ART. XI.—*The Carboniferous Rocks of Southeast Kansas*; by
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AT the eastern boundary of Miami County, Kansas, we find the high lands to vary from 950 to 1050 feet above the sea, the valleys being 875 to 910. In the Neosho Valley the elevation at Neosho Falls is about 1000 feet. Up to this place and a little farther we pass over a gently sloping country. It then rises more rapidly, being 1150 feet on higher land. West of the Verdigris the country rises more rapidly and is more rugged.

In Osage County coal is profitably mined, which, according to Prof. Mudge belongs to the Lower Coal-measures. The Lower Coal-measures pass southwardly along the Neosho Valley which seems to occupy a trough in these measures, but eastwardly, including Miami County, the northern half of Anderson and the county northwardly, only the upper series are exposed, connecting with similar measures in Missouri.

West of the Verdigris River the Upper Coal-measures also extend but soon disappear beneath the "Permian." The main productive Coal-measures of Southeast Kansas lie south of Miami County. Passing from Paola southwestwardly to Greenwood County, we find only a thin coal-seam occasionally mined but with no profitable result. Near the line of Greenwood and Woodson Counties a seam of less than a foot thickness is sometimes mined. This is the most western exposure of coal belonging to the Carboniferous formation. In the western part of Woodson and in Greenwood County the lowest exposed rock is 50 feet of coarse sandstone which I have referred to the Lower Coal-measures, but only a few fragmentary remains of plants were found in it. Above this are thin limestone beds full of *Fusulina cylindrica* and nearly 200 feet more of sandstone, with other limestone beds above, containing well known Carboniferous fossils, including *Fusulina cylindrica* and *Chaetetes*. The step now is more rapid to the "Permian."

Entering the State near the line of Cowley and Chautauqua counties, we find ourselves upon a long dividing ridge extending and well defined for seventy miles northwardly.

This ridge is much higher than the country either east or west of it, and is known in southern Kansas as the "Flint Hills," on account of numerous fragments of flint lying strewn over the surface. It includes the Permian rocks of Kansas and might appropriately be termed the "Permian Mountains." Its elevation above the sea is 1560 feet near Greenfield, in northeast part of Cowley County 1600 feet; and the highest point near the corner of Greenwood, Elk and Butler about 1700 feet. This is the

highest ground east of Arkansas and Walnut Valley. On the west side of this ridge the descent is gentle and scarcely perceptible, being 390 feet in 25 miles to the Arkansas Valley. On the east the descent is more abrupt, the ridge presenting rugged walls of limestone separated by shaly slopes, and the hills descend 350 feet in four miles or 390 feet in six miles, and in some places the descent is still more abrupt. From the main ridge sharp spurs extend off from six to ten miles eastwardly. From the peculiar rough character of the eastern face of this ridge good wagon passes are often distant as much as ten miles.

The approaches to this ridge from Fall River Valley is by a succession of terraces or plateaus of upper Carboniferous rocks. At Twin Falls we are on a lower terrace elevated about 1000 feet above the sea. The second terrace is reached six miles southwestwardly at 1160 to 1180 feet. This terrace occupies a large area of the eastern part of Greenwood County with most of Elk. The elevation of the next terrace is about 1300 feet above the sea and it reaches to the foot hills of the Permian and the slopes above blend with the Permian. This will include altogether about 500 feet of Upper Coal-measure rocks in this part of Kansas which lie below the Permo-carboniferous. These beds are mainly shaly sandstones with occasional limestone beds, and as far as observed contain one coal bed of seven inches with two beds of bituminous shale, and one other coal seam of five inches thickness appears just beneath the Permian. The Permian or Permo-carboniferous of the "Flint Hills" include a total of about 500 feet thickness. The following section I have condensed from several taken within twenty miles.

1. Sixty-two feet including chert layers with thin beds of shaly drab-colored limestone; the highest rocks seen in "Flint ridges," observed *Bryozoa* with *Athyris subtilita*, *Productus costatus* and *Hemipronites crenistria*.

2. Ninety feet mostly thin limestone layers chiefly disintegrating on exposure.

3. Seven feet bed of porous chert resting on limestone. *Pinna peracuta* found everywhere. A *Phillipsia* was also obtained.

4. Eighty-five feet chiefly drab shales with some thin layers of limestone and red shale near lower part. Fossils are very abundant and can be picked up in a finely preserved state, and include *Fistulipora* (?), *Productus Nebrascensis*, *P. semireticulatus*, *Meekella striaticostata*, *Chonetes graculifera*, *Terebratula bovidens*, *Athyris subtilita*, *Yoldia subscitula*, *Schizodus Rossicus*, *Myalina perattenuata*, *Hemipronites crenistria*, *Aviculopima Americana*, and other known Upper Carboniferous fossils.

5. Five feet of bluish drab and sometimes buff limestone containing *Eumicrotis Hawni*, *Myalina perattenuata*, *Aviculopecten occidentalis*. [This bed is easily recognized wherever seen.]

6. Ten feet red and green shales.
7. Fifty-three feet beds shale, with some beds of limestone very good for building purposes.
8. Twenty-eight feet limestone abounding in *Fusulina cylindrica*; the middle layers contain blue chert full of *Fusulina* showing the structure very finely.
9. Twenty-eight feet of sandstone.
10. Four feet gray limestone containing *Productus semireticulatus*, *Allorisma granosa*, *A. subcuneata*, *Pinna peracuta*, *Nautilus capax*, etc.

The last bed I regard as the base of the Permian.

Other fossils obtained at the several localities include *Allorisma subelegans*, *A. Topekaensis*, *Macrodon* —, *Nautilus occidentalis*, *Murchisonia* —. Although these fossils seem at home in the Permian, I have obtained them also, with scarcely an exception, from known Upper Coal-measure rocks of Missouri; in fact most of them have been obtained from the rocks of Kansas City.

The limestones of the Permian have been extensively quarried in Kansas from the southern to the northern part of the State, and many tons sent off to the market. Some of the rock quarried is too soft for valuable structures, but many very excellent quarries have been opened.

From levels taken on corresponding beds wide apart, we find there is a regular dip westwardly of not less than 25 feet per mile. Assuming this to be correct we may be safe in saying that there are 1500 feet total thickness of Permian beds in southern Kansas. In the counties of Butler, Cowley, Elk and Greenwood, it is the *newest* rock below the *Quaternary*. No other rocks of later formation than the Permian are found here. The PERMIAN of Kansas rests *conformably* on the *Coal-measures* and there is no decided line of separation between the two. Certain strata can be grouped together as can certain other strata of other formations.

The only marked difference is this: Passing a certain horizon in the ascending series, we find the rocks to be all of a drab, buff or cream color and the limestones more impure and breaking with a rough fracture, and when vertically jointed the angle more nearly approaches a right angle, whereas the Coal-measure limestones are generally more acutely jointed and the blocks are regular rhomboids.

The group of the PERMIAN MOUNTAINS forms an interesting study; the strata are easily traced and the scenery afforded is very fine and views extensive.

The above is an abstract of a more detailed paper.