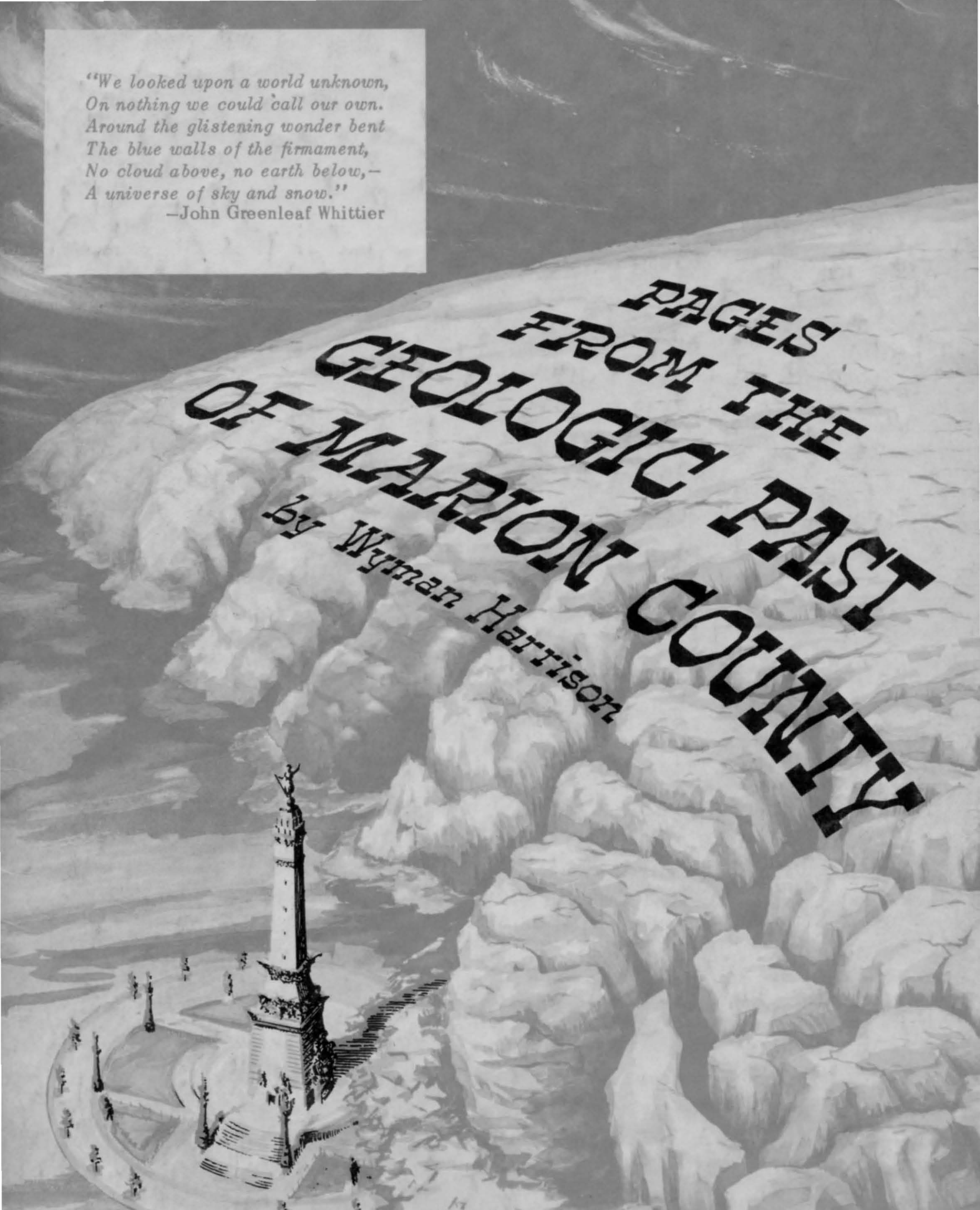


"We looked upon a world unknown,
On nothing we could call our own.
Around the glistening wonder bent
The blue walls of the firmament,
No cloud above, no earth below,—
A universe of sky and snow."
—John Greenleaf Whittier

PAGES FROM THE GEOLOGIC PAST OF MARION COUNTY

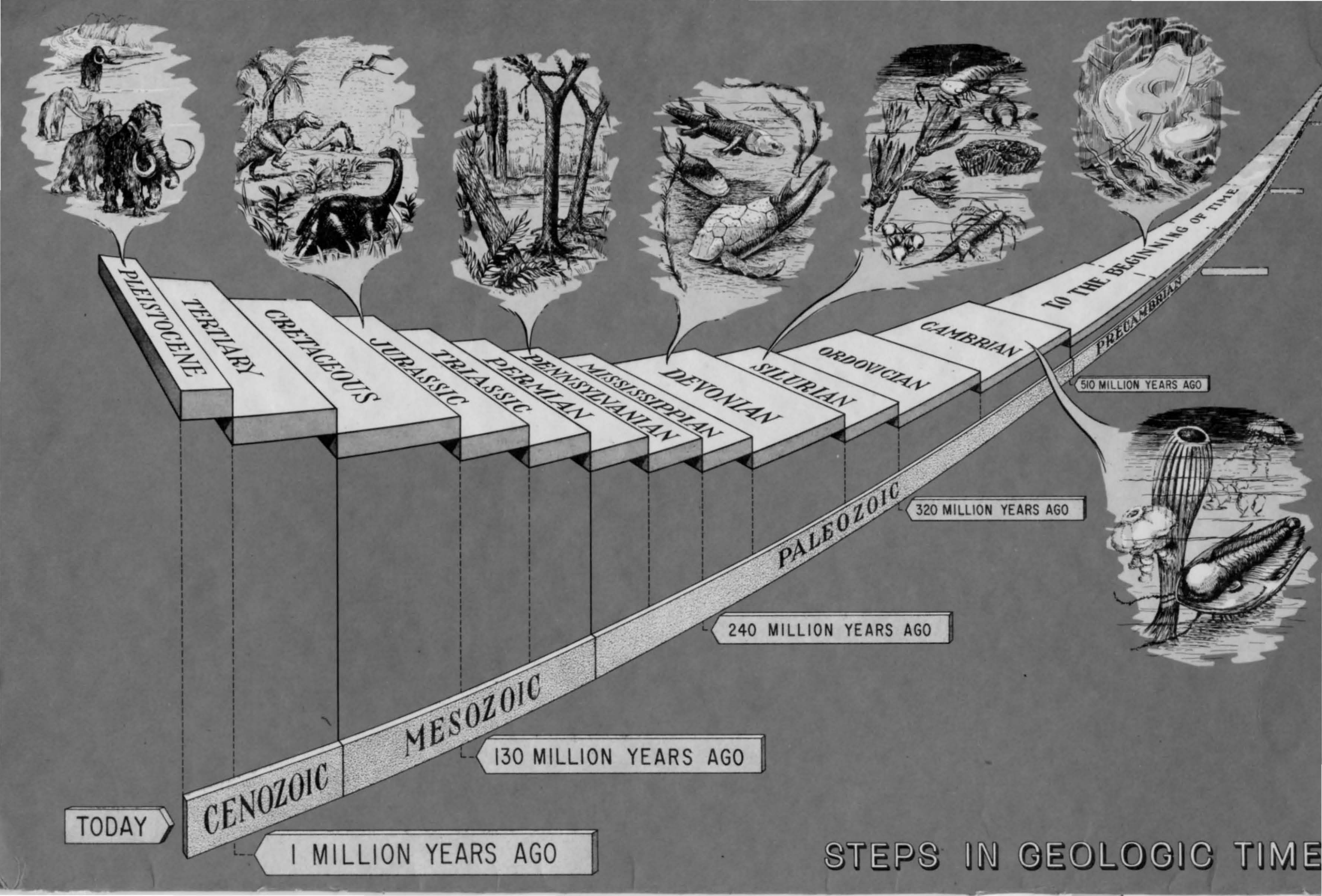
By Wyman Harrison

RJUDAH

Circular No. 9

Indiana Department of Conservation
GEOLOGICAL SURVEY

1963


PLEISTOCENE
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
TO THE BEGINNING OF TIME
PRECAMBRIAN
510 MILLION YEARS AGO
320 MILLION YEARS AGO
PALEOZOIC
240 MILLION YEARS AGO
MESOZOIC
130 MILLION YEARS AGO
CENOZOIC
TODAY
1 MILLION YEARS AGO
STEPS IN GEOLOGIC TIME

STATE OF INDIANA
Matthew E. Welsh, Governor

DEPARTMENT OF CONSERVATION
Donald E. Foltz, Director

GEOLOGICAL SURVEY
John B. Patton, State Geologist
Bloomington

Circular No. 9

PAGES FROM THE GEOLOGIC PAST OF MARION COUNTY

by

Wyman Harrison

Illustrated by Robert E. Judah

Printed by authority of the State of Indiana

BLOOMINGTON, INDIANA

February 1963

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SCIENTIFIC AND TECHNICAL STAFF OF THE GEOLOGICAL SURVEY

A RECORD OF THE PAGES

PLATES

ABOUT THE PAGES

The "pages" of rock strata that together form the geologic history book of Marion County are written in a foreign language of fossils, rock fragments, and mineral grains. We are able to translate the messages from these accumulations of extinct organisms and lifeless mineral matters through the knowledge gained from efforts of many generations of geologists. The meaning of the story of earth history that arises from the work of thousands of geologist translators lies in the connections man finds between his life and the world around him. Knowledge of the geologic history of his backyard, for example, permits a man to see himself in a new dimension--that of time. And he begins to appreciate the enormous amount of time involved in the unfolding or evolution of the world of nature that surrounds him.

To imply that he can find meaning in the geologic history of his backyard may sound altogether too narrow for a man of the space age, who reads daily of efforts to piece together the history of the entire material universe. But a century ago, one of the greatest American geologists, J. D. Dana, said that the history of the universe "is like that which has been deciphered with regard to the earth; it only carries the action of physical forces, under a sustaining and directing hand, farther back in time." One understanding--that of earth history--leads into another--that of the history of the universe.

Geologist Dana prefaced his famous "Manual of Geology" with the following remarks, which are as meaningful for this pamphlet of space-age times as they were for a textbook of the gaslight days:

> If the author has sought to exalt a favorite science, it has been with the desire that man--in whom geological history had its consummation, the prophecies of the successive ages their fulfillment--might better comprehend his own nobility and the true purpose of his existence. [1]

The author is especially grateful to Mrs. Rosemary Carr, of the Children's Museum of Indianapolis, for critically reading the manuscript and for her many helpful suggestions and criticisms.

Wyman Harrison[2]

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[1] J. D. Dana, 1863, Manual of Geology: Philadelphia, Pa., Theodore Bliss, 798 p.

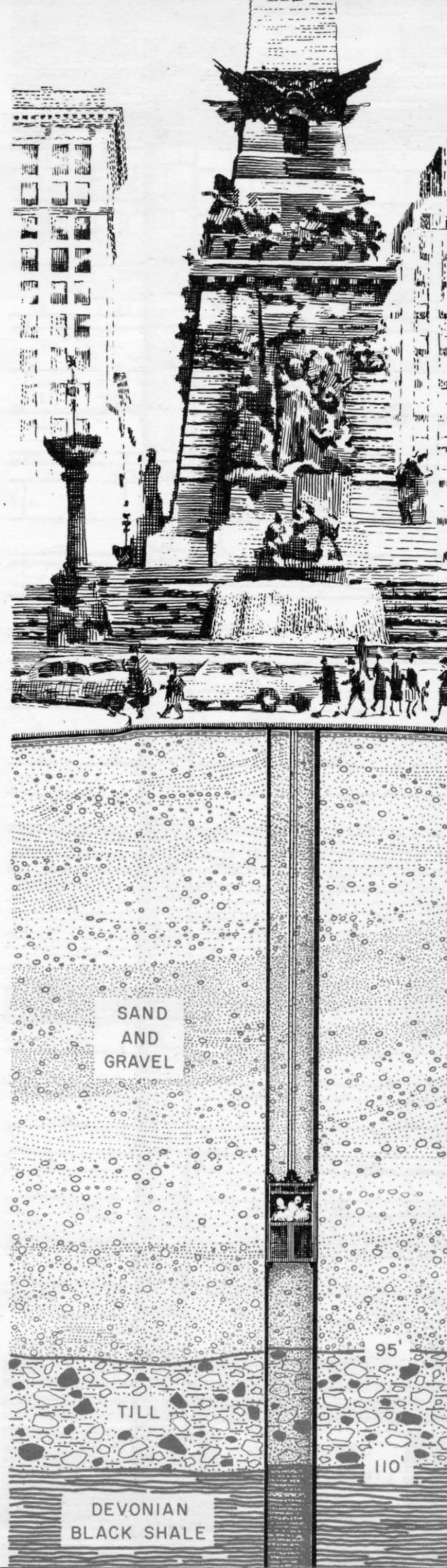
[2] Formerly glacial geologist of the Indiana Geological Survey; now Associate Marine Scientist, Virginia Institute of Marine Science, Gloucester Point, Va.

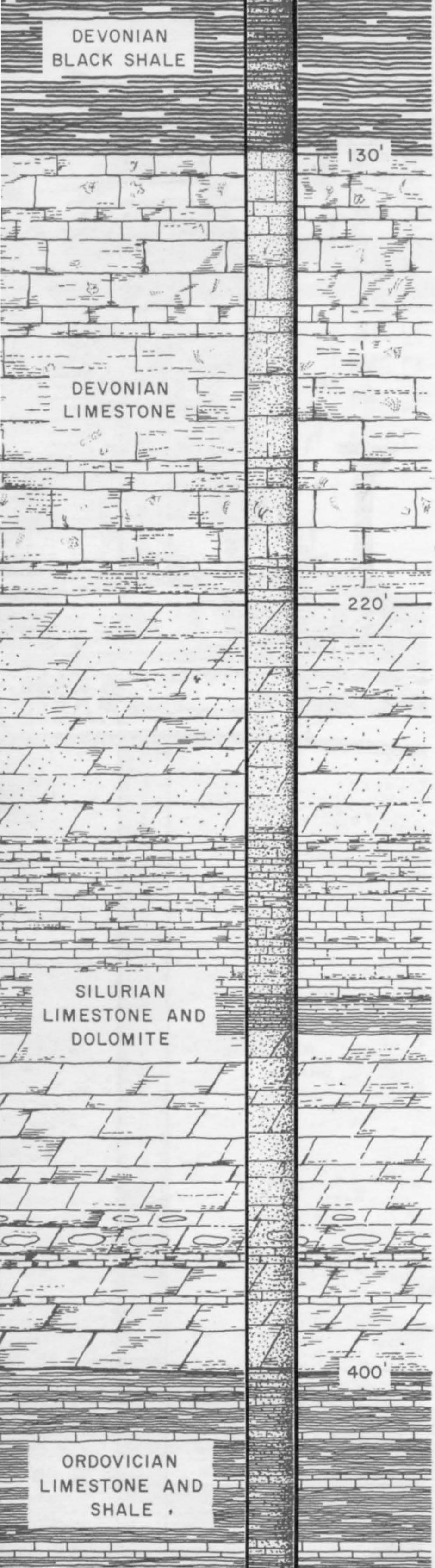
THE SETTING AND A CHALLENGE

A great expanse of gently rolling plain stretches across central and north-central Indiana--a plain that here and there is dotted with groups of low hills or is broken by deep valleys. Marion County lies within the boundaries of this physiographic feature that geologists call the Tipton Till Plain. (See physiographic map on the back cover.) Such a setting appears commonplace, but studies of the geologic materials that underlie this plain reveal the startling fact that it was produced by glaciers between 15,000 and 25,000 years ago. A challenging thought, but we can learn firsthand about the recent geologic history of Marion County by our own study of its glacial materials. And what happened before the Ice Age? To answer this second challenging question we need to know something of the different geologic materials that lie deep beneath the surface of Marion County--geologic materials like limestone and shale that make up the bedrock floor of the county, or like granite, which lies even farther below.

BENEATH THE SURFACE

Think of the elevator in the Soldiers and Sailors Monument in Monument Circle, downtown Indianapolis. (See pl. 1 in pocket inside back cover for locations.) Now pretend that the elevator shaft, instead of stopping near pavement level, continues downward toward the center of the earth. Imagine also a window in the elevator that permits one to see the natural walls of the





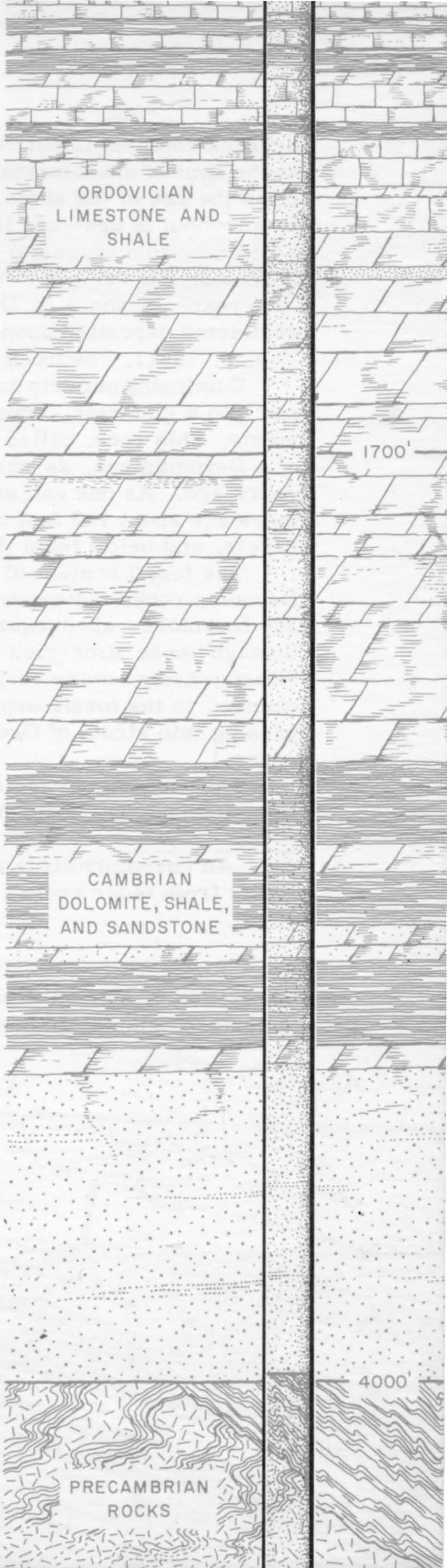
shaft itself. Let us climb into our imaginary elevator and take a ride downward toward the center of the earth, observing the geologic materials as we go.

We begin a slow descent. The first 5 feet or so below street level appear to be composed of old pavement and building materials of early Indianapolis. This zone quickly gives way to layer upon layer of sand and gravel--materials that reveal-ingly look much like those deposited along the bottoms of glacial streams of the present day. The sand and gravel beds beneath downtown Indianapolis were laid down some 20,000 years ago, when the margin of a melting ice sheet stood across what is now the northern part of Indianapolis and Marion County. The valleys of Fall Creek and White River were filled to overflowing with raging torrents of glacial melt water. Many such watercourses in central and northern Indiana carried thousands of tons of rock flour out and away from the melting ice sheet. The silt and clay particles were "washed" from the sand grains and pebbles as these coarser particles were deposited on the stream bottoms. When geologists find this sand and gravel material today, they call it glacial outwash.

The cross section (p. 10-11) shows the outwash deposit under Monument Circle. This cross section indicates the arrangement of the layers of geologic materials--gravel, limestone, shale, and so on--from one corner of the county to the other. The actual line along which the cross section was made corresponds to the line A-A' shown on plates 1 and 2 (pocket inside back cover). The cross section is based on wells records, commonly called logs, which are descriptions of geologic materials found during well drilling.

We continue downward through no less than 95 feet of outwash sand and gravel before coming to a hard blue-gray clay containing boulders and pebbles. This "hardpan," as well drillers know it, is a glacial boulder clay left by one of the early ice sheets that covered Marion County. Such a deposit of "rock flour" is called till by geologists. Till was deposited directly from slow-melting basal glacier ice; that is, it was not "washed" and sorted into different sizes by glacial melt water, as was the outwash lying above it. (The bed of till that we have discovered is shown on the cross section as the thinning edge of a thick till unit that lies northeast of Monument Circle.) This till unit takes us back in time nearly 200,000 years into middle Pleistocene time. The position of the Pleistocene Epoch, the most recent division of geologic time, is at the top of the geologic time scale that is shown inside the front cover.

Our imaginary elevator ride has taken us about 110 feet below the pavement in downtown Indianapolis. We now come to a striking change in material. This new material is black and has a smooth fine-grained surface. It looks hard and not at all like the boulder clay above it. Geologists call such rock shale. This shale was formed by the accumulation of countless tiny rock and mineral fragments along the floor of an ancient sea. Originally clayey and silty, the deposit has been so highly compressed and has become so solidified that it is called "bedrock." The shale



bedrock contains fossil remains of organisms that lived in the sea at the time of shale formation, and these organic remains give clues as to the age of the shale. The particular shale that we have found is Devonian in age--not less than 275 million years old.

There is a large gap in time (time chart inside front cover) between the 200,000-year-old till of Pleistocene age and the 275-million-year-old shale of Devonian age. The series of Pleistocene sediments deposited upon the Devonian and other rocks (cross section, p. 10-11, "bedrock surface") is unconformable[3] with them.

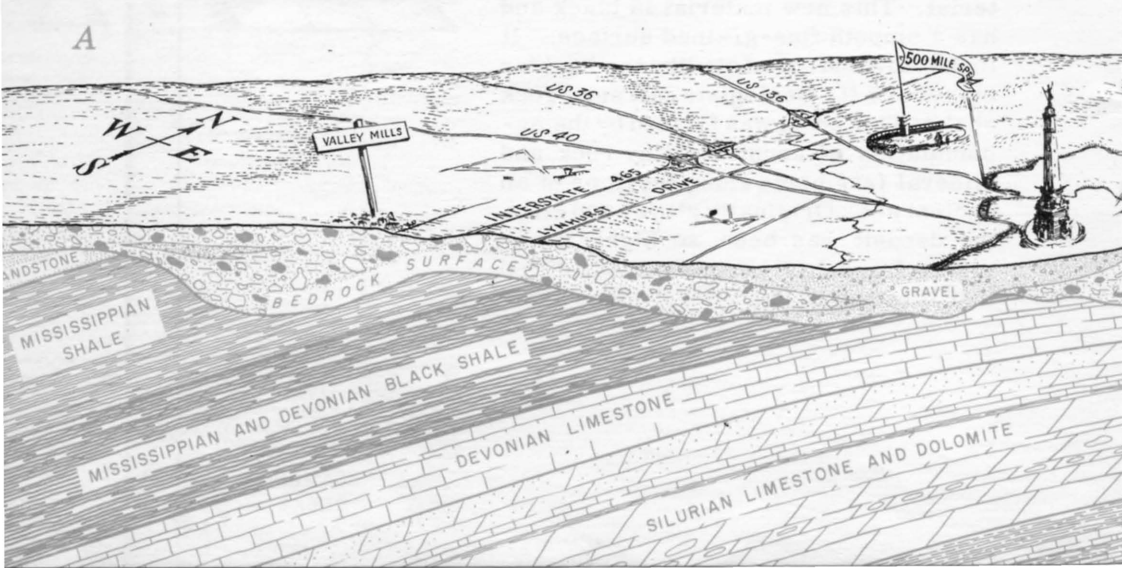
Continuing our trip downward we now pass out of the black shale and into a gleaming, white, hard rock containing many shell fragments. This rock, called limestone, was laid down upon the bottom of a Devonian sea, as was the shale above it, more than 275 million years ago. As one can see from the cross section on pages 10-11, there are about 100 feet of Devonian limestones beneath Monument Circle, and below them lies another limestone formation.

The fossil content of the limestone formation lying beneath the Devonian rocks indicates that the formation is Silurian in age. For 200 feet more--about equal in height to a 20-story building--we pass through these lime-rich Silurian rocks. Beneath the 200 feet of Silurian sedimentary rocks we again come to a time line, based on changes in the fossil organisms in the rocks, and find ourselves passing into strata of Ordovician age. (See time scale, inside front cover.)

The Ordovician sedimentary rocks are once again shale and limestone but are about 375 million years old. In all, Ordovician

[3] An unconformity is a surface of erosion that separates younger strata from older rocks.

Cross section of Marion County along line A-A' of plates 1 and 2 showing ground surface, glacial materials, bedrock surface, and bedrock formations

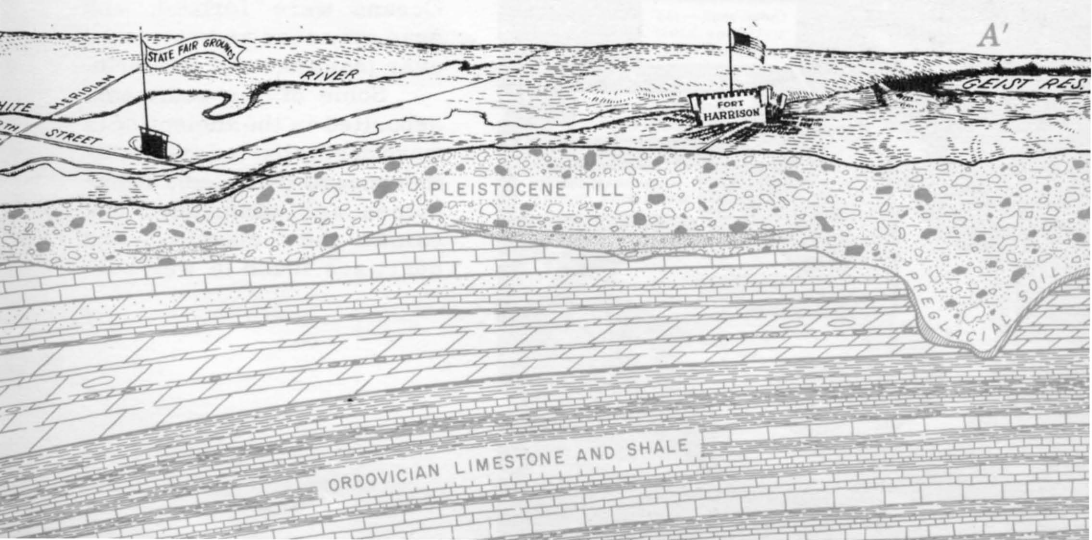


rocks are about 1,300 feet thick under Indianapolis--a thickness equal to nearly five times the height of the Soldiers and Sailors Monument.

The cross section (p. 10-11) shows only the upper few feet of the 1,300 feet of Ordovician rocks beneath Monument Circle, and none of the deeper and older rocks are shown. From deep wells drilled in surrounding areas, however, we know that Cambrian rocks are found under the 1,300 feet of Ordovician rocks. The Cambrian rocks, at least 450 million years old, are sedimentary rocks that were deposited in ancient seas, as were the limestones and shales above them. We pass through nearly 2,300 feet of Cambrian dolomite and sandstone before we come once again to rocks that are distinctly different from anything we have seen.

The new rocks that we see contain no fossils and are very hard. They are granite, marble, gneiss, and other igneous and metamorphic rocks. Together they form what is commonly called the basement-rock complex of Indiana. Rocks of the basement complex are Precambrian in age (time scale, inside front cover), more than 550 million years old. The nearest localities where these rocks can be found at the earth's surface are in Tennessee and southern Canada. The surface of the Precambrian rocks in Canada arches gently upward like the surface of a medieval shield; thus this arching rock surface is called the Canadian Shield. Everywhere in Indiana the Precambrian rocks lie buried beneath a thick blanket of younger sedimentary rocks, and they are known only from the cuttings of a few drilled wells.

Our imaginary elevator ride has taken us over 4,000 feet below the surface of the earth--some 3,300 feet below sea level. We have no direct information as to the nature of the Precambrian rocks at



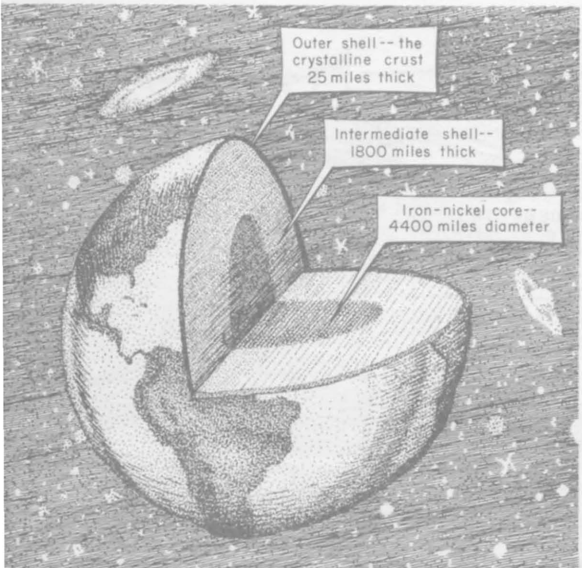
greater depths. Studies of earthquake waves, however, reveal that the Precambrian rocks under Marion County are part of a 15-mile-thick granitic layer that overlies a 10-mile-thick gabbro layer. These two layers constitute the earth's crust. The crust rests on the mantle, a 1,800-mile-thick shell of highly compressed rock materials having a density, relative to water, ranging from 3.3 to 5.7. The core of the earth--some 4,400 miles in diameter--from geophysical evidence is considered to be fluid, to have a density of 10 to 12, and to be composed of a mixture of nickel and iron. (See drawing on this page.)

GEOLOGIC HISTORY AS TOLD BY THE ROCKS

Now that we know something of the kinds of geologic materials to be found below the surface of Marion County, let us begin a return trip to the surface in our imaginary elevator. As we rise, let us read from the rock formations the history of that part of the earth presently known as Marion County. We begin the story of earth history with the Precambrian rocks.

FROM THE BEGINNING--THE PRECAMBRIAN EON

Sometime after the birth of our planet from the sun--the earth's birthday being about 5 billion years ago--the molten surface cooled to the point that it was possible for a solid crust to form. Mountain ranges and ocean basins existed in this initial crust, just as at present, and the geologic processes that gradually transform the earth's surface today also operated then. For approximately 3 billion years the earth was probably lifeless. The only changes were physical ones: mountain ranges were thrust up in response to the tremendous contractive forces of the cooling crust, and highlands were worn down by weathering and other agents of erosion. Oceans were formed, and seas advanced and retreated over many parts of the earth.



Some of the sediments deposited in the ancient seas were deeply buried and metamorphosed (changed); limestones and sandstones became the marbles and quartzites found in well cuttings today. Beneath Indiana, however, the record of Precambrian time is indicated mostly by granitic rocks, which are solidified molten material. At this point we must reflect in wonderment, for nearly all geologic time is recorded in these rocks about which we know so little--yet several hundred million years are to be accounted for in the rocks above.

THE BLOSSOMING OF LIFE–THE PALEOZOIC ERA

After 3 billion lifeless years and 2 billion years of perhaps only microscopic life of the Precambrian Eon, organic creation blossomed forth, and the seas swarmed with plants and animals of ever-increasing size. Many of the animals had hard parts that have been preserved unto this day. Rocks containing fossils of this earliest period are, by definition, Cambrian rocks, and they ushered in what has been called the Paleozoic (ancient life) Era. The periods of the Paleozoic Era are shown in the time scale (inside front cover).

There are no lower Cambrian sediments beneath Indianapolis, but we can tell that toward the end of Cambrian time the area that is now Marion County had become the bottom of a shallow sea, and the sandstones and dolomites that were mentioned earlier were deposited. Although the land surface may have undergone elevation or depression several times relative to the ancient sea level, a shallow sea generally continued to cover the area during the latter part of the Cambrian Period.

This shallow sea persisted into Ordovician time (time scale), when fossiliferous shales and limestones were deposited. Limestones deposited during late Ordovician time bring us within the range of the sedimentary-rock formations shown on the cross section (p. 10-11). The rocks shown as overlying upper Ordovician rocks are largely middle Silurian in age. Beneath Marion County the Silurian formations include only a little material deposited during early Silurian time. This fact indicates that the land surface emerged slightly above sea level during much of that time.

A similar condition exists slightly higher in the geologic section of the earth's crust shown in the cross section, where limestone of middle Devonian age overlies limestones of middle Silurian age. Sedimentary rocks of late Silurian and early Devonian age are absent. This relation "is general over the Ohio Valley, where pure Middle Devonian limestone rests disconformably on similar strata of Middle Silurian age.... Obviously the emergent continent lay quiet and but little above sea level during the long interval [between middle Silurian and middle Devonian]."[4] As we continue to rise toward the surface, the impressive change in rock types from white limestone to black shale carries us into late Devonian time. We are now at the bedrock surface (cross section).

THE PALEOZOIC BEDROCK SURFACE--A PROFOUND REFERENCE PLANE IN TIME

Let us pause momentarily on our upward journey to consider the nature of the bedrock surface. The cross section (p. 10-11) indicates that the bedrock surface is an irregular one. It is, in fact, as irregular as the actual ground surface in many parts of southern Indiana where the bedrock is not buried under a thick blanket of glacial sediments. Thus the deep bedrock valley shown on the right-hand side of the cross section is not a particularly surprising feature, for in southern Indiana, beyond the limit of glaciation, such valleys are common.

This deep valley also shows up as an elongate area of Ordovician and Silurian rocks near Oaklandon on the bedrock-geology map (pl. 1). But the cross section and patterns do not allow us to visualize the fine configuration of divides and valleys on the bedrock surface--such divides and valleys as we know exist, primarily from the study of many score wells in the county. A sketch showing the probable ancient stream pattern on the bedrock surface is superposed on the bedrock-geology map (pl. 1).

The cross section (p. 10-11) indicates that the various rock formations that we have been considering are not horizontal but dip gently to the southwest. The angles of dip are shown to be much steeper than they actually are because of the exaggeration of the vertical scale on the cross section. Bedrock formations beneath Marion County dip toward the center of a basin that was formed in southeastern Illinois during late Paleozoic time. Because these formations dip, their contacts with each other trace out lines along the bedrock surface--lines that trend approximately northwest-southeastward. Of the rocks that make up the bedrock surface, the oldest (of late Ordovician age) occur only in the bedrock valley in the northeast corner of the county. The youngest rocks of the bedrock surface are sandstones of early Mississippian age and occur in the southwest corner of the county.

We continue our imaginary journey upward through the earth's crust and forward through time and become aware of profound changes on the upper side of the bedrock surface.

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[4] C. O. Dunbar, 1949, Historical geology, New York, John Wiley & Sons, Inc., p. 185-186.

LOST AGES–THE MESOZOIC AND CENOZOIC ERAS

The youngest rocks at the bedrock surface under Marion County--upper Mississippian rocks--are some 250 million years old. The surface between these 250-million-year-old rocks and the 500-thousand-year-old sediments that overlie them represents a great gap in time that includes most of late Paleozoic time (time scale, inside front cover), all Mesozoic (middle-life) time, and nearly all Cenozoic (recent-life) time. We have only the slightest inkling of what went on in the area of central Indiana during these lost ages. If sediments younger than Mississippian in age were laid down--and it is probable that some were--they were later eroded away.

Thus, across a mere rock surface, we jump through the age of reptiles to the age of man. Many of the records of Nature's experiments--the dinosaur, the horse, the ape, as well as other creatures--cannot be found in Indiana, although they can be found in rocks to the east and west. Only the latest page of history--when man came into his own--is preserved, but beneath Marion County there is just a blank page of red clay and gray glacial drift, barren of human remains.

For a short time during the latter part of the Tertiary Period of the Cenozoic Era (time scale) and for about half of the Quaternary Period, the bedrock surface under Marion County was above sea level, and a soil was slowly formed on the bedrock. This soil is strikingly red in places where it was formed from limestone, as in southern Indiana. Such a soil, buried in Marion County, has been logged for a few wells, along the slopes of the deep bedrock valley under Oaklandon, for example (cross section, p. 10-11).

The boundary between the Tertiary Period and the Quaternary Period (or Pleistocene Epoch) was marked by a gradual cooling of the earth's atmosphere. About half a million years ago the first of four great ice sheets started moving out in all directions from centers of snow accumulation in eastern Canada. As far as is known, the first of the ice sheets never reached central Indiana. In time, and for reasons unknown to geologists, the glacier melted, and the climate became warm again.

Then, after several thousand years had passed, the climate again cooled, and another great ice sheet was formed in Canada and spread southward. This time the glacier advanced over all of northern and central Indiana and even into parts of southern Indiana. The margin of this second ice sheet, known as the Kansan glacier, reached the position shown on the physiographic map (back cover). From this point forward in time we have emerged from the lost ages, and the rock materials in Marion County resume the record of geologic history.

THREE BLANKETS OF DRIFT–THE PLEISTOCENE EPOCH

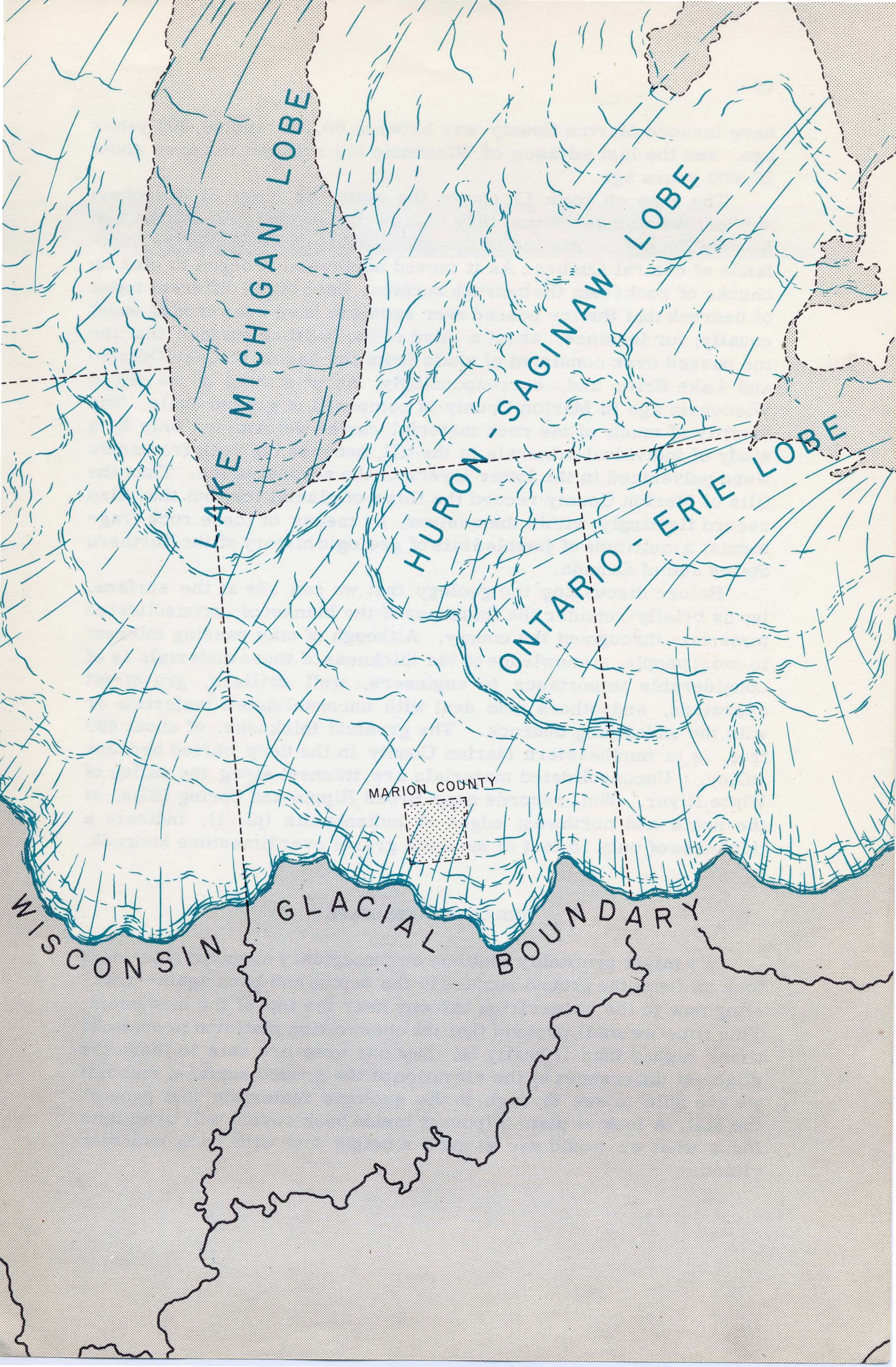
The Kansan ice sheet carried millions of tons of ground rock in its lower layers. It had picked up this material as it had moved over and eroded the bedrock or unconsolidated materials in its path. After the ice had melted, the bedrock surface became buried beneath a blanket of glacial drift. The term "glacial drift" refers both to the till, or boulder-clay, that was deposited by the ice and to the outwash, or sand and gravel, that was deposited in front of the ice. This first blanket of glacial drift filled in the bedrock valleys and the lowlands so that, after the glacier had melted, the surface of central Indiana presented the appearance of a rolling plain--at least by comparison with the rather hilly surface that existed before the glacier passed over.

With the return of climatic conditions similar to those of the present day--or perhaps slightly warmer and dryer--soils began to be formed on the surface of the Kansan drift blanket. The interval of time between the Kansan glaciation and the next, or Illinoian, glaciation is known as the Yarmouth (interglacial) Age.

After Yarmouth time the Illinoian ice sheet was formed and spread very far south into Indiana, as is shown by the Illinoian glacial boundary. (See back cover.) When the Illinoian glacier had melted, like the Kansan before it, Marion County was blanketed with another layer of glacial drift. In many places the Yarmouth soil was not disturbed by the Illinoian glacier but simply was buried by the Illinoian drift. This buried soil has been found in some places by well drillers. A buried soil zone is shown near the right-hand side of the cross section (p. 10-11). It was discovered during the drilling of two water wells at the depth where the drill bit passed through orange-brown clays, whose color is characteristic of materials that have been weathered at the ground surface.

After the Illinoian glacier had deposited its till and outwash, there was probably very little bedrock that had not been buried by the Kansan and Illinoian glacial drift. The interglacial age that followed the Illinoian glaciation is called the Sangamon, and during Sangamon time soils were formed on the surface of the Illinoian drift sheet. The time in earth history was probably between 90,000 and 60,000 years ago. It is thought that familiar man first appeared on earth during this time.

The last glacier to deposit a blanket of drift in Marion County was the Wisconsin glacier. The Wisconsin (glacial) Age lasted from approximately 60,000 to 11,000 years ago, and during this time there were several advances of the margin of the ice sheet over Marion County. The earliest time during which Wisconsin ice may



LAKE MICHIGAN LOBE
HURON SAGINAW LOBE
ONTARIO-ERIE LOBE
MARION COUNTY
WISCONSIN GLACIAL BOUNDARY

have invaded Marion County was between 60,000 and 40,000 years ago, and the last advance of Wisconsin ice reached the area about 20,000 years ago.

The map on page 17 shows the main ice lobes of Wisconsin age and the flow paths that they took as they moved into Indiana and Marion County. This ice is thought to have originated in the highlands of central Quebec. As it moved southward it began to pick up chunks of rock from the bedrock surface. Each of the different types of bedrock that the ice passed over seems to have been eroded about equally; for instance, about a third of the bedrock surface that the ice passed over consisted of shale from the basins of Lake Ontario and Lake Erie, and, correspondingly, about a third of the till of Wisconsin age in Marion County is composed of ground shale. The identity of much of the rock material can be determined only by a study of individual minerals in the till, because the rock fragments were pulverized in the lower layers of the advancing ice. Thus the tills of Marion County record the flows of glacial ice, but they also record fleetingly within themselves, by means of these rock fragments, a multitude of jumbled bits of geologic history of the Northern States and of Canada.

Before discussing the geology that we can see at the surface, let us briefly consider the thickness of the blanket of unconsolidated materials throughout the county. Although of only passing interest to most people, a knowledge of the thickness of these materials is of considerable importance to engineers, well drillers, gravel-pit operators, and others who deal with unconsolidated materials or with the underlying bedrock. The greatest thickness, of about 400 feet, is in northeastern Marion County in the deep buried bedrock valley. Unconsolidated materials are thinnest along the valley of White River. Well records near Broad Ripple and Spring Hills, at the north and northwest edges of Indianapolis (pl. 1), indicate a thickness of only 15 feet of sand and gravel over limestone bedrock.

THE LAND TAKES SHAPE

We might profitably continue our imaginary elevator ride--that took us from the ground surface to the depths and back again--traveling now to the observation balcony near the top of the monument. This time we shall pretend that the observation platform is some 20 times higher than it really is, that our eyes are able to judge the slightest differences in the elevation of the ground surface, and that we are able to see through to the geologic materials just beneath the soil. A look at plate 2 (pocket inside back cover) will bring into focus what we would see at such a height and with such superior vision.

Plate 2 is a map of Marion County showing the distribution of the different types of geologic materials that lie at the surface or just beneath the soils: sand and gravel, till, alluvium, and peat. Thus we can visualize the shapes of these deposits as one would see them if one looked downward on them from above. Plate 2 also may be considered as a geomorphic map, because from the shapes and natures of the deposits we can name and interpret the origin of the landforms in Marion County.

The view from the observation platform easily shows such familiarly named topographic features as valleys, ridges, plains, hills, and depressions. But with the map of geologic materials we realize that some of the valleys containing much sand and gravel are melt-water channels, that the plains underlain by sand and gravel are outwash plains, and that the plains underlain by till, or till plains, are areas of ground moraine. Ridges underlain by till are interpreted as end moraines, and hills composed of sand and gravel are called kames.

Each of these names implies a particular origin, and now that plate 2 has provided us with a means of accurately visualizing the present-day surface, let us fully appreciate the view from our imaginary observation balcony, 6,000 feet above Marion County. Here we can view the events that brought about the formation of the geomorphic features that make up the ground surface. We turn back time some 21,000 years.

The last glaciation.—We look down. There below us, in dazzling whiteness, is a great sheet of ice. To the northeast the altitude of its surface increases; to the southwest the surface slopes downward until, near what is now Martinsville, the edge is reached. The front cover is an artistic conception of this now-vanished glacier, and it recalls events in the recent geologic past of Marion County that are startlingly different from those which transpire today. When the glacier margin stood at its southernmost position, the ice was some 1,500 feet thick over what is now downtown Indianapolis. In all, some 90 cubic miles of ice covered Marion County at the time the glacier had spread to its southernmost limit.[5]

A few hundred years pass; the climate warms; ever increasing quantities of melt water issue from beneath the ice margin and gather on the glacier's surface to course down the sloping snout; sparkling rivulets of purest water grow to thunderous debris-choked torrents; and we know that the glacier is beginning to melt away.

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[5] The southernmost limit of this particular glacier is called the Champaign boundary by geologists, because the deposits associated with this boundary are continuous to Champaign, Ill., where the boundary was first named.

The shape of the land surface of Marion County originated during the melting of this last great glacier. When the ice began to melt, it melted at different rates over the surface, at the margin, and in the debris-charged basal layers. Melting at the margin resulted in "backwasting," so to speak, toward the northeast from whence the margin had "advanced."

Quantities of melt water arrived at the retreating glacier margin by way of ice-walled channels. The waters were then diverted into streams that ran parallel to the ice front or away from it and out over the local ground slopes. Many of the present valleys (pl. 2) in Marion County were initiated by streams of melt water flowing in ice-walled channels. Other valleys cut by streams of melt water running parallel to former ice-marginal positions are called ice-marginal valleys. Both types of valleys are filled with outwash (sand and gravel).

In some places the torrents of melt water in the ice-walled channels cut valleys at more than one level in the underlying drift. Former "high-level" valleys appear today as valleys whose floors are at higher altitudes than those of other valleys nearby. These "high-level" valleys contain either very small modern streams or no streams at all.

The major valleys in Marion County, like the valleys of White River, Fall Creek, the East Fork of Whitelick River, the north part of Eagle Creek, Buck Creek, and Mud Creek, were formed by melt-water streams flowing in ice-walled channels. Valleys that were formed by streams that flowed alongside of the ice edge are Pleasant Run, Goose Creek, Little Buck Creek, lower Lick Creek, Dollar Hide Creek, lower Eagle Creek, upper Crooked Creek, Williams Creek, Fishback Creek, and Shoal Creek valleys. (See plate 2 for locations.) The valley of White River is a major drainage line in central Indiana; it was a sluiceway for torrents of glacial melt water.

Wherever the ice had melted without moving forward, a till plain or area of ground moraine (pl. 2) was formed. Most of the surface between streams that is shown on plate 2 is underlain by till which was deposited by being "dropped out" from disintegrating glacier ice. The resulting hummocky surface is one of low relief; that is, the differences in elevation between high and low spots within small areas are less than about 10 feet.

A general melting back of the glacier margin to the northeast was broken by a few short-lived readvances. Each time that the ice mass came temporarily to life the margin advanced again for a few miles. Such minor fluctuations of the generally retreating margin resulted in deposition of thin layers of fresh till or outwash upon earlier drift deposits. End-moraine patches appear to have been formed in at least two places (pl. 2). They resulted from the dumping of till along the ice margin or from the pushing up of ground moraine into a low ridge.

Many large cracks or crevasses were formed along and within the decaying ice. Melt-water streams and debris landslides deposited sand and gravel in the crevasses open to the sky. These deposits appear today as low hat-shaped hills, called kames, or as low, straight ridges. The surficial-geology map (pl. 2) shows the many kames and ridges that were formed during the melting of this last ice lobe that covered Marion County. In a few places crevasses extended to the base of the glacier, and wet till either was pressed up into these crevasses or was slumped into them as the till began to melt free from the crevasse walls. Low, straight ridges of till were formed. In other places curved ridges of till were formed around ice blocks that became isolated from the rapidly decaying ice margin. A few of these ridges outlined all the former ice block, but most of them outline only part of it.

During the melting of this ice of the last glacier advance (front cover), a few large blocks of ice became detached from the glacier margin and were buried beneath outwash. Slow melting of these ice blocks caused depressions to form in the surface of the outwash materials. With the return of vegetation to Marion County, these depressions eventually became the sites of bogs. Bogs were formed in places where the level of water in the ground stood near the surface of depressions, as at Bacon Swamp, a bog in northern Indianapolis (pl. 2).

After the main valleys had been filled with outwash, the melt-water streams increased in size and began to cut down into the deposits. Patches of the original valley fill were left here and there along the sides of valleys (pl. 2); these patches are called terraces today.

Although some deep valleys were cut into the drift plain as the ice melted, the final surface was generally a flat one and underlain mostly by till. This fact explains why the county is located by physiographers in the Tipton Till Plain physiographic unit. (See physiographic map on back cover.)

The present interglacial age.—Following the disappearance of the last glacier in central Indiana some 18,000 to 19,000 years ago, plants and animals began moving into the ice-free area, and soils began to be formed on the surface of the glacial drift. Streams flowing in the old glacial melt-water valleys began to remodel the valley floors and to cut sideways into the valley walls. Glacial materials were eroded and reworked by these streams and were deposited on the flood plains in the valleys. These processes of valley widening and reworking of glacial materials have continued until the present day.

According to several recent concepts of earth history, we are now in an interglacial age, and many geologists think that there will be another glaciation of North America in a few thousand years. Perhaps then Marion County will again undergo a facelifting at the hands of the glaciers.

SELECTED REFERENCES

For those readers who wish additional information on Indiana geology, the following list of references may prove useful. Each of the publications is illustrated and written in nontechnical language. (A list of geologic publications of Indiana may be obtained free of charge upon request to the Publications Section, Geological Survey, Indiana University, 1005 East Tenth Street, Bloomington, Ind.)

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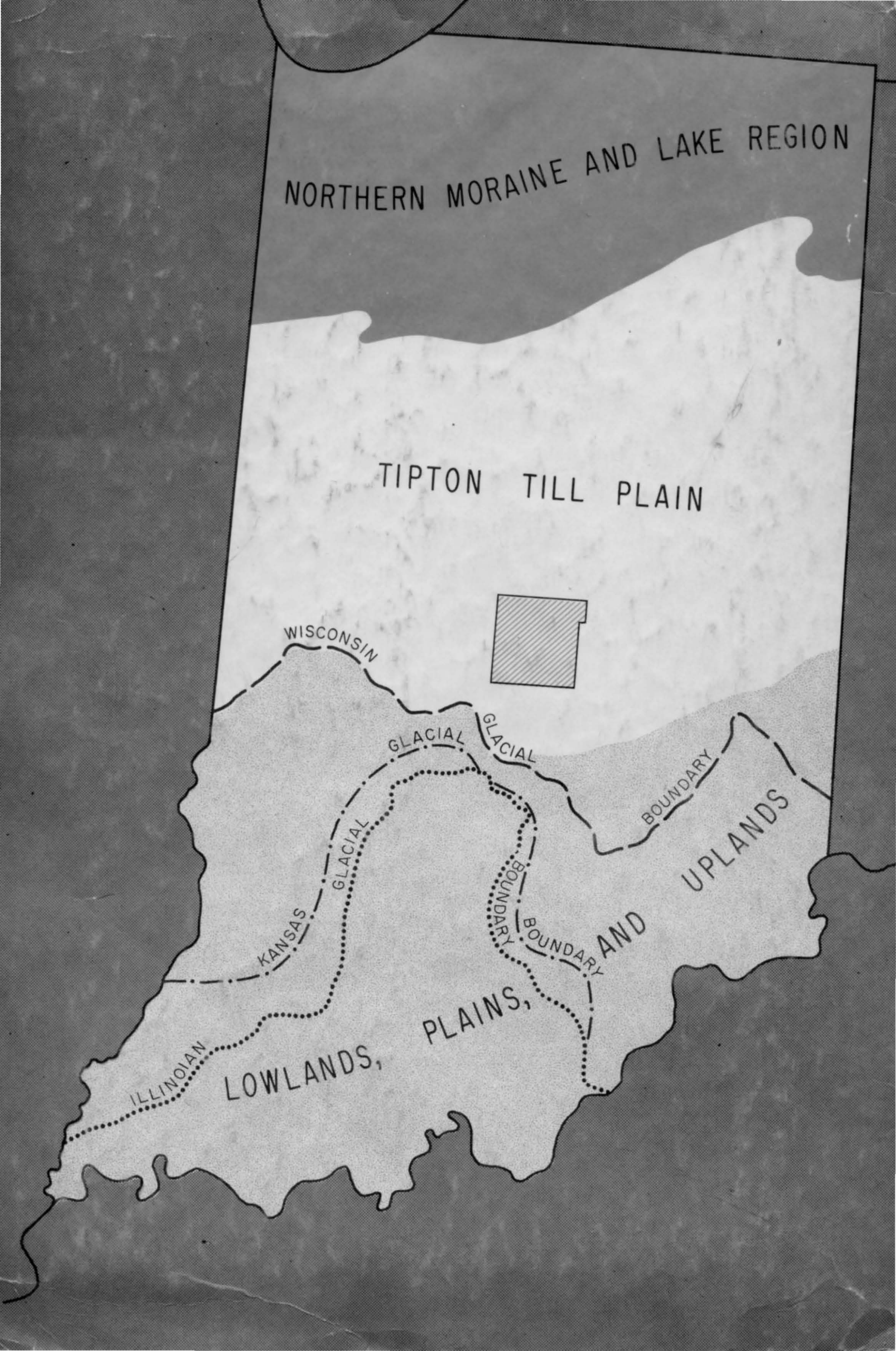
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