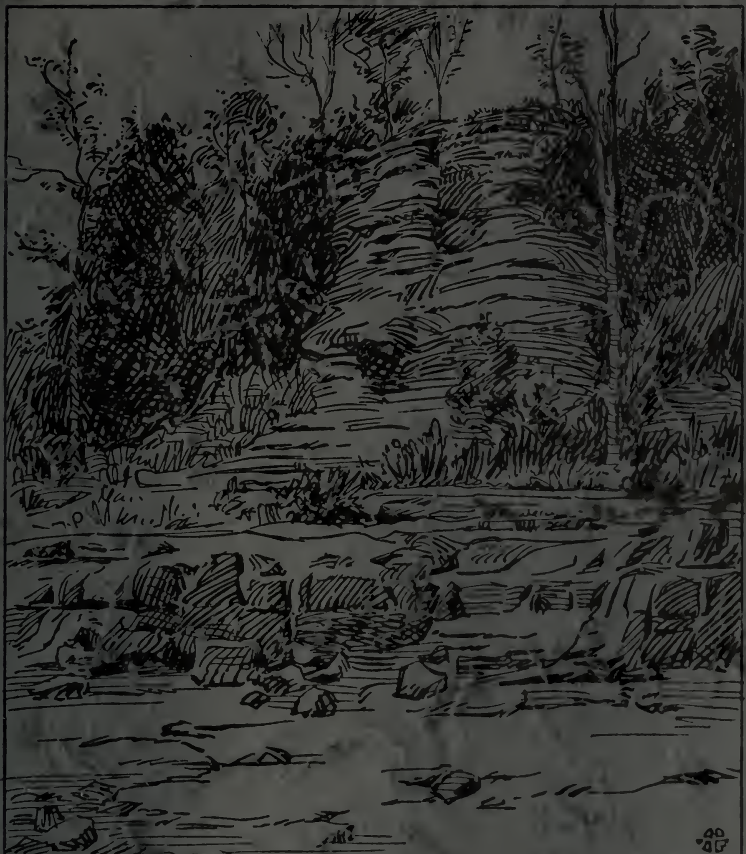


The Story of The Geologic Making of Southern Illinois

by Stuart Weller

Tower Rock, Hardin County

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
M. F. WALSH, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

EDUCATIONAL SERIES NO. 1

The Story of the Geologic Making of Southern Illinois

BY

STUART WELLER

Printed by authority of the State of Illinois

URBANA, ILLINOIS
1927

Reprinted 1931

Jeffersons Printing & Stationery Co.
Springfield, Illinois
1931

Letter of Transmittal

State Geological Survey Division, Urbana, May 27, 1931

M. F. Walsh, Chairman, and Members of the Board of Natural Resources and Conservation,

Gentlemen:

The first edition of Education Series No. 1, "The Story of the Geologic Making of Southern Illinois," by the late Professor Stuart Weller, has become exhausted and a second edition is necessary to meet the demands of our public schools and of our laymen for this popular treatment. I therefore respectfully recommend its reprinting.

Sincerely yours,

M. M. Leighton, *Chief.*

Preface

In southern Illinois lies a region which occupies about one twenty-eighth of the area of the State and which differs markedly in appearance from the rest of the State. By far the greatest portion of Illinois is made up of flat, fertile prairies; indeed, in the central section, hills are exceedingly scarce. A traveler making his way south from Harrisburg in Saline County finds that he has left the prairies behind and that he is among hills, the highest one of which—Williams Hill in Pope County—attains an elevation of 1,065 feet. In no other part of the

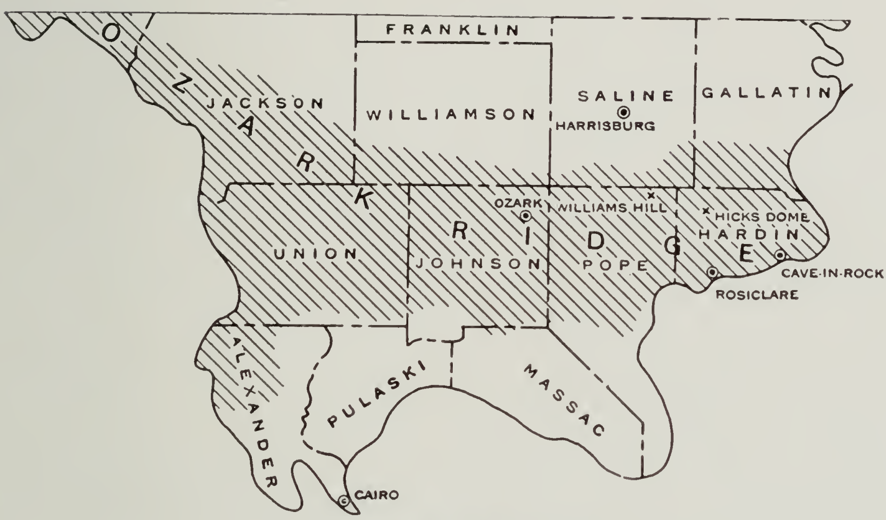


Fig. 1.—Map of southern Illinois showing approximate boundaries of Ozark Ridge.

State save in Jo Daviess County in the northwest corner are there higher hills. The traveler finds short, swift streams and steep ascents, hidden nooks and outlook points, and a relief made most engaging to the eye by reason of rapidly changing scenes. And nowhere does he find the extensive fields and farms so characteristic of the prairies.

This area of southern Illinois covers a strip about 70 miles long and from 15 to 40 miles wide (fig. 1). It extends from Mississippi River on the west to Ohio River on the east, and lowlands lie both to the north and to the south of it.

The history which follows attempts to outline briefly the manner in which southern Illinois came to be as we know it. Much detail necessarily has been omitted, and much remains to be learned, but not a year passes without the acquisition of some new information which helps to complete the story.

THE STORY OF THE GEOLOGIC MAKING OF SOUTHERN ILLINOIS*

By Stuart Weller

INTRODUCTION

When man began to wonder about the reasons for things and began to seek out the causes for the great variety of natural phenomena which surrounded him, he began the ascent of the intellectual ladder many of whose steps he has already climbed, but from the top of which he is still much farther removed than from the bottom. In the early stages of this intellectual growth he had no perception of natural law and he of necessity had to explain the phenomena of nature through supernatural agencies. Thus grew up the myths of creation as well as other myths and stories to account for all of the unexplainable phenomena about him. Many, many generations passed before man's intelligence began to give him some conception of the workings of the laws of nature. Undoubtedly, from time to time some great genius arose whose sense of curiosity was more intense than that of his fellows,—one who was capable of searching deeply into the reasons for things and who was able to make some addition to the knowledge of the human race. Comparatively few generations of men have passed since Newton formulated the law of gravitation, perhaps the most far-reaching of all natural laws. Copernicus, who founded all modern astronomy by his discovery that the earth was not stationary but revolved about the sun, was born less than 500 years ago. Even today the vast majority of human beings, and among them great numbers of our own people, have but little conception of the meaning of

---

* This paper is based on an address given by the author as retiring president of the Illinois State Academy of Science at the Harrisburg meetings, April 30, 1926, and published in the Proceedings of the Academy, vol. 19, pp. 27-49.

science, and still hold to all sorts of supernatural explanations of phenomena which they observe every day.

Reduced to its last analysis, science is the search for the reasons for things. Every man of science knows that every phenomenon in nature has a cause, a reason, and just as truly every phenomenon has an effect. The search for the causal relations of all these phenomena is his task. If he is unable to discover a reason for the facts which he observes, he does not appeal to some supernatural explanation; he knows that his researches have not yet penetrated far enough into his problem. The men of science of our generation are those in whom the sense of curiosity concerning nature is most keenly developed. They are continually asking themselves the question, "Why?" and are never satisfied until some reasonable and logical explanation is found. Every child starts his career as an active researcher. He observes all sorts of phenomena about him which arouse his curiosity, and he repeatedly asks the question "Why?" All too often his questioning soon surpasses the ability of his parents and teachers to make answer and he is told not to ask such foolish questions. Doubtless many an able man of science has been lost through the stifling of childish questioning. Fortunately a few remain in whom this curiosity cannot be stifled, else the progress of our race would come to a standstill.

EARLY CONCEPTIONS

Among the phenomena which early attracted the attention of man, were the features of the landscape which surrounded him, the hills and valleys, the mountains and the sea. Because of their apparent stability, explanations for these phenomena were not sought as early as were explanations for the apparent movement of heavenly bodies. If any thought was given to the subject, it was assumed that the hills and valleys and moun-

Features of the landscape

tains and seas had always been and would always be. This conception of permanence is still with us and not infrequently we see references to the everlasting hills, although every geologist knows that neither the hills nor the highest mountains are everlasting.

Another group of objects which came to the attention of early observers were the fossil shells seen in all sorts of situations. During the Middle Ages fossils aroused much discussion and numerous explanations were offered for them. Some thought them to be sports of nature; some believed them to be discards thrown aside by the Creator of all things; but the final explanation which seemed to satisfy most men was that they were the remains of sea animals which were swept from the sea and were lodged upon the land during the Noachian Deluge. Of course the geologist today knows that these objects are the remains of animals and plants, many of them marine, which one time lived and flourished in the places in which the evidences of their existence are now found. At that time the ocean waters covered those areas now dry land but formerly parts of the sea bottom.

Fossils

GEOLOGIC TIME AND PROCESSES

It was only a little more than a hundred years ago that students of geology began to realize that the present configuration of the earth's surface has been established through the agency of slowly acting processes which are in operation today and which have been continuously in operation for long periods of time, rather than through abrupt, cataclysmic revolutions which occurred at comparatively short intervals. We have come to realize that geologic time is long—exceedingly long when measured by the scale of human existence—and we look upon its duration as being comparable, in a degree, to the vast extensions of space recognized by the astronomer. And with an increase in our knowledge of the earth's history comes an expansion in our conception of geologic time. In the history of the earth a million years are but as a day, and forces and processes which seem to have only a small effect when seen from day to day are capable of producing tremendous effects when continued over long periods of time. During a summer shower, all of us have seen material transferred from the hilltops to the valleys and if enough time is allowed and enough showers fall upon a hill, eventually that hill will be leveled to the plains. In the geologic past this very transfer of material has taken place repeatedly. Mountains as high as the highest upon earth today have been eroded down to the level of the sea; other mountains have been raised up and have in turn been worn away.

Modern conceptions

The geologist interprets the history of the earth's past recorded in the rock strata of its crust through an understanding of the processes which are active today. It goes without saying that in the erection of a pile of lumber the boards in the bottom of the pile were laid down first. Likewise the lowermost beds in the rock strata of the earth's crust in any given region were, axiomatically, laid down first and consequently are the oldest. Figure 2 shows horizontal beds of limestone. In order for the lowermost bed to have its position with respect to the other beds above it, it had to be laid down first. Hence, it is the oldest bed, and the beds above it are successively younger.

Correlation of rocks

If the solid rock formations were everywhere uncovered and had never been disturbed, it would be a comparatively simple matter to trace the beds from place to place and establish their true relations. In most regions, however, these conditions do not exist. The rocks are covered in many places by unconsolidated residuum and soil. In parts of Illinois whole counties are without a single solid rock outcrop; in many others the outcrops are so few and so widely separated that the beds cannot be traced. Then again, through the agency of great deformative processes the rocks have been broken into blocks which have been shifted up and down and horizontally to such an extent that the individual beds are no longer continuous.

Under these conditions it has been necessary for the geologist to establish some means of tracing rock beds from place

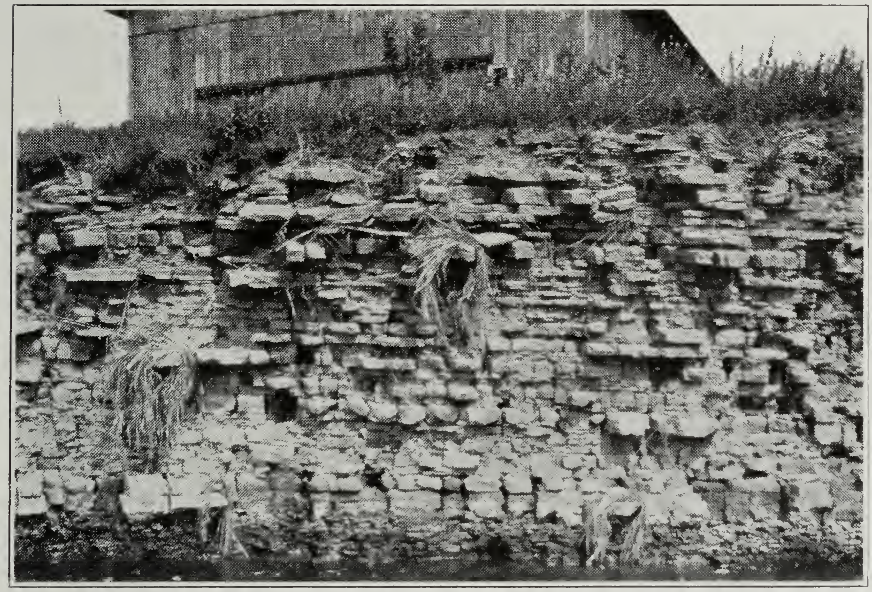


Fig. 2.—Exposure of limestone beds in Kankakee County, Illinois.

to place, and long study has shown that the only reliable criteria are the organic fossils contained in the rocks. These fossils furnish a record of the evolution of the life of our globe, the scattered remains of succeeding generations which exhibit the gradual changes through which living creatures have been passing. The life of no period of geologic time is the same as that of the preceding or of the succeeding period;

consequently a knowledge of the succession of living things upon the earth affords us a most reliable criterion for the determination of the relative ages of the rock strata which come under our observation. It must be recognized that our knowledge of these long-extinct inhabitants of the earth is as yet but fragmentary, but every year adds to our information, and already we can make a serviceable application of accumulated facts in our interpretation of geologic history. With further information greater and greater refinements in our interpretations will become possible.

Movements in earth's crust

If the earth's crust had undergone no deformative changes during its long period of existence, all sediments which were accumulated under marine waters and in which are buried the remains of marine organisms, would still be submarine in position and would be inaccessible for study. It is known, however, that crustal movements have taken place even in historical time. Certain portions of our shorelines are known to be rising relative to the ocean level and other portions are sinking. Not infrequently violent earthquakes occur in the course of which notable crustal changes take place. Rocks which are manifestly of marine origin since they contain fossil shells of marine organisms, are now found thousands of feet above sea level; they must have been elevated to their present position or the sea must have receded. Probably both elevation and recession occurred. Rocks which must have been formed originally as nearly flat-lying sediments deposited in water, are now steeply inclined in many places, and are even folded, crushed and broken. The existence of tremendous forces which have been at work in earth-growing processes is thus made manifest.

No sooner was land exposed above the level of the sea than it was subjected to the processes of erosion. Water falling as rain and always seeking a lower level started to wear away the

Erosion of earth's surface

elevated rocks and gradually wore them down to sea level, just as the hills between Harrisburg and Ohio River are at present being gradually reduced by every rain which falls upon them.

Deformation and unequal erosion have resulted in the exposure somewhere at the surface of the earth of sedimentary rocks of all ages. In future geologic periods, rocks which now exist at the surface will have been worn away and their materials will have been carried down the streams to the ocean and redeposited to form younger rocks, much as sediments are now accumulating in the delta of Mississippi River.

Division of geologic time

Our present knowledge of the earth has progressed far enough to make it possible for geologists to recognize a number of distinct divisions of geologic time. Of course time is continuous and uninterrupted, and we can divide it into distinct periods only on the basis of events. Our subdivision of time in human history has been wholly dependent upon the occurrence of events. The discovery of a new continent in the fifteenth century initiated into human history a new period of the utmost importance. The events which led to the declaration of war in Europe in 1914 ushered in a period which has changed and is changing the destinies of most of the nations of the world. The transition of one period into another may be gradual like the passing of spring and the coming of summer, or it may be abrupt and unexpected like the beginning of the great World War. The periods of geologic history are not unlike those of human history. They are definitely marked from one another by events like the growth of great mountain ranges, or the appearance of a new type of life. Some transitions have been abrupt and have been accomplished in an exceedingly short time, geologically speaking; others have been so slow as to make difficult the setting of a precise boundary between two rock systems although each has distinct characteristics.

Eras of geologic time

It has come to be the custom of geologists to use as their basis for the larger divisions of earth history the character of the life of the era. Azoic time was an era during which no life existed. Eozoic was the era of the dawn of life with the introduction of unicellular organisms. The Archeozoic era was the age of larval life, and the Proterozoic the age of primitive invertebrates. All earth history to the close of Proterozoic time is so ancient that our information regarding it is most hazy. The Proterozoic was followed by eras concerning which our information is less limited although it is far from complete. The Paleozoic era was the time of ancient life forms, now mostly extinct, but some of them were more or less related to our contemporaneous life. The Mesozoic era was the time of medieval life which, although almost wholly unlike living forms of today, still had much more in common with them than had the life of the Paleozoic. The Cenozoic era was the time of modern life which was much like that of today. The last, or Psychozoic, era is the age of man.

Periods of geologic time

Each one of these great eras is divided into periods some of which have been named geographically after some district in which rocks representing the period are well exhibited. One great period of the Paleozoic era has been named the Devonian because it was first studied and its fossil life was first described at Devonshire, England. Following the Devonian was a great period known as the Mississippian, so named because its rocks are best represented in the Mississippi Valley region of this country. The Mississippian was succeeded by a period during which the great coal formations of eastern North America were laid down. The name Pennsylvanian has been given it because the rocks are widely developed in Pennsylvania.

TABLE 1.—*Table of geologic time divisions.*

Era	Period (time term) or System (rock term)	Character of rocks in Southern Illinois
Cenozoic "Recent life" (Age of mammals)	Recent	Surficial deposits
	Pleistocene	
	Tertiary	Absent
Mesozoic "Middle life" (Age of reptiles)	Cretaceous	Absent
	Comanchean	
	Jurassic	
	Triassic	
Paleozoic "Ancient life" (Era of invertebrate animals and non-flowering plants)	Permian	Absent
	Pennsylvanian (Coal Measures)	Conglomerates, sandstones, shales, and coal
	Mississippian Upper	Sandstones, shales, and limestones
	Mississippian Lower	Principally limestones
	Devonian	Limestone and shale
	Silurian	Limestone
	Ordovician	Limestone and sandstone
	Cambrian	Not exposed
Proterozoic "Primitive life"		
Archeozoic "Larval life"		

Table 1 gives the eras and periods of geologic time. As the Archeozoic era is the oldest that we know and its rocks were formed first, it is placed at the bottom of the list. Similarly, the Cenozoic era is the youngest and is placed at the top of the column. More detailed information regarding the geologic time table and geologic principles can be found in the standard text books on geology.

ROCKS OF SOUTHERN ILLINOIS

By reason of the processes which have been described all too briefly, rocks belonging to the Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian periods are now exposed at the surface in southern Illinois.

The Ordovician and Silurian rocks are exposed in the Mississippi River bluffs in western Alexander County. Devonian rocks are found in two areas; (1) along Mississippi River in Alexander County, Union County, and a very small part of Jackson County; and (2) in Hardin County.

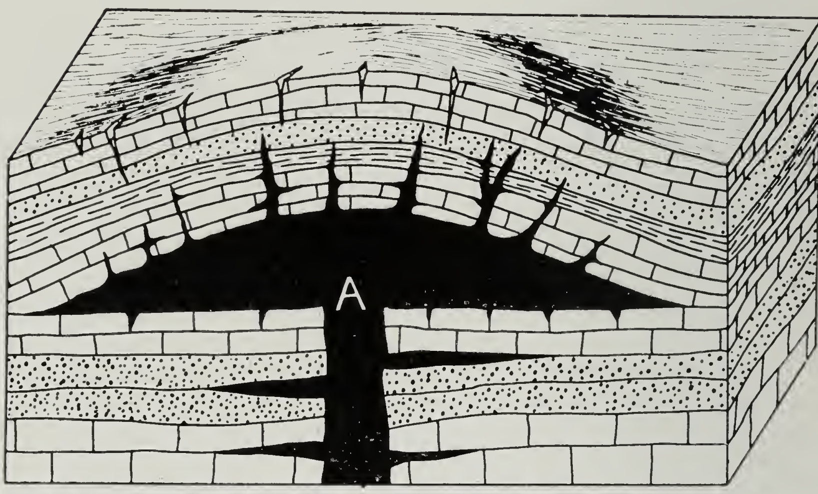


Fig. 3.—Diagram to illustrate effect on horizontal beds of intrusion of molten rock or lava (A).

The second area of Devonian outcrop is limited and is known to geologists as Hicks Dome. It is a structure which is comparable to a doming of the earth's crust. Figure 3 illustrates the probable manner of formation of this dome. The rock strata were at one time nearly horizontal. A mass of material (A in the diagram), probably in

Hicks Dome

the form of molten rock or lava, was injected into the crust beneath the horizontal strata. This mass pushed up the beds above it and a doming at the surface resulted. The molten material is now completely cooled and solidified. After the uplifting, erosion began on the higher parts of the dome and the overlying strata were worn away until now the lower and older beds are exposed in the center of the dome. Figure 4 is a geologic cross-section of Hicks Dome, in which the vertical scale has been much exaggerated.

Devonian and older rocks

Wherever a deep drill-hole is sunk for oil or for other purposes, the geologist can make logical deductions from the information which it gives regarding the rocks penetrated. So we know that the Devonian rocks continue beneath the surface from the area of exposure in Hardin County, across southern Illinois into Union County where they are again exposed, and into south-

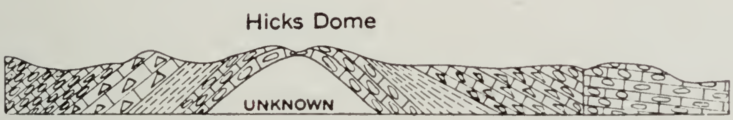


FIG. 4.—Geologic cross-section of Hicks Dome, Hardin County.

eastern Missouri. To the east and south they are completely hidden by younger, overlying strata. Of course the Devonian rocks are not the oldest rocks in southern Illinois. We know about the rocks and their attitudes in other parts of the Mississippi and Ohio valleys and, making logical deductions, we know that beneath the Devonian rocks of Hardin County are formations representative of all the major geological systems below the Devonian. Some of these older rocks, as stated above, are exposed in the Mississippi River bluffs.

The southern slope of the Ozark hills south of Harrisburg is underlain by rocks of Mississippian age; the higher parts are composed of Pennsylvanian strata. These Pennsylvanian rocks dip to the north, and at Harrisburg the strata which are exposed at the tops of the Ozark hills are found far beneath the surface. Figure 5 shows this condition in diagrammatic form. The coal beds which are so extensively mined in southern

Mississippian and Pennsylvanian rocks

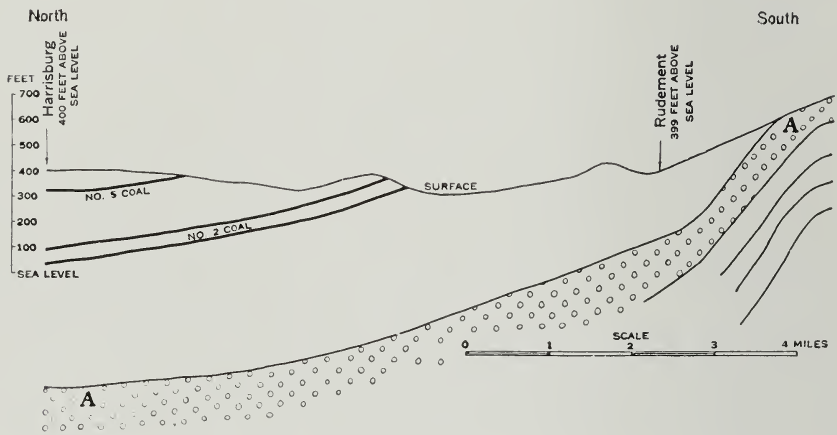


Fig. 5.—Diagram illustrating dip of rocks south of Harrisburg. Vertical scale much exaggerated. Bed A outcrops at the surface at the top of the hill south of Rudement, but at Harrisburg it is far beneath the surface.

Illinois belong stratigraphically far above the sandstone which forms the tops of the Ozark hills. When they were originally deposited, the coal beds were undoubtedly continuous with the existing coal fields of western Kentucky, but subsequently an area in Hardin County and adjacent portions of Kentucky was uplifted and not less that 3,000 feet of hard rock strata have been removed by the slow processes of erosion. The Ohio River has cut its valley through all these strata.

HISTORY OF THE MAKING OF SOUTHERN ILLINOIS

No history of the making of southern Illinois can be complete without taking into account those rocks older than the Devonian, but as the major events which led to the present configuration occurred after this period, and as in only a small area are older rocks exposed, we shall begin our story with Devonian conditions.

The oldest Devonian rocks are limestones in which are buried numerous fossil shells of marine animals, and we can confidently assert that during Devonian times southern Illinois was covered by a great shallow sea which extended north to Canada, northeast to New York State, and east to the Allegheny Mountains. This sea had great islands; one extended north from where Cincinnati, Ohio, now stands; another was in central Tennessee about where Nashville now exists. We know from the fossil evidence that this sea did not extend west of the Mississippi River except in southern Missouri. To the south it must have had connection with the open ocean.

Devonian sea

At the end of Middle Devonian time, it is known that great crustal disturbances took place in southeastern Missouri. Great faults were formed with a maximum dislocation of the beds of 1000 feet. There is no evidence to show that any similar deformative disturbance took place in southeastern Illinois, but the great earthquake tremors which the Missouri disturbances must have created certainly affected this portion of Illinois. In southeastern Missouri the earth movements left the ancient sea bottom well above sea level. It is not improbable that southern Illinois was also dry land for a time, although it was certainly again submerged in late Devonian time when

Crustal disturbances in Devonian times

it became a part of a widespread interior sea which extended from the Appalachian Mountains on the east to Oklahoma on the west, and as far north as Lake Erie at least. It extended as far southeast as Chattanooga, Tennessee, but its southern extent is not known definitely, for the sediments deposited are hidden under much younger rocks.

The character of the late Devonian deposits indicates that the waters of this interior sea were more or less stagnant. The sediments were fine muds with a large admixture of organic matter which gave the consequent shales their intensely black color. Quantities of the minute spore cases of an ancient type of plant were buried in these muds and are now preserved in the fossil condition. Animal fossils are scarce, and those which are present show that the sea was not a typical body of marine water and that it had only indirect communication with the ocean water surrounding the continent.

Character of deposits in Devonian sea

This great interior sea with its more or less stagnant waters must have existed a long time, humanly speaking, for no less than 400 feet of the characteristic black shales accumulated, at least locally. The period, however, was brief as geologic time is reckoned, and at its close the whole of southern Illinois was elevated above sea level. Once again began the wearing down processes of erosion which are always effective when a land surface is elevated and whose vigor depends on the climate, the elevation above sea level, and the distance from the sea.

At last the region was submerged again as a result of crustal deformation or of a rise in sea level due to changes elsewhere, and earth history passed from the Devonian into the Mississippian period. The Mississippian sea which covered southern Illinois during this time was a widespread body of water over the interior of the continent. It spread northward in the present Mississippi Valley

Mississippian sea

at least as far as Iowa and northern Illinois and doubtless at times it extended into southern Wisconsin. At the time of its greatest extent it spread as far to the northwest as Montana and as far to the southwest as New Mexico. To the southeast it reached Alabama and Georgia but on the east it was limited by a great land mass known as Appalachia which occupied a position east of the present Appalachian Mountains. The Mississippian sea, no doubt, had free communication with the open ocean to the south.

Conditions in the Mississippian sea were vastly different, however, from those which gave rise to the great accumulation of Devonian shales, for in it were deposited mainly limestones whose fossil contents consist of typical marine organisms. The oldest formations deposited in this Mississippian sea are the limestone formations which encircle Hicks Dome. Younger rocks are exhibited in the limestone bluffs of Ohio River which are more or less continuous from Rosiclare to Cave-in-Rock, in Hardin County. The same limestone formations are found in that part of the county where sink holes are so numerous.

There are several distinct limestone formations in the Lower Mississippian. These have been named the Iowan series because they are well developed and were first described in Iowa.

Mississippian limestones

They are distinguished by the character of the strata themselves and by the differences in fossil content. The changes reflected by the formations were caused by changes in the boundaries of the sea, in the depths of the water, and in the purity of the water. The purer limestones consist largely of calcium carbonate which was withdrawn from solution in the sea waters through the agency of shell-forming animals. Some of the shells were broken and even ground into fine powder by the movements of the water and formed the lime muds of the sea bottom; others were buried with little or no injury in these lime muds. Doubtless many bacteria were present which caused the precipitation of lime.

Ozarkia

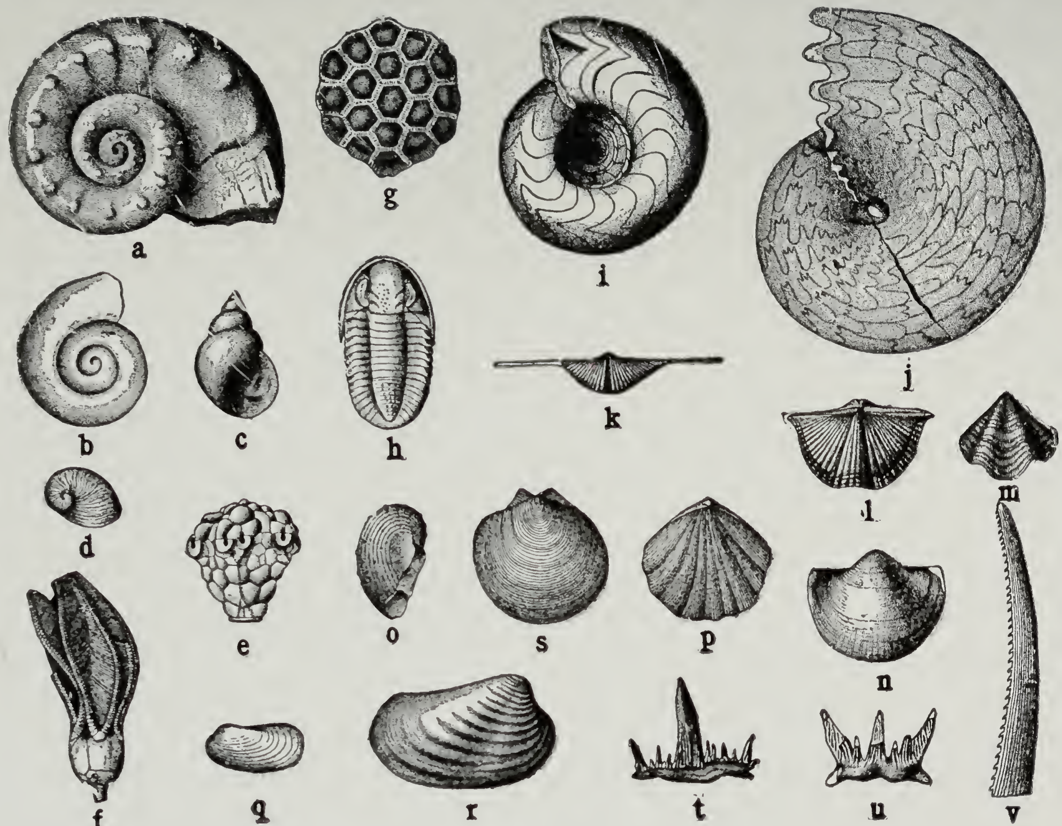
During part of the time, the Ozark region of Missouri constituted a great island, Ozarkia, which furnished materials to the sea to form shales, sandstones, and impure limestones. Then again the island was entirely submerged and, since the source of land-derived sediments was removed purer limestones accumulated.

Cincinnatia

Cincinnatia was another great, low-lying island, which extended north from Cincinnati, Ohio. East of it was an arm of the sea, which extended into Michigan and in which little limestone formed, since a continuous supply of non-calcareous material was furnished by Appalachia. The shorelines of this great interior sea shifted continually by reason of the crustal movements of the earth, but there is no evidence that southern Illinois was raised above sea level before the close of the period.

Life in the Iowan sea

The Iowan sea teemed with a great variety of life as to form, but instead of the clams and snails which make up so great a part of the fauna of our present oceanic waters, there were great numbers of brachiopods and crinoids, types of life which are met with only rarely in the seas today. There were also a few trilobites, a life form which is now wholly extinct, some snails, clams, and corals. (See fig. 6.) All these forms were creatures which formed hard, stony shells which were capable of fossilization. There were great numbers of fishes also, all of them related to the sharks. Some must have grown to a large size; their sole records are their fossilized teeth and fin spines. There were doubtless also many soft-bodied animals, as there are in the seas today, which were wholly incapable of leaving records of their existence, as well as sea weeds of various sorts.



LEGEND

a, b, c, d: gastropods
e, f: crinoids
g: coral
h: trilobite
i, j: cephalopods
k, l, m, n, o, p: brachiopods
q, r, s: pelecypods
t, u: shark's teeth
v: shark's spine

FIG. 6. A group of Lower Mississippian fossils.*

* From Chamberlin, T. C., and Salisbury, R. D., Geology, vol. II. By permission of Henry Holt & Company, publishers.

Following the long period of limestone formation, southern Illinois was raised above sea level; indeed it is not unlikely that the whole of the interior of the continent became dry land. Processes of erosion became active but the low relief of the land prevented rapid erosion and no great thickness of the limestone was removed. The emergent condition continued for a considerable length of time but not so long that some forms of animal life which had inhabited the Iowan sea survived elsewhere and re-entered the area with a new period of submergence.

Chester embayment

The new period of submergence in southern Illinois brought with it a new set of conditions. The rock-forming materials were no longer almost pure lime, but included also great quantities of sand and fine mud which built up the Chester series. At the present time the Chester formations constitute the surface rocks upon much of the southern slope of the Ozark hills in southern Illinois and in places they continue to the Ohio River bluffs and even across the river into Kentucky. The basin in which this series of rocks accumulated was very different from the great interior sea in which the limestones of the Iowan series were formed. In Illinois the basin was simply a great embayment which extended northward between Cincinnatia on the east and Ozarkia on the west, to about the middle of the State. Into this embayment emptied great rivers whose sources doubtless were far to the north in what we now know as Canada. These rivers brought down much sand and fine mud which they dumped into the Chester embayment. The waves along the shores sorted the materials and deposited them in different places; the sands, which represented the coarser materials, settled near shore; the finer materials or muds were held in suspension, were carried out to sea, and finally settled in the deeper waters away from the shores, to form the mud beds from which the shales now conspicuous in the Chester series were developed. In places in the deeper waters, conditions were favorable for the existence of a wonderful variety of living animals, whose remains were buried in the limy shale beds where their hard parts were preserved and from which an abundance of fossils may now be collected. In other places in this Chester sea, conditions permitted the accumulation of pure limestones which can now be seen in many of the exposures of Chester rocks.

The shifting shoreline

Had the shoreline of the Chester embayment remained stationary throughout Chester time, there would have been deposited one great sandstone formation near shore, which would have become finer and finer off shore, merging into a shale formation composed of the fine muds which had been held in suspension, and still farther out from shore into a limestone. But such simple conditions did not prevail. The shores of the embayment shifted constantly, and the areas which at one time were submerged became exposed because of the rising of the land or the lowering of the sea level—only to be covered again by the sea because of a reversal of conditions. At intervals the whole of southern Illinois was above water, and the shoreline lay to the south perhaps across what is now Kentucky. As a result of these shiftings in the position of the shoreline, that portion of southern Illinois where Chester rocks form the surface was successively within the zones of sandstone, shale, and limestone formation, and so the Chester strata are an alternating series of these different rocks. The Chester section gives evidence of no less than eight shiftings in the shoreline.

Vegetation of post-Chester times

After the final withdrawal of the Chester sea, the whole of the southern portion of North America doubtless became dry land and remained as dry land for a long time. A rich vegetation sprang up, very different from what now covers the region. Instead of the usual types of forest trees and herbaceous and shrubby plants with which we are familiar, a large number of the trees and other plants were fern-like in character; others were gigantic relatives of the little club mosses of the northern portion of our country which now grow to a height of only a few inches and are not found at all in southern Illinois. Others were great tree-like relatives of the horsetails which now grow as slender plants only a few feet high at most, and still others were cone-bearing trees with long and broad grass-like leaves. Nowhere in all these forests was there a single representative of the plants bearing showy and sweet-scented flowers which make our own landscapes so beautiful.

Animal life of post-Chester times

The air-breathing animals of these forests were also strange forms when compared with those we know today. Doubtless there were numerous forms related to our living salamanders, lizard-like forms who spent their early life stages in the waters of ponds and swamps, much as does the tadpole which is the early stage of the toad or frog. Perhaps there were a few air-breathing reptiles, lizard-like creatures, which lived on land. There may have been some land snails and fresh water snails and clams. Flying about in these forests were many extraordinarily large insects, of the cockroach and dragonfly type for the most part. One dragonfly with a wing spread of thirty inches is known, and some of the cockroaches which lived during this period were more than a foot long.

Conditions at beginning of Pennsylvanian time

This period was the beginning of what we call Pennsylvanian time. Dry land then prevailed in this section of the continent, but to the east—along the border of old Appalachia from Pennsylvania southward to Georgia—great quantities of terrestrial deposits of coarse sands and conglomerates and some coal were accumulating. To the southwest, in Oklahoma and beyond, aquatic sediments, in part marine, were being deposited.

How long this dry-land condition continued in Illinois cannot be measured in years. Popularly speaking, the time was long, and even from the standpoint of geology it was a notable interval. During this time, the land surface was undergoing slow erosion; since the region was not highly elevated above sea level, the erosion was not as vigorous as in more mountainous regions. Large river systems were developed, and some hundreds of feet of the older sediments were removed.

Pottsville sediments

Later a sinking of the land resulted in a great wash of terrestrial sediments overspreading the region. These consisted of coarse sands and conglomerates, which filled the depressions in the land surface, and some finer sands and sandy shales. In some places conditions were favorable for the accumulation of vegetable matter in swamps; the peat which was then formed later became coal.

These sediments furnish the record of events in the Pottsville epoch of early Pennsylvanian time, and their remnants now form the crest of the so-called Ozark ridge which extends east and west across the State south of Harrisburg (fig. 1). At Harrisburg, these same beds are far beneath the surface, because of their northward dip brought about by later deformation in the region, but they were originally laid down in an essentially horizontal position.

Origin of Illinois coal basin

After a time, the region which extended south beyond Ohio River, north into northern Illinois, and west across Iowa, Missouri, and Arkansas to Kansas and Oklahoma, became stabilized at a level not much higher than that of the ocean. Upon this low, flat expanse the drainage became more or less stagnant and great swamps came into existence (fig. 7), some of them of great extent, in which the abundant remains of vegetation slowly collected. The conditions were such that this vegetable matter did not decay readily, and it accumulated first as great beds of peat. Occasionally quantities of sand and mud were washed into the basin probably as a result of slight elevations of lands to the north, and the peat beds were thus buried under strata of sandstone and shale. At other times, marine waters came in and spread over the area and lime-

FIG. 7.—Reconstruction of swamp forest in Pennsylvanian time. After H. Potonie.

stone beds, some nearly pure and others more or less impure, all carrying characteristic marine shells, were formed in the basin. Again, muds were deposited under marine conditions, a fact of which the presence of marine shells is an evidence. Such conditions were followed by a recurrence of swamps in which more peat beds were formed.

The result of these successive changes was the building up of a series of sandstones, shales, coals, and limestones which constitute the section now found in the Illinois coal basin. The great weight and pressure of the superimposed strata upon the peat beds caused these beds to be transformed gradually into the coal which is the important mineral resource of southern Illinois.

During this period of accumulation, the sediments were laid down in an approximately horizontal position, and the coal beds of Illinois and of western Kentucky were continuous. Yet today the Illinois fields are separated from the Kentucky fields, and between them are found rocks which are much older than the coal-bearing strata. Obviously, some deformation in the earth's crust was responsible for the elevation of these older rocks above the coals. To the geologist comes the problem of finding an explanation for the condition which exists; why was this portion of the earth's crust deformed, and when did the deformation take place?

Relation of uplifted area to Missouri Ozarks

A significant fact concerning the uplifted area in southern Illinois is its position directly east of the Ozark region of Missouri, which we know was uplifted repeatedly during Paleozoic and later geologic times. It is not unlikely that the uplift in Illinois was due, in part at least, to the proximity of the area to the Missouri Ozarkia and its connection with it; so we may very properly speak of the highlands of Illinois as a continuation of the Ozarks. That the connection is popularly recognized is shown by the fact that a small town in southern Illinois bears the name Ozark.

The present elevation of the Illinois Ozarks is by no means equal to their original height. Perhaps more than a thousand feet have been removed from the tops of these hills by erosion, and, although they could never have been really high mountains, yet they must have been a much more formidable range than they are now. Their present elevation is due to the facts not only that the rocks were bowed up in the past, but also that the older rocks which have been uncovered are harder and more resistant to erosion than the rocks to the north. Consequently they remain as high parts simply because they are not easily worn away. Had they been softer than the younger rocks, a depression or valley instead of a range of rugged hills would mark the belt of the uplift.

In the eastern portion of the elevated belt across southern Illinois, other factors besides proximity to the Missouri Ozarks had their influence. One of these was the intrusion of igneous material into the earth's crust which caused the strata to dome up, as in the case of Hicks Dome. As already stated, we now find limestones of middle Devonian age exposed at the surface in the center of the dome, and if all the strata which erosion has removed could be replaced, it would be found that the doming was sufficient to form a mountain which must have towered above its surroundings.

Igneous intrusion

The molten material was injected also into cracks and fissures in the existing strata, and formed thin dikes (fig. 8) which have been found in coal mines near Harrisburg, and at many other localities between Harrisburg and Princeton, Kentucky. These dikes are all similar in character and must be connected at some unknown depth with a great mass of igneous rock which underlies the region. But the depth of this igneous rock mass may never be known unless some extremely deep drilling should be undertaken at a future time.

The injection of the igneous material led to another change, namely, faulting. The phenomenon of faulting involves the formation of more or less vertical or oblique cracks in the earth's crust, extending to unknown depths, and the slipping of the rock strata on either side of the cracks vertically, or horizontally, or both. Such dislocations in the rock strata are known as faults. In all faults

Faulting

except where the motion is entirely horizontal, the rock strata on one side of a fault are raised relative to the beds on the opposite side; the side which is raised is known as the upthrow side, and the opposite as the downthrow side of the fault. Faulting may be produced by the exertion of a tension or stretching force in the earth's crust. When such a force is exerted upon the rocks, many irregular cracks are likely to be

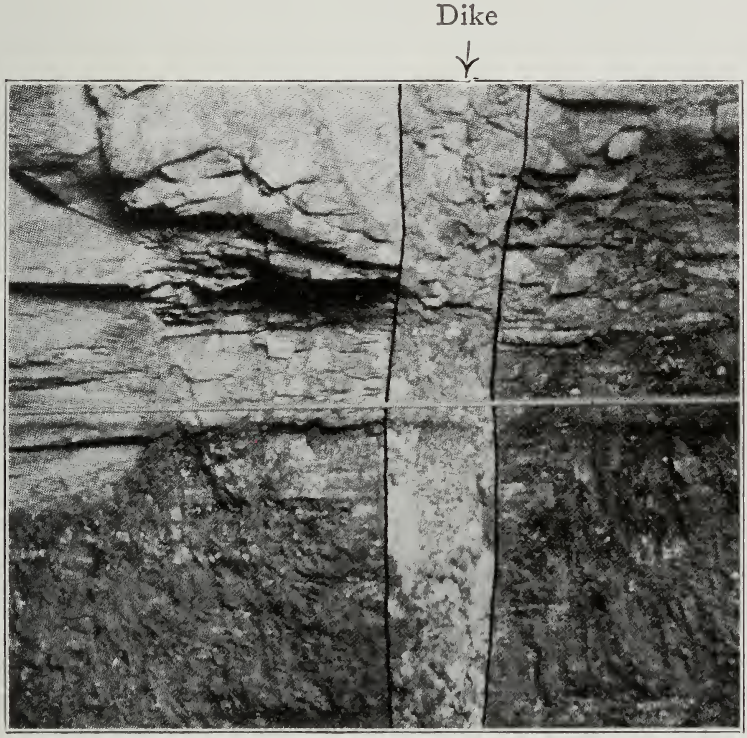


Fig. 8. Dike in a mine in Saline County.

formed, the major ones of which will have a general direction at right angles to the direction of the tension force. The rocks will give way in the weakest place, which may be a belt of considerable width, in which the cracks may outline a regular mosaic of blocks of various sizes and shapes. The blocks so formed will slip downward and may tip upon each other and finally come to rest when the tension force has been relieved. (Fig. 9.) So in this area, as the beds were domed up, the inelastic crust was forced to stretch and innumerable cracks formed. The wedge-shaped blocks which were formed slipped and slid on each other and by their adjustment they took up the slack produced by the stretching. The readjustments along these fractures form the complicated system of faults which exists in southeastern Illinois and western Kentucky. Along some faults the dislocation has been as great as 2000 feet, elsewhere only a few feet.

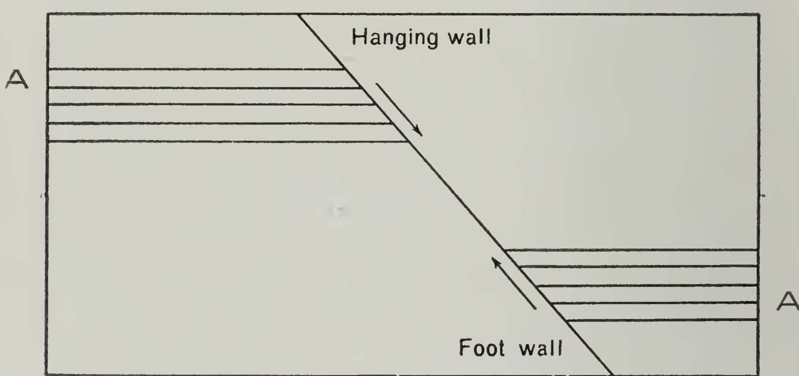


Fig. 9. Diagram to show the movement of rock strata in normal faulting. The hanging wall moved down with respect to the foot wall. Bed A was continuous before the faulting took place.

The phenomena of igneous intrusion and faulting are believed to be responsible for the accumulation of the famous fluorspar deposits of Illinois and Kentucky. (Fig. 10.) Igneous rocks are known to be a source of fluorine and most of the important ore bodies in the district are found in veins located along fault lines. In a few places the fluorspar is not associated directly with a fault, but it is near some fault to which it is doubtless genetically related.

Fluorspar deposits

The determination of the time when all the deformation and accompanying phenomena took place is a problem for the geologist. We know certainly that it occurred after the formation of the Pennsylvanian rocks for they are involved in the deformation. In the extreme southern portion of Illinois are Cretaceous strata, late Mesozoic in age, which, so far as we know, are not deformed, but the deformed older rocks pass beneath them. With these data, which are all we have at the present time, we can only say that the disturbance took place

Time of deformation

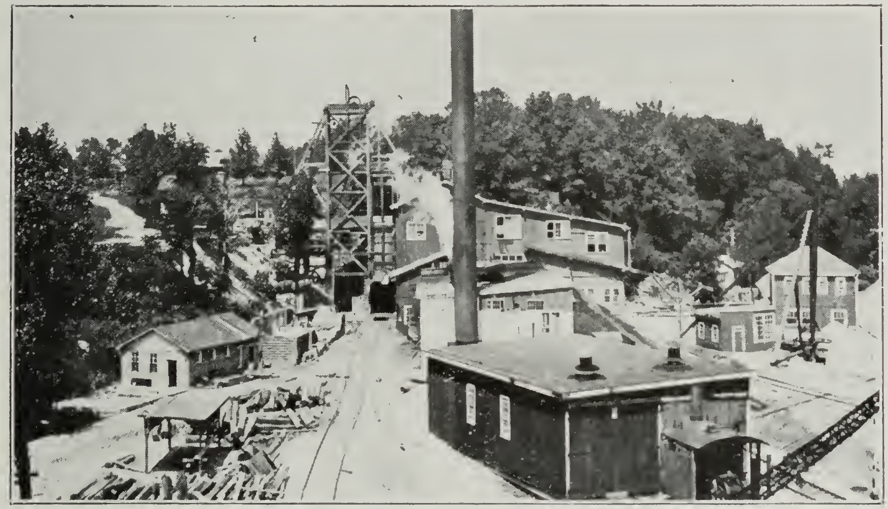


FIG. 10.—A fluorspar mine in southern Illinois.

after the last of the Pennsylvanian rocks were formed and before the deposition of the Cretaceous rocks, but this interval represents millions of years. The fault movements were probably distributed over a long period of time, for no geologist believes that they can be instantaneous. It is altogether probable that slight movements are still taking place along some of the fault lines. Scarcely a year passes without the recording of one or more slight earthquake shocks in this portion of Ohio

Valley, which are more than likely the results of settlement along some of the previous lines of deformation. A little more than 100 years ago a severe earthquake occurred in the middle Mississippi Valley which may have been caused by an adjustment of greater magnitude than usual along one of the fracture lines. It may be asserted with certainty that during the active period of all this deformation, frequent earthquakes of great severity shook southern Illinois.

It is not at all unlikely that a preliminary uplift of the whole Illinois Ozark region, associated with adjustments in the Missouri Ozarkia and not accompanied by notable faulting, occurred long before the igneous intrusion and complex faulting in the eastern portion of the region. All of the facts are not yet known, but every season of observation adds to our understanding.

There is no evidence that the sea ever entered Illinois north of the uplift after the deformation. The region remained as an extended land area for an inconceivably long time.

Mesozoic and Cenozoic conditions

Throughout Mesozoic time it doubtless was the home of successive generations of gigantic reptiles which are known to have inhabited North America during this time (fig. 11), and these creatures were doubtless followed by the great mammalian hordes that characterized Cenozoic time. Through these millions of years, the vegetation of the region also underwent profound changes, but none of the record is preserved. We know little of the topographic features of the land during this time—whether it was a plains or hill country—and little of its drainage; but it is likely that the relief was much greater than that of our Illinois prairies.

In Cretaceous time, an arm of the sea did reach into the southern tip of Illinois from the Gulf of Mexico, but the absence of any typical marine fossils in the beds may mean that

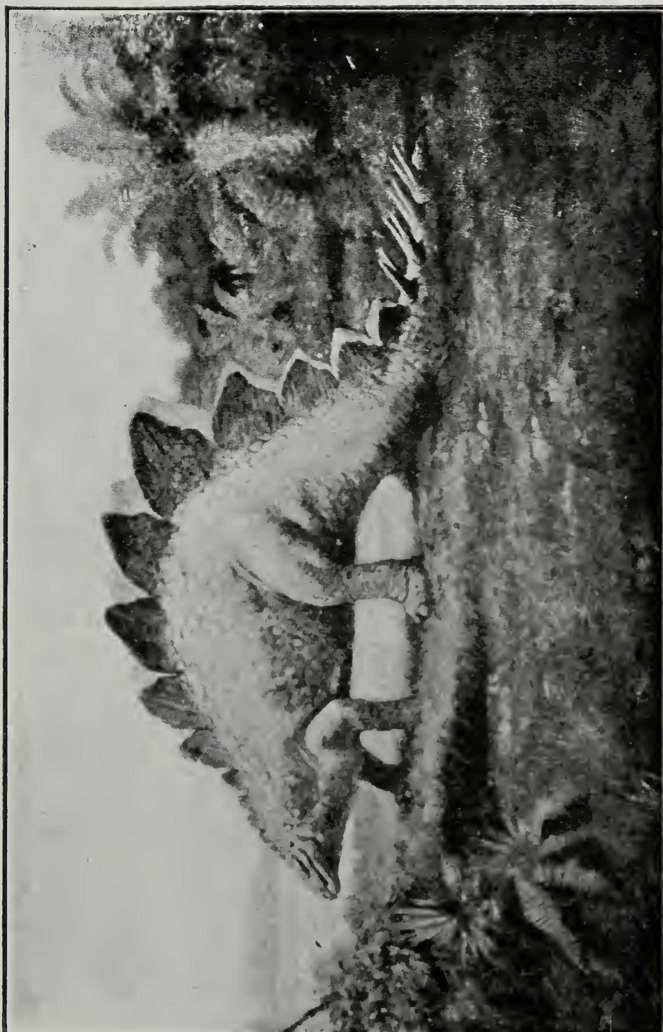


Fig 11. *Stegosaurus*, an armored dinosaur of the Mesozoic.*

* From Chamberlin, T. C., and Salisbury, R. D., Geology, vol. III. By permission of Henry Holt & Company, publishers.

typical marine conditions never existed. There are also widely distributed deposits in the south, probably Tertiary in age, but it is not likely that they are marine. They were formed when topographic conditions were far different from those of today, long before Ohio River and its tributaries were a part of the landscape.

With the coming of the Pleistocene time and the great ice age, glaciers came down from the north, one of which reached the vicinity of Harrisburg. These destroyed or drove out all animal and vegetable life, and their deposits filled the depressions in the surface, leaving it approximately as we know it today.

Pleistocene time

We look backward upon the many millions of years during which all of these events have come about. When we realize that the entrance of man into the story is the very latest event of all, we can only be amazed and overwhelmed by a glance into the future. There is every reason to predict that the continuation of this history into the future may be as long as the time which has passed. Man is a mere infant; he has taken only the first step in his career, but he has learned to control his environment as no other animal has ever done. The law of progress is manifest, and we cannot help feeling that in the distant future our descendants will look back upon us in much the same manner as we now look back upon the men of the Old Stone age.

GLOSSARY

Brachiopods—Marine, invertebrate shell-animals, like those commonly known as "lamp shells". They have two "shells" or valves which are different, one from the other, but are bilaterally symmetrical. See fig. 6, p. 25.

Cephalopod—Marine, single shelled invertebrate animal, whose shell may be either straight or more or less coiled in one plane and consists of several separate chambers. The pearly nautilus is a living example of this type of animal. See fig. 6, p. 25.

Conglomerate—A rock formed by the cementation of gravel.

Crinoid—Marine animal sometimes called "sea lily". It is attached to the sea floor by a stalk and its upturned mouth is surrounded by long, feathery arms. See fig. 6, p. 25.

Crustal—Pertaining to the outer portion of the earth, or that portion whose nature is partly known from geological examinations.

Deformation—Warping, folding or any massive displacement of the earth's crust.

Delta—Deposit of sediment at the mouth of a river.

Dike—A body of rock formed by the solidification of fluid rock which was forced into a fissure.

Embayment—A considerable portion of shallow ocean water upon the continent.

Emergence—A change in the relations of land and ocean resulting in the conversion of the ocean bed into land.

Era—A major subdivision of geologic time.

Erosion—Wearing away. Erosion is the term applied to all the processes by which earthy matter or rock is loosened and removed from one place to another.

Evolution—A term usually applied to those changes which animal and plant life have undergone in the history of the earth, resulting in the origin of new and varied forms.

Fault—A displacement along a fracture interrupting the original continuity of a rock formation.

Fauna—A natural assemblage of animals inhabiting a given area, or existing within a certain period.

Fluorspar—A mineral composed of calcium and fluorine, usually transparent and purplish or pinkish in color.

Fossil—Any remains, impression, or trace of an animal or plant of past geological times which have been preserved in rocks.

Gastropod—A single-shelled invertebrate animal, whose shell, if coiled, is conical in shape. Snails and slugs are living examples. See fig. 6, p. 25.

Glacier—A field of ice of such thickness that it moves outward from the center of accumulation.

Historical time—The time covered by human history as recorded by actual inscriptions and writings.

Intrusion—A mass of igneous rock which, while molten, was forced into or between other rocks.

Invertebrate—An animal which does not possess a spinal column.

Larval—Pertaining to an early stage in the development of some animals. The caterpillar or worm which eventually becomes a butterfly is a typical example.

Limestone—A sedimentary rock composed of consolidated lime mud or fossil shells, or both.

Noachian Deluge—The great flood of biblical fame.

Outcrop—Exposure of rock.

Peat—Accumulation of vegetal material under swamp conditions.

Pelecypods—Two-valved shell animals, such as clams, scallops, oysters, and mussels. The two shells are mutually symmetrical, but there is no symmetry in either shell. See fig. 6, p. 25.

Period—A major sub-division of a geologic era.

Relief (topographic relief)—The difference in elevation between the highest and lowest points of an area.

Residuum—Final products of rock decomposition in place.

Sandstone—A rock formed by the cementation of sand grains.

Sedimentary rocks—Rocks formed by the accumulation of sediment either in water or in air.

Shale—A rock formed by the compacting or cementation of clay or mud.

Spore—The reproductive body of flowerless plants. Spores are minute germs which have the same function as seeds.

Stratigraphic—Pertaining to the order and relative position of the rocks of the earth's crust. For example, in Saline County the Harrisburg coal bed lies stratigraphically below the Herrin coal bed.

Stratum—A layer of rock.

Structure—The position or attitude of rock strata with reference to a horizontal plane. For example, rock strata have a horizontal structure if they lie horizontally.

Submergence—A change in the relation of land and ocean whereby a former land area is covered by the sea.

Surficial deposits—Unconsolidated material lying on bedrock.

Trilobite—An extinct marine animal which resembles the crabs, crayfish, and lobsters. See fig. 6, p. 25.