POSSIBILITY OF MISSISSIPPI VALLEY-TYPE MINERAL DEPOSITS IN INDIANA

Special Report 21

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Possibility of Mississippi Valley-Type Mineral Deposits in Indiana

By NELSON R. SHAFFER

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Possibility of Mississippi Valley-Type Mineral Deposits in Indiana

By NELSON R. SHAFFER

Abstract
The midwestern United States is recognized as a lead-zinc metallogenetic province because of its low-temperature Mississippi Valley-type ore deposits. These deposits are found in Paleozoic dolomitic host rocks, commonly on the flanks of structurally high areas far from areas of igneous activity. They have simple mineralogies, mostly sphalerite, fluorite, galena, or barite, that are believed to have formed at low temperatures (70° to 200°C) from concentrated brines. One commonly accepted explanation of the origin and characteristics of Mississippi Valley-type deposits is that they were the natural consequence of basin development when sedimentary connate waters, the metal-bearing brines, migrated updip from the basin and precipitated ore minerals on encountering sources of reduced sulfur.

Indiana lies within a structural framework and contains many geologic features that appear suitable for the development of Mississippi Valley-type deposits. A structurally high area, the Kankakee and Cincinnati Arches, crosses Indiana from northwest to southeast and separates the Michigan and Illinois Basins. Potential-ore host rock occurs in the Knox Dolomite (Cambro-Ordovician); the Black River and Trenton Limestones (Ordovician); the Salamonie Dolomite, the Louisville Limestone, and the Wabash Formation (Silurian); the Muscatatuck Group (Devonian); and the Sanders and Blue River Groups (Mississippian). Unconformities are at the top of the Knox, the Trenton, and the Wabash. Many occurrences of sphalerite, fluorite, barite, and galena in Indiana had already been noted, and more than 90 new ones were found during this study. Most new occurrences were in the Black River-Trenton section, especially in northern Indiana where the rocks had been extensively dolomitized. In northern Indiana many minerals occur in the dolomitized reef facies of the Silurian System and in the overlying Devonian limestones. In southern and southwestern Indiana sphalerite and fluorite occur in the Salem and Ste. Genevieve Limestones. Preliminary information from fluid inclusions in sphalerite samples indicates that some specimens formed at temperatures within the range reported for Mississippi Valley-type deposits. Favorable geology, ore minerals in minor amounts, and tentative evidence that ore-type fluids passed through suitable host rocks indicate that undiscovered Mississippi Valley-type ore deposits possibly exist in Indiana.

Introduction
The midwestern United States is generally recognized as a lead-zinc metallogenetic province because of many lead-zinc ore deposits. These deposits, collectively called Mississippi Valley-type, have similar geologic characteristics and, according to many geologists, a similar origin in the Midwest. Deposits of this type occur in southeastern Missouri, the Illinois-Kentucky fluorite district, the tri-state region of Oklahoma, Kansas, and Missouri, the upper Mississippi Valley, eastern and central Tennessee (fig. 1), and foreign countries.

Common features of these deposits, as summarized by Ohle (1959, 1970), Snyder (1968), Heyl and others (1974), and many others, include: (1) occurrence in shallow-water carbonate rocks of Paleozoic age, mostly in dolomitized areas; (2) location on flanks of structurally high areas, mostly far from igneous or tectonically active areas; (3) simple mineralogy of sphalerite, galena,
fluorite, and barite with carbonate or quartz gangue and traces of asphaltic material; (4) apparent formation in open spaces at low temperatures (70° to 200°C) from highly saline brines; (5) galena with anomalous lead isotopes; and (6) highly variable sulfur isotope ratios. Callahan (1964) pointed out the association of many deposits with unconformities and suggested that unconformities contribute to ore formation, but others dispute the importance of unconformities in localizing ore.

Many explanations of the observed characteristics and the origin of these deposits have been advanced. One explanation by Noble (1963), Jackson and Beales (1967), Beales (1975), and many others is that Mississippi Valley-type ore deposits are formed as a normal step in the evolution of sedimentary basins. As part of this evolution, connate brines in deep parts of the basin become enriched in metals and are heated to moderate temperatures, perhaps as a byproduct of petroleum formation (Dozy, 1970; Macqueen, 1976). The warm, metal-rich brines migrate updip (fig. 2A) to structurally higher areas in a manner similar to petroleum migration. Deposits form when the brines encounter suitable traps (fig. 2B) and sources of reduced sulfur that cause precipitation of dissolved metals as sulfides. The most likely source of sulfur is H₂S-rich natural gas, but other sources could be oil shales, petroleum, coal, or syngenetic pyrite (Ohle, 1977).

Not all workers agree with this explanation (for example, Ohle, 1977), but it is plausible, and metal-rich subsurface brines do occur (Billings and others, 1969; Carpenter and others, 1974). This and other theories on the formation of Mississippi Valley-type deposits have been summarized by Bastin (1939), Brown (1967, 1970), White (1968), and many others.

If near-surface igneous sources are not needed to form deposits, as most workers will admit, and if brines formed in large sedimentary basins can cause mineralization, then Indiana possibly contains Mississippi Valley-type ores. It lies in the lead-zinc region of the central United States, and it has a structurally high area—the Cincinnati and Kankakee Arches—that trends diagonally across the state and separates two basins containing large volumes of Paleozoic carbonate rocks. Ore deposits occur along this arch in central Kentucky and central Tennessee and along a possibly related feature in northern Illinois. Indiana's proximity to known ore districts, the gross similarities of its geology to that of mineralized areas, and recent theories about the origin of Mississippi Valley-type ores make Indiana a favorable area for these deposits.

**Geologic Setting**

Indiana occupies about 36,290 square miles of the stable craton in North America, which according to King (1959) has undergone only minor tectonic activity. Unconsolidated glacial materials cover the bedrock in about five-sixths of the state (fig. 3). Bedrock consists of 3,000 to 14,000 feet of Paleozoic sedimentary rocks that fill the Michigan and Illinois Basins and drape over a basement high (fig. 4) that crosses Indiana from northwest to southeast (fig. 5). The structurally high area consists of two parts: the Kankakee Arch, which is a southeasterly extension of the Wisconsin Arch, and the Cincinnati Arch, which is the northwestern part of a structural feature that extends southward through Ohio, Kentucky, and Tennessee, where it is covered by rocks of the Mississippi Embayment. The two arches join near Logansport in northwestern Indiana along a structurally low feature that is marked on its northwest side by the Royal Center Fault (fig. 5).
Figure 2. Diagrams illustrating recent theory of origin of Mississippi Valley-type ores (A) and possible trapping structures for oil or ore fluids (from Carpenter and others, 1975) (B).
EXPLANATION

McLemore Group
Shale, sandstone, limestone, thin coals

Carbondale Group
Shale, sandstone, limestone, thick coals

Raccoon Creek Group
Sandstone, shale, clay, limestone, thin coals

West Baden, Stephensport, and Buffalo Willow Groups
Shale, sandstone, limestone

Blue River Group
Limestone, dolomite

Sanders Group
Limestone

Borden Group and Rockford Limestone
Shale, siltstone, limestone

Coldwater Shale
Gray shale

Eells and Sunbury Shales
Gray, green, and black shales

New Albany Shale
Black shale

Antrim Shale
Black shale

Muscatatuck Group
Limestone, dolomite

Silurian rocks
Limestone, dolomite, siltstone, shale

Maquoketa Group
Shale, limestone

Uppermost Cambrian and Lower and Middle Ordovician rocks
Dolomite, limestone, sandstone

Figure 3. Map of Indiana showing bedrock geology. Areas north of the indicated glacial boundaries are covered with drift.
Ore deposits occur along the Cincinnati Arch in Kentucky and Tennessee and along the Wisconsin Arch in the upper Mississippi Valley district. The arches are not anticlines that resulted from uplift but are areas that remained relatively stable as surrounding basins subsided. They form a broad, relatively flat area of about 10,000 square miles. Sedimentary rocks dip from the ill-defined crest of the arch into the basins at only 25 to 60 feet per mile, but dips steepen toward the center of the basins. Older rocks crop out along the arch area, and younger rocks are exposed in the basin areas (fig. 3).
Figure 5. Map of Indiana showing tectonic features and faults. Modified from Blakely and Varma (1976).
The Illinois Basin underlies about 20,000 square miles of Indiana and contains an estimated 108,000 cubic miles of rock (Bond and others, 1971). It is roughly spoon shaped, the deepest point lying about 14,000 feet below the surface in southeastern Illinois. The large structures in the Illinois part of the Illinois Basin and of interest to this study are: the north-southward-trending LaSalle Anticline in the eastern part; mafic igneous dikes in the southeastern part; and the Rough Creek Fault System in the southern part. The latter is a major fault system that has maximum displacements of more than 2,000 feet. It and a northeast-southwestward-trending fault system that extends into the Wabash River valley are closely connected with mineralization in southeastern Illinois. The Rough Creek Fault System can be tied in with other structural features across much of the eastern United States to form the 38th parallel lineament of Heyl (1972). Parts of this system and faults in the Wabash River valley affect southern Indiana. (See figs. 3 and 4.)

The Michigan Basin is roughly circular and contains about 108,000 cubic miles of sedimentary rocks; an estimated 47 percent are carbonate rocks, 23 percent sandstone, 18 percent shales, and 12 percent evaporites (Combs, 1971). Precambrian basement rock is estimated to lie 14,000 to 15,000 feet beneath the surface at the deepest point, which seems to have changed position through time but is presently near the center of Michigan (Ells, 1971). The basin contains northwestward-trending anticlines, some of which are faulted, structures related to buried reefs, and structures related to salt flowage or solution. Oil is produced in the basin, and ascending fluids that caused dolomitization are evident (Cohee, 1948). Shawe (1976) suggested that heated ascending fluids caused solution of limestone, dolomitization, and formation of minor sulfides in the Albion-Scipio Trend of Michigan. In Indiana the Michigan Basin is fringed by a large reef bank (fig. 11).

Major faults in Indiana are the Mt. Carmel, Fortville, and Royal Center Faults. The Mt. Carmel in south-central Indiana has been traced 55 miles. It is a normal fault and has a displacement of 80 to 175 feet, and its west side is down (Melhorn and Smith, 1959). Structures associated with this fault have produced gas. The Mt. Carmel Fault and smaller faults in Floyd (Harris, 1948) and Perry (Hughes, 1951) Counties appear at the surface. The Fortville Fault trends northeast-southwestward through parts of Madison and Marion Counties and has displacements of about 100 feet. A similar fault, the Royal Center, is in Cass, Marshall, and Kosciusko Counties. The latter two faults, whose traces at the bedrock surface are covered by glacial drift and were found by drilling, cut across the Cincinnati Arch. Some faults are known to occur in but not above the Trenton Limestone (Rooney, 1966), and a small but complexly faulted area occurs near Kentland in northwestern Indiana. This area, known as a cryptoexplosion feature, has been studied by Gutschick (1976) and Tudor (1971). It is 4 miles across, and the central part of this circular disturbed area contains rocks that have been uplifted more than 1,500 feet. It resembles such structures as those at Serpent Mound, Ohio, Flynn Creek, Tennessee, and Rose Dome, Kansas.

Sedimentologic evidence from facies changes in the Trenton, noted by Rooney (1966), seismic evidence by Woollard (1958), and interpretation of geophysical measurements by Henderson and Zeitz (1958) suggest that a hinge line runs across southern Indiana and connects the faulted and mineralized area in southeastern Illinois and the St. Lawrence River valley disturbances. According to Rooney, this hinge may somehow be connected with the Precambrian Grenville boundary postulated by Rudman and others (1965) to occur east of this general region. Possible hinge areas may also be marked by reef banks around the Michigan and Illinois Basins.

Structurally, Indiana appears suited to host ore. It contains a major positive area (Cincinnati and Kankakee Arches). Deep basins on either side of the arches contain thick sequences of potential source rocks that have been buried deeply enough to produce oil or gas and probably also warm mineralizing fluids. Faults occur that could transmit heated fluid upward, even from the Precambrian basement. Potential-ore traps are afforded by these and major unconformities.
Stratigraphy
Potential-ore host rocks occur throughout the stratigraphic section. General information concerning the extent, thickness, lithology, and features pertinent to their potential role as source or host rocks is summarized below for some rock units in Indiana.

The Paleozoic rocks in Indiana (fig. 6) consist mainly of shallow-water carbonate rocks, sandstones, shales, evaporites, and coal. The carbonate rocks are of main concern for this study because most Mississippi Valley ore deposits are hosted by dolomite or limestone. Organic-rich black shales, such as are found in the New Albany Shale, or coals of Pennsylvanian age have some potential for mineralization and should not be overlooked, but carbonate rocks are the mostly likely host rocks. Precambrian basement rocks generally lie too deep below the surface to be considered as reasonable exploration targets, but highs on the Precambrian surface may help channel ore fluids or localize ore.

PRECAMBRIAN
The Paleozoic sedimentary section rests unconformably on Precambrian basement rocks. Only about 20 wells have penetrated this basement, so only broad generalities are known about it. Kottlowski and Patton (1953) and Greenberg and Vitaliano (1962) have described Precambrian rocks of Indiana petrologically, and Rudman and others (1965) have summarized the general distribution of rock types. Bradbury and Atherton (1965) have described Precambrian rocks in Illinois, and Botoman (1975) and Owens (1967) have described those in Ohio. Rudman and others (1965, 1972) have summarized geophysical evidence of the basement rocks in the Midwest and Indiana, and Lidiak and others (1966) have reported isotopic ages obtained from basement rocks of the Midwest. These reports indicate that the basement consists of igneous and metasedimentary rocks about 1.1 to 1.3 billion years old. Igneous lithologies range from abundant granites to sparse basalt, and metamorphic lithologies consist mainly of marble and metasediments. Direct evidence for pronounced highs on the bedrock surface that could help localize ore is lacking, but these highs have been postulated.

Interpretations of the basement surface, based on geophysics and information from a few wells, must be very general (fig. 7), but they are valuable because ore tends to occur around high areas. Because of poor well control, only the broad general form of the Cincinnati Arch and the basins can be clearly proved, but geophysical evidence (Henderson and Zeitz, 1958) suggests several distinct topographic highs on the basement surface. But recent work by Rudman and others (1972) explains that geophysical anomalies are due to intrusives or flows of dense magnetically susceptible materials into lighter acidic rocks rather than to relief on the Precambrian surface. Basement scarps have been observed beneath structures in the sedimentary section, and the basic form of the Precambrian surface is assumed to be reflected by overlying sediments (Bond and others, 1971). Relief on the unconformity at the Precambrian surface should be expected. And although a figure of 1,600 feet of relief over about 45 miles in Ohio (Green, 1957) is suspect, well data indicate nearly 700 feet of relief in western Illinois (Bond and others, 1971).

CAMBRIAN AND CAMBRO-ORDOVICIAN
The first sedimentary unit that overlies the Precambrian crystalline rocks in Indiana is the Mount Simon Sandstone. It is medium- to coarse-grained poorly consolidated sandstone that ranges in thickness from 500 feet in southeastern Indiana to more than 2,000 feet in the northwest; the lower 300 to 400 feet of this unit is reddish because of high feldspar content. It is correlative with the Lamotte Sandstone of Missouri and is called the Mount Simon Sandstone in Illinois, Michigan, and Ohio. This unit probably does not contain ore; but it might act as a permeable bed for transmitting deep fluids from the center of the basin to the margin, and its feldspars might provide a source of metals.

Above the Mount Simon lies the Eau Claire Formation, which is mainly dolomitic sandstones, shales, and siltysl dolomites containing abundant glauconite grains. It thins eastward from more than 700 feet to 500 feet and correlates with the Franconia Formation or Galesville Sandstone of Illinois. The Eau Claire is a possible source for metal-bearing brines.

The Knox Dolomite of Cambro-Ordovician
age conformably overlies the Eau Claire. It contains an estimated 27 percent of the sedimentary rocks of Indiana and is correlative with ore-bearing rocks elsewhere in the Midwest. The Knox ranges from 500 to 1,500 feet in thickness and is composed mainly of gray, white, or tan finely crystalline dolomite, but in places it contains minor amounts of limestone and chert. A thick (400-foot) bed of clean quartz sand is contained within the Knox in southeastern Indiana (Patton and Dawson, 1969). The Knox thins northward because of depositional thinning and erosional truncation of younger beds (fig. 8). Considerable erosion occurred at the top of the Knox. Patton and Dawson (1969) presented evidence for petroleum accumulations in butte-like erosional remnants of the Knox Dolomite and pointed out excellent conditions for entrapment at the top of the Knox throughout most of central and eastern Indiana.

Gutstadt (1958) correlated Knox rocks with those as young as the Shakopee Dolomite or Prairie du Chien Group of Illinois and Cotter Dolomite of Missouri. He made no correlation with the Knox Group of Tennessee, but he considered that the Shakopee was lithologically similar to the top of a unit in Kentucky called by Freeman (1953) the Jefferson City-Cotter formation. He doubted that truncation was the sole cause of the Knox thinning northward and stated that the upper Knox equivalents are in central and eastern Indiana.

The Knox represents one of the best potential-ore hosts in Indiana because it is mineralized in the Midwest; it has an erosional unconformity at its top; it overlies and even has within itself permeable units; it is known to contain some oil; it has dolomite as the dominant lithology; and it contains a few small shows of sphalerite. It represents a reasonably shallow exploration target along the Cincinnati Arch and is only sparsely drilled in much of Indiana.

ORDOVICIAN

Unconformably atop the Knox lie rocks of the Chazyian Series that contain the St. Peter Sandstone and the Joachim Dolomite of the Ordovician System. The St. Peter is loosely consolidated fine- to medium-grained sandstones, and soft green shale occurs spottily at its base; the Joachim is a tan finely crystalline dolomite (Gutstadt, 1958). Both formations thin eastward and are absent in parts of eastern Indiana. The maximum thickness of the St. Peter is 135 feet, and that of the Joachim is about 70 feet. Although the Joachim may have some ore potential, it is rather thin; the St. Peter is an unlikely host but could have offered avenues for fluid movement.

Overlying the Joachim is a section of Middle Ordovician carbonate rocks—the Black River and Trenton Limestones. The Black River is brown lithographic to fine-grained limestone that has some dolomite or argillaceous units. It ranges in thickness from about 100 feet (fig. 9A) in the north, where it is dolomitized, to more than 600 feet in the southwest, where it is limestone with an argillaceous section at the base. Thin bentonitic shales in the upper part of the Black River may represent the Pencil Cave or Mudcave Bentonite of the Tyrone Limestone in Kentucky. Because of its fine grain size and low permeability, the Black River would not likely contain ore. But it is correlative with the Platteville Group of northern Illinois, an ore-bearing rock, and could be a host if fracturing or dissolution produced local areas of increased porosity or open spaces.

The Trenton Limestone (fig. 9B) ranges from 0 to about 225 feet in thickness (fig. 9C) and thins southward. It consists of tan fine- to medium-grained limestone, but it is extensively dolomitized (fig. 9D) in northern and especially northwestern Indiana. Many vugs with dolomite rhombs are present in dolomitized areas, and pyrite is common in the upper parts. These rocks hosted huge deposits of oil and gas in east-central Indiana, and many samples throughout northern Indiana show oil or bituminous residues. Evidence for a widespread unconformity at the top of the Trenton was given by Rooney (1966), who mentioned examples of drilling probably intersecting caves. This suggests that extensive solution and possibly karstification affected the Trenton. The Trenton has good ore-hosting potential because it is correlative with units that contain ore, it is known to have contained fluids capable of dolomitization, and it contains oil. Solution of upper parts of the Trenton probably occurred, and a relatively impermeable shale unit now overlies
this upper surface. The Trenton is correlative with the Galena Group of Wisconsin and Illinois.

The Trenton is covered by 200 to 1,000 feet of interbedded shales and limestones of the Maquoketa Group (Ordovician) that is a clastic wedge of rocks whose thickest area is to the east. Calcareous gray or brown shales make up most of this unit, and limestones are only about 20 percent. The limestones have been dolomitized in northwestern Indiana. Gutstadt (1958) and Gray (1972) have described the Maquoketa in detail. This formation shows little promise for ore, but it may have acted as a cap rock that impeded the flow of mineralizing solutions.

SILURIAN
Silurian rocks (fig. 10) unconformably overlie the Maquoketa and consist in ascending order of the thin basal (4- to 14-foot) limestone known as the Brassfield Limestone; the thick (90- to 200-foot) gray fine-grained unit called the Salamonie Dolomite; the thin (10- to 30-foot) argillaceous carbonate or shale called the Waldron Shale or Formation; 50 to 85 feet of mottled brown fine-grained to sublithographic carbonate rocks named the Louisville Limestone; 100 to more than 400 feet of the Huntington Lithofacies (reef facies) and the nonreef facies of the Wabash Formation; and thin (0 to 90 feet) fine-grained limestones or dolomites of the Salina Formation. Rocks of Silurian age are perhaps the most extensively studied rocks in Indiana. They have been studied by Pinsak and Shaver (1964), Shaver (1974a, 1976), Becker (1974), and many others. The Salamonie, the Huntington Lithofacies of the Wabash, and the Salina have some ore potential.

The Salamonie Dolomite is made up of light-gray fine-grained porous dolomite and dolomitic limestone. It contains beds of vuggy dolomite and is cherty in many areas. In southern Indiana it is subdivided into the Osgood and Laurel Members. The Salamonie of northern Indiana correlates with the gray and white rocks of the Niagara Group of Michigan or with the Joliet Dolomite of Illinois. The Salamonie has some potential to host ore because it contains permeable vuggy dolomite, especially in northern Indiana, it is bounded below by an unconformity in much of Indiana, and it is covered by impermeable shale.

Above the Waldron lies light-gray to brown fine-grained argillaceous dolomite or dolomitic limestone known as the Louisville Limestone. This unit is mottled and contains laminae of a black organic component. Reefs make up a significant part of the Wabash Formation. As previously mentioned, large barrierlike banks occur around the basins. Smaller individual reefs or reef complexes containing several reefs dot the state (fig. 11). Reef rocks are porous, and most of them are almost pure dolomite. They are assigned to the Huntington Lithofacies and are surrounded laterally mainly by fine-grained argillaceous and cherty carbonate rocks of the Mississinewa Shale Member and the Liston Creek Limestone Member. Reefs are valuable sources of dolomite aggregate in northern Indiana, and solution features are commonly observed in places where large sections are exposed in quarries. Several large specimens of sphalerite have been found in these exposures. Silurian reefs have a good potential for being mineralized because they are relatively porous and are surrounded by much less porous rock, many of them are composed of dolomite, many of them contain dead oil, and some of them show solution features below a major unconformity. Reefs host or are associated with Mississippi Valley-type deposits elsewhere, but Silurian rocks throughout the world rarely contain this type of deposit.

DEVONIAN
Overlying Silurian rocks are Lower and Middle Devonian (fig. 12) carbonate rocks. Lower Devonian formations are known to occur only in southwestern Indiana at depth. Becker (1974) noted that Lower Devonian rocks are mainly carbonate rocks or cherty carbonate rocks. Where Lower Devonian rocks are absent, carbonate rocks of the Muscatatuck Group unconformably overlie Silurian rocks.
Figure 6. Rock units in which minerals have been found and generalized stratigraphic column of Indiana showing major rock units mentioned in the text. Modified from Shaver and others (1970).
Figure 7. Maps of Indiana showing generalized contours on the Precambrian surface inferred from geophysical measurements (from Henderson and Zeitz, 1958) (A) and structure contours on the Precambrian surface and elevations of Precambrian rocks in wells (modified from Bond and others, 1971; Becker and others, 1978) (B).
EXPLANATION

-3176
Well location showing elevation at Precambrian surface

-4,000
Structure contour on Precambrian surface
Contour interval 1000 ft.
500 ft auxiliary contours are shown with dashed lines.
Datum is mean sea level

Fault
Hachures on downthrown side
(from Dawson, 1971)

Figure 7—Continued
Figure 8. Maps of Indiana showing structure contours on top of the Knox Dolomite (modified from Bond and others, 1971) (A) and thickness of the Knox Dolomite in Indiana (from Bond and others, 1971; Dawson, 1960; and Gutstadt, 1958) (B).
EXPLANATION

Isopach contour showing thickness of Knox Dolomite
Contour interval 500 ft.
250 ft auxiliary contours are shown with dashed lines.

Figure 8—Continued
The Muscatatuck Group (Shaver, 1974b) contains Middle Devonian carbonate rocks that are assigned to the Jeffersonville Limestone and the overlying North Vernon Limestone in areas southwest of the Cincinnati Arch or to the Detroit River Formation and the Traverse Formation in the area north of the arch. Becker (1974) has described Devonian rocks southwest of the arch; Doheny and others (1975) have reported on the Detroit River, and Droste and Shaver (1975) and Lazor (1971) have studied the Traverse Formation of northern Indiana.

The basal Devonian rocks in central Indiana are assigned to the Geneva Dolomite Member of the Jeffersonville Limestone. The Geneva ranges from 0 to 60 feet in thickness in central Indiana but does not occur everywhere in the state. It consists of buff to brown granular dolomite that commonly contains vugs, carbonaceous laminae, crystalline calcite, and, in west-central Indiana, rounded frosted quartz. This member has potential as an ore host but is rather thin.

South of the Cincinnati Arch the Jeffersonville Limestone overlies Lower Devonian carbonate rocks or Silurian rocks. It thickens southwestward from 25 to about 150 feet. The Detroit River makes up the lower part of the Muscatatuck Group and overlaps various Silurian units in the area north of the arch. The Jeffersonville is made up of fine- to medium-grained light-brownish limestones that are sandy, dolomitic, or cherty in places. It thickens southwestward from 25 feet on the outcrop to 150 feet in southwestern Indiana. The Detroit River Formation contains dolomites and evaporites of sabkha origin, porous replacement-type dolomite, and lithographic limestones (Doheny and others, 1975). It thickens northward from the arch from 0 to 160 feet. These units correlate with the Grand Tower Limestone of Illinois.

The North Vernon Limestone, which contains 1 to 80 feet of variable carbonate rocks in southwestern Indiana, and the Traverse Formation, which consists of 0 to more than 100 feet of fine to coarse limestones and dolomitic limestones in the north, complete the Muscatatuck Group.

Rocks of the Muscatatuck Group have fair potential for mineralization, especially in the north where breccias are noted in the Traverse Formation or where solution of evaporites in the Detroit River Formation might produce open spaces or breccias and in the south where the vuggy dolomitic Geneva Dolomite Member of the Jeffersonville Limestone is present.

The top of the Devonian section is represented by black organic-rich shales of the New Albany Shale. The upper part of the New Albany is Early Mississippian in age. It is separated from a thick sequence of shales and siltstones of the overlying Borden Group (Mississippian) by the thin Rockford Limestone. None of these units are likely to be suitable hosts, although local syngenetic metal enrichment could occur in sulfide-rich parts of the New Albany Shale, which might also contribute metals or sulfur.
Figure 10. Map of Indiana showing thickness and outcrop of Silurian rocks. Modified from Becker (1974).