CHAPTER V.

LITHOLOGY OF THE COAL MEASURES.

GENERAL CONSIDERATIONS.

It is a well known fact in geology that whenever a series of sedimentary rocks are exposed there are always certain kinds of beds which are usually found intimately associated. The relations of the different members of a given series or sequence are such that when only one of them is visible in a natural outcropping or in an artificial cutting it may be inferred that the others are also represented in some way or other either above or below the layer noted. This general succession of particular beds in certain groups of strata is easily explained upon the supposition that in each case there was a similarity of physical conditions under which the different successions were laid down. Thus, whenever a particular set of conditions prevails for the formation of any one of the beds in question the circumstances leading up to this special construction, and rendering possible the accumulation of the deposit must necessarily give rise in the process to other conditions favorable to the laying down of some of the other layers related to the series. This succession may not be carried through all the stages necessary to the formation of the last in the series for other physical changes may interrupt the usual order of deposition. Hence, only a part of the entire repetition may occur at a particular time, as is quite frequently the case; while elsewhere the complete sequence is present.

This relation and association of particular kinds of beds is nowhere better exemplified than in the Coal Measures of Iowa. The succession of strata commonly observed in connection with the coal seams is quite constant, as is well shown by an examination of the various vertical sections of the beds. Immediately below the coal vein, no matter how thin it may be, there is found almost without exception, a bed of white or ash colored clay, highly plastic, homogeneous and free from pebbles. It resists the action of fire in a remarkable way and consequently is of great value in the manufacture of brick or utensils which are to be subjected to a high degree of heat. On account of this property it is commonly called fire clay. Its position and physical properties are better understood when it is remembered, as will be fully shown farther on, that this under-clay formed the old soil upon which the coal plants grew. Superimposed on the fire clay is the coal seam of greater or less thickness. Above this again is a black, highly bituminous clay-shale, usually fossiliferous, and varying in thickness from a few inches to twenty-five or thirty feet or more. Next is a layer of sandstone or shale; rarely limestone. Sometimes the dark shale overlying the coal is extremely thin and a heavy sandrock appears to lie immediately upon the coal. This sequence, then, is the one which is commonly noticed in Iowa in connection with the coal seams. Fuller appreciation of its importance economically comes with the proper recognition of the relatively small proportion of the entire mass of Coal Measures that the coal itself forms.

In order of their abundance the rocks of the Iowa Coal Measures are clay-shales, sandstones, limestones and coals. The secondary part which the calcareous beds play in the lower division of the Upper Carboniferous of the state, sharply distinguishes the formation from the older Paleozoic rocks of the same area. Below, the Coal Measures rest on a great basement of massive limestones with but few clay or sand beds of separation. Not less striking is the relative thinness, as a rule, of the individual layers which follow and replace one another upwards and laterally in rapid succession. Often within a vertical distance of a few inches or a few feet, layers of clay, sand or shale are succeeded by different strata; or they are changed both in color and chemical composition.

If the upper and lower divisions of the Coal Measures in Iowa were to be contrasted upon a single lithological character it would be found that the former is prevailingly calcareous; the latter prevailingly argillaceous. Further comparing, the Upper Measures have even their clay-shales charged with disseminated lime; the Lower Measures have their limestone beds commonly in thin bands, few in number. The sand beds in the superior portion of the Upper Carboniferous are usually shaly, mixed with much calcareous and clayey material; in the inferior part the arenaceous formations are often great sandstones, frequently of very considerable geographic and vertical extent. As regards carbonaceous materials there is a very great predominance in the "lower" Coal Measures — not only disseminated through the clays making them often highly bituminous, but concentrated in very pure seams and beds furnishing by far the greater part of the coal mined in the state. The "upper" Coal Measures, though carrying some workable coal, are, as compared with the formations immediately underlying them, meagerly supplied with bituminous matter.

The two subdivisions of the Upper Carboniferous being so well distinguished in a general way by their differences in constructional materials, as well as in other ways, it would seem desirable to treat more especially and in detail the lithological features of the lower and upper members separately.

LOWER COAL MEASURES (DES MOINES FORMATION).

Clay-Shales.—As already intimated these materials make up by far the greater part of the Carboniferous as as represented in Iowa. On exposure to atmospheric agencies they quickly disintegrate into soft clays and are easily carried away by running water. For the most part they are ashen, drab, or black in color, though red, yellow, buff and blue shades are of not uncommon occurrence. In some localities the variegated shales, blue, red, drab, yellow and ashen, indiscriminately mingled, predominate.

The shales may be (1) argillaceous, (2) arenaceous, (3) calcareous, or (4) bituminous. These all merge into one another but in places there may be sharp dividing lines between them. By the gradual addition of fine sandy material on the one hand they pass imperceptibly into sandy shales; these again into shaly sandstones and finally into hard, compact sandrock. On the other hand, through the increase of lime constituents, these deposits grade into calcareous shales and then into earthy limestones and finally to ordinary limerock. In another direction carbonaceous matter may rapidly become prominent; the shales acquire a dark color, assume a highly bituminous character and finally pass into coaly layers. These gradual transitions may take place laterally in the same horizon, or vertically from one layer to another.

TYPICAL DEVELOPMENT OF COAL MEASURE SHALES.—DES MOINES.

The light colored shales frequently form beds of considerable thickness, the prevailing color being drab or bluish. They are compact, more or less massive with the lines of stratification poorly defined. When first encountered in artificial excavations, as in railway cuttings or coal shafts, these shales are quite hard and extremely tough. During the process of removal they yield but little to the pick and require as much blasting as for ordinary limestone or sandrock. Upon exposure to the weather these shales readily go through a process of "slacking," as it is called by miners, after which they become fine, highly plastic clays. The shales under consideration form the best of material for the manufacture of brick, the bluish tinted varieties being much sought for in making "pavers," which need to be very dense, hard and partially vitrified when burnt.

The most important, economically, of the light colored shales are the fire clays, which form the under-clay of the coal seams. No matter how thin a vein of coal may be the fire clay is almost invariably found below it. This substratum has a thickness of from one foot to half a dozen or more feet, but ordinarily has a measurement of three or four feet. It is a fine, soft, homogeneous clay, white or ashen in color, highly plastic, and resists the action of heat in a remarkable manner, hence its name. The relations of the coal and its under-clay indicate clearly that the white layers are to be regarded as the soil which supported the luxuriant plant growth of the ancient marshes, just as at the present time there is found at the bottom of many modern peat bogs a fine clay of similar character. The peculiar properties of the fire clays are probably due in large part to the action of the water-loving plants which flourished on this rich submerged soil; for it is a well established fact that aquatic vegetation removes from the soil all or nearly all the alkalies, iron, sulphur and a considerable percentage of the silica, leaving finally a light colored clay rich in alumina. The abstraction of the alkalies from the clay takes out those constituents which act as fluxes when the substance is highly heated. In ordinary clays these materials allow melting when brought in contact with fire, forming a glass-like mass, which is in reality a complex system of small glassy threads binding together the impurities. In fire clays the absence of fluxing components prevent the argillaceous mass from fusing.

In many places in the light colored clays crystallized gypsum occurs abundantly. At Des Moines for instance where diamond shaped crystals of selenite are plentiful, it is not infrequent that there are found individuals greatly elongated in the direction of the vertical axis, sometimes to a length of eight to ten inches. In the latter habit twinning is quite common. Often the crystals are acicular and radiating from a center form little rosettes, which lie in great numbers on the exposed surface of the clays. Occasionally the light colored shales also afford impressions of ferns and lepidodenron roots, but for the most part they are unfossiliferous.

There occurs often in the gray shales and also, but less frequently, in the dark colored varieties, a structure which is popularly called cone-in-cone. It is found in layers or sheets from two to six or eight inches in thickness and of varying extent. Ordinarily it appears as series of small cones set one within the another, the separate piles closely pressed together, the bases being parallel with the surface of the layer. Usually it appears to be a concretionary or pressure structure caused by

ELK CLIFF, COAL MEASURE SANDSTONE, ROUSSEAU.—MARION COUNTY.

slipping of certain of the hardened clay layers. To all appearances it seems to be composed of the same clayey material as the beds in which it occurs. The explanation of the formation of cone-in-cone has always been a subject about which there has been considerable doubt. The solutions of the problem have been numerous, but so far as they have been noticed none are very satisfactory. Recently a number of occurrences of cone-in-cone from different parts of the state have been carefully examined. Certain examples from Marion and Boone counties were found to be crystallizations of gypsum, numberless small needles being set nearly parallel with one another but in reality radiating from centers. In all cases the needles were arranged perpendicular to the bedding planes of the shale just as in the deposits of massive gypsum of Webster county, Iowa, and elsewhere. From this very pure variety of cone-in-cone in which the needles are quite transparent and display clearly the gypseous character of the "cones" there are all gradations of clay impurities until so little of the hydrous sulphate of lime remains that the composition cannot be distinguished optically from the beds inclosing it. These isolated layers of cone-in-cone then may be regarded as depositions of gypsum not unlike the massive deposits seen at Fort Dodge, but with clay impurities so abundant as to obscure the real mineralogical character of the substance. Similar crystallizations of minerals having a strong crystallizing power are not uncommon. Calcite is perhaps one of the most familiar examples. Often the impurities of clay or sand are so great in amount that the calcareous solution penetrating the unconsolidated beds allows individual calcite crystals to crystallize out in characteristic forms but with so much clay or sand incorporated that they look like clay or sand models of different calcites.

The arenaceous shales differ greatly in color and character. In some varieties the sand particles are so very fine they can scarcely be detected except by the magnifying glass. From this extreme the grit may increase in quantity and size of grains until a well marked sandy shale is noticed which may, however, pass into shaly sandstone. The beds of this description are of little economic value but are often mixed with certain clays in the manufacture of brick. Shales bearing a considerable amount of sandy material are usually poor in organic remains; though impressions of plants are sometimes quite abundant.

The calcareous shales are of relatively small importance in the lower part of Coal Measures. They occur chiefly in the neighborhood of the thin limestone bands which are found in various places. They frequently form marly layers which are often crowded with fossil shells. These shales are usually full of small limestone concretions which cause considerable trouble when the shales are used in the making of brick and tile, as the calcareous nodules form quicklime in burning. This interferes seriously with the durability of the product.

The dark colored shales vary greatly in composition but they all contain more or less carbonaceous matter. Some varieties are massive with no indications of stratification while others have this feature very prominently developed and cleave in large flat leaves as thin as paper. In many of these shales oily matter is widely disseminated and in many cases could probably be obtained in commercial quantities through proper distillation. Considerable pyrite is present scattered through the black shales.

QUARTZITIC CONCRETIONS IN REDROCK SANDSTONE.–MARION COUNTY.

Sometimes it is in fine particles but usually is in small concretionary masses. Frequently crystals of this mineral with bright faces occur. The amount of bituminous matter is commonly too great to allow the beds to be used for brickmaking. These shales usually graduate into coal and consequently mark valuable coal horizons. At the same time they are often quite deceptive to many persons who drill wells or prospect for coal and they lead to the eager search for mineral fuel in places where there is no hope of finding it. For the most part the bituminous shales are highly fossiliferous. Plants, well preserved, are often abundant. Animal remains in large numbers occur, the gasteropods and lamellibranchs forming the chief groups. Plate vi shows a typical development of Coal Measure shales; it represents a portion of the clay pit at the Iowa Pipe and Tile Works at Des Moines. The section is:

		FEET.
11.	Drift	4
10.	Shale, yellowish, sandy	8
9.	Sandstone, fine grained, rather massive	6
8.	Shale, argillaceous, light colored	9
7.	Coal, impure	4
6.	Sandstone, fine grained, white	3
5.	Coal	1
4.	Fire clay	3
3.	Shale, drab, coaly below	2
2.	Shale, light colored, gritty	3
1.	Shale, dark gray	4

Sandstones.—There is a large amount of sandy material in the Coal Measures of the region under consideration so mixed with clay as actually to form sandy shales. In some cases, however, the sand constitutes a rock which is sufficiently compact to afford material for ordinary rough masonry. The hard portions of the sandstones are for the most part very limited, being only two or three feet in thickness; or are in the form of large spherical concretions in a softer matrix. The concretionary masses sometimes attain a diametric measurement of five or six feet. Within the limits of the area in question there are some notable exceptions to the general character of the arenaceous deposits; as for example the Redrock sandstone. This sandstone has long attracted popular attention. The bright vermillion cliffs rise to a height of 100 to 150 feet above the water surface of the Des Moines river. The red coloration of the rock is, however, local, merging laterally and downward into a yellow or buff color. At Redrock cliff the stone is for the most part massive; but rather soft and thin bedded above. At this place it is a very fine grained and homogeneous sandrock, some portions even affording excellent material for grindstones. But southwestward and at Elk Bluff, two miles below, the sandstone passes into a fine grained, ferrugineous conglomerate. The bluff is fully 150 feet in height and rises perpendicularly out of the river as shown in plate vii. Occasionally large spherical concretions are met with which closely resemble metamorphic quartzites. (Plate viii.) The rock is entirely massive; the horizontal lines shown in the plate are projections left by the channeling machine used in quarrying. In the upper part it becomes thinly bedded, with a considerable amount of clay intermingled. The base is rich in plant remains; lepidodendrids, sigillarids, calamites and ferns of many species. The upper surface has been subjected to sub-aerial erosive agencies, as has been fully shown in another place.* The formation is, then, an enormous consolidated sand bed having a geographic extent of more than twenty miles in

*Am. Jour. Sci., (3), vol. XLI, pp. 273-276. 1891.

CROSS BEDDING IN COAL MEASURE SANDSTONE.—REDROCK QUARRY.

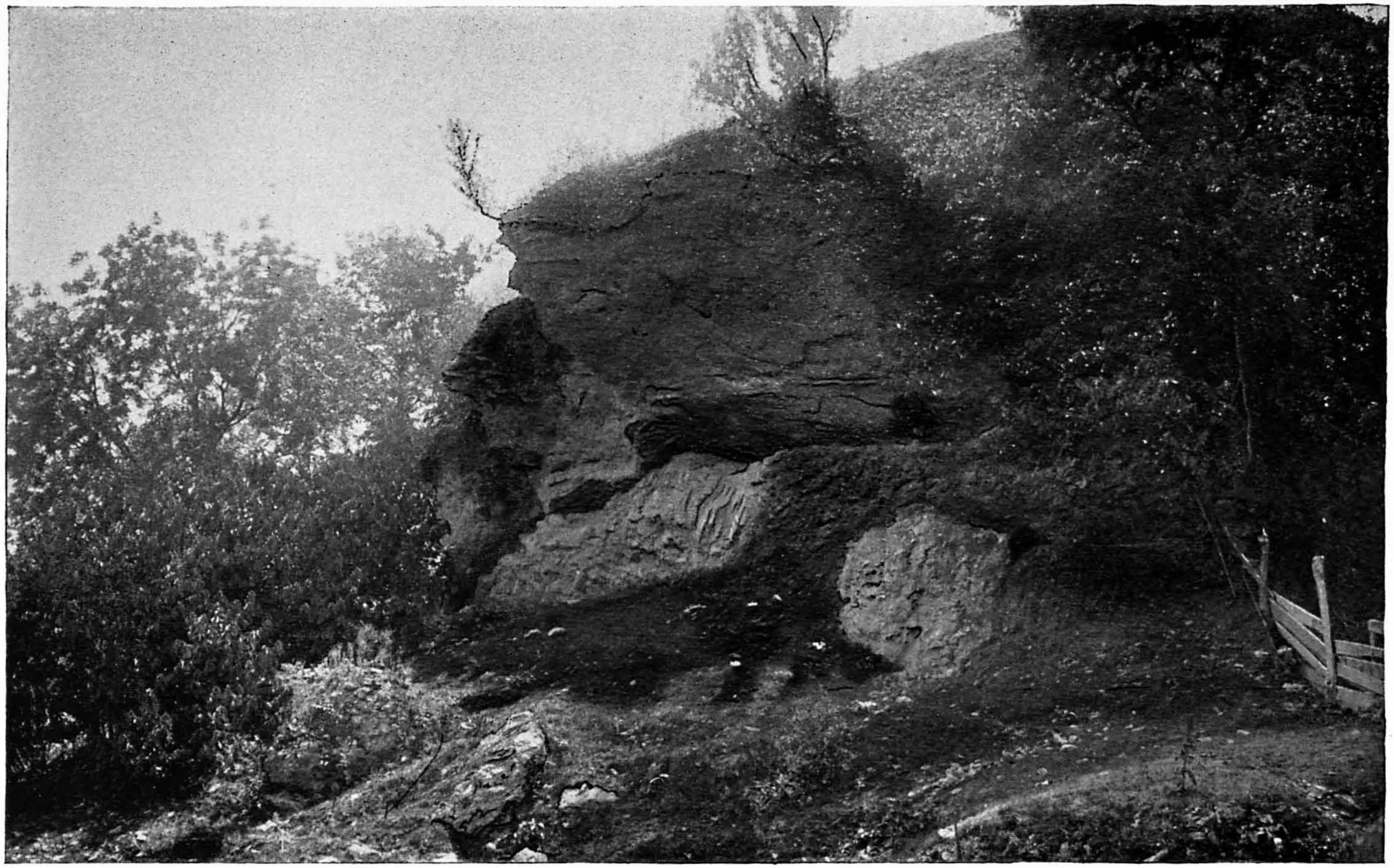
one direction and at least six or seven miles in the other, with a maximum thicknes not less than 150 feet.

The sandstone of Redrock has recently come into prominence as a building stone and is now used more or less extensively throughout the state for the better class of architectural work. Long ago this rock was utilized in various structures at Des Moines and elsewhere, but the method of obtaining it, by blasting, shattered the stone so as to render it almost worthless for building purposes. It soon fell into disrepute and for more than thirty years has not been used except for unimportant local masonry. Recently extensive steam sawing apparatus has been brought in, and the stone removed in huge blocks before reduction by further sawing to sizes required. In this way the sandstone is not injured as was the case when the quarrymen resorted to blasting. The resistence to crushing power of the better portions of the rock is now considered to be nearly equal to any sandstone of similar character in the country.

Both the conglomeratic and upper portions of the sandstone are beautifully cross bedded. At the Redrock quarry especially good examples may be noticed. Plate ix shows a portion of a ledge in which the false bedding in made quite striking through weathering.

Farther down the Des Moines river in Mahaska county are similar cliffs of Lower Coal Measure sandstones, the principal one of which is known as "The Bluffs" or Raven Cliff. Whenever these great sandstones are cut through by the water courses precipitous cliffs are formed like those just described. They are found in many places; in Wapello county near Eldon; on the Des Moines below Moingona in Boone county; in Warren county at Ford; in Dallas county; near Eldora in Hardin county; and less prominently elsewhere. Away from the streams the great consolidated sandbeds also occur but they are apt to be passed by unnoticed as they do not form prominent relief features.

Of the other compact sandrocks of the same geological age the most important, perhaps, is what is known as the "basal sandstone" of the Coal Measures. Instead of being a single bed, as might be inferred from the name, it is in fact made up of a number of isolated masses. The name, however, is still very appropriate as the rocks under consideration are usually found at the base of the Coal Measure series, having filled depressions and old gorges eroded in the underlying limestones during the laying down of the Upper Carboniferous series. The basal sandstones are more conspicuous perhaps in the outliers of Carboniferous strata where the superincumbent beds have been removed through erosion. At Keokuk, in Lee county, sandrocks of the character just described form the upper part of the bluffs along the Mississippi and Des Moines rivers. They have a thickness of twenty-five feet or more and are durable enough in places to furnish material for ordinary masonry. A bluff of this sandstone is shown in plate x. The same arenaceous beds rest directly upon the St. Louis limestone, the upper surface of which is seen in many places to be deeply eroded and uneven. The sandstone at the bottom is very unevenly cross bedded, indicating the shallowness of the waters in which it was deposited. Similar massive sandstones have long been quarried at Muscatine where certain parts of the beds have hard concretionary masses of spherical shape very much like those referred to in connection with the Redrock sandstone. Other exposures of Carboniferous sandstones are found along the Iowa



OVERHANGING LEDGE; BASAL SANDSTONE RESTING ON SAINT LOUIS LIMESTONE.—KEOKUK.

river, where they are to be seen lying in Devonian gorges as at Iowa City.

The organic remains found in the sandstones or the more compact of the sandy shales are almost entirely plants. Beautiful ferns are not uncommon. Many kinds of Lepidodendron and Sigillaria are very abundant, and huge calamites are not rare. In certain parts of the Redrock sandstone, south of Pella, Marion county, for example, it is not unusual to see tons of great plant trunks, finely marked, lying in the talus at the foot of the mural escarpments along the Des Moines river. Other localities are equally prolific of vegetable remains.

Calcareous Beds.—The limestones of the Lower Coal Measures play an unimportant part in the lithological features of the region. With a few exceptions they consist merely of a few thin bands chiefly in the upper portion of the section, above the lower Coal Measures, as commonly designated in this state. Though seldom exceeding ten or twelve inches in thickness, these calcareous bands are more persistent and are more easily recognizable over wide areas than any of the other horizons. They are fragmentary or nodular, very impure from a large admixture of clayey material, and more or less highly fossiliferous.

There are some few exceptions, however. In Appanoose county, for instance, there are two limestones which have a wide geographical extent and bear a definite relation to the coal seam most generally worked. They are known as the "seventeen-" and "fifty-foot" limestones. The one is usually three feet in thickness; the other six feet. They also extend into the neighboring counties and southward into Missouri.

At the mouth of Cedar creek in Mahaska county, a couple of miles below Bellefountaine, a six foot layer of limestone is found capping a thick massive sandrock which is apparently the southern prolongation of the Redrock sandstone. At this place it has been cut through by Carboniferous streams.

Overlying many of the coal seams is an impure, bituminous limestone usually containing considerable iron. It is commonly charged with fossils, many of them marine species. It is quite probable that some of these beds are represented in other districts by purer limestones. They often are nodular and then pass under the name of "boulders."

Coals.—Little need be said here concerning the lithological character of the coals of the state. They are all of the bituminous varieties, though a few limited deposits of tolerably good cannel coal are known. The seams vary from a few inches to seven or eight and even ten feet in thickness; the average of the veins at present worked being between four and five feet. These beds are disposed not in two or three continuous layers over the entire area as has been commonly supposed, but in numerous lenticular masses from a few hundred yards to several miles in extent. As a rule the coals of the state are rather soft. They often contain some pyrites, and not infrequently there are small flakes of lime or gypsum along the line of stratification and fracture. Thin shaly seams also occur. Almost without exception the workable coal beds are underlain by a soft white clay which is often taken out along with coal and made into fire brick. Usually roots of lepidodendrons are found abundantly in this under clay. The roof of the coal beds is usually a bituminous, fissile shale; intensely black below but commonly becoming lighter colored upwards. The thickness of the "roof" may vary from a few inches to fifteen or twenty feet.

Frequently just above the coal, in the lowermost layers of the roof, there is a black nodular band of hard calcareous material, the individual spherical masses being called locally "nigger heads." The larger of these may measure ten or twelve feet in diameter. They are sometimes charged with fossils, chiefly lamellibranchs and gasteropods in great variety. The "nigger heads" are quite distinct from the septarial masses often associated with the coal and having the same general appearance.

There are also associated with the coal layers a compact, massive rock having a somewhat metalic ring when struck with the hammer. It is one of the ores of iron and is commonly called clay iron stone. At Flagler, in Marion county, one bed ten inches thick divides a five-foot vein of coal into two parts.

UPPER COAL MEASURES (MISSOURI FORMATION).

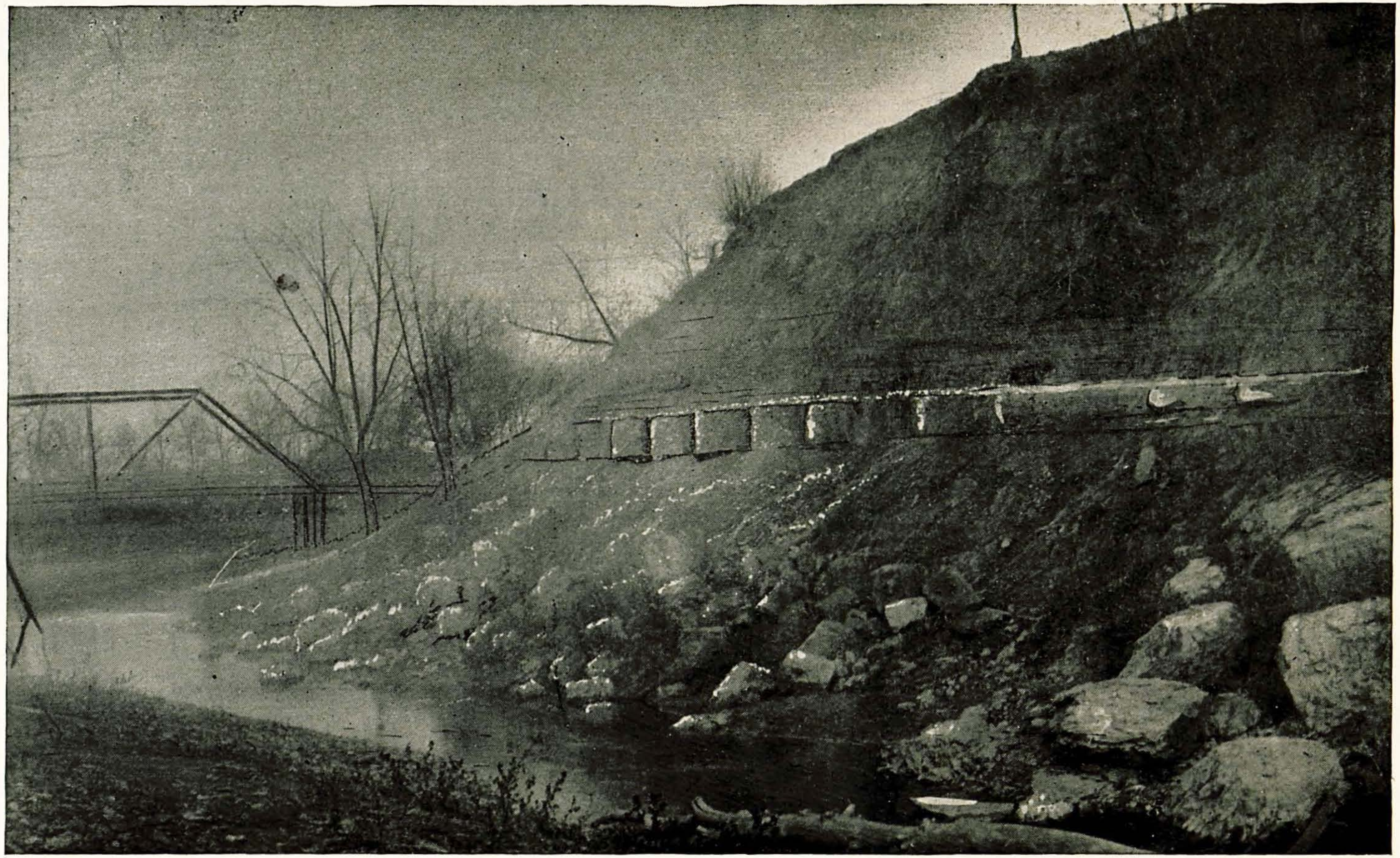
Clay-Shales.—As in the lower division of the Iowa Coal Measures the argillaceous materials of the upper part predominate over the other components. But instead of being dark colored as a rule the clays of the upper division are light colored — calcareous rather than bituminous. The transitions from one lithologically distinct bed to another are much more gradual and layers are far more presistent than in the Lower Coal Measures. A pure clay stratum acquires more and more calcareous material until through various shaly stages it eventually becomes a well marked limestone. The clays carrying a high percentage of lime are popularly termed "marlites" and commonly yield large numbers of molluscan shells in a good state of preservation. Although there are bituminous shales in the Upper Measures of the state, they are, for the most part, quite limited.

Limestones.—Next to the clays the limestones rank in importance in the making up of the Upper Coal Measures. Their presence forms the most prominent lithological difference between the upper and lower divisions. In thickness the beds vary from a few inches to twenty or thirty feet and upwards. Many of the bands are somewhat earthy, but very compact and break with a conchoidal fracture. The thicker layers may be thick- or thin-bedded, the latter being more common. Fossils abound in nearly all the limerocks, especially those inclosed in calcareous shales.

The limestones, even in thin bands, are the most persistent of all the strata of the region; single beds having a wide geographical extent. Hence in the recognition of horizons at different places the layers in question become very valuable as means of correct correlation.

The hard calcareous beds, beginning in the uppermost part of the lower Coal Measures with a few thin impure bands of very limited extent, rapidly increase in number, thickness and importance until at the top of the series, they form great beds.

Arenaceous Materials.—The sands of the Upper Coal Measures are largely disseminated through clays forming sandy shales or shaly sandstones. The massive sandstones are not common. They are chiefly confined to limited layers of a few feet in thickness. Occasionally a bed of considerable vertical measurement is met with in the lower portions of the formation, but it is always very local.



LOWER COAL MEASURE LIMESTONE.--MYSTIC.

Coal. Over a large part of the upper Measures, coal seams of economic importance are not common. The seam twenty inches thick which occurs in Page, Taylor and Adams is perhaps the most important one at present known. It is well exposed in the bluffs of the Nodaway and its branches and has a considerable geographical extent. Deep borings, however, will probably disclose a large amount of workable coal. In fact this has already been accomplished with profit at Leavenworth, Kansas, and neighboring places.

UPPER COAL MEASURE LIMESTONE.—EARLHAM.