# MINERALS OF INDIANA

*by*

RICHARD C. ERD AND SEYMOUR S. GREENBERG

Indiana Department of Conservation
GEOLOGICAL SURVEY
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# MINERALS OF INDIANA

BY RICHARD C. ERD[1] AND SEYMOUR S. GREENBERG

## ABSTRACT

Undisturbed Paleozoic sediments form the bedrock surface of Indiana. The most common minerals in these sediments are calcite, clay minerals, dolomite, glauconite, goethite, gypsum, hematite, limonite (hydrous iron oxides), quartz, and siderite. Found less abundantly are anhydrite, apatite, aragonite, barite, celestite, copiapite, epsomite, fluorite, marcasite, melanterite, millerite, pyrite, pyrrhotite, smythite, sphalerite, strontianite, sulfur, and wad. These minerals occur in veins and cavities; along bedding, joint, and fracture surfaces and stylolite seams; and In geodes in limestones. Reported and observed locations and modes of occurrence are presented for each of the minerals except most clay minerals. The more unusual minerals that occur in glacial materials of Indiana, native copper, diamond, galena, native gold, and native silver, are described in detail.

A literature study was the basis for a brief discussion of the history of Indiana minerals. The present report questions the reported occurrences in Indiana of native bismuth, graphite, malachite, moissanite, nitromagnesite, and stibnite.

## INTRODUCTION

### PURPOSE AND SCOPE

This work was undertaken to study and describe the minerals of Indiana and to list the localities at which they have been found. Clay minerals (except allophane and halloysite), soils, detrital minerals, and minerals found in glacial materials (except the more unusual varieties) are not included in this study. The minerals and mineraloids mentioned in this report are listed in the index.

We have sought to include all previous references to Indiana's minerals and have indicated those entries that are doubtful and those entries for which we were unable to confirm a reported occurrence. About 8 weeks of the summer of 1950 were spent field checking localities in 37 counties (fig. 1). There are very few outcrops of bedrock in the most northerly part of the State. Most of the active and many abandoned crushed limestone quarries, a few coal strip mines, and road and railroad cuts were examined, but no search for outcrops was made. Laboratory studies of much of the material collected have been made. Only an imperfect picture of Indiana's minerals can be presented at this time. Additional minerals and new localities and modes of occurrence will undoubtedly be found in Indiana by future workers.

[1] U. S. Geological Survey, Menlo Park, Calif.

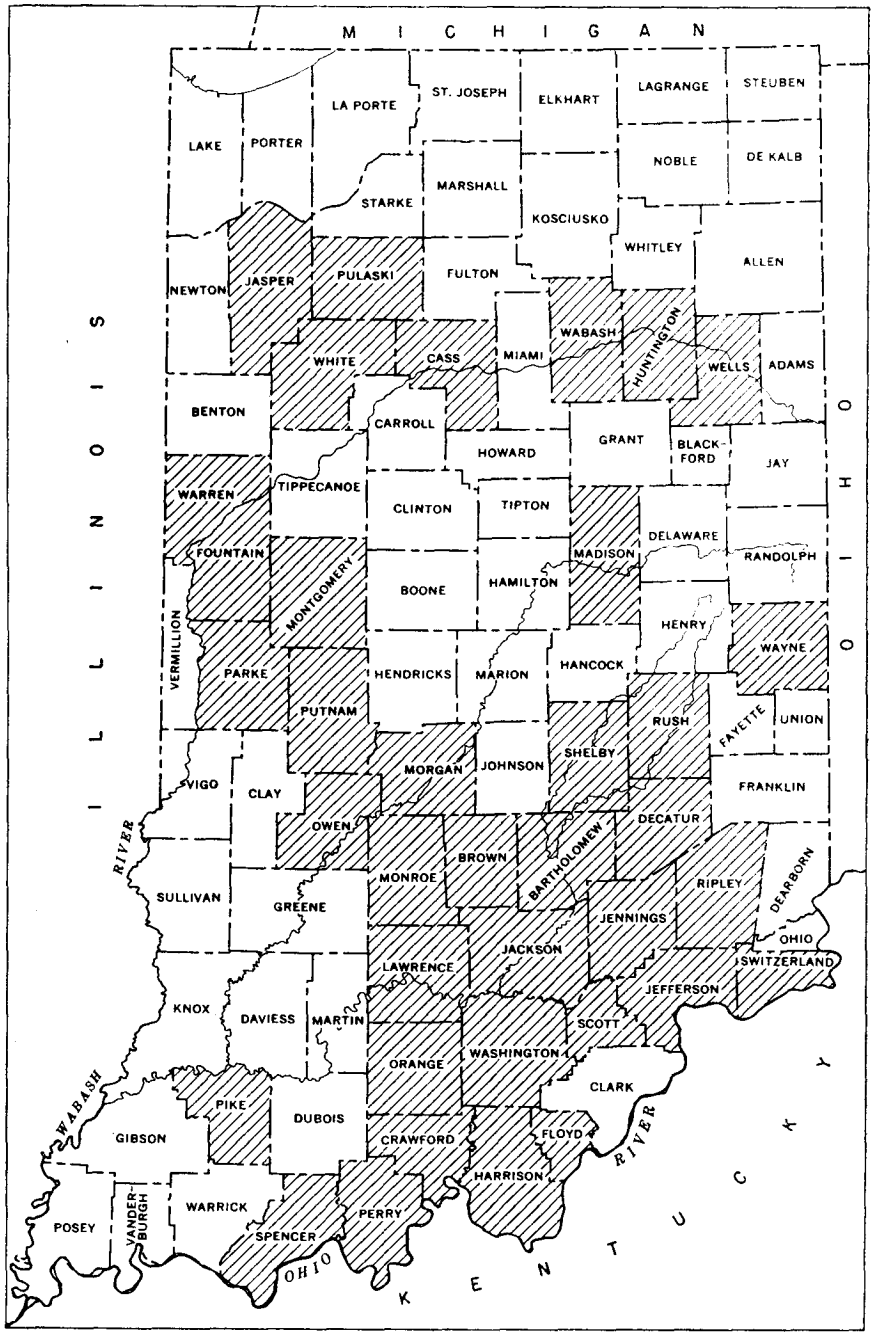


Figure 1.-Map of Indiana showing counties. A field check was made in the counties that are shaded.

ACKNOWLEDGMENTS

We wish to thank Dr. Charles A. Deppe, of Franklin College, for showing the S. S. Gorby Collection, which is housed there; Mr. W. B. Reeves, of Greencastle, for letting us examine a collection of geodes from Big Walnut Creek, Putnam County; and many quarry operators for granting us permission to examine their quarries.

## HISTORY

Within historic time the Indians were the first to be interested in minerals in Indiana. Colonel George Croghan, who wrote one of the earliest accounts of the land which is now Indiana, was captured by a band of Kickapoo Indians in 1765 near the mouth of the Wabash River and was taken by them up the Wabash, past Port Vincent (Vincennes), to the Vermillion River. Here he observed occurrences of red ocher of iron from which the river took its name, and which was used by the Indians in that vicinity to paint themselves. Farther up the Wabash at Fort Ouitanon, near the present city of Lafayette (there is confusion as to the exact location), Colonel Croghan noted (1831, p. 267) : "On the south side of the Ouabache runs a high bank, in which are several fine coal mines,...." These coals probably had been utilized by the nearby French settlers, but conceivably the Indians made use of them as a pigment.

Another early American explorer, Henry R. Schoolcraft, said (1825, p. 111-112) of the Indians

> Among the males we observed many to have their leggings, and shot pouches, garnished with a kind of rude copper bell, of a conical form; made by beating out masses of native copper, which they occasionally find on the upper parts of the Wabash.

Presumably the Indians also imported some copper from the Lake Superior copper mines, which had been worked by them even before the discovery of America. References to copper artifacts are many (see Copper, p. 24) ; a good account is given by Hoy (1886).

The Indians knew of and used Wyandotte Cave in Crawford County (4).[2] Ball (1941, p. 39) summarized the various accounts as follows:

> The Indians found that Wyandotte Cave, Crawford County, Ind., contained two desirable products, a jaspery flint and stalactites of satin spar. They car-

[2]Localities are given by the name of the county followed by a number in parentheses. This number refers to the list of localities (p. 53).

ried on mining a full mile within the cave, lighting their labor with flaming torches. From the lenses of flint protruding from the limestone walls they hacked flint flakes, with granite hammers, and also cut from a giant stalactite some 1,000 cubic feet of glistening alabaster. The imprints of their mocassins were still visible on the floor of the cave 80 years ago. They also dug down from the surface in one place until the cave formation was encountered and mined alabaster open cut. Deer antlers were used as picks in this work.

Ball further related (1941, p. 46) that fluorite, picked up from outcrops in southern Illinois, was used as ornamental stone by the Indians of Indiana; in addition, they made use of aragonite, calcite, gypsum, hematite, marcasite, mica, pyrite, quartz, and galena. Their use of galena, which they found in the glacial materials or acquired by trade from outside the State, led early settlers to believe that the Indians knew of secret lead and silver mines in Indiana. Many futile attempts were made to locate these mines.

Reports of lead (see Galena, p. 29) and other metal deposits were investigated and discredited by the geologists first commissioned by the young State to survey the various counties. The most notable among these were the brothers David Dale Owen and Richard Owen, E. T. Cox, and John Collett. Many other professional and amateur geologists made valuable contributions; two of the latter, W. B. Stilson (1818) and J. T. Plummer (1843), gave useful accounts of the minerals which they found in certain parts of the State. Brown (1817, p. 62, 65, and 80) mentioned several minerals that the pioneer settlers might expect to find in the new State of Indiana.

## GEOLOGIC SETTING

Sediments of late Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian ages form the bedrock surface of Indiana. Their general distribution is shown on the geologic map (fig. 2), and their stratigraphic position is shown in table 1. A mantle of unconsolidated glacial drift and later gravels, sands, and muds covers approximately three-fourths of the State (fig. 2). This mantle may be as much as 550 feet thick.

The southeastern part of Indiana lies on the Cincinnati Arch, and another positive area extends across northern Indiana. To the west and southwest of these structural highs the rocks dip gently and thicken southwestward into the Illinois Basin. North of the positive area in the northern part of the State the rocks dip northward into the Michigan Basin. A few minor faults are present. The largest and most important is the Mt. Carmel Fault,

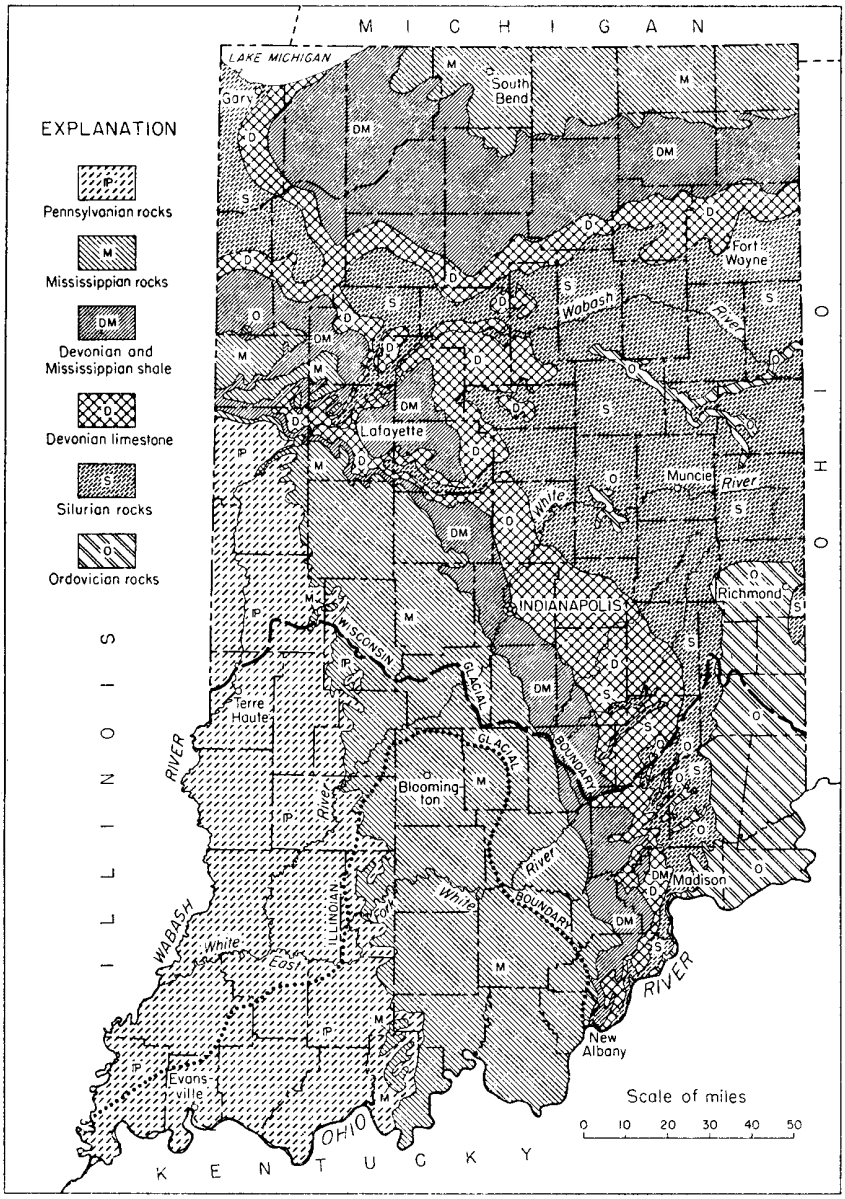


Figure 2.-Generalized geologic map of Indiana. From Patton, 1955, fig. 1.

which extends for about 50 miles along the east flank of the Illinois Basin. A small but strong structural anomaly is found near

| System | Series | Group | Formation | Member |
|---|---|---|---|---|
| Pennsylvanian | Allegheny | | Dugger Formation | Coal VI |
| | | | | |
| | | | Linton Formation | Coal IV |
| | | | Staunton Formation | Coal III |
| | Pottsville | | | |
| | | | Mansfield Formation | |
| Mississippian | Chester | | | |
| | | | Tar Springs Formation | |
| | | | Glen Dean Limestone | |
| | | | | |
| | | | Big Clifty Formation | |
| | | | Beech Creek Limestone | |
| | | | Elwren Formation | |
| | | | Reelsville Limestone | |
| | | | Sample Formation | |
| | | | Beaver Bend Limestone | |
| | | | Bethel Formation | |
| | | | Paoli Limestone | |
| | | | Aux Vases Formation | |
| | Meramec | | Ste. Genevieve Limestone | Levias |
| | | | | Rosiclare |
| | | | St. Louis Limestone | |
| | | | Salem Limestone | |
| | | | Harrodsburg Limestone | |
| | Osage | Borden | | |
| | | | Edwardsville Formation | |
| | | | Floyds Knob Formation | |
| | | | Carwood Formation | |
| | | | Locust Point Formation | |
| | | | New Providence Shale | |
| | Kinderhook | | Rockford Limestone | |
| | | | New Albany Shale (upper part) | |
| Devonian | Bradfordian | | New Albany Shale (lower part) | |
| | Erian | | North Vernon Limestone | Beechwood |
| | | | | Silver Creek |
| | Ulsterian | | Jeffersonville Limestone | |
| | | | | |
| | | | Geneva Dolomite | |
| | | | Kenneth Limestone | |
| Silurian | Cayugan | | Kokomo Limestone | |
| | Niagaran | | Huntington Dolomite | |
| | | | Liston Creek Limestone | |
| | | | Mississinewa Shale | |
| | | | Louisville Limestone —?— | |
| | | | | |
| | | | Laurel Limestone | |
| | | | Osgood Formation | |
| | Albion | | Brassfield Limestone | |
| Ordovician | Cincinnatian | Richmond | Elkhorn Formation | |
| | | | Whitewater Formation | |
| | | | Saluda Limestone | |

Kentland in southern Newton County. Here middle Ordovician limestones and dolomites have been folded, broken, and elevated to the surface probably by a deep-seated disturbance in the earth's crust.

No igneous or metamorphic rocks have been found in the Paleozoic bedrock of Indiana. Igneous and metamorphic rocks have been penetrated in deep wells drilled into the Precambrian basement rocks (Kottlowski and Patton, 1953). The Precambrian rocks identified were hornblende micrographic granite, dolomitic marble, siliceous argillite, augite andesite microporphyry, quartzite, and slate.

The nearest igneous rocks are post-Pennsylvanian mica peridotite dikes found in the Illinois-Kentucky area associated with the Shawneetown-Rough Creek Fault Zone. Dikes of a similar character have been found in Kansas and southwestern Pennsylvania.

Evidence of hydrothermal activity in Indiana has not been observed. Shrock and Malott (1933, p. 369) stated that no traces of hydrothermal alteration have ever been seen at the Kentland structure, and Logan (1922a, p. 840) concluded that the slight mineralization which was found along the surface of the Mt. Carmel fault plane was due to the action of ground water. Callaghan, however, stated (1948, p. 39) that the hydrated halloysite at Gardner Mine Ridge (see p. 36) conceivably could have been formed through the action of hydrothermal solutions.

## OCCURRENCE AND DISTRIBUTION

The most common Indiana minerals are those which might be expected in undisturbed sedimentary rocks: calcite, clay minerals, dolomite, glauconite, goethite, gypsum, hematite, limonite, quartz, and siderite. Most of the more unusual minerals are found in the lower part of the Harrodsburg Limestone and to a less extent in the upper part of the underlying Edwardsville Formation. This stratigraphic unit is at the top of the Osage Series (the top of the lower part of the Mississippian System). The lower part of the Harrodsburg Limestone is a thin-bedded argillaceous locally arenaceous limestone containing in some places abundant quartz geodes. The greatest variety of minerals occurs in these geodes.

Other notably mineralized formations are the Ordovician Elkhorn Formation, the Silurian Brassfield and Liston Creek Limestones, the Devonian Geneva Dolomite and Jeffersonville Limestone, and the Mississippian St. Louis and Ste. Genevieve Lime-

stones. The minerals occur in veins and cavities ; along bedding, joint, and fracture surfaces and stylolite seams; and in geodes in limestones and dolomitic limestones and, to a less extent, in dolomites. In shales most of the mineralization is found in concretions. Other minerals have been deposited by the evaporation of water as efflorescences on sheltered outcrops or as "formations" in caves.

## DESCRIPTION OF INDIVIDUAL MINERALS

### ALLOPHANE

$xAl_2O_3?ySiO_2?zH_2O$

Although allophane is not uncommon, few occurrences have been reported from Indiana. Thompson (1886, p. 38) said ". . . Professor Gorby, while surveying the 'flint beds' of Tippecanoe County, found a coarse, greenish-blue allophane associated with other silicious deposits there." A specimen labeled "allophane" from the "Niagara" near Delphi, Carroll County, is in the S. S. Gorby Collection at Franklin College. This may be the material referred to by Thompson. He also mentioned (1889, p. 38) that allophane occurs in the glacial materials associated with "chalk."

The most extensive occurrence of allophane is in the Gardner Mine Ridge deposit of halloysite in Lawrence County (p. 36). Ross and Kerr (1934, p. 137) noted that some of the allophane at this deposit contained 7.15 percent $P_2O_5$, and they suggested (1934, p. 147) that this allophane be called allophane-evansite. At Gardner Mine Ridge allophane and allophane-evansite are associated with halloysite at the base of the Mansfield Formation (Ross and Kerr, 1934; Callaghan, 1948, p. 17-18). A detailed study of the properties of allophane from this deposit was made by White (1953). Crandallite, which was formed from the allophane-evansite, is intimately associated with some of the allophane at Gardner Mine Ridge (Greenberg and Elberty, 1958). Callaghan (1948, p. 34) in describing an X-ray trace of allophane said that "the X-ray pattern suggests a material having the structure of jarosite or natro-alunite but might possibly be a crystalline phosphate mineral such as pseudowavellite." Crandallite and pseudowavellite can be considered a single species (Palache, Berman, and Frondel, 1951, p. 837).

Allophane was found by John B. Patton (1950, oral communication) in the Ralph Rogers Co. quarry at Springville in Lawrence

County (1). The analysis of this allophane that was made by Maynard E. Coller in the Geochemistry Laboratory of the Indiana Geological Survey is given below:

| | *Percent* |
|---|---|
| $SiO_2$ | 10.7 |
| $Al_2O_3$ | 37.2 |
| Ignition loss | 51.6 |
| | ----- |
| | 99.5 |

The refractive index of this allophane was 1.476.

## ANHYDRITE
$CaSO_4$

Anhydrite is apparently rare in the surface rocks of Indiana. Small amounts of bluish-white anhydrite are associated with fine-grained gypsum and euhedral selenite in pockets in the Harrodsburg Limestone in Lawrence County (8). The anhydrite from this locality possesses a weak to moderate pink fluorescence, which is not observed in the associated gypsum. Anhydrite also is found as inclusions in quartz in the Harrodsburg geodes.

Subsurface studies by McGregor (1954) show that anhydrite is found in the lower part of the St. Louis Limestone in southwestern Indiana. Bundy (1956b) described the petrology of these anhydrite deposits.

## APATITE
$Ca_5 (PO_4)_3 (OH,F,C1)$

Collophane probably is the most common variety of apatite in Indiana. A specimen of collophane from Cass County (1) is isotropic and has a refractive index of 1.615. A massive anisotropic apatite, which has wavy extinction and recognizable organic structures, is commonly associated with the collophane. A specimen of this anisotropic variety from Cass County (1) has refractive indices of 1.625 ($\omega$) and 1.620 ($\epsilon$). The latter material probably is carbonatian fluorapatite, but its exact position in the apatite group is not known. Fluorapatite has been reported from Indiana only as rare minute inclusions in quartz grains in the Mansfield Formation (Hopkins, 1896, p. 201). Collophane occurs as small pebbles or nodules associated almost invariably with glauconite and usually with pyrite, quartz, and calcite.

Apatite is found in upper Ordovician limestone (Elkhorn Formation) in Wayne County (1). Dawson (1941, p. 7) reported

that it lies at or near the base of the Beechwood Member of the North Vernon Limestone, which rests unconformably upon the Silver Creek Member. A specimen in the mineral collections of Indiana University came from near the top of the Silver Creek Member; this specimen contains large phosphate nodules. Campbell (1946, p. 837-838, 847-849) mentioned that jet-black phosphorite and pebbles ranging from half an inch in diameter to several inches long in elongated flattened forms had been found in the lower part of the New Albany Shale. In the Devonian rocks of northern Indiana, phosphate pebbles occur in a glauconitic calcareous sandstone in Cass County (1). At this locality the phosphate pebble-glauconite layer probably is near the Silurian (Kokomo Limestone) -Devonian (Jeffersonville Limestone?) disconformity (Cumings and Shrock, 1928, p. 124; Patton, 1949, p. 14, 16-17).

A glauconitic pebble conglomerate, which is several inches thick, and which contains pebbles and fragments of bone phosphate (including good specimens of shark teeth), occurs near the Edwardsville-Harrodsburg contact in Monroe County (6). Malott (1952, p. 71) mentioned that small phosphatic nodules had been found in a Chester sandstone (Big Clifty Formation) in the Arthur quarry near Newark, Greene County.

Apatite has been found in Bartholomew (1), Cass (1), Jennings (1), Monroe (6), and Wayne (1) Counties.

## ARAGONITE
## $CaCO_3$

Most of the aragonite that was collected showed a medium to intense yellow or yellowish-white fluorescence and a greenish-yellow phosphorescence under short-wave ultraviolet radiation. Particularly strong responses were displayed by aragonite from Monroe (18) and Washington (9) Counties.

Aragonite has been found in association with calcite, dolomite, hydromagnesite, siderite, marcasite, pyrite, gypsum, barite, and celestite. Aragonite is much less commonly found than calcite and is most abundant in cave deposits. The famous large "Pillar of the Constitution" of Wyandotte Cave is composed chiefly of aragonite (Farrington, 1901). Together with calcite aragonite forms the pendulous stalactites, or it may occur as powdery or fibrous crusts on the roofs of caves. Aragonite is found with hydromagnesite in this kind of crust on the roof of Marengo Cave in Crawford County (1). Some of the calcareous tufa formed on the

banks of the Wabash River (see Calcite, p. 20) may be aragonite in part.

Aragonite is less commonly found in solution cavities or on joint surfaces in limestones and also in quartz geodes. Fix (1939) mentioned that aragonite occurs with mammillary calcite above the geode zone in a Harrodsburg Limestone quarry in Monroe County (10). We were unable to confirm this occurrence, but we did find abundant strontianite at the locality mentioned. A rather unusual occurrence of aragonite is in the pearls of clams which are occasionally found in the Ohio, Wabash, and White Rivers and in other rivers of Indiana. Logan (1922a, p. 1057) stated that some of these pearls are reported to have sold for more than a hundred dollars.

Aragonite has been found in Brown (1), Crawford (1), Harrison (3), Monroe (5, 10, and 18), Montgomery (3), Perry (1), and Washington (9) Counties.

## ASPHALT
(Hydrocarbon compounds)

Asphalt is not a definite mineral species, but rather it is a complex mixture of hydrocarbon compounds that is closely associated with certain minerals. The more liquid varieties have a bright greenish-yellow fluorescence, but jet-black solid asphalt that we tested did not fluoresce with a short-wave (2537 A) ultraviolet lamp.

The pasty viscid variety of asphalt known as maltha is found commonly in cavities in the Jeffersonville Limestone and was noticed especially in Bartholomew County (1), where it was found in pockets lined with calcite and fluorite. It also was noted in a slightly more solid form at or near this horizon in Cass County (1). A glossy, black, hard asphalt with a splintery to conchoidal fracture is found in several places in the St. Louis and Ste. Genevieve Limestones. Here it occurs as disseminated particles in chert and is associated with dark-purple fluorite, calcite, pyrite, and (in Lawrence County (2)) millerite. Traces of asphalt are present in geodes in Lawrence County (7).

Asphalt was first noted in Indiana by Plummer (1843, p. 298) in pockets in the "cliff limestone" (Niagaran?) of Wayne County. Collett (1872a, p. 299, 302, 306, 313) mentioned various occurrences, mostly in Devonian rocks, in Jasper, White, Carroll, and Cass Counties and (1874b, p. 340) an occurrence in Knox County. Collett also described (1879, p. 445) the "Tar Springs" near Sul-

phur, Crawford County, which discharge small quantities of asphalt with water; this locality was also mentioned by Blatchley (1903a, p. 40). Some occurrences in Gibson County were described by Fuller and Clapp (1904, p. 9) as follows:

> During the drilling of a well by the Interstate Gas and Oil Company at Princeton, in 1902, a 5-foot bed of asphalt was reported at a depth of about 500 feet, or a little over 100 feet below the Petersburg coal. Small samples of the material brought cut by the bailer showed the asphalt to be a Jet black, nearly pure variety closely resembling Trinidad asphalt in its reactions to physical and chemical tests. A small bed of similar material is reported to have been encountered in the Old Hall well, on the southwest outskirts of Princeton, about a mile south of the new well, while in the Oswald mine, three-fourths of a mile to the west, a black substance, known as liquid asphalt, seeps into the bottom of the mine at 430 feet to such an extent that some of the rooms have been abandoned and closed. It is said to enter through a nearly vertical "break" filled with clay.

R. S. Blatchley (1907) also mentioned these occurrences in his description of the Princeton Oil Field.

Asphalt has been found in Bartholomew (1), Carroll, Cass (1), Crawford, Gibson, Harrison (2), Jasper, Knox, Lawrence (2, 7, and 13), Monroe (9), Putnam (6), Wayne, and White Counties.

## BARITE
## $BaSO_4$

Barite in Indiana occurs in limestones and shales of Ordovician to Pennsylvanian age. It has been found in association with quartz, limonite, calcite, dolomite, pyrite, sphalerite, and strontianite, but not, however, in close association with celestite. Pyrite, marcasite, millerite, goethite, and gas (or liquid) inclusions are present in most barite from Indiana. Pyrrhotite (or smythite?) was found as inclusions in barite from Monroe (19) and Jackson (1) Counties in geodes in the Harrodsburg Limestone. In the upper Ordovician and lower Silurian rocks of southeastern Indiana barite commonly is colored pink to rose red by minute inclusions of goethite?. Barite from Wayne County (1) fluoresced with a moderately strong pink color under a 2537 A wave length ultraviolet lamp; no fluorescence was noted in other specimens.

Barite occurs in mineralized corals (*Columnaria alveolata*) and stromatoporoids in the upper Ordovician (Saluda Limestone and Whitewater and Elkhorn Formations) and in vugs and cavities in these same Ordovician units and in the Brassfield Limestone. It was noted as a trace constituent in insoluble residues of Niagaran rocks of southeastern Indiana by Priddy (1939, p. 495). One oc-

currence (in Jennings County (1)) has been observed in rocks of the Devonian System. Barite in Mississippian rocks is found in geodes (Edwardsville Formation and Harrodsburg Limestone), in vugs and cavities (St. Louis, Ste. Genevieve, and Paoli Limestones), and, as the fibrous variety, in thin seams in shales (Edwardsville Formation and the shale above the Beaver Bend Limestone). It partially cements some of the Chester sandstones (McCartney, 1931). In the Pennsylvanian shales and Quaternary gravels barite fills cracks in limonite concretions; similar material was found by Plummer (1843, p. 305) in the glacial drift. The largest specimen of barite collected in Indiana is a nodular mass of dense white platy barite, 10 centimeters in diameter, collected by C. A. Malott in 1940 from the top of the Paoli Limestone 0.5 mile west of Hendricksville, Greene County.

Barite was observed in Indiana near Richmond, Wayne County, as early as 1843 by Plummer (p. 283). Richard Owen (1862, p. 54) mentioned the occurrence of barite associated with galena near Rising Sun, Ohio County, but this occurrence has not been confirmed. Collett (1874c, p. 295) reported the following occurrence in Lawrence County

> Near the palatial residence of Barton Williams In the southwest corner of Indian Creek township, occurs a typical bed of "pebbly conglomerate," and a stratum of fibrous spar having a faint tinge of blue color: the latter has apparently the specific gravity of "heavy spar" (Barytes), but the structure, color, etc., is that of Celestine (sulphate of Strontia). For determination I refer to the Chemist's report.

The chemist's report could not be found, but the material referred to is probably barite (not celestite). Barite occurs above the Beaver Bend Limestone in shales low in the Chester Series in Lawrence County (13).

Barite has been found in Decatur (1), Jackson (1 and 2), Jefferson (1), Jennings (1), Lawrence (2, 3, 4, 7, 10, and 13), Monroe (1, 3, 5, 6, 7, 10, 12, 13, 17, 18, and 19), Montgomery (1 and 3), Morgan (1), Orange (1), Owen (4), Parke (1), Perry (2), Putnam (1 and 3). Ripley (1), Switzerland (1), Warren (1), Washington (1, 4, and 10), and Wayne (1 and 2) Counties. The occurrence in Decatur County was reported by Grossman (1942) ; in Monroe County (10) by Fix (1939) ; and in Putnam County (3) by Reeves (1950).

## CALCITE
## $CaCO_3$

Commonly observed habits of calcite from Indiana are obtuse to acute rhombohedral, cuboid, scalenohedral, and tabular. Large crystals (some over a foot long) having a dipyramidal habit and displaying prominently the form {8 8 $\bar{16}$ 3) occur in Cass County (1). Crystals that are almost as transparent as Iceland spar are found on dolomite in quartz geodes in Monroe County (10). Nailhead spar (parallel growths of flat rhombohedral crystals) is commonly found, especially in Monroe County (5). Two generations of calcite may be found as a crystal within a crystal. The earlier and usually more acute crystal of many calcite crystals is made apparent by inclusions of hydrocarbon compounds or iron sulfides near the outer surface of the earlier crystal or on the interface between the crystals. Many of these interfaces contain solution effects. Commonly the later crystal has a blunter habit and is more transparent than the earlier crystal.

In Cass County (1) some of the calcite crystals are colored black to dark green by platy dendritic growths of included marcasite (Smith and Schroeder, 1929). Other occurrences of black calcite are in Madison County (1) ; at the Newton County Stone Co. quarry near Kentland, Newton County; and near Pekin, Washington County (Professor Ralph E. Esarey, oral communication, 1950). Manganese, iron, magnesium, and zinc were detected microchemically in salmon-pink calcite from Monroe County (5). A spectrochemical analysis (by R. K. Leininger of the Indiana Geological Survey) of yellow calcite, associated with celestite and gypsum, from Lawrence County (8) showed that magnesium and minor manganese were present. (Al, Ba, Si, and Sr were sought for but were not detected.)

Almost all calcite fluoresced with a medium to strong response when it was examined with a short-wave (2537 Å) ultraviolet light. Pink, red, and yellow were the colors exhibited most frequently ; in some specimens several colors were present in the same specimen, and thus zoning, which was not otherwise apparent, was displayed. Weak greenish yellow phosphorescence was observed in the calcite examined.

Marcasite, pyrite, pyrrhotite, smythite, millerite, quartz, barite, and fluorite have been found as inclusions in calcite from Indiana. Calcite is associated with most minerals found in the State. It

occurs abundantly in rocks of all ages and types in Indiana. As limestone, limy shale, and limy dolomite it constitutes a large part of the sedimentary sequence in the State; in some sandstones it forms the cement. In some coals it occurs as concretions or lines joint cracks.

Lapham (1828, p. 69) noted calcite in rocks of the Borden Group at New Albany, Floyd County. This occurrence was later mentioned by Dana (1844, p. 548) and Anonymous (1950, p. 273). "Fine rhomboidal" crystals were seen in Jefferson County (1) by David Dale Owen (1838, p. 16). Borden (1875a, p. 154) described outcrops along Graham Creek in Jennings County 4 miles north of Dupont as ". . . nests, of talc spar crystals, a yard in width, and [which] afford some good cabinet specimens." Large crystals are found in some of the Silurian bioherms, such as one at Rich Valley in Wabash County (1). Large crystals and isolated masses of calcite are found in the Geneva Dolomite. Dawson (1941, p. 24) suggested that many of "these 'calcite separations' occurring in the Geneva are due to extreme over-calcification of fossils." Some euhedra have been noted in overcalcified *Bellerophon sp.* in Lawrence County (5). Probably the best specimens of calcite can be found in Monroe County (10) ; the locality has been described extensively by Fix (1939).

The large crystals and massive varieties of calcite found in caves of Indiana have been admired from the time of the Indians to that of present-day visitors. Blatchley (1897, p. 131), describing Coon's Cave, about 8 miles southwest of Bloomington, Monroe County, wrote: "For two or three feet above the waterline the walls of this room are covered with small but most beautiful crystals of calcite, which reflected the light of our candles in a most brilliant manner." Farrington (1901, p. 265), who visited the same cave (but called it Coan's Cave), reported that:

> The calcite crystals which line the walls of the pool are made up of the unit rhombohedron *r* (1011) and the unit prism of the first order *m* (1010). The crystals have all grown in a direction at right angles to the plane of their attachment. The prism Is quite short, and no crystals are doubly terminated. The crystals vary in size from quite minute to those the size of an ordinary acorn. It is noticeable that they Increase in size toward the bottom of the pool. . . . In this part of the cave stalactites and stalagmites of the ordinary type appear in close association with the crystal deposits just described. The formations have a similar origin in that they are both deposits of carbonate of lime from solution in water. They differ only In the condition that in the making of stalactites and stalagmites the water was moving, while in the making of crystals it was standing still.

Wyandotte Cave in Crawford County (4) also attracted the attention of Farrington (1901), who found that the helictites in the cave are composed of calcite. McGrain (1942) described the helictites from the "New Discovery" at Wyandotte Cave.

Deposits of tufa (a spongy porous rock composed of calcite) along the Wabash River and on Deer Creek in Carroll and Tippecanoe Counties were described by Schoolcraft (1824, p. 47; 1825, p. 117-118), D. D. Owen (1839, p. 21), Richard Owen (1862, p. 98), and Wilson (1906). Large beds of marl occur in many of the glacial-lake basins of northern Indiana. The marl is impure calcium carbonate, probably calcite for the most part. Stromatolites (water biscuits), or ovoid algal concretions, composed of calcite were found recently on the south shore of Lake James, Pokagon State Park, Steuben County, by W. G. Schlecht, of the U. S. Geological Survey. They are found in small heaps, especially around such obstacles as posts, at the high-water line of the lake.

Unusual specimens of calcite can be found in Bartholomew (1), Cass (1), Decatur (1), Harrison (2, 4, and 5), Huntington (1), Jasper (1), Jefferson (1), Jennings (1), Lawrence (5, 7, and 8), Madison (1), Monroe (3, 5, 10, 12, 17, and 18), Perry (1), Ripley (1), Rush (1), Shelby (1), Wabash (1), Wayne (1), and Wells (2) Counties.

## CELESTITE
$SrSO_4$

Celestite is found as tabular {001} crystals or as elongated [001] or [010] crystals. Forms noted on crystals from Lawrence County (8) are *c* {001}, *d* {101}, *l* {102}, *o* {011}, and *m* {210}. At another locality in Lawrence County (7) *z* {211} was found on thin prismatic [010] crystals. The common form *a* {100} has not been observed on Indiana celestite. The macrodomes {101} and {102} of most crystals are striated parallel to their common edge.

Celestite is associated with gypsum, calcite, quartz, and sphalerite. It has not been found in close association with barite, although the two minerals have been found at the same localities in Lawrence (7) and Monroe (10) Counties. It is not associated with strontianite in most localities, but it has altered to tufts of this mineral in Lawrence County (7). Minute inclusions of marcasite impart a yellow color to some of the celestite from Lawrence County (8). Gypsum and gas also are found as inclusions.

The chief occurrence of celestite is with calcite in quartz geodes of the Harrodsburg Limestone. Commonly these geodes are

crushed at their bases and slightly flattened. Kulp, Turekian, and Boyd (1952) made a study of the strontium content of several limestones. They found that the Harrodsburg contained relatively low amounts of strontium in comparison with other Indiana limestone. They believed that this was due to the recrystallization of the Harrodsburg during which some of the strontium was liberated. The strontium in the celestite may have come from this source. In Owen County (3) celestite occurs as intersecting pale blue plates in pockets in the St. Louis Limestone.

Plummer (1843, p. 283) stated that laminae of celestite crossed pockets of calcite in rock near Richmond, Wayne County. This material may be barite, which occurs in the Elkhorn Formation there. Celestite reported by Collett (1874c, p. 295) from near Williams, Lawrence County, may have been barite. Priddy (1939, p. 495) noted traces of celestite in the insoluble residues of some Niagaran rocks of southeastern Indiana.

Celestite has been found in Lawrence (7 and 8), Monroe (10), Owen (3), and Washington (3) Counties. Celestine, a small town in Dubois County, is named after the second Bishop of Vincennes (Chamberlain, 1849, p 189) and not after an occurrence of the mineral.

## CHALCOPYRITE

$CuFeS_2$

Chalcopyrite is an exceedingly rare mineral in Indiana. It was reported by Grossman (1942, p. 212) as tiny crystals encrusting a blackish-stained dolomite in Decatur County (1) and by Professor Ralph E. Esarey (1950, oral communication) from some of the thin Chester limestones in Martin County. The first occurrence could not be confirmed, and the second needs verification. A few minute crystals of chalcopyrite, on gray barite crystals, occur in a quartz geode from Parke County (1).

## COPIAPITE

$(Fe\ Mg)\ Fe_4(SO_4)_6(OH)_2 \cdot 20H_2O$

Copiapite from Spencer County (1) was found encrusting shale above Coal III. The mineral at this locality occurs in fresh euhedral crystals, which are as much as 1 millimeter in diameter, and which contain no inclusions. It is here found with other iron sulfates (possibly melanterite, siderotil, and coquimbite). The optical properties of this copiapite from Spencer County (1) are $\alpha$ = 1.508, $\beta$ = 1.530, $\gamma$ = 1.577, 2V = 70°, biaxial positive;

pleochroic : X = yellow, Y = pale yellow, and Z = canary yellow.

No previous reference to the occurrence of copiapite in Indiana was found, perhaps because copiapite may have been mistaken for sulfur in Indiana coals. This mineral has been found in Morgan (2), Spencer (1), and Wells (2) Counties.

## COPPER
Cu

Nuggets of copper transported by glacial action from the Lake Superior copper district have been found in 18 counties of Indiana from its east to west boundaries and as far south as Vanderburgh County. Crook (1929, p. 119) stated that the copper erratics from central Indiana to western New York may be referred to the Kansan Stage of glaciation, whereas those in western Indiana, Illinois, and eastern Iowa were transported during the Illinoian or later ice stages. Salisbury (1886) noted that in general the copper specimens diminish in size in their southerly occurrence.

Schoolcraft (1825, p. 111-112) found the Indians using implements and ornaments fashioned from copper, which they found in the upper regions of the Wabash River. Gorby (1886b, p. 303) said

> Although pieces of copper are occasionally found in the Drift of this State, it is altogether probable that the great mass of that metal used in the manufacture of the relics found here was procured from the great copper-producing districts of Lake Superior. Among the implements and ornaments of copper found in Indiana may be mentioned mauls, hammers, axes, awls, ear-rings, bracelets, beads, etc. The articles enumerated have all been made of native ore, hammered into the required shape. The beads were made of copper hammered into sheets, cut into strips and rolled into small, hollow, cylindrical bodies that could readily be strung on a string. The bracelets and rings were made by hammering the ore into a light rod and then bending it into the required shape, the ends usually overlapping each other.

The localities at which native copper has been found and references to these localities are given in table 2.

## DIAMOND
C

Diamonds with dodecahedral and hexoctahedral? habits have outnumbered the octahedral stones found in Indiana. Many of the crystals are flattened on the octahedron; twinning on this face is common. The faces commonly are curved and striated. Indiana diamonds are white, yellow, and pale shades of greenish yellow, brownish yellow, brown, pink, blue, and green.

Table 2.-*Reported occurrences of native copper in Indiana*

| County | Reference | Remarks |
|---|---|---|
| Brown | Richard Owen (1862, p. 118)<br>Collett (1875, p. 109) | Near Speareville. |
| Dearborn | Warder (1872, p. 403) | 26 oz; near Weisburg on Tanner's Creek. |
| De Kalb | Dryer (1889, p. 104) | Wilmington Township. |
| Elkhart | Salisbury (1886, p. 49) | 2 lb; 3 miles from Elkhart. |
| Franklin | Haymond (1869, p. 190)<br>Salisbury (1886, p. 49) | 6 lb; no locality given.<br>Near Brookville. |
| Henry | Salisbury (1886, p. 49) | |
| Jefferson | Rev. John Sparks (1950, oral communication) | Near Madison. |
| Knox | Collett (18746, p. 367) | |
| Miami | Salisbury (1886, p. 49) | 30 lb; near Peru. |
| Marshall | Vaughn (1933) | 1.027 g; 1 mile east of Tyner. |
| Parke | Esten (1928) | Boulder Canyon, Turkey Run State Park. |
| Pike | Collett (1872e, p. 284) | |
| St. Joseph | Mahin (1933) | 27 lb; in a gravel pit near Niles Ave., South Bend. |
| Vanderburgh | Collett (1876a, p.294)<br>Sutton (1882, p. 182) | |
| Vermillion | Bradley (1869, p. 170)<br>Salisbury (1886, p. 49) | Near Eugene. |
| Warren | Collett (1874d, p. 244) | |
| Wayne | Salisbury (1886, p. 49) | 17 oz; near Richmond. |
| White | Salisbury (1886, p. 49) | 3,126 g; Moot's Creek. |

Diamonds have been found in glacial materials in Brown and Morgan Counties (Cox, 1879a, p. 116-117; Brown, 1884, p. 83; Blatchley, 1903b; Sterrett, 1913, p. 1039; 1914, p. 665-666; Schaller, 1918, p. 892-893; Blank, 1935; Wade, 1950). About 30 stones have been found; these diamonds have ranged in size from less than one-eighth carat to the Stanley diamond, which weighed 4 7/8 carats before it was cut. W. S. Blatchley (1907, p. 71) reported that most of the diamonds were clear and flawless and were valued at that time at five to two hundred dollars. Detailed descriptions of the stones and the localities at which they were found were given by Blatchley (1903b, p. 38-41) and Wade (1950). The most recent find, a flattened octahedral crystal of 3.93 carats, was found by a farmer near Peru, Miami County; Wade (1950) identified

and described it. This find indicates that diamonds can occur in counties other than Brown and Morgan that are covered by glacial materials. Logan (1922a, p. 1056) identified minute crystals of diamond from glacial materials, but he gave no further details or localities.

A small (1.7 carats) diamond from Brown County is on display in the collection of North American diamonds in the U. S. National Museum. It was purchased from Tiffany's in New York (J. H. Benn, 1953, oral communication). This diamond was studied by Holden (1944, p. 10) with particular reference to fracture lines developed on the faces of the stone. Three Indiana diamonds may be seen in the Indiana State Museum in the basement of the State House, Indianapolis (E. H. Sarles, 1952, oral communication).

## DOLOMITE
$CaMg(CO_3)_2$

Dolomite from Harrison County (3) had $w$ = 1.692. Qualitative microchemical tests of this material indicated a moderate iron and slight manganese content. Ferroan dolomite from Monroe County (5) had w = 1.708, which was the highest index of refraction obtained from specimens examined. Pale-brown crystals of ankerite were reported from Harrodsburg geodes in Putnam County (3) by Reeves (1950).

Dolomite is associated with calcite, aragonite, siderite, barite, quartz, pyrite, millerite, and sphalerite. Pyrite, pyrrhotite, and smythite have been noted as inclusions in Monroe County (10).

Pink dolomite, which probably is pseudomorphous after scalenohedrons of calcite, is found in septarian concretions in the New Albany Shale in Jennings County (1). Borden and Harrodsburg geodes commonly contain large crystals of dolomite. Stockdale (1931, p. 196) mentioned dolomite-bearing geodes in the Floyds Knob Formation at Floyds Knob, Floyd County. McGrain (1943, p. 153, 156) stated that local concentrations of dolomite in drusy vugs are present in the upper part of the St. Louis and lower part of the Ste. Genevieve Limestones in western Harrison County. Although large crystals can be found elsewhere in Indiana, the Harrison County dolomite is unequalled for size and perfection of specimens.

Dolomite is very abundant in some sedimentary rocks. In Indiana, rocks of this type are represented by the Huntington and Geneva Dolomites, which contain as much as 45.1 percent and 42.7

percent $MgCO_3$ respectively (Patton, 1949). Dolomitic limestones are found chiefly in the following stratigraphic units: Saluda, Elkhorn, Laurel, Louisville, basal Jeffersonville, Silver Creek, lower Harrodsburg, Salem (part), and St. Louis. Silurian organic reefs, or bioherms, are also notably dolomitized (Cumings and Shrock, 1928). The petrology of some of the Silurian dolomites of northern Indiana was studied by Ericksen (1949). Any limestone formation in the State may contain large crystals of dolomite along joint surfaces and in drusy vugs and smaller crystals scattered throughout its matrix.

Good specimens of dolomite have been found in Crawford (2), Decatur (1), Floyd, Harrison (1, 2, 3, and 5), Huntington (1), Jackson (1 and 2), Jefferson (1), Jennings (1), Lawrence (13), Monroe (3, 5, 6, 10, 16, 17, and 18), Parke (1), Putnam (5), Scott (1), and Wells (1) Counties. The occurrences at Decatur (1) and Monroe (10) were reported by Grossman (1942) and Fix (1939) respectively.

## EPSOMITE
## $MgSO_4 \cdot 7H_2O$

The best known occurrence of epsomite in Indiana is in the Wyandotte Cave, Crawford County (4). This occurrence was first mentioned by Silliman (1818, p. 49), who stated that epsomite was ". . . beautifully crystallized, in masses composed of delicate white prisms, in a cave in the Indiana Territory, not very remote from Louisville, in Kentucky ; it is said to be so abundant that the inhabitants are reported to carry it away by the wagon load ; . . . ." Stilson (1818) stated that originally the floor of the cave was covered to a depth of several inches with pure, brilliant, needle-shaped crystals, and Cleaveland (1816) reported that the mineral appeared in masses weighing as much as 10 pounds or was disseminated in the cave earth, 1 bushel of which yielded 4 to 25 pounds of the salt. Collett (1879, p. 475) observed that "at the top of this mountain [a cave formation] were seen banks of white, needle-shaped or hairy crystals of epsom salts; handfuls were gathered two inches long, and if not removed for twelve months they continue to exude from the porous matrix until they attain a length of from three to five inches ; . . . ." Blatchley (1897, p. 150) reported that the State Legislature regarded the cave as a nuisance and, in 1843, passed an ordinance that forced the owner to fence up the entrance to the cave, purportedly to prevent cattle from entering and licking the epsom salts. However, the cave and its

salts had become a well-known tourist attraction by 1849 (Chamberlain, 1849, p. 200). Jackson (1953, p. 13) suggested that ". . . passage of thousands of visitors through the cave avenues has had some adverse effect upon the formation of these salts." But he stated that the mineral, although not as abundant now as formerly, may still be found in the dry parts of the cave. Epsomite in this cave also was mentioned by Adams (1820), Brown (1854, p. 310), Owen (1862, p. 126, 150-158), (Cox 1872a, p. 152), and Hovey (1896, p. 145).

Epsomite occurs commonly as an efflorescence on weathered outcrops of shale, limestone, or dolomite. It was found as an efflorescence on rocks of Ordovician age near Richmond, Wayne County, by Plummer (1843, p. 307). A white efflorescence noted on limestone of Niagaran age by Cumings and Shrock (1928, p. 117) possibly was this mineral. Lapham (1828, p. 69) remarked upon the efflorescence that coats rocks of the Borden Group at New Albany, Floyd County. Epsomite appears on outcrops of all the formations of this group (Stockdale, 1931). Thin, powdery crusts of the mineral may be found on the Edwardsville Formation and on the lower part of the Harrodsburg Limestone in Monroe County. Anderegg and others (1928) observed that epsomite and minor amounts of gypsum formed as efflorescences on buildings built of Salem Limestone owing to the evaporation of capillary water which contained salts dissolved from mortar. Epsomite has been found in Crawford (4), Monroe (5), and Perry (3) Counties.

## FLUORITE
## $CaF_2$

Fluorite from Indiana is colorless, light blue violet, dark purple, yellow, amber, or reddish brown. The color, especially in many of the blue and purple varieties, is arranged in zones parallel to {100). Many of the blue-purple and amber fluorites are closely associated. The mineral fluoresces yellow, greenish yellow, or yellowish orange. A medium to strong greenish phosphorescence was noted in these hydrocarbon-bearing specimens. Fluorite is associated with calcite, dolomite, marcasite, and an unidentified asphaltic compound. No inclusions other than hydrocarbons were observed.

The mineral has been found only in rocks of Devonian or Mississippian age in Indiana except for trace amounts in the insoluble residues of Niagaran rocks of southeastern Indiana (Priddy, 1939, p. 495). In Bartholomew County (1) fluorite occurs with calcite and marcasite in veins and in vugs in the Jeffersonville Lime-

stone, and in Shelby County (1) it occurs with lamellar calcite, marcasite, and organic matter. In some places at both localities the mineralization is localized along stylolite seams.

Fluorite is nowhere common in Indiana, but it has been found associated with calcite and dolomite in cavities and veins and on joint surfaces in the St. Louis Limestone in Harrison County. It was first noticed there in outcrops of the St. Louis in and near the Blue River at Milltown by Collett (1879, p. 453). The mineral also is found in pale bluish-purple to blackish-gray chert nodules and lenses in the St. Louis Limestone. Here it occurs with pyrite and asphalt in patches of limestone in the chert, but more commonly it is found as isolated crystals scattered throughout the chert. Euhedral rhombs of dolomite and irregularly shaped blobs of hard asphalt are associated with the fluorite. In places the fluorite and dolomite have been dissolved out of the chert by weathering, and thus cube- and rhomb-shaped cavities have been left. A similar occurrence of fluorite has been observed in the St. Louis Limestone in Monroe County (9). Fluorite has been found in Bartholomew (1), Harrison (1, 2, 3, and 5), Monroe (9), Shelby (1), and Washington (10) Counties.

## GALENA
PbS

Galena has been found mostly in small cleaved chunks in glacial materials of Indiana. D. D. Owen (1839, p. 17) found small nuggets of galena ". . . on the west fork of Tanner's creek, in Dearborn county; but there is no appearance of there being a body of it; indeed, I have reason to believe that the small specimens found originated in a bowlder." Richard Owen (1862, p. 170) noted galena near Prairieton, Vigo County; he believed that the mineral was obtained from glacial materials by Indians. In his report on Knox County (1862, p. 179) he said that ". . . we obtained a sample of lead ore of rich quality from this county; but as yet there seems no certainty as to its extent. Mr. James Dick found it on his farm near Dicksburg, two miles below the railroad bridge across White River, probably in a quaternary deposit."'

The mineral also was reported in glacial materials of Brown County (Collett, 1875, p. 109), Gibson County (Collett, 1874a, p. 418), Knox County (Collett, 1874b, p. 367), Morgan County (Brown, 1884, p. 81), Vermillion County (Bradley, 1869, p. 170), and Warren County (Collett, 1874d, p. 244). Warder (1872, p. 420) stated "there are traditions that the Indians gathered

the ore by the apron full, and pieces of galena have been picked up in various places, but no vein has been discovered, and I have seen no specimen known to belong to this geological district [Dearborn, Ohio, and Switzerland Counties]." Some of the pieces found have been fairly large. Dryer (1889, p. 104) mentioned a specimen weighing 10 pounds that was found near Corunna, DeKalb County.

Nuggets found in the glacial drift or imported from Wisconsin by the Indians gave rise to many false reports of lead mines in Indiana. Two excerpts from Hobbs' (1872, p. 354, 367) report on the geology of Parke County are typical:

> A "lead mine" legend is remembered with interest in this vicinity [near Catlin]. The Indians, in an early day, are said to have found an abundant supply of lead on or near section 36 [T. 15 N., R 8 W.], which they melted and ran into bullets. They kept the locality a profound secret. The penalty for showing it to the white man, was cutting out the tongue. . . . There has been much searching for the hidden treasure, but no one has been able to find it.
>
> A short distance above Milligan's Iron Bank [sec. 3, T. 16 N., R. 8 W., about 1½ miles northwest of Annapolis] is a legendary spot. In "early times," the Indians, it is said, found a supply of lead in the bed of Sugar Creek at this place. They would wade into the stream and feel the ore with their feet and thus procure their supplies. They were not disposed to show the pale faces the spot, and soon after they had left their hunting grounds, the construction of the Wabash and Erie Canal demanded a feeder dam across the stream below and the search for lead in its bottom was made hopeless. The canal dam having gone into decay the stream may in time be reduced to its former level and the lead hunters may yet hope for success.

Reputed lead deposits or mines and quarries were supposed to have existed in Wayne County (Plummer, 1843, p. 283), Vermillion County (Brown, 1854, p. 320), Ohio, Miami, Tippecanoe, and Crawford Counties (Owen, 1862, p. 35, 53-54, 74, 159), Franklin County (Haymond, 1869, p. 189-190), Perry County (Cox, 1872b, p. 77), and Gibson and Warren Counties (Collett, 1874a, p. 418; 1874d, p. 244). Most of the geologists whose reports are cited vigorously denied that lead ore had been, or ever would be, found in the sedimentary rocks of the State. Fix (1938, p. 1), however, stated that very small quantities had been found in the sedimentary rocks of Indiana. Chunks of galena and fluorite were found near an abandoned iron smelter which is situated on a low terrace near the East Fork of White River in the NW¼NW¼ sec. 29, T. 1 N., R. 4 W., Dubois County. John B. Patton, of the Indiana Geological Survey, said (1952, oral communication) that the galena probably had been brought to this spot with fluorite (probably from the fluorspar district at Rosiclare, Ill.) to be used as a

flux in smelting the local iron ore. The flux probably was hand cobbed, and the chunks with high galena content were thrown aside because they were undesirable in the smelter.

Galena has been reported from geodes in Lawrence County (Collett, 1874c, p. 278), Morgan County (Brown, 1884, p. 81), and Washington County (Gorby, 1886a, p. 133) and from clay ironstone nodules in Vermillion County (Bradley, 1869, p. 170). Galena probably is present in small quantities in the sedimentary rocks of Indiana, but its only authenticated occurrence is as nuggets in glacial materials of the State.

## GLAUCONITE

Approximately $K(Fe^{2\cdot3}, Mg, Al)_2AlSi_3O_{10}(OH)_2$

Glauconite is present in most of the limestones and shales; it is less common in the sandstones of Indiana. The mineral gives a dull-green color to many of the shales and limestones. Glauconite is characteristically associated with phosphate pebbles, iron sulfides, calcite, dolomite, and quartz.

Glauconite is found notably in the Ordovician Elkhorn Formation in Wayne County (1). Priddy (1939) noted that glauconite occurs as detrital grains or occupies openings in fossils in the insoluble residues of Silurian rocks (Brassfield Limestone, Osgood Formation, and Laurel Limestone) of southeastern Indiana. Glauconite, partly replaced by calcite, was observed by Ericksen (1949) in the Liston Creek Limestone in Grant and Wabash Counties. The mineral is found as detrital grains in a calcite-cemented sandstone in the Devonian Jeffersonville Limestone? in Cass County (1) and is fairly common in this formation in southern Indiana. In Bartholomew (1) and Jennings (1) Counties glauconite may be found with pyrite and phosphatic pebbles at the contact of the North Vernon Limestone and the New Albany Shale. In the Mississippian System, glauconite is found in the Rockford Limestone in Floyd County (Stockdale, 1931, p. 73) and along joints, fractures, bedding planes, and stylolite seams in the Harrodsburg Limestone in Monroe County (10) (Fix, 1939). It constitutes a large part of the insoluble residue of the Harrodsburg Limestone (Martin, 1931). A thin intraformational conglomerate with flattened pebbles of glauconite is found near the Edwardsville-Harrodsburg contact in Monroe County (6). The Levias Member of the Ste. Genevieve Limestone in some places contains notable amounts of glauconite. Abundant glauconite has been found in

Bartholomew (1), Cass (1), Decatur (1), Jennings (1), and Wayne (1) Counties.

## GOETHITE

$HFeO_2$

Goethite constitutes most of the material formerly called limonite ; however, because the term limonite has been used in previous records and descriptions, the bulk of occurrences are described under that heading (p. 39). Only occurrences in which the material has been identified as goethite are given here.

In Indiana goethite is commonly massive and extremely fine granular (usually cryptocrystalline) ; it also occurs as prismatic [001] vertically striated crystals or, by flattening on {010}, as minute scales or tablets. Forms observed on crystals from Brown County (1) were *m* {110}, *b* (010), *e* {021}, and *p* {121}?.

Crystals of goethite have been found in geodes of the Edwardsville Formation and the lower part of the Harrodsburg Limestone. There is a collection of these geodes from Monroe County at the Michigan School of Mines and Technology at Houghton, Mich. Some of these geodes contain crystals of goethite which were first recognized by the collector and donor, Mr. C. A. Lamey. In geodes from Brown County (1) prismatic crystals of marcasite were found altered to blackish-brown, slender, rodlike crystals of goethite. The crystals were 1.5 millimeters in height and 0.1 millimeter in width and were found with aragonite on quartz crystals. In the same geodes pyrite has been altered to nearly perfect spheres of goethite. In Monroe County (6) goethite occurs as small velvety-brown micaceous plates with calcite, aragonite, siderite, and pyrrhotite in quartz geodes. Goethite commonly occurs as a surficial red coating on (or as complete pseudomorphs after) pyrite; as feathery aggregates pseudomorphous after fibrous marcasite (Wayne County (1) ) ; and as rhombohedral boxworks pseudomorphous after siderite in geodes (Monroe County (3) ). Bundy (1956a, p. 11-13) found goethite in sandstones and shales of the Mansfield Formation, and he noted (1956a, p. 13) that the inner parts of concretions in this formation contained goethite and finely disseminated magnetite. Goethite has been found in Brown (1), Decatur (1), Lawrence (12), Monroe (3, 5, 6, 10, and 19), Montgomery (3), Wayne (1), and Wells (2) Counties.

## GOLD

Au

Gold has been found in Indiana as small rounded grains or flattened flakes rarely exceeding 3 millimeters in diameter. The

largest nugget found weighed 132 grains (8.55 grams) (Blatchley, 1903b, p. 24). Specific gravities of flakes of gold from Brown County ranged from 16.8 to 18.5. In a U. S. Mint Report of July 12, 1901, the fineness of a 14.05-ounce sample of Indiana gold was given as 909½.

Wylie (1850) first reported gold from Indiana, and Christy (1848, p. 80) was the first to postulate a glacial origin. Burchard (1881, p. 181) mentioned that gold had been sent to the U. S. Mint from Brown County, and Brown (1884, p. 81) told of the discovery of gold in Morgan County by miners who returned from California in 1850. Gold might have been known in Indiana before 1850, however, because Cox (1879a, p. 116) said:

> In the latter county [Brown] gold was washed from the drift sands in the valleys of most of the streams flowing into Bean Blossom creek at a very early day, and the county has been the scene of numerous mining excitements within the last forty years. Its geological position was well studied by the first State Geologist, the late Dr. David Dale Owen, and as early as 1837 he cautioned the public against expending large sums of money in mining adventures, since the gold had been brought from the metalliferous veins which have their existence north of the lakes.

The occurrence of gold in Indiana has been studied chiefly by W. S. Blatchley, who pointed out (1903b, p. 17-18) that:

> Gold is liable to be found in the glacial gravel deposits of any portion of the State and especially in those which lie directly on the bed rock. It is, however, only at the edges of these [Illinoian and Wisconsin] main terminal moraines, where the material composing the drift has been most weathered and washed, and where streams flowing from the moraines have deposited beds of gravel over the bed rock in their valleys, that the gold has been accumulated in greatest quantity.

W. S. Blatchley (1903b) gave a detailed list of localities at which gold had been found, and Logan (1922b) gave a general account of gold in Indiana. Table 3 lists the 25 counties from which gold has been reported and the references to them. Those references which do not appear in Blatchley's account are given in some detail in this table.

Possibly as much as twenty thousand dollars worth of gold has been mined from the glacial deposits of the State (Hafer, 1921), but the economic situation is no better today than 57 years ago, when Blatchley wrote (1903b, p. 38) that "enough has been said to show that gold doubtless occurs in every county within the drift area, but it is very improbable that it is accessible in paying quantities in any except Brown and Morgan ; and there only under improved methods of separation."

Table 3.-*Reported occurrences of native gold in Indiana*

| County | References |
|---|---|
| Brown | Wylie (1850)<br>Richard Owen (1862, p. 118.120)<br>Collett (1875, p. 107)<br>Cox (1879a, p. 116)<br>Blatchley (1903b) |
| Cass | Blatchley (1903b) |
| Carroll | Richard Owen (1862, p. 98) : "Between two and three miles from Delphi, considerable samples of gold have been washed. . . ."<br>Thompson (1892, p. 185) : ". . . and in the vertical crevices of the Devonian lime stone in the bed of the creek [Deer Creek] farther east small quantities of gold have been found." |
| Clark | Blatchley (1903b) |
| Clinton | Richard Owen (1862, p. 113.114): "Accompanied by the editors and several other gentlemen from Frankfort, we visited the gold locality on the Kilmore branch, which heads on Indian prairie and runs into the south fork of 'Wild Cat.' We found it, as expected, in a pocket of Drift; . . . ." |
| Dearborn (and Ohio) | Warder (1872, p. 420)<br>Con (1879a, p. 106)<br>Sutton (1882)<br>Blatchley (1903b) |
| Franklin | Haymond (1869, p. 190) |
| Gibson | Collett (1874a, p. 418): "Native gold and galena imported by the boulder ice, have been found in small lots in wells near the center of the ancient trough of the Wabash; the former in nuggets weighing from two to three grains." |
| Green | Wylie (1850) |
| Harrison | Collett (1879, p. 378) reported magnetite with gold in "glass sand mines: From two miles south of Bridgeport to the mouth of Mosquito Creek." |
| Henry | Richard Owen (1862, p. 82.83): "Gold is washed abundantly from the Quaternary gravel drift near the mouth of a small stream and a mill-race, emptying about eight miles from Newcastle into Blue River; . . . ." |
| Jackson | Wylie (1850)<br>Blatchley (1903b) |
| Jefferson | Blatchley (1903b) |
| Jennings | Borden (1876, p. 178) |
| Knox | Collett (1874b, p. 367) |
| Montgomery | Collett (1876b, p. 370, 392, 407) |
| Morgan | Wylie (1850)<br>Brown (1884, p. 81)<br>Blatchley (1903b) |
| Ohio | (See Dearborn.) |
| Owen | Collett (1876c, p. 308) reported gold dust associated with magnetite along the streams of Fish, Lick, and Rattlesnake Creeks. |
| Pike | Collett (1872c, p. 284) |
| Putnam | Blatchley (1903h)<br>Smith (1946, p. 128) mentioned gold found on Mosquito Creek, south of Putnamville. |
| Sullivan | Sutton (1882) |
| Vanderburgh | Collett (1876a, p. 294) |
| Vermillion | Bradley (1869, p. 170) noted minute quantities of gold in one of the "small streaks of gravel." |
| Warren | Collett (1874d, p. 224, 244) |

## GYPSUM
## $CaSO_4 \cdot 2H_2O$

Gypsum is found in Indiana in many stratigraphic units especially in shales (usually as the fibrous satin spar variety) or at contacts between shales and limestones. It is very commonly found in cave "formations" as beautiful shiny crystals that cover the roof and walls. Gypsum found in Borden shales in Morgan County (1) possessed a yellow fluorescence of moderate intensity, but all other specimens examined were nonfluorescent.

Plummer (1843, p. 283) found minute crystals of the mineral in an argillaceous limestone near Richmond, Wayne County. Priddy (1939, p. 495) reported that there was gypsum in the insoluble residues of Silurian rocks of southeastern Indiana. He stated that the mineral occurred as satin spar in vugs in dolomite and as selenite in limestone. Gypsum is common in rocks of the Borden Group, and selenite in these strata in Floyd County was noted by Dana (1844, p. 548), Owen (1846, p. 439-440), and Borden (1874, p. 161). Beautiful, colorless crystals of selenite from Floyd County (1) have been described (Anonymous, 1950, p. 149). Borden (1874, p. 161; 1875b, p. 122) mentioned that gypsum occurs as platy and needle-shaped crystals in cracks in the New Providence Shale in Clark and Scott Counties. Greene (1880, p. 432) found traces of the mineral in Borden rocks in Monroe County.

Gypsum is found in many places as cavity fillings and in quartz geodes of the lower part of the Harrodsburg Limestone. Gorby (1886a, p. 133) found the mineral in geodes in Washington County. Crystals of selenite occur in a matrix of fine-grained gypsum in Lawrence County (8). Fix (1939) described tabular crystals of gypsum in geodes in Monroe County (10). Subsurface studies in southwestern Indiana (McGregor, 1954) show that gypsum (and anhydrite) are found in the lower part of the St. Louis Limestone. Bundy (1956b) described the petrology of these deposits. Massive gypsum was found in nodules and in drusy quartz vugs in the St. Louis Limestone in Washington County (10). Small seams of selenite were found in the Rosiclare Member of the Ste. Genevieve Limestone in Owen County (6). Gypsum is abundant in rocks of the Chester Series in some places. In Lawrence County (12) a layer of selenite a few inches thick lies between the Beaver Bend Limestone and the Sample Formation. This locality was described by Logan (1922a, p. 1052). An occurrence in the Bethel Formation

in Lawrence County (1) was noted by R. K. Leininger (1951, oral communication), and a "deposit" of satin spar in sec. 22, T. 4 N., R. 3 W., Martin County, was reported by Owen (1862, p. 174). Gypsum also is common in Pennsylvanian shales and coals. Blatchley (1896, p. 110) stated

> On the land of J. L. Schiller (S. E. ¼ of S. E. ¼ Sec. 6, Tp. 1 S., R. 3 W.) [Dubois County], occurs an outcrop of pale blue lire clay 31 feet thick. Through the lower part of it are scattered many crystals of selenite . . ., varying in size from 1 inch in length downwards. The owner burns the clay in a kiln, reducing th(se crystals to a powder, and then uses it as a fertilizer with good results. These crystals of selenite are found in numerous other deposits of fire clay east of Jasper, and have also been noted at other points in the State as at Mecca, Parke County, on the land of S. L. McCune. The crystals are oftentimes acicular, and radiating from a common center, form little rosettes which lie in great numbers on the exposed surface of the clays.

Blatchley (1896, p. 81) also reported gypsum in a clay deposit southeast of Clay City, Clay County. Dove (1919, p. 223) noted that a thin white scale of gypsum lines joint cracks in Pennsylvanian coals in many places.

Gypsum crystals and "growths" in Indiana caves, especially Wyandotte Cave (Crawford County (4) ), have been mentioned by Stilson (1818), Cox (1872a, p. 151-152), Cope (1872, p. 158), Collett (1879, p. 483-484), Merrill (1895), Hovey (1896, p. 145-151) and Blatchley (1897, p. 164). Hovey (1896, p. 151) described floriform crystals of gypsum sometimes known as oulopholites. These forms are well illustrated in drawings by Hovey (1896, p. 138, 144) and in photographs by Spencer (1921, p. 268-269). Gypsum crystals coat the walls of Marengo Cave, Crawford County (1), and have been reported from Eller's and Saltpetre Caves in western Monroe County (14 and 15) by Blatchley (1897, p. 135-136).

Gypsum has been found in Clark, Clay, Crawford (1 and 4), Dubois, Floyd (1), Fountain (1), Lawrence (1, 8, and 12), Monroe (10, 14, and 15), Morgan (1), Owen (6), Parke, Perry (1), Scott, Washington (3, 7, and 12), Wayne, and Wells (2) Counties.

## HALLOYSITE

$(OH)_8Si_4Al_4O_{10}$ - $(OH)_8Si_4Al_4O_{10}\cdot 4H_2O$

(hydrated and dehydrated halloysite)

The most extensive occurrence of hydrated and dehydrated halloysite in Indiana is the Gardner Mine Ridge deposit in Lawrence County (sec. 21, T. 4 N., R. 2 W.). The geology and mineralogy of this deposit have been described by Callaghan (1948), who called

the hydrated variety endellite. The halloysite, ranging in thickness from 1 foot to 10 feet, occurs at the erosional contact of the Pennsylvanian Mansfield Formation with underlying Mississippian formations of the Chester Series. Halloysite also is found a few feet above the contact. Alexander and others (1943, p. 13) observed that the specific gravity of the material from Gardner Mine Ridge ranged from 2.16 to 2.59. The deposit was first reported by Cox (1875a), who called the clay "indianaite." The clay was identified as halloysite by Goldsmith (1876) and Dana (1884, p. 55), but subsequently it was called kaolin by Maurice Thompson (1886). This name persisted until Ross and Kerr (1934, p. 136) redescribed the clay as halloysite. Other studies of the geology of the deposit have beep, made by W. H. Thompson (1889), Blatchley (1896, p. 103-106), Logan (1922a, p. 662-714), and Logan and Ries (1922). The halloysite from Gardner Mine Ridge is the American standard for this clay as established by Kerr and Kulp (1949, p. 4-5). Allophane, allophane-evansite, and minor amounts of alunite, goethite, and gibbsite occur as associated minerals (Ross and Kerr, 1934). Quartz, orthoclase, sericite, rutile, and apatite? were observed in a microscopic examination by Kerr, Main, and Hamilton (1950, p. 27).

Greene (1880, p. 447) found waterworn fragments of "kaolin" (halloysite?) in Monroe County, but he declared that no beds of the clay were to be found there. Subsequently, Logan (1919) described several occurrences in this county. Collett (1876c, p. 358-359) reported "kaolin" from Owen and Parke Counties and (1876b, p. 418) from Montgomery County. He also reported (1879, p. 377-378, 416) "indianaite" at several localities in southeastern Harrison County. Blatchley (1896, p. 88, 101) mentioned several occurrences in Greene and Martin Counties. Logan (Logan and Ries, 1922, p. 149) stated that the clay also had been reported from Dubois and Crawford Counties. He gave (1922a, p. 733-756) a list of the localities at which "kaolin" had been found. Callaghan (1948, p. 15), in a discussion of these localities, said that "most of these localities are now lost, and if rediscovered, modern techniques of clay mineral determination would have to be used to know if all were halloysite. The writer's examinations of a few localities suggest that most are the halloysite type of clay. Logan's descriptions all suggest sporadic distribution and small size for the deposits."

## HEMATITE
$Fe_2O_3$

Hematite occurs in Indiana as earthy or ocherous masses; good crystals have not been observed. It is associated with limonite, siderite, wad, pyrite, quartz, and apatite. Hematite from Owen County (7) contains collophane as white crusts and veinlets.

Although not as abundant as limonite (p. 39), hematite is a common mineral in Indiana. It occurs chiefly as the earthy variety in the lower part of the Pennsylvanian Mansfield Formation near its erosional contact with the underlying Mississippian formations. Hematite from this stratigraphic interval was utilized as an iron ore in the early period of Indiana's history. The sources of the ore and locations of the furnaces were given by Shannon (1907). Ocherous hematite was observed near the Vermillion River (from whence its name) in Vermillion County in 1765 by Col. George Croghan (1831, p. 266). Cox (1869b, p. 108-109) mentioned that hematite occurred in Greene County near its boundary with Owen County in the vicinity of Fish Creek and 1.5 miles east of Solsberry ("Salisbury"). In Owen County (7) hematite forms an irregular bed about 1 foot thick at the contact of the Beech Creek Limestone and the Mansfield Formation. Cox (1871a, p. 77) noted a hematitic ocher near Alfordsville, Daviess County, and (1871b, p. 97-102, 105-106) hematitic and limonitic ochers near Dover Hill, Martin County. Cox (1871c, p. 142-143) reported that red ocher was found between St. Vincent and Celestine, Dubois County, and that it had been formerly mined and ground for pigment at Ferdinand. Hobbs (1872, p. 374) found hematite near the base of the Mansfield Formation in Parke County. Stockdale (1931, p. 89-91, 134-135) described hematite that occurred in concretions weathered from the New Providence Shale and Locust Point Formation of the Borden Group in Clark and Jackson Counties. In Monroe County (22) small spherical concretions composed mainly of limonite and hematite have been weathered out of Chester sandstones. Hematite has been found in Clark, Daviess, Dubois, Fountain, Greene, Jackson, Martin, Monroe (22), Montgomery (3), Owen (7), Parke, and Vermillion Counties.

## HYDROMAGNESITE
$Mg_4(OH)_2(CO_8)_3 \cdot 3H_2O$

Hydromagnesite occurs associated with fibrous aragonite in powdery crusts on the roof of Marengo Cave, Crawford County

(1). This is the only known occurrence of the mineral in Indiana. The hydromagnesite probably was derived from a dolomitic part of the Ste. Genevieve Limestone and probably was formed at low temperatures. The temperature of the cave has been uniform; Collett in 1879 (p. 453) gave the temperature as 52° F., and Addington (1927) reported 54° F. The hydromagnesite has a strong pinkish-white fluorescence.

## LIMONITE
hydrous Iron oxides

Limonite is a term conveniently employed to describe naturally occurring hydrous iron oxides. Much of what was formerly called limonite is actually goethite (p. 32) ; however, most occurrences are reported here under limonite.

In Indiana, limonite occurs in all types of sediments from Ordovician shales to present-day gravels, sands, muds, and soils. It typically is formed by the weathering of pyrite, marcasite, and aiderite. Limonite is found in large quantities in bog-iron deposits, which once were utilized as a low-grade ore of iron.

The first geologists of Indiana devoted much of their attention to the search for such deposits, and most of the important occurrences were discovered at an early date. David Owen (1838, 1839, and 1846) reported bog ore from nearly 20 counties. Other early occurrences were given by Stilson (1818), Plummer (1843, p. 309), Brown (1854, p. 330-332), Richard Owen (1862), Cox (1869a, p. 83-84), Bradley (1869, p. 167-170), and Haymond (1869). A comprehensive study of the Indiana "iron ores" was made by Shannon (1907) and Beede and Shannon (1907) ; Logan (1922a, p. 757-765) summarized the results of their findings. The deposits have not been utilized since about 1900, because large deposits of high-grade iron ore, such as those of the Lake Superior region, became available.

The bog-iron ore occurs in the poorly drained lakes and marshes of northern Indiana. The limonite is found in the marginal deposits of lakes and marshes or at the bottom of peat bogs, where it forms a hardpan as much as 2 feet thick. Most of the "ore" is admixed with organic and phosphatic material, clay, and sand. Masses of limonite that weigh several tons have been found in a few places.

Residual limonite occurs as layers, lenses, and concretions in Mississippian and Pennsylvanian sediments. In the Borden shales of Scott, Clark, and Floyd Counties, limonite is found associated

with siderite and hematite in concretions and bands. It is common as pseudomorphs after disseminated crystals of pyrite or marcasite in many of the Chester formations, especially the Paoli and Reelsville Limestones. Malott (1951, p. 241) noted peculiar twisted ribbons of limonite in a sandstone that he found a short distance east of St. Croix, Perry County. Limonite is found abundantly at the base of the Pennsylvanian Mansfield Formation in its outcrops in Vermillion, Parke, Vigo, Clay, Owen, Greene, Monroe, Lawrence, Martin, Orange, Crawford, and Perry Counties.

## MARCASITE
$FeS_2$

Marcasite in Indiana is commonly massive, and less commonly it is fine granular, fibrous, or in concentric structures. Crystals are tabular {010}, pyramidal, or prismatic [001]. The faces are commonly curved, and prism faces are striated [001]. The forms observed were *b* {010}, *r* {140}, *m* {110}, and *e* {101}. Stellate fivelings produced by repeated twinning on {1011 were found in Huntington County (1). Inclusions of marcasite in calcite, barite, celestite, or quartz are generally capillary crystals or thin aborescent plates.

Marcasite was found in the insoluble residues obtained from the upper part of the Osgood Formation and from the Laurel Limestone of southeastern Indiana (Priddy, 1939, p. 495). Grossman (1942, p. 212) reported that the mineral formed threadlike inclusions in calcite in the Brassfield Limestone from Decatur County (1). Crystals of marcasite occur in vugs and small quartz geodes in the Mississinewa Shale in Huntington County (1). At this locality the mineral is associated with sphalerite, calcite, and small amounts of fine-grained pyrite. In Wells County (2) acicular crystals of marcasite line cavities in dolomitic Liston Creek Limestone. Smith and Schroeder (1929) described capillary inclusions of marcasite lying along cleavage planes of large calcite crystals found in residual clay near the Kokomo-Jeffersonville? contact in Cass County (1). A similar occurrence is found in Wabash County (1). Small quantities of the mineral are associated with calcite and fluorite in the Jeffersonville Limestone in Bartholomew County (1). Euhedral marcasite is found in Harrodsburg geodes in few places. Many minute lath-shaped crystals of marcasite simulate cubes of pyrite in celestite in some of these geodes from Lawrence County (8). Many shales of the Borden Group contain small nodules of marcasite.

Marcasite was found in shaly limestones and sandstones of the Chester Series. Euhedral crystals are abundant in some places in a glauconitic sandy limestone of the Aux Vases Formation (basal Chester) in Monroe County (21). Smith (1943) described a large mass of "pencil" marcasite from Putnam County (4). Olive-green marcasite is found there on Ste. Genevieve Limestone at its contact with Pennsylvanian shale (Malott, 1952, p. 24). Logan (1922a, p. 698) mentioned concretions of marcasite in a dark clay resting on sandstone in the Elwren Formation at the Gardner Mine Ridge deposit in Lawrence County. (See p. 36.) Small crystals may be found in vugs in the lower part of the Glen Dean Limestone in Perry County (1).

Marcasite either occurs as bands and lenses or replaces calcareous concretions and plant remains in Pennsylvanian coals and shales. The marcasite is characteristically fine grained and is difficult to distinguish from intimately associated pyrite. As no distinction has been made in previous reports, occurrences of fine-grained iron disulfide are listed under pyrite (p. 45).

Marcasite has been found in Bartholomew (1), Cass (1), Decatur (1), Fountain (1), Huntington (1), Jackson (1 and 2), Lawrence (8), Monroe (10 and 21), Morgan (2), Owen (4), Perry (1), Pike (1), Putnam (1 and 4), Wabash (1), and Wells (1 and 2) Counties.

## MELANTERITE

$FeSO_4 \cdot 7H_2O$

Melanterite occurs as efflorescences on pyritiferous shales and is associated with siderotil?, copiapite, potash alum, halotrichite?, epsomite, and gypsum. In several places melanterite (copperas) was used by the early settlers as a mordant in dyeing. Cramer (1811, p. 131) stated

> In the bank of Silver creek (a small stream that falls into the Ohio just below Clarkesville [and that forms the boundary between Clark and Floyd Counties]) about two miles from its mouth is found large quantities of copperas, a place well known by the name of Copperas Banks. The copperas taken from this bank is found to be equal (although not so clear in its present state) as any brought to this country.

The “copperas banks” found on the New Albany Shale in Floyd and Clark Counties also were mentioned by Borden (1874, p. 159) and by Duden (1897, p. 108, 110). The latter described the formation of melanterite and associated alum. Campbell (1946, p. 846) stated that the “Upper Blackiston Member” of this shale is

characterized in most places by coatings of melanterite which form on its protected surfaces. He reported that copperas occurred on the "Blackiston Member" which cropped out on the south bank of Deer Creek, southeast of Delphi, Carroll County. This occurrence had been noted previously by Thompson (1892, p. 185).

Efflorescences of melanterite are found on some shales of the Borden Group. Collett (1876b, p. 387) described the occurrence of this mineral on these shales at Crawfordsville and 5 miles southwest of Ladoga in Montgomery County. Nodules of marcasite in Borden shales have altered to melanterite in Morgan County (2). Collett (1879, p. 431) noted copperas on pyritiferous Chester shales in Crawford County.

The mineral coats Pennsylvanian coals and shales and is an alteration product of "coal brass" (pyrite and marcasite). It was first observed in these rocks by Owen (1839, p. 24), who described an occurrence on Roaring Creek, a tributary to Sugar Creek, north of Annapolis, Parke County. Hobbs (1872, p. 363) remarked that the copperas was so plentiful there that the settlers utilized it in dyeing processes. They also obtained copperas from coal-mine waters in Pike County (Collett, 1872c, p. 258). Dove (1919, p. 223) stated that the mineral was so common on the older faces in coal mines that it was used as a guide to the location of lenses and bands of pyrite.

Melanterite has been found in Carroll, Clark, Crawford, Floyd, Fountain (1), Montgomery, Morgan (1 and 2), Parke, Perry (3), Pike (1), Pulaski (1), and Wells (2) Counties.

## MILLERITE
NiS

Millerite occurs in Indiana as tufts composed of slender hair-like crystals elongated along [0001]. At some localities a single rod of millerite projects outward from the surface of an enclosing calcite crystal and then splits into several strands which resemble a horsetail.

Millerite occurs chiefly as inclusions in calcite and barite and is associated with dolomite, strontianite, marcasite, pyrrhotite, and pyrite in quartz geodes of the Harrodsburg Limestone and Edwardsville Formation. Stockdale (1931, p. 178) found the mineral in geodes of the Carwood Formation in Jackson County (3). Millerite as interwoven mats is found in hollow silicified crinoid stems in Borden reef material in Montgomery County (1). In Lawrence County (2) millerite is associated with a hard black asphaltic sub-

stance in open spaces of chert nodules. The nodules of chert are from the Levias Member of the Ste. Genevieve Limestone, and the open spaces are lined with drusy quartz. Millerite also has been found in vugs in the Levias at another locality in Lawrence County (13).

A dark-green to straw-yellow mineral, an alteration product of millerite, has been found in microscopic quantities in Lawrence (2) and Monroe (5, 6, 19, and 20) Counties. It probably is similar to hydrous basic nickel iron sulfates described by Heyl, Milton, and Axelrod (1959). This alteration product of millerite probably was first described by Howarth (1930, p. 3). In Indiana the mineral is pseudomorphous after rods of millerite. The color of the mineral masks interference colors, but the mineral probably has low birefringence; the mean index of refraction is 1.598. It is insoluble in water, but it dissolves without effervescence in dilute acids. Millerite has been found in Jackson (3), Lawrence (2 and 13), Monroe (1, 3, 4, 5, 6, 7, 10, 17, 19, and 20), and Montgomery (1) Counties. The occurrence at Monroe (10) was reported by Fix (1939).

## NITROCALCITE

$Ca(NO_3)_2 \cdot 4H_2O$

The reported occurrences of nitrocalcite in Indiana need verification. Stilson (1818) reported nitrocalcite (and nitromagnesite) from Wyandotte Cave, Crawford County (4). McMurtrie (1819) stated that the earth in the cave ". . . contains about five pounds of the nitrate of lime or magnesia, to the bushel, and is composed of decaying animal and vegetable matter." The owner of the cave, Dr. Adams, also described (1820) the deposits of "Saltpeter earth" which were mined for the manufacture of gunpowder during the War of 1812. The early history of the cave and its deposits was given by Collett (1879, p. 464). Remains of the equipment used in mining the salts were found by Hovey (1896, p. 134) and Blatchley (1897, p. 149-150). Saltpetre Cave, in Crawford County (3), also contained deposits of nitrocalcite which were mined for use in gunpowder (Cox, 1872a, p. 152; Collett, 1879, p. 507; Blatchley, 1897, p. 173).

An analysis reported by Cox (1879b, p. 163) of earth from Wyandotte Cave, similar to that which was used for the manufacture of saltpeter, gave 8.06 percent CaO, 4.58 percent MgO, and 3.50 percent $HNO_3$. Though no potassium was shown in the analysis,

Cox assumed that the "nitre" was potassium nitrate and constituted 6.55 percent of the cave earth.

An analysis of the earth from Saltpetre Cave in Monroe County (14) by Hess (1900, p. 130) gave 2.31 percent CaO, 2.26 percent alkalies, and 1.88 percent $HNO_3$. This cave was described by Blatchley (1897, p. 136) and Esarey (1939, p. 11).

Collett (1874c, p. 298) mentioned that ". . . much nitrous earth spangled with shining crystals . . ." was found in the upper part of Connelly's (Connerly's) Cave in Lawrence County (11) ; he also noted (1874c, p. 291) an occurrence in Dry Cave (Lawrence County (6) ). Donaldson's (Donnelson's) Cave (Lawrence County (9)) was mined for "nitre" as early as 1800 (Collett, 1874c, p. 304) ; the mineral also is reported from this cave by Hovey (1896, p. 124) and Blatchley (1897, p. 142). Logan (1922a, p. 1052) said that he had ". . . collected some of the crystals [of nitrocalcite] from a cave south of Georgia in Lawrence County. These crystals occurred in the surface of an earthy deposit on the floor of the cave. This earthy deposit was in places four feet thick."

## OPAL

$SiO_2 \cdot nH_2O$

Opalized wood from the New Albany Shale in Henry County fluoresced with a play of colors. This opalized wood and a few veins in the Tar Springs Formation of the Chester Series in Perry County are the only known occurrences of common opal in Indiana; precious opal is unknown in the State.

## POTASH ALUM

$KAl(SO_4)_2 \cdot 12H_2O$

No natural occurrences of "alum" have been verified by the authors. Potash alum may occur, however, with other sulfate minerals on pyritiferous shales in many places in Indiana.

The first mention of "alum" in Indiana was by David Dale Owen (1839, p. 24), who described an occurrence in Parke County. J. D. Dana (1844, p. 548) listed "feather alum" "in most of the S. W. counties." "Alum" also was reported in the coals in sec. 12, T. 1 N., R. 8 W., Pike County (Collett, 1872c, p. 258) ; at an old deer lick named Stover's Mill, NE¼, sec. 29, T. 19 N., R. 4 W., Montgomery County (Collett, 1876b, p. 391) ; as crystals on Devonian shales at Falling Springs, near the mouth of Deer Creek, Carroll County (Thompson, 1892, p. 185) ; and together with melanterite on exposures of the New Albany Shale in Silver Creek,

near New Albany, Floyd County (Duden, 1897, p. 110). Dove (1919, p. 223) observed "alum," together with gypsum and other sulfates, in vertical joint cracks in coal.

## PYRITE
$FeS_2$

Forms noted on Indiana pyrite were *a* {100}, *e* {102}, *o* {111}, and *s* {213}. Cubic and pyritohedral faces are striated parallel to their common edge. Some pyrite has penetration twinning; the twin axis is [001], and the twin plane is {011}. Simple cubes have been observed in Decatur County (1). Pyrite may have botryoidal, fibrous, globular, or radiated structures, or it may be massive and fine granular. Botryoidal pyrite and marcasite arranged in concentric shells were found in the Liston Creek Limestone in Wells County (2).

Pyrite is associated with marcasite, sphalerite, glauconite, and quartz. Cubic or octahedral inclusions of pyrite are found in calcite and dolomite, and threadlike inclusions were noted in crystals of barite in Jackson (2) and Jennings (1) Counties. An imperfect cube, about 2 inches on an edge, of zoned pyrite with inclusions of rounded and frosted quartz was found by W. D. Thornbury (1950, oral communication) in Miami County (1). Limonite pseudomorphous after pyrite is common. Pyrite pseudomorphous after cockscomb crystals of marcasite has been found in the Paoli Limestone in Owen County (4) and near Marengo, Crawford County. In Wells County (1) pyrite is pseudomorphous after tiny scalenohedrons of calcite. Many calcareous and phosphatic shells and woody tissues are replaced by pyrite.

Disseminated pyrite is common in the Niagaran rocks of both northern and southern Indiana (Cumings and Shrock, 1928, p. 58; Ericksen, 1949; Priddy, 1939). Pyrite in a variety of forms occurs in petroliferous Huntington Dolomite in Pulaski County (1). A layer of pyrite, 1 inch to 6 inches thick, is found in most places at the base of the New Albany Shale (Owen, 1846, p. 441; Borden, 1874, p. 158; Duden, 1897, p. 109; Campbell, 1946, p. 838, 846). In addition, small crystals are disseminated throughout the shale. Christy (1848, p. 33) said that the pyrite found in outcrops along the Blue River near Edinburg, Johnson County, led many people to search here for gold and silver. The mineral occurs as nodular masses and concretions in Borden shales (Stockdale, 1931, p. 130, 157) and in quartz geodes in the lower part of the Harrodsburg Limestone. In Washington County (5) numerous minute cubes of

pyrite give a shining and glistening appearance to parts of the St. Louis Limestone. Considerable pyrite was noted in this formation in Putnam County (1). The Paoli and Reelsville Limestones of the Chester Series contain much disseminated pyrite.

Pyrite from Pennsylvanian shales and coals has been mined for the manufacture of sulfuric acid in Knox, Parke, and Vigo Counties. The pyrite occurs as bands, lenses, and pyritized trunk and stem fragments and as replacements of large calcareous concretions (coal balls). Some of these balls may be several feet in diameter and may weigh more than a ton. Collett (1872b, p. 203) suggested that the entire balls represented coprolites of ". . . wonderful monsters endowed with power and capacity to destroy and digest the gigantic *Edestus* [*vorax,* Leidy-a giant shark] and similar animals." Mamay and Yochelson (1953) described the peculiar assemblage of marine invertebrate and terrestrial plant fossils found in some of these coal balls. These authors did not propose any origin for the balls, but they did point out that spore concentrations in some specimens are difficult to account for except as fecal pellets of a herbivorous animal.

Holbrook (1919) suggested that reduction of sulfate waters by organic matter produced the bands and lenses of pyrite. Pyrite in Indiana coals was described by Dove (1919) and Holbrook (1919). Good specimens of pyrite have been found in Bartholomew (1), Cass (1), Decatur (1), Fountain (1), Huntington (1), Jasper (1), Jennings (1), Monroe (3, 10, and 21), Pike (1), Pulaski (1), Putnam (3), Rush (1), Wells (1 and 2), and White (1) Counties. The occurrences at Monroe (10) and Putnam (3) were reported by Fix (1939) and Reeves (1950) respectively.

## PYRRHOTITE

$Fe_{1-x}S$

Pyrrhotite was first reported from Indiana by Erd (1954, p. 103) and later was described in detail by Erd, Evans, and Richter (1957). The mineral occurs in hexagonal basal plates generally less than 1 millimeter in diameter. Pyrrhotite, commonly accompanied by smythite, was found as inclusions in calcite in geodes from Monroe County (6). At another locality in Monroe County (10), pyrrhotite, smythite, millerite, marcasite, barite, and pyrite are found as inclusions within a single crystal of calcite. Pyrrhotite, as inclusions in calcite, dolomite, barite, or rarely quartz, has been found in vugs and geodes of the Harrodsburg Limestone and

Edwardsville Formation. Pyrrhotite has been found in Jackson (1) and Monroe (3, 5, 6, 10, 18, and 19) Counties.

## QUARTZ
$SiO_2$

Quartz is found in all types of rocks in Indiana, and, as a rock-forming mineral, is present as sandstones and arenaceous shales and limestones. It is associated with nearly all other Indiana minerals and may contain rutile, zircon, apatite, pyrite, marcasite, or millerite.

Large crystals of quartz (rock crystal) are most commonly found in Harrodsburg and Borden geodes. Stilson (1818) noted that these geodes were weathered from Harrodsburg Limestone, and he found them in the bed of Leatherwood Creek in Lawrence County. In a description of this limestone in Owen County, Collett (1876c, p. 317) said that "the geodes are characteristic and an interesting feature. Rough and uncouth outwardly, they are filled with nature's brightest, purest gems, and freshly broken, sparkle with imprisoned light of past ages." Other early descriptions of the geodes were given by Owen (1862, p. 125-126), Collett (1874c, p. 278), and Greene (1880, p. 438). More recently they have been described by Fix (1939).

Minute, and often beautiful, crystals of quartz are found in many Indiana limestones. Priddy (1939) noted such crystals in the Niagaran rocks of southeastern Indiana, and Dawson (1941, p. 19) reported that they compose nearly an entire bed, 1 foot to 3 feet thick, at the base of the Jeffersonville Limestone in eastern and northern Jennings County. Authigenic quartz crystals were also found in this formation in Bartholomew (1) and Cass (1) Counties.

Chert, a cryptocrystalline variety of quartz, is abundant in the sedimentary rock sequence in Indiana. Sweet and Woods (1942) made a petrographic and chemical study of Indiana cherts in concrete aggregates and noted that the cherts contained chalcedony, calcite, dolomite, pyrite, and iron oxides. The distribution of chert in Indiana was studied by Bennett and Barrett (1919). Chert occurs as nodules and lenses and is especially abundant in the Liston Creek, Laurel, and Kenneth Limestones ; the Silver Creek Member of the North Vernon Limestone; and the St. Louis and Ste. Genevieve Limestones. Nodules and irregular masses of dense black chert, or flint, are characteristic of the St. Louis and Ste. Genevieve Limestones in Harrison County (D. D. Owen, 1838, p. 14; Richard

Owen, 1862, p. 154; McGrain, 1943, p. 153, 156). Agate is found chiefly in geodes of the Edwardsville Formation.

Good specimens of quartz have been found in Brown (1), Floyd (1), Harrison (4 and 5), Huntington (1), Jackson (1 and 2), Lawrence (7 and 8), Monroe (3, 5, 6, 10, 17, 18, and 19), Montgomery (1), Owen (2), Putnam (1 and 2), Washington (3, 4, 8, and 9), and White (1) Counties. The occurrence at Monroe (10) was first reported by Fix (1939).

## SIDERITE
$FeCO_3$

Most siderite occurs in Indiana as concretionary nodular masses and lenses admixed with clay and silica (clay ironstone or kidney ore). Well-developed rhombohedral $(10\bar{1}1\}$ crystals, some of which possess curved faces, are found in Jackson (1) and Putnam (6) Counties.

Siderite is associated with the iron oxides, pyrite, aragonite, calcite, dolomite, sphalerite, and quartz. In Pennsylvanian shales it also is commonly associated with bituminous matter and thus is known as "black band ore." It alters to limonite (goethite) or less commonly to hematite. Limonite pseudomorphous after anhedral or euhedral siderite is found in geodes.

Stockdale (1931, p. 89-91, 134-135) reported that siderite occurs with hematite, limonite, and pyrite as concretions, lenses, thin bands, and heavy layers in the New Providence Shale and to a lesser extent in the Locust Point Formation of the Borden Group. It also is found in small concretions in the upper part of the Carwood Formation. It was first noticed in Borden rocks by Owen (1838, p. 21) near New Providence, Clark County. Borden (1874, p. 161-163; 1875b, p. 121) and Cox (1875a, p. 12; 1875b, p. 47) noted that the mineral occurred in Clark, Scott, Floyd, and Jackson Counties. Small scattered occurrences also were found in exposures of the Borden Group in Brown, Lawrence, Monroe, Morgan, and Washington Counties (Logan, 1922a, p. 760).

Small quantities of siderite occur in geodes, on joint surfaces, and in veins of the Harrodsburg Limestone. In northern Monroe County and northeastern Owen County thin veins of siderite transect the beds and cut through quartz geodes of this formation. Siderite occurs in the St. Louis Limestone in Montgomery County (3) and on joint surfaces and in cavities in the Ste. Genevieve Limestone in Putnam County (6).

Much siderite has been found as lenticular or kidney-shaped concretions or as bands in shaly limestones of the upper part of the Chester Series and in shales of Pennsylvanian age. Bundy (1956a, p. 12) reported that siderite had been found in the centers of concretions in the Beech Creek Limestone. Owen (1839) mentioned occurrences in Clay, Fountain, Greene, Knox, Parke, Perry, Vanderburgh, Vermillion, and Warren Counties. Siderite has been found in Brown, Clark, Clay, Crawford, Dubois, Fountain, Floyd, Greene, Jackson (1), Knox, Lawrence, Martin, Monroe (1, 5, 6, 19, and 20), Montgomery (3), Morgan, Orange, Owen (2), Parke, Perry, Pike, Putnam (6), Scott, Spencer, Vanderburgh, Vermillion, Vigo, and Washington (9) Counties.

## SILVER
Ag

Cramer (1811, p. 136) mentioned a silver mine on the north side of the Wabash River in what is now Carroll County. Owen (1839, p. 8-9) described some fruitless efforts of early prospectors to mine silver in Dubois County. A "so-called 'silver mine'" was said to have been located near the junction of the Little Vermillion River and Johnson Creek in Vermillion County (Bradley, 1869, p. 168). Collett (1874d, p. 244) repudiated "tales of French Priests, [who] locate silver and lead mines on Little Pine creek," in Warren County. A popular mineralogical journal of 1885, "The Hoosier Mineralogist and Archaeologist," edited by H. F. Thompson, described (v. 1, nos. 3, 4) a supposed discovery of silver ore near Augusta, Pike County. W. H. Thompson (1889, p. 85) said that "traces of silver have been discovered in some of our limestones...."

As most of these early geologists repeatedly pointed out, however, silver occurred in Indiana only in glacial materials. It was found to be alloyed with gold (Blatchley, 1903b, p. 25) or appeared as a nugget (Hueber, 1946).

## SMYTHITE
$Fe_3S_4$

The first reported occurrence of smythite was from Indiana (Erd, Evans, and Richter, 1957) ; this article listed the properties of the mineral. Smythite occurs as inclusions in calcite, barite, dolomite, and quartz in geodes of the lower part of the Harrodsburg Limestone and the Edwardsville Formation. Pyrrhotite, marcasite, pyrite, millerite, and barite are associated inclusions.

Smythite was found in Monroe (2, 5, 6, 10, 12, and 18) and Jackson (1) Counties. The material from Monroe County (6) was the chief basis for the study by Erd, Evans, and Richter (1957, p. 310). Only minute quantities of this mineral have been found in Indiana.

## SPHALERITE
ZnS

Most of the sphalerite from Indiana is massive, but crystals as large as 20 millimeters were found. On the crystals the most common forms are *a* {100}, *d* {110}, and *o* {111}. Generally, crystals are twinned on *o* {111}, and multiple twinning produces pseudohexagonal symmetry.

Sphalerite is present only in small amounts in any one locality, yet it is widespread in Indiana. The mineral occurs chiefly in Silurian to Mississippian limestones and dolomites and in Pennsylvanian shales. It has been found in association with pyrite, marcasite, millerite, quartz, calcite, dolomite, aragonite, siderite, strontianite, celestite, and barite. Sphalerite that has been partially altered to earthy smithsonite or minute crystals of sulfur was found in Monroe County (5 and 20). Sphalerite has been observed in Ordovician rocks in Wayne County (1). In northern Indiana it occurs in dolomite druses and in quartz geodes in the Mississinewa Shale and also fills cavities in the Liston Creek Limestone. In Devonian rocks sphalerite has been found in cavities in the Jeffersonville Limestone with calcite and dolomite. Sphalerite is found in Mississippian rocks, especially in quartz geodes and on joint and fracture surfaces near the Edwardsville-Harrodsburg contact. It was noted at this horizon in Monroe County by Christy (1848, p. 33). Twinned crystals were found in vugs in the Salem Limestone in Washington County (11). Sphalerite occurs associated with calcite and in many places barite in veinlets in the St. Louis and Ste. Genevieve Limestones. It was found in limonitized fossil wood with barite in the sandstone within the Mansfield Formation in Warren County (1) and also is found in the shale above Coal VI in nodules of siderite, pyrite, or marcasite. Dove (1921) reported that iron sulfide nodules from above Coal VI in Knox County (1) contained sphalerite.

Sphalerite was first reported from Indiana by David Dale Owen in 1839 (p. 29). He found the mineral in siderite concretions in a sandstone in Knox County. Brown (1854, p. 320) and later Bradley (1869, p. 168) mentioned the occurrence of sphalerite in outcrops of shales overlying Coals IV and VI along the Little Ver-

million River, Vermillion County. This mineral also was noted in siderite concretions from the shale above Coal VI in Pike and Warren Counties by Collett (1872c, p. 261, 284; 1874d, p. 214). Richard Owen (1862, p. 60, 67, 165, 174) noted sphalerite in Delaware, Henry, Huntington, Martin, Miami, Wabash, and Warren Counties. Owen described sphalerite (1862, p. 165) associated with "notable quantities of cobalt" from a coal mine 2.5 miles south of Attica, Fountain County. The material described by Owen was analyzed by E. T. Cox, then of the Arkansas Geological Survey, who reported (1869c, p. 116-117) that it contained a notable quantity of remingtonite (a supposed hydrous cobalt carbonate now discredited as a mineral species). Occurrences of sphalerite in Harrodsburg and Borden geodes in Lawrence, Brown, Morgan, and Washington Counties were described by Collett (1874c, p. 278; 1875, p. 86), Brown (1884, p. 81), and Gorby (1886a, p. 133). Collett (1874d, p. 223) reported that there were geodes containing sphalerite in an outcrop of sandstone on Pine Creek, Warren County. Specimens of the mineral from Harrison, Miami, and Tippecanoe Counties are in the S. S. Gorby Collection at Franklin College.

Sphalerite has been found in Bartholomew (1), Delaware, Harrison, Henry, Huntington (1), Jackson (1 and 2), Jasper (1), Jennings (1), Knox (1), Lawrence (1 and 7), Madison (1), Miami, Monroe (3, 5, 6, 7, 8, 9, 10, 11, 16, and 20), Montgomery (2 and 3), Owen (1, 2, 4, and 5), Parke (1), Putnam (1, 2, 3, 5, 6, and 7), Scott (1), Spencer, Tippecanoe, Warren (1 and 2), Washington (2, 4, 6, 7, 9, 10, and 11), Wayne (1), and Wells (2) Counties. The occurrences at Monroe (10) and Putnam (3) were reported by Fix (1939) and Reeves (1950) respectively.

## STRONTIANITE
$SrCO_3$

Strontianite is found in Monroe County (10) as fuzzy white hemispheres that encrust crystals of calcite in pockets in the upper part of the Harrodsburg Limestone. Some strontianite has inclusions of minute cubes of pyrite; other strontianite occurs on crystals of drusy quartz. At other localities the mineral was found associated with calcite, dolomite, quartz, and sphalerite in geodes of the Harrodsburg Limestone or Edwardsville Formation. In a few of these geodes strontianite occurs as an alteration product of celestite. Associated with calcite, dolomite, barite, millerite, and marcasite it has been found in vugs in the Levias Member of the

Ste. Genevieve Limestone in Lawrence County (13). Strontianite has been found in Lawrence (7 and 13), Monroe (7 and 10), and Montgomery (1) Counties.

## SULFUR
S

Stilson in describing southern Indiana wrote (1818, p. 133)

> Many of the springs are strongly impregnated with sulphur, and some of them are saturated with sulphuretted hydrogen. I found the opinion universally prevalent among the people of this state, that the first appearance of these sulphur springs was immediately subsequent to the earthquakes of 1812 [New Madrid]. They say, that then new springs, impregnated with sulphur, broke out, and the waters of some old springs, for the first time, gave indications of this mineral. A sensible farmer, who has a large sulphur-fountain, boiling up from the bottom of a river near its bank, assured me, that there was no trace of this spring until after the period to which I have alluded. He could have no interest to deceive me; and if he did deceive me, his conduct could originate only in that love of the marvellous which is so characteristic of the human mind. He moreover assured me that the "water had been growing weaker, (to use his phrase) ever since its first appearance."

Owen (1839, p. 11 )discredited a so-called "White Sulphur Spring" at French Lick, Orange County, which also was supposed to have been caused by the New Madrid earthquake.

Slight amounts of sulfur, formed by the oxidation of pyrite, have been found associated with Indiana coals (Logan, 1922a, p. 1057). Dove (1919, p. 223) wrote that "gob fires, where combustion is slow, often distill free sulphur from the pyrite, forming miniature fumaroles about which delicate needles of yellow monoclinic sulphur collect."

Priddy (1939, p. 495) found traces of sulfur in Niagaran rocks of southeastern Indiana. Minute euhedra of sulfur, associated with smithsonite, occur as an alteration product of sphalerite in Monroe County (5 and 20).

## WAD
Hydrous manganese oxide

Borden (1875b, p. 132) reported that E. T. Cox found 5 to 7 percent manganese oxide in siderite and limonite concretions in rocks of the Borden Group in Clark, Floyd, and Scott Counties. Logan (1922a, p. 1055-1056) summarized the various occurrences as follows:

> Small quantities of the oxides of manganese have been found in the Kaolin [halloysite] deposits of Indiana. Some of the geode-like concretions in the Mansfield iron ores contain cavities lined with oxides of manganese. The iron

ores of the lower Knobstone [Borden Group] also contain oxides of manganese. Manganese ores have been reported as occurring in deep wells in the southeastern part of the state, but no deposits of economic importance have been found.

Some of the black stain found in geodes weathered from the Harrodsburg Limestone is probably wad, but there is too little material present for positive identification.

## DOUBTFUL AND DISCREDITED MINERAL OCCURRENCES

The following reported mineral occurrences in Indiana have not been described previously in this report because they are doubtful or discredited:

Native bismuth was listed by Cleaveland (1822, p. 682). Richard Owen (1862, p. 113, 165) mentioned reports of "cobalt ore" from Clinton and Warren Counties. Graphite or graphite-like material termed "plumbago" or "black lead" was mentioned in reports on the coals of Indiana (Hobbs, 1872, p. 360, 364-365). Collett (1879, p. 453) noted a "green stain of copper" (malachite) on chert in the St. Louis Limestone near Milltown, Crawford County. Malachite also was reported from Jennings County (1) (Hueber, 1951) ; this latter occurrence, however, is glauconite. Moissanite in the Salem Limestone was reported by Ohrenschall and Milton (1931, p. 96), but it is now believed to have been present owing to contamination (Milton, 1952, oral communication).

Stilson (1818) noted stibnite in Indiana. David Dale Owen (1839, p. 6) stated that "a small specimen of sulphuret of antimony was found in this county [Posey], on a branch of Mackaddo creek at John McGregor's farm; but no body of this ore has yet been discovered." Richard Owen (1862, p. 88) referred to supposed antimony ore that was found about 30 feet below the surface in a well near Vernon, Jennings County. Stibnite also was mentioned by Cleaveland (1822, p. 682), who credited Col. G. Gibbs with the report.

## LIST OF SELECTED LOCALITIES WITH PAGE REFERENCES

[An asterisk indicates those localities examined by the authors.]

Bartholomew County

*1. Meshberger Stone Co. quarry 2 miles northeast of Elizabethtown, NE¼, sec. 6, T. 8 N., R. 7 E. p. 16, 17, 18, 22, 28, 29, 31, 40, 41, 46, 47, 51.

Brown County:
*1. Road cut on Indiana 46, 100 feet north of entrance to Brown County State Park, 2 miles southwest of Nashville, NE¼,NW¼, sec. 35, T. 9 N., R. 2 E. p. 17, 32, 48.

Cass County:
*1. France Stone Co. quarry 2.5 miles east of Logansport, NE¼ sec. 27, T. 27 N., R. 2 E.
p. 15, 16, 17, 18, 20, 22, 31, 32, 40, 41, 46, 47.

Crawford County:
*1. Marengo Cave, northeast edge of Marengo, center NW¼ sec. 6, T. 2 S., R. 2 E.
p. 16, 17, 36, 38.
*2. Road cut on Indiana 62 near Wyandotte Cave, 0.25 mile east of Wyandotte, NW¼, sec. 27, T. 3 S., R. 2 E. p. 27.
3. Saltpetre Cave, 0.3 mile northwest of Wyandotte Cave, NW¼ sec. 28, T. 3 S., R. 2 E.
p. 43.
*4. Wyandotte Cave, at Wyandotte, NE¼ sec. 28, T. 3 S., R. 2 E.
p. 9, 22, 27, 28, 36, 43.

Decatur County:
*1. New Point Stone Co. quarry 1 mile north of New Point, S½SW¼SW¼ sec. 8, T. 10 N., R. 11 E. p. 19, 22, 23, 27, 32, 40, 41, 45, 46.

Floyd County
*1. Floyd County Stone Co. quarry 1 mile southwest of Edwardsville, NE¼NEI¼ sec. 11, T. 3 S., R. 5 E. p. 35, 36, 48.
Fountain County
*1. Morgan Coal Co. pit 3 miles northeast of Kingman, SW¼ SE¼ sec. 20, T. 18 N., R. 7 W.
p. 36, 41, 42, 46.
Harrison County
*1. Louisville Cement Co. quarry at northwest edge of Milltown, SW¼ sec. 10, T. 2 S., R. 2 E.
p. 27, 29.

*2. Road cut on Indiana 62, 5 miles west of Corydon, SW¼NE¼ sec. 20, T. 3 S., R. 3 E.
p. 18, 22, 27, 29.
*3. Road cut on Indiana 62, 5.1 miles west of Corydon, NE¼SW¼ sec. 20, T. 3 S., R. 3 E.
p. 17, 26, 27, 29.
*4. Corydon Stone Co. quarry (abandoned) 2.5 miles southwest of Lanesville, NE¼SW¼ sec. 25, T. 3 S., R. 4 E. p. 22, 48.
*5. Corydon Stone Co. quarry at northwest edge of Corydon, SE¼SE¼ sec. 25, T. 3 S., R. 3 E. p. 22, 27, 29, 48.

Huntington County:
*1. Erie Stone Co. quarry at east edge of Huntington, SE¼SW¼ and SW¼SE¼ sec. 12, T. 28 N., R. 9 E. p. 22, 27, 40, 41, 46, 48, 51.

Jackson County:
*1. Seymour Gravel Co. quarry (abandoned) 2 miles northwest of Medora, SE¼SE¼ sec. 29, T. 5 N., R. 3 E. p. 19, 27, 41, 47, 48, 49, 50, 51.
*2. Old abandoned quarry immediately west of the Seymour Gravel Co. quarry (see above), SW¼SE¼ sec. 29, T. 5 N., R. 3 E.
p. 19, 27, 41, 45, 48, 51.
3. Sparksville Quarry, 1 mile east of Sparksville, SE¼NE¼ sec. 18, T. 4 N., R. 3 E.
p. 42, 43.

Jasper County:
*1. Babcock Construction Co. quarry at southeast edge of Rensselaer, SE¼SE¼ sec. 30, T. 29 N., R. 6 W. p. 22, 46, 51.

Jefferson County:
*1. Cut along the Pennsylvania Railroad at north edge of Madison, NE¼SW¼ sec. 34, T. 4 N., R. 10 E. p. 19, 21, 22, 27.

Jennings County:
*1. Paul Frank Quarry, northeast edge of North Vernon, NE¼ sec. 34, T. 7 N., R. 8 E.
p. 16, 19, 22, 26, 27, 31, 32, 45, 46, 51, 53.

Knox County:

1. Bicknell Coal Co. (Pan Handle Mine), 2.5 miles southwest of Bicknell, SE¼ Block 142, Washington Township. p. 50, 51.

Lawrence County:

*1. Ralph Rogers Co. quarry 2 miles southwest of Springville, SE¼SE¼ sec. 29, T. 6 N., R. 2 W. p. 14, 15, 36, 51.

*2. Webster Quarry (abandoned), 3.5 miles southwest of Springville, SW¼NE¼ sec. 31, T. 6 N., R. 2 W. p. 17, 18, 19, 42, 43.

*3. Outcrop along the Leesville Road 0.5 mile south of U. S. 50 and 2 miles northwest of Leesville, SE¼NE¼ sec. 17, T. 5 N., R. 2 E.
p. 19.

*4. Outcrop in drainage ditch along Indiana 58, 3 miles northeast of Bedford, SW¼SE¼ sec. 5, T. 5 N., R. 1 E. p. 19.

*5. Williams Limestone Co. quarry (abandoned) at east edge of Bedford, NW¼NE¼ sec. 24, T. 5 N., R. 1 W. p. 21, 22.

6. Dry Cave, 2.5 miles southwest of Oolitic. Entrance on side of hill in the NE¼ sec. 12, T. 5 N., R. 2 W. p. 44.

*7. Abandoned quarry and cut along the Baltimore and Ohio Railroad 2 miles southeast of Buddha, NE¼NW¼ sec. 23, T. 4 N., R. 1 E.
p. 17, 18, 19, 22, 23, 48, 51, 52.

*8. Lehigh Portland Cement Co. quarry 2 miles northeast of Mitchell, S½ sec. 30, T. 4 N., R. 1 E. p. 15, 20, 22, 23, 35, 36, 40, 41, 48.

9. Donaldson's (Donnelson's) Cave, Spring Mill State Park, 2 miles east of Mitchell, SW¼ sec. 33, T. 4 N., R. 1 E. p. 44.

*10. Cut at the overhead cross of Indiana 450 over the Chicago, Milwaukee, and St. Paul Railroad 1 mile west of Williams, SE¼SW¼ sec. 6, T. 4 N., R. 2 W. p. 19.

11. Connelly's (Connerly's) Cave, 1.5 miles east of Huron. Entrance at foot of hill in sec. 4, T. 3 N., R. 2 W. p. 44.

*12. Cut along the Baltimore and Ohio Railroad 1 mile east of Huron, S½ sec. 5, T. 3 N., R. 2 W. p. 32, 35, 36.
*13. Nally, Ballard, and Cato quarry 0.5 mile west of Georgia, SE¼NE¼ and NE¼SE¼ sec. 12, T. 3 N., R. 2 W. p. 18, 19, 27, 43, 52.

Madison County:
*1. Standard Materials Corp. quarry at northwest corner of Lapel, E½NW¼ and W½NE¼ sec. 28, T. 19 N., R. 6 E. p. 20, 22, 51.

Miami County:
1. Outcrop along Big Pipe Creek 1 mile north of Bunker Hill, SW¼NE¼SW¼ sec. 29, T. 26 N., R. 4 E. p. 45.

Monroe County:
*1. Road cut on new Indiana 37, 7.5 miles north of Bloomington, NE¼SE¼ sec. 21, T. 10 N., R. 1 W. p. 19, 43, 49.
*2. Road cut on new Indiana 37, 5.25 miles north of Bloomington, SE¼SW¼ sec. 33, T. 10 N., R. 1 W. p. 50.
*3. Abandoned quarry 0.5 mile east of Unionville on Indiana 45, NW¼SW¼ sec. 10, T. 9 N., R. 1 E. p. 19, 22, 27, 32, 43, 46, 47, 48, 51.
*4. Abandoned quarry just north of the west end of the tunnel for the Illinois Central Railroad 1 mile west of Unionville, SE¼NW¼ sec. 8, T. 9 N., R. 1 E. p. 43.
*5. Road cut on new Indiana 37, 5 miles north of Bloomington, NE¼NW¼ sec. 4, T. 9 N., R. 1 W. p. 17, 19, 20, 22, 27, 28, 32, 43, 47, 48, 49, 50, 51, 52.
*6. Road cut on new Indiana 37, 2 miles north of Bloomington, NW¼SW¼ and SW¼NW¼ sec. 21, T. 9 N., R. 1 W. p. 16, 19, 27, 31, 32, 43, 46, 47, 48, 49, 50, 51.
*7. Small abandoned quarry 1.8 miles east of Bloomington on Indiana 45, sec. 25, T. 9 N., R. 1 W. p. 19, 43, 51, 52.
*8. Outcrop in small tributary to Griffys Creek 1 mile north of Bloomington, SW¼NW¼ sec. 27, T. 9 N., R. 1 W. p. 51.

*9. Outcrop and wash in small stream near University Reservoir at northeast edge of Bloomington, SE¼NW¼ sec. 34 and NE¼SW¼ sec. 27, T. 9 N., R. 1 W.
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*10. Bloomington Crushed Stone Co. quarry 0.5 mile north of Bloomington, SW¼NW¼ sec. 28, T. 9 N., R. 1 W.
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*11. Exposure in temporary excavation, Indiana University Campus, Bloomington, NE¼SW¼ sec. 33, T. 9 N., R. 1 W. p. 51.

*12. Road cut on Indiana 46 (Stobo bioherm) 5 miles east of Bloomington, SW¼NE¼ sec. 4, T. 8 N., R. 1 E. p. 19, 22, 50.

*13. Road cut on Indiana 37 south of Monon Railroad overhead bridge 0.5 mile southeast of Clear Creek, SW¼NW¼ sec. 28, T. 8 N., R. 1 W.
p. 19.

14. Saltpetre Cave, 4 miles southwest of Bloomington, NW¼ sec. 15, T. 8 N., R. 2 W.
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15. Ellers Cave, 5 miles southwest of Bloomington near the Illinois Central Railroad, SW¼ sec. 15, T. 8 N., R. 2 W.
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*16. Abandoned quarry on Ketchem Road 2.75 miles west of Smithville, SW¼NE¼ sec. 6, T. 7 N., R. 1 W.
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*17. Smithville Quarry (abandoned), 1 mile southeast of Smithville, SW¼NW¼ sec. 11, T. 7 N., R. 1 W.
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*18. Road cut on Indiana 37, 0.75 mile north of Harrodsburg, NW¼SE¼ sec. 20, T. 7 N., R. 1 W.
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*19. Road cut on Indiana 37 at the south edge of Harrodsburg, W½SE¼NE¼ sec. 29, T. 7 N., R. 1 W.
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*20. Road cut on Indiana 37 south of the bridge over Clear Creek 1.25 miles south of Harrodsburg, NE¼SW¼ sec. 32, T. 7 N., R. 1 W.
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*21. Quimby and Stephen Quarry, 2 miles south of Stanford, SW¼SE¼ sec. 6, T. 7 N., R. 2 W.
p. 41, 46.
*22. Mr. H. F. Rogers' farm 2.5 miles southwest of Harrodsburg, SW¼NW¼ sec. 36, T. 7 N., R. 2 W.
p. 38.

Montgomery County:
*1. New Ross Limestone Co. quarry 1.5 miles southwest of New Ross, NE¼NE¼ sec. 3, T. 17 N., R. 3 W.
p. 19, 42, 43, 48, 52.
*2. Parkersburg Quarry (abandoned), 0.5 mile north of Parkersburg, S½NW¼NW¼ sec. 32, T. 17 N., R. 4 W.
p. 51.
*3. Waveland Stone Co. quarry 2 miles southwest of Waveland, SE¼SW¼ sec. 34, T. 17 N., R. 6 W.
p. 17, 19, 32, 38, 48, 49, 51.

Morgan County:
*1. Brooklyn Shale Co. pit 0.5 mile southwest of Brooklyn, NE¼NE¼ sec. 35, T. 13 N., R. 1 E.
p. 19, 35, 36, 42.
*2. Road cut on Indiana 67 near junction with Indiana 39, 1 mile west of Martinsville, NE¼SW¼ sec. 32, T. 12 N., R. 1 E.
p. 24, 41, 42.

Orange County:
*1. Radcliff and Berry, Inc. quarry 1 mile northwest of Orleans, SW¼SE¼ sec. 24, T. 3 N., R. 1 W.
p. 19.

Owen County:
*1. Cut on secondary road 2 miles north of Gosport, NE¼NE¼ sec. 29, T. 11 N., R. 2 W.
p. 51.
*2. Cut near railroad station at southeast corner of Gosport, NE¼SW¼ sec. 32, T. 11 N., R. 2 W.
p. 48, 49, 51.
*3. Dunn Limestone Co. quarry 3.5 miles northeast of Spencer, NE¼SW¼ sec. 10, T. 10 N., R. 3 W.
p. 23.

*4. Abandoned quarry at the junction of Indiana 46 and secondary road to Gosport 4 miles east of Spencer, SE¼SE¼ sec. 24, T. 10 N., R. 3 W.
p. 19, 41, 45, 51.
*5. Outcrop along McCormicks Creek, McCormicks Creek State Park, NE¼, sec. 22, T. 10 N., R. 3 W.
p. 51.
*6. France Stone Co. quarry 1 mile southwest of Spencer, NE¼ sec. 30, T. 10 N., R. 3 W.
p. 35, 36.
*7. Hahn Brothers Quarry, 3 miles southwest of Freedom, SW¼SE¼ sec. 31, T. 9 N., R. 4 W. p. 38.

Parke County:
*1. Wallace Quarry (abandoned), 3 miles east of Grange Corner, NE¼ sec. 7, T. 17 N., R. 6 W.
p. 19, 23, 27, 51.

Perry County:
*1. Lutring and Sons Quarry, 0.6 mile east of Branchville, SE¼ sec. 18, T. 4 S., R. 1 W.
p. 17, 22, 36, 41.
*2. Scheeler Quarry, 1 mile northeast of Derby, NW¼SE¼ sec. 33, T. 5 S., R. 1 W.
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*3. Road cut on Indiana 66, 0.75 mile east of Troy, NW¼SE¼ sec. 13, T. 6 S., R. 4 W.
p. 28, 42.

Pike County:
*1. Enos Coal Mining Co. pit 2 miles northwest of Spurgeon, SW¼NW¼ sec. 2, T. 3 S., R. 8 W.
p. 41, 42, 46.

Pulaski County:
*1. Francesville Stone Co. quarry 2 miles south of Francesville, NE¼SW¼ sec. 16, T. 29 N., R. 4 W.
p. 42, 45, 46.

Putnam County:
*1. Russellville Stone Co. quarry 0.5 mile south of Russellville, NW¼SE¼ sec. 8, T. 16 N., R. 5 W.
p. 19, 41, 46, 48, 51.

*2. Abandoned quarry 4 miles south of Russellville, center SE¼ sec. 28, T. 16 N., R. 5 W.
p. 48, 51.
3. Big Walnut Creek, 5 miles northeast of Greencastle, T. 15 N., R. 4 W.
p. 19, 26, 46, 51.
*4. Midwest Rock Products Corp. quarry (abandoned) at east edge of Greencastle, center sec. 22, T. 14 N., R. 4 W.
p. 41.
*5. Ohio and Indiana Stone Co. quarry 1 mile southwest of Greencastle, junction of secs. 19, 20, 29, and 30, T. 14 N., R. 4 W.
p. 27, 51.
*6. Lone Star Cement Co. quarry 0.25 mile southeast of Limedale, junction of secs. 28, 29, 32, and 33, T. 14 N., R. 4 W.
p. 18, 48, 49, 51.
*7. Indiana State Farm quarry 1 mile southwest of Putnamville, NW¼SW¼ sec. 17, T. 13 N., R. 4 W.
p. 51.

Ripley County:
*1. Road cut on Indiana 129, 6 miles south of Versailles, NE¼NW¼ sec. 8, T. 6 N., R. 12 E.
p. 19, 22.

Rush County:
*1. Rush County Stone Co. quarry at west edge of Moscow, W½ SE¼ sec. 18, T. 12 N., R. 9 E.
p. 22, 46.

Scott County:
*1. Scott County Stone Co. quarry 2 miles south of Blocher, NE¼NW¼ sec. 20, T. 3 N., R. 8 E.
p. 27, 51.

Shelby County:
*1. Cave Stone Co. quarry 0.5 mile west of Morristown, NE¼NW¼ sec. 32, T. 11 N., R. 7 E.
p. 22, 29.

Spencer County:
*1. Road cut on Indiana 70, 0.2 mile west of junction with Indiana 66, 2.5 miles west of Maxville, SE¼SW¼ sec. 9, T. 6 S., R. 4 W.
p. 23, 24.

Switzerland County:
*1. Tri-County Stone Co. quarry 3 miles northwest of Bennington, NE¼NW¼ sec. 9, T. 5 N., R. 12 E.
p. 19.

Wabash County:
*1. Abandoned quarry in reef near Rich Valley 3 miles west of Wabash, SE¼NE¼ sec. 13, T. 27 N., R. 5 E.
p. 21, 22, 40, 41.

Warren County:
*1. Bluff along Mud Pine Creek 1.5 miles west of Rainsville, SW¼NE¼ sec. 29, T. 23 N., R. 8 W. p. 19, 50, 51.
*2. Small coal mine on north side of Indiana 63, 4.5 miles south of West Lebanon, SW¼SW¼ sec. 2, T. 20 N., R. 9 W.
p. 51.

Washington County:
*1. Abandoned quarry on the west side of Indiana 135 at north edge of Plattsburg, SW¼SW¼ sec. 4, T. 3 N., R. 4 E.
p. 19.
*2. Cut along the Monon Railroad at south edge of Harristown, west line SE¼ sec. 24, T. 2 N., R. 4 E.
p. 51.
*3. Ralph Rogers Co. quarry (abandoned) 1 mile south of Salem, NW¼SE¼ sec. 20, T. 2 N., R. 4 E.
p. 23, 36, 48.
*4. Cut for dam spillway 2 miles south of Salem on the east side of Indiana 135, NW¼NE¼ sec. 32, T. 2 N., R. 4 E.
p. 19, 48, 51.
*5. Outcrop in small stream 1.75 miles west of Salem, SW¼SW¼
sec. 12, T. 2 N., R. 3 E.
p. 45.
*6. Salem Lime and Stone Co. quarry (abandoned) 1 mile west of Salem, SW¼SE¼ sec. 13, T. 2 N., R. 3 E.
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*7. Hoosier Lime and Stone Co. quarry 0.7 mile west of Salem, NE¼ sec. 24, T. 2 N., R. 3 E.
p. 36, 51.
*8. Road cut on Indiana 60, 3 miles northwest of Pekin, SW¼NE¼ sec. 2, T. 1 N., R. 4 E.
p. 48.

*9. Road cut on Indiana 60 immediately south of locality 8 (above), 3 miles northwest of Pekin, NW¼SE¼ sec. 2, T. 1 N., R. 4 E.
p. 16, 17, 48, 49, 51.
*10. Small abandoned quarry 1.25 miles west of Pekin, SW¼SE¼ sec. 22, T. 1 N., R. 4 E.
p. 19, 29, 35, 51.
*11. Abandoned quarry 2.25 miles west of Pekin, SW¼SE¼ sec. 21, T. 1 N., R. 4 E.
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*12. Abandoned quarry on the west side of Indiana 135, 4 miles southwest of Pekin, SE¼SE¼ sec. 5, T. 1 S., R. 4 E.
p. 36.

Wayne County:
*1. DeBolt Quarry, 3 miles southeast of Richmond, NE¼SW¼ sec. 11, T. 13 N., R. 1 W.
p. 15, 16, 18, 19, 22, 31, 32, 50, 51.
*2. Abandoned quarry immediately west of bridge of Indiana 227 over Elkhorn Creek 2.25 miles northwest of Boston, NE¼SW¼ sec. 22, T. 13 N., R. 1 W.
p. 19.

Wells County:
*1. Erie Stone Co. quarry 1.5 miles north of Bluffton, SW¼ NW¼ sec. 28, T. 27 N., R. 12 E.
p. 27, 41, 45, 46.
*2. Heller Stone Co. quarry 7 miles west and 1 mile north from Bluffton, NW¼SE¼ sec. 29, T. 27 N., R. 11 E.
p. 22, 24, 32, 36, 40, 41, 42, 45, 46, 51.

White County:
*1. Monon Crushed Stone Co. quarry 1 mile south of Monon, SE¼NE¼ sec. 28, T. 28 N., R. 4 W.
p. 46, 48.

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[Substances fully described are shown in capital letters.]