

CHAPTER IV.

GENERAL GEOLOGY OF THE COAL REGION.

Geographical Limits of the Iowa Area.—The Iowa Coal Measures cover a little more than one-third of the entire surface of the state. Geometrically the area is a trapezoid with the entire southern boundary of the state forming one side, the Missouri river another; an irregularly curved line connecting Keokuk and Ft. Dodge a third; while the fourth, or northwesterly side, is not as yet well defined on account of the deep deposits of drift materials covering the region, but it is probably approximately along a sinuous line running from Ft. Dodge to Council Bluffs.

Beyond the boundaries mentioned, especially to the eastward, outliers of coal deposits are scattered even as far north as Jackson county on the Mississippi river. Many of these isolated basins often afford seams of coal sufficiently thick for profitable working.

The distribution of the coal-bearing rocks of the state as briefly described above is shown graphically on the accompanying geological map (plate ii). It will be noticed that the rocks having the same geological age as the coal of Iowa, and in which there is more or less likelihood of obtaining coal are distributed over half of the total number of counties in the state. The area covered by these Carboniferous strata is not far from 20,000 square miles.

It must not be inferred, however, that the coal is equally distributed over all this area; for such is not the case. The broad belt running southeast and northwest and traversed its entire length by the Des Moines river from Ft. Dodge to Keokuk has heretofore been found to be much more productive of coal than other parts of the district. Lately in places outside of this belt coal has been discovered in abundance and mines are rapidly being opened throughout the districts, often where the presence of the mineral was before unsuspected.

Topography.—The surface of the Iowa coal region is topographically a gently undulatory plane, moderately elevated and tilted slightly southward. The larger water courses traversing this district have cut their channels rather rapidly to a moderate depth. On this account in the vicinity of these streams the country is much more broken than in the interior and the slopes descend often quite abruptly.

The eastern two-thirds of the coal district is drained by waterways flowing southeasterly into the Mississippi river. In the western third the streams flow southwesterly into the Missouri. In the southeast the principal water courses are two sluggish branches of the Skunk river which meander along the extreme margin of the coal region. Immediately west of this basin the Des Moines river, flowing southeastward, drains more than one-third of the entire area. Still farther westward are the two branches of the Grand river, the Nodaway and the Nishnabotna. All of these streams belong to the types which are so characteristic of the drift region of the upper Mississippi valley. Their drainage basins are comparatively very long and very narrow, and trend approximately

parallel to one another. The observations of McGee on the streams of northeastern Iowa apply equally well to those of many other parts of the state. "The most striking characteristic of all these streams is their great length in proportion to their volume, and the striking characteristic of the basins is their length and slenderness. Moreover, there is a dearth of small tributaries, and so occasional lakes and ponds (generally too small to appear on maps), swamps, and extensive sloughs are common. Indeed the slough is a characteristic feature of the region. It stands midway between the swamp and the upland prairie. In pioneer days, when the prairie surface was heavily grassed, these tracts were thousands of square miles in extent, particularly in spring time, and were impassable to vehicles for most of the summer. Muskrats and crayfish inhabited them. They were dotted with the houses of the former and perforated with the chimneys of the latter. With the incursion of settlers some of the sloughs dried up spontaneously, others were drained, and now nearly all have been invaded by the plow, or at least converted into pasture lands."

The altitudes of the different parts of the plain already referred to are shown by the elevations of the places in the subjoined table :

Keokuk	625
Keosauqua	720
Bloomfield	860
Centerville	1,010
Fairfield	770
Ottumwa	750
Albia	950
Chariton	1,030
Washington	740
Sigourney	770

Oskaloosa	850
Knoxville.....	910
Indianola.....	970
Winterset.....	1,130
Montezuma.....	950
Newton.....	960
Des Moines.....	920
Adel.....	975
Boone.....	1,160
Ft. Dodge.....	1,175
Osceola.....	1,125
Council Bluffs.....	1,140
Red Oak.....	1,035

Where the largest streams cut the elevated plain the altitudes are from 150 to 200 feet lower than those of the general surface.

All of the coal region of Iowa lies within the limits of the glaciated area and the entire surface is covered consequently by a great mantle of soft, incoherent clays and sands commonly known as drift. This mass of glacial débris has a thickness from a few feet to several hundred feet. It rests on an unevenly weathered and eroded surface. The pre-glacial channels and gorges are often quite deep cutting into the Coal Measure strata often through the coal beds themselves. Frequently, at a considerable distance below the present surface of the ground, coal beds occur having practically no substantial roof. In the northern portion of the Iowa coal field soft Cretaceous sediments overlie the Coal Measures. Although known definitely only at a few points, as in the vicinity of Ft. Dodge, the Cretaceous probably covers the Coal Measure rocks to a much greater extent than has been commonly heretofore supposed. Hence on account of the character of the materials overlying the coal the topography of the Coal Measures is greatly subdued.

GEOLOGICAL FORMATIONS OF THE STATE.

The geographical distribution and the more salient features of the various geological formations represented in the state may be briefly alluded to here in order that the relations of the coal-bearing strata and older deposits may be more clearly understood. As may have been already inferred from what has been said, the strata are relatively little disturbed and lie in broad nearly level sheets, which often rise in low folds or sink in shallow synclines.

As commonly regarded, the oldest of the rocks exposed in Iowa are found in the extreme northwestern corner of the state. The next oldest are in the northeastern corner at the very base of the high bluffs along the Mississippi river. Around the latter point all the later beds are laid down with a slight inclination to the south and west.

Sioux Quartzite.—The rocks exposed within the limits of the state which are usually considered to be the most ancient geologically are those called the Sioux quartzite or Sioux "granite." They form outcrops of considerable extent in the northwestern part of Lyon county. While there is no doubt that all the stratified sediments of Iowa rest, at no very great depth, upon the great fundamental complex of crystallines which probably support all the sedimentary rocks of the globe, the Sioux quartzite and its associated masses are the only truly metamorphosed or massive crystalline rocks having a surface exposure in the state. The common phase of the rock under consideration is a completely vitreous type not unlike red jasper in general appearance and properties. Other parts of the mass are less indurated; and still others are simply loose sand. In places the formation is distinctly conglomeratic. Although the quartzite has

been rendered in places so thoroughly crystalline since its original deposition as an ordinary clastic, no eruptive rocks have been noted in the vicinity until very recently. Within a few miles of the Iowa border large exposures of a black trap rock have been found in the midst of the Sioux quartzite. Microscopic examination shows that it is a coarse-grained, olivine diabase—a massive basic rock of unquestionably igneous origin. A little to the southward, in Sioux county, beds of flint-like lavas have been encountered in boring. These rocks are typical quartz-porphyrries. They were first struck in the well at Hull at a depth of about 750 feet.

Saint Croix Sandstone.—This formation is a thick unconsolidated sandbed exposed in the extreme northeastern corner of the state along the Mississippi river. The greatest vertical measurement found in Iowa is about 300 feet; but borings show that it has a maximum thickness of not less than 1,000 feet. While for the most part it is a soft sandstone wearing away rapidly under atmospheric influences, there are in places clay seams and thin layers of limerock frequently developed. In the neighboring states the calcareous and argillaceous beds assume a much greater importance and form shales and shaly limestones which are charged with the remains of trilobites. This sandstone has been called by most writers on the geology of the Upper Mississippi valley the "Potsdam" and has been regarded as the western extension of the formation known by that name in New York.

Oneota Limestone.—This is the formation usually known as the lower Magnesian limestone. It is exposed only over a very small area in the northeastern portion of the state, but attains a thickness of between two and three hundred feet. Along the border of the Mississippi it

rises above the soft St. Croix sandstone in bold mural escarpments and castellated walls. For the most part the rock is a rather impure dolomite with occasional thin sandstone layers in the upper part. In color it is buff to brown. It is often vesicular and cavernous. In Wisconsin and Minnesota the Lower Magnesian limestone embraces other layers than those represented in Iowa. The principal beds thus referred to are called Willow River limestone and New Richmond sandstone in Wisconsin, and the Shakopee limestone and white sandstone in Minnesota.

St. Peter Sandstone.—Overlying the Oneota limestone is a heavy bed of pure siliceous sandstone, very friable and with few lines of stratification. It is occasionally somewhat indurated, but as a rule is incoherent. In the upper Mississippi region it has long been known under the name of the "pictured rocks," best exposed perhaps in the vicinity of McGregor. Northward along the boundary of the state thin limestone layers are often intercalated. In places this sand formation graduates downward by a rapid increase of calcareous matter into the Oneota limestone.

Trenton Limestone.—This rock is of the ordinary blue variety instead of the dolomitic, as is common in the other Silurian limestones. It is very compact, highly fossiliferous, and is texturally very distinct from the associated formations.

Galena Limestone.—In northeastern Iowa the heavily bedded brown dolomite which immediately overlies the Trenton limestone is called the Galena limestone. Its maximum thickness in the state is between two and three hundred feet, being greatest, perhaps, in the immediate vicinity of Dubuque, where it forms the principal part of

the high castellated bluffs along the river. Some sandy material is found in different parts of the formation, but the partings are usually clay. The limestone is traversed in all directions by vertical cracks, horizontal partings and broad cavities, which form one of its most characteristic features. In these openings are deposited the lead and zinc ores of the region.

Maquoketa Shales.—Along the entire western slope of the Turkey river, and below the mouth of that stream on the Mississippi as far as Clinton county, there is exposed between the Galena limestone and the Niagara an extensive bed of bluish or greenish shales. Disintegrating readily under the influences of weathering, these shales allow the massive overlying dolomites to form bold mural escarpments which extend the entire length of the river mentioned. The shales have not been reported north of the Iowa boundary. Beginning at a point in Winneshiek county about twenty miles from the Minnesota line the Maquoketa shales have a thickness of only a dozen feet or more. This thickness rapidly increases until at its southernmost exposure it attains a vertical measurement of more than one hundred and twenty-five feet. At Dubuque a few feet of these shales are seen in isolated patches on the summits of the bluffs. For the most part these shales form alternating bands of dark and light colored clays with occasional thin seams of impure limestone. On the upper Maquoketa where the typical locality is located, the shales are highly charged with many species of fossils.

Niagara Limestone.—The Upper Silurian limestones which form the high escarpment on the western slope of the Turkey river and continue southward along the Mississippi nearly to Davenport are chiefly massive, yellowish

or brownish dolomites having a great uniformity of texture. The greatest thickness is perhaps over three hundred feet. At the southern end they are heavily bedded and in many places the beds are folded and tilted very considerably, sometimes as much as fifty or sixty degrees.

LeClaire Limestone.—This formation like the Niagara is a dolomitic limerock. It is about two hundred feet in thickness. If the Anamosa beds are included, the formation is the uppermost member of the Silurian system in Iowa. It has been united with the Niagara below, but it is believed that the two formations are sufficiently distinct in their faunal, stratigraphical and lithological characters to warrant special designations.

Independence Shale.—For a long time the Devonian beds of Iowa were regarded as made up almost entirely of limestone. Hall and others found clay beds in the northern part of the state; while still more recently Calvin has discovered important shale layers at the base of the Devonian, in Buchanan county. The latter beds are made up of dark carbonaceous clays with thin bands of impure concretionary limerock. In places the shales are so highly charged with bituminous matter that considerable excitement has been caused at different times on account of their supposed nearness to coal deposits. Remains of plants have been found scattered through these clays and they have also accumulated so abundantly locally as to form thin veins of true coal. The shales also yield a very considerable number of animal remains.

Cedar Valley Limestone.—As already remarked the greater portion of the Devonian in Iowa is made up of limestones, for which it seems desirable to revive Owen's old name of Cedar Valley. These limerocks present

very considerable differences in lithological characters, although for the most part they are ordinary limestones that pass rapidly into argillaceous, dolomitic, or even bituminous phases. Many of the beds are very massive though others are somewhat shaly. Everywhere the rocks of this age are highly charged with fossils of many kinds.

Montpelier Sandstone.—This name is applied to certain arenaceous beds which are well exposed in Muscatine county, and which have been recently differentiated by Calvin from the lower Carboniferous sandrock found farther to the southward. They are Devonian in age, but were formerly regarded as being identical with the Kinderhook sandstone exposed in the vicinity of Burlington. The Montpelier sandstone lies immediately above the Devonian limestone. The chief exposures of this rock are near the mouth of Pine creek in the county mentioned.

Lime Creek Shale.—These beds have long been supposed to form the uppermost member of the Devonian in Iowa. They are well exposed in many places, in Floyd county especially; some of the most important outcrops being at Rockford and along Lime creek. At the latter place there is exposed a vertical thickness of about one hundred feet of argillaceous shales which are highly fossiliferous.

Mississippian Series.—At the base of the Carboniferous rocks as represented in Iowa and forming one of the most important geological formations exposed within the limits of the state is the great series of limestones which have commonly been termed the Subcarboniferous. These rocks form a sinuous belt twenty-five to forty or more miles in width midway between the Cedar and Des

Moines rivers. The zone mentioned thus extends from the southeastern corner of the state northwestward as far as the Minnesota line. The Mississippian series as represented in the continental interior is made up of four distinct formations. Only three of these, however, are exposed in Iowa. They are the Kinderhook, Augusta and the St. Louis formations. The subdivisions here given have already been described in detail.

Pennsylvanian Series.—Economically the most important geological formation of the state is the Coal Measures. As now recognized in Iowa the series is divided into the Missouri stage, corresponding to the Upper Coal Measures, and the Des Moines stage, corresponding to the Lower Coal Measures. The former may be regarded as forming the more strictly marine deposits of which the latter are the marginal accumulations. The lithological and stratigraphical characters of the series are fully described in subsequent chapters.

Nishnabotna Sandstone.—Lying unconformably upon all older geological formations in the northwestern part of the state is a series of shore deposits which have a thickness of probably more than three hundred feet. Although the exact boundary of the eastern extension of this deposit is not definitely known, recent borings indicate that the beds have a much wider geographical distribution than has been generally supposed.

There are four formations in Iowa which are probably referable to the Cretaceous, though the exact stratigraphical equivalents of two of these are at present somewhat doubtful. They are the Ft. Dodge beds—gypsum deposits—and the Nishnabotna sandstone. Although the latter beds have been usually referred to the Cretaceous they have never been directly traced to the outcrops

of the Woodbury shales. The geographic distance between the nearest exposures of the two formations as at present known is very considerable. If the Nishnabotna is Cretaceous, it may be the equivalent either of the Woodbury shales or of the Niobrara chalk; which one it is cannot now be stated. At present time it seems best not to attempt a specific correlation of the gypsum deposits, or of the Nishnabotna sandstone, but merely regard them as Cretaceous in age. The sandstones and loose sands that have been called Nishnabotna are to be regarded as shore deposits, along with numerous other beds of similar character which occasionally are found as outliers through central and northern Iowa. The Nishnabotna as reported by White has a thickness of fifty to seventy-five feet; and is seen exposed in the southeastern part of Guthrie county; southern Montgomery county and elsewhere in the western parts of central Iowa.

Fort Dodge Beds.—This name is applied to the gypsum deposits and certain associated beds which are well exposed in the neighborhood of Fort Dodge. The gypsum attains a vertical measurement of from two to thirty feet, its average thickness being, perhaps, about fifteen or sixteen feet. It occupies an area in the central part of Webster county, of about twenty-five square miles. It is traversed north and south its entire length by the Des Moines river and is cut through by many of the smaller tributaries of this stream. Probably more than one-half of the entire deposit has been removed through erosion by the chief water course. The most extensive exposures now opened are about four miles below Ft. Dodge.

Woodbury Shales.—As already intimated the typical outcrops of this formation are to be seen in Woodbury county along the Big Sioux river. The formation

corresponds essentially with the Dakota and Fort Benton groups of Hayden. The beds represent shore deposits and it seems desirable to retain the name in preference to the two proposed by Hayden. "Woodbury sandstones and shales," as defined by White, expresses more accurately than any other name yet proposed the lithological features of the rocks as represented in Iowa. The Woodbury shales are made up in certain places largely of the sandstones, which sometimes form hard concretionary masses not unlike quartzite. In some localities these masses are so near together that they may be quarried to advantage for building stone. The most important of these openings is in the vicinity of Sioux City and is now known as the Reese granite quarry.

Niobrara Chalk.—These beds in their chalky facies have been observed in Iowa in the vicinity of the Big Sioux river. They are known to occur as far east as Auburn, in Sac county, and are probably represented still farther eastward by more strictly shore deposits. They consist of fine calcareous layers appearing not unlike clay at first glance.

Surface Deposits.—In the greater part of the upper Mississippi valley all the indurated rocks are covered to a depth of from a few inches to two or three hundred feet with a mantle of glacial débris. This, in its lower portion, is a heterogeneous mass of clay, sand, gravel and boulders which is seen almost everywhere within the state, and is known by the name of drift, or is a fine homogeneous clay-like material often showing a tendency towards stratification and is known as the Loess. In addition to these surface deposits there are the fine sediments laid down in river valleys, making up what is commonly known as the flood plains, and is specifically called alluvium.

GENERAL GEOLOGICAL RELATIONS OF THE COAL MEASURES IN IOWA.

The total thickness of the rock formations in Iowa approximates 5,000 feet. Of this the Coal Measures occupy one-third or about sixteen hundred feet. The strata as a whole, although thin in comparison with the same formations in other states, form a measurably complete series. As already seen, the Paleozoic beds from the Cambrian to the Carboniferous are very fully represented. The Mesozoic deposits, of Cretaceous age chiefly, are found in considerable thickness. Over all spreads a thick mantle of drift or glacial débris.

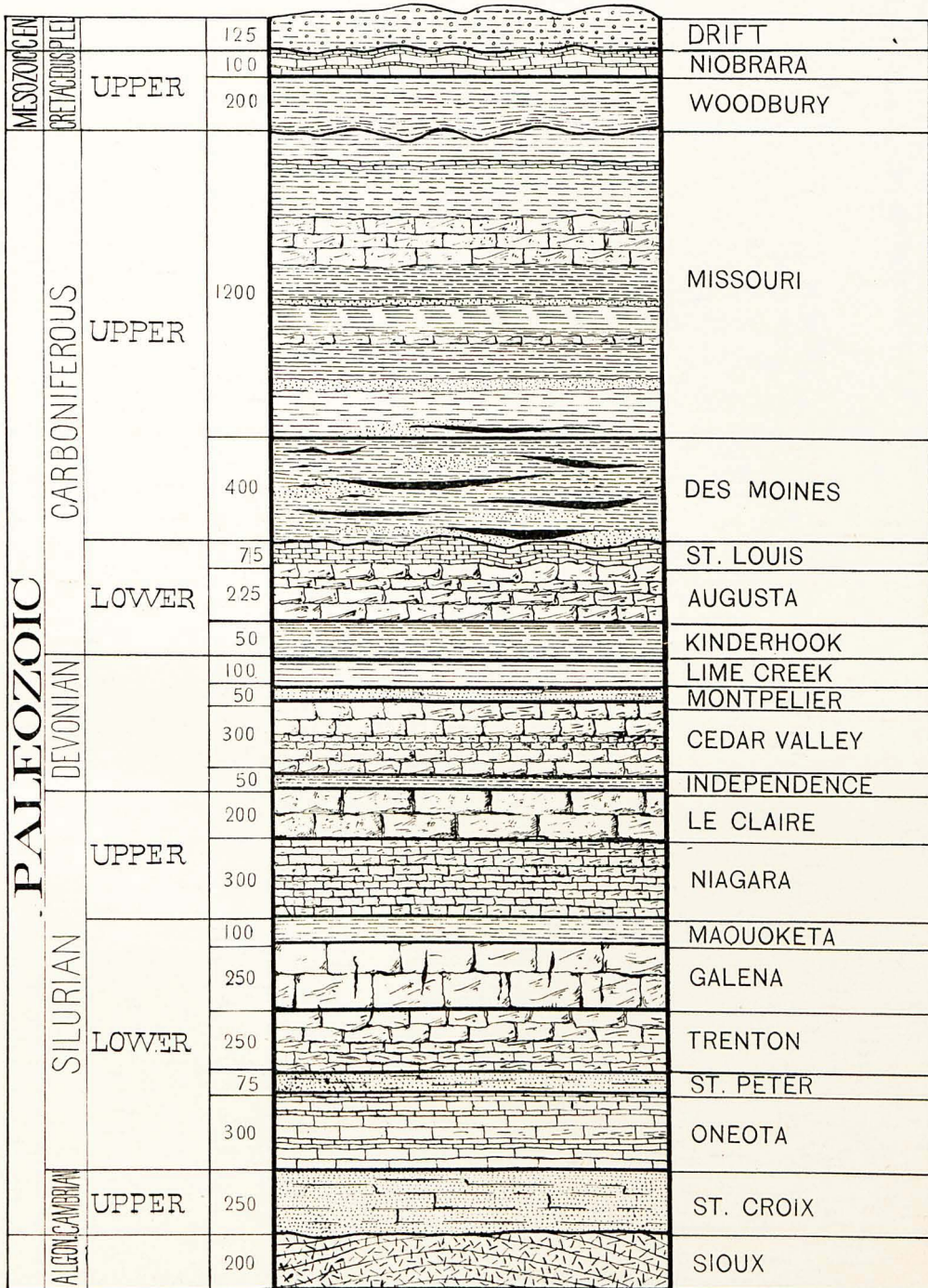
The leading lithological characters and relative thickness of the different rock beds as represented in Iowa are shown in the accompanying general section of the state. (Plate iii.)

As early as 1857, in a paper published in the *American Journal of Science*, James Hall wrote: "I have ascertained in the most satisfactory manner that the coal fields of Iowa, Missouri and Illinois rest unconformably upon the strata beneath, whether these strata be Carboniferous limestones, Devonian, Upper Silurian or Lower Silurian rocks."* Although no details were given, nor any references to the evidence made, this appears to be the first notice calling attention to the existence of a physical break in the Carboniferous rocks of the Mississippi basin.

A decade later White,† calling attention to the same fact, stated that another unconformity existed between the St. Louis limestone and the underlying rocks of the Lower Carboniferous. These remarks also appeared

**Am. Jour. Sci.*, (2), vol. XXVII, p. 197. New Haven, 1857.

†*Am. Jour. Sci.*, (2), vol. XLV, pp. 331-334. New Haven, 1868.



GENERAL GEOLOGICAL SECTION OF IOWA.

subsequently in the Iowa Report.* They are all very general in their character, but there is added to Hall's observation the important fact that the St. Louis limestone also overlaps in the state the older formations.

In Iowa, at least, it appears that the extension of the Coal Measures beyond the boundaries of the St. Louis limestone was much more than an overlap in the ordinary sense of the word, such as might have taken place off shore in gradually deepening waters. It was a sinking of an ancient land surface that had been more or less profoundly carved into hills and vales, affording protected nooks favorable to swamp formation, and the rapid accumulation of vegetable materials.

Since the observations recorded by Hall and White were originally published little work bearing upon the subject in hand had been done until quite recently. In Missouri, Iowa and western Illinois much valuable information has accumulated during several years past, so that now the principal changes of level during the Carboniferous over the region mentioned are tolerably well understood. The nature of the unconformities referred to by the writers named has been made out with considerable detail; while numerous minor physical breaks have been recognized.

The problem therefore centers around the oscillation of the old Carboniferous shore-line in the upper Mississippi basin. The changes are graphically shown in the accompanying diagram, representing the movements of the land margin in the direction of greatest shifting. The Devonian rocks doubtless extend northward beyond the present limits of Iowa. Toward the close of the Devonian period the seas over this region gradually contracted.

* Geology Iowa, vol. I, pp. 225-229. Des Moines, 1870.

This recession continued more rapidly as the Lower Carboniferous period was ushered in, until the water line reached nearly the present southern boundary of Iowa. The St. Louis epoch represented a period during which there was a general depression of the land allowing an overlap of the St. Louis rocks of more than two hundred miles, the seas extending nearly or quite to the present Iowa-Minnesota line. Another cycle of the great continental change then set in pushing the shore-line rapidly some five hundred miles southward to the vicinity of the present city of St. Louis. For the most part the Coal

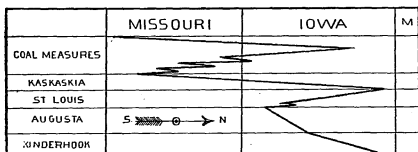


Figure 4. Changes of the Carboniferous Shore-line in the Upper Mississippi Basin.

Measures represented a period of general though not uninterrupted subsidence. During the latter part of the period the waters receded rapidly far below the Missouri and Iowa boundary. A long time intervened before the seas again occupied the Iowa territory. This incursion was recorded in the Cretaceous deposits of the north-western part of the state.

This, then, is a brief statement of the shore-line changes during and following the Carboniferous in the upper Mississippi valley. The phenomena recording these movements may now be briefly summarized. A general geological section in a north and south direction through



Figure 5. Generalized section along the Mississippi from the Minnesota Line to the Mouth of the Ohio, showing Geological Relations of the Formations.

eastern Iowa shows that the different geological formations occupy successively smaller areas of the Iowa region until the top of the Keokuk is reached. During all this time no apparent sinking of the sea bottom took place.

Along the line of the Mississippi river shore deposits were laid down in southeastern Missouri and western Illinois, with open sea deposits farther southward and probably also west of the Missouri river. A new period of subsidence ushered in the Upper Carboniferous over this part of the American continent.

While the Kaskaskia beds were being deposited south of the mouth of the Missouri river agencies of degradation were busily at work over all the Iowa and northern Missouri areas, as will be more fully shown presently. The St. Louis limestone was deeply eroded as is plainly shown in numerous places. The depressions, channels and gorges were soon filled with clays and sands, while here and there thick beds of carbonaceous matter were deposited.

A generalized section, modified after Hall, and shown in figure 5, graphically summarizes the stratigraphical features of the region as recently made out with considerable detail. Number 1 is Cambrian; 2, Silurian; 3, Independence

shales; 4, Cedar Valley limestone; 5, Kinderhook shales; 6, Augusta limestone; 7, St. Louis limestone; 8, Coal Measures.

In considering now the nature of the physical break at the base of the Coal Measures in Iowa and Missouri, attention must be directed briefly to a few of the leading sections showing the line of separation between the two formations.

One of the most important exposures bearing upon the question under consideration has been fully described in connection with the cross-section of the Lower Coal Measures of the central part of the state. It was shown that in Marion county between Harvey and Redrock, in a distance of less than ten miles, not less than seventy-five feet of shales were present between the two different horizons of the Coal Measures reposing upon the St. Louis limestone. The great part of the vertical distance just referred to appeared to be due to irregularities in the limestone, which were carved out through erosion prior to the laying down of the Coal Measures.

Near Fairfield in Jefferson county the Coal Measure clays, with their seams of carbonaceous matter, rest directly upon the uneven surface of the St. Louis marls which cap the limestone of the same age. The Lower Carboniferous rocks contain fossils in abundance.

At Keokuk, Coal Measure deposits are found in numerous places near the top of the bluffs. The St. Louis limestone as represented in this locality is partly a compact limerock, regularly bedded, partly a brecciated limestone. Everywhere in the vicinity the basal sandstone—a rather soft, friable rock of buff or brownish color—covers the uneven channeled surface of the St. Louis limestone. Some of these sandstones with accompanying



UNCONFORMITY OF COAL MEASURES AND ST. LOUIS LIMESTONE. KEOKUK.

dark shales, apparently rest also on the Keokuk limestone. Plate iv shows a typical section in which the sandstone is seen resting immediately upon the limestone. The latter is brecciated; the former exhibits very decided cross-bedding.

At various places in Keokuk and Mahaska county borings, as well as exposures, indicate that the irregularities in the surface of the St. Louis limestone are even greater than those in Marion county already described. The borings just referred to are quite numerous and special care had been taken for the reason that search was in progress for a "second" vein of coal—a seam thought to exist much lower than the one at present being worked. In one place where the St. Louis limestone was exposed at the surface operations with a diamond drill had begun in hopes of reaching the "lower" coal bed. The reason given for carrying on the work in this manner was that a mile away the coal at present worked was many feet lower down than the limestone outcrop and therefore the coal bed must lie beneath.

Relations similar to those above described have also been observed in connection with the St. Louis limestone and Lower Coal Measures at Fort Dodge and elsewhere in Webster county. Identical cases might be repeated again and again, if it were necessary in the present connection. They occur not only in connection with the rocks named but also with the Devonian as at Iowa City and the Silurian as at LeClaire. (Plate v.)

The unconformity of the Coal Measures is fully described in connection with the remarks on the stratigraphy of the region. The characters of the local unconformities are shown in the sections at Redrock, in Marion

county, near Bellefountain, in Mahaska county, as well as in other places.

GEOLOGICAL SUBDIVISIONS.

With the exception of a few carbonaceous seams in the Cretaceous rocks in the northwestern part of the state the coal bearing strata of Iowa belong to the median portion of the Carboniferous age, or Coal Measures. The rocks of this formation are made up largely of argillaceous materials, with some sandstones and limestones, the coal beds forming an inconspicuous part of the entire series. It has been customary in Missouri and Iowa to subdivide the Coal Measures into :

- (3) Upper Coal Measures.
- (2) Middle Coal Measures.
- (1) Lower Coal Measures.

The exact lines of demarkation have been very different in the various states within the limits of the interior region. In Iowa and Missouri for instance the "lower" Coal Measures of the former do not correspond at all with the similarly named division represented in the latter state; and the same may be said in regard to the so-called middle and upper divisions of these two provinces. White, following the idea already suggested, also divides the Coal Measures of Iowa into Lower, Middle and Upper sections, each of which he regarded about 200 feet in thickness. Recently it has been shown* that the respective thicknesses of the three formations already referred to are very different from the measurements ascribed to them by the author just mentioned. The vertical distance between the base and the top of the lower member is more than double the distance usually

* Keyes: *Bul. Geol. Soc. America*, vol. II, pp. 277-292. Rochester, 1891.



CARBONIFEROUS SANDSTONE IN OLD DEVONIAN GORGE.—IOWA CITY.

given, or over 400 feet. White's middle member is very much thinner than was at first supposed. From investigations lately made in both Iowa and Missouri the actual thickness of the "Upper" Coal Measures is found to be more than four times the vertical distance formerly estimated, that is, more than 800 feet.

In considering the Coal Measures as a whole two tolerably distinct classes of sediments are readily recognized: (1) the marginal or coastal deposits; and (2) the beds laid down in the more open sea.

These two categories are sharply contrasted lithologically, stratigraphically and faunally. The first is characterized by the rocks being predominantly clay shales and sandstones with practically no limestones. The individual beds have usually a very limited extent, and replace one another in rapid succession both laterally and vertically. The sandstones often form great lenticular masses, sometimes deeply channeled on the upper surface and the excavations filled with Coal Measure clays. These and many other phenomena attest a constantly shifting shore-line and shallow waters. The fossils contained are nearly all brackish water forms or shore species. The remains of pelagic organisms are not numerous.

On the other hand the second class above mentioned is made up largely of calcareous shales, with heavy beds of limestone, the layers are evenly bedded, and extend over very considerable distances. The faunas are chiefly composed of the more strictly open sea forms.

As the conditions of deposition were evidently those of a slowly sinking shore, the marginal deposits as a whole practically underlie the open sea formations, the former being regarded as the "lower" Coal Measures and the latter as the "upper" Coal Measures. At the same

time it must be remembered that this does not necessarily imply that the "lower" Measures are to be regarded as much older than the "upper;" but rather that along the great and successive planes of sedimentation, different beds of the upper and lower divisions were laid down contemporaneously.

While the general divisions of the Coal Measures may be readily recognized it does not seem advisable to draw an exact line of demarkation between the two formations until the evidence of the faunal studies already begun has been fully taken into consideration, and a comparison of the results of the different methods of solving the problem is made.

With this idea of the Coal Measures of the Interior basin the limits of the two formations in Iowa assume somewhat different lines of separation from those that have been commonly recognized.

It has been proposed therefore to divide the "Upper" Carboniferous or Pennsylvanian series, into:

- (2) The Missouri Stage.
- (1) The Des Moines Stage.

The Des Moines formation corresponds essentially to the group of strata commonly called "lower" Coal Measures. It represents the marginal deposits of the Upper Carboniferous. It takes its name from the Des Moines river which flows for more than two hundred miles directly through the beds of this terrane. It extends in a broad belt into Missouri and follows around the northern and western boundaries of the Ozark uplift into Kansas and Indian Territory and continues into central Texas.

The Missouri Terrane is practically identical with the "upper" Coal Measures, and represents the more strictly marine beds. It is the formation typically developed in

the northwestern part of the state of Missouri. The Missouri river also winds its way for more than 400 miles through the beds of this stage, exposing numberless excellent sections on both sides of the stream throughout the entire distance. The strata occupy the interior central portion of the great bay-like expansion of Carboniferous, of which the Des Moines beds form the marginal zone.

