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Under the drift in the Missouri Valley are Lacustrine clays and sand, which, further west lie directly beneath the loess, strongly suggesting the conclusion that Lake Missouri may have been the direct successor of the line of grand Tertiary lakes, so ably outlined by King (Expl. 40th Paral., vol. I, p. 458).

Fourth. Lake Cheyenne occupied the plains from Texas to Manitoba and eastward well toward the Mississippi during the Pliocene.

Fifth. Sioux Lake in the Miocene covered the western portion of the Great Plains.

Sixth. In the Eocene, the surface of the plains was dry, but probably not so further north. If not, then this Eocene lake or bay would fill the gap and connect this royal line of lakes with the ocean. Possibly Lake Missouri may have done so much later with the Gulf of Mexico.

ON THE FOLDING OF CARBONIFEROUS STRATA IN SOUTHWESTERN IOWA.

BY PROF. J. E. TODD.

(Abstract.)

Most who examined the rocks along the Missouri River in the region under consideration have been constrained to record some folding, but such statements have been rather indefinite and have hardly expressed sufficiently the abruptness of the folds.

Before noting the evidence of foldings it will be well for us to briefly notice the character of the strata folded. They consist of a mixture of limestone, clays, marlites, slates and sandstone. The change from one to another is usually abrupt and frequent. Meek concluded that the nature of a stratum changed so much horizontally that lithological characters were of little importance in determining equivalence

in adjacent localities. This may be true compared with some regions, but the more frequent exposures of the present time make it quite possible to show that the strata have fair persistence, and may be traced scores of miles, by their lithological and stratigraphical characters alone.

A fairly complete section of the rocks of southwestern Iowa may be found by placing in order the section at Wyoming, the section at Nebraska City, with Croxton's boring, (*vide* Hayden's Final Report, Nebraska, pp. 101, 106), the sections at Wilson's, (White's Report on Iowa, Vol. 1, p. 358), the section at Rock Bluff, and the section below Plattsmouth, (Hayden's Report). Giving this in brief form, omitting the finer details we have the following:

SECTION OF UPPER CARBONIFEROUS ROCKS IN SOUTHWESTERN IOWA.

1. 18 to 19 ft. Blue, red and ash colored clays, with two distinct layers of limestone 2 feet and 4 feet in thickness respectively.
2. 10 ft. Yellowish, micaceous, soft sandstone.
3. 39 ft. Drab, ash, lead colored and chocolate colored clays, with only one thin layer of bluish limestone.
4. 12 ft. Limestone in thin layers, light yellow and gray.
5. 185 ft. Thin layers, mostly of gray shades, though red and blue occur, with five thin beds of limestone and four of sandstone. (This is derived only from Croxton's boring and is quite indefinite both as to its real character and as to its relation to observed sections).
6. 12 ft. Bluish limestone, inter-stratified with black shades and with nearly one foot of fair coal near its center.
7. 30 ft. Drab clays, enclosing three distinct shades of limestone, 2 to 4 feet thick.
8. 20 to 24 ft. Compact limestone, thin bedded and stylolitic more or less.
9. 6 to 12 ft. Drab clays carbonaceous in two horizons and containing two thin strata of limestone.
10. 12 to 25 ft. Soft, fine-grained, yellow sandstone.
11. 35 to 45 ft. Clays and slates, bluish and gray, containing 3 or 4 strata of limestone, one much the thickest, sometimes 7 feet thick.

12. 16 to 20 ft. Limestone yellow and gray (*Fusulina*).
 13. 5 ft. Clays.
 14. 4 ft. Yellowish incoherent sand.
 15. 10 to 12 ft. Limestone.
 16. 25ft. Greenish and chocolate clays above and shales below.
- 449 to 490 ft. Total thickness.

This is a rather surprising result, after we have been accustomed to referring only 200 feet to the upper carboniferous, as estimated by Dr. White. Some of this may be considered somewhat doubtful still, but at least 350 feet is demanded by facts, as we shall see. The most frequently exposed members of the series are the upper and lower beds of limestone, Nos. 8 and 13, which, from their relation to the clays and sand, are especially apt to form benches, cliffs and rock-houses. It is the upper of these which has furnished the most stone in quarries as at South Bend, Weeping Water, Bennett and Roca, in Nebraska, and Shaw's and Wilson's, in Iowa. The sandstone 12 to 15 feet below the limestone was considered by Dr. White to be the lowest stratum exposed in southwestern Iowa. Several years residence in the region, and numerous observations of many exposures which were not accessible to Meek and White, have led the writer to conclude:

First. That thirty to fifty feet of strata below the said sandstone are exposed in the vicinity of Pacific Junction, as also at Plattsmouth.

Second. That the sandstone which Dr. White discovered south of Fremont City is not the equivalent of the said sandstone in the lower part of Wilson's Quarry, as he inferred, (White's Geol. Vol. 1, *in loc.*), but is of a considerable higher geological horizon. This is shown by the following facts.

(1.) Although the two sandstone strata may be traced at nearly the same level within a half a mile of each other, yet their associated strata are entirely different. One is No. 2,

the other No. 11. The former is the sandstone in the Nebraska City and Wyoming sections, the latter that in the Cedar Bluff and Rock Bluff sections, on the Nebraska side.

(2.) At Jones' Point, just above the junction of the Weeping Water with the Missouri, there is a fine expanse, which seems to have escaped Meek and Hayden. It shows a dip of four to five degrees to the south-southeast, which carries over 100 feet of strata, which are exposed as the summit of an anticlinal, shown about a mile north, entirely below the level of the river, in less than that distance.

(3.) The highest limestone in Croxton's boring at all comparable with stratum 8, is that of Nos. 34 and 35, (*vide* Hayden's Final Report, Nebraska, p. 106), 200 feet below the surface of the Missouri. As this stratum has been quite constant for twelve to fifteen miles east and west, it may fairly presumed to be so to this distance south, and making fair allowance for the obscurities of boring records we may consider the identification quite probable if not demonstrated.

(4.) Taking the bottom of stratum 8 as our plane of reference, we find a high anticlinal axis in the vicinity of Platts-mouth on the Missouri, and a little east of Weeping Water town, on the stream of that name, and a lower one more clearly exposed one and one-fourth miles above Jones' Point on the Nebraska side of the Missouri, and a little south of Wilson's on the Iowa side of the valley. The sharp fold immediately south of the latter which has been noted at Jones' Point may become a fault south of Wilson's.

The position of the bottom of stratum 8 is illustrated concisely in the following table:

	Omaha.....	Bellevue.....	La Platte.....	Platts-mouth.....	Rock Valley.....	Kenosha.....	North of Jones' Point.....	Jones' Point.....	Wyoming.....	Nebraska City..
Altitude of limestone above Missouri River.....	38.?	0.	35.?	140.	103.	50.	.90	-.50	-200.	-225.
Distance in miles south of Omaha.....	0.	5.	8.	14.	19.	22.	.26	.27	.30	35.

(5.) The trend of the fold at Jones' Point is north 50 degrees, east 60 degrees, approximately parallel with the northern border of the carboniferous, viz: a line passing through Dunlap, Iowa, and Rockport, Omaha and Ashland, Nebraska. Also with several exposures in Nebraska and Iowa which may be found to be along the higher anticlinal, viz: Roca, Bennett, Weeping Water, Glenwood, Malvern Macedonia, etc.

(6.) Paleontological evidence seems to coincide with the conclusions from stratigraphy. Of the more than one hundred species, listed by Meek as found in eastern Nebraska, twenty are found north the steep fold at Jones' Point and not south; forty-seven are found south which are not north, and thirty-five are found on both sides of the line.