

# THE ANTHRACOLITHIC<sup>1</sup> OR UPPER PALEOZOIC ROCKS OF KANSAS AND RELATED REGIONS

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A recent monograph by Dr. George H. Girty<sup>2</sup> contains certain statements which are so misleading that I desire to briefly call attention to them. In the main they refer to some remarks of mine<sup>3</sup> concerning earlier conclusions published by Dr. Girty relating to the age of the Guadalupian and its correlation with the Upper Paleozoic formations of Kansas.

Dr. Girty has attributed a threefold argument to me<sup>4</sup> which he then proceeds to take up in detail.<sup>5</sup>

In regard to the age of the Guadalupian which is his first point, I quoted *exactly* the words used by Dr. Girty in his two papers and gave them in the order in which they were published.<sup>6</sup> In no way did I attempt to obscure his meaning or mislead the reader concerning it. I *did note* that he had changed quite decidedly from his first opinion concerning the age; but I made no comment and in no way attempted to criticize his opinions. His statement in this last work that I am correlating the Guadalupian with the Upper Permian is erroneous, for I have never expressed *any* opinion concerning the age of the Guadalupian.

In the second place I compared the lists of fossils from the Hueco and Kansas formations published at that time by Dr. Girty, as I

<sup>1</sup>The Anthracolithic is a term proposed by Waagen for the united Carboniferous and Permian systems (*Palaeontologia Indica*, Ser. XIII, Vol. IV, "Geological Results," p. 241). It is here used when speaking of the Carboniferous and Permian systems taken together or as an equivalent of the somewhat indefinite term of Upper Paleozoic.

<sup>2</sup>"The Guadalupian Fauna," *United States Geological Survey, Professional Paper 58*, 1908 [1909].

<sup>3</sup>*Am. Geol.*, Vol. XXXVI, 1905, pp. 156-58.

<sup>4</sup>"The Guadalupian Fauna," *op. cit.*, p. 40.

<sup>5</sup>*Ibid.*, pp. 40-42.

<sup>6</sup>See pp. 156 and 157 of my paper.

stated in my article, and failed to find a single listed species common to the Hueco and Marion formations, the latter occurring next above the Chase stage in Kansas. His statements concerning the correlation between the Kansan and Texan formations I understood to be founded upon paleontologic evidence and my remarks were based simply upon an examination of such published evidence.

In regard to the third point it is true that I understood Dr. Girty's statement in 1905 to refer to the *time* of the deposition of the Capitan, Kansas deposits, and Permian, but as he now explains it he intended to refer especially to their *terminology*. So far as terminology is concerned, as I now understand Dr. Girty and the facts, I should say that the term Guadalupian series essentially as Dr. Girty originally proposed it, *except* that he gave it as "Guadalupian period,"<sup>1</sup> would, for the present at least, be used for the Texan deposits. In Kansas the Upper Paleozoic deposits are known under the names of the Big Blue and Cimarron series. If the Big Blue, Cimarron, and Guadalupian series were deposited during Permian *time* I see no serious objection to putting them in the Permian *period* or system, recognizing this division as co-ordinate in rank with the Carboniferous and other periods of the Paleozoic in accordance with the usage of the majority of geologists who have carefully considered the classification of the Upper Paleozoic. Later studies may show more accurately the relationship of the Texan and Kansan series and make necessary changes in the local classifications. Dr. Beede has suggested the quite different conditions under which these two faunas lived, stating that "one is a cosmopolitan, open-sea, coastal shelf fauna while the other is a more isolated epicontinental sea fauna rather thoroughly separated from its neighbor on the south and perhaps belonging to a different climatic zone."<sup>2</sup>

The assumptions, in connection with the three points noted above, which appear in the work under discussion, I am not responsible for, and therefore they require no further notice.

The expression "Kansas 'Permian'" appears very frequently in the Introduction to "The Guadalupian Fauna" and often it

<sup>1</sup> *Am. Jour. Sci.*, 4th ser., Vol. XIV, 1902, p. 368.

<sup>2</sup> *Jour. Geol.*, Vol. XVII, p. 678.

is used as though it were equivalent to the series of formations for which I have used the designation of Permian system. At this place it is well to state that, so far as terminology is concerned, I consider the Permian division as having the rank of a *period* in time (*system* on the rock scale), and not that of an *epoch* (*series* on the rock scale), in accordance with the usage of most of the recent leading American and European standard manuals of geology.<sup>1</sup> In certain papers published by the United States Geological Survey or with its permission I have used the name Permian with the taxonomic rank of an *epoch* or *series*, because required to do so by the rule of the United States Geological Survey which states that "in the Carboniferous, Permian, Pennsylvanian, and Mississippian" are series "now recognized as applicable to North America."<sup>2</sup> Dr. Girty uses the term "Permian epoch"<sup>3</sup> in accordance with the rule of the United States Geological Survey. If this fact be kept in mind it will explain some of the differences in correlation between the papers of Dr. Girty and my own.

Concerning the lower limit of the Permian system in Kansas I wrote in 1895:

If it be considered better to put all the beds in either the Carboniferous or Permian system, it might be just as well to refer the deposits generally called Permo-Carboniferous to the Permian. If such correlation be agreed upon, then, in Kansas, the line separating the Cottonwood and Neosho formations would become the line of division between the Carboniferous and Permian systems.<sup>4</sup>

Furthermore, on pp. 795, 796 I continued as follows:

Consequently we would refer the Wabaunsee and Cottonwood formations to the Upper Coal Measures. The Neosho and Chase formations are transitional

<sup>1</sup> See Chamberlin and Salisbury, *Geology*, Vol. II, 1906, p. 619; Scott, *An Introduction to Geology*, 2d ed., 1908, p. 637; Geikie, *Text-Book of Geology*, 4th ed., 1903, Vol. II, p. 1063; De Lapparent, *Traité de géologie*, 5th ed., Vol. II, 1906, p. 752; Suess, *The Face of the Earth (Das Antlitz der Erde)*, Sollas' translation, Vol. II, 1906, p. 249 (*La Face de la terre*, Margerie's translation, Tome II, 1900, p. 407); Kayser, *Lehrbuch der Geologie*, 3d ed., II. Teil, 1908, p. 256; Credner, *Elemente der Geologie*, 9th ed., 1902, pp. 367, 490; Dannenberg, *Geologie der Steinkohlenlager*, erst. Teil, 1909, p. 42; Toula, *Lehrbuch der Geologie*, 1900, pp. 200, 231; Neumayr, *Erdgeschichte*, Vol. II, 1890, p. 199; Frech in *Lethaea geognostica*, Theil I, "Lethaea palaeozoica," 2. Bd., 3. Lief., 1901, p. 453; Koken, *Die Leitfossilien*, 1896, p. 550.

<sup>2</sup> *Twenty-fourth Ann. Rept.*, 1903, p. 27.

<sup>3</sup> "The Guadalupian Fauna," *op. cit.*, p. 42.      <sup>4</sup> *Jour. Geol.*, Vol. III, p. 793.

from the Upper Coal Measures to the Permian, as first defined by Murchison for Russia, and belong to the division which has generally been called Permo-Carboniferous, in this country. In accordance with the views of the majority of present European geologists familiar with this problem it is probably better to include the Permo-Carboniferous rocks of Kansas in the Permian series. . . . The Marion formation belongs to the undoubted Permian and contains only fossils which are characteristic of that series.

In Russian geological literature the term Permo-Carboniferous frequently occurs, the lower terrane of which is the Artinsk and the upper the Kungur; but the later standard European works on geology refer these terranes to the Permian.<sup>1</sup> I have followed them in putting the Kansas Permo-Carboniferous in the Permian. Dr. Kayser in the last edition of his *Formationskunde* states that the Permian formation of the interior Russian-Uralian district is divided in the following manner:

Tartarian stage	}	Permian in the strict sense.
Russian Zechstein (limestone)		
Kupfer sandstone		
Lower Red Beds		
Kungur stage	}	Permo-Carboniferous of Russian geologists. <sup>2</sup>
Artinsk stage		

Dr. Kayser has written me recently that:

As far as the Artinsk formation is concerned, I still entertain the same opinion as at the time of the writing of the last edition of the *Formationskunde*, i. e., I look upon it as the *base of the Permian*. The Ammonite fauna of the Artinsk, which varies considerably from the Carboniferous, and the flora seem to me in this respect decidedly significant.<sup>3</sup>

The line of division between the Carboniferous and Permian I always considered a debatable one. In my paper of 1902 it was thought that the evidence favored drawing it at the top of the Neosho member of the Garrison formation or at the base of

<sup>1</sup> Geikie, *Text-Book of Geology*, 4th ed., Vol. II, 1903, p. 1077; De Lapparent *Traité de géologie*, 4th ed., Vol. II, pp. 968, 993; Kayser, *Lehrbuch der Geologie*, 3d ed., pt. II, 1908, p. 290; Frech, *Lethaea geognostica*, Theil I, "Lethaea palaeozoica," 2. Bd., 2. Lief., 1899, chart opposite p. 394, and 3. Lief., 1901, pp. 493-99; Credner, *Elemente der Geologie*, 9th ed., 1902, p. 517; Toula, *Lehrbuch der Geologie*, 1900, pp. 219, 238.

<sup>2</sup> *Lehrbuch der Geologie*, Pt. II, 1908, p. 290.

<sup>3</sup> Letter of November 11, 1909.

the Wreford limestone of the Chase stage.<sup>1</sup> This agreed quite closely with the later correlation of Dr. Tschernyschew who drew the line separating the homotaxial equivalents of the Russian Upper Carboniferous and Permo-Carboniferous at the base or in the lower part of the Chase stage. The following is a translation of Dr. Tschernyschew's views: The Neosho beds, and possibly also the lower part of the Chase, appear analogous to the Russian Schwagerina horizon [the Schwagerina beds form the upper division of the unquestioned Upper Carboniferous of Russia, just below the Artinsk] and the remainder of this, as well as the Marion beds, one must consider as homotaxial with the Russian Permo-Carboniferous and lower Permian. Finally, the Wellington and Cimarron beds may correspond to the lower red-colored Permian in eastern and northern Russia.<sup>2</sup>

More accurate information concerning the horizon of certain vertebrates described by Dr. Williston from southern Kansas led the writer in 1907 to suggest that perhaps the Cottonwood limestone at the base of the Garrison formation, which is nearly the same as the first provisional line, "is really nearer the line of division between the Pennsylvanian and Permian than the Wreford limestone at its top."<sup>3</sup> This line is from 140 to 145 feet lower than the base of the Wreford limestone and about 14 feet lower than the line suggested in my first paper on the classification of these rocks in 1895.<sup>4</sup>

When my earlier papers were written no fossils had been found in the Cimarron series or Red Beds and in 1897 I stated that "the correlation of these rocks with either the Triassic or Permian is a matter of uncertainty."<sup>5</sup> In 1906 Doctors Gould and Beede published an account of the discovery of Permian fossils in a sandstone west of Alva, Oklahoma, the stratigraphic position of which was given

<sup>1</sup> *Jour. Geol.*, Vol. X, Chart of "Classification of the Upper Paleozoic Formations of Kansas," opp. p. 718.

<sup>2</sup> *Mém. comité géologique*, Vol. XVI, No. 2, 1902, pp. 392, 393 of Russian text and p. 703 of German text. For translation see *Am. Geol.*, Vol. XXXVI, 1905, p. 154, and Schuchert in *Am. Jour. Sci.*, 4th ser., Vol. XXII, 1906, p. 38.

<sup>3</sup> *Jour. Geol.*, Vol. XV, p. 823.

<sup>4</sup> *Ibid.*, Vol. III, p. 800.

<sup>5</sup> *Univ. Geol. Surv. Kansas*, Vol. II, p. 92.

as in the Red Bluff sandstone<sup>1</sup> which occurs well toward the top of the Cimarron series as found in Kansas. Finally, in 1907, Dr. Beede described a fauna from Dozier, in the Panhandle of Texas, which occurs stratigraphically, according to Doctors Beede and Gould, in the Quartermaster division of the Oklahoma formations which they state "is the highest formation in the Red Beds, and the fossils came from well up in this formation."<sup>2</sup> According to these geologists the Quartermaster division occurs entirely above the top of the Cimarron or Red Beds as found in Kansas. Dr. Beede described the faunas from the Whitehorse sandstone and the Dozier beds under the title of "Invertebrate Paleontology of the Upper Permian Red Beds of Oklahoma and the Panhandle of Texas" and said:

These collections are of great importance, as they furnish the final evidence that the Red Beds, below the Dockum beds, of the Oklahoma-Panhandle region are Paleozoic in age. . . . The faunas are somewhat heterogeneous as to origin. Some of the species seem to be directly derived from the Kansas Permian or Pennsylvanian, while others, as pointed out in the discussion of the species, are derived from the European Permian, especially that of Russia.<sup>3</sup>

In the lower part of the Enid division at a horizon corresponding with the upper part of the Wellington shales of Kansas,<sup>4</sup> which is the highest formation of the Big Blue series, near Nardin and Orlando, Oklahoma, vertebrate fossils were found. The specimens from Orlando were studied by both Doctors Williston and Case and a preliminary list was furnished by Dr. Williston who wrote Dr. Gould as follows concerning it: "Altogether you see that these fossils point unmistakably to the Permian."<sup>5</sup> Dr. Case furnished a report on these fossils for publication and in conclusion said:

The result of the determination of these fossils has been to settle the long mooted question of the age of the Red-beds. . . . The Red-beds of Oklahoma,

<sup>1</sup> Beede, *Am. Geol.*, Vol. XXVIII, July, 1901, pp. 46, 47. The fauna was first described by Dr. Beede in the "Advance Bulletin of the First Biennial Report of the Geological Survey of Oklahoma," April, 1902. Later it was more fully described by the same author in the *Kansas Univ. Science Bulletin*, Vol. IV, March, 1907, pp. 115-72, Pls. V-IX; Gould, *Jour. Geol.*, Vol. IX, July, 1901, pp. 337-41.

<sup>2</sup> *Kansas Univ. Science Bull.*, Vol. IV, p. 141.

<sup>3</sup> *Ibid.*, pp. 115, 142.

<sup>4</sup> Beede, *Kansas Univ. Science Bull.*, Vol. IV, 1907, p. 138; Gould, *Jour. Geology*, Vol. IX, 1901, p. 339.

<sup>5</sup> *Sec. Biennial Rept.*, Dept. Geol. and Nat. Hist., Territory of Oklahoma, 1902, p. 60.

then, or at least the members as high as the Greer formation [the base of which is near the top of the Kansas deposits] are of Permian age.<sup>1</sup>

Fossil plants were collected in the Wellington shales<sup>2</sup> in the southern part of Dickinson County, which were studied by Dr. Sellards who wrote as follows concerning them:

There are, in the collections so far made, some twenty-six or twenty-seven determinable species, distributed in fourteen genera. The plants indicate unmistakably the true Permian age of the formation in which they are found. Many of the species are characteristically Permian, and only a very small proportion of the species identical with Upper Carboniferous species.<sup>3</sup>

Part of this material was communicated to the National Museum by Dr. Sellards and examined by Mr. David White of the United States Geological Survey, who wrote as follows regarding it:

If the composition of the entire flora proves to be of so young a character as the material described or placed in my hands by Mr. Sellards, his conclusion that the beds are of so late date as the Lower Permian will appear to be fully justified. . . . However, such pteridophytic material as has come to me for examination is more nearly typical and characteristic of the Permian than any flora that I have yet seen from another formation in the United States. If the plants preliminarily listed above are representative of the plant life of the Upper Marion or the Wellington formation, the flora of these beds is probably of a date fully as late as the earlier of the floras generally referred to the Permian in western Europe. In any event a flora containing these species can hardly be older than the topmost Carboniferous, or transitional from the Upper Carboniferous to the Permian.<sup>4</sup>

In January, 1903, Dr. Sellards wrote me as follows:

The fossil plants in my opinion support your belief in the existence of true Permian in Kansas (below the Red Beds). The flora of the Marion (or Wellington) differs specifically almost *in toto* from that of formations as low down as the Lawrence shales [which occur in the Pennsylvanian near the top of Professor Haworth's Douglas stage] and indicates as I have already stated (*Kans. Acad. Sci.*, 1900; *Kans. Univ. Bull.*, Vol. IX, Jan., 1900) a lower Permian age. The plants in this case are pretty conclusive and the genera and species are identical with or most closely related to those of the lower Permian of Europe.<sup>5</sup>

<sup>1</sup> *Ibid.*, p. 68.

<sup>2</sup> Stratigraphic identification by Dr. J. W. Beede, see *Am. Jour. Sci.*, 4th Ser., Vol. XXVII, 1909, p. 169.

<sup>3</sup> *Trans. Kansas Acad. Sci.*, Vol. XVII, 1901, p. 209.

<sup>4</sup> *U. S. Geol. Surv., Bull.* 211, 1903, p. 117.

<sup>5</sup> Letter of Jan. 12, 1903, and see *Am. Geol.*, Vol. XXXVI, p. 149.

Dr. Sellards also found well-preserved insects associated with the plants in the Wellington formation of Dickinson County which he contrasted as follows with those from near Lawrence, Kansas:

The insects from the Marion seem on the whole very different from those of the Lawrence shales and other Coal Measure deposits. . . . These collections [of fossil plants from the Wellington] have since been increased and it may now be said with a good deal of confidence that, although a few species have survived from the Upper Coal Measures, the Marion [Wellington] contains on the whole a distinctly Permian flora. The marked change in the insect fauna in passing from the Lawrence shales to the Marion [Wellington] formation is therefore paralleled by the plant evolution.<sup>1</sup>

This fairly full summary of the conclusions of the various paleontologists who have carefully studied the fossils from the deposits under consideration in Kansas and Oklahoma, previous to the publication of my last note on this subject in December, 1907,<sup>2</sup> is given in order to show the limits of the Permian as indicated by fossils and that, with the exception of Dr. Girty,<sup>3</sup> all agreed in referring them to the Permian. It is believed by the writer that the above evidence warrants the provisional correlation of these Kansas deposits with the Permian, until it is shown by someone that such correlation is erroneous, and that the Permian system extends to the top of the Cimarron series or Red Beds as found in Kansas. References to and quotations from the works of various European geologists who have correlated these deposits with the Permian have been given in earlier publications. Finally, it is to be noted that the fossil evidence now in hand indicates that the base of the Permian system in Kansas begins as low as the Cottonwood limestone, or perhaps a little lower, and that the succeeding rocks in Kansas to the top of the Red Beds belong in this system, *because* still higher deposits to the south in Oklahoma and the Panhandle of Texas contain a Permian invertebrate fauna as described by Dr. Beede. The above-defined deposits are those which I call the Permian system and for which I have accepted the division into two series, viz., the Big Blue and Cimarron, proposed by Professor Cragin in 1906.<sup>4</sup>

<sup>1</sup> *Am. Jour. Sci.*, 4th ser., Vol. XVI, 1903, pp. 323, 324.

<sup>2</sup> *Jour. Geol.*, Vol. XV, p. 822.

<sup>3</sup> *Ibid.*, Vol. X, 1902, p. 723; *U. S. Geol. Surv., Bull.* 211, 1903, pp. 74-77.

<sup>4</sup> *Colorado College Studies*, Vol. VI, March, 1896, pp. 3, 5, 18.



Dr. Girty states:

In the first place, here and elsewhere in speaking of the Kansas "Permian" I refer to the Chase and Marion formations, but not to any of the higher beds, as I believe that the only practical method of correlating terranes so widely separated as those of Kansas and Russia is by paleontologic evidence; and since the evidence of invertebrate paleontology only is that which I am in a position to understand and weigh, it is natural that any statement of mine must apply to that portion of the Kansas section where invertebrate fossils are found, and cannot consistently apply to formations overlying the Marion, where invertebrate evidence appears to be absent. Furthermore, unless otherwise indicated, in speaking of the Permian I refer primarily to the Russian Permian exclusive of the underlying Artinsk or Permo-Carboniferous.<sup>1</sup>

It will be seen on comparison with what I have given above that according to Dr. Girty's definition what he has discussed as the "Kansas Permian" includes only a *part* of the deposits which the Kansas geologists refer to that system. In other words, it does not fully represent the Big Blue series and none of the Cimarron series is included; consequently this fact should be kept in mind when considering what he has said in reference to the "Kansas Permian." The horizons at which the invertebrate fossils were found in Oklahoma and northern Texas have been accurately fixed in relation to the Kansas deposits by stratigraphic work from Kansas to Texas, so that the consideration of their faunas is entirely appropriate in determining the age of the Kansas deposits. The Whitehorse sandstone fauna was known to Dr. Girty at the time he wrote this monograph, since he refers to it on p. 48.

There is a difference of opinion among European geologists as to whether the Artinsk, which is the lower division of the Permo-Carboniferous of the Russian geologists, should be included in the Permian. I have always recognized this fact; but it has appeared to me that the usage of the majority of those best acquainted with the subject favored its reference to the Permian. An extract from the work of Dr. Carl Diener, the accomplished professor of paleontology in the University of Vienna, who has so fully described the Permo-Carboniferous and Permian of the central Himalayas of India, and who has clearly stated the views of the two noted Russian geologists who favor the separation of the Permo-

<sup>1</sup> "The Guadalupian Fauna," *op. cit.*, pp. 46, 47.

Carboniferous from the Carboniferous and Permian systems, is important in this connection:

Karpinsky and Tschernyschew, two authors, to whom the most detailed studies of the Artinskian fauna are due, strongly advocate the distinction of the permocarboniferous from carboniferous and permian systems, and are decidedly averse to uniting it with either the one or the other. Tschernyschew especially strongly combats the view of the majority of geologists who proposed to unite the permocarboniferous with the permian, as a lower division of the system. According to him a separation of the permocarboniferous from the permian system is demanded by the general aspect of the fauna, in which the carboniferous types greatly predominate, chiefly among the brachiopoda. If it ought to be united either with the carboniferous or permian system, in spite of its distinctly intermediate position, it must necessarily be placed in the former, on the strength both of the carboniferous character of its fauna and of historical priority, since the Artinskian sandstone had been correlated with the carboniferous millstone-grit of western Europe by Sir Roderick Murchison, who first introduced the name of permian.

Against the first argument the objection may be raised that notwithstanding the prevalence of carboniferous types in the Artinskian fauna, the latter "marks a very important moment in the history of development of organic remains, namely, the first appearance of true ammonites with complicated sutures." Nor is the large percentage of carboniferous types in the Artinskian fauna an astonishing fact, in view of the absence of any break in the sequence of marine beds from the upper carboniferous to the true permian strata. . . . Bearing in mind the gradual passage from an upper carboniferous to a permian fauna through the intermediate group of rocks, the question to be answered is, which consideration is of the greater importance in defining the boundary between the two systems, the appearance of a new group of cephalopoda, which become of an unparalleled stratigraphical value in Mesozoic times, or the presence of a belated fauna, composed of forms which are generally not well adapted for the characterization of narrowly limited horizons.

The majority of geologists have decided in favor of the first alternative. Gümbel, Krasnopolsky, Kayser, Waagen, Credner, Munier-Chalmas and A. de Lapparent, Frech—to enumerate only a small number among them—are unanimous in regarding the permocarboniferous as the lowest division of the permian system.

A discussion of the permocarboniferous problem from a historical point of view leads to a similar result. This side of the question has been especially treated by Frech, whose reasoning I consider to be entirely justified.<sup>1</sup>

<sup>1</sup> "The Permocarboniferous Fauna of Chitichun," No. I, *Mem. Geol. Surv. India*, ser. XV, "Himálayan Fossils," Vol. I, Pt. 3, 1897, pp. 87-89. This quotation may also be found in an article by Professor Schuchert in *Am. Jour. Sci.*, 4th ser., Vol. XXII, 1906, pp. 143, 144.

Dr. Diener's account of the correlation of the Upper Paleozoic formations of central Europe with those of Russia is also interesting. The professor wrote as follows:

In the Rhenish regions, where the sequence of terrestrial and lacustrine plant-bearing strata of this epoch is most complete, the true coal measures come to an end with the Ottweiler Schichten, whereas the following series of rocks, comprising the Cuseler and Lebacher Schichten, have been united in a lower division of the permian system by Gumbel. In the Carnian Alps plant-bearing beds, containing a rich flora of the Ottweiler Schichten, alternate with *Fusulina* limestones, which have been proved by Schellwien to be homotaxial with Nikitin's Gshelian stage in Central Russia. As has been noticed by Geyer, this alternating series of dark *Fusulina* limestones and plant-bearing beds is conformably followed by a compact mass of white *Fusulina* limestones (Troglkofelkalk) containing *Spirifer supramosquensis* Nikitin, which must be correlated with the topmost carboniferous *Fusulina* limestones (Schwagerina horizon) of the Ural Mountains. The homotaxis of the Ottweiler Schichten and of the Carnian *Fusulina* limestone, which itself corresponds in age to the uppermost carboniferous beds of Central Russia (Gshelian stage) and of the Ural (Cora horizon, and Schwagerina horizon), apparently requires the boundary line between the two systems to be drawn immediately above the Schwagerina limestone of the Ural and Timan, and below the Artinskian stage.<sup>1</sup>

Professor Diener still believes that the Artinsk belongs in the Permian, as may be seen in the following quotation from a recent letter:

The Artinskian stage of Russia I still consider as forming the lowest stage of the permian system. Its cephalopod fauna differs decidedly from any which has been found in the upper carboniferous rocks of the Ural. As a boundary line must necessarily be drawn between the two systems, this line—artificial as it is—should be drawn at the base, not at the top of the Artinskian stage.<sup>2</sup>

In all my references, however, to the correlations of the Kansas deposits with those of Europe by European geologists, I have given exactly the name of the European division with which they made correlation and if it were with the Artinsk or Permo-Carboniferous it was so stated.

On page forty-eight Dr. Girty states that "Tschernyschew correlates part but not all of Prosser's 'Permian' with the Artinsk"; while on the following page he says, "if the Kansas 'Permian'

<sup>1</sup> *Ibid.*, p. 89.

<sup>2</sup> Letter of November 24, 1909.

is Artinsk, as Tschernyschew believes." The translation of Dr. Tschernyschew's statement is as follows:

The Neosho beds and possibly also the lower part of the Chase, appear analogous to the Russian Schwagerina horizon and the remainder of this as well as the Marion beds one must consider as homotaxial with the Russian Permo-Carboniferous and lower Permian. Finally, the Wellington and Cimarron beds may correspond to the lower red-colored Permian in eastern and northern Russia.<sup>1</sup>

The following correlation table of the Russian and American formations, omitting the column for California, Nevada, Utah, and Colorado, follows Dr. Tschernyschew's general discussion of these deposits:<sup>2</sup>

Ural and Timan	Texas and Arkansas	Kansas, Nebraska, Iowa, Missouri
Artinsk deposits	Wichita and Clear Fork beds	Marion Beds
Schwagerina horizon	Albany and Cisco beds	Chase beds Neosho beds
Cora horizon	Canyon and Strawn beds	Missouri series and Cottonwood beds of Kansas and Nebraska Wabaunsee beds
Omphalotrochus horizon		Oread limestone and Osage shales of Kansas Series from the Garnet to the Oswego limestones in Kansas. Des Moines beds in the state of Missouri

It is to be remembered that Dr. Tschernyschew believes in the separation of the Permo-Carboniferous from the Carboniferous and Permian systems. He places the Artinsk in the Permo-Carboniferous and directly overlying the Artinsk is the dolomitic limestone (Kungur) the base of which marked the lower limit of Murchison's original Permian, according to some authors, while others make its top the base. The Permo-Carboniferous of the Russian geologists is generally

<sup>1</sup> *Mém. comité géologique*, Vol. XVI, No. 2, 1902, p. 703. The original is as follows: "Die Neosho-Schichten und vielleicht auch die untere Partie der Chase-Suite erscheinen dem Schwagerinen-Horizonte Russlands analog und der Rest von dieser, sowie die Marion-Schichten muss man als dem russischen Permo-Carbon und unterer Perm homotaxial ansehen. Die Wellington- und Cimarron-Schichten endlich dürften der unteren roth gefärbten Perm-Suite im Osten und Norden Russlands entsprechen."

<sup>2</sup> *Ibid.*, p. 395 of Russian and 706 of German text.

composed of the Artinsk (CPg) and the superjacent dolomitic limestones (CPc).

Hans v. Staff has recently published the following table of the Russian Upper Carboniferous *Fusulina*-bearing horizons:<sup>1</sup>

Permo-Carboniferous	CPg <sup>1</sup>	Arta [Artinsk] stage		Lower Rothliegende	Lower Dyas
Upper Carboniferous	C <sub>3</sub> <sup>2</sup>	Schwagerina horizon		Horizon of <i>Schwag. princeps</i>	Upper upper Carboniferous
	C <sub>3</sub> <sup>3</sup>	Cora horizon	<i>Omphalotrochus</i> horizon (Bed of Gshel)	Bed of <i>Spirifer supra-mosquensis</i>	Middle upper Carboniferous
	C <sub>3</sub> <sup>4b</sup>	Cora limestone and oölite with <i>Omph. Whitneyi</i>			
	C <sub>3</sub> <sup>4a</sup>	Limestone with <i>Spir. Marcoui</i>			
Middle Carboniferous	C <sub>2</sub>	Transgression in the Timan	Moskau bed	Bed of <i>Spirifer mosquensis</i>	Lower upper Carboniferous

Dr. Girty criticizes the statements which I have made concerning certain fossils; but as the invertebrate fauna, exclusive of the insects, is being critically examined by Dr. J. W. Beede who has studied it more thoroughly than anyone else, I will not devote any particular space at present to the consideration of this part of the subject, with the exception of calling attention to some facts which support my identification of the Kansas specimens as *Fusulina*.

Dr. Girty has written as follows:

It might also be pointed out that just below the Artinsk a zone in the Russian section is characterized by a profusion of *Schwagerina* occurring in association with *Fusulinas*. Now *Schwagerina* has never been reported from the Mississippi Valley, while I have recently<sup>2</sup> offered reason for believing that the *Fusulinas* of the Kansas section, if they do not belong to a different genus, at least show important differences from the typical *Fusulinas*. These facts seem to destroy Mr. Prosser's argument so far as this item of evidence is concerned. At the same time these very forms furnish more stable evidence looking somewhat in the same direction.<sup>3</sup>

<sup>1</sup> *Palaeontographica*, Vol. LV, 1908, p. 149.

<sup>2</sup> *Am. Jour. Sci.*, 4th ser., Vol. XVII, 1904, pp. 234-40.

<sup>3</sup> *Ibid.*, pp. 43, 44.

It is quite true that Dr. Girty wrote me when the manuscript of the Cottonwood Falls folio was being revised, stating "that the common so-called *Fusulina cylindrica*, or *Fusulina secalica*, of the Mississippi Valley is not congeneric with the real *Fusulinas* of Russia, or at any rate belongs to a distinct subgenus."<sup>1</sup> It seemed to me that the specimens in the Cottonwood limestone and associated formations of Kansas were *Fusulina*, which I stated to Dr. Girty. He answered as follows:

I am sorry that you do not agree with me in the matter of *Triticites*, but it matters less what you think or what I think than what the consensus of Paleontologic opinion decides. I feel confident *Triticites* will be accepted as a good subgenus and probably as a genus. Nevertheless I would be glad to convince you and am sending a couple of examples of *Fusulina*. That from 2,931 shows the fluted partition wall when viewed against its surface. That from 2,957 shows the edges of the partition walls and the pattern which their undulating edges make in conjunction with one another. You doubtless have good specimens of *Triticites* in your own collection. You will observe that in the latter the partition is quite straight, and if you bear in mind the differences upon which other genera are established among the foraminifera you will feel a little more like accepting *Triticites*. . . . Please return the specimens which are from western Texas. They show the same structure as typical *Fusulina* from Russia, but are much more elongate.<sup>2</sup>

These Texas specimens were compared with some from the Cottonwood limestone of Kansas and specimens of the latter were found with fluted partition walls essentially the same as in the former, according to my observation. I also wrote Dr. J. W. Beede concerning these Kansas specimens, who answered that "the Cottonwood limestone specimens are true *Fusulinas*"<sup>3</sup> and later in answer to my direct question said that "the Cottonwood specimens *certainly* have fluted septa."<sup>4</sup>

The literature also supported the above identification and as far back as 1866 Dr. H. B. Geinitz identified specimens which had been collected by Jules Marcou from Plattsmouth, Nebraska, as *Fusulina cylindrica* Fischer and *F. depressa* Fischer.<sup>5</sup>

In 1872 Meek published the following paragraph under his descrip-

<sup>1</sup> Letter of April 13, 1904.

<sup>3</sup> Letter of May 11, 1904.

<sup>2</sup> Letter of May 9, 1904.

<sup>4</sup> Letter of May 14, 1904.

<sup>5</sup> "Carbonformation und Dyas in Nebraska" (*M. d. K. Leop.-Carol. Abad. d. Naturf.*), p. 71, Pl. V, Figs. 5a, b, and c, and p. 72, Pl. V, Figs. 6a, b, and c.

tion of specimens from the Coal Measures of southeastern Nebraska which he identified as *Fusulina cylindrica* Fischer:

In following the general practice of referring this to the Russian species, I am not only governed by comparisons with figures and descriptions of the latter, but I have had an opportunity to make direct comparison with specimens of *F. cylindrica* kindly sent to me by Colonel Romanowski, of the Russian mining-engineers' department, from the Ural Mountains. It is true these Russian specimens are not in a condition to show very clearly in polished sections the minute details of their internal structure under the microscope, but so far as I have been able to determine from the comparison, they seem to agree well with the American form.<sup>1</sup>

Orestes H. St. John collected specimens from many of the Kansas horizons which he sent to Möller who carefully studied them and referred them to European species. As for example, he referred with a ? mark *Fusulina cylindrica* Meek, Neb. 1872, Report, pp. 140, 141, Pl. I, Fig. 2, to *Fusulina montipara* Ehren,<sup>2</sup> and in the same way Figs. 3a and 3b, Pl. V, and Figs. 8a and 8b, Pl. VII, of the Meek and Hayden report were considered with a ? mark as synonyms of *Fusulina Verneuili* Möller.<sup>3</sup> Later he accepted the species *Fusulina ventricosa* Meek and Hayden for part of the Kansas valley forms; and other specimens, which he stated were very well figured in the Meek and Hayden reports (Pl. II, Fig. 1; Pl. V, Figs. 3a and 3b; Pl. VII, Figs. 8a and 8b, and *Palaeontology of the Upper Missouri*, 1865, Pl. I, Figs. 6a-6c), he considered a variety of the above-mentioned species and denoted it as *F. ventricosa* Meek and Hayden var. *Meeki* Möller.<sup>4</sup> Then follows a list of localities in the Kansas valley from which specimens of these two forms were sent him by Professor Orestes St. John. *Fusulina ventricosa* var. *Meeki* he stated is distributed throughout all the strata from which St. John sent him specimens, and he noted it particularly in those specimens with the numbers 1-5 and 11.<sup>5</sup> This statement is accompanied by a note, apparently furnished by St. John, which states that "No. 11 is in the Kansas valley, bed No. 28, Manhattan, Kan. This is the highest or most recent horizon, in which *Fusulina* has been found and is near the base of the so-called Permo-Carboniferous of American

<sup>1</sup> *Final Rept. U. S. Geol. Surv. Neb. and Adjacent Territories*, p. 140.

<sup>2</sup> *Mém. Acad. Imp. Sci. St. Pétersbourg*, Ser. VII, Vol. XXV, 1878, p. 62.

<sup>3</sup> *Ibid.*, p. 64.

<sup>4</sup> *Ibid.*, Vol. XXVII, 1879, p. 5.

<sup>5</sup> *Ibid.*, p. 6.

geologists. This bed is 330 to 430 feet above No. 95 of the Kansas valley section."<sup>1</sup>

Dr. E. Schellwien has recently stated in his description of *Fusulina montipara* (Ehrbg.) Möller that: those portions of Möller's treatise, which refer to the American forms, are to be stricken out.<sup>2</sup> A footnote on the same page contains the statement by Schellwien that: Möller apparently was in doubt, whether or not the American Fusulinas were identical with *F. montipara*. In the appendix (which the writer has not seen) he has later expressed himself as being opposed to a union of the forms.

Dr. Schellwien has also stated that in America a *Fusulina* occurs in Iowa, Indiana, and Nebraska which is described from there under the name *Fusulina cylindrica* and departs so little from *F. regularis* Schellwien that they probably must be united.<sup>3</sup> The last-named species was reported by Dr. Schellwien from the Upper Carboniferous of the Karnic Alps. In his later work he has again referred to the close relationship existing between the eastern Alpine *Fusulina regularis* and the widely distributed group of North American *F. secalis* [*secalica*] Say.<sup>4</sup>

Dr. Schellwien further said that the so often cited *Fusulina cylindrica* in all probability does not occur in America. The genuine *Fusulina* before me from Iowa, Illinois, Indiana, Missouri, and Nebraska all belong to one and the same group, yet these forms exhibit only a small part of the American Fusulinas.<sup>5</sup> The opinion that *F. cylindrica* Fischer does not occur in the United States is stated more positively in Schellwien's last work on the Fusulinas where he said: The American Fusulinas which will be described in a later number show no relationship whatever to *F. cylindrica*.<sup>6</sup>

Dr. Beede first called attention to the description of the American forms by Say in 1823 under the name of *Miliolites secalicus*, fourteen years earlier than the description of the genus *Fusulina* and European species of *F. cylindrica* by Fischer v. Waldheim, and revived

<sup>1</sup> *Mém. Acad. Imp. Sci. St. Pétersbourg*, Ser. VII, Vol. XXVII, 1879, pp. 5, 6.

<sup>2</sup> *Palaeontographica*, Vol. LV, 1908, p. 185.

<sup>3</sup> *Ibid.*, Vol. XLIV, 1897, p. 251.

<sup>5</sup> *Ibid.*, Vol. XLIV, p. 280, n. 3.

<sup>4</sup> *Ibid.*, Vol. LV, 1908, p. 183, n. 4.

<sup>6</sup> *Ibid.*, Vol. LV, 1908, p. 162, n. 3.



Say's name as *Fusulina secalica* which he used in general for the Kansas specimens which had heretofore been called *F. cylindrica*.<sup>1</sup>

From Hooser, Cowley County, in southern Kansas and probably from the Neva limestone, which occurs some 40 feet below the horizon of the Cottonwood limestone, Erich Spandel described seven genera and nine species of Foraminifera. One of these he identified as *Fusulina* cf. *regularis* Schellwien and stated that the chambers correspond the best with *F. cylindrica* Fischer, modified by Möller, and *F. regularis* Schellwien. Since the outside, however, corresponds to the last species, so I believe, it is identical with the same or quite nearly related.

Those specimens described and figured by H. B. Geinitz from the Permo-Carboniferous of Plattsmouth, Nebraska, under the names of *Fus. cylindrica* Fischer, and *Fus. depressa* Fischer, appear to be identical with those here discussed.

Two of the new species of Foraminifera were named *postcarbonica* and Spandel wrote as follows regarding the correlation of this horizon:

The genus *Monogenerina* is new which appears to be restricted to the Permo-Carboniferous. The other genera are already known to us from the Carboniferous. The presence of *Fusulina* gives the fauna a more Carboniferous character, the frequent appearance of the *Nodosaridæ* with three species refers the same, however, to the lower limit of the Permian.<sup>2</sup>

In 1903 Professor J. A. Udden reported "great numbers of *Fusulina cylindrica*" in the calcareous rocks of the Missourian series in Fremont and Mills counties in southwestern Iowa, bordering on Nebraska, which was stated to be interesting "as furnishing an additional item for consideration in correlating the uppermost members of the Carboniferous of America with those of Europe, where the same forms occur at about the same level in the geological scale."<sup>3</sup>

The above observations and statements appeared fairly conclusive; but in order that there might be no mistake a specimen was sent

<sup>1</sup> *Univ. Geol. Surv. Kansas*, Vol. VI, 1900, p. 10.

<sup>2</sup> *Abhand. d. naturhistorischen Gesellschaft in Nürnberg*, 1901, p. 19.

<sup>3</sup> *Jour. Geol.*, Vol. XI, p. 284. For the geological sections and various lists of fossils containing *F. cylindrica* see Professor Udden's report on the geology of these two counties in Vol. XIII, 1903, of the *Iowa Geological Survey*, pp. 137 ff.

over to the late Dr. E. Schellwien at the University of Königsberg, who was generally considered as the leading authority in the world upon the Paleozoic Foraminifera. After examining the specimen he wrote me a letter which has been translated as follows by Berthold A. Eisenlohr, associate professor of the Germanic languages and literatures in the Ohio State University:

BERNSTEINSAMMLUNG DER UNIVERSITÄT 18/7, '04  
KÖNIGSBERG I. PR.

MY DEAR COLLEAGUE:

I have examined the *Fusulinas*, which you were so kind as to send me for investigation, after making thin sections of them. They are genuine *Fusulinas* of the *Fus. regularis* Schellw. type, a form which is rather widely distributed in America and also occurs in lower horizons as the Cottonwood limestone. I beg to remark that I have at my command a rather large amount of material in North American *Fusulinas*, most of which comes from the National Museum. *Fusul. cylindrica* does not occur at all in America. I hope to be able to finish my work on the *Fusulinas* next winter and will then send it to you. I regret that I have not enough separates of my earlier papers in this subject. . . .

With my kindest regards,

Yours very truly,  
(Signed) E. SCHELLWIEN

Since the above letter was written H. Yabe, of the Imperial University of Tōkyō, has published "A Contribution to the Genus *Fusulina*" in which occurs the following statement concerning specimens of *Triticites secalicus* Say sent him by Dr. Girty:

As I examined their sections under the microscope, I was fully convinced of the correctness of his remarks on the peculiar structure of the form; yet I am still in doubt whether it is possible to separate satisfactorily the American form from the group of *Schwagerina* with a fusiform shell, such as *S. fusulinoides* Schellwien and *S. fusiformis* Krotow. The former, according to Schellwien, has "die grosse Centralkammer, die Hin- und Herbiegung der Septen, die in der median Ebene nie den Boden erreichen, Merkmale welche den *Fusulinen* zukommen," while *Triticites secalicus* possesses, besides these characters, the thick septa of a *Fusulina* s. s. Therefore, until more important differences from *Fusulina* s. s. and *Schwagerina* are found, it seems to me unnecessary to keep *Triticites* as a distinct genus, or even as a new subgenus.<sup>1</sup>

Dr. Schellwien in his last monograph on the *Fusulinas* under the observations relating to the species *F. montipara* (Ehrbg.) Möller makes the following statement:

<sup>1</sup> *Jour. of the College of Science, Imperial University*, Vol. XXI, Art. 5, 1906, p. 5.

The most important characters of our species consist in the described manner of rolling up, the marked prominence of the mouth, but especially in the slight folding of the septa, a peculiarity which characterizes the majority of American *Fusulinas* and has led Girty to describe a genus of his own, viz., *Triticites*.<sup>1</sup>

The important point to be noted in all these references to Schellwien's work is that he *always* referred the American forms under discussion to the genus *Fusulina*.

Professors Grabau and Shimer in their excellent work on "North American Index Fossils" list the abundant American species as *Fusulina secalica* (Say) followed by *F. cylindrica* in parentheses as a synonym which is stated to be widely "distributed throughout the Middle and Upper Carbonic."<sup>2</sup> Professor Ernst Koken on his world paleogeographic map of "Land und Meer zur permischen Zeit" shows the genus *Fusulina* in Kansas.<sup>3</sup>

Recently Dr. Beede has found typical Schwagerinas in the Neva limestone associated with *Fusulina* of the *longissima* type on the one hand and with a micro-foraminiferal fauna of Permo-Carboniferous character on the other, similar to that described by Spandel.<sup>4</sup>

It appears, therefore, that the evidence from the Foraminifera is much more strongly in favor of the general correlation which I have made of the Upper Paleozoic rocks of Kansas than I had claimed.

The following statement by Dr. Girty is to be noted: "In a paper just received Mr. Yabe expresses the opinion that the generic term *Triticites*, which I introduced for the type of *Fusulina* found in the Mississippi Valley, is a synonym not of *Fusulina* but of *Schwagerina*."<sup>5</sup> Then follows nearly a page discussion of the correlation of the Kansas deposits, providing this *change* in generic position of the specimens which he had named *Triticites* be accepted. Dr. Girty

<sup>1</sup> *Palaeontographica*, Vol. LV, 1908, p. 186. Dr. Lewis A. Rhoades, professor of Germanic languages and literatures in the Ohio State University, has looked over this translation together with some others in this article and has kindly suggested some changes which I have made.

<sup>2</sup> *Op. cit.*, I, 1906, p. 12.

<sup>3</sup> *N. Jahrbuch f. Min., Geol., u. Pal.*, Festband 1907, p. 546 and Pl. XIX.

<sup>4</sup> See *Univ. Geol. Surv. Kan.*, Vol. IX, 1909, pp. 348, 374, and Dr. Beede's review of "The Guadalupian Fauna" in *Jour. Geol.*, Vol. XVII, 1909, p. 677.

<sup>5</sup> "The Guadalupian Fauna," *op. cit.*, p. 44.

does not say where this paper by Mr. Yabe may be found; but it appears probable that it is the one cited above. If this be correct then the statements by Mr. Yabe touching this question are as follows: "I am still in doubt whether it is possible to separate satisfactorily the American form [*Triticites*] from the group of *Schwagerina* with a fusiform shell. . . . Therefore, until more important differences from *Fusulina* s. s. and *Schwagerina* are found, it seems to me unnecessary to keep *Triticites* as a distinct genus or even as a new subgenus."<sup>1</sup> In this paper and preceding ones Dr. Beede and myself have used the generic names of *Fusulina* and *Schwagerina* in the sense in which they are generally used by European and American paleontologists who are particularly acquainted with the Paleozoic Foraminifera; not in the sense here suggested by Dr. Girty.

Dr. Girty cites two other genera, *Pseudomonotis* and *Bakewellia*.<sup>2</sup> The genus *Pseudomonotis* does occur in rocks in Kansas considerably older than those which I have considered Permian; but such occurrence had not been reported when my early papers were published. In regard to *Bakewellia* Dr. Girty says: "After critically examining the best specimens of *Bakewellia* which could be obtained I have been brought to entertain serious doubts as to their generic identity with the Bakewellias of the English Permian as represented in King's monograph. The dentition appears to be different and they seem to lack the characteristic series of ligamentary pits." Dr. Beede who has collected and studied a large number of specimens belonging to this type says that "some of the species probably belong to Yakowlew's genus *Cyrtodontarca* from the Permo-Carboniferous of southeastern Russia, while the others may be closely related to them. The Coal Measures rocks of the world, so far as I am aware, nowhere exhibit the faunal assemblage of these shells and the associated pelecypods found in these strata in Kansas."<sup>3</sup>

The conclusions of Professor Fritz Frech as given in his discussion of the line between the Dyas [Permian] and Carboniferous is of decided interest in this connection and corroborative of the views of Dr. Beede. Dr. Frech wrote as follows, as translated by the late Associate Professor Charles W. Mesloh of the Ohio State University:

<sup>1</sup> *Loc. cit.*, p. 5.

<sup>2</sup> "The Guadalupian Fauna," *op. cit.*, p. 43.

<sup>3</sup> *Jour. Geol.*, Vol. XVII, p. 676.

The dividing line between the Carboniferous and Dyas [Permian] formations cannot be drawn with full certainty in every region since, especially in the Dyas, the development of a local flora is nearly always the rule and decisive differences do not exist in the brachiopod fauna.

Yet an agreement seems to be gradually forming everywhere: The line dividing the Carboniferous from the Rothliegende [lower Permian of Germany] is generally placed between the Ottweiler and Cusel beds; only concerning the determination of the age of the French equivalents of both do differences of opinion still exist.

It is everywhere easy to distinguish Schwagerina strata and the Arta [Artinsk] stage where the Medlicottiadæ and the oldest Arcestidæ occur. If the Arta stage and the Sosio limestone is considered a transitional horizon, i. e., as Permo-Carboniferous, there remains almost nothing of our formation.

Also, where the characteristic Dyas bivalves (*Pleurophorus*, *Schizodus*, *Bakewellia*, *Pseudomonotis*) occur in masses (Kansas) there can be no doubt about the dividing line. The great development of the Stegocephala, whose Carboniferous ancestors occur sparingly, is also characteristic of the Dyas.

On the other hand, the development of the still very widely distributed brachiopods is such, that only in the lower Dyas of the Mediterranean district a few new genera, and in the north only a few new species appear. To offset the slow retrogression of the Carboniferous brachiopod group, as we see e. g. in Kansas, there are no additions of any kind.<sup>1</sup>

Professor Frech's deduction from the evidence of the Kansas pelecypods is quite different from that of Dr. Girty and is important to bear in mind in considering the age of these formations. Dr. Frech wrote that: in the brachiopod formations enter layers agreeing petrographically which contain a fauna of small Dyas bivalves (*Bakewellia*, *Pleurophorus*, *Schizodus*). But in the two transition horizons (Neosho and Chase) the Carboniferous brachiopods predominate. The Marion strata are the first to be filled exclusively by upper Dyas bivalves and with variegated gypsum-bearing marls devoid of fossils.<sup>2</sup>

Dr. Girty states that "he [Prosser] finds the Kansas 'Permian' fauna much more distinct from the underlying Pennsylvanian than appears to me warranted, and he correlates it too confidently with the Russian Permian."<sup>3</sup> In regard to the opinion expressed in the first clause of the above sentence those who have followed this discussion have seen that there are other paleontologists who have

<sup>1</sup> *Lethaea geognostica*, "Lethaea paleozoica," 2. Band, 3. Lief., 1901, pp. 490, 491.

<sup>2</sup> *Ibid.*, 2. Lief., 1899, p. 377.

<sup>3</sup> *Op. cit.*, p. 42.

studied the fossils of these deposits who find the differences between the Kansan Pennsylvanian and Permian life greater and more marked than I have ever claimed. As to the second opinion I have attempted to consider *all* evidence concerning the age of these formations, whether it agreed with the results of my studies or not, and to give it due weight in forming my opinion regarding the correlation of these deposits.

Concerning the correlation of the Kansas deposits with the Russian Permian it is interesting to note that Murchison—the author of the Permian system—accepted it. He wrote as follows:

Only of late years have we obtained information of the Permian species of America. It is interesting to find there that the same genera characterize the last of the Palaeozoic systems as in Europe. In Kansas, Texas, and Nebraska, Permian rocks occur containing *Productus*, *Camarophoria*, *Strophalosia*, *Strep-torhynchus*, *Chonetes*, *Spirifer*, *Edmondia*, *Gervillia*, *Monotis*, *Schizodus*, *Murchisonia*, *Orthoceras*, *Bellerophon*, and *Fenestella*. Not only are the genera the same there as in the eastern hemisphere, but in several cases the species are identical with those found in the Magnesian Limestone and Zechstein. These fossils have been described by Messrs. Meek and Hayden, Swallow and Hawn, Shumard, and very recently by Geinitz.<sup>1</sup>

Since the writer's last reviews of the literature regarding the correlation of the Upper Paleozoic of Kansas and related regions<sup>2</sup> several papers have been published which are of importance in this discussion. In this last review, however, I seem to have overlooked Dr. C. R. Eastman's paper on the "Carboniferous Fishes from the Central Western States" in which he reviewed briefly the correlation of the Upper Paleozoic formations of the Kansas-Nebraskan area and wrote as follows:

But in the upper terrane, the so-called "Red Beds" or Cimarron series, which exhibit a thickness further southward of from 1,000 to perhaps 2,200 feet, no fossils have been found which are at all closely related to those of the Coal Measures, and writers are pretty generally agreed in correlating this series with the Upper Permian (Neo-Dyas) of Europe.

In the same way there appears to be good reason for believing that the lower part of the Big Blue series (Chase and Neosho strata) correspond to the Artinsk stage, which is the oldest Permian of Russia.<sup>3</sup>

<sup>1</sup> *Siluria*, 5th ed., 1872, pp. 341, 342.

<sup>2</sup> *Jour. Geol.*, Vol. X, 1902, pp. 721-37; *Amer. Geologist*, Vol. XXXVI, 1905, pp. 142-62.

<sup>3</sup> *Bull. Mus. Comp. Zoology Harvard College*, Vol. XXXIX, 1903, p. 165.

I will now mention several articles which are somewhat remotely related to the Kansas question. A collection was made in 1901 from the Wichita beds near Seymour, Baylor County, in northern Texas for the Royal Museum of Munich by Charles H. Sternberg who had previously collected in the same general region for the Museum of Comparative Zoölogy of Harvard University and for Professor Cope, a popular account of which may be found in his book.<sup>1</sup> The specimens sent to the Royal Museum of Munich have been described by Dr. Ferdinand Broili and L. Neumayer and it is to be especially noted that Dr. Broili made a trip to this country and spent two weeks in the field with Mr. Sternberg while the collection was being made. Dr. Broili in his monograph describing the Permian Stegocephals and reptiles of Texas in this collection has expressed the following opinion concerning the age of the deposits in Vermilion County, Illinois, which Professor Cope called Permian, and those near Seymour in northern Texas under his general discussion of the Permian of Illinois and Texas: The Wichita beds in Texas compared with the bone bed of Illinois in my opinion represent in point of time the younger formation.<sup>2</sup> Near the close of this discussion Dr. Broili again referred to the correlation of the Permian deposits of these two states as follows: These circumstances, I believe, make the supposition appear legitimate that the strata of Texas, when compared with exposures in Illinois, represent in point of time the younger formation. Another point which likewise favors this opinion is the fact that the genera from the two localities agree, but not the species.<sup>3</sup>

Finally, near the close of the monograph, under his general conclusions, Dr. Broili made the following statement concerning the vertebrate fossils: As we may then infer from the foregoing, the vertebrate fossils from the North American Permian consequently afford a considerable number of points of similarity with European and African forms; these relations might turn out to be even closer, especially if the Russian deposits should be more carefully investigated in their paleontological relations.<sup>4</sup>

<sup>1</sup> *The Life of a Fossil Hunter*, 1909, pp. 205-65.

<sup>2</sup> *Palaeontographica*, Vol. LI, 1904, p. 5. This monograph, however, did not come under my notice until after the publication of my paper of September, 1905.

<sup>3</sup> *Ibid.*, p. 6.

<sup>4</sup> *Ibid.*, p. 105.

Broili's monograph is followed by L. Neumayer's paper on the coprolites of the Texas Permian, which form a part of the above-mentioned collections.<sup>1</sup>

Professor Case has spent considerable time in studying the stratigraphy and fauna of the Red Beds of northern central Texas and has published several papers relating to the subject. One is entitled "The Character of the Wichita and Clear Fork Divisions of the Permian Red Beds of Texas."<sup>2</sup> The last one is called "A Great Permian Delta and Its Vertebrate Life, with Restorations by the Author."<sup>3</sup> A slightly earlier one is "On the Value of the Evidence Furnished by Vertebrate Fossils of the Age of Certain So-called Permian Beds of America."<sup>4</sup> In this paper the vertebrate evidence concerning the age of certain beds in Illinois and Texas is considered and the author's conclusions are as follows:

1. The evidence from vertebrates is not sufficient to demonstrate the Permian age of the beds in Illinois and Texas, they may reach down into the Carboniferous or they may extend upward into the Triassic.

2. There is no unlikelihood that reptilian life began in the Carboniferous. The evidence is rather affirmative than otherwise.

It is becoming more and more evident from the vertebrate paleontology that the Red Beds of North America and their eastern equivalents represent an enormous interval of emergence which may well have begun while Carboniferous (Pennsylvanian) forms still lingered in the waters and have continued until Triassic types were well established.<sup>5</sup>

The last paper dealing with the stratigraphy of this part of Texas was read by Professor C. H. Gordon at the Baltimore meeting and was entitled "The Red Beds of the Wichita-Brazoo Region of North Texas." He stated that—

formations to which the names Wichita and Clear Fork have been given, when traced along their strike toward the southwest, are found to grade into those included under the terms Cisco and Albany. The former have been regarded as Permian, while the latter have usually been assigned to the Pennsylvanian. Some authors, however, have suggested that the Albany should be considered Permo-

<sup>1</sup> *Palaeontographica*, Vol. LI, 1904, pp. 121-28, Pl. XIV.

<sup>2</sup> *Am. Mus. Nat. Hist.*, Vol. XXIII, 1907, p. 659.

<sup>3</sup> *Pop. Sci. Month.*, Dec. 1908, p. 557.

<sup>4</sup> *Jour. Geol.*, Vol. XVI, Sept.-Oct., 1908, p. 572.

<sup>5</sup> *Ibid.*, p. 580.



Carboniferous. . . . It is the conclusion of the author that the Red Beds of this region are the near-shore representatives of the Albany and the decision as to their age will rest upon that of the latter.<sup>1</sup>

The above paper in part appears to support the earlier conclusions of Professor W. F. Cummins who had "found the fact well established that the Wichita and the Albany divisions were the same in time of deposition."<sup>2</sup> This opinion was positively and clearly stated in 1908 by Professor Cummins in his paper on "The Localities and Horizons of Permian Vertebrate Fossils in Texas" where he wrote as follows:

These beds in the southern part of this field were called the Albany beds and were assigned to the Coal Measures. Subsequent study, however, disclosed the fact that the beds were stratigraphically continuous with the Wichita, being simply deposits in deeper waters, and in all subsequent publications they have been included in the Wichita, referred to the Permian, and the name Albany dropped.<sup>3</sup>

Dr. Percy E. Raymond has discovered reptilian and amphibian fossils near Pitcairn, fifteen miles east of Pittsburgh, Pennsylvania, in the upper part of the Pittsburgh red shale which occurs near the middle of the Conemaugh formation of the Pennsylvanian series.<sup>4</sup> These fossils have been described by Professor Case who states that "in general the collection resembles rather those from Texas than those from Illinois, but the specimens are far too few to base any generalizations as to distribution upon them."<sup>5</sup> His conclusion is that—

it certainly places the advent of a distinctly terrestrial reptilian fauna earlier than has hitherto been supposed. The suggestion may not be impossible that conditions for terrestrial life of a high order were reached earlier in the east than in the west, and that the Carboniferous swamps of Pennsylvanian time, giving place to upland surfaces before the advance of the Appalachian uplift, made possible a type of life that was homotaxially equivalent to a similar type, which developed at a later time in the west.<sup>6</sup>

Dr. I. C. White regards this discovery by Dr. Raymond as strongly confirmatory of the Permo-Carboniferous age of the main portion of

<sup>1</sup> *Science*, N. S., Vol. XXIX, May 7, 1909, p. 752.

<sup>2</sup> *Trans. Texas Acad. Sci.*, Vol. II, 1897, p. 97.

<sup>3</sup> *Jour. Geol.*, Vol. XVI, pp. 738, 739.

<sup>4</sup> *Science*, N. S., Vol. XXVI, Dec. 13, 1907, p. 835.

<sup>5</sup> *Annals Carnegie Mus.*, Vol. IV, 1908, p. 235.

<sup>6</sup> *Ibid.*, p. 240.

the Conemaugh, which he had suggested at an earlier date,<sup>1</sup> and writes as follows concerning it: "The possibility that the lowest *Conemaugh reds* might mark the dividing line between important formations, such as the true *Coal Measures* and the *Permo-Carboniferous*, has received strong confirmation during the past year."<sup>2</sup> In the chapter on the "Monongahela Series" Dr. I. C. White states that "hence there can be little doubt that this upper two-thirds of the *Conemaugh series*, together with the deposits of the *Monongahela*, correlate in time with the *Permo-Carboniferous* beds of Europe."<sup>3</sup>

Mr. Ralph W. Stone has published the following opinion concerning the age of the Dunkard formation, which is the one succeeding the Monongahela:

The organic remains of the Dunkard group, according to David White, comprise fossil plants in large numbers and ostracods with occasional occurrences of pelecypods and fish fragments. . . .

This flora of the Dunkard is interesting on account of species that are either unique or closely related to forms present in rocks of Mesozoic age.<sup>4</sup>

Dr. G. C. Martin has recently made the following statement concerning the same question: "The equivalents of these beds [Dunkard] in Pennsylvania and West Virginia have, from a study of their floras and faunas, been referred to the Permian series of the Carboniferous. Some doubt still exists as to their age, but in all probability they are, in part at least, Permian."<sup>5</sup>

In the "Tableau du Synchronisme des Assises Permiennes" in the last edition of De Lapparent's *Traité de géologie* the Permian is subdivided into three *étages* which in ascending order are the Artinskian or Autunien, Penjabien or Saxonien, and Thuringien. The Kansan formations are correlated as follows in this table: the Neosho and Chase are put in the Artinskian or Lower Permian; the Marion and Wellington in the Penjabien or Middle Permian; and the Red Beds or Cimarron series in the Thuringien or Upper Permian.<sup>6</sup> Under the discussion of the Penjabien or Middle Permian

<sup>1</sup> *W. Va. Geol. Surv.*, Vol. II, 1903, p. 256.

<sup>2</sup> *Ibid.*, Vol. Two (A), 1908, p. 622.

<sup>3</sup> *Ibid.*, p. 687.

<sup>4</sup> *Geologic Atlas U. S.*, Folio No. 121, 1905, p. 7.

<sup>5</sup> *Ibid.*, Folio No. 160, 1908, p. 8.

<sup>6</sup> *Op. cit.*, 5th ed., 1906, p. 1026.

is the statement that "Les *Marion beds* du Kansas, à *Bakewellia* et *Pseudomontis*, sont peut-être de cet âge, ainsi que les *schistes de Wellington*."<sup>1</sup> Under that of the Thuringien it is stated that "Les couches de *Cimarron*, qui font partie des *red beds* et surmontent l'assise de *Wellington*, renferment dans l'Oklahoma des lits à *Pleurophorus* et *Bakewellia*. Il s'y trouve du gypse et des dolomies."<sup>2</sup>

On the "Carte Géologique de l'Amérique du Nord," compiled by Bailey Willis and published in 1906 for distribution at the tenth session of the International Geological Congress in September of that year in Mexico, the area of the rocks under discussion extending from southeastern Nebraska southwesterly across Kansas and Oklahoma to central Texas is mapped as Permian. Professor Willis made the following statement concerning it:

Les couches de la période Carbonifère sont parmi les plus différenciées de l'Amérique du Nord; on y reconnaît ordinairement trois divisions principales: le Mississippien, le Pennsylvanien et le Permien, et ces divisions sont représentées sur la carte autant qu'elles peuvent être distinguées. . . . Le Permien (Formation Dunkard) de la Pennsylvanie n'est pas représenté séparément. Le Permien du Nouveau Brunswick est montré sur la carte ainsi que la large zone de grès permien et de couches rouges qui s'étend vers le sud-ouest, depuis le Kansas jusqu'au Texas.<sup>3</sup>

Professors Chamberlin and Salisbury fully accept the Permian age of the Kansas deposits as is shown by the following excerpts from their magnificent work on general geology:

West of the Mississippi, the Permian system has a more extensive development [than to the east], though far less widespread than the Pennsylvanian. The Permian strata are best known in Texas, Kansas, and Nebraska, and though the sea was not entirely excluded from this region, it appears, where present, to have been shallow. Locally and temporarily, inland seas were cut off from the ocean. Early in the period the Texan area of sedimentation seems to have been separated from the Kansan by the beginnings of the Ouachita mountains. . . .

In Kansas and Nebraska the older Permian beds are marine. . . . The marine Permian of Kansas is overlain by beds containing gypsum and salt and possessing other features which show that the open sea of the region was succeeded by dis severed remnants, or by salt lakes whose supply of fresh water was exceeded

<sup>1</sup> *Ibid.*, p. 1016.

<sup>2</sup> *Ibid.*, p. 1025.

<sup>3</sup> *Congrès Géologique International*, Compte Rendu, X<sup>ème</sup> Session, Mexico, 1906, 1st fas., 1907, p. 219.

by surface evaporation. Connected with these saline and gypsiferous deposits, and overlying them, are the "Red Beds," sometimes referred to the succeeding Trias; but they appear to be late Permian, in the main at least.<sup>1</sup>

Professor Scott also states a similar conclusion in his general work on geology where he says that:

In the region beyond the Mississippi the Permian beds thicken southward, attaining in southern Kansas a thickness of 2,000 feet, and in Texas of more than 5,000 feet. The mountains of Oklahoma, which may have been raised late in the Carboniferous or early in the Permian, separate the Texas and Kansas areas. . . .

In the latter part of the period, lagoons were cut off from the sea and converted into salt and bitter lakes in which the salt and gypsum of Kansas and the gypsum of Oklahoma and Texas were precipitated. Occasionally the sea broke into these lakes, bringing a marine fauna with it for a short time.<sup>2</sup>

Professor Scott is an accomplished vertebrate paleontologist and under his account of "Permian Life" is the statement that—  
the most important character that distinguishes the life of the Permian from that of all preceding periods is the appearance in large numbers of true *Reptiles*. There is no reason to suppose that such a variegated reptilian fauna can have come into existence suddenly, and their ancestors will doubtless be discovered in the Carboniferous; but while no true reptiles are certainly known from the latter, in the Permian they are the most conspicuous elements of vertebrate life.<sup>3</sup>

Under the description of the Carboniferous Dr. Kayser, the distinguished professor of geology in the University of Marburg, writes that: The marine Upper Carboniferous of Kansas has become known to us in particular through the numerous works of Charles Prosser. Tschernyschew and others have brought out most prominently the great similarity of the fauna with that of the Timans and Urals.<sup>4</sup>

Finally, under the description of the Permian Dr. Kayser states:

In the United States we find in the east (Virginia, Pennsylvania, and so forth) conformably over the productive upper Carboniferous [Upper Productive Coal Measures] the so-called Barren Measures [Upper Barren]. They contain *Calli p-*

<sup>1</sup> *Geology*, Vol. II, 1906, pp. 620, 621; also, see *A College Text-Book of Geology*, by the same authors, 1909, pp. 660, 661.

<sup>2</sup> *An Introduction to Geology*, 2d ed., 1908, p. 639.

<sup>3</sup> *Ibid.*, p. 652.

<sup>4</sup> *Lehrbuch d. Geologie*, 3d ed., Pt. II, "Geologische Formationskunde," 1908, p. 236.

*teris conjerta*, *Taeniopteris*, and other characteristic Permian forms together with Carboniferous types of plants exposing, probably, a representation of our Rothliegende.

In the western and southern states, on the other hand, there occurs quite similar to that in Russia, closely associated with extensive marine upper Carboniferous deposits, in large part chalky, equally extensive marine Permian deposits, likewise largely chalky. This is especially so in Kansas, Nebraska, and the adjoining territory. The beds in question, designated by very different names (Wichita and Clear Fork beds [Cummins], Neosho, Chase and Marion [Prosser], etc.), contain in the lower part numerous Theriodonts (*Naosaurus* and others), Stegocephals (*Eryops*, *Cricotus*), and fish (*Pleuracanthus*, *Janassa*, etc.), recognized by Cope as Permian; in the upper part, beside numerous mostly Carboniferous species (especially Brachiopods—*Productus*, *Marginifera*, *Enteles*, *Derbyia*, *Camarophoria*, *Spirifer*, etc.—, Lamellibranchs and Gastropods), are Permian Ammonites (*Medlicottia*, *Popanoceras*, *Waagenoceras*). Above follows, as representative of the upper Permian, a predominant red-colored, unfossiliferous formation composed of sandstones, clays, and shales, gypsum and salt bearing, comparable to the Russian Tartarian group.<sup>1</sup>

The Tartarian is the upper stage of the Russian Permian and some of the Russian geologists have considered it as of Triassic age.

Dr. E. H. Sellards has described under the title of "Types of Permian Insects"<sup>2</sup> a rich insect fauna found in the Wellington shales, three and one-half miles southeast of Banner City, Dickinson County, Kansas. Over two thousand specimens have been collected and it is stated to be "the most complete record of Permian insect life thus far obtained."<sup>3</sup> The last paper contains a section on the "Correlation of the Insect-bearing Horizon" in which the most striking characters of the fauna are pointed out. It is stated:

The order Plecoptera, or Ephemerids, is somewhat abundant in the Wellington shales. In Part II of this paper I have described ten genera and thirteen species constituting a new family of this order. Insects which appear to be prototypes of the Ephemerids exist in some abundance in the Coal Measures. Handlirsch has recognized Ephemerids as occurring sparingly in the Permian of Russia. With this exception true Ephemerids have not previously been identified from Paleozoic deposits. The relative abundance of this group of insects in the Wellington shales affords an exceptionally strong argument for the Permian age of that formation.<sup>4</sup> . . . .

<sup>1</sup> *Ibid.*, pp. 301, 302.

<sup>2</sup> *Am. Jour. Sci.*, 4th ser., Vol. XXII, 1906, p. 249; *ibid.*, Vol. XXIII, 1907, p. 345; and *ibid.*, Vol. XXVII, 1909, p. 151.

<sup>3</sup> *Ibid.*, 4th ser., Vol. XXII, p. 249.

<sup>4</sup> *Ibid.*, Vol. XXVII, Feb., 1909, p. 170.

It has usually been observed in collecting from Paleozoic localities, that cockroaches exceed in number of individuals all other insects combined. In the Wellington shales the cockroaches are much in the minority. A collection of something over two thousand insect specimens was found to contain only about seventy cockroaches. From these, two genera and ten species were identified. Of the two genera, one is the well-known Coal Measure and Permian genus *Eloblattina*. The second genus is new. The ten species obtained are new. The rarity of cockroaches in the Wellington is in marked contrast to their relative abundance in most Coal Measure and early Permian localities.<sup>1</sup> . . . .

Among the few insects obtained from the Permian formation of Russia, Handlirsch recognizes, as previously stated, the occurrence of true Ephemeroptera. The Russian deposits have also yielded forms regarded as representing Paleohemiptera and Mantoidæ. These last two groups have not been recognized in the Kansas Permian. The presence of the Ephemeroptera, however, forms a strong tie in common between the insects of the Russian and the Kansas Permian.<sup>2</sup>

Fossil plants which are associated with the insects at this locality have also been described by Dr. Sellards, and he writes in no uncertain way concerning their geological age. He says:

In the writer's opinion, the plant fossils indicate unequivocally the Permian age of the formation from which they come. The evidence as to the age of the Wellington shales, derived from the flora, is thus summarized in the report referred to [*Kansas University Geological Survey*]: "More than two-thirds of the Wellington species are either identical with or most closely related to species or genera characteristic of the European Permian. The points which seem to have the most importance as bearing on correlation of the Wellington are the following: (1) The complete absence from the Wellington of species in any way confined to or distinctive of the Coal Measures. (2) The comparatively small number of species originating as early as Upper Coal Measure time. (3) The presence of a few species common to and characteristic of the Permian of Europe. (4) The close relation of the new forms to species characteristic of the European Permian. (5) The distinctly Permian facies of the flora as a whole and its marked advance over the flora of the Upper Coal Measures.

"The advance in the flora consists in the number of species and in the abundance of individuals of callipterid and tæniopterid ferns, and of the new fern genus, *Glenopteris*, which appears to be related, on the one hand, to callipterid ferns of Permian types, and, on the other, to the Triassic genera *Cycadopteris* and *Lomatopteris*.

"The evidence derived from the fossil plants as a whole seems to assure the reference of the Wellington to the true Permian in the European sense."

<sup>1</sup> *Am. Jour. Sci.*, 4th ser., Vol. XXVII, Feb., 1909, p. 171.

<sup>2</sup> *Ibid.*, pp. 172, 173.

This conclusion drawn from the plant fossils is now fully confirmed by the evidence derived from the insects.<sup>1</sup>

Dr. Sellards also describes a flora from the Wreford limestone concerning which he writes as follows:

A good deal of interest is attached to the discovery of plants in the Wreford limestone, especially as this formation has been recently regarded as the base of the Permian in Kansas. Nine species have been obtained from this locality as follows: *Baiera* sp., *Callipteris conferta*, *Callipteris* sp., *Cardiocarpon* sp., *Carpolithes* sp., *Cordaites* sp., *Rhabdocarpus* sp., *Sigillaria* sp., *Walchia pinniformis*. The collection obtained from this formation is small and comes from a single locality near Reece, Kan. The association of the flora so far as obtained is with Wellington rather than with Coal Measures flora. The presence of *Walchia* in abundance, and of callipterid ferns, along with the small species of seeds common to the Wellington, together with the absence, so far as yet noted, of all of the common Coal Measures species, gives the flora of the Wreford, as developed at Reece, a distinctive Permian facies.

Coal Measures species, although rare in the collection obtained from the Wreford limestone at the Reece locality, recur in some abundance in the horizon at Washington, regarded by Beede as near the top of the Chase formation.<sup>2</sup>

At the Baltimore meeting, December 31, 1908, Dr. Beede presented a most important paper on the "Relationships of the Pennsylvanian and Permian Faunas of Kansas and Their Correlation with Similar Faunas of the Urals." He stated that "owing to physical changes which occurred during the close of Pennsylvanian time, there occurred a great reduction of Pennsylvanian species, followed by the introduction of Permian species. This introduction of new species becomes very noticeable in the Elmdale formation and its base is considered the base of the Kansas Permian."<sup>3</sup>

Since the above was written the writer has received the May-June number of the *Journal of Geology* in which appears the correlation paper on the "Upper Carboniferous" by George H. Girty<sup>4</sup> followed by the one on "The Upper Paleozoic Floras, Their Succession and Range," by David White,<sup>5</sup> both of which were read at the Baltimore

<sup>1</sup> *Op. cit.*, p. 173. Also see *Univ. Geol. Surv. Kansas*, Vol. IX, 1908 [1909], p. 463.

<sup>2</sup> *Ibid.*, Vol. IX, pp. 463, 464.

<sup>3</sup> *Science*, N. S., Vol. XXIX, April 16, 1909, p. 637. Also see *ibid.*, May 7, 1909, p. 752.

<sup>4</sup> *Op. cit.*, Vol. XVII, July, 1909, pp. 305-20.

<sup>5</sup> *Ibid.*, pp. 320-42.

meeting of the American Association for the Advancement of Science, in December, 1908. It is too late to discuss or make use of these papers in this article. It may be said, however, that Dr. Girty states that "the propriety of employing the term Permian in the geology of North America seems to me decidedly doubtful, at least in so far as the evidence of invertebrate fossils is concerned."<sup>1</sup> Mr. White, on the other hand, discusses, under "the Permian floras," following the account of "the Carboniferous floras," those from the Permian of Prince Edward Island, the Dunkard of southwestern Pennsylvania and West Virginia, the Chase of Kansas, and the Wichita of Texas, all of which he apparently places in the Permian. These will be followed immediately by another correlation paper on "The Faunal Relations of the Early Vertebrates" by Professor Samuel W. Williston.<sup>2</sup> Later will appear a critical review of "The Guadalupian Fauna,"<sup>3</sup> and a correlation article on "The Bearing of the Stratigraphic History and Invertebrate Fossils on the Age of the Anthracolithic Rocks of Kansas and Oklahoma,"<sup>4</sup> both of which are by Dr. J. W. Beede. Finally, it may be said that Dr. Beede has studied the stratigraphy, distribution, and invertebrate paleontology of the Upper Paleozoic or Anthracolithic deposits from Nebraska to Texas more thoroughly than any other geologist has yet done and, therefore, his conclusions are entitled to most careful consideration.

JULY 24, 1909

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While this article is passing through the press certain additional information has reached me. The following letter from Professor Yakowlew is important since it gives a summary of the present opinion of the Russian geologists concerning the classification of the Artinsk:

INSTITUTE OF MINES, ST. PETERSBURG

November 30, 1909

*Professor Ch. S. Prosser, Ohio State University, Columbus, Ohio:*

DEAR SIR: You ask me some questions concerning the Upper Paleozoic deposits of Russia. You wish to know where I draw the line between the Carboniferous and Permian systems in Russia and in which system I place the Artinsk.

<sup>1</sup> *Jour. Geol.*, Vol. XVII, July, 1909, p. 319.

<sup>2</sup> *Ibid.*, pp. 389-402.

<sup>3</sup> *Ibid.*, pp. 672-79.

<sup>4</sup> *Ibid.*, pp. 710-29.



The question about the Artinsk can be solved by comparing its fauna with the fauna of the Permian lying higher and that of the upper Carboniferous lying lower. I think there would be more resemblance with the fauna of the upper Carboniferous. However, the thickness of the Artinsk and the Permian is not very great and their fauna may not be very different. On the other hand some Russian authors are inclined to relate Artinsk to the Permian system; they do so on historical foundation, as the extent of the Carboniferous system had been determined in science before Murchison and we have no right to enlarge it by adding Artinsk. We may sooner unite Artinsk with the Permian system, the extent of which is not so definitely established as that of the Carboniferous. In Russia the term Permocarbiniferous is used to designate Artinsk, if it is not related to the Permian nor to the Carboniferous systems, but placed between them, as done by Karpinsky (though without sufficient paleontological grounds), when he established Artinsk. If Artinsk is united with Carboniferous system, the term Permocarbiniferous will not have to be used in the sense just mentioned, it will be superfluous. No one in Russia is inclined to designate by the name Permocarbiniferous the total of the Permian and the Carboniferous systems, as it is sometimes done in the West of Europe. The Russians keep to one of the two opinions, they either take Artinsk for the Permocarbiniferous, that is for the intermediate between the Carboniferous and the Permian, or unite it with the Permian. But I do not think anyone would unite it with the Carboniferous. I think that there might be Artinsk in Kansas and in Nebraska, as there is much in common between the Donetz fauna described by me, with the fauna of Kansas and Nebraska. But whether the Permian fauna exists in North America is an open question to me. . . .

Yours sincerely,

NICHOLAS YAKOWLEW

Dr. Fritz Frech, the distinguished professor of geology in the University of Breslau, has written me as follows under date of December 21, 1909:

Answering your kind letter of the end of October I give my opinion on the Dyas [Permian] as follows: I include the Arta [Artinsk] stage in the lower Dyas as the type of this lower stage. I have had no ground to change the opinions, expressed in *Lethaea palaeozoica* (2. Band, commencing on p. 493), concerning the correlation of the Dyas.

A letter from Alexander Krasnopolsky, Géologue en chef du Comité géologique de Russie, was received January 6, 1910, a translation of which follows:

The Permo-Carboniferous deposits of the western slope of the Urals—investigated by me—represent two formations, the Artinsk and the Kungur.

These deposits are characterized (aside from the species particularly peculiar to them) by Carboniferous and also by Permian species.

Since these deposits lie directly over the *Fusulina* limestone of the Urals (which must be looked on as equivalent to the very uppermost formations of the Carboniferous), we may not refer the deposits in question to the Carboniferous system.

On the other hand, I do not find it wholly easy to refer these deposits (and the Lower and Middle *Productus* limestone of India corresponding to them) to the Permian formation, as I earlier thought possible; for the Permian system, in the sense used by Murchison, itself must begin only with the formations which lie over the Kungur strata—more exactly, only with the limestones of the Province of Kostroma, which contain an older fauna than does the Zechstein of western Europe.

It is interesting to note that what Dr. Tschernyschew said of the outcrops of Artinsk and Upper Carboniferous near the city of Oufa in eastern Russia is certainly paleontologically suggestive of the Kansan deposits. He wrote as follows:

Les bords pittoresques du lac de l'usine de Simsk offrent une coupe classique pour l'étude des dépôts d'Artinsk et des sédiments carbonifères sousjacents. . . .

Les calcaires qui alternent avec les grès consistent par places presque en entier en grosses fusulines (*Fusulina Verneuli* Moell.). Près de la même digue on voit apparaître de dessous les grès d'Artinsk et en concordance avec lui le grès carbonifère qui contient, avec coquilles de *Fusulina Verneuli* Moell., *Productus semireticulatus* Mart., *Productus longispinus* Sow., *Martinia glabra* Mart., des restes de *Dielasma* et de *Spirifer* (du type de *Spirifer mosquensis* Fisch.).<sup>1</sup>

The argument has been advanced that because Carboniferous brachiopods occur in the Kansas deposits, which I have referred to the Permian, they could not belong in the Permian system. Professor Diener has studied exhaustively the faunas of the Salt Range *Productus* limestone of India and the Alpine Permian and in a recent letter he refers to the results of this study. If his conclusions are correct it will be seen that the occurrence of Carboniferous brachiopods in deposits superjacent to those which contain Foraminifera characteristic of the uppermost Carboniferous of Russia, as is the case in Kansas, is no argument at all against the Permian age of these Kansan deposits. Professor Diener calls attention to the dis-

<sup>1</sup> *Guide des Excursions du VII Congrès Géologique International*, III (A partir de la ville d'Oufa jusqu'au versant oriental de l'Oural), 1897, pp. 21, 23.

pute as to the Carboniferous or Permian age of the Salt Range Productus limestone and then says:

This erroneous correlation [with the Upper Carboniferous] is based on the exaggerated importance of numerous species of Brachiopoda which are common to both rock-groups [Carboniferous and Permian]. . . . I have examined large collections of Himalayan anthracolithic fossils, the descriptions of which have not yet been published, and I am convinced now of the absolute impossibility of basing any safe correlation on the evidence of brachiopods. I have found that the majority of brachiopods considered hitherto as typical leading fossils of Permian beds are distributed equally through Carboniferous and Permian rocks. Foraminifera are far more important as stratigraphical evidence. The fusulinae of the Productus limestone of the Punjab differ specifically from those of the Russian Upper-Carboniferous rocks. So do the Ammonites, whereas the brachiopod fauna undergoes but very little change between the two systems.

I have recently prepared a paper on the brachiopod fauna of the Alpine Bellerophonkalk. This is a stage, which from its stratigraphical position must be placed rather high in the Permian system. In its brachiopod fauna truly Carboniferous types, however, still predominate, thus proving the insufficiency of brachiopods for exact correlations.<sup>1</sup>

Mr. G. B. Richardson, Dr. J. W. Beede, and Mr. David White presented papers, based on their field work of last summer, at the Boston-Cambridge meeting of the Geological Society of America which prove the Permian age of the Kansas deposits which I have referred to that system. The following abstract of Dr. Beede's article on "The Correlation of the Guadalupian and Kansas Sections" was published in the "Preliminary List of Papers" for that meeting:

The Guadalupian limestones of western Texas and southern New Mexico are overlain by the Pecos Valley Redbeds. These beds present the same lithologic features and are of similar succession as the Redbeds on the eastern side of the Llano Estacado and carry a fauna closely related to them. The gypsums appear to be the equivalents of the Greer gypsums as exposed in Oklahoma and Texas. If this correlation is correct, then the base of the Capitan limestone is on the same stratigraphic level, approximately, as the base of the Elmdale formation of Kansas and the base of the Guadalupian series on the level of the base of the Cherokee shales. The five thousand feet of Hueco beds would fall below this level.

The same list also contained the following abstract of Mr. White's paper on "Permian Floras in the Western 'Red Beds'":

<sup>1</sup> Letter of November 24, 1909.

Characteristic floras, found in a brief tentative search of red beds at three points in Colorado and New Mexico, not only prove Permian age but also indicate great thickness of Dyas in certain "Red Beds" sections in the Rocky Mountains. Examination of lower middle Wichita in Texas and additional collections from Chase (Wreford and Winfield beds) and Wellington of Kansas and from Red Beds within the same limits in Oklahoma confirm lower Permian correlations.<sup>1</sup>

A recent article by Dr. Austin F. Rogers of Stanford University is important in noting the similar mineral deposits in the upper part of the Big Blue series (Lower Permian) of Kansas and those of the Zechstein (Upper Permian) of Germany, and calling attention to the probable arid climate in the northern hemisphere during Permian time which these mineral deposits indicate also prevailed during that time in Kansas. Dr. Rogers writes as follows:

The salt and anhydrite occur in the lower Permian. According to Plate V of the report on Kansas salt,<sup>2</sup> the salt-beds are between the Wellington and Marion formations. Not a single fossil was found on the saltmine dumps, and this is not strange when we consider the conditions under which these deposits were formed. From evidence gathered in various places it seems certain that throughout the northern hemisphere an arid climate prevailed in the Permian. The poverty of fossils, the occurrence of Red-beds, and the presence of extensive beds of gypsum and salt, all point to the fact that Kansas was like the rest of the northern hemisphere during Permian time. Now the occurrence of anhydrite with the salt is additional evidence that the Kansas Permian is like the Permian (Zechstein) of Germany during which time the salt deposits of Stassfurt, Leopoldshall, Vienenburg, and Bernburg were formed. At all these localities anhydrite occurs with salt.<sup>3</sup>

The following recent letter from Professor P. Krotow of the University of Kasan, Russia, who has thoroughly studied the Artinsk and associated formations of Russia, is especially important in giving a brief general account of these formations together with a table showing their correlation with the corresponding ones of western Europe. The letter was written in English in which only two or three minor changes have been made:

The term Permo-Carbon is used in Europe with two meanings: (1) The French call the Permo-Carboniferous system the united deposits of both systems:

<sup>1</sup> Twenty-second winter meeting, Boston-Cambridge, Mass., December 28-30, 1909, p. 24.

<sup>2</sup> *Annual Bulletin of the Mineral Resources for 1908.*

<sup>3</sup> *Am. Jour. Sci.*, 4th ser., Vol. XXIX, March, 1910, p. 260.

the Carboniferous and the Permian; (2) In Russia we call Permo-Carbon the intermediary horizons between the Carboniferous and the Permian systems, characterized by a mixed fauna and flora, consisting of Carboniferous and Permian species with the incorporation of some original species, which are met with only in these layers.

In Russia,<sup>1</sup> as well as in western Europe, these intermediary horizons are composed of layers previously looked upon partly as Carboniferous, partly as Permian.

For instance, in Russia in the composition of Permo-Carbon enter: The Artinsk or pepper sandstone, which Murchison referred to the Carboniferous system, as well as the limestone and plaster-stone of Kungur, which Murchison referred to the Permian. Artinsk or pepper sandstone with Permo-Carboniferous fauna composes the Artinsk-Stufe, the lower layers of Permo-Carbon. It lies immediately on several kinds of limestone (Fusulina limestone and Schwagerina limestone), which must be unconditionally related to the Carboniferous system. On "Artinsk-Stufe" lies the "Kungur-Stufe" which forms the upper layers of Russian Permo-Carbon. On these strata in Russia lie lime-marly Platten which form the transition from the Permo-Carbon to the Permian system. The Permian system itself in Russia begins with coppery limestone and red-clays, on which directly follows the Zechstein-limestone. In Germany in the composition of Permo-Carbon equivalent to Artinsk and Kungur-Stufen, enter: Lebacher Schichten (in Saarbrücken), Brandschiefer (in Saxony), Kohlenrothliegendes (Bohemia).

To make it clearer I give the following scheme:

EUROPEAN RUSSIA		WESTERN EUROPE
Permian system	Zechstein Red-clay Coppery sandstone	Zechstein Rothliegendes, etc.
Permo-Carbon	Kungur-Stufe  Artinsk-Stufe	Lebacher Schichten Brandschiefer Cuseler Schichten Kohlenrothliegendes, etc.
Carboniferous-Stufe	Fusulina and Schwagerina limestone, etc.	Productive Gruppe Kohlenkalk

As to the question whether Permian-Carbon belongs to the Carboniferous or the Permian system, that, from my point of view, is quite a matter of indifference. But we generally connect Permo-Carbon with the Permian system.<sup>2</sup>

Febr. 24, 1909

<sup>1</sup> Krotow, *Artinskische Etage; Geol. Forschungen am West-Abhange d. Urals; Notiz auf d. Brief Herrn Nikitin über Permocarbon.*

<sup>2</sup> Letter of February 19, 1910.