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extent of at least twenty miles; and probably stretches out much farther. At Redrock Cliff the stone is massive for the most part, but rather soft and thin-bedded above. At this place it is a very fine grained and homogeneous sand rock, some portions even affording excellent material for grindstones. But southeastward, and at Elk Bluff, two miles below, the sandstone passes into a fine-grained, ferruginous conglomerate. The dip is everywhere to the south and west; and at a short distance above the quarry, a short distance above the village, the inclination is very considerable. A mile beyond, the sandstone has disappeared completely and the section shows only shales and clays. The space between the latter exposure and the last known outcrop of the sandstone is perhaps half a mile, the interval being hidden by quaternary deposits down to the water level. The abrupt change in the lithological characters of the rocks in so short a distance has been mentioned by Owen and by Worthen; but the true explanation is entirely different from the suppositions of those writers.

Recent observations have cleared up many of the hitherto doubtful points concerning the geological history of the Redrock sandstone. It is not the basal member of the coal measures, as was regarded by Worthen; nor is it a shore extension of the Kaskaskia limestone; neither is its geographic extent as limited as has been supposed. Twenty miles to the southeast of Redrock a sandstone of great thickness, having identical lithologic characters and with a similar stratigraphical position is believed to be its extension southward. And it may also rise a few feet above low water in the northwestern corner of Marion county. The most interesting consideration in regard to this Redrock sandstone is the fact of its considerable elevation above the surface of the sea and its subjection to subaerial erosive agencies for a long period of time before submergence again took place. During that interval the great thickness of sandstone was probably almost entirely removed in places.

GEOLOGICAL STRUCTURE AND RELATIONS OF THE COAL-BEARING STRATA OF CENTRAL IOWA.

BY CHARLES R. KEYES.

(ABSTRACT*).

The exposed stratified rocks of central Iowa are made up chiefly of Lower Coal Measure clays, shales and sandstones. In the southeastern portion of the area the upper member (for Iowa) of the Sub-Carboniferous—the St. Louis limestone—is exposed along the Des Moines river. To the westward the so-called Middle Coal Measures and the Upper Coal Measures are represented. Hitherto it has been supposed that the three recognized divisions of the upper Carboniferous rocks in the State have each a maximum thickness of about two hundred feet. Lately, however, the Upper Coal Measures alone have been discovered to have at

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least double this estimate; and at a still later date the vertical extent of the other two formations has been found to differ very much from the limit usually assigned: the Middle Coal Measures being considerably thinner than was supposed, and the Lower Coal Measures very much thicker.

From an economic standpoint, the coal of the region forms by far the most important deposit. The seams vary from a few inches to seven or even eight feet in thickness; the average of the veins at present worked being between four and five feet. These are disposed, not in two or three continuous layers over the entire area, but in numerous lenticular masses from a few hundred yards to several miles in diameter. A single horizon may thus contain several of these lens-shaped beds of greater or less extent. Along the line of the general section the coal-bearing horizons have been found to number more than a score; and the extension of the investigations beyond the limits of the particular area here considered has very greatly increased this figure. Recognizing this fact, the aggregate amount of coal is far in excess of what has been supposed hitherto. The peculiarities of its disposition and the consequent popular misunderstanding concerning the actual extent and distribution of the coal beds has led to a large but useless expenditure of capital. This phase of the question will receive further expansion in another place.

Summing up the more salient features in the present preliminary consideration of the Coal Measures of central Iowa, it may be said that:

1. The Lower Coal Measures are very much thicker than has been hitherto supposed.
2. The so-called Middle Coal Measures are not so extensive, vertically, as was once supposed; and the designation as a formation name is of very doubtful utility, at least in so far as Iowa is concerned.
3. The recognition of the very subordinate importance of the "Middle" member suggests that the Coal Measures in Iowa may more properly be regarded as forming two, instead of three, divisions.
4. The unconformity of the Lower Coal Measures of Iowa upon limestones of the Lower Carboniferous is much more pronounced than heretofore suspected. The confirmation of this statement is found in excavations recently made at Elk Cliff, at Harvey, at Fairfield, in Jefferson county, and elsewhere.
5. The striking unconformities in the Lower Coal Measures have never been so apparent as at present. The most remarkable instance of this sort is the case of the Redrock sandstone. The vast sand bed had manifestly been consolidated and elevated above the surface of the sea for a considerable distance; then it was subjected to long-continued denudation, as is shown in the deep gorges and ravines which are still preserved in the hard sandstone. So widespread and intense was the action of the erosive agencies that the great sandstone, more than one hundred and fifty feet in thickness, was largely removed; and at the present day only a few isolated outliers tell of its former great extent. When regional submergence again set in, the old gorges and shore depressions were occupied by coal swamps.
6. The earliest formed coal seams are far more extensive, both geographically and vertically, than the later ones. On the whole, the coal of Iowa may be regarded as distributed in innumerable lenticular basins, sometimes several miles in diameter and six or seven feet in thickness centrally, sometimes only a few hundred yards in extent. These occur at many different horizons and interlock with one another, so that a boring may pass through a score or more coal horizons without meeting more than one or two veins of sufficient thickness for profitable working.