COMMON ROCKS, MINERALS, AND FOSSILS FOUND IN INDIANA

by

NED M. SMITH, ARTHUR C. BROOKLEY, JR.,
AND DUNCAN J. MCGREGOR

Indiana Department of Conservation
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INTRODUCTION

Rocks, minerals, and fossils of Indiana are the foundation, directly or indirectly, of the economic well-being of the state. Utilization of rocks, minerals, and fossils has contributed to the development of civilization. Those persons who have the ability, initiative, and vigor to utilize the earth's mineral resources advantageously are most likely to progress and prosper.

One of the responsibilities of the Indiana Geological Survey is the investigation of mineral wealth within the state. Not only should the citizens of Indiana be informed about these resources, but also people in other states should know that Indiana is a mining, as well as an agricultural and a manufacturing, state.

Because of rather extensive exploitation of limestone, dolomite, clay, shale, sand, gravel, coal, water, and oil resources in Indiana, more people are becoming aware that the science of geology exists and that much can be gained by an understanding of it. The interest of Hoosiers, as well as other people, in Indiana's rocks, minerals, and fossils is revealed both by the many inquiries received by the Geological Survey for information concerning Indiana's mineral resources and by the specimen samples sent to the Survey for identification. This circular has been prepared, therefore, primarily to accompany a set of common rocks, minerals, and fossils found in Indiana. These specimens are described in some detail in nontechnical terms in order that students in secondary schools, amateur collectors, scout organizations, and other interested persons and groups can become familiar with them.

The authors can neither cover fully in this brief report all characteristics and variations of any given specimen nor describe in detail the infinite varieties of each rock, mineral, and fossil found in Indiana. For special information regarding Indiana geology, the reader should consult the more detailed reports of the Geological Survey and its predecessors. The staff of the Indiana Geological Survey hope that the study of specimen rocks, minerals, and fossils will help in answering some of the questions about Indiana geology.

ROCKS

Definition and classification

Rocks are naturally occurring substances composed of one or more minerals that form an essential part of the earth's crust. Rocks are classified according to origin as igneous, metamorphic, or sedimentary.

Igneous rocks are formed from molten rock or magma. They vary extremely in chemical composition, color, and texture (the physical characteristic determined by the size and arrangement of the mineral grains found in the rock).

Metamorphic rocks are formed by changing the physical or chemical character of other rocks. These changes are caused by heat, pressure, and hot and cold solutions. Metamorphic rocks vary as much as igneous rocks in chemical composition, color, and texture and have a distinctive appearance.

Six deep holes drilled in Indiana show that igneous and metamorphic rocks may be found beneath the surface, but no native igneous and metamorphic rocks are found at the surface. Glacial materials that cover most of Indiana contain various-sized fragments of igneous and metamorphic rocks, but these rocks were carried down from the north by the advancing ice sheets.

Sedimentary rocks are transported and deposited by water, wind, and ice. All native rocks in Indiana that we see and use are of sedimentary origin. Even the glacial materials that contain large amounts of igneous and metamorphic rock fragments were deposited in Indiana by sedimentation. Not all sedimentary rocks are hard and compact; some are loose and friable.

Sedimentary rocks are divided into three subclasses: fragmental, precipitated, and organic. A single rock type, such as limestone, may belong to one subclass or more, according to the manner in which it was formed.

Geologists commonly refer to fragmental rocks as clastics and further divide and name them according to particle size. For example, conglomerates are composed of cemented pebbles; sandstones of cemented sand grains; shales of compacted muds or clays; and siltstones of compacted, fine sands and muds. If these materials are not cemented or compacted, they are called, according to fragment size, gravel, sand, silt, or clay.

Precipitated rocks are formed either by the evaporation of mineral-bearing water or by some physical or chemical change within the mineral-bearing water. Limestone, dolomite, rock salt, gypsum, and chert are common rocks formed by precipitation.

Such rocks as coal and some limestones have been formed by the accumulation of organic remains. Coal is formed from plant remains from which most of the water and gases have been eliminated by pressures created by the overlying rocks. Organic limestones are formed from the accumulation of shell fragments; these limestones also may be called clastic (fragmental).

Texture

Texture (physical appearance) of a rock is expressed in terms of crystallinity, granularity, and fabric. Crystallinity is concerned with the extent to which crystals are formed; granularity expresses the size of crystals or grains of a rock; and fabric describes the interrelationship of crystals, grains, or other constituents. Thus, rocks of the same general composition and origin may be described differently according to texture.

Composition and utilization of Indiana's rocks

As the glacial materials in Indiana consist of fragments of many rock types, the mineral composition of these materials varies greatly. Glacial materials are used as the source of sand and gravel for road metal and construction aggregate.[1] Some glacial silts and clays are used in manufacturing bricks, drain tile, and other ceramic products.

Fragmental rocks are composed mainly of silica and varying amounts of iron oxide, alumina, and oxides of other metals. A sandstone that contains less than 1 or 2 percent of impurities, that is, components other than silica, is classed as high-silica sandstone; it is used in manufacturing clear glass. Colored glass is manufactured from Indiana's sands and sandstones. Bricks, tile, and other ceramic products are made from Indiana's fine-grained clastics, such as clay and shale. Sandstone is quarried and used as dimension stone in Indiana. Shale is used as a source of silica and alumina in manufacturing cement, and certain shales are used in making rock wool.

Precipitated rocks are subdivided into carbonates and noncarbonates. Carbonate rocks effervesce if a small amount of dilute hydrochloric acid is dropped on them, whereas noncarbonate rocks do not effervesce. Marl, limestone, and dolomite are Indiana's carbonate rocks; chert and gypsum are its precipitated noncarbonate rocks.

Marl is a fresh-water deposit consisting of calcium carbonate, silt, and some organic material. Limestone contains calcium carbonate and varying amounts of magnesium carbonate, aluminum oxide, iron oxide, silicon dioxide, titanium dioxide, and traces of many other elements. Dolomite is a double carbonate of calcium and magnesium and minor trace constituents. As the amount of magnesium in limestone increases, the carbonates change from pure limestones to dolomitic limestones and from dolomitic limestones to true dolo-

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[1] Sand and gravel, other than those from glacial materials, are found in stream valleys. These deposits, formed by the disintegration and transportation of bedrock and previously existing glacial materials, are fragmental sediments.

mites or dolostone.[2] Carbonate rocks are used for road metal, construction aggregate, cement, flux stone, agricultural lime, and as a source of calcium, calcium oxide, and pure calcium carbonate for chemical industries. Indiana has much limestone and dolomite suitable for all these uses.

Many rocks in Indiana contain beds, lenses, and ball-like masses of chert. Quartz is a crystalline silica mineral precipitated from silica-rich solutions. Chert, also called flint, is a silica mineral composed of quartz crystals so small that they can be seen only with the aid of a microscope.

Gypsum (hydrated calcium sulphate) is found in surface rocks in Indiana largely in the form of nodules or ball-like masses. Gypsum and anhydrite (dehydrated calcium sulphate) are reported to occur in beds from 300 to 600 feet beneath the surface in Martin County. Gypsum is used in the raw (uncalcined) state as a retarder in cement and for agricultural purposes. When gypsum is calcined,[3] it is used for plate glass and terra-cotta plasters, pottery plasters, orthopedic and dental plasters, base coat, sand gauging plasters, wallboard, sheathing board, and tile.

Rock salt is not known to exist either at the surface or in subsurface rocks in Indiana, but brines are found in wells drilled in many parts of the state. Early settlers in Indiana evaporated brines to obtain salt.

Coal is an organic rock composed of consolidated, carbonized vegetal matter and impurities. When coal is burned, gases and heat are given off and the impurities are left as ash. The quality of a particular coal is determined by the amount of ash and by the amount of heat produced in burning.

Peat, a beginning stage in the transformation of organic material into coal, is found in the glaciated area of Indiana. It is used by horticulturists and others to improve poor soils. Anthracite, a metamorphic coal, is not found in Indiana, but many grades of bituminous coal are mined for use by railroads and electric generating plants and for space heating. Coking coal (metallurgical coal) has been produced also from coal mined in Indiana.

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[2] Rocks composed of a single mineral are referred to commonly by the mineral name. Thus, the terms dolomite, chert, and gypsum are used both as mineral and rock names. Dolostone is sometimes used for a rock that is composed mostly of the mineral dolomite.

[3] When gypsum is subjected to heat most of its chemically combined water is driven off. This process is referred to as calcination and the product as calcined gypsum. The common trade name for calcined gypsum is plaster of paris.

Organic limestone and dolomite, similar in composition to other limestones and dolomites, are found in Indiana. Reef rocks, largely dolomite, are quarried in northern Indiana for the same purposes as other limestones and dolomites, and a special organic limestone found in Indiana is quarried for building stone and dimension stone. This limestone also is classified as clastic, that is, the fossil shells that formed the limestone probably were transported and deposited in a similar manner as sand is transported and deposited to form sandstone.

Petroleum and natural gas are obtained from such sedimentary rocks found in Indiana as sandstone, shale, limestone, dolomite, and reef rock.

Water is found in all bedrock in Indiana, in glacial materials, and in streams and lakes. In order that water may be obtained from drilled or dug wells, it must be contained in rock or in unconsolidated materials that are both porous (capable of holding water) and permeable (capable of permitting water to move through). Even a rock which does not satisfy these requirements may furnish ample water supplies if it is cracked, fissured, or shattered, either naturally or artificially. Shale, clay, siltstones, some limestones, and well-cemented sandstones commonly do not produce water because they are impermeable. As water taken from most limestone is salty and hard, it is unfit to drink.

Distribution, relationship, and age of Indiana's rocks

The simplified geologic time scale (fig. 1) shows the major divisions of geologic time. This time scale is arranged so that the oldest rocks are shown at the bottom; the more recent rocks are at the top. The rocks laid down during a geologic period are divided into mappable units, commonly on the basis of lithology; these units are called formations. For example, if a hole was drilled near Vincennes, the drill would begin in glacial material and penetrate rock belonging to all rock periods from the Pennsylvanian down to the pre-Cambrian, as shown in figure 1.

A generalized geologic map of Indiana (fig. 2) shows the distribution of bedrock formations that lie beneath Recent stream and lake deposits and glacial materials. The only rock exposed north of the Illinoian glacial boundary is in quarries and along streams that have carried the covering materials away. As there are few rock exposures north of the Wisconsin glacial boundary, the little that is known about bedrock in that part of Indiana is derived from samples taken in quarries and from oil and water wells drilled into the rock.

Use of geologic maps, which show the trend (strike) of various rock formations, in conjunction with topographic maps, which show the relationship of valleys, hills, streams, etc. by means of contour lines (lines connecting points of the same altitude), enables one to determine the relative size, altitude, and shape of rock bodies many hundreds of feet below the surface. Although indications of valuable resources may not be apparent on the earth's surface, a geologic map is most useful as an aid in locating oil accumulations, water supplies, coal, iron, limestone, clay, sand and gravel, and other valuable substances hidden below the cover of soil and rock. The geologic map also is most useful in studying the history of mountain ranges, the evolution of fossil organisms, the changes in climate, and the history of the earth itself.

Structurally high and low areas are formed when portions of the earth move upward, downward, or horizontally. In fact, movements of the earth have occurred many times in the past and are taking place today. The relationship between the structurally high or positive features (commonly known as domes, arches, and uplifts) and the structurally low or negative features (commonly known as geosynclines or basins) is shown in figure 5. The profile (fig. 4) shows this relationship diagrammatically. The generalized cross section (fig. 3) shows the relationship between the various rock systems and the positive and negative areas. One should note that the rocks dip into the structurally low areas (the Michigan and Illinois Basins and the Appalachian geosyncline). Thus, west and southwest of the Cincinnati Arch and the positive area that extends across northern Indiana the rocks dip westward into the Illinois Basin. East of the Cincinnati Arch the rocks dip into the Appalachian geosyncline, and north of the positive area in northern Indiana the rocks dip northward into the Michigan Basin.

MINERALS

A mineral is a naturally occurring inorganic substance that has distinctive physical and chemical properties. In addition, many minerals possess definite geometric or crystalline forms.

Although many minerals are found in Indiana, only a few are found in large quantities. Calcite, quartz, and clay minerals are the most abundant. Other minerals are widely dispersed, are deeply buried, or are in extremely small grains. Therefore, only an expert by means of hard labor and diligent searching can find most of the minerals in Indiana.

A distinction is made between minerals that occur in clay size (less than 2 microns in diameter), such as quartz and calcite, and the clay minerals. A clay mineral is a crystalline substance consisting essentially of impure hydrous aluminum silicate, is never larger than clay size, and is restricted in its chemical composition.

ERAS	PERIODS	ESTIMATED LENGTH IN YEARS	TYPE OF ROCK	ECONOMIC PRODUCTS
CENOZOIC	Quaternary	1,000,000	Glacial drift; river and lake silts, sands, and gravels; dune sand; loess; soils; marl; peat.	Sand and gravel for road metal, construction aggregate, miscellaneous uses; sand and silt for foundry industry; clay for ceramic products; marl and peat.
	Tertiary	59,000,000	Only deposits known in Indiana are unconsolidated sands and cherty gravels thought to be late Tertiary in age.	Sand.
MESOZOIC	Cretaceous	80,000,000		
	Jurassic	35,000,000		
	Triassic	25,000,000		
PALEOZOIC	Permian	40,000,000		
	Pennsylvanian	40,000,000	Alternating shale, sandstone, limestone; coal.	Coal, oil, gas, shale for ceramic products; dimension sandstone; minor limestone for agricultural lime and construction aggregate.
	Mississippian	30,000,000	Upper part: Alternating sandstone, shale, limestone. Middle part: Limestone, some shale, chert, dolomite. Lower part: Siltstones, shales, some limestone.	Limestone for road metal, construction aggregate, agricultural and chemical lime, and cement; dimension limestone; shale for ceramic products and cement; oil and gas.
	Devonian	40,000,000	Upper part: Black shale. Lower part: Limestone and dolomite.	Limestone and dolomite for construction aggregate, road metal, agricultural lime, limestone for cement; oil and gas.
	Silurian	30,000,000	Limestone, dolomite, shale; chert.	Limestone and dolomite for construction aggregate, road metal, agricultural lime; oil and gas; shale for rock wool.
	Ordovician	70,000,000	Upper part: Limestone, shale, shaly limestone. Limestone, shale, sandstone, cherty dolomite.*	Oil and gas; minor limestone for agricultural lime, road metal, and construction aggregate.
	Cambrian	90,000,000	Shale, sandstone, shaly dolomite.*	
PRE-CAMBRIAN		1,500,000,000	Marble and other metamorphic rocks; granite and other igneous rocks.*	

*Not exposed at surface in Indiana

Figure 1. *Simplified geologic time scale showing the major divisions of geologic time.*

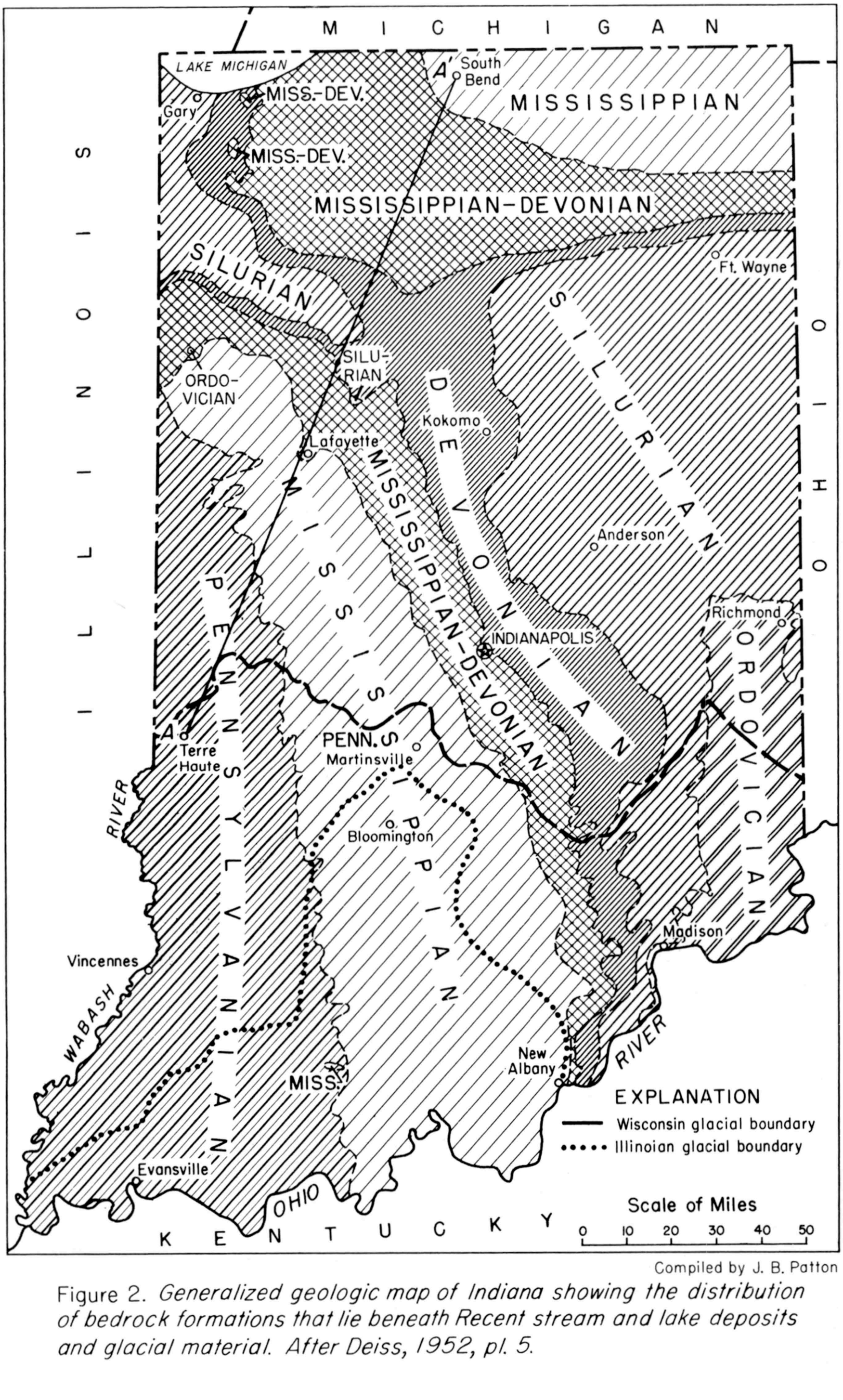

Figure 2. *Generalized geologic map of Indiana showing the distribution of bedrock formations that lie beneath Recent stream and lake deposits and glacial material. After Deiss, 1952, pl. 5.*

Clay minerals are found in shales, silts, and clays in Indiana and are necessary materials for making ceramic products. Rather extensive deposits of a clay mineral that is similar to the kaolin mineral group has been found along the boundary between the Pennsylvanian and Mississippian rocks in Martin, Lawrence, Monroe, and Greene Counties.

FOSSILS

Definition and characteristics

Fossils are either the remains or undeniable traces of plants and animals that lived in the geologic past and that have been preserved in the rocks of the earth's crust. To be considered a fossil, an object must furnish some evidence that it is the remains of an animal or plant that once lived, it must give some indication of the character (size, shape, structure, ornamentation, etc.) of either part or all of the plant or animal, and finally it must be of an age older than the present time unit.

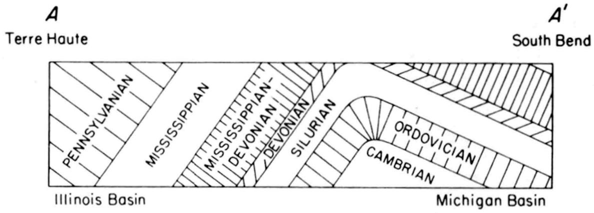

Figure 3. *Cross section along line A-A', figure 2, showing the relationship between the various rock systems and the positive and negative areas.*

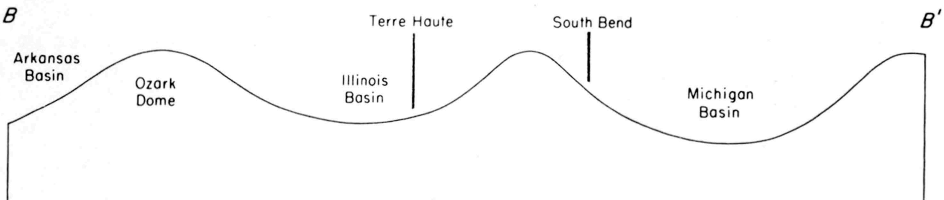

Figure 4. *Profile along line B-B', figure 5, showing the relationship between positive and negative areas.*

The actual remains of many organisms either decay or are dissolved; that which is left behind is called a mold. If the mold is filled with some material, replicas (or casts) of the original organism are formed.

Tracks, trails, footprints, burrows, tubes, and borings are impressions that animals have left as they traveled over or through mud and sand bottoms. These markings were covered rapidly by sediment, and thus they now are preserved in rock. Even though no part of the animal remains, the fact that the impressions are of organic origin cannot be denied, and, therefore, these impressions are regarded as fossils.

The study of fossils is called paleontology, and the scientist who studies fossils is called a paleontologist.

Mode of preservation

Unaltered.--Most animals and plants undergo changes during fossilization and are altered by mineral substances. A few fossils consist of the hard parts of an animal or the woody tissue of a plant that are preserved unaltered in the sediment in which they are buried. Examples of animal remains that have been preserved unaltered are the bones and especially the teeth of mammals, fishes, and reptiles.

Altered.--Hard parts of many animals, notably the bones or shell, have a pitted or roughened surface caused by a slight dissolution of the original material. This kind of alteration is called leaching or weathering. Many shells or bones are invaded by ground water carrying lime (calcium carbonate) in solution. Lime is deposited in the pores and open spaces of the shell and later crystallizes into the mineral calcite without altering the original shell or skeletal material. This process is termed infiltration by calcite. The original material of an organism may be either partly or completely dissolved and at the same time may be replaced by chemical substances that are carried and deposited by ground water. These chemical substances later crystallize into minerals. In this process, called either silicification or pyritization according to the nature of the replacing mineral substance, the minute structure may be destroyed but the form of the organism is preserved. Carbonization takes place when water and gases escape as the animal or plant decays; only a mass or film of carbon is left behind.

Classification

The organic world consists of two kingdoms: plants and animals. These kingdoms are divided into smaller and smaller units until the

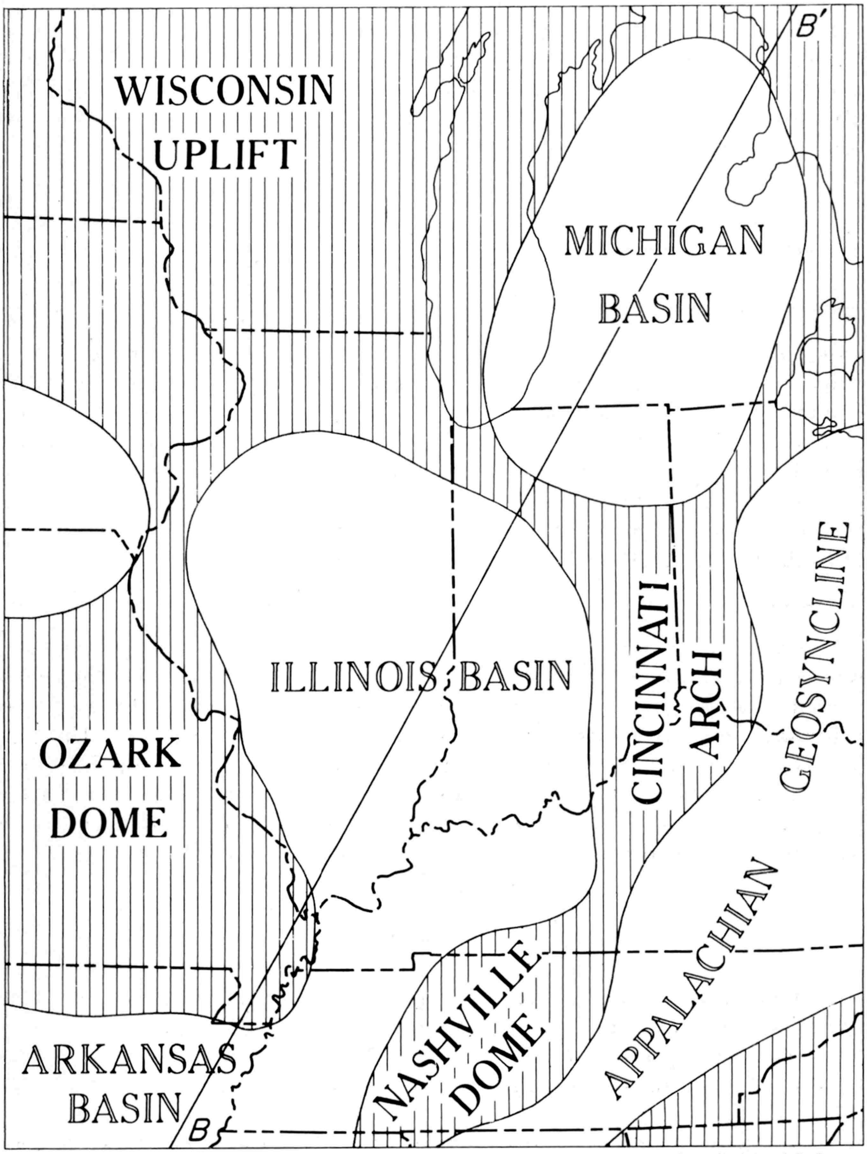

Figure 5. *Tectonic map of late Devonian and Mississippian periods showing the relationship between the positive and negative areas. After Deiss, 1952, pl. 4.*

final unit, the individual, is reached. In the broadest sense there are two major divisions of the animal kingdom: the vertebrates (animals with backbones) and the invertebrates (animals without backbones). Subdivision of the animal kingdom into various units is illustrated in the following table by the classification of man (vertebrate) and the common house fly (invertebrate). Subdivision of the plant kingdom into various units also is illustrated by the classification of the elm tree.

Classification of animals and plants

	Animal		Plant
	Vertebrate	Invertebrate	
Kingdom	Animalia	Animalia	Plantae
Phylum	Chordata	Arthropoda	Spermatophyta
Class	Mammalia	Insecta	Angiospermae
Order	Primate	Diptera	Dicotyledones
Family	Hominidae	Muscidae	Ulmaceae
Genus	Homo	Musco	Ulmus
Species	sapiens	domestica	americana
Individual	John Brown	house fly	elm tree

Each fossil has a binominal (two-part) Latin or Latinized name, which is given to it according to a standard set of rules. These International Rules of Zoologic Nomenclature were established by an international committee of zoologists and paleontologists. For example, the name given to man, Homo sapiens, is a double (binominal) Latin name. The first name is that of the genus and is always capitalized. The second (or specific) name, which usually refers to a distinctive feature of the species, is never capitalized.

Uses

Fossils are used in establishing the relative ages of various rock units. Geologists have found that each separate stratigraphic or layered rock complex, and even a single bed or layer, is characterized by its own particular assemblage of fossils. The older the rock, the more strikingly different from Recent organisms are its fossil remains; the younger the rock, the greater the resemblance to Recent forms. Some fossils are more useful than others in determining age; they are known as index fossils. An index fossil must be readily recognizable and fairly abundant and must have a limited vertical extent and a wide horizontal (geographic) extent. Geologists frequently rely on fossil assemblages and index fossils in correlating rocks in one locality with those rocks in other localities.

Fossils are useful in determining ancient geography and the physical character of the body of water or the land mass where the plants or animals lived. Fossils tell us whether the water was shallow or deep, fresh or salty, near to or far from land, in the open sea or in an enclosed basin. Fossils indicate the nature of ancient climates, that is, whether the water and land were warm or cold and whether the land was moist or dry.

Finally, the fossil record preserved in the rocks indicates that animals and plants changed with the passing of time. Changes in the fossils supply definite lines of ancestry within the various tribes of the organic world. Fossils thus help in substantiating the law of organic evolution.

Distribution of fossils in Indiana

Approximately five-sixths of Indiana is covered by a thick layer of glacial material called drift. A driftless area in southwestern Indiana (fig. 2) indicates that this part of the state is unglaciated. Bedrock exposed in the driftless area and the older rocks of the southeastern part of the state contain many fossils. The best places to look for fossils are stream beds, gullies, ravines, cliffs along rivers where rocks are exposed naturally, and road cuts, quarries, and other excavations made by man.

Fossils representing both the plant and animal kingdoms are found in Indiana. Plant fossils, for the most part, are the trunks, branches, and leaves of ancient trees; they are found most commonly in the coal-bearing rocks of Pennsylvanian age in southwestern Indiana.

Although both vertebrate and invertebrate fossils are found in Indiana, the invertebrates are by far the most common. In fact, invertebrates constitute about 85 to 90 percent of the known species of the animal kingdom. Vertebrates are found more commonly in geologically younger rocks, most of which are not found in Indiana.

SUITE OF SPECIMENS FROM INDIANA

Rocks and minerals

Specimens in the suite that accompanies this circular are numbered to correspond with the numbers preceding the descriptions given below. Rocks and minerals that are discussed in the circular but which are not included in the suite are not available in quantity, do not make satisfactory specimens for distribution, or are very common and well-known materials. For these reasons, sand, gravel, marl, peat, oil, natural gas, and water are not included in the suite.

Specimen no. 1. Coal.--(Pennsylvanian system). The sample is from the Brazil Block coal bed. Brazil Block coal probably is the best and has the lowest ash content of the bituminous coals mined in Indiana. It characteristically breaks into blocks rather than into flat sheety pieces. Brazil Block coal, as well as other Indiana coals, is sold under various trade names rather than under the appropriate geologic name.

Specimen no. 2. Mansfield sandstone.--(Pennsylvanian system). Mansfield sandstone is quarried in Indiana for use as building stone. Variegated colors of this sandstone present pleasing architectural effects when it is used as split-face and saw-face veneer.

Specimen no. 3. Ste. Genevieve limestone.--(Mississippian system). This limestone is crushed for use as construction aggregate, agricultural lime, and road metal and in making cement. It is representative of many such crushed limestones. This particular specimen is typical of very finely granular precipitated limestone.

Specimen no. 4. Ste. Genevieve limestone.--(Mississippian system). Specimen no. 4 differs from no. 3 in appearance, even though it is from the same geologic formation. It is used for the same purposes as no. 3 except that it is a high-calcium (nearly pure) limestone that can be used as a source of calcium carbonate by chemical industries. Because the nearly round grains of the specimen resemble small eggs, this type of limestone is called oölitic limestone after the Greek words meaning egg-like. Calcium carbonate that forms this limestone is precipitated by different sea organisms to form a calcareous ooze on the sea floor. This ooze is rolled about on the sea floor until ball-like masses are formed, much in the same manner as large snowballs are made.

Specimen no. 5. Salem limestone.--(Mississippian system). The Salem limestone, sold under many trade names, is quarried for building and dimension stone in Lawrence, Monroe, and Owen Counties. The part of the Salem limestone that is used as a dimension stone is a high-calcium, fragmental, organic limestone. Its very small fossils can be seen best with a microscope or a hand magnifier. It occurs in massive, homogeneous beds that permit the removal of blocks of nearly any desired size. After the stone has been removed, it may be sawed, carved, and planed into any shape. This soft stone is extremely easy to cut. The part of the Salem limestone that is not used as dimension stone is an impure dolomitic limestone of little value.

Specimen no. 6. Harrodsburg limestone.--(Mississippian system). The Harrodsburg limestone is crushed for use as construction aggregate, agricultural lime, and road metal. The specimen in the suite is an example of a crystalline limestone.

Specimen no. 7. New Albany shale.--(Mississippian-Devonian systems). Petroleum products can be distilled from crushed New Albany shale. The cost of obtaining petroleum products from this shale is greater, however, than the cost of obtaining them from crude oil.

Specimen no. 8. Jeffersonville limestone.--(Devonian system). This specimen from a laminated zone of the Jeffersonville limestone illustrates a crystalline limestone, all crystals of which probably are oriented in the same manner. Although the Jeffersonville limestone is crushed and used in the same way as other limestones, the laminated zone should not be used as concrete aggregate. Splitting of the rock along the laminations may take place during periods of freezing and thawing and thus cause the concrete to break.

Specimen no. 9. Mississinewa shale.--(Silurian system). The calcareous Mississinewa shale has been used in the past in manufacturing rock wool. In recent years, however, steel-mill slag has been cheaper to use. Rock wool plants, therefore, use this shale only when their stocks of slag are low.

Specimen no. 10. Reef dolomite.--(Silurian system). This specimen of dolomite is from a fossil reef in northern Indiana. The rock from this reef is quarried, crushed, and used for all aggregates. In other places in Indiana and in surrounding states, oil and gas are obtained from similar reefs.

Specimen no. 11. Geode and quartz.--(Mississippian system). Geodes are pebble- to boulder-sized concretion-like objects found in sedimentary rocks. Geologists believe that mineral-bearing water descending through rock deposits various minerals in cavities to form geodes. All geodes have outer shells composed of chalcedony, a non-crystalline silica mineral, and contain a variety of minerals, mainly calcite and quartz, that become more abundant toward the interiors. The interior of a geode may be either partly or completely filled. The part of a geode in this suite has been split in order to show the interior crystals of quartz.

Specimen no. 12. Calcite.--Calcite, a mineral found in all carbonate rocks in Indiana, is composed of calcium carbonate; it is the chief mineral forming limestone. Calcite crystals illustrate the manner in which mineral crystals are found. Each mineral forms with a unique arrangement of its constituent molecules; this arrangement is referred to as the crystalline habit of the mineral. This habit may be seen in many minerals, as each crystal is bounded by several crystal faces. Calcite like many other minerals breaks easily along the planes of its crystal faces. When minerals part easily along such faces, the mineral is said to cleave and to have cleavage faces.

Specimen no. 13. Kaolin-like clay mineral.--This is a mineral found along the boundary between the Pennsylvanian and Mississippian rocks. Examination of this specimen discloses that one cannot identify the clay mineral with the naked eye. Therefore, X-ray procedures are used in studying and identifying clay minerals and other clay-sized particles.

Specimen no. 14. Gypsum. --(Mississippian system). The sample of gypsum enclosed with the suite of rocks and minerals was obtained from a ball-like mass of gypsum found in either the St. Louis limestone or the Harrodsburg limestone.

Fossils

Specimen no. 15. Plant. --The specimen(s) is/are the trunk, branch, stem, frond, or leaf of ancient trees that lived about 250, 000, 000 years ago. Many of the fossils were the ancestors of well-defined modern tribes, such as the horsetails or scouring rushes, ground pines or club mosses, tree and seed ferns, and the conifers. Examples in the suite illustrate several kinds of preservation. The majority of specimens are imprints embedded in an iron-stained, fine-grained sandstone nodule. Some imprints may be the result of carbonization, a few are molds, and the rare exception may be a cast. Nodules are found in sandy shales or clay shales associated with the coal-bearing rocks of Pennsylvanian age in southwestern Indiana.

Specimen no. 16. Brachiopod. --A brachiopod is an attached, solitary invertebrate that lives in the sea. Its soft parts are enclosed between two shells that are mostly composed of calcium carbonate. The shells are joined or hinged posteriorly along a "hinge" line. Most of these animals are attached to the sea bottom by a fleshy stalk (pedicle) that emerges from a small hole in the posterior margin of one of the shells (pedicle valve) or between the two shells. Some brachiopods plaster themselves to other brachiopods; others lack a pedicle and attach themselves to rocks and other objects by the entire surface of the ventral valve (the valve that in most brachiopods contains the pedicle).

Brachiopods should not be confused with another animal called a pelecypod (clam). Brachiopods possess equilateral symmetry and are inequivalvular; pelecypods are equivalved and possess inequilateral symmetry (fig. 6).

The hard parts of some brachiopods have been preserved unaltered. In some brachiopods the calcareous shells have been replaced by silica. Remains of many brachiopods are found as either internal or external molds. [4]

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[4] In some rocks the substance of the original shell has been removed by solution, but an external (outside of shell) or interior (inside of shell) mold that shows the form of the original shell has been left.

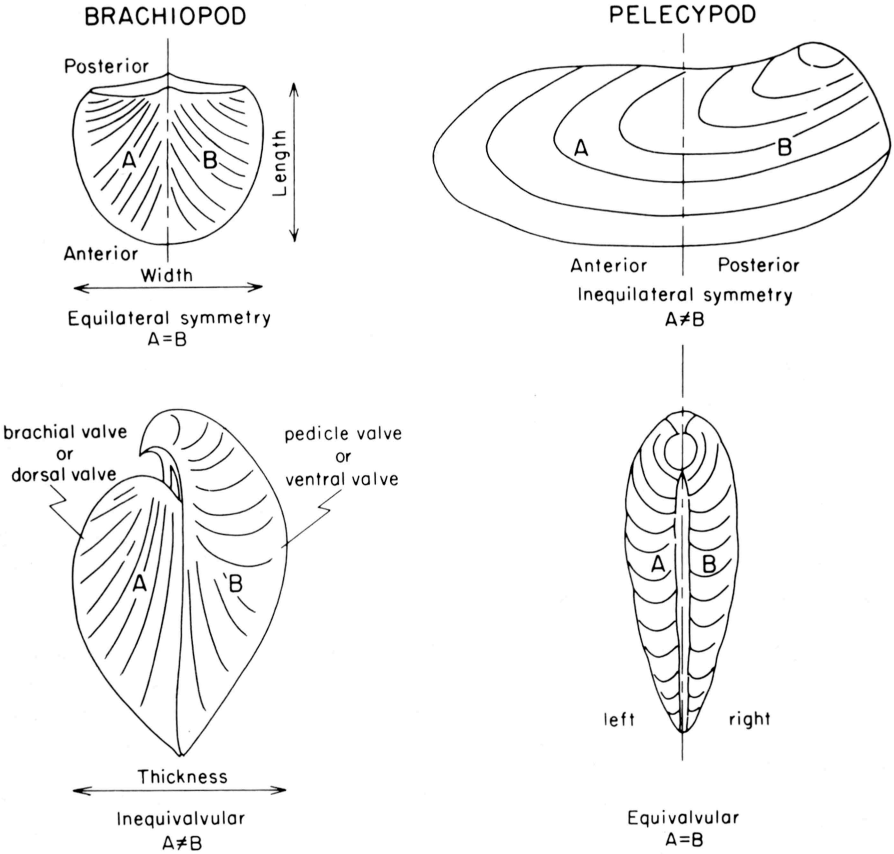

Figure 6. *Brachiopoda and Pelecypoda compared with reference to plane of bilateral symmetry.*

Although brachiopods are found in most calcareous rocks in southern Indiana, probably they are most abundant in the limestones and calcareous shales of the Ordovician rocks in southeastern Indiana and in the Mississippian limestones that come to the surface in a broad band extending from Greencastle southward to the Ohio River. Many brachiopods are found in the long Pennsylvania Railroad cuts north of Madison, in Jefferson County.

Specimen no. 17. Coral. --A coral is an attached, solitary or colonial, sea-dwelling animal that secretes an external skeleton of calcium carbonate. The animal is called a polyp and its skeleton a coral. The skeleton has radiating plates called septa, which grow inward from the outer wall of the skeleton, and which are secreted by infoldings of the body wall of the animal.

Present-day corals flourish in warm waters at temperatures of about 68° to 70° F. Most corals live in waters that are not more than 600 feet deep. Most present-day reef-building corals are found within a 20° to 30° latitude range from the equator. In general, it is believed that corals which formed ancient reefs lived in an environment similar to that in which corals now dwell. Thus, corals are thought to be indicators of ancient climates. Ancient reefs of large size are found in Indiana at Wabash, Logansport, Bluffton, and Huntington.

Corals in Indiana are preserved in their original condition, are infiltrated with calcium carbonate, or are silicified. They commonly are found in Silurian and Devonian rocks; some also are found in Mississippian rocks.

Specimen no. 18. Crinoid.--A crinoid is a plant-like sea-dwelling animal that often is called a sea lily. The animal consists of three parts, the body proper, or calyx, which encloses the soft organs; the arms, or brachia, which transmit the food to the mouth; and the stem, which connects the body to some object or to the sea bottom. The body is composed of calcareous plates arranged in tiers, beginning at the stem. As most of these calcareous plates fall apart before the animal is preserved, complete crinoids are rarely found. The specimen in the suite is a crinoid stem.

Crinoids tend to grow in patches on the sea floor and are apt to form large mounds when they die. Several mounds, called ancient reefs or bioherms, have been found in the Mississippian formations in Indiana. A bioherm may be seen on the north side of State Road 46 about 7 1/2 miles east of Bloomington.

Specimen no. 19. Microfauna.--The last specimen in the suite is an assemblage of small fossils of various groups of animals, such as Foraminifera, brachiopods, crinoids, and gastropods. This fauna is from the Salem limestone.

REFERENCES CITED

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