GEOLOGY.

The coal measures of Indiana form a portion of what is sometimes called the "Great Illinois Coal Field," a name given to the western coal measures by the late Dr. D. D. Owen, one of the very earliest of our pioneers in geology. This name not only applies to the coal area of Illinois and Indiana, but likewise to that of Western Kentucky, Arkansas, Missouri, Iowa, Kansas and Nebraska, from the fact that, they were all considered as parts of one great basin. The area of the coal measures in Indiana, which, in advance of a computation to be made from an actual detailed survey, may be stated to approximate (6,500) six thousand five hundred square miles, or one-fifth part of the entire State. Insignificant as this coal area may appear when compared to that of the whole United States, which has been estimated at 130,000 square miles, it is, nevertheless, more than half as large as the entire coal area of Great Britain and Ireland.

There are, perhaps, no phenomena connected with the changes to which the surface of this planet has been subjected, that appear so inexplicible and well calculated to fill the mind of the student of geological history with wonder and astonishment, as the occurrence of extended beds of mineral fuel, alternating with shale, sandstone and other rocks, through a great depth of strata. For so vast an accumulation of carbonaceous matter, at first view, there would appear to be no solution found in the causes now in action on the globe. But it is now, however, generally conceded that the deposition must have taken place

in water, from the fact of finding associated with the coal plants that grew in swamps, and the carbon of the plants in such a perfect state of preservation; the latter could not have been the case had the plants, like the forests of the present time, been exposed to the decomposing influences of the atmosphere.

Still further argument in favor of the theory that the plants of the coal grew in large marshy lakes, somewhat similar to the peat-bogs of the present time, is afforded by the characteristic beds of clay (fire clay), more or less plastic and arenaceous, which forms the under-stratum to all coal seams—leading to the inference that it formed the soil on which the plants of the coal period grew, being everywhere fiilled with the roots of trees, whose trunks and branches are found preserved in the roof-shales, and sometimes in the coal itself. It is not uncommon to find, in the entries of coal mines, the roof-shales beautifully ornamented with a continuous sheet of the compressed carbonized trunks of *sigillaria lepidodendron*, and other plants, with their surface-marks perfectly distinct and well preserved.

The plants of the coal period were not sub-aqueous, but required the influence of the sun's rays to promote their growth, just as we see in the great peat-bogs of the present time. By long continued subsidence, and subsequent elevation of the surface, the necessary conditions were obtained for the production of the coal.

The carboniferous age occupies a position about midway in that portion of the earth's crust which is accessible for study.

It has been divided into three periods. The lower is largely composed of limestone, and is known as the sub-carboniferous period—mountain limestone of the English geolgists. The middle division forms the true carboniferous period, from the fact of its being the great repository of mineral carbon—stone coal. It is estimated that ninety-nine hundredths of all the coal that is mined comes from this geological period. The permian epoch forms the up-

per division of the carboniferous age; but, at present, it is a matter of some doubt in the minds of many of our geologists—after considerable strife among them to establish claims to priority of discovery—whether the evidence, so far furnished, will justify its recognition as distinct from the carboniferous period.

The carboniferous period is usually divided into two epochs: millstone grit, or conglomerate, and coal-measures; the latter being again, sometimes, subdivided into lower and upper coal-measures, but I can find no necessity for or evidence to sustain this sub-division, either in Kentucky, Illinois, or Indiana. The upper or barren coal-measures of Owens' Kentucky Reports being nothing more than a repetition of his lower coal-measures seen at localities where, from local causes, the coals are of less thickness, or are entirely wanting, and their places are occupied by shale or other mineral matter. The millstone grit epoch lies at the base of the coal-measures, and is usually represented by a massive sandstone that is nearly always charged wtth quartz pebbles varying in size from a buckshot to that of a quail's egg. Though good thick beds of workable coal are found below this conglomerate in Indiana, Kentucky, and elsewhere in the United States, they are of rare occurrence in England, and the miners of that country have consequently given to it the name of "farewell rock." From the geological position of the millstone grit, it becomes necessary that we should give it our especial study, from the fact of its forming an important horizon to guide the miner in his search after coal—a task that is by no means so easy as at first view might appear, for the massive sandstone, which forms its principal feature, is not everywhere a conglomerate—that is, charged with pebbles—and at very many localities its lithological character appears in no respect to differ from the massive sandstones which are to be found at a higher geological level in the coal-measures. Nor will the proximity of a sandstone to the underlying carboniferous limestone, in the absence of other evidence, serve at all times for its identity, as the millstone grit may be en-

tirely wanting, and its place represented by superior strata, resting on rocks of a much greater age. An example of the latter condition may be seen at La Salle, in Illinois, where the coal-measures are resting on rocks belonging to the lower Silurian age.

The investigations I have made during the last three years in the Western coal fields have led to the discovery of great errors that exist in the reports of previous surveys made in the same district, at least so far as they relate to the coal-measures of Indiana, Western Kentucky, and Southern Illinois.

In the third volume of the Geological Report of Kentucky, pages 18 to 24, the coal-measures are divided into two epochs, designated as *upper* and *lower* coal-measures. The vertical section of the coals given in the above report is adopted entire in the subsequent report of a Geological Reconnoisance of the State of Indiana by Prof. Richard Owen, and an effort is made therein to have all the coal beds of Indiana conform to the arrangement of the coal beds as laid down in the Kentucky section above referred to.

Now, from the best of evidence, I feel authorized to say that this classification of the coals can no longer be retained, neither as regards the division of the strata into epochs, nor in the number and order of the coal beds. What has been designated by Owen and other geologists, in the district above referred to, as *upper* coal-measures, turns out to be merely a repetition of the *lower* coal-measures of the Kentucky section, seen where the shales have an increased thickness; and the beds of coal elsewhere referred to as the *lower* coal measures are either entirely wanting, or are reduced to a few inches in depth. Indeed, all the investigations I have so far been able to make go to show that it is only around the rim or margin of the western coal basin, and not throughout its *central area*, that we are to look for a succession of thick beds of coal. As we approach toward the central part of the basin, the coal beds which surround it are either entirely absent, or have dwindled down to seams that are only a few inches in thickness, their

places being occupied by a preponderance of argillaceous shale, some sandstone, and an occasional stratum of limestone.

The increased thickness and lithological character of the strata forming the central area of the Great Illinois Coal Field, with their paucity of coal, appears to point to the fact that their deposition took place in deep and quiet water, where the favorable conditions which prevailed so fully for the accumulation of carbonaceous matter in the shallower waters along the margin, were here, not such as would admit of a luxuriant growth of plants so essential for the formation of thick beds of coal. From numerous irregularities to be found in the coal measures, in many localities, we are further led to conclude that the bottom of the large marsh, or peat bog, in which coal beds were formed, was not an entirely level surface, but was subject to the same changes and inequalities that are to be found in the great peat bogs of the present day; and that it was traversed by streams, both large and small, in such a manner as to cause an accumulation of carbonaceous matter in one locality, and cut it away in others.

From this view of the subject, it is not at all strange that we should find coal absent in strata at some localities which are coal bearing at others.

The conglomerate, and likewise other massive sandstones, are often seen charged with fragments of coal and stems of trees, as though the currents which transported the sand and gravel of which the rock is composed had, in some places at least, cut away underlying coal seams; and it may be observed, as a general rule throughout this coal field, that wherever the usual argillaceous or bituminous roof shales are absent, and the sandstone is found resting immediately on the coal itself, the latter will seldom show its normal depth, from the fact that a portion of the top part of the bed was swept away by the forces which brought in the sand, and, in such cases, it is not at all unusual to find in the sandstone an abundance of plant remains, such as *Lepidodendron*, *Sigillaria*, *Calamites*, etc.

In the chronological arrangement of the western coal beds, published in the third volume Geological Report of Kentucky, and subsequently adopted in the Report of a Geological Reconnoissance of Indiana, published in 1859, there is, in addition to the error of separating the productive and barren coal strata into separate epochs, a further misplacement of strata and duplication of coal-beds below the "*Anvil Rock*" *sandstone*, which forms an important geological horizon in western Kentucky and Southern Illinois. Commencing with No. 1, B, of the Kentucky section, which is seen at Cannelton, Indiana, at Hawesville on the opposite side of the river, and at Bell's and Casey's mines on Tradewater river, a few miles to the eastward of Caseyville, on the Ohio river, in Union county, Kentucky, we have a generally recognized synchronism over a broad area of the coal measures, for the first bed of coal above the conglomerate that is of sufficient thickness to be economically worked.

Now, assuming this coal bed to be correctly placed, there is, thirty or forty feet above it, a thin seam, No. 2, that is nowhere over the district mentioned thick enough to work. But the "*Ice-house*" coal, No. 3, is the equivelant of No. 1, B, it having been mistaken for a higher coal. And the "*Curlew coal*," No. 4, is the equivalent of No. 11. Being seen in the Curlew hill, near Caseyville, it was mistaken for a lower coal.

The massive sandstone above the "*Curlew coal*," designated as the "*Mahoning sandstone*," in the reports above referred to, is consequently nothing more nor less than the "*Anvil Rock*" *sandstone* seen at another locality.

In consequence of the magnitude of these errors, the usefulness of the Kentucky section is completely destroyed in so far as regards the synchronism of coal beds, and its adoption, long unquestioned in this State, has been productive of much confusion.

In advance of a more thorough study of the coal measures of this State, it is a matter of some importance to be able to decide upon a system of numbering that will

not prove objectionable before the completion of the survey, and yet enable us to show at a glance, in each section, the equivalent beds of coal. For the present, therefore, I have thought best to omit the system of numbers, and adopt, instead thereof, corresponding letters for equivalent coal beds. By this means we may be able to construct, after completing the detailed survey of the coal measures, a general vertical section that will prove harmonious in all its parts.

Notwithstanding the amount of study that has already been given by geologists to the coal measures of the West, we are just beginning to clear away the errors of preconceived notions, and instead of building conclusions upon speculative theories, the theories themselves are being made to rest upon *bona fide* examinations and well authenticated facts.

In tracing a seam of coal, it must be borne in mind that the quality of the coal in any given seam will seldom serve for its identity over any great extent of country, as in this respect it is subject to great variation. The same seam may be a free burning, hard, bituminous splint coal in one place, and a caking highly bituminous soft coal at another; nor will it do to rely upon the thickness of a bed of coal as a sure means of identity over any great extent of country, as in this it is also subject to great changes.

A single coal bed seldom exceeds five or six feet in thickness; when of greater thickness than this it is apt to contain a parting of fire-clay, which tends to show that it is a double seam, and liable, in other localities, to be separated by many feet of strata.

The efforts that have been made to identify the coal seams by the organic remains found in the roof shales, have also proved equally uncertain.

In consideration of the above facts, we are led to the conclusion that the only sure way of tracing the identity of a coal seam over a great extent of country, is to pay strict attention to the study of all the accompanying strata.