R. 1 W., are capped by this bed.

The St. Peter Sandstone is unfossiliferous in the mapped area.

Zircon is the dominant heavy mineral, and in order of decreasing abundance the other heavy minerals are leucoxene, tourmaline, ilmenite, and anatase (Krumbein and Sloss, 1953, p. 111).

Dapples (1955, p. 467) believed that the St. Peter Sandstone was probably derived from older quartz-rich sediments from the Canadian Shield and was deposited as a continuous series of coalescent shoreline sands that migrated over a stable shelf.

PLATTEVILLE FORMATION

The Platteville Formation of Middle Ordovician age was named by Bain (1905, p. 18–19) for rocks exposed west of Platteville, Wis. It conformably overlies the St. Peter Sandstone in the mapped area, and is divided into four members, which in ascending order are: Glenwood Shale, Pecatonica Dolomite, McGregor Limestone, and Quimbys Mill Members.

The thickness of the Platteville ranges from 52 feet in the northwest corner of the Rewey quadrangle to 63 feet in the southeast corner of the Mifflin quadrangle, owing to a gradual east-southeastward thickening of the Quimbys Mill Member.

Heavy minerals in the formation are generally garnet, tourmaline, and zircon (Agnew and others, 1956, p. 276–283).

GLENWOOD SHALE MEMBER

The Glenwood Shale Member, the lowest member of the Platteville Formation, was named by Calvin (1906, p. 60, 61, 75) for exposures of 15 feet of sandy shale in Glenwood Township, Iowa, about 85 miles to the west. In the mapped area, it is from 0.8 feet to 1.3 feet thick. Generally, the Glenwood Shale Member is poorly exposed except in gullies, where it forms reentrants between the St. Peter Sandstone and the Pecatonica Dolomite Member.

The member consists of moderate-olive-brown, grayish-green, and yellowish-green slightly fissile sandy shale. The lower part contains rounded fine to medium clear and frosted quartz grains and is mottled with dusky-brown limonite streaks. Pyrite and limonite cement the sand grains locally. The quartz sand is similar to that in the underlying St. Peter Sandstone and probably represents a mixing of the upper unconsolidated St. Peter Sandstone with clay during deposition of the Glenwood Shale Member.

Clay in the Glenwood Shale Member exposed about 5 miles southeast of the mapped area has been identified as illite.[3]

Descriptions of the Glenwood are given in the following sections.

Outcrop at a spring in north-central part of NW¼ sec. 17, T. 4 N., R. 2 E.

	Thickness (feet)
Pecatonica Dolomite Member:	
Dolomite, light-gray, fine-grained; contains rounded medium-grained quartz grains, black phosphatic nodules, and reddish-brown shale	0.3
Glenwood Shale Member:	
Sand, frosted quartz, ferruginous, medium, rounded	.1
Clay and shale, sandy, gray; unit contains medium-rounded frosted quartz grains	.2
Ferruginous zone; sand-clay transition zone into shale below	.1
Shale, sandy, silty, moderate-olive-brown, fissile	.4
Shale, pale-yellow, sandy; medium-rounded frosted quartz	.2
St Peter Sandstone:	
Sandstone, frosted quartz, pale-yellow to white, rounded, medium-grained, soft to moderately indurated	.5
Sandstone, frosted quartz, rounded, medium-grained, hard ferruginous layer; iron-oxide cement	.4
Covered.	

Outcrop of Glenwood Shale Member exposed in north bank of stream about 15 feet above water in the NW¼NW¼ sec. 29, T. 4 N., R. 1 E.

	Thickness (feet)
Glenwood Shale Member:	
Shale, sandy, dusky-yellowish-green, mottled; fissile when dry	0.2
Clay, sandy, dusky-yellow; fine-grained, rounded quartz sand	.1
Clay, sandy, moderate-yellow; iron-oxide stains locally	.1
Clay, greenish-gray, sandy; fine-grained rounded quartz sand; scattered iron-oxide stains	.6
St. Peter Sandstone:	
Sand, quartz, grayish-yellow, fine, well-rounded, spherical, loose, argillaceous; many iron-oxide concretions	.5
Covered.	

PECATONICA DOLOMITE MEMBER

The Pecatonica Dolomite Member of the Platteville Formation was named by Hershey (1894, p. 175) for dolomite beds exposed southeast of the mapped area in the Pecatonica River valley in northwestern Illinois. It is known locally as quarry rock because it was used extensively for building stone by the early settlers. The best exposures in the mapped area are in the quarries west of the river in the NW¼SE¼ sec. 4, T. 3 N., R. 1 W., at the bridge in the NW¼SE¼ sec. 20, T. 4 N., R. 1 E., and along the road in the NE¼ sec. 34, T. 5 N., R. 1 E.

[3] Clay minerals in this report were identified by John Hosterman and Harry Klemic, U.S. Geol. Survey, by X-ray diffraction analysis.

This member, which is 20 feet thick in the mapped area, consists of yellowish-gray and olive-gray fine- to medium-grained thick-bedded dolomite. The weathered surface is usually pale-yellowish orange. Locally, the upper part is thin to medium bedded and has light-brown shale along the bedding planes. Black phosphatic (francolite) [4] nodules, 1 to 2 mm in diameter, and rounded medium quartz sand occur in dolomite in the basal 1 foot of the Pecatonica. One and, in places, two corrosion zones ⅛ to ¼ inch thick pock-marked with depressions 1 to 2 inches deep, which contain iron oxide and quartz sand, also occur in the lowest dolomite bed, just above the Glenwood Shale Member. The phosphatic nodules, quartz sand, and corrosion zones near the base of the Pecatonica are well exposed along U.S. Highway 151 at the east side of sec. 16, T. 4 N., R. 2 E., on the east border of the Mifflin quadrangle.

The Pecatonica Dolomite Member is moderately fossiliferous, but the fossils are not well preserved. Most of them are casts and molds of brachiopods and gastropods. Conodonts are in some brown shale partings. (See "Records of drill holes," USGS 5, USGS 7, and USGS 12, pages 333, 336, and 341).

M'GREGOR LIMESTONE MEMBER

Kay (1935, p. 286) named the McGregor Member from rocks exposed near McGregor, Iowa, about 50 miles northwest of the mapped area. It is called the "Trenton lime" by miners and water-well drillers in the mining district.

In the mapped area, the McGregor Member is about 30 feet thick except where altered, probably by solutions related to those that deposited iron, zinc, and lead sulfide minerals. Those solutions leached the limestone, which in places has been compacted into shaly limestone. The thinnest section observed is in a roadcut south of the stream in the south-central part of sec. 20, T. 4 N., R. 1 E., where the McGregor Member is only 18 feet thick.

The McGregor Member has two units in most of the mapped area. The lower unit, the Mifflin of Bays (1938) is generally about 17 feet thick and consists of pale-yellowish-brown to light-gray sublithographic to fine-grained thin wavy-bedded argillaceous limestone and dolomite. Shale at the bottom of the McGregor Limestone Member in the NW¼ sec. 21, T. 4 N., R. 2 E., contains illite; clay from an open joint or "crevice" at the same place contains mixed layer clay minerals. The upper unit, the Magnolia of Bays and Raasch (1935, p. 298), is generally about 13 feet thick and consists of pale-yellowish-brown to light-gray sublithographic to fine-grained limestone and dolomite. It is generally thicker bedded and more evenly bedded than the underlying unit. The thickness of each

[4] Francolite identified by X-ray diffraction analysis by Harry Klemic, U.S. Geol. Survey.

unit differs slightly from place to place but the differences are complementary. Small, almost microscopic red specks are scattered through the sublithographic limestone.

In the northwestern part of the mapped area both units of the McGregor Member are limestone except for two "islands" of dolomite; in the southeastern part of the Rewey quadrangle and the southern part of the Mifflin quadrangle, both units are dolomite. In the dolomite zone only one limestone island and one limy dolomite island were observed, but additional unexposed islands of limestone in the dolomite facies or islands of dolomite in the limestone facies may be present.

The contact of the limestone facies and the dolomite facies is in a transition zone made up generally of basal limestone and overlying dolomite that trends northeastward across the mapped area in a manner similar to that of a facies change in the Quimbys Mill Member. Some interbedded limestone and dolomite, however, occur in both units of the McGregor Member in the zone. This zone of transition is about 2 miles wide in the southwest corner and 6 to 8 miles wide in the northeast corner.

The McGregor Member contains two small corrosion zones near the upper contact at the west edge of the Mifflin quadrangle in the SE¼ sec. 9, T. 4 N., R. 1 E. These corrosion zones are similar to those in the Pecatonica Dolomite Member. In some places the upper 2 or 3 feet of the McGregor Member resembles the overlying Quimbys Mill Member. In these places the member can be distinguished by very small red specks that are not present in the Quimbys Mill Member.

The McGregor Member is very fossiliferous where it is limestone and less fossiliferous where it is dolomite. Most of the fossils are brachiopods, bryozoans, gastropods, and crinoid stems, but a few are trilobites and graptolites.

The McGregor Member is a potential zinc- and lead-bearing zone, although most of the mining has been in rocks above it. Zinc sulfide was reported in this member at the Last Chance mine (Lincoln, 1947, p. 4), and lead and barite were found at the Nigger Jim mine (Heyl and others, 1959, p. 266).

QUIMBYS MILL MEMBER

The Quimbys Mill Member of the Platteville Formation was named by Agnew and Heyl (1946) for rock exposed in a quarry about 12 miles south of the mapped area where it consists of 6 feet of limestone overlain by 6 feet of dolomite. This member is known locally as glass rock because it breaks with a conchoidal fracture and has a glasslike ring when struck with a hammer.

Agnew and others (1956, p. 262, 283) believed that a regional disconformity exists at the top of the Quimbys Mill Member because this member thins westward and the members of the overlying Decorah Formation thin and are absent to the east. Also, the upper surface of the Quimbys Mill Member locally contains pits and involutions of rocks of the overlying unit. The overlying Decorah Formation probably is conformable with the Quimbys Mill member in the mapped area.

The Quimbys Mill Member thins uniformly from 13 feet in the southeast corner of the mapped area to about 1 foot in the northwest corner (fig. 44). The only pitted surface observed in the mapped area is in a gully in the NE¼ sec. 14, T. 4 N., R. 1 W., where the member is 2½ feet thick. The pits are about 1 inch in diameter and 1 inch deep, and are lined with 1 to 2 mm of iron oxide. Some pits contain a cemented mixture of Quimbys Mill sublithographic limestone fragments, some medium- to coarse-grained limestone fragments, and fossil fragments. At other exposures of the contact between the Quimbys Mill and the overlying Spechts Ferry Shale Member of the Decorah Formation the contact is even and apparently conformable.

The Quimbys Mill Member consists of limestone and dolomite in the mapped area (fig. 44). It is limestone in the western and northern parts of the Rewey quadrangle and in a small area in the northwestern part of the Mifflin quadrangle. It is dolomite in the southeastern part of the Rewey quadrangle and in the southern half of the Mifflin quadrangle. In an area of transition between these facies, dolomite at the top thins northwestward and limestone at the bottom becomes relatively thicker.

Dolomite islands in the limestone facies are present in the northwestern part of the Rewey quadrangle where the Quimbys Mill Member is very thin, and a limestone island in the dolomite facies is in the southeastern part of the Mifflin quadrangle. Additional islands of each type may be present but are unexposed.

The Quimbys Mill limestone is dark yellowish brown to pale yellowish brown, sublithographic to very fine grained, and brittle. The beds are generally 4 to 8 inches thick, but locally they are more than 1 foot thick. A single exposure of limestone breccia, probably a solution breccia, occurs at the top of the limestone behind a barn in the SW¼SE¼ sec. 12, T. 4 N., R. 1 W. A 2-inch fucoid zone is about 0.2 foot below the top of the Quimbys Mill where the member is limestone. The limestone beds pinch and swell locally and grade into dolomite, as shown in a quarry in the NE¼NW¼ sec. 12, T. 4 N., R. 1 E.

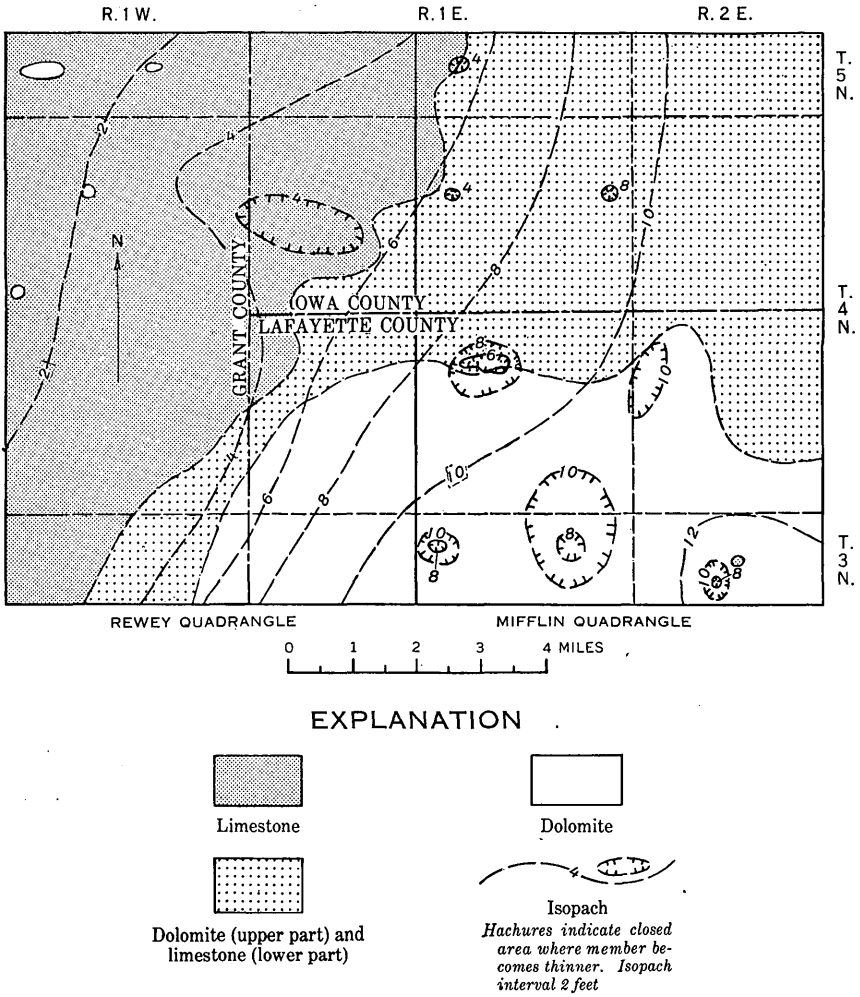

Figure 44.—Lithofacies and isopach map of the Quimbys Mill Member of the Platteville Formation in the Rewey and Mifflin quadrangles, Wisconsin.

Most of the dolomite is pale yellowish brown, very fine grained to fine grained, and medium bedded to locally thin bedded. Locally, it is altered to dusky brown. White chert nodules occur in the dolomite in a few places.

The bottom of the Quimbys Mill Member is marked by a moderate- to dark-yellowish-brown calcareous shale ¼ to 4 inches thick, and in places as many as four brown shale layers are near the bottom where the member is limestone.

The stratigraphic relationships of the dolomite, limestone, and shale of the Quimbys Mill Member are shown in the following section.

Section of the Quimbys Mill Member of the Platteville Formation exposed in a gully near a house in SW¼SE¼ sec. 33, T. 5 N., R. 1 E.

	Thickness (feet)
Dolomite, moderate-brown, fine-grained	0.9
Dolomite as in unit above, but changes laterally to limestone	.25
Limestone, light-yellowish-brown, very fine grained	.9
Shale, dark-yellowish-brown	.15
Limestone, dark-yellowish-brown, very fine grained	.5
Limestone as in unit above, with shale	.15
Limestone as in units above	.85
Limestone, light-yellowish-brown, sublithographic; brachiopods on irregular bedding surface; has fractured surface	.45
Limestone, moderate-yellowish-brown, sublithographic; has undulating fractured surface	.4
Shale, brown	.15

Small asymmetric ripple marks, as much as 1 inch in amplitude and 2 inches between crests, were observed on the surface of the Quimbys Mill limestone in the gully west of the house in the SW¼ SE¼ sec. 33, T. 5 N., R. 1 E., just about 100 feet west of the aforementioned section. They were formed by a current that flowed northeastward. Symmetrical ridges and depressions that are about 6 inches deep and about 1 foot wide trend eastward in the same exposure.

The limestone of the Quimbys Mill Member contains abundant brachiopods, some cephalopods, bryozoans, and a few trilobites. By contrast, the dolomite contains few fossils, possibly because of obliteration of organisms during diagenesis. The complete fossil assemblage has not been studied, although a few fossil lists have been prepared (Agnew and others, 1956, p. 284).

Many diggings and mines have produced zinc and lead ore from the Quimbys Mill Member, which has been an important host rock in the mapped area.

DECORAH FORMATION

The Decorah Formation of Middle Ordovician age was named by Calvin (1906, p. 60, 84) for rock exposed in Decorah, Iowa, about 80 miles west of the mapped area. In the mapped area, it consists of three members which in ascending order are: Spechts Ferry Shale, Guttenberg Limestone, and Ion Dolomite. This formation is conformable with the underlying Platteville Formation and the overlying Galena Dolomite.

Agnew and others (1956, p. 264) and Weiss (1957, p. 1032–1033) described a limestone that occurs between the Spechts Ferry Member and the Platteville Formation in southeastern Minnesota, northeastern Iowa, and part of southwestern Wisconsin. Agnew and others (1956) believed this limestone to be part of the Decorah

Formation, whereas Weiss placed the limestone in the Platteville Formation and called it the Carimona Member. Carlson (1961, p. 110) indicated that a limestone bed 4 to 6 inches thick crops out between the Spechts Ferry Member and Quimbys Mill Member north of the Rewey quadrangle and probably correlates with Weiss' Carimona Member. This limestone bed was not observed in the mapped area; thus it is probable that the Carimona Member wedges out north and west of the Rewey quadrangle.

The thickness of the Decorah Formation ranges from 33 feet in the southeastern part of the Mifflin quadrangle to about 40 feet in the northwestern part of the Rewey quadrangle. The thickening of the formation toward the west conforms to regional change of the Spechts Ferry Shale Member. Parts of the Decorah Formation near sulfide mineral deposits are altered and compacted, and the thickness of the formation is decreased.

SPECHTS FERRY SHALE MEMBER

The Spechts Ferry Shale Member, known locally as the claybed, is the lowest member of the Decorah Formation. The type section of the Spechts Ferry Shale Member is at Spechts Ferry, Iowa, about 16 miles southwest of the mapped area, where it is about 8.5 feet thick (Kay, 1928).

The Spechts Ferry Shale Member thins uniformly from 8 feet in the western part of sec. 21, T. 4 N., R. 1 W., to one-half foot in the southeastern part of the mapped area. It consists mainly of limestone but includes shale and dolomite. The limestone is pale yellowish brown to pale greenish yellow and is mostly sublithographic, but some beds are very fine to fine grained. The limestone is thin to medium bedded, fossiliferous along bedding planes, and locally coquinoid; the uppermost limestone bed contains brown phosphatic nodules. The dolomite beds are similar to the limestone in bedding, color, and texture. The shale is yellowish brown to green and is in beds that range from thin films to 6 inches in thickness. In the eastern part of the area where the member is thin, the limestone-shale ratio is about 1 to 1, but in the west where the member is thicker, the ratio is more than 5 to 1.

In the western and central parts of the mapped area where the Spechts Ferry Shale Member is more than 3 feet thick, it contains a white to grayish-yellow clay near the base and a grayish-yellow-green shale at the top. Both the white clay, about 0.4 foot thick, and the green shale, as much as 0.6 foot thick are composed of illite and montmorillonite. Allen (1932) identified a clay in the Spechts Ferry similar to the basal clay of the Spechts Ferry in the Rewey and Mifflin quadrangles as bentonite or metabentonite. He found that the clay contains crescent-shaped shards, sanidine, apatite, zircon, and occasional rounded grains of minerals foreign to volcanic deposits, such as garnet.

In the eastern part of the mapped area the member apparently contains only one shale or clay zone that is believed by the writer to correlate with the basal clay in the western part. However, the scarcity of exposures in the eastern part prevents a direct correlation.

The Spechts Ferry Member contains only sparsely disseminated zinc and lead minerals and, so, is not an important ore-bearing zone, although it contains zinc ore in the Senator mine in the SW¼ sec. 28, T. 5 N., R. 1 E.

GUTTENBERG LIMESTONE MEMBER

The Guttenberg Limestone Member of the Decorah Formation, known locally as oil rock, was named by Kay (1928, p. 16) for an exposure of limestone near Guttenberg, Iowa, about 35 miles west of the mapped area. In general, it is poorly exposed in the mapped area, but some fair exposures are in roadcuts in the SE¼ sec. 4, T. 3 N., R. 1 W., and in the SW¼ sec. 26, T. 4 N., R. 1 W. One of the few good natural exposures of the Guttenberg Limestone Member is in the south bank of the stream in the SW¼ sec. 1, T. 4 N., R. 1 W. It is described in the following section.

Section of the Guttenberg Limestone Member NW¼SE¼SW¼ sec. 1, T. 4 N., R. 1 W., southeast of Arthur, Wis., in south bank of stream

	Thickness (feet)
Top of Guttenberg Limestone Member:	
Limestone, pale-yellowish-brown, sublithographic; few fossils	1
Limestone, dark-yellowish-brown, very fine grained, thin- and wavy-bedded (beds are ½–2 in. thick), very fossiliferous, especially brachiopods and crinoid stems	4
Limestone, dark-yellowish-brown, fine-grained; many brown shale partings between coquinoid beds of limestone; middle bed is 2–3 in. thick and is pale-yellowish-brown limestone	2.5
Limestone, pale-yellowish-brown and dark-yellowish-brown, fine-grained, wavy-bedded	3.5

Where the Guttenberg Member is unaltered, its thickness ranges from 10½ to 14 feet and averages 12 feet. Locally, however, it has been thinned to about 4 feet by solutions that leached the carbonate rocks and left only a shaly residue.

The Guttenberg is chiefly limestone in the northern and western parts of the mapped area and dolomite in the southern and southeastern parts. The boundary between the limestone and dolomite facies follows approximately that in the Quimbys Mill Member of the Platteville Formation (fig. 44). Isolated areas or islands of dolomite and dolomitic limestone occur in the northwestern part of the Rewey quadrangle. These islands occur at the same places that dolomite islands occur in the underlying McGregor and Quimbys Mill Members of the Platteville Formation and also in sec. 12, T. 4 N., R. 1 E., and sec. 7, T. 4 N., R. 2 E.

The limestone is dark yellowish brown to pale yellowish brown and sublithographic to coarse grained. Beds are thin to medium and wavy, and contain dusky-brown carbonaceous shale partings. In the mapped area the limestone is very fossiliferous. Brachiopods are most abundant, but there are also mollusks and trilobites. In some places individual beds of coquina are interlayered with sublithographic limestone.

The dolomite is dark yellowish brown and fine to medium grained. Beds are wavy and thin to medium, and contain fossils that have been replaced by calcite. The dolomite beds, however, do not contain as many fossils as the limestone beds. Some dusky-brown shale separates the individual beds but is not as abundant as in the limestone facies.

The upper part of the Guttenberg Member grades into the overlying Ion Dolomite through a 1-foot transition zone in which mottled brown and yellow limestone and dolomite contain blebs of green or brown clay.

Generally in the vicinity of mineral deposits and in associated synclines the Guttenberg Member is thinner because the carbonate strata have been leached and the residue compacted. Heyl and others (1959) discussed in detail the process of thinning by solution and shalification of the carbonate rocks in the mining district.

The Guttenberg contains zinc and lead minerals in veins and disseminations in many places in the mapped area. The minerals in the member may be in sufficient quantity to be ore but have been mined chiefly where the strata above or below also are mineralized.

ION DOLOMITE MEMBER

The Ion Dolomite Member of the Decorah Formation was named by Kay (1928, p. 16; 1929, p. 650) for rocks exposed at Ion, Allamakee County, Iowa, which is about 40 miles northwest of the Rewey quadrangle. Later work by Paul Herbert, Jr., (Agnew and others, 1956, p. 293) made it advisable to redescribe the type section to include in the Ion the upper 4½ feet of Kay's Guttenberg Limestone Member.

At the type section, the Ion Member consists of 22 feet of limestone and shale and contains fossils such as *Prasopora*, *Glyptorthis*, and *Dinorthis* in abundance. In the mapped area it consists of 20 feet of dolomite with local limy zones and thin green shale zones at the top and near the bottom. *Prasopora* occurs in the topmost beds but is rare. Locally, the Ion in the vicinity of ore bodies has been thinned by selective leaching of the carbonate strata.

The Ion Dolomite Member in the mapped area is subdivided into two distinctive lithologic units. The lower unit is 6 to 7 feet of yellowish-gray, olive-gray, and dark-greenish-gray dolomite and dolomitic limestone that contains abundant yellowish-green clay films and blebs and one or two yellowish-green shale zones as much as 4 inches thick. The dolomite is generally fine to medium grained and medium to thick bedded. Limestone occurs in the bottom of the lower unit in some places and is coarsely crystalline and more fossiliferous than the dolomite. The bottom part is a mottled transition zone that grades into the underlying Guttenberg Member. Rounded quartz sand grains are disseminated in the lower 1 foot of this unit, and pyrite cubes are disseminated in the shale partings. The lower unit is called the blue by local well drillers and miners.

The upper unit consists of 13 to 14 feet of light-olive-gray, yellowish-gray, and moderate-yellowish-brown dolomite that is fine to medium grained and medium to thick bedded. The topmost zone contains one and, in some places, two pale-green dolomitic shale layers; green shale is disseminated in the upper 4 feet, and *Prasopora* occurs in the top dolomite bed. Olive-gray, yellowish-gray, and green shaly partings are common along the bedding planes. The principal clay mineral in the green shale is illite, whereas in some crevices in the upper part of the Ion it is montmorillonite. The unit is called the gray by miners. An example of part of the upper unit can be seen in the following section.

Top part of the Ion Dolomite Member and lower part of the Galena Dolomite exposed in a quarry on the east side of the stream in NE¼SE¼ sec. 5, T. 3 N., R. 2 E.

	Thickness (feet)
Top of quarry:	
Galena Dolomite:	
Dolomite, yellowish-brown, medium-grained, massive (beds 5 ft thick) somewhat vuggy. Lowest white chert band is 9 ft above contact. Thinner bedded at top because bedding is emphasized by weathering	10+
Decorah Formation:	
Ion Dolomite Member:	
Shale, green	.05
Dolomite, yellowish-brown, medium-grained; thin (0.05 ft) green shale streaks parallel to bedding at intervals of 0.2–0.3 ft; rock is 30–40 percent shale	1.5
Dolomite, yellowish-gray to brownish-gray, medium-grained; mottled with green shale	2.5
Shale, green, fissile	.2–.3

Dolomite, yellowish-gray to brownish-gray, fine-grained; green shale ---------- 4.0+
Floor of quarry.

The Ion contains lead and zinc ore in some mines. Ore was mined from both the lower and upper units in the Ebenezer mine in sec. 30, T. 5 N., R. 1 E., and lead ore occurs in the lower unit in the Nigger Jim mine in sec. 22, T. 4 N., R. 1 E.

GALENA DOLOMITE

The Galena Dolomite of Middle Ordovician age was named by Hall (1851) for rocks exposed near Galena, Ill., about 25 miles south of the mapped area. This formation, one of the major ore-bearing units in the mining district, contains lead sulfide deposits that are joint controlled and zinc, iron, and lead sulfide deposits that are in inclined and horizontal fractures. Crushed rock from the Galena Dolomite is used extensively as road material.

Complete sections of Galena Dolomite are preserved only in the southern part of the mapped area around the mounds; elsewhere, erosion has removed part or all the formation. Churn-drill holes indicate that the thickness of the Galena Dolomite ranges from 217 to 228 feet in the mapped area.

The Galena Dolomite conformably overlies the Decorah Formation. Exposures of the contact between the Galena Dolomite and the overlying Maquoketa Shale are so sparse that it is not known whether the contact is conformable or disconformable. Agnew [5] believed the contact to be conformable in the mining district; the evidence, however, is inconclusive.

Exposures of Galena Dolomite in the mapped area are poor except in roadcuts and quarries. Weathered surfaces have a distinctive vuggy appearance.

The Galena Dolomite in the Upper Mississippi Valley region has been divided into three members on the basis of paleontologic criteria. In ascending order these members are: Prosser Cherty Member, Stewartville Massive Member, and Dubuque Shaly Member. Agnew and others (1956, p. 265–269) noted that it is difficult to recognize these members in the mining district but that the Galena Dolomite can be divided into two distinctive lithologic units: a cherty lower unit and a noncherty upper unit. This lithologic subdivision of the Galena Dolomite was used in the present study.

[5] Agnew, A.F., 1948, The Middle and Upper Ordovician strata of the Upper Mississippi Valley, a restudy: Stanford Univ., Calif. unpublished Ph. D. thesis.

CHERTY LOWER UNIT

In these quadrangles complete sections of the cherty lower unit were penetrated by nine U.S. Geological Survey drill holes; the thickness of the cherty unit in these holes ranges from 96 to 112 feet and averages 102 feet. (See "Records of drill holes.")

The cherty unit, locally called the drab, is mainly grayish-orange and light-grayish-orange dolomite that contains white to gray chert nodules. The dolomite is medium to fine grained and thick to medium bedded. The chert nodules are concentrated in layers parallel to bedding surfaces. In some layers the nodules are sufficiently concentrated that the effect is a layer of solid chert; in others they are sparse. Flattened and amoeboid-shaped nodules of chert are as much as 3 inches thick, 8 inches wide, and 12 inches long, but the average size is about 1 inch thick, 3 inches wide, and 5 inches long. The lower 10 feet of the cherty unit contains sparse green clay blebs. White clay was noted about 48 feet below the top of the cherty unit in drill cuttings from the SE¼ sec. 1, T. 3 N., R. 1 E. The white clay is probably bentonite, as Agnew and others (1956, p. 297–299) reported bentonite in the cherty unit. Brown crevice clay from the upper part of this unit exposed in a roadcut in the west-central part of sec. 29, T. 4 N., R. 2 E., is composed chiefly of montmorillonite.

Agnew and others (1956, p. 296–297) were able to divide the cherty unit into zones that are based on the presence or absence of chert nodules and on the fossil *Receptaculites oweni* Hall. Their four zones in ascending order, are: (1) zone D, a moderate yellowish-brown dolomite 10 feet thick that contains no chert and is transitional from the underlying Ion Dolomite Member of the Decorah Formation, (2) zone C, a grayish-orange dolomite 12 to 15 feet thick that contains abundant chert nodules parallel to and along bedding planes in the thick-bedded dolomite, (3) zone B, a grayish-orange dolomite 10 to 15 feet thick that contains chert nodules and abundant *Receptaculites oweni* Hall, and (4) zone A, a grayish-orange dolomite 70 feet thick that contains chert nodules.

Zone A is further divided into four units that are described in descending order. Unit 1 is 32 feet of cherty dolomite that is massive at the top and thin bedded below. The base is marked by a thin shale that locally is bentonite. Unit 2 is 6 feet thick and consists of thin-bedded dolomite with sparse *Receptaculites* and *Ischadites* and some chert. Unit 3 is also 6 feet thick and lithologically the same as unit 2, but chert is more common. Unit 4 is 26 feet thick and is a thick-bedded dolomite with chert sparse at the top but common near the base. *Receptaculites* and *Ischadites* are present sparsely near the middle of unit 4.

NONCHERTY UPPER UNIT

The noncherty upper unit of the Galena Dolomite, which apparently conformably overlies the cherty unit, ranges from 105 to 125 feet in thickness and averages about 120 feet. Locally called the buff, this unit includes the upper, noncherty part of the Prosser Cherty Member, all the Stewartville Massive Member, and all the Dubuque Shaly Member.

The lower 75 to 85 feet of the noncherty unit is grayish-orange and pale-yellowish-brown very fine to medium-grained thick-bedded dolomite. This part of the unit includes the noncherty part of the Prosser Cherty Member and all the Stewartville Massive Member. *Receptaculites oweni* Hall is common in a 20-foot zone about 38 feet above the base of the unit.

The upper 35 to 45 feet of the noncherty unit is light-olive-gray to pale-yellowish-orange silty to very fine grained argillaceous thin- to medium-bedded dolomite. This part of the noncherty unit correlates with the Dubuque Member, and it is more argillaceous and thinner bedded than the underlying part of the unit. Dusky-yellowish-brown to pale-yellowish-brown dolomitic shale is common along bedding planes. *Lingula iowensis* Owen is common in this member. Small white siliceous crinoid columnal segments and siliceous bryozoan fragments are noted in drill cuttings. (See "Records of drill holes," USGS 10 and USGS 26.)

Agnew and others (1956, p. 297–299) reported that bentonite is found locally about 18 feet above the base of the noncherty unit along a bedding plane that commonly contains shale. They believed that the discontinuous seams of bentonite in the units "denote volcanic activity similar to that which supplied the bentonitic material of the Decorah."

UPPER ORDOVICIAN SERIES

MAQUOKETA SHALE

The Maquoketa Shale of Late Ordovician age was named by White (1870, p. 181) for shale exposed along the Little Maquoketa River about 30 miles southwest of the mapped area. The Maquoketa overlies the Galena Dolomite and is overlain by the Edgewood Dolomite of Early Silurian age.

In the mapped area the Maquoketa Shale is approximately 130 feet thick; an exact thickness could not be determined because the contact with the overlying Edgewood Dolomite is concealed by soil and rubble. In the mining district the thickness of the Maquoketa ranges from 108 to 260 feet, and the variation in thickness is probably due to an erosional unconformity at the top (Agnew and others, 1956, p. 300–301).

The only exposures of Maquoketa Shale observed in the mapped area consist of gray to brown clay that is in the lowest 5 feet of the formation. This clay is exposed in many of the springs and bogs at the heads of gullies near the mounds in the southern part of the mapped area. Two zones that contain abundant depauperate phosphatic pelecypods, crinoid segments, gastropods, and cephalopods, as well as light-gray to brown phosphatic, (francolite) nodules, occur in this basal clay. These zones range from 6 to 12 inches in thickness and are generally separated by 3 or 4 feet of shale; the lower zone is generally thicker and more fossiliferous.

The lower 90 feet of the Maquoketa Shale penetrated in a drill hole at the northwest end of the Platte Mounds in the NE¼SE¼ sec. 31, T. 4 N., R. 1 E. (drill hole USGS 10, p. 339) consists of interbedded shale and dolomite. Most of the shale is olive gray, but some is dark yellowish orange. The dolomite is dark yellowish orange to olive gray and very fine grained. Some small (1 to 2 mm) black francolite nodules occur sporadically in the shale or clay. Small (1 to 2 mm) crinoid columnal segments occur along with fragments of other fossils, minor pyrite and scarce white chert.

Geologists who have studied the Maquoketa Shale have had different opinions about its relationship to the underlying Galena Dolomite. Agnew [6] believed the lower contact to be conformable, even though he recognized that replacement of fossils by pyrite and the presence of large crystals of barite, phosphatic nodules, pellets, and depauperates indicate a "time of marked change in sedimentation at this horizon." Trowbridge and Shaw (1916, p. 71) believed the contact to be unconformable, although the flat erosion surface indicates that little erosion was possible.

The contact between the Maquoketa Shale and the overlying Silurian rocks is known to be unconformable in the mining district (Agnew and others, 1956, p. 301; Brown and Whitlow, 1960, p. 23–33).

Although no lead and zinc minerals were observed in the Maquoketa Shale in the mapped area, some small deposits of zinc and lead sulfides in this formation are known elsewhere. Cox (1914, p. 84) and Agnew and others (1956, p. 301) noted the presence of sphalerite and barite in several localities, but none of these is of commercial value. Prospect pits near the base of the shale in the

[6] See footnote on page 300.

NW¼NE¼ sec. 2, T. 3 N., R. 1 E., apparently were mined for clay rather than for zinc or lead minerals.

The fauna of the Maquoketa Shale has been studied by Trowbridge and Shaw (1916) and Ladd (1929).

SILURIAN SYSTEM

LOWER SILURIAN SERIES

The study of the rocks of Silurian age in the Rewey and Mifflin quadrangles was influenced by Brown and Whitlow (1960), who subdivided the rocks near Dubuque, Iowa. Formerly the Silurian rocks in the Wisconsin part of the mining district were known as Niagara Dolomite (Bain, 1906, p. 33–34; Grant, 1906, p. 50–51; Trowbridge and Shaw, 1916, p. 75–81; Strong, 1877, p. 687; and Hall and Whitney, 1862, p. 59).

EDGEWOOD DOLOMITE

The Edgewood Dolomite of Early Silurian age overlies the Maquoketa Shale in the three mounds in the southern part of the mapped area. A complete section of the Edgewood Dolomite is present at Platte Mounds, which is capped by the overlying Kankakee Formation. Excellent exposures of Edgewood are found in quarries on the west side of Platte Mounds in the NE¼ sec. 6, T. 3 N., R. 1 E., and on the south side of Belmont Mound in the NE¼ sec. 3, T. 3 N., R. 1 E.

The Edgewood Dolomite is about 145 feet thick in the mapped area, although the thickness cannot be determined exactly because soil covers the upper and lower contact. Near Dubuque, Iowa, Brown and Whitlow (1960, p. 34) found that the Edgewood Dolomite ranges from 9 to 116 feet in thickness and fills the irregularities in the eroded surface of the Maquoketa Shale. They also found that the thicknesses of the two formations are nearly complementary.

About 70 feet of Edgewood Dolomite is exposed in a quarry on the south side of Belmont Mound. The lowest 12 feet of rocks in the quarry is olive-gray fine-grained thin- and wavy-bedded argillaceous dolomite and fissile olive-gray shale. These rocks are overlain by about 28 feet of olive-gray thick-bedded cherty argillaceous dolomite. The chert occurs as white, yellow, and gray nodules 1 to 3 inches thick that are alined parallel to bedding planes and are ½ to 1 foot apart vertically. The cherty dolomite is overlain by about 30 feet of noncherty dolomite that is yellowish gray to grayish orange, fine to medium grained, and argillaceous. This noncherty dolomite is wavy bedded in the lower part and thick bedded in the upper part.

Scattered exposures from the top of the quarry to the top of Belmont Mound indicate that the upper part of the Edgewood Dolomite is yellowish-gray fine-grained medium-bedded dolomite.

Edgewood Dolomite is exposed at the north end of Platte Mounds and Belmont Mound as large blocks that have broken along joints and slumped.

At Platte Mounds the upper part of the formation contains silicified fossils. Grant (1906, p. 51) and Bain (1906, p. 34) identified *Halysites catenulatus* Linnaeus, *Favosites favosus* Goldfuss, and *Favosites niagarensis* Hall, and casts of *Pentamerus oblongus* Sowerby. Cephalopods also have been found at the top of the quarry on the west side of Platte Mounds.

KANKAKEE FORMATION

The Kankakee Formation was named by Savage (1916, p. 305–324) for exposures of rock along the Kankakee River in Macon County, Ill., where it unconformably overlies the Edgewood Limestone. Less than 5 feet of the Kankakee Formation is preserved at the top of Platte Mounds in the NW¼ sec. 5, T. 3 N., R. 1 E. The rocks exposed consist of massive blocks of white to yellowish-brown chert that contain many quartz-lined vugs. This chert probably came from a chert layer or layers in dolomite.

QUATERNARY SYSTEM

LOESS

Loess is not exposed but is mixed with the residual soil from a few drill holes. Loess, a grayish-orange silty clay, is as much as 40 feet thick along the east bluffs of the Mississippi River (Trowbridge and Shaw, 1916, p. 102), but it thins progressively toward the east. The Rewey and Mifflin quadrangles are near the east border of the loess deposits.

ALLUVIUM

Alluvial deposits of Recent age are in many stream valleys in the mapped area. Deposits that are 200 feet or more wide have been shown on the geologic map (pl. 20).

The alluvium generally forms vertical stream banks and is generally 5 to 10 feet thick in the larger stream valleys. It consists generally of silty very light gray to yellowish-gray clay with disseminated iron oxide and is locally crossbedded. In many exposures the clay is intermixed with lenses of sand and gravel that consist of pebbles of country rocks and angular pieces of white to reddish-brown chert.

DEPOSITS OF UNKNOWN AGE

QUARTZ SANDSTONE BOULDERS

Boulders composed of quartz sand that resemble grains of the St. Peter Sandstone have been observed stratigraphically above the St. Peter in the mapped area along the center of the west line sec. 8, T. 4 N., R. 2 E., in the SW¼NW¼ sec. 12, T. 4 N., R. 1 E., and in the NW¼NE¼ sec. 19, T. 4 N., R. 1 E. In sec. 8 they are about 3 feet in diameter, are medium grained, ferruginous, and well cemented with iron oxide and silica, and lie on the Pecatonica Dolomite Member of the Platteville Formation. The boulders in sec. 12 are exposed on a slope near an outcrop of the Quimbys Mill Member of the Platteville Formation.

Just southwest of the Rewey quadrangle a large sandstone boulder was reported by Agnew (unpublished data) to be at least 8 by 3 by 1½ feet. It is near the top of the cherty unit of the Galena Dolomite.

Many other sandstone boulders have been reported throughout the mining district (Hall and Whitney, 1862, p. 137; Shaw, 1873, p. 25–56; Strong, 1877, p. 667; Grant, unpublished data, 1903; Heyl and others, 1959).

The most logical explanation for the origin of the boulders seems to be that relatively sudden hydraulic action forced sand from the St. Peter Sandstone upward into joints as they were being formed and that this sand was later cemented by silica, iron oxide, and carbonate. When erosion lowered the surface of the carbonate rocks that enclosed the dikes, the relatively hard and insoluble sandstone was left as boulders.

STRUCTURE

GENERAL DISCUSSION

The dominant structural features in the Upper Mississippi Valley mining district are low broad folds that modify nearly flat-lying rocks. Heyl and others (1955, p. 231) reported that the largest folds in the mining district range from 20 to 30 miles in length and 3 to 6 miles in width, have amplitudes of 100 to 200 feet, and are commonly asymmetrical with the steeper limbs of anticlines on the north side. These authors also reported that the average dip of rocks in the mining district is 17 feet per mile to the south-southwest.

The structural features in the mapped area conform to the district pattern. The dominant features are a regional dip averaging 15 to 20 feet per mile to the south, a broad asymmetric anticline, and a syncline just north of the anticline. Smaller structural features in the area include domes, basins, vertical and inclined joints, and small faults.

The geologic structure of the mapped area is shown in plate 20 by contours showing the top of the Platteville Formation. The points on which the contours are based are shown by drill-hole symbols and by small crosses at outcrops. All differences in altitude of the datum surface are assumed to be due to tilting or folding, unless there is direct evidence of faulting. As the writer observed only two faults, each of less than 1 foot displacement, the assumption is probably valid.

FOLDS

The largest fold in the mapped area is an asymmetric anticline about 7 miles long. The crest of this anticline trends generally N. 75° W. from the west part of the Mifflin quadrangle, but the trend of the steep north limb is nearly east. The fold plunges to the east in sec. 15, T. 4 N., R. 1 E., and to the southeast in sec. 22, T. 4 N., R. 1 E. The west end of the anticline plunges toward a shallow northwest-trending syncline. The anticline is not continuous with other structural highs in the mapped area; however, it is along the trend of the Mineral Point anticline (Heyl and others, 1959, p. 27–31), which extends 10 miles northeast and 20 miles northwest from the mapped area.

The steep limb of the anticline in the mapped area dips 8° N. in the quarry in the NW¼NW¼ sec. 12, T. 4 N., R. 1 W., and 10° NE. in the SE¼ sec. 9, T. 4 N., R. 1 E. These dips are the steepest observed on the north flank of the fold, and as the average dip on the north flank is only 4° they are probably local features. The structural relief on the north flank is more than 120 feet in half a mile from the crest of the anticline to the trough of the syncline to the north in sec. 12, T. 4 N., R. 1 W.

The south limb of this anticline has an average dip of less than 1° and a maximum structural relief of more than 250 feet in a little more than 3 miles. The dip on this limb is slightly steeper along an eastward-trending monocline that extends across the southern part of the Rewey quadrangle. The south limb of the anticline is about 5 miles wide from sec. 7, T. 4 N., R. 1 E., to the south edge of the mapped area in sec. 7, T. 3 N., R. 1 E., and is about 3 miles wide from sec. 22, T. 4 N., R. 1 E., to the axis of an eastward-trending syncline in the SW. cor. sec. 3, T. 3 N., R. 1 E. Maximum closure is about 70 feet.

The rocks exposed on the anticline range from the Prairie du Chien Group on the east and west ends to the cherty unit of the Galena Dolomite in the middle. The Decorah Formation and the cherty unit of the Galena Dolomite cover most of the north flank of the anticline, although the Platteville Formation and the St.

723-183—64——5

Peter Sandstone are exposed in some of the deeper gullies. The rocks exposed on the south flank range from the St. Peter Sandstone to the Edgewood Dolomite and Kankakee Formation at the mounds.

A syncline about 5 miles long and about 1 mile wide at the widest point is north of the anticline just described. It has a closure of more than 50 feet. The maximum structural relief exceeds 120 feet in one-half mile on the south limb, which rises southward toward the crest of the anticline. The maximum structural relief on the northeast flank is about 80 feet in 2 miles from the SE¼ sec. 1, T. 4 N., R. 1 W., to the center of sec. 32, T. 5 N., R. 1 E. On the northwest flank the maximum structural relief is 130 feet in about 4 miles from the SE¼ sec. 1, T. 4 N., R. 1 W., to the SE¼ sec. 28, T. 5 N., R. 1 W.

The rocks exposed in this syncline range from the St. Peter Sandstone to the noncherty unit of the Galena Dolomite.

The structural high in secs. 26, 27, 34, and 35, T. 5 N., R. 1 W., which trends northwestward out of the Rewey quadrangle, is also part of the Mineral Point anticline. The north limb of this structural high dips about 3° NE. Bedrock exposed on this anticline in the mapped area consists of the Platteville Formation, the Decorah Formation, and the cherty unit of the Galena Dolomite.

The broad dome in the northeast corner of the Rewey quadrangle has a closure of about 20 feet and a maximum structural relief of about 80 feet on both the northwest and the southwest sides.

A syncline that is northwest of the dome in the northeastern part of the Rewey quadrangle has 30 feet of closure and trends northeastward. It is 2 miles long and has a structural relief of 80 feet as measured from the trough of the syncline to the crest of the dome. Several lead and zinc deposits are on the flanks of this syncline.

The northern part of the Mifflin quadrangle is characterized by irregularly shaped domes and basins that do not form definite structural trends. The domes have about 20 feet of closure and are generally from 1 to 2 square miles in area. The basins have from 10 to 30 feet of closure and are generally less than a square mile in area.

Rocks exposed on these domes and basins range from the Prairie du Chien Group to the cherty unit of the Galena Dolomite. Allingham (1963) indicated that similar basins and domes in the adjoining Mineral Point quadrangle may be caused by irregularities in the upper surface of the St. Peter Sandstone that reflect domes and interdome areas in the Prairie du Chien Group. Most of the structural-control points on which these domes are based are at the top of the St. Peter Sandstone or the top of the Platteville Formation. These two horizons are probably below the zones where solution thinning was most effective; therefore, if most of the basins are not caused by irregularities in the upper surface of the St. Peter Sandstone, they are tectonic features.

A broad, shallow syncline south of the monocline in the southwestern part of the Mifflin quadrangle and southeastern part of the Rewey quadrangle trends southwestward toward Platteville, Wis. Small synclines extend northeastward into the southern part of the mapped area as branches of a broad syncline south of the Rewey quadrangle. These synclines have local structural relief of 20 to 30 feet, and may have been deepened by solution of carbonate rocks.

These small synclines may contain ore that is of economic importance, as lead and zinc sulfide deposits follow closely the trend of the two westernmost synclines in secs. 10, 11, and 12, T. 3 N., R. 1 W., just south of the mapped area.

Several small basins and domes occur in the west-central part of the Rewey quadrangle.

The structure in the southern part of both quadrangles is probably more complex than shown on the map (pl. 20). More outcrop and drill hole data would probably show many basins and domes superimposed on the regular trends of the structure.

FAULTS

Only two faults, both of very minor displacement, were found although soil cover probably conceals many others. One fault is in a quarry in the eastern part of sec. 5, T. 3 N., R. 2 E.; it strikes eastward, is vertical, and cuts the horizontal beds of the Ion Dolomite Member of the Decorah Formation and the cherty unit of the Galena Dolomite. The fault surface is exposed on the north wall of the quarry where the north side has dropped about 6 inches. The other fault is in a roadcut on the east side of State Highway 80 on the west line of sec. 36, T. 5 N., R. 1 W.; it strikes about N. 80° W. and dips 65° NE., and rocks on the north side are dropped about 1 foot. The fault cuts horizontal beds in the cherty unit of the Galena Dolomite and is associated with a joint that strikes about N. 80° W. and dips 85° S. The fault surface and the joint form a rubble-covered wedge with the apex near the top of the roadcut. The lateral extent could not be determined for either fault.

A fault or faults may exist near the east end of the basin in sec. 29, T. 4 N., R 2 E., where some strikes and dips are contrary to the structure as shown on the map. No offset beds or faults were observed in this area, and outcrops are too scattered to determine the probable attitude of the faults if they exist. The writer believes the opposing dips represent a local structure.

Slickensides on large float sandstone blocks in a gully in the NE¼NW¼ sec. 22, T. 4 N., R. 1 W., may indicate a small fault in the area. If a fault is present it probably would have the same northeastward trend as the gully, but no fault was observed.

High-angle thrust faults of about 30 feet vertical displacement are along the steep side of the asymmetric anticlines near the mapped area as well as elsewhere in the mining district (Heyl and others, 1959, p. 35, 36). It is possible that soil conceals similar faults along the anticlines in the mapped area.

Heyl and others (1959, p. 37, 58) have mapped a transverse shear fault, the Mifflin fault, which has a strike of N. 40° W. and at least 65 feet vertical displacement and 900 to 1,000 feet horizontal displacement, just north of the Mifflin quadrangle. Carlson (1961) and the writer found no surface evidence to support the extension of the fault into the Mifflin quadrangle, although in the Old Slack mine (Heyl and others, 1959, p. 37, 265) a shattered zone and an abrupt 15- to 20-foot rise in the beds to the northeast of this zone may represent the vertical component of displacement of the fault. A brecciated zone about 200 feet wide was found by drilling southeast of the mine, and this may also indicate an extension of the fault into the Mifflin quadrangle.

Minor thrust faults and bedding-plane faults are associated with the zinc sulfide deposits in the mapped area. The writer believes that these faults resulted from subsidence due to thinning of underlying beds by solution rather than from tectonic activity; these faults are discussed further in the section on mineral deposits.

JOINTS

All rocks exposed in the mapped area except the Maquoketa Shale and the St. Peter Sandstone have well-formed steeply dipping joints. In places outcrops of the St. Peter Sandstone are poorly jointed. An average of all joints measured in the quadrangle shows that vertical joints are about six times as abundant as inclined joints. Most of the inclined joints dip from 65° to 75° and are rarely as low as 32°.

Figure 45 is a joint diagram for both the Rewey and Mifflin quadrangles showing the strikes of vertical and inclined joints. The joints can be grouped into one dominant set and several

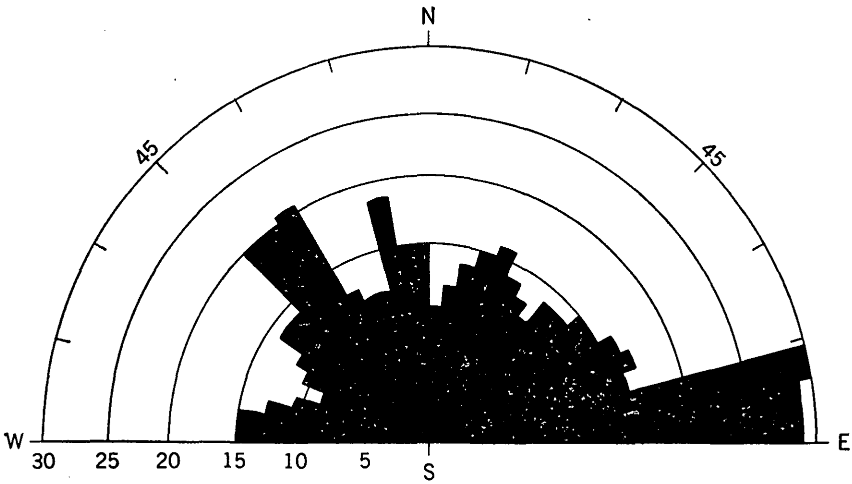

FIGURE 45.—Diagram of the joint directions in the Rewey and Mifflin quadrangles. The diagram is based on weighted averages. The number of joints in a 5-degree segment is an average of the number of joints in that segment and adjoining 5-degree segments. Each circle represents 5 joints.

subordinate sets. The dominant set strikes between N. 75° E. and east and occurs extensively in both quadrangles.

Joints that are open or filled with reddish-brown clay are called crevices. They are shown on the map (pl. 20) where they have surface expression because they may be upward extensions of joints that contain lead deposits. An open crevice in a field in the SW¼ sec. 6, T. 4 N., R. 2 E., is indicated by the alinement of several small sinkholes, which trends N. 80° W.; the largest sinkhole is 8 feet wide and more than 10 feet deep. Some crevices trending northward and northeastward are reflected on the surface and in some gullies, such as in the SE¼SE¼ sec. 23 and the NE¼ sec. 35, T. 4 N., R. 1 W.

Much of the lead ore mined in the mapped area came from joint-controlled galena deposits, and the strike of these joints can be determined by the alinement of the old prospect pits, such as those in the SW¼ sec. 8, T. 4 N., R. 1 E., and in the S½ secs. 2 and 3, T. 3 N., R. 1 W.

Drainage in the mapped area is controlled partly by joints and perhaps partly by folds. In secs. 17, 18, 20, and 21, T. 4 N., R. 2 E., the Pecatonica River turns at right angles and follows the northeast- and northwest-trending joint pattern. The small valleys in the area also follow these trends. The course of the Little Platte River in sec. 12, T. 4 N., R. 1 W., and sec. 7, T. 4 N., R. 1 E., and Williams Branch in secs. 9, 10, and 15, T. 4 N., R. 1 E., follow the trend of an asymmetric anticline

Shear zones of closely spaced joints from a few inches to 4 feet apart were observed at two places; a vertical shear zone a few feet wide strikes N. 5° E. near U.S. Highway 151 in sec. 16, T. 4 N., R. 2 E., and a shear zone more than 20 feet wide is exposed in the upper part of the St. Peter Sandstone in the NE¼ sec. 17, T. 4 N., R. 2 E. This shear zone is formed by two sets of shears; one set strikes N. 10°–30° E. and dips 45° NW. and the other set strikes N. 65° E. and dips 45° NW. This zone contains rhombic blocks of sandstone that are about 3 feet wide and 4 feet long.

ORIGIN AND AGE OF DEFORMATION

The regional structure of the mining district and adjoining area has been studied by Heyl and others (1959), who stated that the eastward-trending regional folds and the northwestward- and northeastward-trending local folds, joints, and faults are probably the result of regional compressive tectonic forces. The compressive forces folded the rocks by differential outward movements of the near-surface Paleozoic strata away from the Illinois basin and to a lesser degree from the Forest City basin, which are south and southwest of the mapped area, relative to inward movements of the underlying Precambrian basement rocks on the edges of the basins as they were being formed. The compressive forces pushed against a buttress formed by the Wisconsin dome and Precambrian rocks to the north and east of the mining district.

Reynolds (1958) believed that the strata were slightly folded by vertical forces that produced uplift or downwarp, which probably resulted from faulting in the Precambrian basement.

The joints in the dominant set, which strikes N. 75°–90° E., are roughly parallel to the regional strikes of the rocks in the mapped area and may be related to the regional southward tilt of the rocks. They may, however, be tension fractures which were originally compression joints at right angles to the north-south direction of the main compressive force, as suggested by Heyl and others (1959, p. 62). The joints that strike northwestward in a subordinate set in the Rewey quadrangle parallel the northwestward trend of the Mineral Point anticline in the northwestern part of the quadrangle. The subordinate northeastward-trending set in the Mifflin quadrangle parallels the Mineral Point anticline which trends northeastward from the mapped area. The joints that are not in either of these subordinate sets are probably related to local folds.

Deformation was post-Early Silurian, as it affected rocks that are Early Silurian in age. Younger rocks are absent in the mining district; so, a minimum age for the deformation must be obtained from evidence outside the district. Heyl and others (1959, p. 54) concluded that the major deformation was probably related to the last stages of the Appalachian and Ouachita orogenies, which took place in late or post-Pennsylvanian times, and that, because of a "lack of Pennsylvanian and post-Pennsylvanian sedimentary rocks in the upper Mississippi Valley region, this deformation cannot be dated more exactly than probably post-middle Pennsylvanian and pre-Cretaceous in age."

The regional tilt of the rocks is probably due to uplift of the Wisconsin dome.

ECONOMIC GEOLOGY

METALLIC DEPOSITS

HISTORY AND PRODUCTION

The history of the development of the Upper Mississippi Valley zinc-lead district is long and colorful. In 1690, Nicolas Perrot, a French trader, established a trading post opposite the present site of Dubuque, Iowa, to obtain lead ore mined by the Indians, but it was in the 1820's when a real influx of miners into the district began. The first miners dug lead ore from joint-controlled deposits of galena and from residual deposits in soil derived from rocks that contained galena. About 1860 technological improvements made it profitable to recover the zinc that is associated with galena in the joint-controlled deposits and also in pitch-and-flat deposits, which are stratigraphically lower than the joint-controlled deposits. Since the late 1800's lead has been recovered mainly as a byproduct of zinc mining.

According to Heyl and others (1959, p. 74, table 1; p. 77, table 2), the Upper Mississippi Valley zinc-lead district produced 832,365 short tons of metallic lead from 1800 to 1954. From 1859 to 1952, 44,331,543 short tons of zinc ore yielded 1,209,965 short tons of metallic zinc.

The first large ore body mined in the mapped area was at the Penitentiary (Blackjack) mine in the NE¼ sec. 34, T. 5 N., R. 1 E. It was discovered in 1835, and the mine was operated continuously from about 1842 until 1910. Galena was the main ore mineral until 1864 when sphalerite was found in the deeper parts of the mine and became the main product. Most of the other mines in the mapped area, the Old Squirrel, the Squirrel, the Old Gruno, the Clayton, the Senator, the Coker No. 2, the Dale Rundell, the Washburn, the LaFollette, the Old Slack, and the Ebenezer mines operated from 1890 to about 1923. The Coker

No. 3 mine stayed in operation until 1926. After 1926 little mining was done until World War II (Heyl and others, 1959).

The Defense mine in sec. 28, T. 5 N., R. 1 E., which operated from June 1942 to September 1945, was the last mine to operate in the Mifflin quadrangle. The New Dale Rundell mine in sec. 31, T. 5 N., R. 1 E., which operated from 1943 to 1944 and from December 1946 to March 1947 (Heyl and others, 1959), was the last mine to operate in the Rewey quadrangle.

Production of zinc and lead ore from some of the mines in the mapped area has been reported by Heyl and others (1959, p. 258–266) as follows: Coker No. 3, 170,000 tons; Senator, 50,000 tons, and Defense, 3,500 tons. About 300,000 tons of ore was produced at the Coker No. 2 mine in the Rewey quadrangle and an estimated 160,000 tons of zinc ore and 2,400 tons of lead ore were recovered from the Penitentiary mine. The writer estimates the total ore produced from the Squirrel mine is 37,000 tons, 20,000 tons of which came from the Mifflin quadrangle. About 15,000 tons of ore was produced at the New Dale Rundell mine. It is estimated that production totaled 720,900 tons of zinc and lead ore from these mines in the mapped area.

No complete records are available for the amount of ore produced from the other mines nor from the thousands of lead pits in the mapped area. Production is estimated to have been one-fourth as much as from the combined large deposits, or 180,000 tons of zinc and lead ore. Therefore, some 900,000 tons of zinc and lead ore was produced in the mapped area.

The grade of the ore produced is not known, but it probably ranged from 5 to 13 percent zinc, and the ratio of zinc to lead in the zinc mines was about 10 to 1. Ore from lead diggings had a higher percentage of contained lead because it was selectively mined and because zinc minerals were leached out above the water table.

PITCH-AND-FLAT DEPOSITS

The term "pitch-and-flat deposit" was introduced by Percival (1855, p. 29) to apply to a peculiar system of inclined and horizontal veins in some ore deposits in the Upper Mississippi Valley mining district. The pitch-and-flat deposits contain mainly zinc ore and are the most important type of mineral deposit both in the mapped area and in the entire mining district. Most of these deposits consist of one or more stairlike fractures that are filled with ore or gangue minerals, but some deposits have curved inclined fractures that are not stairlike (fig. 46, this report; Heyl and others, 1959, p 109, 116, fig. 71, and pls. 22, 24). A vein in

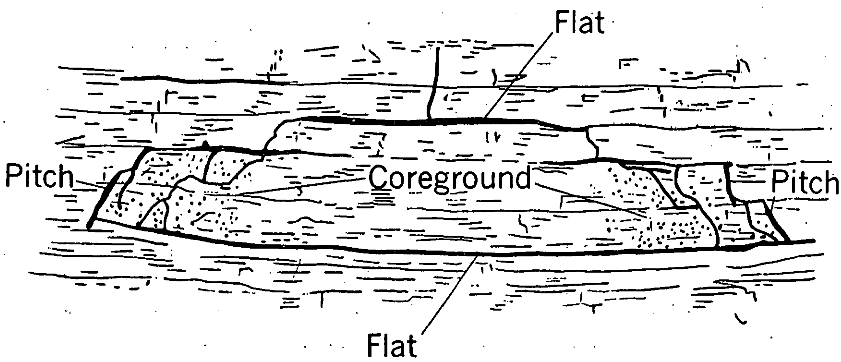

FIGURE 46.—General section of the Penitentiary mine, Mifflin, Wis., showing stairlike fractures typical of some pitch-and-flat deposits. (Modified from Chamberlin, 1882, p. 475.)

a fracture that is inclined to the beds is called a "pitch." Pitch fractures commonly displace the beds a few inches to a few feet, and the footwall is most commonly displaced downward. Thus the pitch fracture is a small reverse fault. A vein in a fracture that is parallel to the beds is called a "flat." Sheets of ore or gangue minerals that were deposited along bedding surfaces in the footwalls are also called flats. In many pitch-and-flat deposits one stairlike or curved inclined fracture or system of fractures is opposed by a similar outward dipping fracture. Two additional terms, "core ground" and "brangle," are used in describing pitch-and-flat deposits. In general, "core ground," refers to the footwall block between two outward dipping pitches, but the term is also applied specifically to rock in the footwall block that contains disseminated ore minerals.

"Brangle" refers to brecciated blocks that contain ore or gangue minerals in the fractures. In some deposits, core ground, brangle, or both make up a large part of the ore, whereas in others core ground or brangle are not present.

Figure 46 shows stairlike fractures in cross section. Note that the inclined fracture terminates in a flat near the base of the deposit as well as at the top. Generally the inclined fractures dip from 30° to 60° and average 45°. In most deposits the basal flat is in the Spechts Ferry Shale Member of the Decorah Formation or the Quimbys Mill Member of the Platteville Formation. The top flat is generally in the lower part of the cherty unit of the Galena Dolomite.

Most pitch-and-flat deposits occur in synclines or basins as expressed at the top of the Guttenberg Limestone Member of the Decorah Formation. In plan, pitches generally trend parallel to the axis of a syncline or the edge of a basin and dip away from the

723-183—64——6

axis of a syncline or the center of a basin. Heyl and others (1959, p. 109, 123; 1955, p. 234–235) have classified pitch-and-flat deposits with reference to the horizontal trace of pitches. They described deposits with relatively straight traces as "linear" and those with curved traces as "arcuate."

Chamberlin (1882, p. 469–470) reported that the typical pitch-and-flat deposit was about 75 feet wide from the base of one pitch to the base of the opposing pitch, about 40 feet wide at the top flat, and about 50 feet from the bottom flat to the top flat. These figures are probably typical for the linear deposits and some small arcuate deposits. Some arcuate deposits are as much as 800 feet from base of pitch to base of opposing pitch, but commonly the core ground in these large arcuate deposits does not contain ore. (See the map of the Coker No. 2 mine, in Heyl and others, 1959, p. 41, fig. 27.) The height of pitches in some ore deposits exceeds 125 feet.

In some deposits the pitches contain more ore than the flats; in others, as in the Penitentiary and Gruno mines in the Mifflin quadrangle, the flats contain more ore than the relatively short pitches (fig. 46, this report, and Bain, 1906, p. 100).

MINERALOGY OF PITCHES AND FLATS

Sphalerite (zinc sulfide) is the principal ore mineral in the pitch-and-flat deposits. Galena (lead sulfide) is also an ore mineral in these deposits but is recovered mainly as a byproduct, the zinc-lead ratio being about 10 to 1. Abundant gangue minerals are pyrite and marcasite (iron sulfides), and calcite (calcium carbonate); barite (barium sulfate) and dolomite (calcium magnesium carbonate) are subordinate gangue minerals. The ore and gangue minerals occur as veins in the pitches and flats, as fracture fillings in brecciated rock, and as disseminations in the footwall.

Where the deposits are above the water table, the sphalerite alters to "drybone" smithsonite (zinc carbonate), and pyrite and marcasite alter to limonite (iron oxide). The surfaces of galena crystals are altered to cerussite (lead carbonate) above the water table, and the coating of cerussite protects the galena from further alteration.

The veins of ore and gangue minerals are as much as 2 feet wide, but they are generally 4 to 6 inches wide. A typical pitch vein is zoned; that is, a thin film of pyrite or marcasite coats the wallrock; the next zone contains mainly sphalerite that is dark reddish brown and occurs as colloform bands; the next zone contains abundant pyrite, marcasite, and calcite, and sparse galena; the center zone is commonly calcite, although it may be deposits; but some carbonate cement between the dolomite grains is leached, and only rhombic dolomite crystals remain. The alteration of host rock is probably caused by ground water or by fluids related to the deposition of sulfide minerals.

ORIGIN OF PITCHES AND FLATS

The origin of the pitches and flats has intrigued geologists for many years. Some geologists believe the fractures that contain ore were caused directly by tectonic forces; other geologists believe the fractures were caused by collapse of overlying beds into spaces formed by the leaching of limestone.

Heyl and others (1959, p. 63–66) are proponents of a tectonic origin for the pitches and flats. They believed the fractures to be reverse and bedding-plane faults, resulting from lateral compressive forces; however, solution of calcareous beds during ore deposition aided the tectonic process.

Reynolds (1958) and Willman, Reynolds, and Herbert (1946) believed that solutions related to ore-bearing fluids altered and thinned limestone beds and that this thinning resulted in sag and collapse of the overlying beds. Ore then filled the fractures caused by the collapse. Reynolds (1958, p. 162) stated: "The location of the ore deposits is controlled by fractures of tectonic origin, but solution and collapse played the dominant role in the formation of the ore receptacle."

Bain (1906) attributed pitch fractures to collapse of the rocks by compaction of original shale rather than to solution thinning. He believed that the dark-brown shale found in the stratigraphic position of the Guttenberg Limestone Member of the Decorah Formation was a sedimentary feature caused by deposition of shale in basins to about the same thickness as limestone in the adjacent nonbasin areas. During lithification of the Guttenberg Member and the overlying rocks, this shale was compacted more than the limestone, permitting pitch-and-flat fractures to form over the shale areas in the same manner that fractures form in a sagging brick wall where part of the support has been removed.

Today, most geologists (Heyl and others, 1959; Reynolds, 1958; Willman and others, 1946) believe that the shale in the Guttenberg Member is the result of the leaching of limestone and resulting compaction of the residue.

The writer did not study the pitches and flats in the mapped area, as the mines were inaccessible; however, he has studied deposits near Shullsburg, Wis., about 15 miles south of the Mifflin quadrangle. The writer believes that the pitch-and-flat fractures were formed as a result of solution of susceptible limestone beds and subsequent a void. Veins in flats consist mostly of sphalerite. These veins generally have an iron sulfide outer zone but lack a central zone of calcite or a void, and a marcasite-pyrite-calcite-galena zone is not well formed. Veins near the top of the pitch and the top flat commonly contain more galena than veins elsewhere in the deposit.

Veins $1/16$ to $1/32$ inch thick and disseminated crystals and aggregates of crystals of sphalerite, pyrite, and galena are in the footwall. The disseminated sphalerite crystals average about one-fourth inch in diameter, and the aggregates of crystals average about 1 inch. Galena crystals disseminated in the footwall average about one-half of an inch and do not tend to form aggregates like the sphalerite.

The pitch-and-flat deposits in and near the mapped area contain small quantities of chalcopyrite (copper iron sulfide) and millerite (nickel sulfide). A single flake of gold was reported from drill cuttings at the Nigger Jim mine (Heyl and others, 1959, p. 84). Gold has also been reported in an assay of sulfide ore from the Calamine quadrangle, which is immediately south east of the Mifflin quadrangle (Harry Klemic, oral communication, 1961).

The paragenetic sequence of ore and gangue minerals in the mining district as reported by Heyl and others (1959, p. 96–101) is, from early to late: quartz (crystalline and cryptocrystalline silica), dolomite, pyrite, marcasite, early platy barite, sphalerite (and wurtzite?), cobaltite(?) or smaltite(?), galena, barite (late), chalcopyrite-millerite, and calcite.

HOST ROCK ALTERATION

The host rock of the pitch-and-flat deposits is altered, and limestone is altered much more than dolomite. Typically part of the limestone in the Guttenberg Member of the Decorah Formation is leached and the residue is compacted into a dark-brown shale known as oil rock. It is not uncommon for the Guttenberg Member to be thinned from a normal thickness of about 12 feet to 4–6 feet in pitch-and-flat deposits. Limestone in the Quimbys Mill Member of the Platteville Formation is also leached and compacted in places, but the effects of alterations are not so great or extensive as in the Guttenberg Member. Grant (1903, p. 32) reported that the normal 21 feet, now considered to be the Spechts Ferry and Guttenberg Members of the Decorah Formation and the Quimbys Mill Member of the Platteville Formation, has been reduced to about 8 feet in the Penitentiary mine. Generally dolomite host rock is not thinned near the pitch-and-flat collapse of the overlying rocks. The solutions that thinned the beds may have been ground waters or mixtures of ground waters and ore solutions. The ore-bearing fluids probably came through preexisting fractures from below.

GASH-VEIN DEPOSITS

The first mining in the district was in near-surface joint-controlled deposits of galena and in related concentrations of galena in residual soil derived from the deposits. In the mapped area the joint-controlled deposits are mainly in the Galena Dolomite, although some are in the upper part of the Platteville Formation and the Decorah Formation. The term "gash vein" was introduced by Whitney (1858, p. 432) to distinguish these stratigraphically limited veins from common fissure veins. A group of closely spaced parallel gash vein ore bodies is known as a "range."

The term "openings" is used to describe local cavities that are commonly vertically above one another along joints and that occur at stratigraphic zones in which the material is particularly susceptible to solution. Many of the larger openings are at the junction of two or more joints that have been enlarged and are 1 to 4 feet wide and 4 to 6 feet high, but in places chambers 30 feet wide and 40 feet high occur. Some openings extend laterally several hundred feet.

Mining in shallow pits in residual deposits of galena exposed the gash-vein deposits in the bedrock. The miners dug shallow shafts in the vein deposits and drove drifts along them; however, the drifts generally extended less than 100 feet from a shaft because the miners had no way of obtaining fresh air and it was easier to sink a new shaft than to haul the ore more than about 100 feet underground. Most of the early workings stopped at or above the water table, as the miners had no efficient way of dewatering the mines.

The location of the gash-vein deposits that were worked is shown by groups of small dots on plate 20. Most gash-vein deposits known in the mapped area are in the northern half and southwestern part of the mapped area. The general trends of the gash-vein deposits are eastward in the southern part of the Rewey quadrangle and eastward and northwestward in the northern part of the Rewey and Mifflin quadrangles. The trends of many deposits are ascertained by shallow pits; however, in some places the pits are not alined because the residual galena deposits were scattered from the gash-vein deposits.

The gash-vein deposits are joint controlled but are not confined to any one type or size of fold; in the mapped area these deposits are on structural highs, on the flanks of folds, and in structural lows.

In some places gash-vein deposits are above pitch-and-flat deposits, but not all pitch-and-flat deposits are thus overlain nor is the location of gash-vein deposits limited to this position.

The gash-vein deposits are generally vertical and are from a fraction of an inch to 5 or 6 feet wide and as much as 15 feet high, although in some places a thin vein of galena may extend vertically for 50 to 100 feet.

MINERALOGY OF GASH VEINS

The main ore mineral in the gash-vein deposits is galena, but small amounts of sphalerite, smithsonite ("drybone"), and some cerussite are common. As Heyl and others (1959, p. 129) noted, however, chalcopyrite and its oxidation products are the principal minerals of the deposits in a few locations—notably east of the mapped area near Mineral Point, Wis. The galena occurs in thin veins as a replacement mineral in dolomite wallrock, as linings of openings, and as fragments of galena that are mixed with debris at the base of openings. Associated minerals are pyrite, marcasite, calcite, and barite. Smithsonite occurs above the water table in the zone of oxidation.

GUIDES TO ORE DEPOSITS

LEAD ORE BODIES

The gash-vein deposits of lead generally occur in the Galena Dolomite. Indications that gash veins may underlie the surface include ocherous soil, residual galena in the soil, crevices in bluffs or stream banks, alined strips of vegetation that are greener than surrounding vegetation in dry weather, yellow grass in early spring, or elongate parallel depressions in pastures. Some plants such as cottonwood, red cedar, white birch trees, and wild peas thrive on the soils that are above mineralized joints, which provide abundant moisture.

Prospecting for gash-vein deposits by vertical drill holes is generally considered to be too expensive, as holes must be spaced very closely together to find the narrow vertical deposits; however, drilling inclined holes may be feasible.

ZINC ORE BODIES

The pitch-and-flat zinc deposits are mainly in the upper part of the Platteville Formation, the Decorah Formation, and the lower part of the cherty unit of the Galena Dolomite. The deposits occur in or on the flanks of small synclines and at the intersection of folds.

Drilling along the trends of known ore deposits or zones of sulfide mineralization or along the trends of small synclines where the favorable rocks are subsurface is one method of finding zinc ore bodies. Widely spaced grid drilling may be used to locate thinned or altered rock in areas where the mineralized host rock is deeply buried and there are no surface indications of mineralization or favorable structures. If thinned or altered rock is found, closer spaced holes may be drilled to delineate ore bodies.

Heyl and others (1959, p. 167–175) gave a comprehensive account of the geologic principles applied to exploration and mining of the ores in the mining district.

ZINC AND LEAD POTENTIAL

An estimate of the zinc and lead potential of the mapped area can be made by applying some empirical relationships. Most of the zinc ore is in pitch-and-flat deposits in the uppermost member of the Platteville Formation, the Decorah Formation, and the lower part of the Galena Dolomite; and these zinc ore bodies are generally in or on the flanks of synclines or basins.

Most of the western half of the Rewey quadrangle is an unlikely place for large pitch-and-flat deposits to occur because erosion has removed the favorable beds in many places, and no shallow synclines or basins apt to contain ore are known.

The southern half of the Mifflin quadrangle and the eastern half and the southern quarter of the Rewey quadrangle are favorable areas for the occurrence of pitch-and-flat deposits. In these areas the structure is favorable in the syncline that extends southwestward from Platte Mounds and the syncline at Rewey. The basin in sec. 29, T. 4 N., R. 2 E., may also be favorable because of the possibility that the rocks were disturbed either by faulting or by solution thinning and collapse. The synclines in secs. 11 and 12, T. 3 N., R. 1 W., may possibly contain pitch-and-flat deposits, as they do in their extensions south of the mapped area.

Very little is known about the geologic structure and zinc and lead potential in the southern parts of the quadrangles because only a few holes have been drilled, and even those are widely spaced, except for some in secs. 6 and 7, T. 3 N., R. 1 E.

The McGregor Member of the Platteville Formation may be a potential ore bearer as it contains zinc and lead minerals at the Last Chance and the Nigger Jim mines. It has not been adequately explored for pitch-and-flat deposits because most prospect drill holes have stopped above the McGregor Member.

The Prairie du Chien Group may include host rock containing lead, zinc, and copper deposits. This group contains small galena deposits near Highland, Wis., about 10 miles north of the mapped area and near Waukon, Iowa (Heyl and others, 1959, p. 136–137).

Sphalerite is known to occur in the Prairie du Chien at the Crow Branch Diggings which is only a mile north of the northwest corner of the Rewey quadrangle. Little is known about these rocks in the mapped area because they are not well exposed and only a few drill holes penetrate them.

As gash-vein deposits are not confined to a particular type or size of fold, they probably also exist in some places that have not yet been explored.

ORIGIN OF THE ORES

The origin of the ores has been the subject of controversy since the 1860's. Heyl and others (1959, p. 146–164) gave an excellent summary of the views held by geologists.

The first idea advanced, a magmatic hypothesis, was that the ore metals came from magmatic sources (Owen, 1848, p. 22–23; Daniels, 1854, p. 31; Percival, 1855, p. 100). From about 1860 to 1900 a widely accepted meteoric hypothesis held that the ore metals were originally precipitated during deposition of the sedimentary rocks and were later concentrated by re-solution, transportation, and deposition by ground water, a process called "lateral secretion" (Whitney, 1862, p. 388–402; Chamberlin, 1882, p. 522–553). In 1900 the artesian circulation hypothesis was advanced by Van Hise (1901). He maintained that the ore metals were leached from the crystalline rocks north of the mining district, carried southward by artesian water, and deposited in the ore-bearing zones. A secondary concentration of ore minerals by downward and lateral secretion resulted in the present ore deposits.

In recent years the magmatic or hydrothermal hypothesis has been revived. Most contemporary geologists associated with the mining district believe that the ores are hydrothermal in origin (Heyl and others, 1959, p. 146, 163, 164; Reynolds, 1958).

DESCRIPTIONS OF MINES

The following section contains mine descriptions of pitch-and-flat deposits that are known in the mapped area. These mines are a part of the Mifflin-Cokerville subdistrict of the mines in Wisconsin according to Heyl and others (1959, p. 258). The mine descriptions are a summary of information from Heyl and others (1959), Hall and Whitney (1862), Strong (1877), Chamberlin (1882), Bain (1906), and Lincoln (1946, 1947). None of the underground workings were accessible to the writer in 1957, 1958, and 1959.

Last Chance and LaFollette mines.—The Last Chance and LaFollette mines, in the NE¼NE¼, sec. 3, T. 4 N., R. 1 W., are in two narrow subparallel sulfide ore bodies trending N. 65° W. The underground workings consist of a shaft 40 feet deep, an 80-foot crosscut that trends northward and connects the two ore bodies, and stopes in the ore bodies. The stopes average 12 feet in height in the south ore body and 4 feet in height in the north ore body. The south ore body is part of the workings of the old LaFollette mine, which was operated about 1910. The Last Chance mine was operated in 1943 and 1944 as an extension of the old LaFollette mine.

In the south ore body sphalerite and marcasite veins are localized in a series of folds and vertical fractures trending N. 65° W. In the north ore body sphalerite and iron sulfide are in a thin flat about 2 feet above the base of the Guttenberg Member of the Decorah Formation; barite is in the shaly residue of the Guttenberg; and some disseminated crystals of sphalerite are near the floor in the north ore body just above the base of the member. In both ore bodies iron sulfide is abundant near the mine walls. Thin veins of galena are in the lower part of the Ion Member of the Decorah Formation in the shaft.

No record of the production from the LaFollette mine is available. The following information about the Last Chance mine is from Lincoln (1947). From September 1943 to October 1944 the mine produced 481.5 tons of hand-sorted ore that contained 40.47 tons of zinc and 4.48 tons of lead. Monthly totals of production show that the grade of the ore ranged from 3.70 to 11.38 percent zinc and averaged 8.40 percent. The contained lead ranged from 0.25 to 3.77 percent and averaged 0.93 percent.

A hole drilled southeast of the south ore body penetrated 14 feet of 8.27 percent zinc ore that extended from the Spechts Ferry Member of the Decorah Formation through the Quimbys Mill Member of the Platteville Formation into the McGregor Member of the Platteville Formation. The ore in this hole may be along a vertical or near-vertical fracture, as nearby holes drilled in the same members did not penetrate ore. Ore in these members may, however, indicate a potential zinc-producing zone below the old workings.

Washburn mine.—The Washburn mine in the SW¼SE¼SE¼ sec. 34, T. 5 N., R. 1 W., was worked intermittently during 1906, 1926, and 1940.

The ore body trends N. 65° W. and is in flats in the Guttenberg Member of the Decorah Formation at a depth of 40 to 50 feet. The underground workings include an incline 500 to 600 feet long, stopes, and three shafts. The original ore face is reported to be about 150 feet wide and 4 to 6 feet high.

The ore body contains sphalerite, abundant iron sulfide, much galena, and some copper and barite.

The total amount of zinc or produced from the Washburn mine is unknown, but about 180 tons of ore which averaged 12.8 percent zinc, 1.84 percent lead, and 17.28 percent iron was produced in 1940.

Ebenezer mine.—The Ebenezer mine, in a shallow syncline, in the SW¼SW¼ sec. 30, T. 5 N., R. 1 E., was operated from 1905 to 1907. The underground workings consist of a shaft 80 feet deep and a stoped area 150 to 200 feet long in a zinc-pyrite ore body that trends N. 60° W. Sphalerite ore occurs in veins rich in iron sulfide in the Ion and Guttenberg Members of the Decorah Formation.

Kuster and Ray mine.—The Kuster and Ray mine is in the NW¼ NW¼ sec. 2, T. 4 N., R. 1 W., about 1,000 feet east of the Last Chance and LaFollette mines. No information about this mine is available.

New Dale Rundell mine.—The New Dale Rundell mine is in the SE¼NE¼ sec. 31, T. 5 N., R. 1 E., on the south limb of a syncline trending N. 70° E., and may be a westward extension of the Coker No. 3 and Senator ore bodies at the northeast.

This ore body was discovered about 1915 but was not opened until the spring of 1943 when a shaft was sunk to a depth of 122 feet. Mining began in June 1943 and ended in January 1944. The mine was reopened and worked from December 11, 1946, to March 14, 1947. The ore body has been mined for a length of about 340 feet. The widest drift is about 70 feet wide, and the stopes are 6 to 15 feet high.

Sphalerite is in pitches and flats and is disseminated in the Quimbys Mill Member of the Platteville Formation and the Guttenberg and Ion Members of the Decorah Formation. The disseminated ore is in beds at and below the mine floor in the southeast drift. The veins contain sphalerite and abundant iron sulfide, especially at the east end of the mine. The ore ranges from 2 to 8 inches in thickness at the northeast end. The disseminated ore is 1 to 1½ feet thick. The ore body and the pitches trend N. 80° E. and have small extensions toward the northwest and southeast. In the southeastward extension the disseminated ore and small faults trend northeastward.

Lincoln (1946, p. 3) reported that 9,928 tons of zinc sulfide ore, which averaged about 10 percent zinc, was produced during 8 months of operation in 1943 and 1944. An additional 5,000 tons is estimated to have been recovered in late 1946 and early 1947. The total estimated amount of zinc sulfide ore recovered from this mine is 15,000 tons.

Coker No. 2 mine and Dale Rundell mine.—The southwestern part of the Coker No. 2 mine is in the SW¼ sec. 29, T. 5 N., R. 1 E., but most of the mine is north of the Rewey quadrangle. The Dale

Rundell mine is in the SE¼ sec. 30, T. 5 N., R. 1 E., west of the Coker No. 2 mine. Both mines are in the same ore deposit. The east end of the ore body was mined for galena in the 1800's, but the mine was reopened for zinc ore in 1899 and operated until April 1926. The ore body was worked briefly in 1947 and ore was hoisted through the Dale Rundell mine shaft. The underground workings total about 12,000 linear feet of stoping 30 to 100 feet wide, 30 to 50 feet high, and 70 to 150 feet below the surface.

The ore was mined from a pitch-and-flat sphalerite and smithsonite deposit trending N. 80° E. in the Decorah Formation and the lower part of the cherty unit of the Galena Dolomite. The west end of the ore body is on the crest of an anticline that trends northeastward and is controlled by an elliptical pitch zone that dips into the anticline.

Several mines in the ore body in both the Rewey quadrangle and the Montfort quadrangle to the north produced about 1,700,000 tons of ore (Heyl and others, 1959, p. 262). However, production from the Coker No. 2 and the Dale Rundell mine produced about 875,000 tons of ore that averaged 25.7 percent zinc in jig concentrate. In the Rewey quadrangle the ore body probably yielded about 300,000 tons of this total.

Coker No. 3 mine (also M & A or Big Tom mines).—The Coker No. 3 mine is in the SE¼ sec. 29, T. 5 N., R. 1 E., and the M & A or Big Tom part of the ore body is in the NW¼NE¼ sec. 32, T. 5 N., R. 1 E. The M & A mine was opened in 1912 but apparently was idle until about 1916 when it was reopened as the Big Tom mine and operated until February 25, 1919. The Coker No. 3 mine, north of the road, was opened about 1920 and was operated until March 13, 1926.

This deposit, on the south limb of a syncline trending N. 70° E., was mined from workings 50 to 100 feet wide, 4 to 15 feet high, and more than 2,300 feet long along its northeastward trend. The southwest end of the main ore body splits into two parts; one trends southeastward about 350 feet, and the other trends southwestward about 500 feet.

Sphalerite and iron sulfide occurs in veins and as disseminations in the lower part of the Decorah Formation and the Quimbys Mill Member of the Platteville Formation. The vein ore is rich in iron. The ore is controlled by a pitch zone trending N. 60° E. and dipping southeastward. About 170,000 tons of ore, which contained about 7 percent zinc, is estimated to have been produced at the Coker No. 3 mine.

Senator mine.—The Senator mine in the northern part of the SW¼ SW¼ sec. 28, T. 5 N., R. 1 E., and the SE¼ sec. 29, T. 5 N., R. 1 E., is on the south limb of a syncline that trends northeastward, but the mine cuts across the structure and trends eastward.

This ore body was discovered about 1907 by drilling. Mining began in 1908 and continued until about 1910 or 1911. It reportedly was reopened briefly in 1916 and was again opened in 1920. The workings consist of a shaft 117 feet deep and a westward-trending drift 1,600 feet long, 60 feet wide, and 5 to 15 feet high. The mine trends generally N. 80° W. but curves to S. 80° W. at the west end. Sphalerite ore is in a pitch zone that strikes eastward and dips southward. The ore, locally high in iron sulfide, is in the lower part of the Decorah Formation and in the Quimbys Mill Member of the Platteville Formation. More than 50,000 tons of sphalerite ore, some of which contained 10 percent zinc, was produced from this ore body.

Defense Mine.—The Defense mine in the E½SE¼ sec. 28, T. 5 N., R. 1 E., was worked from June 1942 until September 1945. This mine is at the northwest end of the syncline that contains other mines near Mifflin, but only half of the mine is in the mapped area.

The underground workings consist of a shaft 78 feet deep and a drift, 10 to 40 feet wide and 5 to 10 feet high that trends N. 60° W. for about 1,500 feet.

The ore body is sphalerite and is controlled by a zone of parallel pitches that dip about 45° SW., and is mainly in veins along the pitches and flats, especially the flats. Thick pyrite masses and some marcasite are associated with the ore. About 3,500 tons of sphalerite ore that averaged about 6 percent zinc was produced from this ore body.

Clayton mine.—The Clayton mine in the S½SW¼SW¼ sec. 27, T. 5 N., R. 1 E., was worked from about 1914 to 1916. It is 1,200 to 1,300 feet southeast of the Defense mine. The mine has two shafts that form a northwest line; the one at the northwest is 120 feet deep, and the other is about 110 feet deep. The sphalerite ore body, an extension of the Defense ore body, lies on the southwest flank of the syncline at Mifflin, Wis. It trends N. 53° W. for about 1,000 feet and is about 40 feet wide.

New Gruno mine.—The New Gruno mine is in the SE¼SW¼ sec. 27, T. 5 N., R. 1 E., about 500 feet east of the Clayton mine. This mine was worked for zinc ore from 1914 to 1916. The ore body trends eastward on the southwest flank of the syncline at Mifflin, Wis. The workings are 100 feet wide but the height and length are unknown. The zinc ore was rich in iron sulfide. Total production and grade are unknown.

Old Gruno mine or Miller mine.—The Old Gruno or Miller mine in the NE¼NW¼ sec. 34, T. 5 N., R. 1 E., was worked from 1900 to about 1912. It trends N. 18° W. for 1,100 feet and then curves northeastward at its north end for about 400 feet. The main shaft is 100 feet deep. The ore body has been mined for a width of about 200 feet in a westward-dipping pitch and three flats in the trough of the syncline at Mifflin, Wis., Bain (1906, p. 99–101) reported that the highest flat was above the Guttenberg Member of the Decorah Formation and was worked in connection with the lowest flat in the Quimbys Mill Member of the Platteville Formation. In places where these flats were productive, the middle flat, which is in the Guttenberg Member, was not productive. The middle flat, however, was possibly more productive near the pitch. Bain considered the flats in this mine more important than the pitch.

The flats are sphalerite veins from 2 to 5 inches thick. In the middle of the Quimbys Mill Member the ore occurs in sheets that lie along and that cut across bedding planes in a zone 2 to 4 feet thick and in veins ¼ inch to 2 inches thick. Disseminated sphalerite is in the Guttenberg and Spechts Ferry Members of the Decorah Formation. In 1912 the jig concentrate from this mine averaged 35 percent zinc.

Penitentiary or Black Jack mine.—The Penitentiary or Black Jack mine in the NW¼NE¼ sec. 34, T. 5 N., R. 1 E., is the oldest mine in the mapped area. The ore body was discovered in 1835, and the mine was in continuous operation from 1842 to about 1910. Strong (1877) and Chamberlin (1882) described this mine.

The workings of three ranges are connected by an adit. In the 1877 the adit was 1,700 feet long. The deposit averages 300 feet in width and the ore ranges from 6 inches to 2 feet in thickness. The mine is gravity drained through the adit. This deposit is in a syncline at Mifflin, Wis., and trends N. 30°–35° W., which approximately coincides with the northwestward trend of the syncline.

Pitches and flats are in the Guttenberg and Spechts Ferry Members of the Decorah Formation. Chamberlin (1882, p. 475) reported that the flats are more important than the pitches (fig. 46). Before 1864 galena in the upper flats was mined, but from 1864 until 1910 sphalerite and smithsonite from the lower flats have been the major ores mined. Disseminated sphalerite and galena were mined from the shale in the Guttenberg and the Spechts Ferry Members of the Decorah Formation.

From 1842 to 1877 about 12,000 tons of jig concentrate was produced (Bain, 1906, p. 98) from an estimated 45,000 tons of sphalerite ore.[7] Also 1,500 tons of galena was produced, which probably was hand cobbed. It is estimated by the writer that since 1877 an additional 115,000 tons of zinc ore and 900 tons of lead was produced. The lead was mined with the zinc in a ratio of approximately 1 to 10. Production thus totaled about 160,000 tons of sphalerite ore and 2,400 tons of galena ore.

Old Slack mine.—The Old Slack mine in the SE¼SW¼ sec. 26, T. 5 N., R. 1 E., is in a northeastward-trending syncline, and the underground workings consist of two shafts, one of which is 18 feet deep, and about 200 feet of northwest-trending drift. This small mine was worked about 1906.

Sphalerite occurs in veins and as disseminations in dolomitized strata of the Guttenberg Member of the Decorah Formation and the Quimbys Mill Member of the Platteville Formation in a shattered or brecciated zone, which has an abrupt 15- to 20-foot rise to the northeast. Heyl and others (1959, p. 265) stated: "Part of the ore is reported to be in a solid vertical vein. Calcite and a very little pyrite and marcasite are the gangue minerals." This ore body is in a southeast extension of the Mifflin fault according to Heyl and others (1959, p. 37, 265).

Squirrel mine.—The Squirrel mine in the SE¼ sec. 25, T. 5 N., R. 1 E., is apparently on the southeast end of the same ore body as the Okay, Slack, Peacock, and Lucky Six mines, which are north of the Mifflin quadrangle and trend N. 80° W. (Agnew and Heyl, 1943; Carlson, 1961). It was operated from 1889 to about 1918.

This mine is in the northwest limb of a northeastward-trending syncline but trends normal to the axis of the syncline. The ore body is about 1,300 feet long in the Mifflin quadrangle, trends northwestward, and joins a northward-trending segment that extends beyond the mapped area. The extent of the northern part is not known. The width of the drift ranges from 100 to 200 feet, and the height is about 6 feet.

Sphalerite ore occurs as disseminations and in veins in the Guttenberg and Spechts Ferry Members of the Decorah Formation and in the Quimbys Mill Member of the Platteville Formation. Locally, galena occurs in large amounts. Heyl and others (1959, p. 265) stated: "The ore bodies are controlled by bedding-plane faults * * * and by small, tight normal and reverse faults that trend N. 80° W., and are very little mineralized." About 2,500 tons of hand-cobbed zinc concentrate and 250 tons of lead concentrate was produced from this mine before 1900. In 1912 the jig concentrates

[7] If the concentrate contained an estimated 30 percent zinc and the original ore averaged 8 percent, then the amount of ore produced was $12{,}000 \times 3.75 = 45{,}000$ tons. (Estimate by writer.)

averaged 50 percent zinc. It is estimated that 37,000 tons of ore was produced, 20,000 tons of which probably came from the part of the mine in the Mifflin quadrangle.

NONMETALLIC DEPOSITS

DOLOMITE AND LIMESTONE

Dolomite has been quarried and crushed for use as road material from the Pecatonica Dolomite Member of the Platteville Formation, the Ion Dolomite Member of the Decorah Formation, the Galena Dolomite and the Edgewood Dolomite in many places in both the Rewey and Mifflin quadrangles. The Galena Dolomite is more widespread than the Edgewood Dolomite in the mapped area and affords a greater amount of rock for road material, as well as for agricultural purposes.

Building stone is available in the Pecatonica Dolomite Member in several places in the mapped area. This rock was quarried by the early settlers for building, and more recently it is being used for foundations of buildings. Both the limestone and dolomite facies of the Quimbys Mill Member of the Platteville Formation are good building stone. Many buildings are partly or wholly constructed of this material.

In some places the limestone of both the McGregor and the Quimbys Mill Members of the Platteville Formation may be useful for the manufacture of cement.

CLAY

The Maquoketa Shale that crops out around Belmont Mound, Little Mound, and Platte Mounds is a source of clay and potentially is a source of ceramic clay. Some pits near the base of the Maquoketa east of Belmont Mound were reportedly dug for ceramic clay. (See p. 303–304 of this report.) Brown and Whitlow (1960, p. 63) also noted that amateur ceramists have used clay from the Maquoketa in Iowa.

SAND AND GRAVEL

The St. Peter Sandstone is potentially a good source of sand for the concrete and glass industries. The St. Peter is a relatively friable clean sand in some places in the mapped area, although in many places it is iron stained.

Chert gravel is available locally in stream-channel deposits in the streams and valleys of the mapped area, especially downslope from the cherty unit of the Galena Dolomite.

BARITE

Several vein deposits of barite are known in the mapped area; especially in the Last Chance, Washburn, and Nigger Jim mines where the barite is associated with sphalerite and galena. The barite is generally white and appears to make up the bulk of the gangue in most of the places where it is found.

PHOSPHATE

Phosphatic nodules are in the basal 5 feet of the Maquoketa Shale in the mapped area. These francolite nodules (p. 303) are disseminated in two layers of clay, each about 12 inches thick, which also contain phosphatic fossils; one layer is at the base of the Maquoketa and the other is 3 or 4 feet above it.

GROUND WATER

The St. Peter Sandstone is the best aquifer in the Rewey and Mifflin quadrangles. Some shallow farm wells, however, tap an adequate source of water from rocks above the St. Peter, such as the Galena Dolomite. According to the farmers in the area, the water table in the rocks above the St. Peter has been dropping steadily. Many farmers are having to drill new water wells or have old wells deepened to the St. Peter.

The rocks below the St. Peter also contain a nominal amount of ground water. The water is used locally where the St. Peter is eroded away. Good springs exist in numerous places in both quadrangles where limestone or dolomite overlies shale and the contact is exposed. Springs generally are at the contact between the Glenwood Shale and the Pecatonica Dolomite Members of the Platteville Formation, at the top of the bentonite layer of the Spechts Ferry Member of the Decorah Formation, at the top of the basal clay or depauperate zone of the Maquoketa Shale (in lowest 5 feet of Maquoketa), and at the top of the Maquoketa where the shale underlies the Edgewood Dolomite.

RECORDS OF DRILL HOLES

Twenty-eight holes were churn-drilled by the U.S. Geological Survey for stratigraphic and structural information in the Rewey and Mifflin quadrangles between October 5 and November 11, 1955. Mr. J. D. Judd, the contractor, and Mr. C. Koomprood and Mr. W. Pahnke, the drill operators, did the work and collected the samples. Geologists of the U.S. Geological Survey studied the samples at the drill site and made generalized records, and the writer studied the samples with a binocular microscope in 1957 and made the following detailed records.

The records are arranged numerically and by the property name. The location of each hole is shown in plate 20.

USGS 1 (GRISWOLD)

Location: SE¼NE¼NW¼ sec. 33, T. 5 N., R. 1 W.
Total depth: 117½ ft
Collar altitude: 1,146.3 ft

	Depth (feet)
Surficial:	
Soil, loess, and residuum	0–10
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange to dark-yellowish-orange, fine-grained; 50 percent of sample is white to light-gray chert; traces of limonite and clear calcite	10–35
Dolomite, grayish-orange to yellowish-gray, fine-grained; traces of chert, limonite, and clear calcite	35–50
Dolomite, grayish-orange, fine-grained; moderate-reddish-orange to grayish-red chert abundant; red specks in chert; abundant limonite and calcite	50–72
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to dark-greenish-gray, fine-grained; olive-gray shale partings; clay; limonite and calcite abundant	72–93
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown to pale-yellowish-brown, fine-grained; moderate-brown clay; trace of chert (float?), pyrite, and limonite	93–107
Spechts Ferry Shale Member:	
Shale and clay, olive-gray; light-olive-gray and dark-greenish-gray, fine-grained, dolomite	107–113
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown to moderate brown, very fine grained; dusky-brown shale at base; trace of pyrite	113–116
McGregor Limestone Member:	
Dolomite, light-olive-gray, very fine grained	116–117½

USGS 2 (JOHN GATES)

Location: SW¼NW¼NW¼ sec. 34, T. 5 N., R. 1 W.
Total depth: 132 ft
Collar altitude: 1,171.8 ft

Surficial:	
Soil, loess, and residuum	0–10
Galena Dolomite:	
Cherty unit:	
Dolomite, pale-yellowish-orange to grayish-orange, fine-grained; white chert: at 10–20 ft, 1–3 percent chert; 20–25 ft, 10 percent chert; 25–35 ft, 5 percent chert; 35–65 ft, traces of chert and clear calcite; 65–85 ft, 10–20 percent chert. Abundant calcite, limonite, and dusky-brown clay. No chert at 85–90 ft but trace of limonite and calcite	10–90

	Depth (feet)
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to olive-gray; speckled with dark gray fine-grained material; greenish-gray shale	90–98
Dolomite, dark-greenish-gray, fine-grained; greenish-gray clay and shale; trace of limonite	98–107
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dusky-yellowish-brown, very fine to fine-grained; dusky-yellowish-brown shale; traces of white chert (float?), pyrite, limonite, and clear calcite in lower part	107–119
Spechts Ferry Shale Member:	
Dolomite, light-olive-gray, dark-gray-speckled, fine-grained; contains greenish-gray shale, light-olive-gray clay, white bentonite, and black phosphatic(?) nodules	119–123
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, fine-grained; moderate-brown shale; trace of white chert (float?)	123–215
McGregor Limestone Member:	
Dolomite, light-olive-gray to greenish-gray, very fine to fine-grained; brown shale	125–132

USGS 3 (JOE GATES)

Location: NW¼SW¼NE¼ sec. 34, T. 5 N., R. 1 W.
Total depth: 90 ft
Collar altitude: 1,134.2 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, dark-yellowish-orange, fine- to medium-grained; white, yellowish-gray, and very pale orange chert; abundant limonite and clear calcite in the lowest 20 ft	5–50
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, dark-yellowish-orange with green tint, fine- to medium-grained	50–60
Clay, greenish-gray; light-olive-gray, fine-grained limestone; abundant clacite and limonite; trace of pyrite	60–70
Guttenberg Limestone Member:	
Dolomite and limy dolomite, light-olive-gray to olive-gray; abundant calcite, limonite, and pyrite	70–80
Spechts Ferry Shale Member:	
Shale, olive-gray, containing conodonts; contains olive-gray fine-grained limestone, brachiopod fragments, white bentonite, black phosphatic(?) nodules, and abundant pyrite	80–86

	Depth (feet)
Platteville Formation:	
Quimbys Mill Member:	
(Apparently too thin to find in drill cuttings.)	
McGregor Limestone Member:	
Limestone, olive-gray; fine-grained; olive-gray, fine- to medium-grained dolomite	86–90

USGS 4 (KIES NO. 1)

Location: NW¼SW¼NE¼ sec. 35, T. 5 N., R. 1 W.
Total depth: 70 ft
Collar altitude: 1,111.4 ft

Surficial:	
Soil loess, and oxidized residuum	0–25
Galena Dolomite:	
Cherty unit:	
Dolomite, moderate-yellowish-brown, fine-grained; medium-grained well-rounded subspherical to spherical slightly frosted quartz grains are cemented by pyrite; traces of limonite, chert, and clear calcite	25–33
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to olive-gray, fine-grained; traces of limonite and pyrite	33–43
Dolomite, dark-greenish-gray, fine- to medium-grained; abundant dark-greenish-gray shale in lower 2 ft	43–51
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, fine-grained; float from above moderate-red to dusky-red chert	51–63
Spechts Ferry Shale Member:	
Shale, light-olive-gray; light-olive-gray fine-grained dolomite; traces of calcite and pyrite	63–66
Platteville Formation:	
Quimbys Mill Member:	
Shale, dusky-brown; dolomite, dark-yellowish-brown, sublithographic to fine-grained	66–68
McGregor Limestone Member:	
Dolomite, light-olive-gray, fine-grained	68–70

USGS 5 (HUGH NODOLF)

Location: SW¼NW¼NE¼ sec. 2, T. 4 N., R. 1 W.
Total depth: 95 ft
Collar altitude: 1,067 ft

Surficial:	
Soil, loess, and residuum	0–5

	Depth (feet)
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, limy, moderate-yellowish-brown to light-gray, fine-grained; light-gray shale and clay	5–15
Dolomite, limy, dark-greenish-gray to dark-gray (mottled with black specks and moderate-yellowish-brown dolomite), fine- to medium-grained; contains greenish-gray shale, yellowish-brown clay, trace of yellowish-gray chert (float?), and calcite; near bottom, the rock is very fine grained olive-gray limestone	15–18
Guttenberg Limestone Member:	
Limestone, pale-yellowish-brown, fine-grained to sublithographic; trace of marcasite and moderate-reddish-brown chert (float?)	18–22
Dolomite, limy, pale-yellowish-brown, very fine to fine-grained; trace of pyrite	22–25
Limestone, pale-yellowish-brown, dark-yellowish-brown, very fine grained to sublithographic; contains pale-yellowish-brown shale, brachiopod fragments, and pyrite	25–30
Spechts Ferry Shale Member:	
Limestone, light-gray, sublithographic to very fine grained; fragments of brachiopods and bryozoans; pale-green shale at the top contains pyrite and black phosphatic(?) nodules; dark-yellowish-brown shale in lower part	30–35
Platteville Formation:	
Quimbys Mill Member:	
Limestone, dark-yellowish-brown and dusky-yellowish-brown, sublithographic; dusky-yellow clay contains microscopic bits of moderate-reddish-orange material; brown shale at base; traces of pale-orange chert (float?), pyrite, and black phosphatic(?) bryozoans	35–41
Limestone, olive-gray to light-olive-gray, very fine grained; some moderate-yellowish-green shale is mottled with dark-greenish-yellow clay and contains disseminated dolomite crystals; white chert (float?) and traces of limonite and pyrite	41–52
Limestone, dark-greenish-gray and light-olive-gray, very fine grained to sublithographic, mottled dark-gray; fragments of brachiopods	52–60
Limestone, light-olive-gray, very fine to fine-grained; abundant light-olive-gray shale; limestone in basal few feet is dark-yellowish-brown to pale-yellowish-brown; trace of limonite	60–71
Pecatonica Dolomite Member:	
Dolomite, olive-gray, dark-gray-speckled, fine-grained to very fine grained; very fine grained moderate-yellowish-brown and dark-yellowish-brown limestone and light-olive-brown shale containing conodonts make up 5–10 percent of the section. Also contains traces of chert (float?), limonite, pyrite, and sphalerite at 82–85 ft; fragments of bryozoans in limestone	71–85

	Depth (feet)
Platteville Formation—Continued	
Pecatonica Dolomite Member—Continued	
Dolomite, dark-yellowish-brown and light-olive-gray, very fine grained; traces of brownish-gray shale, white chert, limonite and pyrite; black phosphatic(?) nodules in basal bed are mixed with fine-grained clear well-rounded and spherical quartz sand in dolomite	85–91
Glenwood Shale Member:	
Shale, bluish-green; mixed in the shale is medium-grained frosted well-rounded and spherical quartz sand; traces of limonite and pyrite	91–92
St. Peter Sandstone:	
Sand, quartz, medium- to coarse-grained, clear and frosted, well-rounded and subspherical to spherical, poorly sorted; pyrite abundant	92–95

USGS 6 (JENKS)

Location: NW¼NE¼NW¼ sec. 18, T. 4 N., R. 1 E.
Total depth: 135 ft
Collar altitude: 1,146.2 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, dark-yellowish-orange, fine- to medium-grained; yellowish-gray chert abundant at 25–30 ft	5–38
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to moderate-yellowish-brown, fine-grained; at 52–58 ft dolomite is dark-greenish-gray and argillaceous; dark-greenish-gray shale and pyrite in lowest part	38–58
Guttenberg Limestone Member:	
Limestone, pale-yellowish-brown to dark-yellowish-brown, very fine to fine-grained, fossiliferous, argillaceous; very pale orange shale in upper part and dark-yellowish-brown shale in lower part; trace of pyrite	58–73
Spechts Ferry Shale Member:	
Limestone, olive-gray, dark-gray-speckled, sublithographic, fossiliferous; light-gray to light-olive-gray shale and clay; pyrite and black phosphatic(?) nodules	73–75
Platteville Formation:	
Quimbys Mill Member:	
Limestone, pale-yellowish-brown to dark-yellowish-brown, sublithographic to very fine grained; dusky-yellowish-brown shale at the base; traces of pyrite and calcite	75–81
McGregor Limestone Member:	
Limestone, light-olive-gray and olive-gray, very fine grained, fossiliferous; basal 3 ft is dolomite; speckled olive-gray calcareous shale at the top; noncalcareous shale abundant in middle part	81–112

	Depth (feet)
Platteville Formation—Continued	
Pecatonica Dolomite Member:	
Dolomite, olive-gray to light-olive-gray, very fine to fine-grained; contains light-olive-gray shale, trace clear calcite, white clay and microscopic pyrite	112–130
Glenwood Shale Member:	
Shale, greenish-gray; contains frosted fine- to coarse-grained quartz sand which is subspherical to spherical and rounded, and cemented by limonite, pyrite, clay, and dolomite	130–132
St. Peter Sandstone:	
Sand, quartz, clear to frosted, fine- to coarse-grained (mode is medium grained), rounded; subspherical to spherical; poorly cemented by limonite, pyrite, clay and dolomite. Pyrite is abundant	132–135

USGS 7 (ROY TURNBULL)

Location: SW¼SE¼NE¼ sec. 17, T. 4 N., R. 1 E.
Total depth: 115 ft
Collar altitude: 1,115.2 ft
NOTE.—Hole caved during drilling

Surficial:	
Galena Dolomite:	
Soil, loess, and residuum	0–5
Cherty unit:	
Dolomite, moderate-yellowish-brown, fine- to medium-grained; trace of grayish-orange chert and clay	5–15
Dolomite, grayish-orange, some moderate-yellowish-brown; 20 percent of samples is grayish-orange to moderate-yellowish-brown clay and about 1 percent is grayish-orange chert	15–30
Decorah Formation:	
Ion Dolomite Member:	
(Unreliable contact—the clay above may be the upper part of the Ion Member.)	
Dolomite, dark-greenish-gray to olive-gray (dark-gray patches), fine-grained, argillaceous; trace of white chert float from unit above	30–37
Guttenberg Limestone Member:	
Limestone, pale-yellowish-brown to dark-yellowish-brown, very fine grained, and moderate-brown shale; unit is fossiliferous (brachiopods); trace of pyrite and calcite	37–50
Spechts Ferry Shale Member:	
Limestone, pale-yellowish-brown, very fine grained, fossiliferous; light-blue-green shale and calcareous moderate-brown shale with dusky-brown specks; traces of white bentonite and black phosphatic(?) nodules	50–52

	Depth (feet)
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-brown, very fine to fine-grained	52–57
Limestone, pale-brown to dark-yellowish-brown, very fine grained to sublithographic	57–60
Limestone, dark-yellowish-orange, very fine grained; traces of dusky-yellowish-brown shale, white chert (float?), and pyrite	60–62
McGregor Limestone Member:	
Dolomite, olive-gray, very fine to fine-grained; traces of white chert (float?) and pyrite	62–68
Limestone, light-olive-gray and olive-gray; at 75–80 ft unit is dark greenish gray and very fine to medium grained; conodonts in light-olive-gray clay; traces of clear calcite, pyrite, and limonite	68–85
Dolomite, dark-yellowish-brown, very fine grained; calcareous moderate-brown shale streaked with dusky-yellowish-brown material and speckled with moderate-brown conodonts; traces of pyrite. clear calcite, and limonite	85–91
Pecatonica Dolomite Member:	
Dolomite, light-olive-gray to olive-gray, fine- to medium-grained; speckled with darker material; traces of pyrite and light-olive-gray shale containing conodont fragments; at 110–111 ft the dolomite is greenish gray and very fine grained, and contains small black phosphatic(?) nodules, dark-gray specks, and poorly sorted rounded and subspherical clear quartz sand grains	91–111
Glenwood Shale Member:	
Shale, pale-green; contains rounded and subspherical clear quartz sand grains, pyrite, and small black phosphatic(?) nodules	111–112
St. Peter Sandstone:	
Sand, quartz, clear and frosted, moderate-yellow to dark-yellowish-orange, medium- to very coarse grained, well-rounded and subspherical, poorly sorted; sand grains in general are loose but some are cemented by pyrite and limonite; traces of moderate-yellow clay and black phosphatic (?) nodules	112–115

USGS 8 (MAYNARD BOCKHOP)

Location: SE¼NE¼SW¼ sec. 21, T. 4 N., R. 1 E.
Total depth: 90 ft
Collar altitude: 1,130.5 ft

Surficial:	
Soil, loess, residuum (moderate-brown clay and very light gray chert)	0–35
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange, medium-grained; very abundant chert (more than 50 percent of samples is very pale orange chert)	34–45

	Depth (feet)
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, grayish-orange, medium-grained; very pale orange clay, chert, and residuum; dolomite has greenish tint; abundant limonite; very argillaceous	45–60
Dolomite, olive-gray, speckled, fine- to medium-grained; float of chert from unit above	60–68
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown, fine-grained; traces of pyrite and limonite	68–79
Spechts Ferry Shale Member:	
Shale, light-olive-gray; light-olive-gray fine-grained dolomite	79–80
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown, very fine grained; dusky-brown shale; traces of sphalerite, pyrite, and calcite	80–88
McGregor Limestone Member:	
Dolomite, slightly mottled olive-gray, fine-grained	88–90

USGS 9 (HARVEY JOHNSON)

Location: NW¼SW¼NW¼ sec. 31, T. 4 N., R. 1 E.
Total depth: 95 ft
Collar altitude: 1,044.2 ft
NOTE.—Hole caved during drilling.

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, dark-yellowish-orange to moderate-yellowish-brown, fine-grained; very pale orange to grayish-orange fossiliferous chert; trace of limonite	5–50
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, yellowish-gray to dark-yellowish-orange, very fine grained; mottled with gray shale; very pale orange siliceous fossil (brachiopod?) fragments	50–65
Guttenberg Limestone Member:	
Dolomite, moderate- to dark-yellowish-brown, very fine-grained; brown shale; limonite, pyrite, and very pale orange siliceous fossil fragments	65–73
Spechts Ferry Shale Member:	
Shale, light-green; traces of pyrite, limonite, and calcite; fossiliferous, one gastropod (2 mm in diameter)	73–74
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, grayish-orange to pale-yellowish-brown, very fine grained; trace of calcite and fossil fragments	74–80
McGregor Limestone Member:	
Limestone, yellowish-gray, very fine grained	80–95

USGS 10 (KIES 2)

Location: SW¼NE¼SE¼ sec. 31, T. 4 N., R. 1 E.
Total depth: 362½ ft
Collar altitude: 1,262.5 ft

	Depth (feet)
Surficial:	
Soil, loess, and residuum	0–5
Maquoketa Shale:	
Dolomite, dark-yellowish-orange to moderate-yellowish-brown, very fine grained; dark-yellowish-orange clay and traces of white chert and small black nodules (phosphatic?)	5–10
Clay and shale, dark-yellowish-orange, argillaceous; dark-yellowish-orange very fine grained dolomite; trace of black nodules	10–20
Clay, olive-gray, silty; silty olive-gray dolomite; very pale orange siliceous crinoid stem segments, 1–2 mm in diameter, at 45–50 ft	20–60
Dolomite, olive-gray, very fine grained to silt sized; olive-gray silty clay; pyrite and crinoid stem segments at 70 ft; depauperate fossils in a clay zone at the base	60–90
Galena Dolomite:	
Noncherty unit:	
Dolomite, light-olive-gray, very fine grained, argillaceous, fossiliferous; abundant pyrite; crinoid stem segments; black bryozoan stem, 1 mm in diameter near 115 ft; minor black nodules (phosphatic?) and some red specks in dolomite, probably iron oxides(?)	90–115
Dolomite, grayish-orange to pale-yellowish-orange, very fine to fine-grained; contains minor pyrite, limonite, crinoid stem segments, black bryozoans and, in lower part, trace of calcite	115–210
Cherty unit:	
Dolomite, grayish-orange, very fine to fine-grained; contains sparse white chert at 210–215 ft, abundant chert at 215–240 ft, sparse chert at 240–250 ft. abundant chert at 250–255 ft, sparse chert at 255–265 ft, abundant chert at 265–285 ft and small (1 mm in diameter) very pale orange crinoid stem segments, sparse chert at 285–295 ft, abundant chert at 295–300 ft; dolomite is moderate-yellowish-brown and very fine grained at 310–318 ft	210–318
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, olive-gray, silt-sized to very fine grained; moderate yellowish-brown to gray dolomite containing pale-green shale and dark-brown shale in lower 8 ft; pyrite and limonite in lower few feet	318–338
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown to grayish-brown, very fine grained; traces of pyrite and white chert	338–352½
Spechts Ferry Shale Member:	
Dolomite, yellowish-gray to light-olive-gray, sublithographic; light-olive-gray shale, pyrite, and white chert (float?)	352½–355

	Depth (feet)
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale- to dusky-brown, sublithographic to very fine grained; moderate-brown shale in basal foot; traces of clear calcite, pyrite, chert (float?), and pale-yellowish-orange clay	355–361
McGregor Limestone Member:	
Dolomite, light-olive-gray, very fine grained	361–362½

USGS 11 (FRITZ GOBRECHT)

Location: SW¼SE¼NE¼ sec. 32, T. 4 N., R. 1 E.
Total depth: 270 ft
Collar altitude: 1,178.2 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Noncherty unit:	
Dolomite, grayish-orange, medium- to coarse-grained, mixed with fine-grained light-olive-gray dolomite; abundant crinoid stem segments, 2–3 mm in diameter; trace of calcite and pyrite	5–25
Dolomite, pale-yellowish-orange to grayish-orange, fine- to medium-grained; cephalopods and crinoid stem segments at 25–35 ft; trace of calcite	25–120
Cherty unit:	
Dolomite, grayish-orange, fine-grained; white chert: 120–150 ft, 5 percent; 150–175 ft, only trace; 175–180 ft, 2 percent; 180–215 ft, trace; 215–220 ft, 5 percent; 220–226 ft, none	120–226
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray, fine-grained, argillaceous; trace of pyrite	226–236
Dolomite, dark-greenish-gray, fine-grained; greenish-gray shale; trace of pyrite	236–244
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown to moderate-brown, fine-grained; traces of pyrite, white dolomite crystals, and white chert (float?)	244–257
Spechts Ferry Shale Member:	
Dolomite, light-olive-gray, fine-grained; greenish-gray shale	257–258
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown and yellowish-gray, very fine grained to sublithographic; moderate-brown to dusky-brown shale at base; traces of white and very pale orange chert (float?), and pyrite	258–266
McGregor Limestone Member:	
Dolomite, dark-greenish-gray to olive-gray, dark-gray-speckled fine-grained, argillaceous; trace of crinoid stems	266–270

USGS 12 (HARDY)

Location: SE¼NE¼NW¼ sec. 33, T. 4 N., R. 1 E.
Total depth: 128 ft
Collar altitude: 1,053.9 ft

	Depth (feet)
Galena Dolomite:	
Dolomite, grayish-orange to pale-yellowish-orange, fine- to medium-grained; white chert throughout, but very abundant (20 percent of sample) at 10–15 ft	0–30
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray, fine-grained	30–42
Dolomite, dark-greenish-gray, fine-grained; dark-greenish-gray shale	42–48
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown, moderate-brown and dusky-yellowish-brown, very fine grained; traces of pyrite, limonite, sphalerite, and galena in lower part	48–62
Spechts Ferry Shale Member:	
Shale, olive-gray; trace of greenish-gray shale	62–63
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown to pale-yellowish-brown; dusky-yellowish-brown shale at the base; trace of pyrite	63–69
McGregor Limestone Member:	
Dolomite, light-olive-gray, very fine to fine-grained; light-olive-gray shale; traces of pyrite and, at 97 ft, sphalerite	69–102
Pecatonica Dolomite Member:	
Dolomite, olive-gray, very fine grained; olive-gray shale containing conodonts; trace of calcite; black phosphatic(?) nodules at base	102–120
Glenwood Shale Member:	
Shale, silty, light-greenish-gray; poorly sorted very fine to medium-grained rounded and subspherical frosted quartz grains	120–124
St. Peter Sandstone:	
Sandstone, quartz, poorly sorted, very fine to medium-grained, rounded and subspherical; poorly cemented by pyrite and clay	124–128

USGS 13 (DOLPHIN)

Location: SW¼NE¼SE¼ sec. 33, T. 4 N., R. 1 E.
Total depth: 249 ft
Collar altitude: 1,134 ft

Surficial:	
Soil, loess, and residuum	0–5

	Depth (feet)
Galena Dolomite:	
Noncherty unit:	
Dolomite, pale-yellowish-orange to dark-yellowish-orange, very fine grained; traces of pale-yellowish-orange siliceous crinoid stem segments, pyrite, and limonite	5–50
Dolomite, very pale orange to grayish-orange, very fine grained; traces of limonite and, at 70–75 ft white clay	50–85
Dolomite, pale-yellowish-orange, very fine grained, more argillaceous than unit above; trace of limonite	85–100
Cherty unit:	
Dolomite, yellowish-gray, very fine grained; white chert (one dolomite crystal enclosed by chert, contact is sharp); traces of limonite	100–145
Dolomite, grayish-orange, very fine to fine-grained; chert: abundant to 170 ft, traces at 170–185 ft, abundant at 185–190 ft	145–203
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, yellowish-gray to greenish-gray, very fine grained; pale-green shale	203–210
Dolomite, grayish-yellow to grayish-orange, very fine grained; trace of pale-green shale	210–215
Dolomite, dark-greenish-gray, very fine grained to fine-grained; mottled with dark specks	215–223
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown, very fine grained, mottled; at 230–232 ft, the pieces of dolomite are slightly banded and are dark brown and light brown; trace of light-brown sphalerite at 223–225 ft; trace of white chert (float?)	223–232
Dolomite, pale-yellowish-brown to dark-yellowish-brown, very fine grained; contains some microscopic cubes of pyrite	232–235
Spechts Ferry Shale Member:	
Shale, light-olive-gray	235–236
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown, very fine grained to sublithographic; dark-yellowish-brown shale containing dolomite at 238–246 ft; abundant pale-yellowish-brown chert at 238–240 ft; abundant pyrite and sphalerite at 240–246 ft	236–246
McGregor Limestone Member:	
Dolomitic limestone, olive-gray, very fine grained; light-olive-gray shale; traces of white chert (float?), pyrite, and limonite	246–249

USGS 14 (F. G. GOBRECHT)

Location: SE¼SE¼NE¼ sec. 4, T. 3 N., R. 1 E.
Total depth: 277 ft
Collar altitude: 1,167.7 ft

Surficial:	
Soil, loess, and residuum	0–5

	Depth (feet)
Maquoketa Shale:	
Shale and clay, moderate-yellowish-brown to dark-yellowish-brown; at 13–15 ft unit is moderate yellowish brown; fine grained dolomite; abundant depauperate fossils; black phosphatic(?) nodules, 1 mm in diameter, and calcite near base	5–20
Galena Dolomite:	
Noncherty unit:	
Dolomite, light-olive-gray to grayish-orange, very fine to fine-grained; moderate-reddish-brown and dark-gray specks; traces of pyrite, limonite, and crinoid stem segments	20–58
Dolomite, pale-yellowish-brown, very fine to fine-grained; traces of pyrite and, at 115–120 ft, sphalerite	58–125
Cherty unit:	
Dolomite, yellowish-gray, very fine to fine-grained; white chert abundant at top and very abundant at 215–230 ft; trace of small (1 mm in diameter) yellowish-gray crinoid stem segments at 150–155 ft; traces of pyrite and limonite at 180 ft and at 230–237 ft	125–237
Decorah Formation:	
Ion Dolomite Member:	
Dolomite; unit is light olive gray to olive gray in upper 14 ft, dark greenish gray and fine grained in lower 6 ft; dark-greenish-gray shale in lower part; traces of pyrite, limonite, and calcite	237–257
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, very fine to fine-grained; mottled in upper part; lowest 2 ft is dusky yellowish brown shale; trace of pyrite	257–267
Spechts Ferry Shale Member:	
Shale, olive-gray; speckled with pyrite and some dark-brown specks	267–268
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, moderate-brown, very fine grained to sublithographic; dusky-brown shale at base; traces of galena, pyrite, and calcite	268–274
McGregor Limestone Member:	
Dolomite, light-olive-gray, very fine grained	274–277

USGS 15 (R. VOIGHTS)

Location: NW¼NE¼NW¼ sec. 10, T. 3 N., R. 1 E.
Total depth: 215 ft
Collar altitude: 1,093.5 ft

Surficial:	
Soil, loess, and residuum	0–10
Galena Dolomite:	
Noncherty unit:	
Dolomite, grayish-orange to pale-yellowish-orange, fine- to medium-grained; traces of limonite and pyrite throughout; trace of light-brown chert at top is probably float from chert of Early Silurian age in soil	10–65(?)

	Depth (feet)
Galena Dolomite—Continued	
Cherty unit:	
Dolomite, pale-yellowish-brown to yellowish-gray, fine- to medium-grained; traces of white chert, yellowish-gray chert, and limonite	65(?)–172
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to dark-greenish-gray (slightly speckled with darker material), fine- to medium-grained; trace of calcite	172–185
Dolomite, dark-greenish-gray, medium-grained, speckled; greenish-gray clay and shale; traces of pyrite, limonite, clear calcite, and crinoid stem segments	185–193
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, dark-gray-speckled; dusky-yellowish-brown shale near base; traces of bryozoan fragments, pyrite, calcite, and dark-yellowish-orange chert (float?)	193–206
Spechts Ferry Shale Member:	
Shale, olive-gray; olive-gray fine-grained limestone, containing microscopic pyrite	206–207
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dusky-yellowish-brown, moderate-brown to pale-yellowish-brown, very fine grained; dusky-brown shale at base; traces of pyrite, limonite, and calcite	207–211
McGregor Limestone Member:	
Dolomite, light-olive-gray, dark-gray-speckled, very fine to fine-grained	211–215

USGS 16 (H. VOIGHTS)

Location: SW¼NE¼NW¼ sec. 2, T. 3 N., R. 1 E.
Total depth: 290 ft
Collar altitude: 1,187.3 ft

Surficial:	
Soil, loess, and residuum	0–15
Maquoketa Shale:	
Shale and clay, olive-gray; phosphatic depauperate fossils near base	15–25
Galena Dolomite:	
Noncherty unit:	
Dolomite, light-olive-gray, fine-grained; depauperate crinoid stem segments; abundant marcasite, pyrite, and calcite; trace of sphalerite at 30–40 ft	25–53
Dolomite, pale-yellowish-orange to grayish-orange, fine-grained; dusky-brown shale partings are at 85 ft and 100 ft; small crinoid stem segments at 53–58 ft. Near the contact with the underlying cherty unit some of the dolomite is pale-yellowish-brown	53–150
Cherty unit:	
Dolomite, very pale orange to yellowish-gray, very fine to fine-grained; white chert at 150–155 ft, no chert at 155–	

	Depth (feet)
Galena Dolomite—Continued	
Cherty unit—Continued	
160 ft, abundant chert in about 10 percent of samples at 160–170 ft and trace of pyrite, trace of chert at 170–180 ft, no chert at 180–195 ft, trace of chert at 195–235 ft; trace of white clay (bentonite?) at 210 ft; trace of brownish-black shale at 195–235 ft	150–235
Dolomite, pale-yellowish-brown, fine-grained	235–246
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, olive-gray to dark-greenish-gray, speckled with darker material in lowest 8 ft; trace of greenish-gray shale and limonite in upper part and dark-greenish-gray shale in lower part, shale more abundant in lower part	246–266
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown and dark-yellowish-brown, fine-grained; moderate-brown shale; traces of pyrite and clear calcite	266–280
Spechts Ferry Shale Member:	
Shale, olive-gray; medium-gray, fine-grained dolomite	280–281
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown to dusky-yellowish-brown, some moderate-brown, very fine-grained to sublithographic; abundant pyrite and clear calcite; trace of white chert (float?)	281–289
McGregor Limestone Member:	
Dolomite, greenish-gray to light-olive-gray, very fine grained	289–290

USGS 17 (BARTELS 1)

Location: NE¼SE¼NW¼ sec. 11, T. 3 N., R. 1 E.
Total depth: 176 ft
Collar altitude: 1,056.6 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Noncherty unit:	
Dolomite, pale-yellowish-brown and grayish-orange, medium-grained, fossiliferous (siliceous gastropod); abundant light-brown chert probably from residual soil	5–25
Cherty unit:	
Dolomite, grayish-orange, yellowish-gray; very fine to fine-grained; locally sublithographic at 50 ft and 65–85 ft; basal 10 ft is dark yellowish orange to dark yellowish brown. Contains white chert; some chert is light brown in upper 20 ft but may be float from the residual soil which probably contains chert of Silurian Age. Small black phosphatic(?) nodules and depauperate fossils (float from base of Maquaketa Shale?) are at 25–40 ft, but the nodules are found down to 65 ft. Unit is fossiliferous containing crinoid stem segments at 40 ft. Traces of calcite and limonite	25–121

	Depth (feet)
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, greenish-gray, olive-gray to light-olive-gray, very fine to fine-grained; pale-green shale, pyrite, calcite, small (½ mm × 1 mm) crinoid stem segments, minor black phosphatic(?) nodules, and very minor light-brown chert float; microscopic pyrite is in the shale. Traces of sphalerite at 128–132 ft and 140–142 ft	121–144
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown and moderate-brown, very fine to fine-grained; some yellowish-gray dolomite in upper 6 ft; traces of calcite, pyrite, limonite, pale-green shale, fossils (brachiopods), and minor black phosphatic(?) nodules near top. Trace of sphalerite at 153–157 ft	144–157
Spechts Ferry Shale Member:	
Shale, pale-green, containing pyrite; light-gray very fine grained dolomite and black phosphatic(?) nodules	157–158
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, very fine grained; moderate-brown shale at base; traces of calcite, pyrite, black phosphatic(?) nodules, chert (float), and, at 158–160 ft, sphalerite	158–169
McGregor Limestone Member:	
Dolomite, limy, light-olive-gray, very fine grained	169–176

USGS 18 (GOKE)

Location: NW¼SW¼SW¼ sec. 1, T. 3 N., R. 1 E.
Total depth: 212 ft
Collar altitude: 1,095.1 ft

Surficial:	
Soil, loess, residuum	0–5
Galena Dolomite:	
Noncherty unit:	
Dolomite, dark-yellowish-orange to grayish-orange, fine- to medium-grained	5–30
Dolomite, yellowish-gray to pale-yellowish-orange, fine-grained, argillaceous	30–62
Cherty unit:	
Dolomite, yellowish-gray, fine-grained; trace to 3 percent of white chert throughout section; traces of pyrite and limonite	62–167
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray, slightly speckled, fine-grained; traces of pyrite and clear calcite	167–180
Dolomite, dark-greenish-gray, fine- to medium-grained, argillaceous; light-olive-gray shale contains graptolites(?); traces of pyrite and limonite	180–187

	Depth (feet)
Decorah Formation—Continued	
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, fine-grained; white streaks in dark dolomite; traces of clear calcite, pyrite, limonite, and, near base, sphalerite	187–202
Spechts Ferry Shale Member:	
Shales, dark-yellowish-brown; pale-yellowish-brown fine-grained dolomite; black phosphatic(?) nodules	202–203
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, moderate-brown to dark-yellowish-brown; pale-yellowish-brown and light-green shale; abundant clear calcite and trace of pyrite	203–209
McGregor Limestone Member:	
Dolomite, limy, light-olive-gray, fine-grained, argillaceous	209–212

USGS 19 (HEINS)

Location: SE¼SW¼NW¼ sec. 36, T. 4 N., R. 1 E.
Total Depth: 170 ft
Collar altitude: 1,105 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Noncherty unit:	
Dolomite, grayish-orange, fine-grained	5–20
Cherty unit:	
Dolomite, grayish-orange, fine- to very fine grained; traces of white chert and calcite	20–50
Dolomite, yellowish-gray, fine-grained; traces of white chert, except at 55–60 ft where the chert is about 20 percent of the sample; traces of calcite and limonite	50–90
Dolomite, grayish-orange, very fine to fine-grained; dolomite contains dusky-brown specks; traces of chert, calcite, and limonite	90–122
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, greenish-gray, fine-grained; greenish-gray shale	122–132
Dolomite, light-olive-gray, olive-gray, and dark-greenish-gray, fine- to medium-grained; traces of calcite and yellowish-gray chert (float?)	132–143
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown to dusky-yellowish-brown, very fine to fine-grained; traces of clear calcite, white chert (float?), and white brachiopod fragments	143–157
Spechts Ferry Shale Member:	
Shale, pale-green; white bentonite; black phosphatic(?) nodules	157–158

	Depth (feet)
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown (in lower part), sublithographic to very fine grained; traces of pyrite, limonite, clear calcite, and white chert (float?)	158–166
McGregor Limestone Member:	
Dolomite, light-greenish-gray to greenish-gray, very fine grained	166–170

USGS 20 (STEINHOFF)

Location: N½NW¼NE¼ sec. 1, T. 3 N., R. 1 E.
Total depth: 152½ ft
Collar altitude: 1,067.4 ft

Surficial:	
Soil, loess, and residuum	0–7
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange (slightly lighter in color below 55 ft), fine- to medium-grained; more uniformly fine-grained in the basal 50 ft; traces of white chert, clear calcite, limonite, and crinoid stem segments	7–106
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to greenish-gray, fine- to medium-grained	106–117
Dolomite, olive-gray, dark-gray-speckled, fine- to medium-grained; dark-greenish-gray clay and shale; traces of white chert (float?) and pyrite	117–126
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown (in lower part), some moderate-brown, fine-grained; traces of fossiliferous white chert (float?), pyrite, limonite, and clear calcite	126–140
Spechts Ferry Shale Member:	
Shale, olive-gray; dolomite speckled light-olive-gray; black phosphatic(?) nodules; trace of pyrite	140–141
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown to moderate-brown, trace pale-yellowish-brown and dusky-yellowish-brown, very fine grained to sublithographic; abundant pyrite at 145–149 ft; trace of calcite in the darkest dolomite	141–149
McGregor Limestone Member:	
Dolomite, light-olive-gray to greenish-gray, very fine grained	149–152½

USGS 21 (SCHULT)

Location: SE¼NW¼SE¼ sec. 1, T. 3 N., R. 1 E.
Total depth: 190 ft
Collar altitude: 1,087.8 ft

Surficial:	
Soil, loess, and residuum	0–5

	Depth (feet)
Galena Dolomite:	
Noncherty unit:	
Dolomite, grayish-orange (dark-yellowish-orange in upper 10 ft), fine-grained	5–42
Cherty unit:	
Dolomite, grayish-orange to yellowish-gray, fine-grained; white chert is about 1 percent of samples at 42–125 ft, at 125–132 ft chert is about 5 percent of the samples; trace of white bentonitic(?) clay at 90 ft	42–142
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, olive-gray (dark-gray specks near top), fine- to medium-grained; olive-gray shale	142–151
Dolomite, dark-greenish-gray, fine- to medium-grained; mottled more than section above; greenish-gray shale; traces of pyrite and clear calcite	151–163
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, fine-grained; traces of pyrite, calcite, bryozoans, and quartz crystals (1 mm long)	163–176
Spechts Ferry Shale Member:	
Dolomite, yellowish-gray, fine-grained; yellowish-gray shale containing conodonts; black phosphatic(?) nodules; trace pyrite	176–177
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown to pale-yellowish-brown, very fine grained; dusky-brown shale at base; traces of pyrite, limonite, chert (float?), calcite, and, at 177–180 ft, sphalerite	177–185
McGregor Limestone Member:	
Dolomite, light-olive-gray, fine-grained	185–190

USGS 22 (E. VOIGHTS)

Location: SE¼NE¼NE¼ sec. 36, T. 4 N., R. 1 E.
Total depth: 120 ft
Collar altitude: 1,053.9 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange, fine-grained; traces of white chert and limonite	5–25
Dolomite, grayish-orange, very fine grained; no chert at 25–30 ft, trace of chert at 30–40 ft, no chert at 40–50 ft, chert at 50–78 ft; traces of clear calcite and limonite	25–78
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, yellowish-gray to light-olive-gray, very fine grained; gray and pale-green shale; traces of clear calcite, pyrite, and limonite	78–90

	Depth (feet)
Decorah Formation—Continued	
Ion Dolomite Member—Continued	
Dolomite, medium-dark-gray, very fine to fine-grained, speckled; pale-green shale; trace of clear calcite near base	90–96
Guttenberg Limestone Member:	
Dolomite, pale- to dark-yellowish-brown, very fine grained; traces of pale-green shale, pyrite, and calcite	96–107
Spechts Ferry Shale Member:	
Shale, medium-bluish-gray, containing microscopic black specks	107–108
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale- to dark-yellowish-brown, very fine grained; traces of green shale (float?) and pyrite; moderate-brown shale at base	108–118
McGregor Limestone Member:	
Dolomite, yellowish-gray to light-olive-gray, very fine grained; trace of white chert (float?)	118–120

USGS 23 (KLINGE)

Location: NW¼NW¼SW¼ sec. 30, T. 4 N., R. 2 E.
Total depth: 120 ft
Collar altitude: 1,066 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, moderate-yellowish-brown (near top), pale-yellowish-orange, and grayish-orange, fine- to medium-grained; about 2 percent of sample is white and iron-stained chert	5–30
Dolomite, same as unit above, but no chert; trace of clear calcite	30–40
Dolomite, grayish-orange, fine- to medium-grained; traces of white chert, calcite, and limonite at 40–50 ft; at 50–60 ft chert is very abundant, about 20 percent, containing a trace of limonite; at 60–78 ft chert is a trace to 5 percent of the sample	40–78
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, dark-greenish-gray, fine-grained; greenish-gray shale; lowest 4 ft contains traces of pyrite and limonite and is more mottled and darker than the upper part	78–96
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown, dark-gray-speckled, fine-grained; traces of white chert (float?), clear calcite, pyrite, and dusky-brown shale; some white siliceous bryozoans at 103–105 ft; trace of sphalerite at 105–109 ft	96–109
Spechts Ferry Shale Member:	
Shale and clay, pale-yellowish-brown; white bentonite; very fine grained mottled light-gray dolomite; black phosphatic(?) nodules (2 mm in diameter); trace of pyrite	109–110

	Depth (feet)
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown, very fine to fine-grained; traces of white chert (float?), clear angular quartz grains, clear calcite, and pyrite in upper part; dusky-yellowish-brown shale at base	110–118
McGregor Limestone Member:	
Dolomite, light-olive-gray to greenish-gray, very fine grained	118–120

USGS 24 (LEO MARTIN)

Location: SW¼NE¼SE¼ sec. 31, T. 4 N., R. 2 E.
Total depth: 125 ft
Collar altitude: 1,040.6 ft

Surficial:	
Soil, loess, and residuum	0–6
Galena Dolomite:	
Cherty unit:	
Dolomite, dark-yellowish-orange (upper 10 ft) and grayish-orange (below), fine- to medium-grained, argillaceous; white chert; trace of pale-yellowish-orange calcite	6–79
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray, fine-grained; greenish-gray shale and clay; some mottling of shale and dolomite	79–90
Dolomite, dark-greenish-gray, dark-gray-speckled, fine- to medium-grained; greenish-gray shale	90–97
Guttenberg Limestone Member:	
Dolomite, dark-yellowish-brown, dark-gray-speckled, fine-grained; dusky-yellowish-brown shale; dolomite contains conodonts and other fossil fragments; traces of clear calcite, pyrite, light-green shale, and, at 100–105 ft, sphalerite	97–110
Spechts Ferry Shale Member:	
Clay (bentonite), white to yellowish-gray; traces of light-olive-gray, fine-grained dolomite, and black phosphatic(?) nodules	110–111
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown, some very pale orange, very fine grained to sublithographic; moderate-brown shale at base	111–122
McGregor Limestone Member:	
Dolomite, olive-gray, very fine grained; traces of pyrite and limonite	122–125

USGS 25 (WILL NODOLF)

Location: SW¼NE¼NW¼ sec. 8, T. 3 N., R. 2 E.
Total depth: 166 ft
Collar altitude: 1,069.4 ft
NOTE:—Hole may have caved during drilling.

Surficial:	
Soil, loess, and residuum	0–5

	Depth (feet)
Galena Dolomite:	
Noncherty unit:	
Dolomite, grayish-orange to dark-yellowish-orange, fine-grained	5–30
Cherty unit:	
Dolomite, grayish-orange to dark-yellowish-orange, fine-grained; traces of limonite; white chert at 30–45 ft; dolomite at 45–115 ft is grayish orange and fine grained and contains white chert, clear calcite, and limonite	30–115
Dolomite, moderate-yellowish-brown, fine- to medium-grained, argillaceous, black-speckled, 15 percent of section is chert and 1 percent is calcite and limonite	115–127
Decorah Formation:	
Ion Dolomite Member:	
Shale and clay, pale-green (near top) to greenish-gray (near base); yellowish-gray fine-grained dolomite; trace of limonite; calcite is 20 percent of a 5-ft section at 135–140 ft; greenish-gray clay is 80 percent of section at 142–145 ft	127–145
Guttenberg Limestone Member:	
Dolomite, yellowish-gray to grayish-yellow, very fine to fine-grained; 5 percent is calcite and about 1 percent is limonite and ochery clay; trace of pyrite	145–154
Spechts Ferry Shale Member:	
Clay (bentonite?), white	154–155
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown, very fine grained; traces of pyrite and white chert (float?)	155–161
McGregor Limestone Member:	
Dolomite, dusky-yellow, very fine grained; clear calcite (about 5 percent) and trace of white chert (float?)	161–166

USGS 26 (POINT FARMS NO. 2)

Location: NE¼NW¼SE¼ sec. 32, T. 4 N., R. 2 E.
Total depth: 145 ft
Collar altitude: 1,052.6 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange, fine- to medium-grained; trace of chert; at 35–40 ft white chert is 5 percent of sample; at 40–60 ft only a trace of chert and white bryozoans	5–60
Dolomite, as in unit above; no chert, but clear angular quartz grains	60–65
Dolomite, grayish-orange, fine-grained; trace of chert at 65–70 ft, but none at 70–75 ft	65–75
Dolomite, grayish-orange, fine- to medium-grained; trace of white chert	75–103

	Depth (feet)
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, olive-gray to greenish-gray, fine-grained; greenish-gray clay and shale; trace of pyrite	103–120
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown, moderate-brown, and dusky-yellowish-brown, very fine to fine-grained; contains conodonts; traces of pale-green shale, white chert (float?), pyrite, limonite, and moderate-yellowish-green calcite	120–132
Spechts Ferry Shale Member:	
Shale, pale-green; yellowish-gray, fine-grained dolomite	132–133
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, pale-yellowish-brown, very fine grained to sublithographic; traces of white chert (float?), sphalerite, limonite, and clear calcite	133–137
Dolomite, dark-yellowish-brown (at 137–140 ft) and pale-yellowish-brown to dusky-yellowish-brown (at 140–144 ft), very fine grained to sublithographic; dusky-brown shale at base; abundant calcite, pyrite; trace of white chert (float?)	137–144
McGregor Limestone Member:	
Dolomite, light-olive-gray, very fine grained	144–145

USGS 27 (POINT FARMS NO. 1)

Location: SW¼NE¼SE¼ sec. 33, T. 4 N., R. 2 E.
Total depth: 132 ft
Collar altitude: 1,075.2 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange, fine- to medium-grained; dolomite is moderate yellowish brown and medium to coarse grained at 5–10 ft, and is grayish orange and generally finer grained below in the unweathered rock; white chert occurs in the dolomite at 15–30 ft and 40–87 ft	5–87
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, pale-yellowish-brown and light-olive-gray, fine-grained, at 87–90 ft; at 90–100 ft the dolomite is dark greenish gray, contains dark-gray specks, and is fine to medium grained; at 100–103 ft the dolomite is dark greenish gray and fine grained and contains abundant dark-gray specks and moderate-green shale; traces of clear calcite and white chert (float?) are at 90–103 ft	87–103
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown and dark-yellowish-brown, very fine to fine-grained, at 103–110 ft; in this interval unit contains bryozoans and traces of pyrite; at 110–117 ft the dolomite is pale yellowish brown and contains calcareous dark-yellowish-brown shale and traces of white chert, pyrite, and bryozoan fragments	103–117

	Depth (feet)
Decorah Formation—Continued	
Spechts Ferry Shale Member:	
Shale, dark-greenish-gray, containing conodonts and black phosphatic(?) nodules	117–118
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, dark-yellowish-brown, medium-grained to sublithographic; dolomite is medium grained in lowest 5 ft; moderate-brown shale occurs at 118–120 ft and dusky-yellowish-brown shale occurs at the base; traces of pyrite, limonite, and white chert (float?) throughout; trace of sphalerite near base	118–127
McGregor Limestone Member:	
Dolomite, greenish-gray to dark-greenish-gray; traces of white chert (float?); pyrite, and limonite	127–132

USGS 28 (KEARNS)

Location: SW¼NW¼NE¼ sec. 33, T. 4 N., R. 2 E.
Total depth: 135 ft
Collar altitude: 1,077.5 ft

Surficial:	
Soil, loess, and residuum	0–5
Galena Dolomite:	
Cherty unit:	
Dolomite, grayish-orange, fine-grained; white chert occurs in the dolomite at 5–25 ft and at 65–80 ft; traces of calcite	5–88
Decorah Formation:	
Ion Dolomite Member:	
Dolomite, light-olive-gray to greenish-gray, dark-gray-speckled fine-grained; traces of greenish-gray shale, clear calcite, pyrite, and brachiopods; dark-yellowish-brown fine-grained dolomite near 100 ft	88–100
Dolomite, greenish-gray, fine-grained; dark-greenish-gray shale and clay that contains conodonts and pyrite; trace of clear calcite	100–107
Guttenberg Limestone Member:	
Dolomite, pale-yellowish-brown to dark-yellowish-brown, fine-grained; dolomite near base is finer grained than that above and is slightly mottled; dusky-brown to moderate-brown shale contains microscopic pyrite; traces of clear calcite, pyrite, and limonite	107–117
Spechts Ferry Shale Member:	
Shale, pale-green; yellowish-gray fine-grained dolomite, slightly mottled with a darker material	117–118
Platteville Formation:	
Quimbys Mill Member:	
Dolomite, yellowish-gray (grading downward) to pale-yellowish-brown, very fine grained; dusky-brown shale at base; traces of white chert (float?), pyrite, and limonite	118–127
McGregor Limestone Member:	
Dolomite, greenish-gray and olive-gray, very fine to fine-grained; trace of white chert (float?)	127–135

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INDEX

Italic page numbers indicate major references

U.S. GOVERNMENT PRINTING OFFICE: 1964