CHAPTER III.

THE CARBONIFEROUS BASIN OF THE MISSISSIPPI VALLEY.

The broad undulatory plain which occupies the heart of the American continent, stretching out from the base of the Appalachians to the foot-hills of the Rockies, makes up the principal portion of what is known as the Continental Interior region. It spreads out in one direction for more than nine hundred, and in another over twelve hundred miles. Its superficial contents are upwards of one million square miles, or more than one-third of the entire areal mileage of the United States. This vast expanse of country, whose surface is unbroken by mountains and whose borders are untouched by the waters of the sea, has been aptly designated a great basin. The Great Mississippi Basin it is called, from the majestic river, the "Father of Waters," which flows centrally through it.

The region may be properly regarded as a wide stretch of low-land sloping gently in all directions from the margins towards the center and southward. The "Great Plains" form the western portion of the region, the rolling prairies of the "Upper Mississippi" the median part, the fertile valley of the Ohio and the Cumberland plateau the eastern section. No marked contrasts of altitude break the surface relief of the Mississippi basin. The

lowest point, in the south-central part, is about four hundred feet above tide-level; the highest places are on the northern and western margins, where the mean elevation is not far from two thousand feet.

Everywhere are evidences of the topographic youth of the region, of a comparatively recent rising of a surface which has lain for ages near the level of the sea, a rising which is probably even now in progress. It is shown in the narrow gorges of the principal water-ways, with their steep-sided bluffs, channeled from hard limerock and indurated clays; in the torrential beds and falls of the minor tributaries as they near the larger streams; in the imperfectly drained uplands which are yet untrenched by clean-cut gashes and freshet runnels, which usher in each new cycle of rapid erosion.

The contrasts of relief to be considered in the interior basin are not those between different parts of the plain itself, but those between the basin as a whole and region immediately around it. Beyond the boundaries in nearly every direction a mountainous physiognomy is presented. The Appalachians on the east and southeast; the Rockies on the west; the highlands of the Great Lake region northward, all stand out sharply against the country they surround. They all tell of powerful dynamic action which has been at work elevating broad stretches of territory; of continental movements which have operated on a grand scale.

On the whole, erosive agencies have not acted very vigorously since the deposits of the Mississippi valley were originally laid down in old Carboniferous times. Through most of the long period, from the eons when the beds were first raised above the level of the waters of the great interior sea at the close of the Carboniferous

age to the present date, the vast region must have been nearly the same level low-land that it is to-day; a plain whose surface has remained nearly at base-level for ages, sometimes rising slightly, sometimes sinking a little, but never oscillating far either one way or the other.

GENERAL GEOLOGICAL FEATURES.

Structure.—Great as is the difference between the broad central area of low-lying plains and its high serrated borders, there is a diversity of structural features in the geological details of each of the two districts, as distinct and as far removed from one another in character as are the two widely separated types of surface sculpture. On the one hand, throughout the marginal region of the interior basin the elevation of the land has been accompanied by violent disturbances in the strata, folding, crumpling, breaking, grinding the once horizontal beds until now they lie at high angles with upturned edges everywhere exposed to the swift ravishes of time. The bold, rugged contours of the mountain surface thus disclose the complicated structure of rocky beds beneath. On the other hand, the low-land plain presents its strata spread out in broad, nearly level sheets much in the same position as when they were first laid down. Although made up almost entirely of sediments dating back in their origin to old Paleozoic times it is indeed quite remarkable that, formed so long ago, remote even in geological units of time, the structural changes should be no greater than they are and that the region should still retain over the greater part of its extent the same simplicity of geological structure that is found to-day among the more modern depositions of the coastal plains which fringe the great land areas of the globe. The hypsometric changes

over the whole region have been, therefore, of the character of continental elevation and depression.

Though composed of flat-lying beds, as a rule, the strata of the Continental Interior nevertheless present evidences of slight orographic movements, shown in a series of low folds which trend north and south in their general direction. The most prominent of these great corrugations are five in number.

In the extreme east of the region there are the most westerly anticlines of the Appalachian system of mountains with its closely appressed folds running southwestward from New England to central Alabama. Next is a broad dome-like elevation which finds expression in the uplift of central Tennessee, the Cincinnati arch and the minor elevations of the older rocks in northern Ohio and western Ontario. The axis of this fold extends from Lake Huron southward, with a little inclination to the west. Midway between the two great mountain chains of America is a third slight fold whose anticlinal axis extends approximately along the line of the Mississippi river. It is shown in the rocks of central Arkansas, in the eastern part of the Ozark uplift, in the many exposures of strata older than the Carboniferous in northeastern Missouri and eastern Iowa, in the "Isle of Wisconsin" and in some of the ancient crystallines of the Lake Superior region. The outcrops of the older Paleozoic rocks along the Mississippi river cannot be regarded as due entirely to unaided erosion. Apparently the deep gorges of the great river are due partly to the result of the ordinary action of running water; partly to the result of an accelerated erosion on account of the gradual elevation of the principal line of drainage. There is evidence at hand to show that the movement, slight as it may be, had already begun before

the close of the Lower Carboniferous in the present upper Mississippi valley. The fourth fold is perhaps somewhat imperfectly defined, but it is indicated by a line of small areas of very ancient rocks trending northwesterly through central Texas and Indian Territory, and protruding through much younger strata. The last is a series of deformations on the extreme west, forming the eastern-most range of the Rockies. The trend of the axis is southeastward.

It is a significant fact that the axes of all five of the great folds when prolonged strike approximately the same point in the Gulf of Mexico, a short distance from the mouth of the Mississippi river, a place where a maximum load of sediments is now being deposited; or, in other words, the axes radiate from this point.

Comparatively simple in its general geological structure, easy of subdivision into tolerably well defined minor groups according to lithological features, and abundantly supplied with characteristic fossils in all its beds, the Paleozoic series of the Interior basin still possesses stratigraphical phases highly complicated in their nature. It is an arrangement of strata such as might occur along the coast of any continental mass receiving sediments from numerous sources and forming very distinct interlocking beds each of which rapidly or gradually thins out in all directions and is replaced by others. It is an arrangement that presents great difficulties to a natural geological classification of the beds that would be applicable to all portions of the district, both on account of the vastness of the province and the multiplicity of conditions under which the depositions were made.

The geological phenomena presented by the interior Coal Measures form the final chapters in the maritime

history of the region. These closing episodes of the Paleozoic in the Mississippi basin have centered around them some of the most instructive phenomena concerning continental growth that can be found anywhere on the globe. The details and correlation of the formations are not yet known with accuracy in all the different parts of the area, but much has been done of recent years toward solving the problems presented.

The geological history of the Carboniferous in the Continental interior is, in its general features, much the same throughout the entire region. The period was ushered in with conditions favorable to the formation of extensive beds of calcareous materials which are now traceable without interruption over broad stretches of country. Upon this great floor, as it were, of limestone the coal-bearing strata were laid down.

Geological Provinces.—The Carboniferous rocks of North America occur chiefly in five geographical areas which are well marked and distinct and which are separated from one another by broad strips of older strata. They are:

(1) The Eastern Border region, of Nova Scotia.

(2) The Appalachian region, stretching in a narrow belt from New York to Alabama.

(3) The Continental Interior region, occupying a broad area on each side of the Mississippi river.

(4) The Rocky Mountain region, of Montana, Wyoming and Nevada.

(5) The Arctic region, of the northern portion of America.

Each of these regions has its stratigraphical peculiarities which readily distinguish it from all others. Only those of the third, however, are of special importance

here. In topographical features, in geological structure, and in the history of formation the marginal zone of the Mississippi basin stands out in strong *bas relief* against the lowland plain of the interior region. Its present boundaries form approximately the limits of an area which in Carboniferous times had a development peculiarly its own and in a great measure unaffected by events transpiring in neighboring districts. The origin and deposition of its strata, the lithological characters of its beds, the succession and evolution of its faunas were wholly independent of the surrounding areas. In short, the Carboniferous Basin of the Mississippi Valley represents, in every sense of the word, what in geology is called a "Geological Province."

It is by their contained fossils that the stratified rocks of the globe are known. It is by the organic remains also that the strata of the different districts are classified and correlated. Yet important as is the systematic study of ancient forms of life it is one of the younger of the geological sciences and the first application of the principle of recognizing strata by their fossils was made less than three-quarters of a century ago.

The study of the rocks of a particular geological formation or age in any one locality naturally leads to the extension of the investigation beyond the boundaries of the political district in which the work began. The investigation may not always be carried on with equal accuracy and with like interest in all parts of the geographical area of the deposits, but if it be exhaustive it usually limits itself finally to the lines where the particular formation disappears through the superposition of later beds, or on account of a thinning out over earlier strata. These

lines commonly mark the geographical limits of the geological province.

The stratigraphical, lithological and faunal characters of a formation are so intimately related that the proper interpretation of any one of the three classes of phenomena presented would, under normal conditions, indicate the more salient features of the other two. In practice, however, there are great difficulties encountered in attempting to infer the entire geological history of a series of beds from a single group of facts. The geological record is more or less incomplete as a rule. The larger part of the preserved records is in great measure inaccessible. Those portions which are open to investigation have as yet been only partially considered. For many years to come the places which may be inspected will require constant study before the history to be made out will be even measurably complete. At the present time, therefore, it becomes absolutely necessary to carry on investigations involving the historical sequence of geological events along all three lines at once. Every fact is needed to throw light upon the general theme. If the problems were attacked in any one of the three directions alone, without due regard for the information presented by the others, very different and perhaps antagonistic conclusions would probably be reached, at least in the present state of knowledge on the subject. In the interpretation, then, of the geological history of a region, and in suggesting a geological classification of the formations in accordance with the interpretation, it is of vital importance that there should be weighed carefully the evidences set forth by the arrangement, composition and contained organic remains of the rock series as a whole and of its several parts regarded as units.

The methods and criteria employed at different times in the classification of geological formations have been various. Some of the leading ones are best known under the headings of: (1) Superposition of the strata; (2) Organic remains contained; (3) Lithological characters of the beds; and (4) Unconformities. The terms are so readily understood in their general application that they scarcely require any farther explanation here. In certain localities some one of the classes of correlative methods will be more applicable than the rest. In other places different criteria for correlation must assume prominence.

The characterization of the Carboniferous as well as the other geological systems rests at present upon far-reaching principles. These have been formulated by Lapworth* as follows:

(1) "That the great geological groups must rest on the broad zoological characters of their included faunas, and not upon local stratigraphical breaks between certain series of rocks or upon local differences in sedimentation; (2) that the most reliable chronological scale in geology is that afforded by the relative magnitude of zoological change; and (3) that the geological duration and importance of any system are in strict proportion to the comparative magnitude and distinctness of its collective fauna."

Applying these principles to the Carboniferous system of the Mississippi basin the criteria defining its limits are embraced, as recently stated by Williams,† under the heads of "geographical position," "geological delimitation," and "biological definition." These principles, with some

*Geological Magazine, new ser., Dec. II, vol. VI, p. 3. 1879.

†Bul. U. S. Geol. Sur., No. 80, p. 61. 1890.

minor modifications, are applicable also to each of the several subdivisions. In the consideration of the Carboniferous rocks of the interior of North America, the system itself, as represented in that region, may be taken up in accordance with the principles already given. The great divisions of the system and their minor formations may likewise be treated in the same way.

In any geological province, especially if it be one having a very considerable geographical extent, the clasification of the strata must always accord with the sequence of events which took place during the formation of the entire series presented. The history is a record of changes in the position of the oceanic shore-line, of continental growth and decline, of secular movements of the earth's crust. When the mountain-making forces have operated vigorously on a large scale the strata become so folded, faulted and disguised that the evolution of land growth over this part of the continent is largely obliterated. But when crustal movements have been slight or gradual and not accompanied by the sharp folding so characteristic of mountainous districts all changes of the ancient shore-line become reliable guides for a natural systematic arrangement of the various formations. In a region like the Mississippi basin made up of great flat-lying sheets of sediments the oscillation of the line separating land and water assumes special importance. The lithological character, the stratigraphical peculiarities, the faunal facies all closely follow inward and landward the advancing shore-line during periods of land subsidence; or proceed outward and seaward with the retreating waters where the coast rises. Ancient oceanic retreats are not clearly marked in the rocks except in a general way by the total absence, perhaps, of certain formations.

The extension of the seas over the land, on the other hand, are more or less well defined over at least some portion of the geological province. The details are disclosed in the unconformities of the strata, which may be either local or wide spreading in their character. Unconformities, therefore, assume important rôles in all regions like those under consideration when it comes to seeking for the most reliable criteria in systematically arranging the strata in accordance with the principles already mentioned.

The Continental Interior Previous to the Carboniferous.—The Archæan crystallines forming the nucleus of the North American continent sweep down from the far north in a broad belt to the southern shore of Lake Superior, where they bend abruptly and pass northeasterly through Ontario and Quebec, striking the Atlantic ocean just above Newfoundland. Around the borders of these old crystalline areas the Paleozoic sediments of the continental interior were laid down. The deposition of each formation carried the old shore-line farther and farther southward until at the close of the Carboniferous period the land surface had been extended to the central portion of what is now the state of Arkansas. From old Laurencian times to the beginning of the Carboniferous the great body of water of which the Gulf of Mexico is the diminutive remnant, and which covered the major part of the present area of North America, rapidly shoaled and deepened many times. A large mass of sediments derived from the secularly decayed crystallines of the ancient land surface constantly crept seaward, forming extensive sand accumulations near shore and farther outward argillaceous beds, which soon mingled with the calcareous materials of the deeper waters. At the commencement of the Carboniferous a vast sea of shallow water spread out over

what was soon to be the heart of a great continent. A long period of quietude existed over the region, during which great beds of limestone were laid down in sheets more or less continuous throughout the area. Both the structural characters of the fossils and the arrangement of the beds indicate a very slow alteration of the sea bottom. The physical conditions imposed formed an especially favorable environment for a wide geographical and geological dispersion of the various forms of organisms. The remarkable uniformity of these conditions over wide areas is amply attested by the occurrence of identical species in localities widely separated geographically. Yet, notwithstanding the extensive distribution of the large majority of forms, many of the tribes were very limited in space, and especially in time. Those groups, therefore, which experienced a wide dispersion form valuable and reliable criteria for correlating horizons far removed from one another. The sequence, however, of strata of different localities can at best be only approximately determined from paleontological data. As suggested by Williams the biological sequence of any limited region does not necessarily indicate the genetic succession of the inhabitants, but merely a sequence of occupants within that particular area. The gradual oscillation of the sea bottom and the continual change of habitat to which most of the forms were subjected would have had a tendency to make their migrations extend over longer periods of time and their specific existence more prolonged than the stratigraphy of any one place would indicate. Thus, certain species would have become extinct in one region and be completely replaced by very different forms, while in distant localities, perhaps, the migratory species would continue to flourish in all their wonted vigor.

Major Members of the American Carboniferous.—In its leading features the geological and geographical limits of the Carboniferous rocks of the Mississippi province are pretty generally understood. The salient faunal characters are even more familiar; since the organic remains, entombed everywhere in great profusion throughout the extent of the later Paleozoic rocks of the region, attracted attention long before the rocks themselves were carefully studied. For more than half a century fossil collectors by the score have taken great delight in delving after new treasures, while during more than two generations students have almost daily brought to light new facts through their own researches and through the comparisons of the myriads of forms already obtained by others.

The Carboniferous rocks of the world are commonly referred to one of three periods: The Lower Carboniferous (Sub-Carboniferous), Carboniferous proper, and the Permian. In the Mississippi basin only the first two of these have heretofore been considered as well marked divisions. The third has had claims of recognition along the Missouri river, but it is doubtful whether it can be differentiated from the series of strata usually called the Upper Coal Measures. Although so important a formation in many parts of Europe, where all three members of the Carboniferous were first studied and defined, the so-called Permian of this country does not assume any great importance as a distinct and separate geological division. The beds of Kansas which have been referred to the uppermost division of the Paleozoic appear for the most part to belong more properly to the Upper Coal Measures, as shown very conclusively by Meek and others.

The Carboniferous rocks of the Mississippi basin form geologically a three-fold division. The line of demarkation

between the lower and median members is the same as that which has been recognized since the region was first studied. The delimiting boundaries of the middle and upper series are as yet somewhat vague but they coincide approximately with those which usually separate the "Lower" and "Upper" Coal Measures. Recently these two series have been called the Des Moines and Missouri formations respectively. A lower portion of the latter was probably formed contemporaneously with the former but as there are doubtless few or no exposures open to view these seaward-lying beds are of small importance practically.

Broadly speaking the three divisions recognized represent marked changes in the relations of the land and water areas of the region. During the Lower Carboniferous, or Mississippian, open sea conditions prevailed widely. While the Lower Coal Measures were being laid down shallow waters continued to follow a northward retreating shore-line, as a long period of continental subsidence set in. The "Upper" Coal Measures represent another cycle when the sea again had full sweep over the region.

The Carboniferous of the Mississippi province has been divided into:

(1) Pennsylvanian Series.

(2) Mississippian Series.

It is quite probable that the first of these should be again divided into two portions having equal rank with the second, and corresponding to the Missouri and Des Moines formations, or "Upper" and "Lower" Coal Measures. The arrangement here suggested applies more particularly to the Interior basin, west of the line of the Mississippi river. It is quite likely that it is also

applicable, with some minor modifications, perhaps, to the Carboniferous area east of the great river, though the geological history of the two districts began to be more or less independent of each other even before the close of the Lower Carboniferous period.

The leading historical events which transpired during the deposition of the Carboniferous sediments in central North America will receive full consideration elsewhere.

THE MISSISSIPPIAN, OR LOWER CARBONIFEROUS, SERIES.

In ascending the Mississippi river from Cairo to St. Louis and from St. Louis to Rock Island one is impressed with a remarkable series of limestones visible on one side of the river or the other nearly the entire distance. They rise in steep acclivities, high mural escarpments and overhanging cliffs miles in extent. Were the section fully exposed and unbroken by the corrading action of running water from the numberless tributaries of the great stream, the rocks in practically parallel bands would be seen rising and sinking in broad graceful undulations like the monstrous folds of some mighty fabled serpent. If the traveler be acquainted with even the rudiments of geological history his interest will be keenly awakened as he passes or tarries at certain landings; Chester, Kaskaskia, Ste. Genevieve, St. Louis, Kinderhook, Warsaw, Keokuk, Burlington. These have become classic names in American geology. Under one of these terms or another are known the vast beds of "Mountain Limestone," as represented in the broad Mississippi basin, extending with more or less regular continuity from the southern shores of Erie to the Lake Valley mining region of New Mexico, and from the "Coteau des Prairies" to the southern prolongation of the Appalachians in northern Alabama.

The maximum thickness of this great succession of Lower Carboniferous strata is probably not far from 1,200 feet; but the actual measurement in any one place is of course considerably less. Shales, sands and limestones they are chiefly, the latter greatly predominating almost to the exclusion of the other rocks, and presenting a very marked contrast to the overlying Coal Measures. The distribution, the lithological characters, the wonderful uniformity in stratification over wide areas and the inclosed faunal remains, tell of a broad open body of water that once stretched out over the interior of the western mainland; of a vast expanse of shallow water broken only here and there by a few small islets; of a long period of quietude when all changes in the depth of the great sea were exceedingly gradual and affected but slowly its host of tenants.

Derivation of the Limestones.—The Mississippian limestones have been derived for the most part from organic remains. At the time of deposition animal life of various types abounded in particular regions, where age after age the hard parts of the numberless species and countless multitudes of individuals accumulated. In other districts corals have usually supplied the bulk of the material for extensive limestone beds; but in the Lower Carboniferous series the organic débris differs from the usual order, in being chiefly composed of the remains of crinoids. In this peculiar feature the rocks as represented in the Interior basin are so distinctive that they were called "Encrinital" limestones by the earlier geologists who explored the region. A very appropriate name it is, for the disjointed skeletal remains form great beds of what has been aptly termed a "crinoidal breccia." The beds, however, are seldom uniform in physical

characters; some layers are very hard and compact; others are easily crumbled. Frequently the strata are full of interstices with scarcely any finer cementing materials. Amongst the skeletal fragments, beds many feet in thickness are literally composed of nothing but broken and shattered calyces of crinoids, fragments of arms and portions of stems. In the massive compact beds the organic remains have been more or less completely comminuted by the grinding action of moving water. But often there are layers separated by clayey or sandy seams. Here lying partly enclosed by the hard limestone are sometimes myriads of stemmed feather stars, perfect as the day when they were entombed, forms of wonderous beauty and rare delicacy, gracefully and intricately intertwined like rich flowing Arabesques, and depicting clearly the condition of their environment when they waved slowly to and fro in the secluded depths of the great Carboniferous sea.

Mingled with the delicately built organisms, but in far less numbers, were forms of a closely related group of stalked echinoderms, the blastoids—very curious bud-like animals which became extinct ere the close of the Paleozoic. Occasionally also there are various species of echinoids, star-fish and ophiurans, the long serpentine rays of the latter sometimes entangled or wound around the arms of the crinoids. Other strata disclose countless shells of mollusks and brachiopods and still others multitudes of delicate retiary bryozoans perfectly preserved in a soft matrix of clay or shale. Another very characteristic feature of these rocks is the remains of fishes, principally the teeth and fin spines of hybodont sharks, and the oral plates of Cestracionts. So plentiful are these hard parts of fishes that locally the layers

containing them are called "fish beds." Indeed it might be truly stated that perhaps no field has ever been more inviting to the student of ancient life than that presented by the Carboniferous rocks of the Mississippi valley. It is matchless in the multitude of forms presented; unrivaled in the continuity and succession of related faunas; unique in its simplicity and vastness. Fruitful as have already been the researches in the region, important facts are being continually brought to light, rendering more and more complete the great scheme of life as it was once, and ever revealing new episodes in the charming story as yet only hinted at in the half-read, ragged leaves of Nature's book.

Such then is the great basement upon which rests the coal deposits of the Continental Interior, by far the greatest single area of coal-bearing strata in the world. Its history is more wonderful than the stories of the East; more marvelous than the myths of antiquity. It forms one of the fairy tales of Science.

Use of Term.—For a long time the term "Subcarboniferous" has been widely used to designate the great series of "Mountain Limestone" forming at the base of the Carboniferous rocks of central North America. Of late years "Lower Carboniferous" has been substituted to a great extent. Still more recently the term "Mississippian" has been employed for the rock series under consideration. The objections to the use of "Subcarboniferous" are numerous. As originally proposed by Owen it embraced all strata below the Coal Measures down to the Hudson River beds, thus including not only the "Lower" Carboniferous but the Devonian and a great part of the Silurian as well. Since the term first came into geological use it has been restricted from time to

time; and only of late years have its limits coincided with the boundaries of the Lower Carboniferous.

The most serious objection to the term "Lower" Carboniferous is that the term is not definite enough, though it may be retained as a substitute in special cases.

The title Mississippian* is a revival, with a slight terminal modification, of an old name originally suggested by Alexander Winchell†. He called the strata of the interior basin ordinarily designated as the Lower Carboniferous rocks, the Mississippi limestone, thus applying the name to the series of beds embraced within nearly the same limits as those included under the more familiar term.

Geographical Distribution.—The Lower Carboniferous rocks of the Mississippi basin are predominantly calcareous in their lithological character. As already said they are distinguished from the other great limestone formations of the region by being made up in great part of crinoid remains.

In the Continental Interior the beds of Lower Carboniferous age have a large surface exposure. They extend in a narrow strip along the northern and western borders of the Appalachian system, from western New York, through Pennsylvania, Ohio, Kentucky and Tennessee, to northern Alabama. In southern Kentucky they extend westward to the mouth of the Ohio. They sweep round the Cincinnati dome into western Indiana. The Carboniferous basin of Michigan lies immediately north of the uplift and is separated from the western Indiana and eastern Ohio strips only by narrow bands of older rocks. The Lower Carboniferous deposits do not

* Williams: Bul. U. S. Geol. Sur., No. 80, p. 135. Washington, 1891.
† Proc. Am. Philosophical Soc., vol. XI, p. 79. Philadelphia, 1879.

appear to be exposed at the surface at all in northern Illinois. From the mouth of the Ohio the strata of this age occur on both sides of the Mississippi river for a distance of more than three hundred miles, reaching northward to the mouth of the Iowa river, about twenty miles above Burlington. From this point they bend northwestward, reaching nearly, if not quite, to the Iowa-Minnesota boundary line. From the mouth of the Missouri the Lower Carboniferous limestones extend around the Ozark uplift, through central and southwestern Missouri to the eastern part of Indian Territory and the northern and central portions of Arkansas. They then continue southwestward into New Mexico.

Geological Delimitation.—Regarding the stratigraphical limits of the Lower Carboniferous rocks of the Mississippi basin little difficulty has been experienced in limiting the formation above. Wherever the superior portion is exposed the limestone gives away abruptly to shales and sandstones; the marine fauna disappears and its place is taken by brackish water and littoral forms; and a line of marked unconformity separates the calcareous and argillaceous beds. The line of demarkation between the two formations is so pronounced that it was one of the first stratigraphical features to force itself upon the attention of the earlier geologists who studied the succession of the rocks in the Mississippi valley. For many years throughout the region it was the starting point for all classifications of the Paleozoic. It was the line from which all correlations of the rocks above and below were begun. It was an horizon which was easily recognized and to which all others could be referred. Above it were the coal deposits which alone enabled a boundless, savage wilderness to blossom, in a single generation, into a

modern nineteenth century civilization. Below it the magical wand was not. Important as it was as a stratigraphical datum-line, as a guide to the prospector for mineral wealth its value was even greater. In its bearing, therefore, upon the geological investigation of the country it has been one of the prime factors of progress and must ever remain one of the leading landmarks in the study of the rock strata of the American interior.

While the top of the Mississippian series over the greater part of its geographical extent is so clearly set off from the overlying formations its basal limits are rather vaguely defined.

When Owen, a third of a century ago, began his geological explorations in the Upper Mississippi valley he placed an indefinite series of strata lying below the Coal Measures in his "Sub-Carboniferous." At a somewhat later date the same author gave as the base of the "Sub-Carboniferous" the blue, fossil-bearing limestones now known as the Cincinnati beds. Half a decade later Owen and Norwood still farther restricted the formation by calling the "black slates" the uppermost member of the Devonian. Thus for the first time the term Subcarboniferous was given the meaning which has of late years been generally attached to it.

In Ohio, where shore deposits make up the Lower Carboniferous rocks for the most part, the stratigraphical considerations to be taken up are somewhat different from those in other parts of the basin. The rocks are chiefly argillaceous shales and grits with limestone at the summit. The series is now widely known as the Waverly beds, the entire sequence probably being the shore equivalent of the great Mississippian limestone of the more central portion of the basin. The black shale (Cleveland

shale) is generally regarded as the base upon which rest the Lower Carboniferous beds of the state named. This thick bed is said to be quite persistent. It extends over a large part of the state and passes southward into central Kentucky. A similar black shale in Tennessee and Kentucky was the upper limiting member of the Devonian, according to Owen and Norwood, as already stated. Meek and Worthen also refer in a number of places to a "black shale" occurring in Indiana and Illinois, which they regard as identical with the Tennessee beds, and which they consider as occupying a similar stratigraphical position. In Missouri there is a thin stratum of dark colored bituminous shale, immediately beneath the Louisiana (Lithographic) limestone. If the black shales just referred to form one and the same stratum and consequently the same geological formation, it is a remarkable fact. Its wide geographical extent, persistence, and lithological uniformity would be indeed something little short of marvelous. The origin of all such shales is practically the same. The deposits are products derived from the denudation of the land, and a sifting of the fine clay particles from the coarser materials, as gravel and sand, through a mechanical separation effected by currents of water. The color, whether gray or blue as when it is originally deposited, or red, brown and black, as it may afterwards have become, is the most prominent physical character of a clay bed at first sight and is perhaps the first feature to attract attention. If, however, towards the close of the Devonian a great expanse of shallow water occupied the northeastern portion of the Continental Interior, in which were abundant growths of seaweed after the manner of the Sargasso seas of to-day, as was suggested by Newberry, the presence of such a

widely distributed stratum of black, organicly colored clay or shale is easy of explanation. The accidentally tinted bed thus becomes a convenient horizon for separating the Devonian and Carboniferous within the region mentioned. But there is considerable doubt at present as to whether the "black shale" actually does form a single horizon over all the eastern area ascribed to it. It is also questionable whether the Devonian of the Upper Mississippi can be properly regarded as ending with the "black shale."

The fossils of the Bedford shale, the lowermost member, according to Newberry, of the Waverly or Lower Carboniferous in Ohio, and the formation immediately overlying the Cleveland black shale, which have lately been studied carefully by Herrick, appear to belong to a lower horizon, and to have a typical Devonian facies.

Still more recently the basal line of delimitation of the Carboniferous has been critically examined in northeastern Missouri. The preliminary results of the examination have already appeared.

The facts, however, may be briefly summarized in this connection as they are important in their bearing upon the classification of the Carboniferous rocks of the region. The subject may apparently open again the "Chemung controversy" of thirty years ago, when the Kinderhook beds of Burlington, Iowa, were regarded by some as Devonian in age. Even a casual consideration of the present question will soon indicate the very different lines and limits of the two problems.

At Louisiana, in Pike county, Missouri, the so-called base of the Carboniferous affords more favorable opportunities for examination than perhaps anywhere else.

Good exposures, however, are numerous along the great river for a distance of more than seventy miles.

The vertical section is as follows:

		Feet.
16.	Limestone, brown and white, compact, encrinital, thinly bedded, with some chert	55
15.	Limestone, white, encrinital, very heavily bedded	12
14.	Limestone, coarse-grained, encrinital, very heavily bedded	20
13.	Limestone, massive, white, encrinital, coarse-grained, with abundant white chert nodules and nodular bands	11
12.	Limestone, brown, encrinital, compact and heavily bedded, somewhat earthy in places	10
11.	Limestone, compact, fine-grained, buff, with few or no partings	8
10.	Shale, sandy, brownish, forming soft friable sandstone locally	12
9.	Shales, greenish, clayey	70
8.	Limestone, thinly bedded, compact, fine-grained, with conchoidal fracture, in layers 4 to 6 inches in thickness, like lithographic stone in texture and appearance	50
7.	Clay-shale, sandy in part, (2 to 4 inches)	
6.	Shales, dark blue or greenish, clayey	2
5.	Shales, black, fissile, clayey	4
4.	Limestone, buff, magnesian, very heavily bedded	10
3.	Oolite, compact, white	5
2.	Clay-shale, blue, with thin bands of impure limestone	60
1.	Limestone, heavily bedded, (exposed)	5

Number 1 is the Trenton limestone; 2 the Hudson River shales; numbers 3 and 4 probably represent the Niagara limestone; the first increases rapidly in thickness southward and in a distance of twenty miles reaches a vertical measurement of thirty to forty feet. Numbers 5 and 6 are probably Devonian, equivalent to the "black shale" of adjoining states. Number 7 is a thin seam two to four inches in thickness and highly fossiliferous. With few exceptions the "lithographic" fossils come from this layer. It probably belongs more properly with beds 5 and 6. Apparently the organic remains are nearly all identical with forms from the Hamilton rocks farther northward. Should the union of this thin highly fossiliferous seam to

the underlying shales be more in harmony with the real relations of the faunas of the respective beds, as now seems likely, then the Devonian facies of the Lithographic (Louisana) limestone is lost entirely. Number 8 is the Louisiana limestone, a compact rather thinly bedded rock, breaking with a conchoidal fracture. It is very poor in fossils. Numbers 9 and 10 are the Hannibal shales, number 11, the Chouteau limestone, with a few fossils. Number 12 is the Burlington limestone with the characteristic basal fauna of the Lower Burlington. Number 13 is also the Lower Burlington limestone but contains a Kinderhook fauna; 14 and 15 belong to the Lower Burlington; 16 contains the typical fauna distinctive of the upper division.

Owen, who was the first to give attention to the geological details of the rocks as exposed along the "Father of Waters" above the mouth of the Missouri, used in 1852, the term "Subcarboniferous," which hitherto had long been applied to all the strata below the Coal Measures as far down as the Lower Silurian series, in a very limited sense. The Louisiana or "Lithographic" limestone was not included; for his "argillaceous marlites" seem to have been regarded as the basal member.

Swallow, Hall and White, who were all well acquainted with the sections and their fossils, correlated the beds immediately below the Burlington limestone with the Chemung (Devonian). In northeastern Missouri and adjoining portions of Iowa and Illinois, the "Chemung" included the Chouteau limestone, Vermicular shales and Lithographic limestone.

Hall, having studied more particularly in Iowa, erroneously regarded certain sandy shales, or yellow sandstones, just below the great limestone at Burlington, identical in

age with a lithologically similar rock fifty miles to the northward, at the mouth of Pine creek, in Muscatine county. Consequently, having investigated the northern locality more thoroughly, perhaps, he very naturally came to the conclusion that the entire formation under consideration as he understood it was actually Devonian. But the rocks of the two places are widely separated in point of time, and it has been shown recently by Calvin* that the latter do really belong to the Devonian.

Meek and Worthen, who had considered chiefly the fossils in the upper part of the so-called "Chemung," both at Burlington, Iowa, and Kinderhook, Illinois, a few miles from Hannibal, Missouri, regarded the fauna more closely related to the Carboniferous than the Devonian. Since the publication of these views writers upon the subject have accepted them and they have been adopted in all of the later geological reports of Illinois, Missouri and Iowa.

By reference to the vertical section already given it will be seen that the commonly called Kinderhook of this region is a three-fold division, the upper and lower portions being limestones and the middle one a clayey or sandy shale. At Burlington the fossils heretofore noted have been found only in the upper part of the formation, though recently an extensive and interesting fauna has been discovered in the clayey portion much lower down. Here the lower calcareous member is not exposed. At Louisiana and vicinity the median member is practically unfossiliferous, as is also the lower, except at the very base.

*Am. Geologist, Vol. III, p. 25. 1889.

It will be recalled that Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarksville, principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, White and Winchell. And it has been noted that most of these fossils have a decided Devonian aspect; that they give a peculiar tone to the fauna of these beds.

Heretofore little mention has been made concerning the exact horizon of the fossils in question, since reference to the "Lithographic" limestone or "Kinderhook" beds has been considered sufficient. Lately, however, extensive collections of fossils have been made at all three of the places just mentioned, as well as at many intervening and neighboring exposures. Everywhere the "Lithographic," or Louisiana, limestone has been found to be practically devoid of organic remains except an occasional form in the thin sand partings above the bottom layer which is less than one foot in thickness.

At the very base of the limestone is a thin seam of buff, sandy shale seldom over three or four inches in thickness (number 7 of section). This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of western Hamilton — the Cedar Valley limestone of Iowa. The sandy seam is underlain by six feet of dark colored argillaceous shale which has been regarded as part of the Devonian "black shale" of the Mississippi basin. This in turn rests upon fifteen feet or more of buff magnesian limestone and oolite of "Niagara" age probably.

Lithologically the thin sandy layer is more closely related to the underlying shales than to the overlying limestones. Faunally it has very much closer affinities with the western Hamilton (Devonian) than with the Kinderhook (Lower Carboniferous).

In Iowa the "Devonian aspect" of the Kinderhook fossils has disappeared largely since Calvin's recent discovery that the "Kinderhook" sandstones of Pine creek, Muscatine county, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view completely by eliminating the species found in the thin sandy seam at the base of the Louisiana, or Lithographic, limestone. Thus the faunas of the Devonian and Carboniferous of the upper Mississippi valley become more sharply contrasted than ever. The apparent mingling of faunas from the two geological systems manifestly is due to erroneous assumption rather than detailed field evidence.

Depriving the "Lithographic" limestone, which attains a thickness of more than sixty feet at Louisiana, in Pike county, Missouri, almost entirely of the extensive fauna commonly ascribed to it, and which, as has been seen, comes from a thin seam lying below the calcareous layers its geological age becomes a problem yet to be solved. The few fossil species known from the limestone itself have been heretofore rarely met with.

It is quite likely, however, that these organic remains will be found eventually scattered through the entire vertical thickness of "Lithographic" beds. But even if it should prove more advisable to place the Louisiana limestone in the Devonian it would not radically change the present classification of the Carboniferous.

The Louisiana limestone appears to thin out rapidly northward. Borings at Keokuk show that there are only ten feet of limestone which can be referred to this formation, only one-sixth of the thickness at the typical locality in Missouri. A short distance beyond it probably disappears altogether.

Until, however, sufficient evidence is adduced to show conclusively that the limestone beds are best united with the Devonian they must be regarded as forming the basal member of the Carboniferous in this region.

In Iowa little is known as yet in regard to the exact relations of the beds forming the top of the Devonian and the base of the Carboniferous.

Biological Definition.—The fauna of the Mississippian series is a strictly marine phase of animal life. It is rather sharply cut off below from the Devonian faunas by the absence of many characteristic genera and by a marked change in the structural features of numerous groups common to both horizons. Above, it abruptly terminates over the greater part of its range with the shore and brackish-water types of the Coal Measures.

Of the different zoological groups the corals, brachiopods, mollusks and crustaceans continued as in the earlier Paleozoic to flourish in large numbers, and myriads of individuals are often collected together in places. A special feature which is quite noticeable in these groups is the prominence which the gasteropods assumed among the mollusks and a great diminution in size and number of the trilobites among the crustaceans. The most important and characteristic biological feature of the Mississippian rocks, however, was the great development and expansion of the echinoderms and fishes. Among the former the crinoids and blastoids assumed

such unusual prominence that Dana has called the period the Crinoidal period of geological history; while Wachsmuth has suggested the names "Crinoidal" and "Blastoidal" limestones to designate the upper and median portions of the series.

Indeed the crinoids and blastoids make up such a conspicuous part of the fauna of the Mississippian that they must ever remain the most valuable and most reliable criteria in the classification of the series in accordance with the life remains. Their existence during a long period of time and their wide geographical distribution gave unusually favorable opportunities for the recording of all the geological changes throughout the entire basin. Besides, their structural features also are particularly well adapted to giving an insight into the physical conditions of their habitat. In the general relations of the plates making up the skeletal parts, in their definite arrangement, in the surface ornamentation, in the delicately constructed arms and characteristic stalks are found admirable features for tracing the evolution of the different forms from the bottom to the top of the series. The different phases passed through in the evolution of the different groups are most noticeable among the actinocrinoids, yet they are also well marked in many other families. In almost every case the various forms beginning in the Lower Burlington were small sized, and delicately ornamented. As the different types advance upwards they rapidly increased in size, the plates becoming very much heavier, the ornamentation coarser, and many structural features greatly exaggerated in various ways.

The blastoids, though abundant in the lower part of the series, became astonishingly numerous in the upper

part, where in many places they almost excluded all the other groups of echinoderms. Near the top they acquired a very large size, certain species assuming enormous proportions.

The hard parts of fishes are exceedingly abundant and in places often make up entire layers. The species are very numerous and the generic types quite varied.

Subdivisions of the Mississippian Series.—The Carboniferous rocks of the Continental Interior have been recently the subject of special investigation. The resulting systematic arrangement, as based upon the best lithological, stratigraphical and faunal evidence now at hand, is that given in the scheme below. The table indicates the relations of the geological terranes as at presence understood. It also shows the arrangement of the various minor subdivisions which have from time to time been described in different parts of the region. The tabulation applies essentially to the more strictly marine deposits which have such a wide geographical distribution. The Waverly shore sediments probably cannot be paralleled in their smaller divisions with the terranes here recognized; but as a whole may be regarded as representing approximately the entire Lower Carboniferous series of the more westerly region of the upper Mississippi.

MISSISSIPPIAN SERIES.	Kaskaskia....	"Chester shales." "Kaskaskia limestone." Aux Vases sandstone.
	St. Louis.....	Sainte Genevieve limestone. Saint Louis limestone. Warsaw limestone (in part not typical).
	Augusta.....	Warsaw shales and limestones (typical). "Geode bed." Keokuk limestone. Upper Burlington limestone. Lower Burlington limestone.
	Kinderhook ..	Chouteau limestone. Hannibal shales. Louisiana limestone.

The basal division, the Kinderhook, is commonly regarded as a triple member of which the upper and lower portions are limestones, the median part clay and sandy shales.

The second grand division of the Lower Carboniferous is the Augusta limestone. This embraces the five divisions of southeastern Iowa called respectively, the lower and upper Burlington limestones, the Keokuk limestone, the "Geode bed," and the typical Warsaw shales and limestones. This formation has been shown to be practically one, upon both stratigraphical and paleontological grounds. Furthermore, local unconformities appear between the upper stratum, the "Warsaw," and the overlying rocks. Aside from the upper portion the Augusta formation is made up almost entirely of massive limestones everywhere highly charged with organic remains. Fossil echinoderms are especially abundant; brachiopods also form a prominent feature. As has been fully set forth in another place the faunas contained in the Augusta beds are to be regarded as perfectly continuous throughout. The limestone is essentially a crinoidal one, though in its upper part this character is not as well marked as toward the base. The section commonly known as the Burlington is everywhere the same coarse-grained, encrinital limestone, usually white and quite pure in certain layers. The basal portion — the "lower" Burlington limestone — usually contains considerable ferric oxide and consequently has a characteristic reddish hue on weathered faces. The lithological features of the Burlington are remarkably constant over broad strips of territory. They have been traced from east central Iowa to western Illinois, to southwestern Missouri and Arkansas. East of the Mississippi the typical exposures of this rock

are unimportant and the sections are confined to the vicinity of the great water-course. The division lines of the two Burlington limestones and of the Keokuk are marked by silicious beds. The lowermost of these chert beds has a thickness of twenty to twenty-five feet. It is made up largely of nodular masses and irregular beds of flint with some calcareous matter. The upper chert bed — the one between the Burlington and Keokuk limestones — was reported by Hall to be upwards of one hundred feet in thickness. Recent observations go to show, however, that it probably has no greater importance than the lower chert bed. Accurate records of borings indicate that the entire thickness of the Augusta beds — from the top of the "Warsaw" to the bottom of the Burlington — is not over 225 feet. Wherever the Augusta limestone is exposed along the Mississippi north of the Missouri river, it stands out over soft Kinderhook shales in rugged, overhanging cliffs or high walls. At Burlington the basal line is marked by heavy layers of limestone which often project to a distance of twenty or thirty feet. The small streams flowing over the limestone break into cascades twenty-five to fifty feet in height.

The upper Burlington division differs from the lower, in its lithological characters chiefly by being more thinly bedded and containing layers of argillaceous shale.

The Keokuk beds are distributed chiefly on the east side of the Mississippi, covering a wide area in Illinois, Indiana, Kentucky and Tennessee. West of the river the best exposures are in southeastern Iowa and northeastern Missouri. At the typical locality the Keokuk beds consist of gray encrinital limestones with considerable chert, in layers or nodules. The lower portion is a heavily bedded, compact limerock having a bluish cast. The upper part is composed of clay shales with calcareous bands.

The Warsaw beds as originally described, consist of two massive layers of yellow limestone separated by thirty feet of blue calcareous shales with many thin limestone seams. Beyond the immediate vicinity of Warsaw the formation has not been recognized in its typical development. The "Warsaw" reported from many localities has in most cases proved to be lower St. Louis.

The light ash-colored limestones, occurring in Iowa and now known under the name of St. Louis, were first mentioned by Owen under the title of concretionary limestone. Near the mouth of the Missouri river where these rocks attain a much greater development Shumard gave them the name of the leading place in the region. Since this recognition by Shumard little difficulty has been encountered in locating the St. Louis limestone over a wide stretch of country. Its northern border is several hundred miles beyond any known exposure of Keokuk rocks. From this limit nearly to the mouth of the Missouri river the limestone is quite thin; but southward it rapidly thickens until in Ste. Genevieve county, Missouri, it attains a measurement of more than 300 feet; and still farther southeastward more than double the thickness known in the state mentioned. Everywhere over the northern area of the St. Louis a characteristic brecciated rock is observable; but south of the Missouri river evenly bedded limerocks are present with occasional extensive beds of oolite.

Frequently, near the base of the limestone is a well marked breccia made up of a very fine-grained, compact blue limestone which breaks with a conchoidal fracture. The fragments are angular and vary in size from a few inches to several feet. The interstices are filled with a clayey calcareous material which is usually much softer

than the limestone and in weathering allows the limestone fragments to project far beyond the matrix. Above the brecciated portion of this limestone the strata are laid down very irregularly, but upward rapidly pass into evenly bedded layers. Capping the St. Louis limestone is often seen ten to twenty feet of white calcareous marl which is usually highly fossiliferous.

The upper member of the lower Carboniferous is the Kaskaskia. North of the Missouri river the epoch was one of denundation but south of the line mentioned deposition continued. The formation is a triple division made up of a basal portion called the Aux Vases sandstone; a median part, the Kaskaskia limestone proper; and an upper portion usually made up of argillaceous shales. The sandstone has been noted from time to time but its true significance does not appear to have been fully understood until quite recently, when the absence of the Kaskaskia rocks north of the Missouri river was also taken into consideration. This sandstone is said to be exposed above the city of St. Louis where it is a dozen feet or more in thickness. Southward it rapidly thickens until in the immediate vicinity of the typical locality it attains a maximum measurement of more than one hundred feet.

The great arenaceous deposit lying immediately below the Kaskaskia limestone has been termed ferruginous sandstone by Shumard and others. Most observers, however, have confounded it with the lithologically similar rock occurring at the base of the Coal Measures, but the latter is located upon instead of under the Kaskaskia. In northern Missouri and Iowa where the superior member of the Mississippian series is wanting the basal sand rocks of the Coal Measures occupy apparently the same

stratigraphical position as the lower Kaskaskia sandstone, that is directly superimposed upon the St. Louis.

Upper Mississippi Region at the Beginning of the Coal Measure Epoch.—The latter part of the Lower Carboniferous age is noteworthy as a period of land elevation. The crustal movements over this part of the earth's surface were continental in their character. The relative change between the land and sea areas was an apparent rising of the former and a gain of vast tracts of territory from the latter along the borders of the growing continent. An entire geological formation,—the Kaskaskia —the uppermost member of the series, was not deposited over a large portion of the present upper Mississippi valley, and the evidence is ample indicating that the shore-line of the old Kaskaskia sea retreated southward during the epoch to a point beyond the present mouth of the Missouri river, a distance of more than four hundred miles from the coast of the St. Louis waters at the time of their greatest expansion. Shore deposits were laid down far beyond any point previously reached in the growth of the nascent continent.

When the oceanic waters again invaded the land the territory upon which most of the coastal sediments were laid down had become an old, water-worn surface, channelled and grooved everywhere, with hills and hillocks, ridges and swells rising up from the numberless waterways. The Kaskaskia epoch, then, was one possessing much more importance than is usually ascribed to it. Over much of the Mississippi valley it represents, between the marine platform beneath the Coal Measures and the coal bearing strata themselves, the long erosion interval during which was formed a great irregular plane of

unconformity for the basal members of subsequent shallow water deposits.

As the land began to slowly sink and the seas commenced to gradually creep inland owing to wide-spread, though slight, perhaps, secular changes in the earth's crust, the physical conditions became very favorable to the formation of luxuriant vegetable growths, destined to make the thick, matted masses which were to be preserved during the ages. The shallow marshes of brackish water, choked with dense jungles of tropical plants, preceded the open seas which subsequently spread over the province, covering all like a mantle.

In the deposition of the coal-bearing strata of the interior a long period was marked out during which there was a prolonged though somewhat intermittent continental subsidence, which continued until a rapid continental movement set in, driving again the maritime border southward far beyond its former position at the close of the Kaskaskia.

PENNSYLVANIAN, OR COAL MEASURE, SERIES.

Occurrence of coal.—It is a significant fact that the Paleozoic coals of the world are all deposited in more or less limited basin-shaped areas. In England, in France, in Germany and in other European countries, in India and elsewhere the coal mining industry is developed only in those districts which geologically are more or less completely isolated. Careful investigation by many different workers in the various coal fields points to a common geological history for all. In America the same phenomena are observable. But in the interior of the western continent the vastness of the area, over which must have extended such a similarity of physical conditions during

the deposition of the coal-bearing rocks, is something remarkable and finds a parallel nowhere on the globe.

When the Coal period set in through the central part of North America the conditions of deposition were practically uniform over the entire extent of the area occupied by rocks of this age. Before, however, sedimentation had progressed very far orographic movements began to change the ordinary sequence of events in different portions of the region. Though comparatively slight in themselves these changes were of continental extent in character. The geological conditions, which at the beginning of the period seem to have been similar over the whole region, ere the close of the period began to assume phases which were variously modified in different places. Two portions especially may be contrasted. These were the coal fields which are now separated by the Mississippi river. The geological history of the two districts even commences to diverge somewhat before the more strictly marine sediments had ceased to be deposited in the upper Mississippi valley region. The considerations referred to in detail hereafter regarding the upper Carboniferous of the Interior basin will be applicable more specifically to the region west of the "great river," sometimes called the "Western Interior" coal field, though in its general bearing the eastern region may be regarded as having a very similar record.

The great economic value of the coal-bearing formation of the Mississippi province has directed particular attention to its geology. Within the limits of the region it may now be said that the Coal Measures have received more careful attention than any other of the geological formations represented. But, at the same time, for this very reason, the stratigraphical importance of the formation

has been very greatly overestimated. It has led to the attachment of far too much significance to really trivial characters which, though they may be quite conspicuous in themselves, are of comparatively small value. Features which in other formations would be entirely overlooked, in connection with coal seams become greatly magnified on account of their bearing upon the expense of mining. Among these factors may be mentioned the various kinds of "faults," slips and "cut-outs." Besides, the great economic value of certain coal beds has led to attempts at correlation, which have often led to very erroneous conclusions. One of the most notable instances is the claim of a number of different workers that they were able to trace single coal seams continuously over all the territory lying between western Pennsylvania and Missouri. Later and more careful investigation has shown that this generalization was entirely unsupported by facts and that it was based upon very insufficient data.

In geographical distribution, in stratigraphical arrangement, in lithological characters and in faunal features the series of beds which bear most of the workable coal seams in the upper Mississippi basin, and which are commonly called the Lower Coal Measures, has an individuality that is peculiarly its own. In all respects it stands out sharply defined from all the formations beneath it. As a whole it presents marked contrasts with all associated strata both younger and older.

Regarding the geographical position in its general relations to the upper Carboniferous rocks, the "Lower" Coal Measures form a broad zone around the areas of the "Upper" division—a zone which separates everywhere the surface exposures of the latter rocks from those of older geological age. The geological delimitation of the

Lower Coal Measures is well defined. In its entirety, as has been indicated already, the Carboniferous of the Mississippi Valley presents three well-marked groups of rocks, the lower and upper members being manifestly marine deposits, the median section clearly a shore formation. Below, therefore, the Lower Coal Measures are cut off by the strictly maritime beds of the Mississippian series; above by the open sea deposits of the "Upper" Coal Measures. The delimiting line of the Lower Coal Measures below is one of marked unconformity. It has already been fully described, in connection with the Mississippian series. There is probably no greater physical break recorded in the entire sequence of Paleozoic rocks of the interior region.

The lithological and stratigraphical characters of the Lower Coal Measures are described in detail in subsequent chapters. The remarks there made apply, with a few modifications and additions perhaps, also to the eastern basin and need no further expansion here.

Prominent among the distinctive characters are the biological features of the Lower Coal Measures. In these respects there is a characteristic littoral, brackish or fresh-water fauna and a luxuriant land or swamp flora as compared with truly marine faunas in the deposits above and below.

Coal Fields of the Interior Basin.—The Carboniferous basin of the Mississippi valley presents four more or less well-defined areas in which coal is obtained. These fields are known as the Appalachian, the Michigan, the Eastern Interior or Central, and the Western Interior.

Appalachian Coal Field. In a broad belt seventy-five to eighty miles in width, it extends a distance of more than seven hundred miles, from western New York

through western Pennsylvania, the eastern borders of Ohio, Kentucky and Tennessee, the western portions of Maryland and the Virginias to northern Alabama. In its general geological structure it is a greatly elongated basin, made up of many folds trending with the eastern cordilleras. In the northern part the Ohio river flows southward through the median portion for nearly one-third of its entire length. The western half has a gradual inclination to the eastward; the eastern half to the westward. In Ohio the western slope is not a uniform one, as was once supposed, for as shown by Newberry, the Coal Measures of the state "lie in a series of subordinate troughs which are in a general way parallel with the axis of the great one of which they are parts." A similar series of folds has been recognized in the eastern half of the same basin, in Pennsylvania. With the nascent Appalachians on the east and the old Cincinnati uplift on the west, the region of the upper Ohio, submerged during Carboniferous times, must have been a long narrow arm of the great interior sea. Many of the minor folds and troughs were doubtless acquired after all the deposits had been laid down.

In the Appalachian, or Alleghany field, the subdivisions of the Upper Carboniferous are as follows:

5. Upper Barren Coal Measures.
4. Upper Productive Coal Measures.
3. Lower Barren Coal Measures.
2. Lower Productive Coal Measures.
1. Conglomerate series.

In a general way this sequence coincides to a remarkable degree with an arrangement recently made out in the Western Interior basin, which will be referred to more specifically in another place.

Michigan Basin. This is a small islolated district occupying about one-third of the areal mileage of the southern peninsula. Although having such a considerable geographical area it is of relatively little importance. The maximum thickness is not over two hundred feet, half of which is occupied by the basal sandstone. Only one or two workable veins of coal are reported; and the mining of commercial supples is confined entirely to two counties.

Eastern Interior Coal Field. The other two areas have been commonly regarded as essentially one, forming what has been called the great Interior coal field of North America. The Mississippi river divides the region into two parts. Along the dividing line the great watercourse has cut its channel completely through the coal strata, which probably were never very thick, exposing on each side, in a narrow strip, rocks much older. Everywhere within the limits of the area just referred to, along the borders of the stream, outliers or pockets of the coal-bearing deposits are found in ancient gorges and depressions, the beds connecting them with the chief masses having been almost completely removed through erosion, leaving only scattered remnants of their once greater extension.

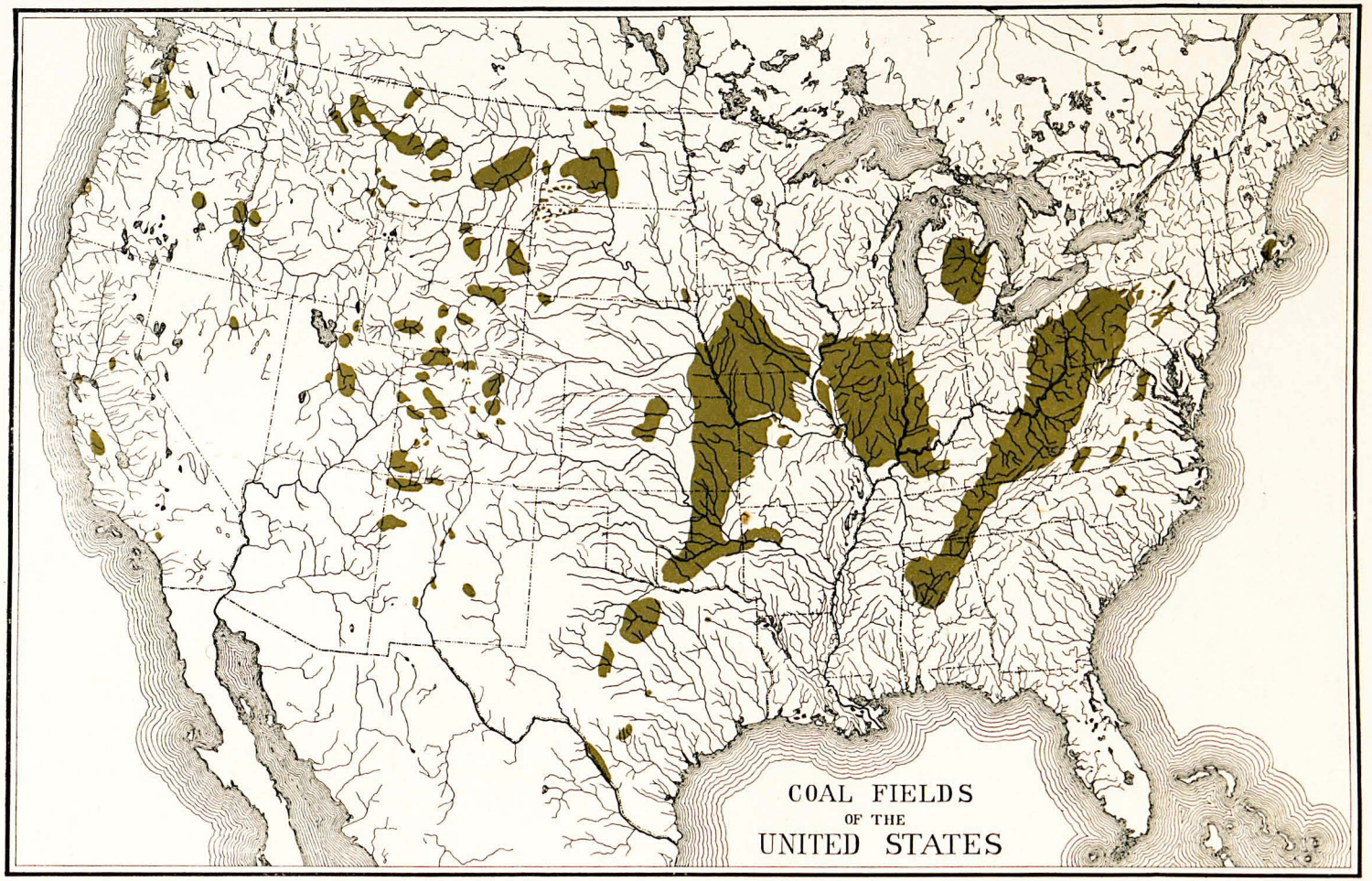
The first of the two fields last mentioned comprises northwestern Kentucky, southwestern Indiana, central and southern Illinois. The basin is elliptical in general outline. It presents a wide marginal zone of coastal sediments carrying the coal of the region and a broad central area representing the more open sea deposits. The first of these formations has been usually known as the Lower Coal Measures and the second as the Upper. The number of seams are upwards of half a dozen and appear to have

a much wider geographic extent than the beds west of the Mississippi river. The various beds have been numbered much after the same plan as in Ohio, but it is very doubtful whether any of them have near the range commonly ascribed to them.

Western Interior Coal Field. Occupying over two-thirds of the great coal producing area divided by the Mississippi river is a field which embraces the southern third of Iowa, the northwestern half of Missouri, the extreme eastern borders of Nebraska, Kansas, and Indian Territory and western Arkansas. It extends still farther toward the southwest in a narrow belt into central Texas. Eastward it thins out and is limited by the older formations which outcrop along the Mississippi river. Westward in the vicinity of the Missouri river it becomes covered by later deposits chiefly of Cretaceous age, so that its exact extent in this direction cannot be determined. On the whole the deposits of coal in single beds are not as extensive as in the region east of the great river, yet the total amount of accessible fuel is probably much greater.

Broadly speaking, the formations of this field correspond in their sequence in a striking manner with the arrangement commonly recognized in the coal bearing strata of Pennsylvania. It is of interest to note the areal distribution of the several formations seen in the western region. The recognition of the coincidence in general arrangement of the Pennsylvania and Iowa coal fields interferes in no way with the acceptance of the views advanced elsewhere, for the present suggestion merely gives, perhaps, undue prominence to certain minor episodes in the geological history of the district.

The geographical position and distribution of the coal bearing areas of the United States is shown in the accompanying sketch map which is modified from that published in the "Mineral Industries," one of the reports of the Eleventh Census of the United States. (Plate i).


COAL FIELDS
OF THE
UNITED STATES

A GEOLOGICAL MAP OF IOWA

BY C.R.KEYES 1894.

LYON OSCEOLA EMMET DICKINSON WINNEBAGO WORTH MITCHELL HOWARD WINNESHIEK ALLAMAKEE
OBRIEN KOSSUTH
SIOUX CLAY PALOALTO HANCOCK CERRO GORDO FLOYD CHICKASAW
CHEROKEE HUMBOLDT FRANKLIN BREMER FAYETTE CLAYTON
PLYMOUTH BUENA VISTA POCAHONTAS WRIGHT BUTLER
BLACK HAWK DELAWARE
IDA SAC WOODBURY WEBSTER GRUNDY BUCHANAN DUBUQUE
CALHOUN HAMILTON HARDIN JACKSON
JONES
MONONA CARROLL BOONE TAMA LINN
CRAWFORD GREENE STORY MARSHALL BENTON CLINTON
HARRISON AUDUBON DALLAS POLK JASPER JOHNSON
SHELBY GUTHRIE POWESHIEK IOWA CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE ADAIR WARREN MARION MARSKA KEOKUK WASHINGTON LOUISA
CASS MADISON
MILLS ADAMS CLARKE LUCAS MONROE WAPELLO JEFFERSON HENRY DES MOINES
MONTGOMERY UNION
FREMONT PAGE TAYLOR RINGGOLD DECATUR WAYNE APPANOOSE DAVIS VAN BUREN LEE

LEGEND

- CRETACEOUS
- U.CARBONIFEROUS
- L.CARBONIFEROUS
- DEVONIAN
- SILURIAN
- CAMBRIAN
- ALGONKIAN

PHOTO LITH. BY A. HOEN & CO. BALTO. MD.