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## Formational Synonymy of the Coal Measures of the Western Interior Basin

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There are traditions to the effect that since the arrival of the white man, Wall lake was tributary to the Boyer river, but for them there seems to be no basis other than the fact that every one noting the conditions, even casually, must see that it would require but a slight change in existing conditions to so deflect the water.

Other considerations which further study might remove from the realm of mere speculation to that of reasonable certainty, would be as to whether this glacial river valley does not represent the pre-Wisconsin course of the Boyer river. The slight study given the question seems to show that north of the Wall lake region the valley of Boyer river is younger than the valley of the same stream farther south. The valley of the 'Coon northeast of Wall lake suggests maturity, and a study of the map forces the thought that the 'Coon river from this point on represents the pre-Wisconsin Boyer river, which was diverted and thrown over into a branch of the 'Coon, or into the upper course of the 'Coon itself, by the Wisconsin moraine. These points can be determined only by a more careful study of the valleys of the streams, and the glacial deposits of the vicinity.

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## FORMATIONAL SYNONYMY OF THE COAL MEASURES OF THE WESTERN INTERIOR BASIN.

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BY CHARLES R. KEYES.

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Of late years the Carboniferous terranes, or formations of the Mississippi basin west of the great river have been widely studied. They are now capable of being classified in detail.

For a long time much confusion existed in regard to the relations that the schemes of various investigators, and especially those of the pioneers, bore to one another, and to the more modern widely correlated arrangement. The adjustment of the results of all workers, extending over a period of fifty years, in a field embracing the greater part of six states, was fraught with many difficulties.

With the modern method of giving geographic names to the terranes there has arisen a strong tendency to ignore the work of the earlier investigators, and to inordinately multiply titles.

As a result, a number of different titles has often been given to the same formation as it appears in different localities, and synonymy has increased amazingly.

In considering the nomenclature it has been the aim to pass over technicalities, and to adhere to the original idea and intent of the author, so far as possible, even when definitions have not been expressed according to present standards. Personal examinations of nearly all the original localities have enabled interpretations to be made that cannot always be gathered from the published descriptions.

Most of the many names for the Kansas beds, appearing in the *Kansas University Quarterly*, were first used incidentally, with no attempt at exact definition. They have no valid grounds for recognition or notice, and were it not for the fact that their authors have claimed priority in naming formations they would not be noted herein. They are, however, given for what they are worth.

The most satisfactory classification of the terranes comprising what has been generally called the coal measures of the region appears to be as follows:

SYSTEM.	SERIES.	TERRANES.	THICK- NESS.
Carboniferous.	Oklahoman.		
	Missourian.	Cottonwood limestone.	10
		Atchison shales.	500
		Forbes limestone.	30
		Platte shales.	150
		Plattsmouth limestones.	30
		Lawrence shales.	300
		Stanton limestones.	35
		Parkville shales.	100
		Iola limestone.	50
		Thayer shales.	75
	Bethany limestones.	100	
	Des Moines.	Marais des Oygnes shales.	200
Henrietta limestones.		100	
Mississippian.	Cherokee shales.	275	

The questions of synonymy are numerous and complex. All important names involved in determining priority of usage are believed to be included in the subjoined list. Their equivalents as now known are enumerated in each case.

#### NOMINAL HISTORY OF THE TERRANES RECOGNIZED.

As use of the names adopted for the general section here given may not be fully gathered from the synonymic list appended it may not be out of place to give a brief account of the nominal history of each.

*Cherokee Shales.*—Little attempt has been made to designate, by geographical names, the basal portion of the lower coal measures. Recently Haworth and Kirk\* have proposed the name Cherokee. While it was not formally nor properly defined at first as a formation name, subsequent description† leaves practically no doubt as to its extension. The name had been previously used by Jenny‡ for the lead-bearing formations of the Mississippian series of southwest Missouri, but only incidentally. Before this author proposed formally to use the title in this way, the term had been appropriated in another sense. Moreover, Cherokee, as applied to the lead-bearing rocks, covers an indefinite sequence of beds, for which specific titles that are well defined had been already widely adopted; so that even if the term in Jenny's sense had been formally suggested it could scarcely be considered as having priority. In this sense also, the term has nowhere been accepted as a geological name, while it has been practically refused recognition by all who have had occasion to refer to it, either directly or indirectly.

*Henrietta Limestones.*—The name Henrietta was used by Marbut§ for a subdivision of the coal measures which gives rise, in southwest Missouri, to a prominent relief feature called the Henrietta escarpment. It consists of several limestone beds of great persistency, separated by shales, but presenting a sharp contrast to the immediately underlying and overlying formations, which consist of shale and sandstones.

In southeastern Kansas it embraces of Swallow's section|| essentially numbers 203 to 217, or from the top of the Pawnee limestone down to the cement rock under the Fort Scott limestone. In the more recent references¶ to the sebeds the same limestones are recognized, but the lower bed is termed the Oswego limestone.

In southern Iowa the limestone in the lower part of Bain's Appanoose formation which contains the great Mystic coal seam, appears to be the real northern extension of the Henrietta.

*Marais des Cygnes Shales.*—There is considerable difficulty in determining just what term should be applied to the shales

\* Kansas Univ. Quart., Vol. II, p. 105, 1894.

† Univ. Geol. Sur. Kansas, Vol. I, p. 150, 1896.

‡ Trans. Am. Inst. Min. Eng., Vol. XXII, p. 171, 1894.

§ Missouri Geol. Sur., Vol. X, p. 44, 1896.

¶ Kansas Geol. Sur., Prelim. Rept., pp. 24-25, 1866.

¶ University Geol. Sur. Kansas, Vol. I, p. 151, 1896.

lying between the Pawnee limestone of the Henrietta and the Bethany limestone of the Missourian series. Haworth\* has recently called the shales in question the Pleasanton, from a town in southeastern Kansas. Swallow,† thirty years before, appears to have had essentially the same idea when he defined the "Marais des Cygnes Coal Series." For both, the type localities are practically the same. The recognized basal limit of the one is identical with the other. With very slight change of idea the upper limitations of the Marais des Cygnes could be considered as coinciding with the base of the Bethany, the same as in the case of the Pleasanton. The great thickness ascribed to the Marais des Cygnes is manifestly due to repetition of the upper part of the section. But Swallow himself recognized the probability of this fact when he stated that "some of the strata may be duplicated in this series, as they are very much disturbed where the sections were made." He also said of certain localities that it was almost impossible to make correct sections.

It is also not improbable that, owing to the lack of good outcrops in this level country, Swallow mistook, in his correlations, a part of the Thayer shales for the beds underneath the Bethany, just as he did in the case of what are known to be the Lawrence shales. The correlations of Swallow are in a notable degree faulty, as we now well know. The typical localities of his Marais des Cygnes are all east of the Bethany escarpment, confirming clearly that there was actually a duplication of beds in this part of his section, as he suspected.

For the strata lying between the Pawnee, the upper member of the Henrietta, and Bethany limestones, Haworth and Kirk‡ first suggested the name Laneville shales. This term was not defined in any way. Subsequently Haworth,§ without the slightest reference to this title, and without a very much better definition for the new name, changed it to Pleasanton shales. In a still later publication|| the latter term was more clearly limited. Laneville was then used in a new sense. Again, within a few months, Haworth relegates Pleasanton to a subordinate taxonomic position, placing it and the Henrietta

\* Kansas Univ. Quart., Vol. III, p. 274, 1895.

† Kansas Geol. Sur., Prelim. Rept., p. 23, 1866.

‡ Kansas Univ. Quart., Vol. II, p. 103, 1894.

§ Kansas Univ. Quart., Vol. III, p. 274, 1895.

|| Univ. Geol. Sur. Kansas, Vol. I, p. 153, 1896.

in the Marmaton formation.\* Unfortunately, Marmaton, in this connection is almost exactly equivalent to the Appanoose of Bain. Besides, the term Marmaton had already been used for the median shale member of the Henrietta.†

Eliminating Swallow's correlations as not essential, matters seem vastly simplified by retaining his title of Marais des Cygnes for the upper number of the Des Moines series, or that part lying between the Pawnee and Bethany limestones, especially in Missouri and Kansas.

*Bethany Limestone.*—The most important limestone of the coal measures is the basal member of the Missourian series, now generally called the Bethany formation. While no special designation was applied to it before Broadhead's, in 1862, this limestone was clearly recognized by a number of scientific travelers. As early as 1840, King‡ called particular attention to these limestones near the Osage river at the western boundary of Missouri. He recognized their three-fold character and pointed out their importance as a stratigraphic horizon.

Owen,§ in 1852, gave a vertical section of the limestone beds under consideration, and their associated strata, as they occur on the Missouri river a few miles below the mouth of the Kaw (Kansas City), near Wayne City. He makes the observation that the beds which are at the water level at the first mentioned place, gradually rise to the eastward. Hawn|| observed the Bethany limestone in making his section along the line of Hannibal & St. Joseph railroad, but he afterwards confounded with it the Iola, Iatan and Stanton limestones. Swallow¶ also noted these beds at Kansas City and Liberty landing on the Missouri river, but he also correlated with them the Stanton (Plattsburg) beds as shown at Leavenworth.

According to the canons of nomenclature and appropriateness of application, the term Bethany appears best suited to the basal member of the Missourian series. Various other titles for these limestones have been proposed. The subject has been recently reviewed.\*\* The great Winterset limestones

\* University Geol. Sur. Kansas, Vol. III, p. 94, 1898.

† Proc. Iowa Acad. Sci., Vol. IV, p. 24, 1897.

‡ Geol. Sur. Osage River, Eleventh Gen. Assem. Missouri, 1st Sess., Sen. Jour., App p. 518, 1840.

§ Geol. Sur. Wisconsin, Iowa and Minnesota, p. 137, 1852.

|| Geol. Sur. Missouri, 1st and 2d. Ann. Repts., p. 125, 1855.

¶ Geol. Sur. Missouri, 1st and 2d Ann. Repts', p. 81, 1855.

\*\* American Jour. Sci., (4), Vol. II, p. 222, 1896.

of Iowa, and the Erie limestones of Kansas are now known to be merely the extensions of the Bethany of Missouri.

In addition to the terrane being identical with the Bethany, the name Erie has been preoccupied many times in geology.

*Thayer Shales.*—The first special mention of these shales in geology was by Broadhead\* in 1884, in his account of the "Carboniferous Rocks of Eastern Kansas." He described the formation in practically the same extension as now understood, gave a good detailed section of them near Thayer, in the western part of Neosho county, Kansas, and repeatedly referred to them as the coal, sandstone or shales of Thayer. Attention was also called to them at Chanute.

The accounts of the work of the University geological survey of Kansas contain numerous references to these shales. In the description of the Neosho River section, Haworth and Kirk† call them the Chanute shales, and without definition allude to their position between the Bethany and Iola limestones. In a subsequent article Haworth‡ describes the shales rather fully at Chanute and Thayer but does not give them a specific name, except incidentally in another connection. The first official publication of the survey§ gives them the name Thayer without any allusion to the former name Chanute that was applied. Although proposed independently by the Kansas authors, the name and first description of the formation should be properly credited to Broadhead.

*Iola Limestones.*—The first application of a distinctive geographical name to this terrane is by Haworth|| in 1894. It was not, however, defined in any sense of the word, and the name was an extension of a rather widely known commercial name of the chief quarry rock of the bed—the "Iola Marble." A year later, Haworth¶ gave a somewhat fuller account, and at a subsequent date the same writer\*\* gave a more complete description, on account of which the name can really lay claim to recognition.

*Parkville Shales.*—For the shales lying between the Iola and Stanton (Plattsburg) limestones, along the Missouri river, the title Parkville has been recently suggested.†† The peculiar

\* Trans. St. Louis Acad. Sci., Vol. IV. p. 481, 1884.

† Kansas Univ. Quart., Vol. II, p. 109, 1894.

‡ Kansas Univ. Quart., Vol. III, p. 276, 1895.

§ University Geol. Sur. Kansas, Vol. I, p. 157, 1896.

¶ Kansas Univ. Quart., Vol. II, p. 109, 1894.

¶ Ibid., Vol. III, p. 276, 1895.

\*\* University Geol. Sur. Kansas, Vol. I, p. 132, 1896.

†† American Geologist, Vol. XXIII, p. 305, 1899.

relations that the various parts of this terrane bear to one another have occasioned some marked complications in terminology.

At the typical locality, in Platte county, Missouri, a few miles north of Kansas City, the shales are about eighty feet thick. In the Missouri river section no important limestone bands occur. In southeastern Kansas a limestone is soon intercalated, reaching a thickness of twenty feet, or more, and subdividing the formation into parts that have been thought prominent enough to secure special names. The shales thus become separated into two parts by the intervening limestone, the upper one being called by Haworth and Kirk\* the Le Roy shale, the calcareous member of Carlyle limestone, by the same writers, and the lower one by the senior author, the Iola shale.† The first named portion was subsequently changed,‡ without explanation, from Le Roy to Lane, the latter name being used also in later descriptions.§

According to deep-well records the Parkville and Thayer shales merge northward beyond St. Joseph, the Iola limestone failing.

*Stanton Limestones.*—Of late years the Kansas geologists have used the term Garnett for the third important limestone formation of the Missourian series.

There are, however, two older names which have to be considered in this connection, both of which were applied to the main body of limestone.

As early as 1866 Swallow|| appears clearly to have had the principal calcareous member in mind when he applied the name Stanton limestone. The name is derived from a town of that title situated in Miami county on the eastern border of Kansas.

The lower shaly portion of his Stanton Limestone series, corresponds to the Parkville shales, and has ascribed to it about the same thickness as shown farther to the north on the Missouri river. The correlations made by Swallow, of the Stanton limestone, as developed in the original locality on the Marais des Cygnes, in Miami county, with the section west of Topeka are, of course, erroneous; for it is now known that there is a stratigraphical interval between the two locations of

\* Kansas Univ. Quart., Vol. II, p. 110, 1894.

† Ibid., Vol. II, p. 124, 1894.

‡ Ibid., Vol. III, p. 277, 1895.

§ Univ. Geol. Sur. Kansas, Vol. I, p. 159, 1896.

|| Kansas Geol. Sur., Prelim. Rept., p. 20, 1866.

more than 500 feet, occupied by the Lawrence shales, Platts-mouth limestones, Platte shales, and certain other limestones.

For the time the Stanton limestone was very well defined, and is now easily recognized at the type locality. It is questionable whether the limits of this term should not be extended slightly, and the name adopted, in place of Plattsburg and Garnett.

In 1873 Broadhead\* called the lower and most important beds of the limestones, which have since been called Garnett, the "Plattsburg group," giving as typical localities Plattsburg, Parksville and Waldron, Missouri. He also called attention to a limestone, upwards of six feet thick, which existed a few feet above the main bed and which was usually exposed with it. A detailed descriptive section is given.

Nearly twenty years before, Hawn† recognized the limestone at Plattsburg but gave it no specific designation, and moreover he confounded it with the Bethany limestone exposed thirty-five miles east of Plattsburg, and with the limestone known locally as the Iatan, which outcrops about the same distance west in the bluffs of the Missouri river.

In 1884 Broadhead‡ gave a more complete description of his "Plattsburg group," adding also that it was well exposed at Eudora, Kansas, and was easily recognized in Johnson and Wyandotte counties in the same state.

In Kansas the limestone appears to be considered under a variety of different names. Haworth and Kirk§ in the Neosho River section called it the Burlington limestone, and also the Garnett, and referred to doubtful correlations with certain limestones on the Kansas river. Haworth and Piatt|| call it the Toronto limestone. The Ottawa limestone of Haworth¶ probably is the same formation. In the following year the same author\*\* describes the Garnett or Burlington limestone as a "system" composed of two main members separated by eight to twelve feet of shale, and further says that according to Bennett the heavy limestone at Plattsburg, Mo., is equivalent to the upper Oread. The Garnett limestone is the title by which the formation is known in the notes

\* Missouri Geol. Sur., Iron Ores and Coal Fields, pt. II, pp. 94 and 111, 1873.

† Missouri Geol. Sur., 1st and 2d Ann. Repts., p. 128, 1855.

‡ Trans. St. Louis Acad. Sci., Vol. IV, p. 482, 1884.

§ Kansas Univ. Quart., Vol. II, p. 110, 1894.

|| Ibid., p. 117.

¶ Ibid., p. 121.

\*\* Ibid., Vol. III, p. 227, 1895.

published in the first volume of the Kansas university survey.\*

The upper limestone is gray and is especially characterized by the fossil *Syntrialasma hemiplicata*; it is widely known as the "Syntrialasma Zone."

*Lawrence Shales.*—The name was suggested by Haworth† for the greater part of the shales lying between the Stanton (Plattsburg or Garnett) and Plattsmouth (Oread) limestones. Afterwards the term was extended‡ to include all of the shales occurring between the two limestones mentioned, and the maximum thickness placed at 300 feet. It was fully described§ the year following. A thin limestone layer, forty to seventy-five feet from the base, which is found in southeastern Kansas, has received the special name of Strawn limestone and Ottawa limestone. In the Missouri River section the limestone near the middle of the Lawrence formation becomes an important member, but its exact relations to the similarly situated limestones in southeastern Kansas is not known. Along the Missouri river the median calcareous member is called the Iatan limestone; the argillaceous member beneath, the Weston shales and the one above the Andrew shales. ||

*Plattsmouth Limestone.*—The typical section of the Plattsmouth limestone early attracted attention. Owen visited the locality more than fifty years ago. From the same limestone at Belleview, a few miles away, he collected a number of characteristic fossils. ¶ He, however, thought that the rocks exposed along this part of the Missouri river belonged to the Carboniferous limestone series (Mississippian), and they were so colored on his map. The marked dip to the southward, which he perceived below the mouth of the Platte river, probably lead him to believe that the coal measures were deposited in a shallow, saucer-shaped basin, of which the opposite rim was near the Mississippi river.

Swallow,\*\* though he mistook the limestone as exposed at Belleview to be the same as that at Parkville and Weston (Stanton limestone), referred the formation to the upper coal series or upper coal measures. During the same year there appeared a geological map of the United States, by Marcou, ††

\* University Geol. Sur. Kansas, Vol. 1, p. 159, 1896.

† Kansas Univ. Quart., Vol. II, p. 122, 1894.

‡ Ibid., Vol. III, p. 277, 1895.

§ University Geol. Sur. Kansas, Vol. I, p. 160, 1896.

|| American Geologist, Vol. XXIII, p. 306, 1899.

¶ Geol. Sur. Wisconsin, Iowa and Minnesota, p. 134, 1852.

\*\* Missouri Geol. Sur., 1st and 2d Ann. Repts., p. 79, 1853.

†† Bull. Soc. Géol. de France, Tome XII, 1855.

in which the formations of the Missouri river were colored as New Red sandstone, or Triassic. The English edition of the map, which accompanies his "Geology of North America," has the same coloration.

Two years later, Hayden\* gave out the results of his observations along the Missouri river, and refers the rocks south of the Platte to the Carboniferous or coal measures.

From observations made during a brief visit to the Missouri river region in Nebraska, by Marcou† and Capellini, the Platts-mouth beds were placed in the lower Dyas or Permian. A year afterwards, Meek‡ pointed out, in a special paper, the fact that the rocks in question belonged to the coal measures, and not to any younger formations. Geinitz,§ who described the fossils collected by Marcou in Nebraska, only incidentally mentions the limestone at Plattsmouth, remarking that it was probably below the Nebraska City sections, and belonged to the "Oberen Kolenkalk," or the upper part of the lower Carboniferous series.

Up to this time, although many references had been made to the formation, no specific designation had been given to the limestone. Meek appears to be the first to attempt to call it by a geographic name. He refers|| about 200 feet of strata below the first heavy limestone above the Plattsmouth to the "Platte division." This included all of the shales now known to be not more than 100 feet thick in the vicinity of the Platte river, the limestone now called the Plattsmouth, and the few feet of shales beneath exposed at the landing. As the major part of "division" is a well defined formation comprised almost entirely of shales, the term Platte has been reserved for that subdivision. Meek,¶ however, in the same memoir referred to, terms the fossiliferous limestones which comprise most of his section as the "Plattsmouth beds." By this name they have since become widely known. For this reason it is believed that the limestone should be continued to be known by the name of a locality which has become classical in American geology.

\* Proc. Philadelphia Acad. Nat. Sci., Vol. IX, p. 110, 1857.

† Bull. Soc. Géol. France, 2e série, t. XXI, p. 137, 1864.

‡ Am. Jour. Sci., (2), Vol. XXXIX, p. 165, 1865.

§ Memoirs, d. d. Leop. Carol. Akad. Nat., 1866, 91 pp.

|| U. S. Geol. Sur. Nebraska, p. 85, 1872.

¶ Ibid., p. 94.

From the town of Plattsmouth the shales dip southward and those exposed at that place are soon lost from view below the river bed. No attempt appears ever to have been made to carefully correlate the formation with any exposed further south, and consequently the beds shown along the Missouri river between St. Joseph and Kansas City have always been considered independently of those of the region to the north. There is, however, one exception. Swallow\* says, incidentally, that a certain limestone of his upper coal series is exposed at Belleview, at the mouth of the Platte, near St. Joseph, and elsewhere southward. This statement is manifestly little more than a happy guess. It was only very recently demonstrated beyond much doubt that the limestone so well exposed at the first named locality and the one in the top of the bluffs near St. Joseph are the same. But as Swallow in the same sentence just referred to made three other different limestones continuous with this one, it is safe to conclude that he had merely surmised the connection between the limestones of all four localities.

In the recent geological work done in Kansas there has come to be widely recognized through the eastern part of the state a conspicuous limestone which has been named after the hill on which the State University stands, the Oread limestone. There is now but little doubt that it is identical with the Plattsmouth limestone of Nebraska and Iowa. The term Oread was first used by Haworth† in 1894. At a subsequent date,‡ the name was extended so as to include two limestones separated at the typical locality by twenty feet of shale. Its wide extent in Kansas was recognized, and it was correlated with the Stanton (or Plattsburg) limestone of Missouri. Bennett§ traced the Oread north from Leavenworth nearly to Iowa Point and regarded it as probably equivalent to Broadhead's No. 150.

*Platte Shales.*—In the Nebraska sections there appear above the Plattsmouth limestone over 100 feet of shales, to which the term Platte may be appropriately applied. The name was first used by Meek,|| who called the rocks exposed from Omaha to Nebraska City the "Platte division" from its

\* Missouri Geol. Sur., 1st and 2d Ann. Repts., p. 79, 1855.

† Kansas Univ. Quart., Vol. II, p. 123, 1894.

‡ Ibid., Vol. III, p. 278, 1895.

§ Univ. Geol. Sur. Kansas, Vol. I, p. 62, et seq., 1896.

|| U. S. Geol. Sur. Nebraska, p. 85, 1872.

development in the vicinity of the mouth of the Platte river where the various outcrops seem to exhibit a thickness of between 200 and 300 feet. This embraced all of the shales from the first important limestone (Forbes-Bed B of Meek's section) above the Plattsmouth, the latter, and some twenty-five feet of shales below. The Plattsmouth forming a well defined member by itself, the name Platte is retained for the major part of the "division," or the shales.

The advisability of recognizing this subdivision was further advocated recently.\*

The fact that the exact equivalency of the Forbes limestones on the Missouri river, with the principal limestones on the Kansas river near Topeka is not yet determined, makes little difference so far as understanding the general stratigraphy is concerned. The Forbes may be the continuation of either the Topeka or the Burlingame limestones. At any rate the Platte is very nearly, if not exactly, the equivalent of Haworth's Shawnee formation.† It thus embraces the Lecompton shales, the Lecompton limestone, the Tecumseh shales, the Deer Creek limestone, the Calhoun shales, and possibly also the Topeka limestone and Osage shales.

*Forbes Limestone.*—In the Missourian series there is one important limestone member between the Plattsmouth and Cottonwood limestones. This is called the Forbes formation from its best outcrops in northwestern Missouri, along the Missouri river. In Kansas it appears to be the Burlingame.

This stratum has been referred to many times in the literature of the region, but it has never received special designation. Marcou‡ assigned it and other beds, as exhibited at Belleview and Omaha, to the Mountain limestone series (Mississippian), and the Plattsmouth limestone farther down the river to the Permian.

Whenever it is with certainty correlated with Burlingame limestones of the Kansas river section, the title will probably have to take the place of one or the other of these. It might be inferred that this could be easily determined from the correlations of the geologists who have been in northeastern Kansas. There are, however, in their work, marked discrepancies. No account is taken of the remarkable syncline in the extreme northeastern corner of the state. Along the Mis-

\* *American Geologist*, Vol. XXIII, p. 380, 1899.

† *Univ. Geol. Sur. Kansas*, Vol III, p. 94, 1898.

‡ *Bull Soc Géol. France*, 2e serie, t. XXI, p. 132, 1864.

souri river the Forbes limestone is carried down beneath the water level. This trough is more than 250 feet deep, and permits the Cottonwood limestone, for example, to extend eastward in a broad tongue more than forty miles farther than would be ordinarily expected. This being the case, the extension of the Burlingame limestone, as put down in the maps of the Kansas geologists, meets in Nebraska the Cottonwood limestone which is nearly 500 feet above.

*Atchison Shales.*—In the most recent papers the name Wabaunsee has been used in connection with the formation under consideration. The latter name is derived from one of the counties in central Kansas where the formation is well exposed. The designation is that of Prosser,\* for a sequence of shales that occupy the interval between the Cottonwood limestone and the Osage coals. It was subsequently made to include a few more feet of shale below the last named horizon, and to extend to the Burlingame (Forbes?) limestone.

There seems to have been another name that has been used in nearly the same sense as Prosser originally used Wabaunsee. This will probably have to be substituted. As early as 1873, Broadhead designated the uppermost beds of the upper coal measures as exposed in northwest Missouri, as the "Atchison County Group." Subsequently he refers often to them in this way. His descriptions of the lithological and faunal characters, though widely scattered, are very complete. Regarding the stratigraphic position of the formation, it reached from the summit of the Missouri section—now known to be about 75 feet below the Cottonwood limestone—almost to the Nodaway coal, which is nearly on the same horizon with the Osage coal of central Kansas. The Atchison beds thus have practically the same limits assigned to them as a quarter of a century later Prosser proposed for the Wabaunsee. They occupy over four-fifths of the interval that the Wabaunsee occupies in the northwest corner of Missouri. For this reason Atchison appears to be the only name that can be legitimately used for the shales between the Forbes and Cottonwood limestones.

The Atchison shales are 500 feet thick on the Missouri river. Near the base is at least one seam of coal of sufficient thickness to profitably mine. This is the Nodaway coal, which has a very considerable extent in northwestern Missouri and southwestern

\* *Journal Geology*, Vol. III, p. 690, 1895.

Iowa. The Aspinwall coal seam in southeastern Nebraska and northeastern Kansas is probably a part of the same stratum.

These extensive shales impart certain peculiarities to the topography of the area occupied by the Nodaway coal that are not noted elsewhere in the Missouri region. The soft rocks have permitted a moderately uniform plain to be worn out. In Missouri, Marbut has designated the plain Maryville lowland, thus recognizing it as one of the important relief features of that state. The shales, moreover, occupy the bottom of what is known as the Brownville syncline. Owing to the attitude of the strata, their softness, and the peculiarities of the drainage of this region, by which the lowland plain has been formed and the contrasts of relief reduced, little information has been heretofore obtained regarding the shales. They have been scarcely noted, though they are two and one-half times as thick as the whole upper coal measures were once thought to be. Since their extent has been recognized the Atchison shales have come to assume more and more importance, until it has come to be suspected that eventually they may possibly have equal taxonomic rank with the Des Moines series.

Prosser's name Wabaunsee is admirably defined, according to modern standards, and to its author represents far more than a term applied in a district in which he has not worked. To an unprejudiced observer, however, and to one who has been over both fields, Broadhead's group cannot fail to be regarded as equally well portrayed.

*Cottonwood Limestone.*—The name Cottonwood limestone has been adopted for the uppermost member of the Missourian series. The rock was widely known as a quarry stone, long before its importance as a geological formation was recognized, it being called the "Cotton-rock," or "Cottonwood Falls rock" or "Cottonwood stone." Thus, the last two names have crept into geological literature and it seems advisable to adopt the title, especially since other geographic names that have been applied to it have been found to be preoccupied. Cottonwood Falls and Manhattan, Kansas, may therefore be considered as typical localities. The formation was called many years ago by Swallow the "Fusulina limestone," from its most characteristic fossil feature, it being composed in certain layers almost entirely of rhizopodous shells, resembling grains of wheat. The stone is widely used for construc-

tion purposes, and is shipped into many states. The stratum has been traced from southeastern Nebraska, where it passes beneath the Cretaceous, entirely across Kansas, into Oklahoma. It often forms a noticeable topographic feature.

## SYNONYMIC LIST.

**Alma stone**, Prosser. (Bull. Geol. Soc. America, Vol. VI, p. 44, 1894.) A local quarry name used in Wabaunsee county, Kansas, for the Cottonwood limestone.

**Altamont limestone**, Adams. (Univ. Geol. Sur. Kansas, Vol. I, p. 22, 1896.) Applied to a thin stratum, in southern Kansas, lying in the Marais des Cygnes shales.

**Altoona limestone**, Haworth and Piatt. (Kansas Univ. Quart., Vol. II, p. 117, 1894.) Not defined; but name used for a part of Bethany.

**Americus limestone**, Kirk. (Univ. Geol. Sur. Kansas, Vol. I, p. 80, 1896.) One of the thin, unimportant, double limestone bands, apparently lying in the lower part of the Atchison (Wabaunsee) formation, in east-central Kansas.

**Andrew shale**, Keyes. (American Geologist, Vol. XXIII, p. 306, 1899.) Incidentally introduced to designate the upper shale member of the Lawrence, along the Missouri river, in Andrew county, Missouri.

**Appanoose beds**, Bain. (Iowa Geol. Sur., Vol. V, p. 378, 1896.) Proposed for shales, in Appanoose county, in southeastern Iowa. It includes the Henrietta and the major part, if not all, of the Marais des Cygnes.

**Atchison county group**, Broadhead. (Geol. Sur. Missouri, Iron Ores and Coal Fields, pt. ii, p. 28, and section p. 379, 1873.) Corresponds almost exactly to the Wabaunsee of Kansas. Applied to the highest beds of the coal measures in the northwest corner of Missouri. The top and base were not clearly defined originally with reference to other sections. It is now known to represent practically the shales lying between the Forbes and Cottonwood limestones.

**Atchison shales**, Keyes. (American Geologist, Vol. XXIII, p. 309, 1899.) Title derived from Broadhead's Atchison county group, which includes essentially what was called recently the Wabaunsee formation. It refers to the uppermost shale terrane of the Missourian series.

**Auburn shale**, Beede. (Trans. Kansas Acad. Sci., Vol. XV, p. 30, 1898.) A term given to a thin fossiliferous bed in the middle Wabaunsee (Atchison), in Shawnee county, Kansas.

**Benedict limestone**, Haworth and Piatt. (Kansas Univ. Quart., Vol. II, p. 116, 1894.) Not defined, but term used for Iola—"the Benedict-Iola system."

**Bethany Falls limestone**, Broadhead. (Trans. St. Louis Acad. Sci., Vol. II, p. 311, 1862.) Applied to the main body of limestones forming the basal terrane of the Missourian series.

**Bethany limestone**, Keyes. (American Jour. Sci., (3), Vol. L, p. 243, 1895.) Proposed for the basal limestone terrane of the Missourian series. A slight modification in meaning of Broadhead's term Bethany Falls limestone.

**Burlingame limestone, Hall.** (Univ. Geol. Sur. Kansas, Vol. I, p. 105, 1896.) Corresponds probably to the Forbes limestone of the Missouri river section.

**Burlingame shale, Haworth.** (Kansas Univ. Quart., Vol. III, p. 278, 1895) A name given to one of the minor beds in the lower part of the Atchison (Wabaunsee) formation in central Kansas.

**Burlington limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 110, 1894.) Temporarily proposed for the Garnett, now known as the Stanton (Plattsburg).

**Calhoun limestone, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 28, 1898.) A term suggested for a locally developed layer in Shawnee county, Kansas, in the upper portion of the Platte shales.

**Calhoun sandstone and shale, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 29, 1898.) Suggested for the upper part of the Platte shales, in Shawnee county, Kansas.

**Carlyle limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 110, 1894.) A term given to one of the limestones occurring seventy-five feet above the base of the Parkville shales in eastern Kansas.

**Cave limestone, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 20, 1866.) In eastern Kansas this is now known as the Iola limestone.

**Cave Rock series, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 20, 1866.) A term applied to what is known as the Iola limestone, and the upper sandstone of the Thayer, in eastern Kansas.

**Chaetetes limestone, Swallow** (Kansas Geol. Sur., Prelim. Rept., p. 19, 1866.) The bed to which this term was applied appears to be really near the base of the Atchison shales, as occurring in Wabaunsee county, Kansas.

**Chanute shales, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 109, 1894.) Proposed for the Thayer shales.

**Chariton conglomerate, Bain.** (Iowa Geol. Sur., Vol. V, p. 394, 1896) Formation of doubtful age, but is placed in the Des Moines series. Occurs in southeastern Iowa, and overlies Henrietta beds.

**Chautauqua sandstone, Adams.** (Univ. Geol. Sur. Kansas, Vol. III, p. 59, 1898.) In central Kansas a local development in the Lawrence shales.

**Cherokee shales, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 105, 1895.) The basal member of the triple Des Moines series. The first references are very indefinite as to limits, but the term was later defined.

**Cherryvale shales, Haworth.** (Univ. Geol. Sur., Kansas, Vol. III, p. 47, 1898.) In southern Kansas the shales separating the middle and upper main limestones of the Bethany are unusually well developed and are given this title.

**Chocolate limestone, Swallow.** (Kansas Geol. Sur., Prelim. Rep., p. 19, 1866.) Title of one of the thin limestones on the Kansas river, west of Topeka, lying in the lower part of the Atchison (Wabaunsee) shales.

**Chocolate limestone series, Swallow.** (Kansas Geol. Sur., Prelim. Rep., p. 19, 1866.) Applied to the beds in the lower part of the Atchison (Wabaunsee) shales as exposed on the Kansas river, west of Topeka.

**Clear Fork group, Broadhead.** (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 170, 1873.) Proposed for the lower seventy feet of the Cherokee shales in Pettis and Johnson counties, Mo.

Columbus sandstone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 106, 1894.) Title given to one of the heavy sandstones occurring in the Cherokee shales of southwest Missouri and southeast Kansas. It is not formally defined.

Cotton rock, Swallow. (Kansas Geol. Sur., Prelim. Rept., p. 16, 1866.) Term applied to one of the thin limestones near the top of the Atchison (Wabaunsee) shales near Manhattan, Kan.

Cottonwood Falls limestone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 112, 1894.) Name merely incidentally mentioned at this time, though afterwards defined. The terrane is the superior member of the Missourian series.

Deer Creek limestones, Bennett. (Univ. Geol. Sur. Kansas, Vol. I, p. 117, 1896.) Applied to a number of thin limestone bands in the Platte shales, east of Topeka.

DeKalb limestone, Bain. (Iowa Geol. Sur., Vol. VIII, p. 276, 1898.) In south-central Iowa applied to one of the upper limestones of the Bethany.

Douglass formation, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 93, 1898.) Proposed to embrace the Lawrence shales and the Plattsmouth limestones.

Dover limestone, Beede. (Trans. Kansas Acad. Sci., Vol. XV, p. 31, 1898.) A name given to a thin stratum in the median part of the Atchison (Wabaunsee) shale, in Shawnee county, Kansas.

Dover shale and sandstone, Beede. (Trans. Kansas Acad. Sci., Vol. XV, p. 31, 1898.) A local name for a part of the middle portion of the Atchison (Wabaunsee) shale, in Shawnee county, Kansas.

Dry Bone limestone, Swallow. (Kansas Geol. Sur. Prelim. Rept., p. 16, 1866.) Near Manhattan, Kansas, applied to a bed near top of the Atchison (Wabaunsee) shales.

Earlham limestone, Bain. (Iowa Geol. Sur., Vol. VII, p. 448, 1897.) The term is used in connection with one of the lower principal limestone beds of the Bethany, in central Iowa.

Earlton limestone, Adams. (Univ. Geol. Sur. Kansas, Vol. III, p. 51, 1898.) Proposed for a limited lenticular bed near the top of the Thayer shales, in southern Kansas.

Eastern and lower coal-bearing division, Winslow. (Arkansas Geol. Sur., Ann. Rept. 1888, Vol. III, p. 22, 1888.) Applied to a part of the coal measures probably lying below the Cherokee, in west-central Arkansas.

Einstein sandstone, Swallow. (Kansas Geol. Sur., Prelim. Rept., p. 21, 1866.) A name given, in eastern Kansas, to the uppermost bed of the Thayer shales.

Elgin sandstone, Adams. (Univ. Geol. Sur. Kansas, Vol. III, p. 64, 1898.) In southern Kansas, applied to beds lying in the Platte shales.

Elk Falls limestone, Adams. (Univ. Geol. Sur. Kansas, Vol. III, p. 65, 1898.) In southern Kansas the term refers to a thin limestone in the lower part of the Platte shales. It probably corresponds to the Lecompton and Deer Creek limestones of the central portion of the state.

Elmont limestone, Beede. (Trans. Kansas Acad. Sci., Vol. XV, p. 30, 1898.) Designation of a thin stratum in the median part of the Atchison (Wabaunsee) shales, in Shawnee county, Kansas.

**Emporia limestone, Kirk.** (Univ. Geol. Sur. Kansas, Vol. I, p. 80, 1896.) Apparently applied to one of the strata near the base of the Atchison (Wabaunsee) shales.

**Erie limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 108, 1894.) Designation of the triple limestone in Kansas, now known to be the Bethany limestone, of Missouri. The title is preoccupied.

**Eudora limestone, Haworth.** (Univ. Geol. Sur. Kansas, Vol. I, p. 136, 1896.) Applied to one of the Stanton (Plattsburg) layers.

**Eureka limestone, Adams.** (Univ. Geol. Sur. Kansas, Vol. III, p. 67, 1898.) According to Haworth, the bed thus named is the Burlingame limestone.

**Forbes limestone, Keyes.** (American Geologist, Vol. XXI, p. 349, 1898.) Applied, in the Missouri river section, to the fifth great limestone terrane of the Missourian series. It is probably equivalent to either the Topeka or the Burlingame limestone of central Kansas.

**Fort Scott cement rock, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 24, 1866.) Applied to what is now regarded as the lowermost limestone member of the Henrietta.

**Fort Scott coal series, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 25, 1866.) A name given locally, in southeastern Kansas, to the uppermost shales of what is now known as the Cherokee, including also the lower limestone of the Henrietta.

**Fort Scott limestone, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 25, 1866.) Name applied to the basal member of what is now called the Henrietta.

**Fort Scott marble, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 26, 1866.) Term given to a locally developed bituminous limerock lying in the upper part of the Cherokee shales.

**Fort Scott marble series, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 26, 1866.) Applied to beds, chiefly shales, near the top of what is now called the Cherokee shales.

**Fragmental limestone, Bain.** (Iowa Geol. Sur., Vol. VII, p. 448, 1897.) Designates the lowermost layer of the Bethany, in central Iowa.

**Fusulina limestone, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 16, 1866.) The Cottonwood limestone of later reports.

**Fusulina limestone, Bennett.** (Univ. Geol. Sur. Kansas, Vol. I, p. 116, 1896.) Applied to the Lecompton limestone, as exposed along the Kansas river.

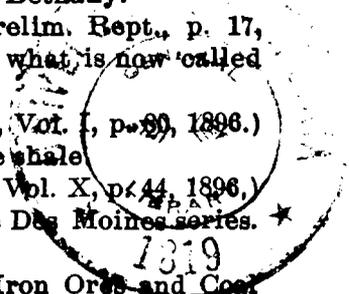
**Fusulina limestone, Bain.** (Iowa Geol. Sur., Vol. VII, p. 448, 1897.) In central Iowa refers to the third heavy limestone of the Bethany.

**Fusulina shales, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 17, 1866.) East of Manhattan, Kansas, the upper part of what is now called the Atchison (Wabaunsee) is so designated.

**Hartfort limestone, Kirk.** (Univ. Geol. Sur. Kansas, Vol. I, p. 80, 1896.) Alludes to a thin stratum near the top of the Lawrence shale.

**Henrietta limestone, Marbut.** (Missouri Geol. Sur., Vol. X, p. 44, 1896.) Incidentally suggested for the middle member of the Des Moines series. Subsequently more fully defined.

**Holden group, Broadhead.** (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 194, 1873.) Includes about sixty feet of the Marais des Cygnes shales, in Johnson and Cass counties, Missouri.



Howard limestone, Adams. (Univ. Geol. Sur. Kansas, Vol. III, p. 67, 1898.) Apparently corresponds to the Topeka (Forbes?) limestone.

Garnett limestone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 110, 1894.) A later Kansas name for the Stanton (Plattsburg) limestone.

Iatan limestone, Keyes, 1899. (American Geologist, Vol. XXIII, p. 306, 1899.) A quarry name incidentally used, in the description of the Missouri river section, to designate the median limestone of the Lawrence shales.

Independence limestone, Haworth and Platt. (Kansas Univ. Quart., Vol. II, p. 115, 1894.) Proposed for the upper of the three heavy limestones of the Bethany, in southern Kansas.

Intermediate barren division, Winslow. (Arkansas Geol. Sur., Ann. Rept. 1888, Vol. III, map, 1888.) Applied to a part of the lower portion of the Cherokee in western Arkansas.

Iola gas rock, Orton. (Bull. Geol. Soc. America, Vol. X, p. 104, 1899.) A sandstone in southeastern Kansas, 75 feet above the base of the Cherokee shales.

Iola limestone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 109, 1894.) The first geographic designation of the second great limestone terrane of the Missourian series.

Iola shale, Haworth. (Kansas Univ. Quart., Vol. II, p. 124, 1894.) An undefined name for the lower part of the Parkville shales.

Knob Noster group, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 176, 1873.) Applied to about 100 feet of the middle Cherokee, in Johnson county, Mo.

Labette shales, Adams. (Univ. Geol. Sur. Kansas, Vol. III, p. 36, 1899.) A term given to the median member of the Henrietta limestone in southeastern Kansas.

Lane limestone, Haworth. (Univ. Geol. Sur. Kansas, p. 136, 1896.) Title of the upper member of the Stanton (Plattsburg) formation, in Franklin county, Kansas.

Lane shales, Haworth. (Univ. Geol. Sur. Kansas, Vol. I, p. 48, 1896.) Name used for part of the shales lying immediately above the Iola limestone, in eastern Kansas.

Lane shales, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 54, 1898.) Title applied in the general Kansas section, to all of the shales between the Iola and the Stanton (Plattsburg). In this sense it is synonymous with Parkville.

Laneville shales, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 108, 1894.) Provisionally proposed, without definition, for the Marais des Cygnes or Pleasanton in eastern Kansas.

Lawrence shales, Haworth. (Kansas Univ. Quart., Vol. II, p. 122, 1894.) As used in this connection the name only applied to a part of the formation as now understood. It was subsequently extended and limited.

Lecompton limestone, Haworth. (Kansas Univ. Quart., Vol. III, p. 278, 1895.) Applied to the first limestone above the Plattsmouth, in central Kansas, lying in the Platte shales.

LeRoy shales, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 110, 1894.) Proposed for the upper part of the Parkville.

Lexington group, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 187, 1873.) Proposed for a part of the Henrietta formation

as developed in west-central Missouri immediately south of the Missouri river.

Lower coal series, Swallow, 1866. (Geol. Sur. Kansas, Prelim. Rept., p. 26, 1866.) Corresponds very nearly to the Cherokee shales in southeastern Kansas.

Lower Pleasanton shales, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 40, 1898.) Applied to the lower half of the upper member of the Des Moines series.

Manhattan stone, Prosser. (Bull. Geol. Soc. America, Vol. VI, p. 37, 1894.) A local name of quarrymen, near Manhattan, Kansas, applied to the Cottonwood limestone. The name is preoccupied.

Marais des Cygnes coal series, Swallow. (Kansas Geol. Sur., Prelim. Rept., p. 22, 1866.) Although duplicated in part, the Marais des Cygnes corresponds essentially to the Pleasanton shales of the later Kansas geologists. The formation is typically exposed in Miami county, Kansas.

Marmaton formation, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 92, 1898.) Proposed for the upper two members of the Des Moines series, the Henrietta and Marais des Cygnes (Pleasanton). Bain's Appanoose has essentially the same delimitation.

Marmaton shale, Keyes. (Proc. Iowa Acad. Sci., Vol. IV, p. 24, 1898.) Suggested for the median shale member of the Henrietta.

Mound group, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 196, 1873.) The upper part of the Marais des Cygnes (Pleasanton) in Cass county, Mo.

Mound Valley limestone, Adams. (Univ. Geol. Sur. Kansas, Vol. I, p. 23, 1896.) Applied to the median heavy limestone of the Bethany as it occurs in southern Kansas.

Mound Valley shales, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 47, 1898.) In southern Kansas, applied to the shales separating the lower and middle main limestones of the Bethany.

Muscotah series of limestones, Knerr. (Univ. Geol. Sur. Kansas, Vol. I, p. 144, 1896.) Title of some thin limestone beds occurring west of Atchison, and about 150 feet above the Plattsmouth limestone. Perhaps equivalent to the Forbes.

Neodesha sandstone, Haworth. (Univ. Geol. Sur. Kansas, Vol. I, p. 131, 1896.) Applied to the massive sandstone occurring in the upper part of the Thayer shales, especially at Neodesha and Thayer, Kansas.

Oread limestone, Haworth. (Kansas Univ. Quart., Vol. II, p. 123, 1894.) Here applied, without definition, to the lower part of what appears to be the Plattsmouth. It was subsequently defined.

Osage shales, Haworth. (Univ. Geol. Sur. Kansas, Vol. III, p. 67, 1898.) Title of the lower part of the Atchison (Wabaunsee).

Osage City shale, Haworth. (Kansas Univ. Quart., Vol. III, p. 278, 1895.) Name given to the lower portion of the Atchison (Wabaunsee).

Oswego limestone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 106, 1894.) A term for the lower member of the Henrietta formation.

Ottawa limestone, Haworth. (Kansas Univ. Quart., Vol. II, p. 121, 1894.) Name incidentally used for the Stanton (Plattsburg) limestone in Franklin county, Kansas. Not defined.

**Parkville shales, Keyes.** (*American Geologist*, Vol. XXI, p. 345, 1898.) A designation for shales exposed on the Missouri river, and included between the Iola and Stanton (Plattsburg) limestone.

**Pawnee limestone, Swallow.** (*Kansas Geol. Sur.*, Prelim. Rept., p. 24, 1866.) The top member of the Henrietta as now known was thus designated.

**Pawnee limestone series, Swallow.** (*Kansas Geol. Sur.*, Prelim. Rept., p. 24, 1866.) In southeastern Kansas, the title covered all of the Henrietta, except the basal limestone.

**Pennsylvanian series, Williams.** (*U. S. Geol. Sur.*, Bull. 80, p. 108, 1891.) Proposed for the Coal Measures of the United States.

**Pennsylvanian series, Beyer.** (*Iowa Geol. Sur.*, Vol. IX, p. 190, 1899.) In Story county, Iowa, the name is used for the lower coal measures.

**Platte division, Meek.** (*U. S. Geol. Sur. Nebraska*, p. 85, 1872.) Applied to shales below limestone bed B (Forbes limestone) down to and including the limestone at Plattsmouth and a few feet of shales beneath.

**Platte shales, Keyes.** (*American Geologist*, Vol. XXIII, p. 308, 1899.) An adaptation of Meek's earlier title of Platte division.

**Plattsburg group, Broadhead.** (*Missouri Geol. Sur.*, *Iron Ores and Coal Fields*, pt. ii, p. 94, 1873.) Applied to a number of limestone beds exposed on the Missouri river above Kansas City, that are essentially equivalent to Swallow's typical Stanton limestone, and Haworth's Garnett as originally used.

**Plattsburg limestone, Keyes.** (*American Geologist*, Vol. XXIII, p. 305, 1899.) An adaptation of Broadhead's earlier term of Plattsburg group, for the third great limestone terrane of the Missourian series. It now embraces a few feet more than was intended to be covered by Broadhead, which properly belong to it. As Swallow's typical Stanton is an exact equivalent to Broadhead's the former term is adopted.

**Plattsmouth beds, Meek.** (*U. S. Geol. Sur. Nebraska*, p. 94, 1872.) Refers to the section exposed at Plattsmouth, which is chiefly the limestone.

**Plattsmouth limestone, Keyes.** (*American Geologist*, Vol. XXIII, p. 305, 1899.) An adaptation of Meek's term for one of the upper limestone terranes of the Missourian series.

**Pleasanton shales, Haworth.** (*Kansas Univ. Quart.*, Vol. III, p. 274, 1895.) The upper member of the Des Moines series was designated by this title. The formation corresponds almost exactly to Swallow's *Marais des Cygnes*.

**Pottawattamie formation, Haworth.** (*Univ. Geol. Sur. Kansas*, Vol. III, p. 93, 1898.) Proposed to include the Bethany limestone, the Thayer shales, the Iola limestone, the Parkville shales and the Stanton (Plattsburg) limestone.

**Quenemo limestone, Hall.** (*Univ. Geol. Sur. Kansas*, Vol. I, p. 104, 1896.) Name of a thin layer, five feet thick, seventy-five feet above the base of the Platte shales, in Osage county, Kansas.

**Raven Cliff sandstone, Bain.** (*Iowa Geol. Sur.*, Vol. IV, p. 341, 1895.) Name applied to one of the thick massive sandstone deposits, in the lower part of the Cherokee, in Mahaska county, Iowa.

**Redrock sandstone, Keyes.** (*Am. Jour. Sci.*, (3), Vol. XLI, p. 273, 1891.) Proposed for a conspicuous and important deposit of massive sandstone in Marion county, Iowa, in the lower part of the Cherokee.

**Robinett flags, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 108, 1894.) Not defined; but applied to certain sandstones, on the Neosho river in Kansas, occurring in the Marais des Cygnes (Pleasanton).

**Rossville shales and sandstone, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 31, 1898.) Proposed for the upper part of the Atchison (Wabaunsee) shales, as exposed in Shawnee county, Kansas.

**Severy shales, Adams.** (Univ. Geol. Sur. Kansas, Vol. III, p. 66, 1898.) Apparently applied to median part of Platte shales in southern Kansas.

**Sharpsburg sandstone, Hawn.** (Missouri Geol. Sur., 1st and 2d Ann. Repts., p. 127, 1855.) Name of a basal sandstone of the coal measures in Monroe county, Mo. This author also correlated with it a sandstone immediately underneath the Bethany in Calwell county, Mo. It belongs to the Cherokee shale.

**Shawnee limestone, Haworth.** (Univ. Geol. Sur. Kansas, Vol. III, p. 93, 1898.) Proposed to embrace the Platte shales, the Topeka (Forbes?) and the lower part of the Atchison (Wabaunsee) shales.

**Shunganunga shale, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 29, 1898.) Lower part of the Atchison (Wabaunsee) shales in Shawnee county, Kansas, is thus designated.

**Silver Lake shale, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 30, 1898.) A local name given in Shawnee county, Kansas, to a part of the Atchison (Wabaunsee) shales.

**Soldier Creek shales, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 30, 1898.) Applied in Shawnee county Kansas, to a portion of the lower part of the Atchison (Wabaunsee) shales.

**Spring rock, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 21, 1866.) Name applied to a thin limestone layer which, in Miami county, Kansas, belongs to what is now called the Thayer shales.

**Spring rock limestone, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 21, 1868.) Name given to a local development in central Kansas, occupying a position in the lower part of the Atchison (Wabaunsee) shales.

**Spring rock series, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 21, 1866.) Name originally intended to cover all beds, except uppermost local sandstone, now known as the Thayer shales.

**Stanton limestone, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 20, 1866.) In eastern Kansas applied to the main body of what was later known as the lower limestone of the Garnett, or the Plattsburg of Missouri.

**Stanton limestone, Swallow.** (Geol. Sur. Kansas, Prelim. Rept., p. 20, 1868.) In central Kansas, it refers to a local development in the lower Atchison (Wabaunsee) shales.

**Stanton limestone series, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 20, 1899.) Includes the lower Stanton (Plattsburg) limestone and the Parkville shales.

**Strawn limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 110, 1894.) Not defined. Applied to a limestone exposed on the Neosho river that lies in the Lawrence shales.

**Swallow limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 105, 1894.) Applied to a thin limestone in the Cherokee shales, in southeastern Kansas, but not defined.

**Syntrialasma limestone, Bennett.** (Univ. Geol. Sur. Kansas, Vol. I, p. 111, 1896.) The lower limestone of the Stanton (Plattsburg) formation was thus designated.

**Tecumseh shales, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 28, 1898.) In Shawnee county, Kansas, applied to middle part of the Platte shales.

**Thayer shales, Broadhead.** (Trans. St. Louis Acad. Sci., Vol. IV, p. 481, 1884.) The "Shales of Thayer" was a title used in referring to a well-described section at Thayer, Kansas.

**Thayer shales, Haworth.** (Kansas Univ. Quart., Vol. III, p. 276, 1895.) A term given to the shale member of the Missourian series immediately overlying the Bethany limestone, and extending to the Iola.

**Toronto limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 117, 1894.) In southeastern Kansas, applied apparently to the Stanton (Plattsburg).

**Topeka limestone, Haworth.** (Kansas Univ. Quart., Vol. III, p. 278, 1895.) In this place merely mentioned as "Limestone near Topeka." Defined afterwards. Forbes limestone of the Missouri river section is the probable equivalent.

**Triple limestone, Haworth and Kirk.** (Kansas Univ. Quart., Vol. II, p. 122, 1894.) Name applied to the Bethany formation in eastern Kansas.

**Upper coal series, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 16, 1866.) This term covers very nearly all of the Atchison (Wabaunsee) shales, except a few feet at the top and bottom, on the Kansas river, east of Manhattan. It appears to have included also a part of the Osage shales below the Burlingame limestone.

**Upper Oswego limestone, Haworth.** (Univ. Geol. Sur. Kansas, Vol. III, p. 34, 1899.) Name given to a part of the lower limestone member of the Henrietta.

**Upper Pleasanton shales, Haworth.** (Univ. Geol. Sur. Kansas, Vol. III, p. 41, 1898.) The uppermost part of the Des Moines series is so called. In southern Kansas a thin limestone called the Altamont is said to be its base.

**Vilas shales, Adams.** (Univ. Geol. Sur. Kansas, Vol. III, p. 51, 1898.) A thin shale immediately beneath the Iola limestone in southern Kansas has thus been termed. It refers to the upper part of the Thayer.

**Wakarusa limestone, Beede.** (Trans. Kansas Acad. Sci., Vol. XV, p. 30, 1898.) Title of a thin bed in the lower part of the Atchison (Wabaunsee) shales, in Shawnee county, Kansas.

**Warrensburg group, Broadhead.** (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 182, 1873.) Applied to the beds associated with the coal at Warrensburg, Johnson county, Mo. It forms the upper part of the Cherokee.

**Weeping Water limestone, Prosser.** (Jour. Geol., Vol. V, p. 159, 1897.) The stratum is probably equivalent to the Forbes limestone, the upper limestone at Rock Bluff, Nebraska.

**Well rock, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 22, 1866.) Applied to what is no doubt the middle main limestone of the Bethany, as shown in Miami county, Kansas.

**Well rock series, Swallow.** (Kansas Geol. Sur., Prelim. Rept., p. 21, 1866.) Term is essentially co-extensive with the Bethany along the eastern

border of Kansas. The formation includes also a part of the duplicated section of the Marais des Cygnes underlying.

Western and upper coal-bearing division, Winslow. (Arkansas Geol. Sur., Ann. Rept. 1888, Vol. III, p. 11, 1888.) Applied to a part of the Cherokee in western Arkansas.

Westerville limestone, Bain. (Iowa Geol. Sur., Vol. VIII, p. 276, 1898.) A title designating a stratum in the lower part of the Missourian, possibly in the Bethany, in Decatur county, Iowa.

Weston shales, Keyes. (Amer. Geologist, Vol. XXIII, p. 306, 1899.) A term used locally on the Missouri river for the lower part of the Lawrence.

Willard shale, Beede. (Trans. Kansas Acad. Sci., Vol. XV, p. 31, 1898.) Part of the middle portion of the Atchison (Wabaunsee) shales, in Shawnee county, Kansas.

Winterset limestone, White. (Geol. Iowa, Vol. I, p. 246, 1870.) A designation given to the limestones exposed in Madison county, Iowa, that are now regarded as essentially an equivalent of the Bethany.

Winterset limestone, Bain and Tilton. (Iowa Geol. Sur., Vol. VII, p. 512, 1897.) Restricted to the uppermost of the three thin, heavy limestones of the Bethany formation, in central Iowa.

Wyckoff limestone, Haworth and Kirk. (Kansas Univ. Quart., Vol. II, p. 111, 1894.) A name used in connection with what is probably a part of the Oread or Plattsmouth limestones. Not defined.

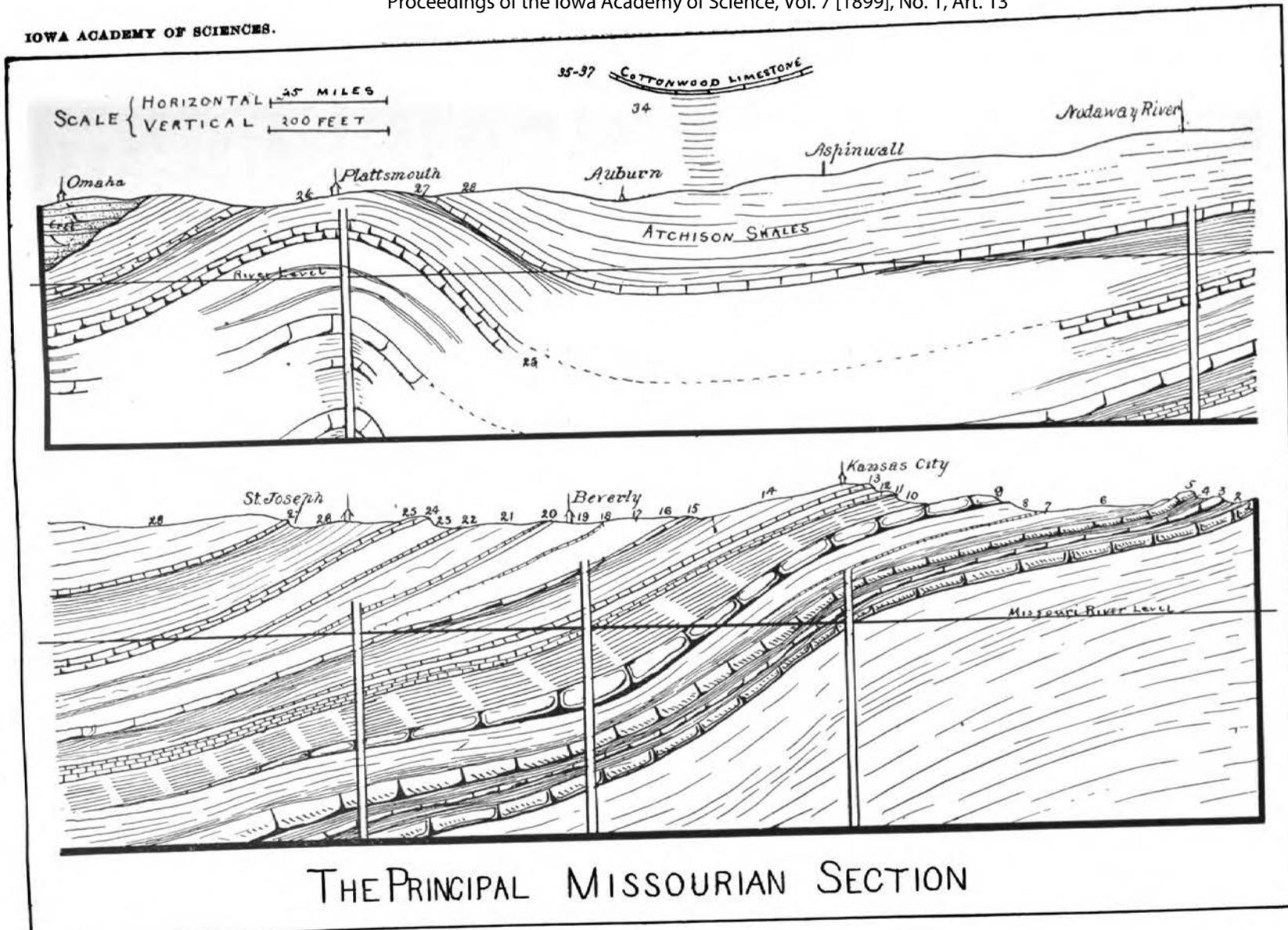
#### EXPLANATION OF PLATES.

**PLATE VI.—Terranes of the coal measures.** The approximate boundaries of the terranes of the coal measures in Iowa, Nebraska, Missouri and Kansas are indicated by the limestone margins. The courses in Kansas were traced chiefly by the geologists of that state. In Iowa and Missouri the geologists of those states have located the boundaries.

**PLATE VII.—General section of coal measures along the Missouri river.** Bethany limestone is represented by numbers 1 to 5; the Thayer shales by 6 to 8; Iola limestone by 9; Parkville shales, 10; Stanton limestone, 11 to 13; Lawrence shales, 14 to 23; Plattsmouth limestone, 24 to 25; Platte shales, 26; Forbes (Burlingame) limestone, 27; Atchison shales, 28 to 34; Cottonwood limestone, 35 to 37.



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THE PRINCIPAL MISSOURIAN SECTION