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Prepared in cooperation with the Wisconsin Geological and Natural History Survey

Whitlow and West—GEOLOGY OF POTOSI QUADRANGLE, WISCONSIN-IOWA—Geological Survey Bulletin 1123-I

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By JESSE W. WHITLOW *and* WALTER S. WEST

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[Plates are in pocket]

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By Jesse W. Whitlow and Walter S. West

ABSTRACT

The Potosi quadrangle comprises 52 square miles in Wisconsin and about 3 square miles in Iowa. The Wisconsin part is in the Driftless Area, but the Iowa part is in the attenuated-pebble drift zone of Chamberlin and Salisbury.

Rocks exposed in the quadrangle range from Early to Late Ordovician in age. The Potosi-Tennyson well, the only deep hole in the quadrangle, bottoms in the Eau Claire Sandstone of Late Cambrian age.

The Prairie du Chien Group of Early Ordovician age is the oldest rock unit exposed in the quadrangle. Cuttings from the Potosi-Tennyson well indicate that the group comprises about 290 feet of siliceous and argillaceous dolomite that contains some rounded quartz sand, greenish-gray shale, iron sulfides, and chert, of which some is oolitic and some is chalcedonic. Only the upper 60 feet of the Prairie du Chien Group is exposed in the Potosi quadrangle.

The St. Peter Sandstone overlies the Prairie du Chien Group unconformably. It ranges from 28 to 60 feet in thickness and is composed of frosted white and clear fine- to coarse-grained quartz sand.

The Platteville Formation conformably overlies the St. Peter Sandstone, ranges from 49 to 55 feet in thickness, and consists of dolomite, limestone, and shale. It is divided as follows, in ascending order: Glenwood Shale, Pecatonica Dolomite, McGregor Limestone, and Quimbys Mill Members. Locally the Quimbys Mill Member and the upper part of the McGregor Limestone Member have been changed to soft shale by solution and leaching of the carbonate and compaction of the insoluble residue.

The Decorah Formation conformably overlies the Platteville Formation and is divided as follows, in ascending order: Spechts Ferry Shale, Guttenberg Limestone, and Ion Dolomite Members. Locally the Ion is limestone, and, at one place, the Guttenberg is dolomite. In general, the thickness of the formation ranges from 38 to 46 feet, but local leaching of the carbonate and compaction of the insoluble residue has reduced the formation to a thickness of 22 feet. Drill cuttings indicate that lead, zinc, and iron sulfides are usually associated with leached and compacted Decorah; however, significantly mineralized rock was not observed in the outcrops. Many of the leached and compacted areas are close to the mined or prospected areas and are probably related to the mineralization. This association is also true of leached Platteville Formation and Galena Dolomite.

The Galena Dolomite conformably overlies the Decorah Formation. In general, the Galena in this area ranges from 224 to 235 feet in thickness and is about equally divided into a lower cherty unit and an upper noncherty unit. Locally as much as the lower 80 feet of the cherty unit is fossiliferous limestone. Leaching of the carbonate and compaction of the insoluble residue has reduced the cherty unit to a thickness of 88 feet in the Piquette No. 2 mine. Leached rock was not noted in the noncherty unit.

The Maquoketa Shale of Late Ordovician age was not seen in outcrop in the area, but its presence on the uplands is known because of debris from the basal phosphatic depauperate fossil zone.

Surficial deposits of Pleistocene age are loess and residual soil in the upland area and alluvial fill in the valleys. Glacial till occurs only on the upland in Iowa. Most of the Mississippi River valley fill is glacial outwash, although some may be reworked loess. The Platte River valley floor is covered by sand, silt, and gravel of local origin.

The strata in this part of the zinc-lead district dip southwestward 15–20 feet per mile. Superimposed on this regional dip are low open folds, domes, and basins. Joints are numerous and well formed. Several small faults and a few clastic dikes are in the area.

Galena was reported in the Potosi quadrangle area as early as 1699, but systematic mining did not begin until about 1800. The peak production of galena was reached about 1845 and then production began to decline. Galena is now generally a byproduct of sphalerite mining.

Zinc carbonate, smithsonite, was first mined in the district in 1859. Mining of zinc sulfide, sphalerite, began later and except for some interruptions has continued to the present day. Sphalerite is now the principal mineral mined in the district.

Early mines for lead and zinc ores were in gash-vein deposits generally found in the upper part of the Galena Dolomite. The ore minerals were deposited principally in westward-trending joints that were enlarged by solution of the wallrock at certain strata in the formation and at intersections of joints.

Later mining has been for ore in the Decorah Formation and the lower beds of the Galena Dolomite. These strata contain the fairly large pitch-and-flat ore deposits in the district. The Piquette No. 2 ore body is this type.

INTRODUCTION

The Potosi quadrangle includes an area of about 52 square miles in Wisconsin and 3 square miles in Iowa. About 7 square miles are occupied by the Mississippi River and its flood plain. The quadrangle is totally within the Wisconsin-Illinois-Iowa zinc-lead district, which is also known as the Upper Mississippi Valley zinc-lead district (fig. 67).

The quadrangle is serviced by public roads and a railroad. The following roads are surfaced: U.S. Route 61, Wisconsin State Route 133, and county trunks B, O, and U (pl. 33). Many unpaved roads are on or parallel to section lines. Very few places are more than half a mile from a public road. The Chicago, Burlington, and Quincy Railroad track is along the Wisconsin side of the Mississippi River, and this railroad serves the quadrangle at Potosi Station (pl. 33).

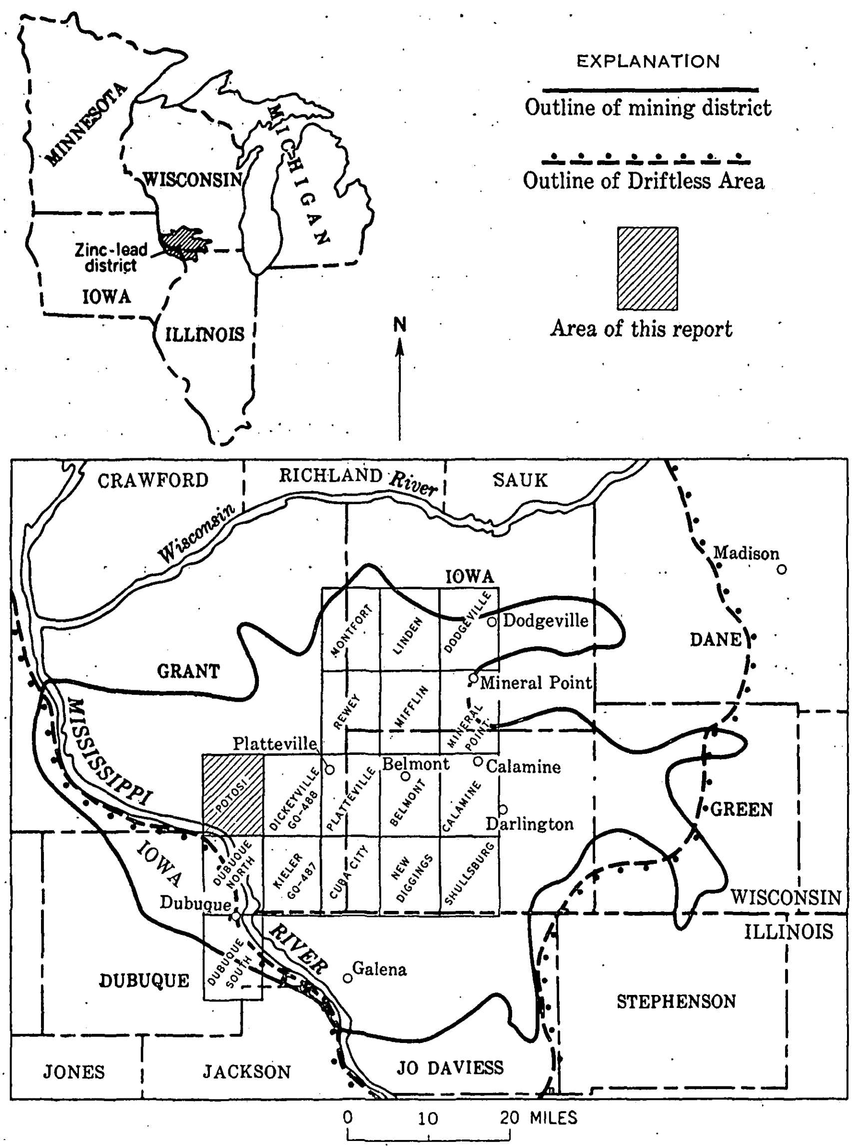

FIGURE 67.—The Wisconsin-Illinois-Iowa zinc-lead district, the Potosi quadrangle, and other quadrangles that have been mapped geologically. The quadrangle maps can be found in the various chapters of U.S.G.S. Bulletin 1123 or in the Geologic Quadrangle map series.

The Chicago, Milwaukee, St. Paul, and Pacific Railroad has tracks along the Iowa side of the Mississippi River valley but no station in the quadrangle.

Potosi, the largest town in the quadrangle, Tennyson, Rockville, and British Hollow were mining communities in the nineteenth century. The only active mine in the area in 1960 was near Tennyson, which was formerly known as Dutch Hollow.

The major occupations in the quadrangle are dairying, raising beef cattle and hogs, and the cultivation of forage and grain crops for livestock feed and seed. Industries are cheesemaking, a brewery at Potosi, an operating zinc mine at Tennyson, and several limestone and dolomite quarries for local construction stone and agricultural lime.

PURPOSE OF INVESTIGATION

This investigation was undertaken to study in detail the relation of geologic features to the mineralized areas in the district as a guide to exploration for zinc or lead minerals and other materials. It is a continuation of the work begun in the Upper Mississippi Valley zinc-lead district in 1942 by the U.S. Geological Survey.

PREVIOUS WORK

The first survey of the Upper Mississippi Valley zinc-lead district was by D. D. Owen in 1839, and a report without maps was published in 1840 (Owen, 1840). A revised edition with plates was published in 1844 (Owen, 1844). Many geologists studied the district between 1840 and 1940, and some of the more noteworthy reports are as follows: J. G. Percival (1855, 1856); J. D. Whitney (1858, 1862); James Hall and J. D. Whitney (1858, 1862); James Shaw (1873); Moses Strong (1877); T. C. Chamberlin (1882, 1883); T. C. Chamberlin and R. D. Salisbury (1885); W. P. Jenney (1894); Samuel Calvin (1894, 1906); A. G. Leonard (1897); Samuel Calvin and H. F. Bain (1900); R. I. Dugdale (1900); H. F. Bain (1905, 1906); U. S. Grant (1903, 1905, 1906); U. S. Grant and E. F. Burchard (1907); W. H. Norton (1912, 1928); G. H. Cox (1914); A. C. Trowbridge and E. W. Shaw (1916); Lawrence Martin (1916); F. T. Thwaites (1923); G. M. Kay (1928, 1935); and W. H. Emmons (1929). These various reports describe and discuss the topography, stratigraphy, minerals, mines, depositional controls, and sources of the ores. Almost every possible origin for the ore has been proposed, but none of the theories has been irrefutably proved.

In 1942 the U.S. Geological Survey began a reconnaissance of the 4,000- to 5,000-square-mile area of the Upper Mississippi Valley zinc-lead district in southwestern Wisconsin, northwestern Illinois, and northeastern Iowa. The results of these district-wide studies have been published (Heyl and others, 1955, 1959; Agnew and others, 1956). Accessible mines were mapped to learn the ore-emplacement controls, and detailed surface maps were prepared of some areas to determine if likely ore-bearing structures were present. An area of nearly 9 square miles in the Potosi quadrangle was mapped and published as Strategic Minerals Investigation Preliminary Map 3–221 (Heyl and others, 1948; Heyl and others, 1959, pl. 6). Geologic mapping of twelve 7½-minute quadrangles in Wisconsin began in 1951, and the fieldwork was completed in 1959; mapping of two 7½-minute quadrangles in Iowa began in 1955, and the fieldwork was completed in 1957 (fig. 67). Results of this quadrangle mapping have been reported by Agnew (1963), Allingham (1963), Brown and Whitlow (1960), Carlson (1961), Klemic and West (1964), Mullens (1964), Taylor (1964), and Whitlow and Brown (1963).

Drilling programs were completed between 1943 and 1956 by the U.S. Bureau of Mines and the U.S. Geological Survey for stratigraphic information and to test likely ore-bearing structures (Agnew and others, 1953; Apell, 1947, 1949a, b; Berliner, 1947, 1948; Brown and Whitlow, 1956; Carlson, 1956; Cummings, 1948; Flint and Brown, 1956; Grosh, 1950, 1960; Heyl and others, 1951; Holt, 1948a, b; Kelly, 1948, 1949; Lincoln, 1948a, b; Terry, 1948; Terry and Lincoln, 1948; and Zinner and Lincoln, 1946).

PRESENT INVESTIGATIONS

In 1959 the geologic mapping program of quadrangles in the Wisconsin zinc-lead area was reactivated. Under the new cooperative project with the Wisconsin Geological and Natural History Survey, geologic mapping of the Dickeyville and Kieler quadrangles was completed (Whitlow and West, 1966). Mapping of the Potosi quadrangle is also part of this renewed program. Strategic Minerals Investigations Preliminary Map 3–221 (Heyl and others, 1948; 1959, pl. 6) has been incorporated into the Potosi quadrangle report but with the following changes: Control-point locations were adjusted to fit the new topographic map; the structure-contour interval was increased to 20 feet; and structure contours were redrawn using the top of the Platteville Formation as the datum. To redraw the contours required the subtraction of 6 feet from all control points; this is the average thickness of the Spechts Ferry Shale Member of the Decorah Formation in the Potosi quadrangle. The fieldwork for the remainder of the Potosi quadrangle was done in 1959 and 1960.

Basic altitudes for mapping in the Potosi quadrangle were bench marks and supplemental points established by the U.S. Geological Survey. The altitudes of most of the structural contour points were determined by use of a surveyor's aneroid barometer which was checked against a basic control site reading every half to three-fourths of an hour. A few points were surveyed with planetable and telescopic

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alidade; this method was also used for level lines run in the Piquette No. 2 mine.

Subsurface geologic data in the Potosi quadrangle are from the records of the Bureau of Mines and from records of well logs copied from the Wisconsin State Board of Health files at Madison, Wis. Local well drillers furnished useful data from their records.

ACKNOWLEDGMENTS

The cooperation and aid of many individuals are appreciated and gratefully acknowledged. The work was done in cooperation with the Wisconsin Geological and Natural History Survey, under the direction of Dr. George F. Hanson, State Geologist. Mr. Milton A. Melcher, Dean of the Institute of Technology of the Wisconsin State College and Institute of Technology, furnished office and work space. Mr. W. A. Broughton, head of the Department of Geology of the school, helped by discussing ideas and making observations. Mr. Francis B. Piquette, mine operator, furnished all geologic and structural data available in and near his mine at Tennyson, Wis. The following well drillers saved and made available samples for stratigraphic data and furnished logs of wells they had drilled: Hauser Well Drilling Co., Faherty Bros., T. R. Beadle, Tony Beets, and Arthur Bauer. The cooperation of local residents and property owners who furnished information on wells, old lead diggings, and mines and who permitted access to their properties is greatly appreciated.

PHYSIOGRAPHY

The land surface in the Potosi quadrangle ranges from steep valley walls and bluffs to gently rolling hills. The topography in the south half and along the east side of the Potosi quadrangle is rugged and has fairly high relief because of the deep valleys of the Mississippi and Platte Rivers and the narrow steep valleys of the youthful tributary streams. The high land in part of the north half of the quadrangle is rolling, has relatively low relief, and is in a late mature stage of erosion. Altitudes range from 603 feet above mean sea level, the normal pool altitude of the Mississippi River above the U.S. Army Corps of Engineers dam at Dubuque, to more than 1,020 feet in the S½SW¼ sec. 12, T. 3 N., R. 3 W. (pl. 33); the total relief is 417 feet. Local relief is as much as 340 feet along the Mississippi River and as much as 310 feet along the Platte River. The greatest relief along the smaller streams is 275 feet, but the relief is generally less than 200 feet.

The major topographic features of the quadrangle are the Mississippi and Platte River valleys. The Mississippi River valley flood plain is today almost covered by backwater from the Corps of Engineers lock and dam 11, which is about 6 miles south of the quadrangle. Maps[1] made of this area before the dams show a fairly wide, flat-bottomed valley that has steep sides in which the river and sloughs cover 30–50 percent of the valley bottom. Fill in this valley is more than 300 feet thick (Brown and Whitlow, 1960, p. 8). The second most prominent topographic feature is the Platte River valley, which has an unknown depth of fill but is probably similar to the Little Maquoketa River valley except that the Platte River valley contains no glacial debris upstream from its mouth. The valley of the Little Maquoketa River has 120 feet of fill 1–2 miles from the mouth of the river (Whitlow and Brown, 1963, p. 157). The seemingly mature stage of erosion indicated by the flat valley floors of the two rivers is caused by the fill; the bedrock bottoms of both valleys are probably in the youthful stage of erosion.

Benches composed of alluvial material and found in the Mississippi River valley 1–6 miles south of the Potosi quadrangle and in the Platte River valley indicate that both valleys at one time contained water as much as 60 feet higher than the normal present pool altitude of the Mississippi River. Erosion has removed most of the higher material but has locally left benches that are 30 and 50 feet above the flood plains of the two rivers.

The valley fill suggests an interrupted cycle of erosion for the Mississippi and Platte Rivers; the interruption was caused by subsidence of the area after an uplift had increased stream gradients, accelerated downcutting, and incised earlier meanders. Trowbridge (1954, p. 802–803) believed that the Mississippi River was an ice-border stream and that all the valley cutting occurred after the Nebraskan Glaciation. The presence of glacial debris on upland areas near the Mississippi River in Iowa and the lack of such debris in Wisconsin supports this conclusion; however, some glacial debris that is possibly outwash material is exposed in gullies in the Driftless Area of Wisconsin in the upland area in sec. 17, T. 1 N., R. 2 W., 4–5 miles south of the Potosi quadrangle.

The Mississippi River is base level for all drainage in this area. Its drainage pattern and that of the Platte River cannot be determined in this quadrangle, but locally the straight line of the bluffs along the valleys suggests that possibly some drainage is controlled by joints. Tributary streams in the area have a dendritic pattern, except locally where the drainage may be controlled by joints.

The Potosi quadrangle is near the west side of the Driftless Area, and that part of the quadrangle in Iowa is in the attenuated-pebble

[1] Sheet 55 of a series of maps prepared by the U.S. Army Corps of Engineers from a survey of the upper Mississippi River from Hastings, Minn., to Grafton, Ill., 1929–30.

drift border shown by Chamberlin and Salisbury (1885, p. 275–277, pls. 24, 27). Distribution of glacial debris noted during fieldwork in this quadrangle adds support to this earlier study.

STRATIGRAPHY

Rocks exposed in the Potosi quadrangle are dolomite, limestone, sandstone, and shale; these rocks range in age from Early to Late Ordovician (pl. 34). Unconsolidated materials comprise loess and, in the Iowa part of the quadrangle, drift of Pleistocene age and valley fill of Pleistocene and Recent age. The Potosi-Tennyson well, the deepest in the quadrangle, bottoms in the Eau Claire Sandstone of Late Cambrian age. The sequence of exposed rocks is conformable except for the disconformity between the Prairie du Chien Group of Early Ordovician age and the St. Peter Sandstone of Middle Ordovician age (pl. 34). Detailed discussions of the regional stratigraphy were given by Agnew, Heyl, Behre, and Lyons (1956, p. 252–302) and Heyl, Lyons, Agnew, and Behre (1959, p. 6–25).

The formations are divided into members which, in general, can be distinguished throughout the zinc-lead district even though carbonate rock members may range from limestone to dolomite. A few fossiliferous zones are very helpful to geologic mapping. On the map (pl. 33) the contacts of the formations are shown on the topographic surface, and this depiction is basically correct except locally, where residual soil and (or) loess is thick. Actual contacts are exposed in gullies, bottoms of small streams, and along some of the bluffs. The most accurately and easily located contact is at the top of the Platteville Formation; the next most easily located contact is at the top of the St. Peter Sandstone. The Decorah-Galena contact is generally accurately located within 10 feet vertically, but there are possible exceptions (p. 547). The position of the Prairie du Chien-St. Peter contact is largely estimated except at the few places where it is exposed.

PRECAMBRIAN ROCKS

No rocks of Precambrian age crop out nor were any penetrated by deep drilling in this quadrangle. The depth of the Precambrian basement rocks is believed to be about 1,100 feet below sea level, based on records of two wells in Dubuque, Iowa, which indicate granitic rock at 1,165 and 1,185 feet below sea level (Iowa Geol. Survey, unpub. data), and a well in Platteville, Wis., which indicates granitic rock at 814 feet below sea level (Wisconsin State Board of Health, unpub. data). The wells at Dubuque are about 7 miles south of the Potosi quadrangle, and the well at Platteville about 7 miles east. Precambrian rock at 71 feet above sea level is indicated by the record of a well at Richland Center, Wis. (Thwaites, 1931, p. 726), about 50 miles north of this area. Precambrian rocks in northern Wisconsin are separated from the overlying rocks of Late Cambrian age by a profound unconformity (Thwaites, 1931, p. 739–745), and the situation is probably not different in the Potosi quadrangle.

UPPER CAMBRIAN SERIES

Rocks of Late Cambrian age do not crop out in the Potosi quadrangle, but about 400 feet of these rocks was penetrated in the Potosi-Tennyson well, which bottomed in the Eau Claire Sandstone at about 80 feet below sea level. Total thickness for the Upper Cambrian Series in the mining district, as indicated by logs of three deep wells, varies from about 1,275 to 1,500 feet. The series is divided into the following formations, in ascending order: Mount Simon, Eau Claire, and Galesville Sandstones of the Dresbach Group; Franconia Sandstone; and Trempealeau Formation. The series is dominantly sandstone but contains some siltstone and dolomite. These sandstones are good aquifers and are the source of water for many of the deep wells.

Lithology of Upper Cambrian rocks penetrated in the Potosi-Tennyson well is indicated by the following condensed log; the samples were churn-drill cuttings that were collected for every 5-foot interval of drilling:

	Feet below well collar
Trempealeau Formation (top of Jordan Sandstone Member, which is top of the Trempealeau Formation, is approximately 650 feet below well collar):	
Quartz sand, yellowish-gray to white, subrounded to rounded, fine- to coarse-grained; contains some yellowish-gray to light-olive-gray dolomite	650–700
Dolomite, yellowish-gray to grayish-pink and some red, fine- to medium-grained, crystalline; contains traces of quartz sand, iron sulfide, glauconite, and chert	700–790
Dolomite, brownish-gray, grayish-red, and grayish-orange, fine-grained, granular, and crystalline; contains glauconite and trace of iron sulfide	790–800
Franconia Sandstone (top is between 800 and 805 feet below well collar):	
Dolomite, light- to olive-gray and brownish-gray to grayish-red, fine-grained, crystalline; contains as much as 20 percent olive-gray silty soft shale, much black and green glauconite that is locally as much as 50 percent of the rock, and traces of calcite and iron sulfide	800–840
Soft shale, moderate-greenish-yellow to grayish-green; contains some calcite or limestone and moderate brown to black specks of glauconite	840–865
Dolomite, pale-orange to yellowish-gray, very fine grained, granular and crystalline, argillaceous; some argillaceous material is soft shale that contains black nodules that are green inside	865–895

	Feet below well collar
Galesville Sandstone (top is approximately 895 feet below well collar):	
Quartz sand, yellowish-gray to very light gray, subrounded to rounded, coarse- to fine-grained; contains as much as 7 percent greenish-black to green glauconite, from a trace to 12 percent yellowish-gray to white dolomite, and a trace of iron sulfide	895–1005
Eau Claire Sandstone (top is between 1,000 and 1,005 feet below well collar):	
Quartz sand, yellowish- to light-gray, clean, subrounded to rounded; ranges from course- to fine-grained but most is medium-grained	1005–1025
As above, but contains 10–35 percent yellowish-gray to white fine-grained crystalline dolomite generally as sand containing some glauconite	1025–1050

LOWER ORDOVICIAN SERIES

PRAIRIE DU CHIEN GROUP

The oldest rock exposed in the Potosi quadrangle is the Prairie du Chien Group, which crops out in the lower slopes of the Platte River valley and some of its tributaries, especially in the north half of the quadrangle. The maximum thickness, approximately the upper 60 feet of the group, is exposed in secs. 17 and 18, T. 3 N., R. 2 W. This group was named by Bain (1906, p. 18) for outcrops near Prairie du Chien, Crawford County, Wis. The rock is commonly known by the old name Lower Magnesian Limestone, given by Owen (1840, p. 17, fig. 2). Cuttings from the Potosi-Tennyson well show that the lower 30 feet is transitional to the Jordan Sandstone Member of the Trempealeau Formation and contains as much as 60 percent rounded quartz sand. Outcrops of the group are similar in lithology to the well cuttings except that iron sulfide minerals are few and only a small amount of glauconite is found.

Bedding is normally regular and is less than an inch to about 1 foot thick. Local irregularities, from a few inches to several feet in amplitude, may be caused by postdepositional slumping or by local solution of carbonate in the underlying beds which results in compaction of the insoluble residue. Cryptozoon colonies, which are common regionally, were not seen in this quadrangle, but they are present in an outcrop of Prairie du Chien about 11 miles north of the quadrangle (Flint, 1956, p. 414). The top of the Prairie du Chien Group is generally a bluish-green to greenish-gray soft shale that contains some chert; many springs are found at this stratigraphic level.

Lithology of the Prairie du Chien Group, as indicated by cuttings from the Potosi-Tennyson well, is normal for the region except for a thick transition zone to the underlying Jordan Sandstone Member of the Trempealeau Formation. The group is approximately 290 feet thick measured to the bottom of the transition zone. This thickness is greater than the maximum of approximately 250 feet given by Heyl, Agnew, Lyons, and Behre (1959, p. 9), though the excess is largely in the 30-foot basal transition zone.

A thick Prairie du Chien section is commonly complemented by a thinner overlying St. Peter Sandstone, and a thin section of Prairie du Chien by a thicker overlying sandstone. Agnew, Heyl, Behre, and Lyons (1956, p. 256) stated that the aggregate thickness of the two units in the Upper Mississippi Valley zinc-lead district is 280–320 feet. The combined thickness of the two units at the Potosi-Tennyson well is about 331 feet.

The Prairie du Chien Group exposed in Winneshiek County, Iowa, was described in detail by Calvin (1906, p. 64–73) and was divided in ascending order as follows: Oneota Formation, New Richmond Sandstone, and Shakopee Dolomite. This threefold division is not recognized in cuttings from the Potosi-Tennyson well. Outcrops in the area do not expose any rock below the Shakopee Dolomite equivalent.

The top of the Prairie du Chien Group is generally considered an erosion surface. Flint (1956, p. 420), on the other hand, suggested that locally the irregular top surface may have been caused by differential compaction of sediments over relatively rigid reefs and that later inter-reef solution and compaction of the upper beds accentuated these irregularities. Exposures in this quadrangle do not definitely support either idea, but the upper surface of the Prairie du Chien Group is irregular as shown in outcrop and as indicated by the variation in thickness of the St. Peter Sandstone in the area.

MIDDLE ORDOVICIAN SERIES

The stratigraphic section of Middle Ordovician rocks of the zinc-lead district is complete in the Potosi quadrangle, but exposures of the upper 100 feet are poor and difficult to find. These rocks comprise dolomite, limestone, sandstone, and shale and are divided in ascending order into the St. Peter Sandstone, the Platteville Formation, the Decorah Formation, and the Galena Dolomite. All the formations except the St. Peter Sandstone are divided into members or units based on lithologic characteristics. The formations seem conformable in this quadrangle, although Agnew, Heyl, Behre, and Lyons (1956, p. 256–259) stated that regionally the Platteville-Decorah contact is disconformable.

ST. PETER SANDSTONE

The St. Peter Sandstone was named by Owen (1847, p. 170) for outcrops along the St. Peter River, now called the Minnesota River, in southern Minnesota. This formation overlies the Prairie du Chien Group disconformably and is approximately 45–50 feet thick. Where the sandstone fills depressions in the top of the Prairie du Chien Group, the St. Peter is locally as much as 397 feet thick, as in the Shullsburg city well 3, 20 miles east-southeast of the Potosi quadrangle. Twenty miles farther east, between Browntown and South Wayne, Wis., where the St. Peter is absent, the Platteville Formation lies on the Prairie du Chien Group (Klemic and West, 1964, p. 370). The St. Peter Sandstone is commonly between 28 and 60 feet thick in the Potosi quadrangle; however, the base of the formation is exposed at only a few places, and the thickness in most of the quadrangle can only be estimated. The sandstone is shown on the map as no more than 60 feet thick in areas where the base is not exposed.

The St. Peter Sandstone in outcrop is a light- to dark-gray massive to thin-bedded and crossbedded quartz sandstone. Wet fresh surfaces are pale grayish orange to yellowish gray. Locally, the sandstone is stained brown and yellow. The sandstone is composed of frosted white and clear rounded fine to coarse quartz sand grains and a minor amount of interstitial argillaceous material; the cement is generally silica but locally can be a ferruginous material. The coarse-grained sand is in the upper part of the formation. The local ferruginous cement is iron sulfide below the water table and hydrous oxides of iron at or above the water table. Generally, the sandstone is poorly cemented, but well drillers report that locally it is very hard. In outcrop a hard ferruginous bed at or near the top of the formation commonly is stained shades of brown and red and is cemented by limonite from the oxidation of iron sulfide minerals.

PLATTEVILLE FORMATION

The Platteville Formation was named by Bain (1905, p. 18–19) for outcrops near Platteville, Wis. It conformably overlies the St. Peter Sandstone in the Potosi quadrangle. Normal thickness of the formation in the area studied is 49–55 feet. The formation is divided into members as follows, in ascending order: Glenwood Shale, Pecatonica Dolomite, McGregor Limestone, and Quimbys Mill Members. The Platteville in the Wisconsin part of the quadrangle is dolomite and shale in the SE¼SE¼ sec. 20, T. 3 N., R. 2 W. (pl. 35). Generally, this information has not been altered or thinned by mineralizing solutions, but locally the upper part of the McGregor and the Quimbys Mill Members have been leached of carbonates; this leaching has left an insoluble residue of soft shale (pl. 35). Compaction of the shale has reduced the thickness of the formation.

GLENWOOD SHALE MEMBER

The Glenwood Shale Member was named by Calvin (1906, p. 60–61, 75) for exposures in sec. 6, T. 98 N., R. 7 W., Glenwood Township, Iowa. It conformably overlies and is gradational from the St. Peter Sandstone, and the maximum thickness in the Potosi quadrangle is about 4 feet. As the shale content increases upward from the sandstone, the Glenwood becomes greenish gray, and outcrops are stained dark yellowish brown and dusky red from oxidized iron sulfide minerals. A dusky-yellow-green to grayish-green shale bed 0.2–0.8 foot thick that contains a small amount of quartz sand is near the top. A limonite-cemented sandy shale bed 0.2–0.5 foot thick generally marks the top of the member in outcrops. Churn-drill cuttings indicate that below the water table this shale bed contains iron sulfide minerals.

The Glenwood is commonly a spring horizon where it is exposed, and the springs aid in locating the St. Peter-Platteville contact in areas of no outcrops.

PECATONICA DOLOMITE MEMBER

The Pecatonica Dolomite Member was named by Hershey (1894, pt. 2, p. 175) for exposures along the Pecatonica River valley in Wisconsin near the Wisconsin-Illinois State line. It conformably overlies the Glenwood Shale Member and ranges from 20 to 25 feet in thickness. Generally, outcrops of the Pecatonica are thick- to massive-bedded fine- to medium-grained fossiliferous dolomite, but in this quadrangle the upper part is commonly thin bedded, similar to the overlying McGregor Limestone Member. The lower 6–8 feet of the Pecatonica is yellowish-gray to light-olive-gray fine-grained argillaceous dolomite that contains yellowish-brown streaks and, in the lower few inches, quartz sand similar to that in the St. Peter Sandstone. Numerous dark-gray to dusky-brown phosphatic fossils, fossil fragments, and phosphatic nodules occur in the basal bed and within the lower 5 feet of the member. The Pecatonica grades upward from the lower 5 feet into a light-olive-gray and olive-gray fine- to medium-grained dolomite that contains medium-gray shale partings. The upper few feet of rock in the member is generally pale-yellowish-brown or dark-yellowish-orange to moderate-yellowish-brown dolomite. Dark-yellowish-brown to dusky-red coatings in fossil cavities and vugs give the Pecatonica a speckled appearance. The small cavities and vugs generally contain calcite crystals. Locally, limestone occurs in part of the Pecatonica Member, especially in the upper beds, but generally the entire thickness of the member is dolomite. The color, texture, lithology, and thickness of this unit are rather constant in the quadrangle.

McGREGOR LIMESTONE MEMBER

The McGregor Limestone Member was named by Kay (1935, p. 286–287) for exposures near McGregor, Iowa. This member, locally

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known in the mining district as the Trenton lime, conformably overlies the Pecatonica Dolomite Member, which has a transition zone about half a foot thick in its upper beds. Thickness of normal unaltered McGregor in the Potosi quadrangle is from 26 to 32 feet. The member is dominantly a light-olive-gray to olive-gray and pale-yellowish-brown sublithographic to medium-grained fossiliferous argillaceous limestone. In the limestone, bedding is thin and wavy; in the lower part of the member in certain localities shale partings are abundant and make up as much as 40 percent of the rock. The upper half of the member generally grades upward into thicker and less argillaceous beds. Although shale is locally conspicuous in the upper part it is scarce in the uppermost few feet.

Dolomitic limestone and dolomite are common in the upper 10 feet of the McGregor, and locally the entire member is dolomite, as in the draw in the N½SE¼SE¼ sec. 20, T. 3 N., R. 2 W. The dolomite is darker and coarser grained than the limestone and in places is similar to the underlying Pecatonica Dolomite Member or the Ion Dolomite Member of the Decorah Formation. The dolomite beds of the McGregor contain less shale than the limestone beds.

An X-ray analysis of samples from the dolomite outcrop in the previously mentioned section 20 shows traces of quartz and feldspar. The quartz content is about normal if compared with X-ray studies of samples from other exposures of the McGregor, but the feldspar content increases. Four thin sections from the dolomite outcrop indicate that as much as 2 percent of the rock is quartz and feldspar grains that range in size from silt to very fine sand; the quartz is generally finer grained than the feldspar. A few of the larger quartz grains are euhedral, but all the feldspar and silt-size quartz grains are anhedral. Both X-ray and petrographic tests show that the feldspar is microcline.

Locally, an indefinite thickness of the upper beds of the McGregor has been altered to a soft grayish-orange to moderate-brown shale (pl. 35) by leaching of the carbonate from the rock. Leached rock in Wisconsin in the E½SE¼NW¼ sec. 7, T. 2 N., R. 2 W., and SW¼SW¼ sec. 12, T. 2 N., R. 3 W., is possibly related to faulting, but no faults are visible at either place.

The thin- and thick-bedded parts of the McGregor Limestone Member correspond in general to the Mifflin and Magnolia units described by Bays and Raasch (1935, p. 298) and by Bays (1938) in an area about 14 miles east-northeast of this quadrangle. Only locally in the Potosi quadrangle could the McGregor be divided into two easily recognizable units.

QUIMBYS MILL MEMBER

The Quimbys Mill Member was named by Agnew and Heyl (1946, p. 1585) for a quarry exposure at Quimbys Mill, Lafayette County, Wis., its type section. This member conformably overlies the McGregor Limestone Member and ranges in thickness from less than 2 inches at Spechts Ferry, Iowa, to 1.5 feet in an outcrop in Wisconsin in the NW¼ sec. 30, T. 3 N., R. 2 W. The member is limestone but has a mottled dusky-brown shale or shaly layer at its base and a similar but thinner shale layer at its top. Although U.S. Bureau of Mines churn drilling is reported to have penetrated 8 feet of Quimbys Mill in the Tennyson area (Apell, 1947, p. 8), this thickness is doubtful because the greatest thickness of Quimbys Mill seen in the quadrangle is 1.5 feet. The lithology of the uppermost part of the McGregor Member and the Quimbys Mill Member are commonly quite similar in outcrop, and this part of the McGregor could easily be mistaken for Quimbys Mill in drill cuttings.

The limestone of the Quimbys Mill Member is moderate yellowish brown to dusky yellowish brown; it is sublithographic to medium grained and is fossiliferous. The limestone is locally known as glass rock because it breaks with a conchoidal fracture and rings when struck with a hammer. Locally, in the Potosi quadrangle, the Quimbys Mill is a dusky-brown fairly soft shale which was called oil rock by early workers (Grant, 1906, p. 35, 37–38).

The Quimbys Mill Member thickens toward the east and south, over a distance of 16 miles, from 0 in the Potosi quadrangle to 12 feet at the type section.

DECORAH FORMATION

The Decorah Formation was named by Calvin (1906, p. 60, 84) for exposures at Decorah, Iowa, where it is predominantly a green shale. Southeast of Decorah this formation contains more carbonate rocks than at the type locality, and in the Potosi quadrangle it ranges from dominantly carbonate rock to about equal parts of carbonate rock and shale. Kay (1928) divided the formation into three members which are, in ascending order: Spechts Ferry Shale, Guttenberg Limestone, and Ion Dolomite. These members can be recognized in outcrops and in cuttings from drill holes. Normal thickness of the formation ranges from 38 to 46 feet in the Potosi quadrangle. Locally, the formation is altered by leaching, dolomitization of limestone, or silicification. Leaching of the carbonate rock and the resultant compaction of the insoluble residue is the most common alteration noted (pl. 35). This compaction has reduced the thickness of the formation by approximately half in Wisconsin in the SW¼SW¼ sec. 12 and in the NW¼NW¼ sec. 13, T. 2 N., R. 3 W. A very thin Decorah section in Wisconsin is also exposed in the SE¼NW¼ sec. 7, T. 2 N., R. 2 W. Other altered and thinned sections are shown on plate 35. Dolomitized rock was noted in SE¼SE¼ sec. 20, T. 3 N., R. 2 W., where the entire

Guttenberg Limestone Member is an argillaceous dolomite. Silicified strata are the least common altered rocks in the mining district and were not observed in the Potosi quadrangle; however, some silicified fossil fragments are in shale of the leached Guttenberg Limestone Member in Wisconsin in the NW¼SW¼ sec. 3, T. 2 N., R. 3 W.

SPECHTS FERRY SHALE MEMBER

The Spechts Ferry Shale Member conformably overlies the Quimbys Mill Member of the Platteville Formation. It was named by Kay (1928) for an outcrop in the ravine at Spechts Ferry, Iowa (sec. 4, T. 90 N., R. 2 E.), near the southwest corner of the Potosi quadrangle. The type section comprises 8.8 feet of dark-greenish-gray shale interlayered with olive-gray, medium-gray, and light-gray lenses and thin beds of hard compact fine-grained argillaceous limestone. The limestone is fossiliferous. Local drillers call this member the clay bed.

The basal bed of the Spechts Ferry is an olive-gray coarse-grained fossiliferous limestone that locally is similar to the underlying Quimbys Mill Member. A persistent layer of bentonite 0.1–0.3 foot thick (Agnew and others, 1956, p. 288–289) overlies the basal limestone. The bentonite is a light-gray soft clay where unoxidized but alters rapidly after exposure to the atmosphere to a pale-yellowish orange to almost white clay locally called pipe clay. The limestone near the middle of the Spechts Ferry varies in amount, thickness, and position. Phosphatic nodules and fossil fragments occur in an argillaceous limestone bed that ranges from 0.2 to approximately 1 foot in thickness near the top of the member. The top bed of the member is shale that ranges from 0.1 to 0.7 foot in thickness.

The Spechts Ferry Shale Member thins to the east and is only 6–7 feet thick along the east side of the Potosi quadrangle. It is 2.1 feet thick at Mifflin, Wis. (Agnew and others, 1956, p. 287), about 14 miles northeast of the quadrangle and is absent at Darlington about 19 miles to the east of the quadrangle (Klemic and West, 1964, p. 377). Drill logs indicate that in mineralized areas in the quadrangle this member is as thin as 3 feet because of leaching of the limestone and compaction of the less soluble material. Good exposures of the member are not common and are found only in steep gullies cut through unaltered rock.

GUTTENBERG LIMESTONE MEMBER

The Guttenberg Limestone Member, which conformably overlies the Spechts Ferry Shale Member, was named by Kay (1928) for outcrops in the bluff northwest of Guttenberg, Iowa. Typical Guttenberg, locally called oil rock, is 11–16 feet thick and averages about 14 feet. The member comprises dark-yellowish-brown to light-olive-gray sublithographic to medium-grained argillaceous and fossiliferous limestone that contains many grayish-brown fossiliferous limy shale partings. A discontinuous layer of chert nodules occurs about 6 feet below the top of the member. Locally, the entire member is dolomite (SE¼SE¼ sec. 20, T. 3 N., R. 2 W.).

Two types of alteration have locally reduced the thickness of the Guttenberg Limestone Member: solution leaching and the resultant compaction of the insoluble residue usually thin the member more than dolomitization of the limestone. Compacted insoluble residue from leached limestone of the Guttenberg Member is exposed several places in the quadrangle (pl. 35). Dusky-brown to reddish-brown soft to medium-hard shale is the only recognizable Guttenberg lithology remaining in outcrops where the entire member has been leached of carbonate, and exposures of a complete section of leached Guttenberg are sparse. The only silicified Guttenberg fossils noted in the quadrangle are found in shaly residue in an outcrop in NE¼NW¼SW¼ sec. 3, T. 2 N., R. 3 W. Silicified limestone of the Guttenberg is scarce in the zinc-lead district. The relation of solution and dolomitization to lead- and zinc-bearing mineral deposits has not been determined in this quadrangle.

Dolomite in the Guttenberg Limestone Member was seen in only one outcrop in the Potosi quadrangle (SE¼SE¼ sec. 20, T. 3 N., R. 2 W.). Because the entire member in this outcrop is dolomite which grades into the overlying Ion Dolomite Member, the upper contact of the Guttenberg cannot be defined at this place. The outcrop dolomite is coarser grained and has a more earthy appearance than the limestone in the Guttenberg Member. Drill holes are not known to have penetrated dolomite in the Guttenberg in the Potosi quadrangle, but dolomite is present to the southwest and south (Flint and Brown, 1956, p. 487–498; Whitlow and Brown, 1963).

ION DOLOMITE MEMBER

The Ion Dolomite Member was named by Kay (1928) for 16 feet of calcareous shale and argillaceous limestone which constitute the upper part of the Decorah Formation near Ion, Allamakee County, Iowa. In the Potosi quadrangle the member conformably overlies, and is transitional to, the Guttenberg Limestone Member. The transitional zone is several feet thick where the lower part of the Ion is limestone and less than 2 feet where the lower part of the Ion is dolomite. Commonly, the change is from brown shale partings in the Guttenberg to bluish-green shale partings in the Ion. In general thickness of the member in the quadrangle is 19–26 feet; the member may be entirely dolomite, entirely limestone, or mixed limestone and dolomite.

Altered and thinned sections are found in many outcrops (pl. 35) and are also indicated by cuttings from drill holes at Tennyson, Wis. (Apell, 1947, p. 8). Local drillers divide the member into the "blue," the lower 7–10 feet, and the "gray," the upper 12–16 feet, and this division, based on color of the drill sludge, can commonly be recognized in drill cuttings and even in exposures where alteration has taken place.

The blue unit of the Ion Dolomite Member is commonly limestone at the base which grades upward through dolomitic limestone to dolomite in the upper part; however, it may be entirely limestone or dolomite or in some places mostly shale. The carbonate rock is medium dark to light olive gray, fine to coarse grained, argillaceous, and fossiliferous. The limestone is generally a lighter color than the dolomite. Beds are less than 0.1 to about 1.2 feet thick and contain many pale-blue to grayish-green shale partings. Beds of grayish-green shale 0.5–1.5 feet thick are common near both the base and top of the unit. Generally where the blue unit is less than 7 feet thick, there is evidence of alteration and solution leaching. Drill logs indicate that the blue unit is as little as 3 feet thick at Tennyson, Wis. (Apell, 1947, p. 8). The upper part of this unit grades into the gray unit of the Ion, commonly without any definite boundary between the two units.

The gray unit of the Ion Dolomite Member is generally thick-bedded moderate-yellowish-brown and yellowish-orange medium- to fine-grained argillaceous and fossiliferous dolomite or limestone; it contains pale-blue-green to yellowish-green shale partings. Limestone is common in the unit (pl. 35), as is shale, although shale is not as common as in the blue unit. Locally, solutions have thinned the normal 12–16 feet of the gray unit to only a few feet, as in Iowa SW¼SW¼ sec. 12, and in Wisconsin NW¼NW¼ sec. 13, T. 2 N., R. 3 W., and possibly in Iowa SW¼NW¼ sec. 4, T. 90 N., R. 2 E. The upper 2 feet of the Ion is transitional to the overlying Galena Dolomite. The highest common occurrence of the pale-blue-green shale partings and a zone of *Prasopora*, a bryozoan, mark the top of the Ion Dolomite Member.

GALENA DOLOMITE

The Galena Dolomite was named by Hall (1851) for exposures in the vicinity of Galena, Ill. It conformably overlies the Decorah Formation in the Potosi quadrangle and ranges from about 224 to 235 feet in thickness, as shown by drill cuttings from wells and prospect holes in the quadrangle and by a composite of measured sections south of the quadrangle. It is divided into the following three members in ascending order: Prosser Member (Ulrich, 1911, p. 368–370, 488, fig. 7, pl. 27), Stewartville Member (Bassler, 1911, p. 25–27; Ulrich, 1911, pl. 27), and Dubuque Shaly Member (Sardeson, 1907, p. 193). The

Prosser extends from the top of the Decorah Formation to the base of the upper *Receptaculites* zone (pl. 34). As this fossiliferous zone is commonly difficult to find, it is not a useful indicator in the mining district. The top of the Prosser cannot be determined by this zone in the Potosi quadrangle, however, the top of the cherty lower part of the Galena is a distinct, natural, and usually rather easily found lithologic division which the authors, therefore, mapped on the basis of the cherty and the noncherty units of Agnew, Heyl, Behre, and Lyons (1956, p. 259).

The Galena Dolomite forms fair to good outcrops for as much as the lower 140 feet of its section in the Iowa part of the Potosi quadrangle, but only a few outcrops in the Wisconsin part of the quadrangle expose sections up to the top of the cherty unit. Generally, no reliable control points can be identified above the lower 60 feet of the formation, and the approximate top of the cherty unit is found in few outcrops and then only near the head of gullies; however, excellent exposures for study and comparison occur in the Dubuque North quadrangle (fig. 67).

CHERTY UNIT

The cherty unit comprises the lower 109–120 feet of the Galena Dolomite (pl. 34) in the Potosi quadrangle. In most outcrops it is a pale-yellowish-brown to light-olive-gray and grayish-orange fine- to medium-grained vuggy fossiliferous dolomite containing abundant chert as nodules or as nearly continuous layers. Some outcrops of the cherty unit are partly olive-gray to pale-yellowish-brown fine- to coarse-grained fossiliferous limestone (pl. 35). Generally, where the Galena Dolomite is limestone, the underlying Ion Dolomite Member is also limestone. A 4–10-foot transition zone of mottled moderate-brown to grayish-brown and dark-yellowish-brown argillaceous dolomite containing much calcite in veins and as cement is between the limestone and the dolomite strata, regardless of the stratigraphic position of these strata in the Galena. This transition zone has been described in the report for the Dubuque North quadrangle (Whitlow and Brown, 1963, p. 151) and for the Dubuque South quadrangle (Brown and Whitlow, 1960, p. 19). Limestone is more common in the Galena section in the Potosi quadrangle than in the Dubuque North quadrangle because the Galena is closer to the limestone facies to the northwest in Iowa (Agnew, 1955, p. 1720).

Chert in the cherty unit is nodular and distributed parallel to the bedding. It grades from yellowish gray to pale yellowish brown and contains fossil molds and brownish-gray fossil markings that give the chert a mottled appearance. Chert near mineralized zones is selectively mineralized and contains microscopic grains of disseminated iron sulfide that color it bluish gray and locally very dark gray. A powdery-white secondary tripoli generally occurs as rinds on the chert nodules in the dolomite and is common on the chert nodules in the limestone; however, some chert nodules grade into limestone without a change in color or texture, and a hardness or an acid test is necessary to distinguish the chert from the limestone in hand specimen. The tripoli may be due to recrystallization of the chert during dolomitization of the primary limestone. Also, some of the tripoli is possibly residual silica from carbonate leaching in the transition zone between the carbonate rock and the chert nodules. Brown and Whitlow (1960, p. 19–20, fig. 5) discussed and illustrated the gradational contact of the limestone and chert.

Locally, the lower 40 feet of the cherty unit is intensely fractured and leached to a moderate-brown and grayish-brown argillaceous dolomite. Part of such a section is exposed in the Piquette No. 2 mine (see p. 558 and pl. 36) near Tennyson, Wis. The lower very cherty part of the cherty unit (pl. 34) is normally 12–16 feet thick but thins to as little as 6 feet in the mine. The increase in the ratio of chert to dolomite indicates that this reduction in thickness is mainly due to partial removal of the carbonate. The carbonate was probably leached by the solutions that deposited sulfides. Outcrops of such reduced sections are stained by hydrous iron oxides derived from the alteration of iron sulfides and commonly contain much calcite.

The top of the cherty unit is marked by two discontinuous layers of chert nodules separated from the main cherty section by 6–9 feet of noncherty dolomite; thus, the top of the chert unit is 6 feet above the main chert section in Iowa and as much as 9 feet above in Wisconsin. The highest chert nodule layers are not always found in cuttings from drill holes; therefore the highest reported occurrence of chert in drill cuttings may be as much as 9 feet below the actual top of the unit. The top of the cherty unit is sparsely exposed in the Potosi quadrangle but is well exposed in the Dubuque North quadrangle.

A persistent zone of abundant chert in the lower part of the cherty unit (pl. 34) was used extensively for stratigraphic control in the quadrangle. The zonal division made by Agnew, Heyl, Behre, and Lyons (1956, p. 296), based on the presence or absence of chert and of *Receptaculites oweni* Hall, is not easily recognized above zone C of Agnew, which is the persistent zone of abundant chert stated above. The underlying zone D of Agnew, Heyl, Behre, and Lyons (1956, p. 296) was also used for structural control.

NONCHERTY UNIT

The noncherty unit includes all the Galena Dolomite above the cherty unit and comprises part of the Prosser Member and all the

Stewartville and Dubuque Shaly Members. This unit ranges in thickness from 115 to 120 feet. The lower 75–79 feet, which comprise the Stewartville Member and part of the Prosser Member, are thick bedded to massive. The strata of the noncherty unit are pale-yellowish-brown to yellowish- and grayish-orange fine-grained porous fossiliferous dolomite. Silicified fossil fragments are found in drill cuttings and occur as high as 15 feet above the base of the unit. *Receptaculites oweni* Hall is common in the upper *Receptaculites* zone (pl. 34). Overlying the Stewartville is 35–40 feet of even-bedded Dubuque Shaly Member, which is seen only as cuttings from drill holes in the upland areas of the quadrangle. This member is believed similar to the same stratigraphic unit in the Dubuque South quadrangle where the member consists of earthy fine-grained dolomite and intercalated beds of dolomitic shale a fraction of a foot thick (Brown and Whitlow, 1960, p. 22).

Outcrops of the noncherty unit that are useful for structural control are very rare in the Potosi quadrangle. This unit is generally the uppermost bedrock in the gently rolling uplands of the quadrangle; consequently there are no outcrops of the Dubuque Shaly Member, and outcrops of lower parts of the noncherty unit are usually poor. A full thickness for the unit is indicated below the surface, however, by cuttings from the Potosi-Tennyson well.

UPPER ORDOVICIAN SERIES

MAQUOKETA SHALE

The Upper Ordovician Series is represented in the mining district by the Maquoketa Shale, which was named by White (1870, p. 180–182) for outcrops along the Little Maquoketa River about 15 miles south-southwest of the Potosi quadrangle. Calvin (1906, p. 94–109) named and described four members in the Maquoketa Beds (formation) in Winneshiek County, Iowa. These members are, in ascending order: Elgin [2] Shaly Limestones, Clermont [2] Shale, Fort Atkinson Limestone, and Brainard Shales. Ladd (1929, p. 329–349) reported that from the type locality of the Maquoketa Shale the carbonate rock content increases to the northwest and the argillaceous material to the southeast. He recognized the units described by Calvin (1906) northwest of the type locality and called them members of the Maquoketa Shale.

Recognition of Maquoketa Shale in the Potosi quadrangle is based on scattered findings by A. V. Heyl, Jr. (oral commun., 1959), of depauperate fauna characteristic of the lower 10–15 feet of the formation (Ladd, 1929, p. 371–375; Brown and Whitlow, 1960, p. 25, fig.

[2] Name not adopted by the U.S. Geological Survey.

3). The thickness of the rock over the Platteville Formation on the upland west and northwest of Tennyson indicates that some Maquoketa Shale should be present. No outcrop of the shale was seen, and none has been reported in the Potosi-Tennyson area by well drillers; however, the lower part of the brown shaly unit of Brown and Whitlow (1960, p. 25) is probably present.

QUATERNARY SYSTEM

GLACIAL DRIFT AND LOESS

All the Potosi quadrangle was included in the Driftless Area by Chamberlin (1883, pls. 28, 31, 34). Chamberlin later revised the limit of the Driftless Area so that the upland just west of the Mississippi River was in the attenuated-pebble drift zone (Chamberlin and Salisbury, 1885, p. 275–277, pls. 26, 27, 29).

Williams (1923) studied glacial till in eastern Dubuque County and concluded that the till is of Nebraskan age because it occurs only as remnants on the divides. Trowbridge (1921, p. 123–125; 1954, p. 801–804) agreed with this conclusion and believed that the Nebraskan Till was deposited on the Lancaster peneplain. He also believed that the present course of the Mississippi River in this area marks the approximate ice border of the Nebraskan Glaciation and the present valleys were cut after the first glaciation. Kansan Till on divides and in valleys in western Dubuque County supports Trowbridge's idea.

No exposures of glacial till are known in the Potosi quadrangle, but a few fragments of igneous and metamorphic rock, and rarely agate, that are from glacial drift occur in stream gravel in sec. 8, T. 90 N., R. 2 E., Iowa. In addition, rounded fragments of iron-formation, igneous rock, and quartz as much as three-quarters of an inch in diameter were seen about 40 feet above normal pool altitude in the scree at the base of the bluffs west of Spechts Ferry. No glacial debris was noted in the Wisconsin part of the quadrangle.

Loess of varying thickness covers most of the upland, but no sections more than 10 feet thick are exposed, and no available well data give an approximate maximum thickness for loess in the Potosi quadrangle. The thickest sections are in gullies and roadcuts in the Iowa part of the quadrangle, and probably the thickest deposits are in the same area.

Loess and till are not shown on the geologic map because no data were found that indicate their distribution in the quadrangle.

ALLUVIUM

The alluvium in the Potosi quadrangle is valley fill that comprises glacial outwash material of late Wisconsin age (Trowbridge, 1954, p. 803) and locally derived debris. The glacial debris and outwash material is restricted to the valley of the Mississippi River and to the valleys of streams in Iowa. In the Potosi quadrangle all streams north and east of the Mississippi River drain the Driftless Area and have no source for glacial debris; therefore, except possibly for some glacial debris backwashed into the mouth of the Platte River, the alluvium in the valleys consists of local rock debris and some loess.

Alluvium in the Mississippi River valley should be similar to the material in sand and gravel pits along the river to the northwest, south, and southeast of the quadrangle. These pit materials indicate that the outwash consists predominantly of debris from metamorphic and igneous rocks of the Lake Superior region. Quartz, chalcedony, iron-formation, volcanic rock, granite, gabbro, and greenstone are the most common large fragments. The light fraction of the minus-40 mesh material consists of much quartz and feldspar, and the heavy fraction contains much magnetic material considerable nonmagnetic mafic minerals, garnet, zircon, a trace of rutile, a rare trace of gold, and other minerals that were not identified. A large gravel pit near Bellevue, Iowa, about 30 miles southeast of the Potosi quadrangle, exposes about 20 feet of coarse gravel that is overlain by about 20 feet of predominantly quartz sand that is very pale orange to grayish yellow. This sand is probably too high above the river to be a Recent flood-plain deposit and is possibly a mixture of upper Pleistocene alluvium and loess deposits. Some of the valley deposits in secs. 11 and 14, T. 2 N., R. 3 W., Wisconsin, may be sand deposits of this type, but most of the exposed valley bottom of the Mississippi River is underlain by flood-plain deposits of indefinite thickness that are younger than the higher terraces and most of the fill in the valley.

The depth of fill in the valleys of the Mississippi and Platte Rivers is not known; however, it may be as much as 300 feet in the Mississippi River valley. This estimate is based on records of wells which indicate 337 feet of fill in sec. 30, T. 89 N., R. 3 E., Iowa (Brown and Whitlow, 1960, p. 8), about 9 miles south of the Potosi quadrangle. Valley fill is found as much as 60 feet above the normal pool altitude of the Mississippi River in the Dubuque North quadrangle, but this high fill is not preserved in the Potosi quadrangle along the Mississippi River. It is, however, preserved along the Platte River in Wisconsin in secs. 6, 7, 8, 17, 18, 19, and 20, T. 2 N., R. 2 W., and possibly in secs. 29 and 30, T. 3 N., R. 2 W.

The thickness of sand, silt, and gravel of local origin that fills the Platte River valley is unknown. This fill may be as thick as that in the Little Maquoketa River valley, which has as much as 65 feet of alluvial deposits about 6 miles upstream from its mouth (Flint and Brown, 1956, p. 484, 495–498).

ALLUVIAL TERRACES

Remnants of an alluvial terrace between 650 and 660 feet above sea level, about 55 feet above normal pool altitude, occur in the valley of the Platte River (pl. 33). These remnants are composed of local rock debris and some loess. Although the terrace is not present in the Mississippi River valley in the Potosi quadrangle, it is well preserved just to the south in the Dubuque North quadrangle and there comprises glacial outwash material and loess (Whitlow and Brown, 1963, pl. 2).

A second, and lower, terrace between 630 and 640 feet above sea level is preserved in the Dubuque North quadrangle. In the Potosi quadrangle this terrace has been eroded from the valley of the Mississippi River and is not recognizable in the Platte River valley. According to Trowbridge (1954), p. 803), both terraces are post-late Wisconsin Glaciation in age.

The terracelike area between 610 and 620 feet above sea level in Wisconsin in secs. 10, 11, and 14, T. 2 N., R. 3 W., is shown on the maps (see footnote 1, p. 539) of the Mississippi River before the construction of the dams as a gently sloping rise from the river flood plain, which is about 600 feet above sea level.

The most southerly site where copper-culture artifacts were found in southwestern Wisconsin is in the NW¼ sec. 14. Artifacts from the site are dated at about 5,000 years of age by the carbon-14 method (Meyer Rubin, oral commun., 1960). The artifacts were found in a mound about 10 feet higher than the surrounding flood plain which indicates that the flood-plain deposits at the site are post-Wisconsin and precopper culture in age.

CLASTIC DIKES OF UNKNOWN AGE

Locations of several clastic dikes that range in thickness from less than 0.1 foot to approximately 3 feet are shown on plate 33. The dikes range from those in which the clastic material is composed entirely of dolomite and chert fragments to those in which the clastic material is quartz sand. The material of the dikes is cemented by dolomite that is similar to the enclosing rock except for lack of stratification.

The thickest dolomite and chert dike is as much as 3 feet thick and contains some galena in vugs. It is in the upper part of the cherty unit of the Galena Dolomite in a quarry in the northern NW¼NW¼ sec. 24, T. 3 N., R. 3 W., Wisconsin. This dike is traceable across the quarry, a horizontal distance of 120 feet, and to the top of the quarry, a vertical distance of 30 feet. The thickest sandstone dike is about 0.3 foot thick and is in the center of N½NE¼ sec. 5, T. 90 N., R. 2 E., Iowa. It can be traced for a distance of 75 feet horizontally and 34 feet vertically from 4.5 feet below the top of the Pecatonica Dolomite Member of the Platteville Formation almost through the McGregor Limestone Member. A clastic dike consisting of dolomite fragments and some quartz sand is in a loose block of the Prairie du Chien Group in the center of N½ sec. 17, T. 3 N., R. 2 W., Wisconsin.

The other clastic dikes found in the quadrangle are thin and are composed of quartz sand. Two are in the Platteville Formation (pl. 33), and one is in the Decorah Formation (pl. 36). No clastic dikes were noted in the St. Peter Sandstone.

The strike of the sandstone dike in N½NE¼ sec. 5, T. 90 N., R. 2 E., Iowa, is N. 36° E. Strikes of the other dikes seen in the Potosi quadrangle are from N. 70° E. to S. 70° E.

Small galena and sphalerite crystals in a sandstone dike in Dubuque, Iowa (Whitlow and Brown, 1963), and galena in vugs in the thickest dike previously described (p. 556), indicate that the dike emplacement antedates or was concurrent with the mineralization.

The quartz sand grains in the dikes are similar to sand grains in the St. Peter Sandstone. Whitlow and Brown (1963) studied the heavy minerals from sandstone dikes in the Dubuque North quadrangle and found that they are similar in kind and approximate quantity to the heavy minerals in the St. Peter Sandstone. From the results of their study, they suggested that the sand in the dikes was emplaced during earthquake disturbances when water mixed with some quartz sand was forced upward by differential hydrostatic pressure into suddenly opened vertical fractures.

The dolomite and chert fragments in clastic dikes are from the wallrock that was broken and crushed by recurring tectonic adjustments along the fractures. The crushed and broken material has generally moved downward by gravity as shown in a dike in the Eagle Point quarry at Dubuque, Iowa.

Quartz sandstone blocks of St. Peter-type sand have been found in the areas of Galena Dolomite, more than 100 feet stratigraphically above the St. Peter Sandstone. Only one occurrence (NW¼NW¼ sec. 10, T. 90 N., R. 2 E., Iowa) was noted in the Potosi quadrangle, but seven localities that have sandstone blocks apparently above the stratigraphic source have been reported in the Driftless Area in Wisconsin (Heyl and others, 1959, p. 46); one occurrence was noted in Iowa in the Dubuque North quadrangle (Whitlow and Brown, 1963). These residual blocks are probably from clastic dikes; however, ice rafting to the present position has been proposed as the possible origin. Lack of other glacial debris at or near the erratic blocks in the Driftless Area and chert fragments in some of the boulders lend support to a clastic-dike origin.

STRUCTURE

A southwestward dip of 15–20 feet per mile, less than 1°, is the dominant structure of the western part of the Wisconsin-Illinois-Iowa zinc-lead district. Superimposed on this regional dip in the Potosi quadrangle is one first-order fold (Heyl and others, 1959, p. 27–31, fig. 13 and pl. 8) and several small synclines, anticlines, basins, and domes that generally have less than 60 feet of relief.

Joints are well formed and numerous. A few faults were noted but none could be traced and projected more than 3,000 feet (pl. 33). In a few areas the strata have some local change of altitude that may be caused by flexures or faults, but structural features could not be mapped in detail because of lack of exposures (fig. 2).

The top of the Platteville Formation in this quadrangle ranges in altitude from less than 620 feet above sea level in NE¼ sec. 9, T. 90 N., R. 2 E., Iowa, to between 820 and 830 feet near the northeast corner of the quadrangle (pl. 33). Total structural relief is about 210 feet, which is approximately the average dip across the northeast-southwest diagonal of the quadrangle.

Structure contours for the geologic map of the Potosi quadrangle are based on the top of the Platteville Formation as the reference datum because of the many exposures of the top of the formation in the quadrangle. Control points as low as the top of the St. Peter Sandstone, about 52 feet below the top of the Platteville, were also used. About one third of the control points are above the Platteville Formation. These points were used with caution because the thinning of strata in the Decorah Formation and in the lower part of the Galena Dolomite makes many control points almost useless for extrapolation. The top of the Platteville Formation is not an ideal surface for showing all structures that may control the deposition of zinc or lead sulfides; contours on top of the Decorah Formation or at some higher datum surface are necessary to show the small structures that may be related to ore deposits in this area. The structure shown on the map of the Piquette No. 2 mine near Tennyson, Wis. (pl. 36), illustrates how contour patterns on two datum surfaces may differ. The thickness of rock between the contoured surfaces is from 25 to 30 feet near the east end of the mine but decreases to as little as 15 feet near the west end.

FOLDS

Folds are low and open in the Potosi quadrangle, and no major anticlines or synclines are found. Heyl, Agnew, Lyons, and Behre (1959, p. 27–31, pl. 8) showed the trace of the Platteville syncline, a first-order structural feature, across the quadrangle southwestward from sec. 31, T. 3 N., R. 2 W., Wisconsin, to near the southwest corner of the quadrangle; however, more detailed structural mapping does not confirm this interpretation. Structural lows in the north side sec. 31, T. 3 N., R. 2 W., and in sec. 1, T. 2 N., R. 3 W., or possibly the lows in sec. 8, T. 2 N., R. 2 W., and in SE¼ sec. 13, T. 2 N., R. 3 W., may be related to the termination of the Platteville syncline at its southwest end. The syncline cannot be traced, however, across the quadrangle at either place.

Two second-order synclines (Heyl and others, 1959, p. 31–34) are in the Wisconsin part of the quadrangle. One trends N. 75°–80° E. from the south side of sec. 32, T. 3 N., R. 3 W., through the south side of sec. 29, T. 3 N., R. 2 W., Wisconsin. Much of the intensively mined area in the Potosi quadrangle (Heyl and others, 1959, pl. 6) is in this syncline, and the largest and deepest basin in the quadrangle is in it at and just west of Potosi (pl. 33). The second syncline trends N. 40° W. from sec. 6, T. 2 N., R. 2 W. to NE¼ sec. 27, T. 3 N., R. 3 W., Wisconsin, where it bends to about N. 75° W. and is traceable beyond the quadrangle through sec. 20, T. 3 N., R. 3 W., Wisconsin.

The other structural features in the quadrangle are a low second-order anticline and domes and basins that are generally less than a square mile in area. The anticline is traceable, through a low structural plateau and two disconnected high areas, from sec. 5, T. 2 N., R. 2 W., westward into secs. 2, 11, and 14, T. 2 N., R. 3 W., and into sec. 5, T. 2 N., R. 3 W., Wisconsin. This anticline crosses the southeast end of the second syncline mentioned previously and separates this syncline from the basin in sec. 8, T. 2 N., R. 2 W. The domes of the anticline, in sec. 7 and also in the common corner of secs. 11, 12, 13, and 14, are of special interest because of faults and altered rocks that are nearby. Both high areas have exposures of leached limestone and compacted residue of the McGregor and Quimbys Mill Members of the Platteville Formation and Guttenberg Limestone Member of the Decorah Formation. Structure contours based on a reference datum above the top of the Decorah Formation in either area probably would not show a dome because of the thinning in the McGregor, Quimbys Mill, and Guttenberg Members; the area in sec. 7 might even be a basin. Domes and some of the basins are probably the result of tectonic adjustments; however, many shallow basins in this quadrangle and probably elsewhere in the zinc-lead district that have less than 20 feet of relief more likely resulted from the collapse of overlying unaltered strata into a zone of leached and thinned carbonate rocks.

JOINTS

Joints are numerous and well formed in the Potosi quadrangle. The attitudes of approximately 1,800 vertical and near-vertical joints were recorded and plotted on diagrams for the entire quadrangle as well as for small local areas. For the quadrangle, as a whole, joints have a random strike; locally, however, they form a joint system. For example, the predominate joint trends in the general area around Potosi and east and northeast of British Hollow are about N. 65° W. and N. 45° E. These two areas include most of the intensively mined ground in the quadrangle. The most westerly striking joints are parallel to the richest lead and zinc deposits that have been mined in the quadrangle and sometimes the joints themselves contain deposits. These joints or fractures are commonly open, and at least some of them were channels for movement of fluids that deposited the ore minerals. By contrast, the northeasterly striking joints are more tightly closed and generally do not contain ore deposits. The joints in the remainder of the quadrangle do not form any definite pattern that is repeated in adjacent areas as, for example, the joints do in other parts of the zinc-lead district (Brown and Whitlow, 1960, fig. 17; Whitlow and Brown, 1963). Few north-striking joints and practically none having this strike are found in the intensively mined area except in a small part of the Piquette No. 2 mine (pl. 36).

Many of the most prominent vertical joints may have minor horizontal displacement. Such minor displacement is well illustrated in the Piquette No. 2 mine, where strike-slip movement is indicated by seemingly displaced intersecting joints on each side of a major joint. Further evidence of strike-slip movement is provided by horizontal grooves on exposed joint surfaces in a quarry in the center of N½ sec. 36, T. 3 N., R. 3 W., Wisconsin, and at the entrance to the Piquette No. 2 mine.

Joints dipping less than 65° are common but not nearly as numerous as the vertical and near-vertical joints. Dipping joints do not form a recognizable system and usually are in areas where the beds dip 2°–5°; the joints generally dip in the opposite direction from the dip of the strata. These joints are possibly related to pitch-type fractures (see p. 563) which are inclined and may be filled wih ore minerals. Later adjustment along the joints caused some vertical displacement of a reverse-fault type.

FAULTS

Few definite faults were observed in the Potosi quadrangle. Some of the intensely broken and altered zones in the quadrangle may actually be faults that show no recognizable displacement. Only the vertical displacement can be measured with any degree of accuracy, and the maximum noted in the quadrangle is about 5 feet. Probably many strike-slip faults were missed because they are difficult to recognize unless a fault surface is exposed, as in the quarry in sec. 36, T. 3 N., R. 3 W., Wisconsin, and in the Piquette No. 2 mine (pl. 36).

A fault in NW¼NW¼ sec. 31, T. 3 N., R. 2 W., mapped by Heyl, Lyons, and Agnew (1948), is now difficult to find because road relocation has covered much of the exposed fault surface and erosion has destroyed additional surface exposures. Other faults are exposed in sec. 7, T. 2 N., R. 2 W.; NW¼NW¼ sec. 13, T. 2 N., R. 3 W.; and secs. 24 and 36, T. 3 N., R. 3 W., Wisconsin. Strata projection from control points on opposite sides of a covered area in sec. 7, T. 2 N., R. 2 W., indicate a possible displacement of several feet between the points. Several faults that have displacement ranging from a few tenths of a foot to 4 feet were mapped in the Piquette No. 2 mine (pl. 36) and are commonly found in areas of intensely fractured rock.

In the Piquette No. 2 mine, many dipping fractures 750–1,200 feet from the portal are reverse faults that have as much as 0.7 foot vertical displacement. Some of these fractures probably have a tectonic origin, but many are thought to result from collapse over a solution-leached zone beneath the mine floor, probably in the Guttenberg Limestone Member of the Decorah Formation. Some of the highest grade ore in the mine was found in this zone of closely spaced dipping fractures.

The dipping fractures in the zinc-lead district are generally found in the Decorah Formation and in the overlying cherty unit of the Galena Dolomite. Relatively few are in the lower part of the Decorah Formation or near the top of the cherty unit of the Galena. Many of the dipping fractures within the limits mentioned are the result of collapse of unaltered rock over a zone of leached and thinned strata. Dipping fractures occur but are scarce in the upper part of the Platteville Formation or above the cherty unit of the Galena Dolomite. The few fractures traceable from the lower part of the Platteville Formation through the Galena Dolomite probably have a tectonic origin, because such persistent fractures do not bottom in leached and thinned strata.

STRUCTURES OF UNCERTAIN ORIGIN

Structural relations are unsolved at several places in the quadrangle; the structural features are indicated by a queried fault symbol on plate 33. They may be faults, homoclines, or local collapse features over areas of solution-leached carbonate rocks. Outcrops in each area are not sufficient to determine the nature of these structures, which are probably not all the same.

ECONOMIC GEOLOGY

MINERAL DEPOSITS

Galena, sphalerite, and smithsonite are the commercial metallic minerals in the Potosi quadrangle. Galena, at the present time, is generally a byproduct of sphalerite mining in the Upper Mississippi Valley zinc-lead district.

Galena was first noted in the general area of Dubuque, Iowa, and Galena, Ill., as early as 1658–59 (Thwaites, 1895, p. 272). The first mining was in 1699 by Le Sueur (Thwaites, 1895, p. 276), who is supposed to have supplied himself with lead from what became known as the Snake Diggings, at Potosi, Wis.; however, it was nearly 100 years later that systematic mining of galena began near or in the area. A detailed history of the discovery, mining, and production of lead and zinc in the upper Mississippi River valley was given by Heyl, Agnew, Lyons, and Behre (1959, p. 67–81).

The minerals of the zinc and lead deposits in the Potosi quadrangle are mostly simple sulfides, carbonates, and sulfates. The primary sulfide minerals are sphalerite, galena, pyrite, marcasite, chalcopyrite, and digenite; these minerals are accompanied by calcite and very rarely by dolomite. Galena is fairly stable and persists above the water table; the others commonly are altered. Enargite, a primary copper sulpharsenide mineral, was found by Heyl (1964, p. 1458–1461) as minute crystals on sphalerite and chalcopyrite in small vugs in the Piquette No. 2 mine. Minerals derived from the oxidation of the primary sulfides and found at or above the water table are smithsonite, cerussite, limonite, melanterite, malachite, azurite, and erythrite. The copper minerals are too scarce to have commercial value and occur only as accessories with galena and less commonly with sphalerite. A moderate-red to moderate-pink bloom in the Piquette No. 2 mine was tentatively identified by A. V. Heyl, Jr. (oral commun., 1959), as erythrite, a cobalt arsenate.

Heyl, Agnew, Lyons, and Behre (1959, p. 252–255) stated that more than 21,300 tons of 80 percent lead concentrate was produced in the Potosi subdistrict between 1862 and 1876. Much of this mining was for surface and near-surface galena and smithsonite, and there was relatively little mining by shaft. No figures for the total production of zinc or lead ores in this subdistrict are available.

The early mining recovered ore minerals that occurred in solution-widened vertical joints in hard unaltered rocks and in soil over bedrock. The deposits in the vertical joints are limited vertically and were called gash veins by Whitney (1858, p. 432) to distinguish them from continuous fissure veins. The local term for such deposits is "crevice deposits."

Crevice deposits are generally restricted to the Galena Dolomite, usually the upper part, above the zone of abundant chert near the top of the cherty unit (pl. 34). A few crevice deposits are traced below the Galena, but none has been reported in the overlying Maquoketa Shale in this area, although some galena has been mined from the basal beds of the Maquoketa elsewhere in the mining district (James Kane, oral commun., 1956). Localization of the crevice deposits was controlled by three factors: (1) stratigraphic zones of greater solubility than the adjacent strata, a situation caused by chemical composition or greater permeability, (2) well-formed steeply dipping to vertical shear joints intersecting these soluble zones, and (3) intersections of such joints. Solutions selectively dissolved the soluble zones crossed by the joints. The resulting cavities, or porous spongelike zones, are called openings (pl. 34) by local miners. These openings occur persistently at the same stratigraphic horizons in most of the zinc-lead district, especially in the western part. Extensive solution of the wallrock at intersections of major joints with other joints commonly produced high openings called chimneys. Mineralized solutions deposited lead and zinc minerals in the openings. Because the joint-controlled openings are discontinuous, deposits in such openings are podlike both horizontally and vertically. Although veins of lead and zinc minerals in the crevice deposits are concentrated in the solution-enlarged openings, they are not restricted to them (Brown and Whitlow, 1960, p. 55), and these minerals also occur as thin fracture fillings between the openings.

Most of the zinc and lead ores mined in the Potosi quadrangle in the last 60 years have come from levels deeper than the crevice deposits, and the ore is predominately in horizontal veins, locally called flats, and in dipping veins, locally called pitches. The pitch-and-flat deposits are generally stratigraphically lower than the crevice deposits. The pitches usually dip less than 60° and are mainly in the Decorah Formation and the cherty unit of the Galena Dolomite. Pitches can rarely be traced into the upper part of the Platteville Formation and are equally scarce in the noncherty unit of the Galena.

The best examples of accessible pitches and flats in the Potosi quadrangle are in the Piquette No. 2 mine (pl. 36). This mine is in the lower beds of the Galena Dolomite, except at and near the portal and in the general area where the workings turn south; at these places the floor is in the upper beds of the Decorah Formation. The major pitches are continuous horizontally for several hundred feet; the minor pitch-type fractures are much shorter. All pitches have a reverse-fault relationship between the hanging wall and footwall, and the vertical displacement is less than 0.7 foot. The map (pl. 36) shows only a few of the dipping fractures. Fourteen major fractures can be found from the south side of the mine to the north side about 1,000 feet from the portal. Dips of the fractures are steeper near the north side than the south side of the mine. Only a south-dipping pitch system is present, and the direction of dip indicates that the mine is on the south side of a synclinal trough or of a solution-thinned area. Disseminated zinc minerals are found at the toe and in the footwall of some of the pitches, and locally they contain a higher grade ore than the pitch zones. This disseminated ore, called core ground, is sometimes the best ore in the mine. Diagrammatic sketches that illustrate the usual location of the disseminated ore in relation to pitches and flats were shown by Reynolds (1958, fig. 3) and by Brown and Whitlow (1960, p. 55–57, pl. 4). Few good examples of flats remain in the mine, though several were seen during mining. Some of the flats were only partly filled by gangue and ore minerals including well-formed crystals of galena. The flats exposed in the fall of 1960 are rather thin and completely filled by sphalerite and (or) galena and usually some calcite.

Only very small amounts of zinc or lead minerals remain in the north and south walls of the mine. These walls mark the limit of economically recoverable mineralized rock both at the level of the mine and below the mine floor as indicated by cuttings from drill holes. Mining and milling methods used at the Piquette No. 2 mine are described by Grosh and Evans (1959).

Heyl, Agnew, Lyons, and Behre (1959, p. 252–255) reported that pitches and flats at other mines in the Potosi subdistrict contained galena and sphalerite veins as much as 4 feet thick. Their report contains information collected between 1942 and 1950 and includes descriptions of many mines.

ORE PRODUCTION POTENTIAL

The potential for future ore production in parts of the Potosi area is good. The Iowa part of the quadrangle, however, lacks prospects and apparently is barren of mineralization. The most productive strata in the Upper Mississippi Valley zinc-lead district are exposed in the quadrangle; however, no mining has been done below the Decorah Formation. Lead and zinc minerals were noted at several places in the east half of the quadrangle and are indicated on plate 33 by chemical symbols. These locations are at both outcrops and mine dumps.

The Prairie du Chien Group contains zinc and lead minerals in parts of the Upper Mississippi Valley mining district, but none were seen in the Potosi quadrangle. Although drill cuttings from the Potosi-Tennyson well show some iron sulfides within the group, lack of zinc or lead mineralization here and elsewhere suggests that the

Prairie du Chien is not likely to contain large ore deposits in this quadrangle, however, it has not been thoroughly prospected.

The St. Peter Sandstone is a poor host rock for zinc or lead ore. Iron minerals are common in the sandstone, but zinc and lead minerals were found only locally in the sandstone northeast and east of the quadrangle.

The Platteville Formation is widely mineralized. Most of the ores in this formation in the mining district are in the McGregor and Quimbys Mill Members. Zinc and lead minerals in these members were noted in an outcrop in the SE¼SE¼SE¼ sec. 1, T. 2 N., R. 3 W., Wisconsin, and as much as 4.85 percent zinc and 1.4 percent lead are reported in samples from drill holes at Tennyson, Wis. (Apell, 1947, p. 10–11). The Tennyson area is the only part of the quadrangle for which logs of drill holes that reached the Platteville Formation are available. Drill cuttings from the McGregor Member at the Potosi-Tennyson well contain some iron sulfides but no zinc or lead minerals. The member is a potential ore horizon in this quadrangle, but the ore would have to be above the average district grade to counter the high cost of mining that would be caused by as much as 8 feet of soft Spechts Ferry Shale Member that overlies the Platteville Formation. The Quimbys Mill contains zinc and lead minerals, but this member is too thin in the Potosi quadrangle to be an important ore horizon. The Pecatonica Dolomite Member contains a few ore bodies in parts of the zinc-lead district, but no mineralized Pecatonica was either observed in this area or reported in logs of drill holes. The Glenwood Shale Member seldom contains more than a trace of zinc or lead minerals, and no trace was noted in this quadrangle.

The Decorah Formation has greater potential for zinc and lead ores than any other formation exposed in the quadrangle, except possibly the Galena Dolomite. Many of the large pitch-and-flat-type deposits in Wisconsin and Illinois are in this formation and are restricted to the Guttenberg and Ion Members. Some of the abandoned mines in this quadrangle had zinc ore in the Ion Dolomite Member (Heyl and others, 1959, p. 252–255). Logs of drill holes in the Tennyson area indicate as much as 14.85 percent zinc in 2 feet and average as much as 8.7 percent zinc in 10 feet of strata in this member, and one hole contained 4.2 percent lead in 6 feet (Apell, 1947, p. 10–13). Sphalerite was found in the exposed Guttenberg Member in the SW¼ sec. 19, T. 3 N., R. 2 W. The Spechts Ferry Shale Member contains zinc and lead minerals but no ore deposits in the mining district, though iron sulfides are common in the member in the Potosi quadrangle.

The Galena Dolomite has an excellent potential for zinc and lead ores. All the early mining in the Potosi subdistrict was in the Galena Dolomite, and most of the later shaft mines were in pitch-and-flat-type deposits in the lower beds of the formation. Nearly all the ore taken from the one active mine in the quadrangle in 1960 came from the lower 45 feet of the Galena Dolomite. Drilling in and near Tennyson, Wis., indicates ore-grade zinc minerals and some lead minerals in this formation (Apell, 1947, p. 8–13). Most of the ore potential for the Galena Dolomite is in the lower part of the cherty unit.

The Maquoketa Shale has no potential for zinc deposits and little for lead deposits. Even if it were a good host rock, there is not enough of it in the Potosi quadrangle to warrant exploration.

NONMETALLIC DEPOSITS

The chief nonmetallic deposits in the Potosi quadrangle are dolomite, limestone, sandstone and sand and gravel from the valley fill of the Mississippi and Platte Rivers. The St. Peter Sandstone is mined for foundry and glass sand at Clayton, Iowa, and for glass sand in Illinois.

There are seven quarries in the Potosi quadrangle, two of them in the Platteville Formation and five in the Galena Dolomite. Agricultural lime was produced at a small quarry in NE¼NE¼NE¼ sec. 21, T. 3 N., R. 3 W., Wisconsin, and a small amount was produced at the quarry 300–350 feet north of Potosi Station. Some dimension stone may have been taken from the quarry in the NW¼SW¼SE¼ sec. 4, T. 2 N., R. 3 W., Wisconsin. Crushed stone for road metal was produced at the other quarries and at the quarry just north of Potosi Station. The quarry in the center N½ sec. 36, T. 3 N., R. 3 W., Wisconsin, was active in 1960. Those in NW¼NW¼ sec. 24, T. 3 N., R. 3 W., and near west side SW¼SW¼ sec. 21, T. 3 N., R. 3 W., Wisconsin have been operated sporadically since 1954. The remainder have been idle for many years. The Decorah Formation of the Potosi quadrangle is not used for agricultural limestone or crushed for road metal; however, the Decorah found about one-fourth mile east of the quadrangle in sec. 21, T. 3 N., R. 2 W., Wisconsin, is used for road metal.

There are no sand or gravel pits in the Potosi quadrangle. The valley fill of the Mississippi River has not been tested for these materials, and probably this valley fill and that of the Platte River valley south of T. 3 N. contains usable deposits.

The total value of the nonmetallic material recovered in the quadrangle is probably less than that received from the zinc and lead minerals; however, the potential value of nonmetallic material available is much greater than that of the metallic minerals.

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