ART. XXIII.—*Jura and Neocomian of Arkansas, Kansas, Oklahoma, New Mexico and Texas;* by JULES MARCOU.

HISTORIC geology, or stratigraphic classification, is a very difficult and at the same time a most important part of the history of our globe. Without exact classification, all becomes confusion, geologic periods are confounded, and we are confronted by the same sort of errors that would occur if some historian were to place the time of Cromwell after the time of Washington.

In all other sciences, like chemistry, physics, anatomy, etc. each new fact can be verified in laboratories, after a period of time relatively short. Not that criticism, and strong and even passionate opposition, are not found in these sciences; we remember well the protest against the experiments made to disprove spontaneous generation. It required much persistency and courage on the part of Pasteur to maintain the truth he had discovered. The chemist Berthelot published in the Revue Scientifique some incomplete investigations of the late Claude Bernard, which he found in loose notes after the latter's death, without even taking the polite precaution to make known to Pasteur his intention of attacking his observations on the non-existence of spontaneous generation. Numerous discussions followed at the meetings of the Academy of Science of the French National Institute, until Pasteur, excited by the incessant attacks of two adversaries, bravely turned towards them and said to one, "Savez-vous ce qui vous manque? vous ignorez l'art d'observer;" and to the other, "Et vous, celui de raisonner."*

The controversy against my observations on the geology of Texas, the Indian Territory and New Mexico, has lasted much longer than the opposition made against Pasteur, for it is now forty-four years since I made them and they have been and are still the subject of constant criticism.

In science, discussion must be based on the observation of facts; in geology, these observations must be made on the ground and at the precise locality under discussion. For years the two localities discussed were not only far distant from civilization, but also situated in a part of the country which, on account of hostile Comanches, Kiowas and Apaches, it was impossible to visit without a large military escort. Consequently my contradictors discussed my observations without a practical knowledge of the stratigraphy; and with a want of

* Discours de M. Joseph Bertrand, directeur de l'Académie Français, séance du 28 Janvier, 1897.

the most elementary kind of knowledge of the genus *Gryphæa*, uniting into a single species six or eight entirely distinct species. It was to be hoped that when, in about 1880, Indian Territory and the Tucumcari region were finally opened for settlement and civilization, my opponents would examine the two localities; one called Comet Creek, now in G. County, Oklahoma, and the other Pyramid Mount in the Tucumcari region of New Mexico. But not at all; to this day, Comet Creek has not been visited by any other practical geologist*; and Pyramid Mount of the Tucumcari area was systematically left out of the route of exploration by the three persons who were there, since 1888. The curious part of it is that the section at Pyramid Mount is most complete, without any obscurity by vegetation, practically a bare wall, and unique in the Tucumcari region for its beauty and perfection from a geologic point of view. I shall not imitate the frankness of my friend Pasteur, and contest the capacity of my adversaries as stratigraphists and paleontologists, but I owe it to science to maintain what I consider to be exact and true; and however tired and wearied by years, by my infirmities and the exceptional length of the discussion—lasting almost half a century—I shall continue not only to affirm the correctness of my observations, but also to ask my numerous adversaries to visit Comet Creek and Pyramid Mount, and beg them to publish the sections accompanied by good figures and descriptions of all the fossils they may gather *in situ*. I am happy to remark, that they will have the great privilege and immense advantage of remaining there as long as they please, to observe and collect specimens, while I was enabled, on account of the rapidity of the march of my military escort, to remain at Comet Creek only one hour and at Pyramid Mount only three or four hours.

The question of the existence of the Jura and the Lower Cretaceous (which I call briefly Neocomian) has taken, thanks to the opposition, such great proportions, that one of my opponents said lately: "There are reasons for suspecting that no marine Jurassic formations of Atlantic sedimentation have as yet been discovered north of Argentina (South America) on the present Atlantic slope of the American hemisphere." (Science, vol. iv, No. 103, p. 920.) A clean sweep of the marine American Jura.

Let us review the main localities in the United States, west of the Mississippi River and east of the Rio Grande del Norte.

Arkansas.—For the sake of brevity, and not to burden the

* Lately the locality of Comet Creek has been visited by Mr T. W. Vaughan, who finds the same beds of limestone containing *G. Rœmeri* (called *G. forniculata*). His description does not differ from the one I have given as far back as 1853. "Outlying areas of the Comanche series"; this Journal, vol. iv, July, 1897.)

reader with too many details, I shall speak only of the Trinity formation, of the locality in Pike County, Arkansas, close to the boundary line of Texas. Mr. Hill, the inventor of the name Trinity formation, has published in the Annual Report of the Geological Survey of Arkansas, for 1888, vol. ii, Mesozoic, two chapters, xii and xiii, in which are described the strata and the fossils, the latter with figures. It is useless to reprint what I have said on each species of fossil; I need only say, that I have shown with accuracy and details, in the American Geologist, Dec., 1889, pp. 357–367, that the whole fauna, without a single exception, is composed of Jurassic fossils, and concluded that instead of being Lower Cretaceous, the strata near Murfreesboro represent in Arkansas and Texas the superior Jura from the Oxfordian upward, including the Purbeck formation.

As an example of carelessness, not to use a stronger word, in quoting a plain paleontological fact, I call the attention of the reader to a quotation of Mr. Hill, at p. 128. In the description of *Ammonites Walcottii*, we read: "It resembles . . . also *Ammonites Yo*, d'Orb. of the Lower Cretaceous." Turning to the great work of the *Paléontologie Française* by d'Orbigny, in order to examine and verify the resemblance of the two Ammonites, I naturally took up the volumes entitled: "Terrain Crétacé." But there is no trace of *Ammonites Yo* in those volumes. As I know the species well and that the form is undoubtedly Jurassic, I took the volumes entitled: "Terrain Jurassique," and there in vol. i, pp. 545–546, is the *Ammonites Yo* with the special location of "Etage Kimmeridgien, Boulogne-sur-Mer." Instead of belonging to the Lower Cretaceous, according to the extraordinary alteration of Mr. Hill, it is an Upper Jura species. Why Mr. Hill took upon himself to change the age of the *Ammonites Yo*, cannot be explained otherwise, than that he wanted to sustain his classification of the Trinity division in the Cretaceous, quoting in his favour the great authority of d'Orbigny. This case shows how unreliable Mr. Hill is, when he writes on paleontology.

Kansas.—As long ago as 1888, I corresponded with Professor F. W. Cragin of Topeka, in regard to a *Cycadoidea* found in Maryland, for the purpose of comparing it with a specimen of the same genus of fossil plant collected in Kansas. On reading Professor Cragin's first two papers on the geology of a part of southern Kansas comprising Barber, Pratt, Kiowa and Comanche counties, south of the Arkansas River, in the upper region of Medicine Lodge River, I thought that the Jura existed there, and wrote so to him. He sent me a small box of specimens, all Cretaceous fossils. After an exchange of a few letters on the subject, the correspondence was dropped.

Lately there came into my hands two publications on these Kansas counties. One is a detailed description of them by Professor Charles S. Prosser, in vol. ii of The University Geological Survey of Kansas, Topeka, 1896; and the other is a paper entitled: On Outlying Areas of the Comanche Series in Kansas, Oklahoma and New Mexico, by Mr. R. T. Hill, this Journal, vol. l, pp. 205–234, issued in September, 1895, but which entirely escaped my notice until one week ago, on account of my time having been completely occupied for several years by the writing and printing of the Life of Louis Agassiz.

I have studied with interest all the part of vol. ii, Kansas Survey, entitled "Cretaceous-Comanche series of Kansas," pp. 96–181. The author gives carefully observed sections, and an important geological map of "Southwest Comanche area." He is clear and exact, but the paleontological part is not only very meagre, but also incorrect so far as relates to the principal and very important fossil found, a rather large *Gryphæa*, collected on the top of one of the Belvidere sections. As he follows and uses the classification of Mr. Hill, my answer will apply to both memoirs.

According to two lists of fossils determined by Mr. T. W. Stanton, at pp. 216 and 219 of Mr. Hill's paper, the *Gryphæa Tucumcarii* Marcou has been found at Blue Cut Mound, four miles southwest of Belvidere, above the *Gryphæa forniculata;* and Mr. Stanton adds: "It is interesting to note that this form (*G. Tucumcarii*), supposed by Prof. Marcou to be Jurassic, here occurs *above G. forniculata*, which he considered Neocomian, though there is only a few feet difference in the beds and they seem to be connected by intermediate forms. The geographic distribution of the two species is about the same" (Hill's paper, p. 216).

At the beginning of the controversy by Mr. James Hall in 1855, continued afterward by Dr. B. F. Shumard, Dr. J. S. Newberry, Mr. R. T. Hill, and others too numerous to name, I realized that a misuse of paleontology had been made, and ever since paleontological misrule has held complete and unchecked sway in regard to the numerous *Gryphæa* found in the whole region south of the Arkansas river. After receiving specimens now and then from Texas and Kansas, I saw clearly that about eight or ten *Gryphæa* existed there at different levels, and that the confusion of species by Messrs. Hall, Rœmer, Shumard, Gabb, Charles A. White, Hill, Cragin and Stanton, was sure to result in a complete revision and exact description of all the *Gryphæa* found in the region. I know, and I have repeatedly said, that the identification of the numerous *Gryphæa Pitcheri* was wrong in almost every case, my own

included. Professor Ferdinand Rœmer made the mistake in 1849 and 1852 in referring a New Braunsfelds and Red River species of *Gryphœa* to the *G. Pitcheri* of Dr. Morton. Following Rœmer, and on account of a complete lack of specimens for comparison, I referred the *Gryphœa* of Comet Creek to the *G. Pitcheri*, although I was in doubt as to the correctness of the determination, for my specimens differed considerably from those figured by Rœmer, and from the one figured by Morton. But at the same time I took the precaution to publish excellent and exact figures, in my two works, issued in 1855 and 1858. For several years, after my hasty visit to Comet Creek, I was convinced that the *G. Pitcheri* found there was a different species from the one published by Rœmer and the one published by Morton; and in 1861, I called the Comet Creek species *G. Rœmeri*, and have even since used that very appropriate name for the *G. Pitcheri* published with figures by Rœmer and myself. ("Notes on the Cretaceous of Texas." Proc. Boston Soc. Nat. Hist., Jan., 1861, vol. viii, p. 95.) Dr. C. A. White did not make use of the name *G. Rœmeri* and without explanation he many years after called the species *Exogyra forniculata*, changing the generic and the specific name.*

This is the way that erroneous paleontology has been constantly used by my adversaries.

We read in Mr. Hill's paper, pp. 225–226: "The species called throughout this paper *Gryphœa forniculata* White, is the same as the one from Comet Creek, Oklahoma, first figured by Prof. Marcou as *Gryphœa Pitcheri* Morton, and later called by him *Gryphœa Rœmeri*. The nomenclature of the Gryphæata oysters of the Comanche series will be thoroughly revised in a separate paper which the writer has in print. Prof. Marcou's name *G. Rœmeri* probably has precedence over *G. forniculata* White, but it may be shown neither of these will stand."

"This Gryphæa so abundant at Belvidere is likewise found in great numbers in the Kiamitia clays, not only about Denison and Fort Worth, but also along a persistent line of 300 miles from Goodland, Indian Territory, to south of the Brazos in Texas. Its hemera (*sic*) in Texas is exclusively confined to the Preston beds, and Prof. Marcou has always held that it is a Cretaceous form; it is the species upon which he established the existence of the alleged Neocomian in America."

* The *Exogyra Texana* Rœm. or *Exogyra flabellata* Goldf. is also a sort of polymorph fossil like the so-called *Gryphœa Pitcheri*. The only way to put an end to the confusion created by calling almost every Exogyra, *Ex. Texana* and every Gryphæa, *Gr. Pitcheri*, is to make a complete revision of all the Exogyra and Gryphæa existing, with very careful study of each species and the exact location of each stratum.

"An interesting fact in the Black Hills and Blue Cut sections is that the large Gryphæa which comes in near the top of the shales is identical with the form collected by Prof. Marcou and is the species called *Gryphæa Tucumcarii* by him (later called *Gryphæa dilatata* var. *Tucumcarii*)."

"Prof. Marcou insisted that the beds from which this species came were of Jurassic age, and upon its occurrence he maintained the existence of the Jurassic system in this region. It occurs at Belvidere, as on the original plains of the Kiamitia near Goodland, in Indian Territory, where it was last year collected by Mr. T. Wayland Vaughan* of my division, and at Kent† in Trans Pecos, Texas, stratigraphically above and intimately associated with the species which he calls *Gryphæa Pitcheri*. Thus we have in Kansas and Indian Territory Prof. Marcou's alleged Jurassic species occurring stratigraphically above species he called Cretaceous, which facts forever remove any previous doubt, if any existed, in favor of his theory of the existence of the Jurassic formation in Texas, Indian Territory, New Mexican region."

There is only a little difficulty in accepting the conclusion drawn by Mr. Hill with such confidence,—the *Gryphæa* collected in great numbers at the top of the section of Blue Cut Mound, near Belvidere, is not the *Gryphæa Tucumcarii!*

I have had in my possession, ever since 1888, beautiful and perfect specimens of that *Gryphæa*, and the idea that a paleontologist of the U. S. Geological Survey and a chief geologist of that Survey should call it *G. Tucumcarii!* was far from my thoughts. When such discoveries were made, as those claimed by Messrs. Hill, Stanton and Vaughan, their first duty was to give good figures and exact descriptions of the *Gryphæa* and put it side by side with the figures and descriptions given by me in 1858 (Geology of North America, etc., plate IV and pages 43 and 38, Zurich, 1858). But as it is a simple assertion, presenting no basis for discussion, the reader of Mr. Hill's paper cannot judge from the paper itself. The *Gryphæa* found on the top of the Belvidere section, above the beds con-

* In Science, April 2, 1897, vol. v, No. 118, p. 559, Mr. T. W. Vaughan says that he found in the vicinity of Arapaho (Oklahoma and Indian Territory) the *Gryphæa Tucumcarii* of Marcou, a fossil asserted by him to be Jurassic, which often occurs imbedded in the same matrix (as the *Gryphæa Pitcheri* of Marcou or *forniculata* of White). Thus he extends the error of Messrs. Hill and Stanton farther south than Belvidere (Kansas). Figures and description of the so-called *G. Tucumcarii* are entirely wanting, and Mr. Vaughan merely makes an assertion without paleontological proofs —Note by J. M.

† At Kent the *Gryphæa Tucumcarii*, which there is the true species, is not *above* the *Gryphæa Pitcheri* (*G. Rœmeri*) but *below*. And the pretended *G. Pitcheri* of Messrs. Dumble and Cummins belongs to two new species entirely distinct from the *G. Rœmeri* or *Pitcheri* (see "The Jura of Texas," loc. cit., p. 153). —Note by J. M.

taining the *Gryphæa Rœmeri* of the Neocomian of Comet Creek, is an entirely different species from the *G. Tucumcarii*, it is a new species which I propose to call *Gryphæa Kansana*. It possesses all the main characters common to all the *Gryphæa* of the Neocomian or Lower Cretaceous of America and Europe. As for Mr. Hill's announcement that "The nomenclature of the Gryphæta oysters of the Comanche series will be thoroughly revised in a separate paper which the writer has in print," almost two years have passed and the paper is not yet distributed. I hope that it will soon be out; and then, I shall publish figures and description of the large *Gryphæa Kansana*, n. sp. Messrs. Hill and Stanton do not seem to realize that if their identification of the Gryphæas at Belvidere and at the Tucumcarii region were correct, their discovery of one above another at one place and the reverse at the other place, in the same geological basin, among almost horizontal strata, would go far towards destroying the paleontological character for classification of strata, discovered almost one century ago, by William Smith, the author of "Strata identified by Organized Fossils" (4to, London, 1816). Happily their identification of the *Gryphæa Tucumcarii* with the *G. Kansana* is incorrect and their classification is based on paleontological misrule. There seems to be a sort of fatality, after the numerous false identification of half a dozen and probably more different species of *Gryphæa*, with the *G. Pitcheri*, to have now the same difficulty of incorrect identification of two distinct species of *Gryphæa*. It is discouraging in the extreme to see such a succession of blunders during more than forty years.

Now a few words on the age and classification of the Belvidere section and other outcrops in Kansas.

Professor Chas. S. Prosser gives a very good account of the strata under consideration, in vol. ii of the Kansas Geological Survey, although he also falls into the error of calling the new *Gryphæa Kansana*, of the top of the Belvidere section, *Gryphæa Tucumcarii*. Above the New Red sandstone formation of the plains south of the Arkansas River, lies in discordance of stratification a sandstone, called by Professor Cragin "the Cheyenne sandstone," of a thickness of about 50 to 60 feet. No characteristic fossils have yet been found in it. In fact fossils are very rare, only a few shells referred with doubt to *Avicula* and *Cucullea* having been found, and these so poorly preserved that Mr. Stanton has declined "to identify them even generically." In the upper part of the Cheyenne sandstone, a small flora, eight species, has been determined by Professor Knowlton, who says: "That up to the present time the dicotyledons from the Cheyenne sandstone are not known outside of the Dakota formation," that is to say the base of the

Upper Cretaceous or Cenomanian of Europe. No conclusion can be drawn from such a meagre florula. A Cycadæ, called *Cycladoidea munita* by Cragin, recalls the Cycadæ of the Purbeck beds of the island of Portland in England. As to the impossibility of having dicotyledonous plants in the Jura, as has been insisted upon by my adversaries, it is a very hazardous supposition without any solid basis to rest upon. The great number of species of dicotyledonous plants of the rich flora of the Dakota formation, indicates that we must expect to find dicotyledonous plants far below that formation; and to say that dicotyledonous plants did not exist during the Jurassic period, is merely a supposition, based on negative proof; a very uncertain, questionable basis to rest upon in our time of belief in evolution as well of plants as of animals. After the ill success of the great paleobotanist Oswald Heer, in the use of negative proof, to deny the existence of dicotyledonous plants in the Cretaceous of America, it is rather strange to see paleobotanists in America falling into the same error.

As the Cheyenne sandstone does not exist everywhere in Kansas, where the Neocomian, called Kiowa shales, is seen, as in Central Kansas, McPherton and Saline Counties; and as at Comet Creek, the Neocomian, with *G. Rœmeri*, rests in such places directly on the New Red sandstone rocks, it is most probable that it belongs to the Jurassic period, and is an eastern prolongation of the yellow and white sandstone of Pyramid Mount. It has the same lithology with brilliant colors, as noted by Professor O. C. Marsh, and future researches will decide its real and exact geological age. A great *desideratum* is the careful examination near Belvidere of the contact of the Cheyenne sandstone with the first three or four beds resting on it. Some sort of discordance, due to erosion and denudation, and perhaps also some little difference in the dip of the strata—a difference which can be only very small considering the almost horizontality of the strata of the plains—may be detected. Of course it will require prolonged research and a very acute practical geological mind, to discover such discordance. But I hope that some day the work will be undertaken. For me such a discovery is only a question of time. So far the discordance may be looked for between No. 6 and No. 7 of Mr. Hill's section. The Kiowa shales of Professor Cragin, so well described by Messrs. Cragin and Prosser, represent the Neocomian or Lower Cretaceous in Kansas, from No. 7 of the Belvidere section up; below they may be Jurassic.

Oklahoma.—The Comet Creek bed, as it is called by Mr. Hill, is not composed "of a single stratum of Gryphæa limestone, five feet thick," as he says (this Journal, vol. l, p. 228); but of five strata or beds, which are described in my "Field

notes," published in vol. iii, Pacific Railroad Explorations, p. 131. Another example of want of exactness in quotation in Mr. Hill.*

The Tucumcari region.—It seems superfluous for me to speak again of my researches; but Mr. Hill's paper obliges me to state more forcibly, if possible, all the facts on which I have founded my conclusions that the Jura exists in this region.

The only section I was able to see and make during my very short stay of only 24 hours, the 21st and 22d of Sept., 1853, owing to the rapidity of our military march, was at an isolated peak west of the Big Tucumcari Mount, which I have called Pyramid Mount. Since the name has been used in the map of Lieutenant A. W. Whipple's expedition, and on my geological map of New Mexico, its geographical position is well established. I chose that hill on account of its complete isolation, and also because, after looking carefully through a spy-glass at the whole surroundings of Plaza Larga, I thought that the beds seemed better exposed to view and would afford me a good section. In this I was not disappointed, for as soon as I reached the foot of the hill, I had before me a most perfect geological section, almost like a wall, with every bed finely in view and accessible. I took the right side of the wall section, and carefully noted every thing I saw. As I have repeatedly published this section, I shall not give it again, only I would say that I did not see any mark of discordance of stratification by break or erosion between the beds of the New Red sandstone and the Jurassic formation. The bed of blue clay, above the yellow and white sandstone, containing near its base the *Gryphæa Tucumcarii* and *Ostrea Marshii*, is fully in view. Before reaching the bed of *Gryphæa*, I failed to find in the sandstone a single fossil. Above the blue clay with *Gryphæa Tucumcarii*, 30 feet thick, there is 52 feet of yellowish and white limestone. In this limestone a few *G. Tucumcarii* were seen, also one or two not well preserved shells of lamellibranchiæ.

I nowhere found the *Ammonites* (*Schlœnbachia*) *Shumardi*, even the smallest fragment. And from the nature of the rubbish (débris) at the foot of the wall of that section, which I examined with great care, I can say, that it is my conviction

* To finish with misquotations, I give the following foot note of Mr. Hill's paper, entitled: "A question of classification" (Science, vol iv, No. 103, p. 918, Dec. 18, 1896): "With the exception of Prof. Jules Marcou, who originally maintained that the Middle and Lower Cretaceous of Texas and the Plain Tertiary were Jurassic, and who still maintains the Jurassic age of the Middle Cretaceous beds of New Mexico and the Lower Cretaceous of Texas. This position has been disproved by research." It is sufficient for me to give it without comment, for seldom has an adversary been cited so inexactly or his researches so incorrectly used.

that the *A. Shumardi* does not exist anywhere at Pyramid Mount; therefore its stratigraphic position in the Tucumcari region must be above the last bed of white limestone, seen at the top of Pyramid Mount. This remark is of great importance, for Professor A. Hyatt, in his exploration of another part of the Tucumcari region, insists that he has found the *A. Shumardi* in company with *Gryphæa Tucumcarii*. However great may be my respect and sympathy for Professor Hyatt, and though I fully acknowledge his great authority on cephalopods, regarding him as one of the few masters on everything touching *Ammonites*, *Nautilus*, *Lituites*, etc., I cannot refrain from expressing my doubt in regard to his finding *A. Shumardi* is the same layer, side by side with *G. Tucumcarii*. That Professor Hyatt saw the Ammonites very near the *Gryphæa*, I have no doubt; but I am sure the Ammonite must be above, even if only a few inches separate them. If the *G. Tucumcarii* exists above the *A. Shumardi*, and this is a well established fact, which can be easily proved by a careful and exact stratigraphist; then *A. Shumardi*, as I have said, is a Jurassic species, notwithstanding that it belongs to the genus *Schlœnbachia*, which in that case made its appearance in America earlier than in Europe.*

That beds found at other parts of the Tucumcari region, lying above the two feet of white limestone of the top of Pyramid Mount, belong to the Lower Cretaceous or Neocomian is very probable, but I am not to be criticised for not finding them, for they do not occur at my section of Pyramid Mount. I found there only the Jura and I followed all the rules of stratigraphic classification, in referring the strata of Pyramid Mount to the American Jurassic formation. I saw clearly when I was on the top of Pyramid Mount, that on the mesa or plateau of the Llano Estacado, more especially toward the east, at Monte Revuelto, there was another series of strata capping the Jura of Pyramid Mount and consequently

* In my paper, "The Jura of Texas" (Proceed. Boston Soc. Nat. Hist, vol. 27, p. 155), I say that Professor A. Hyatt has found at the Tucumcari region the *Ammonites (Schlœnbachia) Shumardi* with the *Gryphæa Tucumcarii*, "and there is therefore no doubt possible in regard to the contemporaneity of the *A. Shumardi* and the *G. Tucumcarii*." Messrs. Dumble and Cummins in their Kent section (American Geologist, vol. xii, 1893, pp. 309-314), also regard the *A. Shumardi* as contemporary with the *G. Tucumcarii*. Although I was not convinced by the assertion of Messrs. Hyatt, Dumble and Cummins, I admitted it, leaving the responsibility on those observers. But now, after the repeated failure of my adversaries to give the exact position in the strata of each species, I am unwilling to accept any longer such supposed contemporaneity, and I think that *Ammonites Shumardi* is younger than *Gryphæa Tucumcarii* and is placed above it in the strata; and that the line of separation between the Jura and the Neocomian at the Tucumcari region and at Kent, is between the beds containing the *G. Tucumcarii* and those above containing the *A. Shumardi*, with a break or discordance of some sort between them.

younger; but it was impossible for me to go to Monte Revuelto, or any other part of the Tucumcari region, to explore that upper series, and consequently I cannot be responsible for not having found at the Tucumcari region the Lower Cretaceous or Neocomian. It is very unjust to attack me in regard to the age of strata which I have not seen, and above all it is highly erroneous to deny the existence of the Jura at the Tucumcari region. My adversaries have made use of the anti-stratigraphic method of placing in a single list all the fossils they got there, without any regard to their relative positions in the strata. This placing in a single mass all the fossils of the Tucumcari region is not the way to make exact observations. I protest loudly against such a procedure. For it is easy to see the special purpose in view, viz: to show Cretaceous species mixed with Jurassic ones, and to conclude that the Jura did not exist there. It is contrary to careful stratigraphy to do so, and very unfair. Each group and even each bed should be given with the list of fossils found in each, otherwise lists of fossils all together are deceptive, and cannot be accepted as paleontological proof of the age of all the strata of a whole region. That the Lower Cretaceous exists at the Tucumcari region I am ready to believe, but the beds belonging to it are all above those which I have classified as Jurassic. In conclusion, I have to say that in the paper of Mr. Hill we have another example of erroneous determination of a *Gryphæa* which has led some geologists to continue their disbelief in the existence of the Jura at the Tucumcari. The Tucumcari region is open to every observer, and I am fully confident of the final verdict.

Tabular view of the strata of the Tucumcari region.

Cretaceous.	Cretaceous strata of Monte Revuelto, six miles east of Pyramid Mount. Thickness about 200 feet. The contact bed with the Jurassic formation has not yet been described.
	Nota bene.—Very likely a discordance of some sort exists at the contact of the Jura and Cretaceous.
Jura.	Jurassic strata existing above the top bed of the Pyramid Mount section. Thickness unknown.
	Jura of Pyramid Mount, with *Gryphæa dilatata* var. *Tucumcarii*, and *Ostrea Marshii*. Composed of yellow and white sandstone, of blue marl, and yellow and white limestone. Thickness about 200 feet.

Keuper or variegated marls of the Trias.

General Classification of the Jura and Neocomian south of the Arkansas river.—When, in 1887, Mr. Hill published his first essay of a "Geologic Section of the Cretaceous strata of the State of Texas, etc." (this Journal, vol. xxxiii, p. 299, April 1887), I saw that there were important mistakes in his classification of the Lower Cretaceous; but I thought that he would correct them, in his further researches. Instead of improving his classification, however, and giving a clearer and more exact nomenclature, confusion has been aggravated, until I think it is time to interfere.

It is strange, that almost perfect stranger as I am, for I have explored a very small part of Texas, only a simple road in the Panhandle—I should be obliged again to attempt a more logical and exact classification, than the one in use by those who have in charge the description of the geology of that great and beautiful State.

In 1860, Dr. B. F. Shumard published his "Section of the Cretaceous strata in Texas" (Trans. Acad. Sc. of St. Louis, vol. i, p. 582); and in 1861, I gave before the Boston Society of Natural History a corrected section, reversing the whole classification from top to bottom (Proceed. Boston Soc. Nat. Hist., vol. viii, January 1861, p. 93). After many years of opposition and discussion my classification has been accepted as correct. It remained only to complete the details of subdivisions, and to keep the Jurassic formation distinct from the Lower Cretaceous. Mr. Hill in his first paper replaced the Jura in the Cretaceous, and ever since with some variations has continued to identify the Jura either with the Washita division, or with the lower part of what he calls the Lower Cretaceous (Trinity division). Only once, after his first visit to the Tucumcari region, has he recognized the strata containing the *Gryphæa dilatata* var. *Tucumcarii* and *Ostrea Marshii* as Jurassic; but as he said, he regretted it directly, and returned with new vigor to his classification of the Texas Jura, in the Lower Cretaceous.

The constant changes in Mr. Hill's classifications render it extremely difficult to understand the meaning of the names he uses for the subdivisions, the great divisions and even his name of "Comanche series," called first "Texas series."* It is almost impossible to keep pace with him. Almost every year since 1887, when he published his first classification, he has brought forward a new one. To render the matter more confusing, the Geological Survey of Texas has also used different classifications in its annual reports, and we have now about ten different classifications to deal with.

*Mr. Hill, in his nomenclature, uses the name "Comanche Peak Group," "Comanche Division" and "Comanche series;" rather too many Comanches.

For the present I shall not enter into any explanation of these classifications or show the numerous discrepancies between them. But I shall say only, that above what has been called "Dinosaur sand" or the true Trinity, we have a certain number of beds, called Glen Rose, Paluxy, Caprina and Caprotina limestone, Gryphæa rock and Walnut clays, Comanche Peak chalk and Goodland limestone—some of which are placed sometimes in the Trinity division, and at other times in the Fredericksburg—which require a careful study before they are placed either with the "Dinosaur sand" or with the Washita division. With this reservation I shall proceed to present a stratigraphic and paleontologic classification of the strata comprised between the undoubted Trias and the undoubted Upper Cretaceous.

A. Beginning with the base, we have first, the Trinity or Bosque division. The first description of it was given by Mr. Hill, in the second volume of the Arkansas Geological Survey, 1888. I repeat that I have shown with details, that the fauna found in it is a Jurassic fauna, without a single form which can be attributed to a Cretaceous species. In Pike County, Arkansas, round Murfreesboro, the upper portion of the Trinity division has been destroyed by denudation and erosion after the upheaval and break at the end of the Jura period. But it may turn out after more minute researches and observations, that the missing upper portion may be found in part, if not *in toto*, somewhere between Murfreesboro, Pike Co., Arkansas, and Tishomingo, Chickasaw Nation, in the Choctaw Nation territory, at or near the small stream called Kiamishi or Kiamashi, where Dr. Z. Pitcher found a small specimen of a *Gryphæa*, called by Dr. Morton *Gryphæa Pitcheri*.

The geographical distribution of the Trinity division follows a curved line from Murfreesboro, Arkansas, to Tishomingo, to Glen Rose, Somerville Co., to Bosque Co., and Trevis Co. in Texas, crossing the Trinity River valley, from which it received its first name from Mr. Hill. Two different *facies* exist on that line. The first or Arkansas *facies* is composed of various rocks, such as grayish yellow limestone and argillaceous sand. The second or Bosque *facies* is less argillaceous, with more limestone, more especially in that portion of the division which has been called "Glen Rose (alternating) bed."* West of Travis Co. or Austin, a third *facies* makes its appearance, formed only of sandstone yellow and white,

* The superposition of some of the subdivisions referred to the Glen Rose is doubtful, and some may belong to a younger formation. The Paluxy sand has also been classified by some as belonging to the Fredericksburg division, while others place it with the Trinity sand, without intercalation of the Glen Rose.

which has been called Paluxy sandstone near Comanche Peak and at the Kent County section; simply yellow and white sandstone at the Pyramid Mount section; and Cheyenne sandstone near Belvidere, Kansas. This third *facies* is the most persistent, occupying all the western country from Kansas to New Mexico, western Texas and very likely northern Mexico.

B. Following the Trinity division and in concordance of stratification we have the Tucumcari division, composed of blue marl at the base, containing a bed formed entirely of *Gryphæa dilatata* var. *Tucumcarii* and *Ostrea Marshii*; then comes a yellowish limestone with two or three feet of white limestone. The top of that formation has not yet been described. Very likely it exists at Monte Revuelto, in the Tucumcari region. The *Gryphæa Tucumcarii* is found scattered, more or less, through the whole division, but more abundantly at the base. At the end of the deposition of this formation, a great break occurred; denudation on a large scale swept away the greatest part of it, leaving now and then a small remnant; for instance at Belvidere, Kansas, where the strata numbered 4, 5 and 6, by Mr. Hill seem to belong to the lowest bed of the blue clay containing *Gryphæa Tucumcarii* of the Pyramid Mount section. At Kent, in Texas, the superior part of the Tucumcari division exists with the *Gryphæa Tucumcarii;* and more of that division will be found in the region of the Pecos River valley and also on the upper Canadian River region. As I have already said, the strata of the Kiamishi Creek valley in the Choctaw Nation, containing the original *Gryphæa Pitcheri* of Morton, may belong to the lower part of the Tucumcari division.

C. We next come to a new great period, the Cretaceous age, beginning with the strata containing an immense number of *Gryphæa Rœmeri.* When I say that the Cretaceous begins with the apposition of the *G. Rœmeri*, it is only a means of calling the attention of the observer in the field, for there are some strata below the true zone of the *Gryphæa Rœmeri.* For instance at Comet Creek, Oklahoma, we have one bed containing *Caprotina Texana*, with a form of *Exogyra Texana;* while at Black Hills, Kansas, we have thirteen feet of shales, numbered 7, 8, 9 and 10 in the section of Mr. Hill, containing no fossils, which very likely are already Cretaceous strata. I recall that No. 6 of Mr. Hill's section belongs still to the Jura, and that denudation or erosion very likely exists between number 6 and number 7, the last number beginning there the truly Cretaceous series. The presence of "occasional minute pebbles" in No. 7, indicate the disturbance after the break occurred at the end of the Jura, and is an important witness of the denudation and erosion.

With the *Gryphæa Rœmeri* zone, we have the beginning of an important series of strata, containing a Lower Cretaceous fauna well characterized and which can be subdivided into four or five sub-fauna and easily followed and studied between Belvidere, Fort Washita, Fort Worth and Comanche Peak.

We have three *facies* of the Lower Cretaceous or Neocomian. One is called the Washita *facies*, composed mainly of limestone and constitutes the true Washita division, as I established it as long ago as 1853, when at Comet Creek, near Fort Washita. The second *facies* is called by Professor Cragin "Kiowa shales," being composed mainly of shales, instead of the great development of limestone of the Washita *facies*. The second *facies* has seemed until now to be confined to the strata of Kansas. Then we have a third *facies* called Fredericksburg division, at Comanche Peak, Walnut, Goodland and further south.

A great deal of confusion has been caused by a sort of duplication of one single series, the true Washita division, which has been called in eastern and southern Texas Fredericksburg division. A careful survey of all the strata composing the Lower Cretaceous between Fredericksburg, Austin, Comanche Peak, Fort Worth, Fort Washita and Comet Creek is much needed. For it is plain that the Comanche Peak and Kiamitia clay or Preston subdivisions are simply the base of the Washita division, which cannot be separated from the Fort Worth limestone.

Therefore, instead of the classification used by Mr. Hill under the single name of "Comanche series" or Lower Cretaceous, composed of these divisions, 1st the Trinity, 2d the Fredericksburg, and 3d the Washita, we have the Jurassic series composed of the Trinity and the Tucumcari division, and the Lower Cretaceous or Neocomian composed of the Washita division; dropping the Fredericksburg, which is only a *facies* of the Washita, and placing the Tucumcari division in its true stratigraphic and paleontologic position.

General tabular view for the whole country south of the Arkansas River:

Upper Cretaceous.

Break.

Neocomian or Lower Cretaceous.	C. Washita Division.	Comprising all the subdivisions, as well as the Kiowa and Fredericksburg *facies*.	
		Zone of the *Gryphæa Kansana*.	
		Zone of the *Gryphæa Rœmeri*.	

Break.			
Jura.	B. Tucumcari Division.	Until now this upper part of the Jurassic formation has been best preserved in the Tucumcari region. A few remnants exist near Belvidere (Kansas), at Kent (Texas), and possibly in the Choctaw Nation. Zone of the *Gryphæa Tucumcarii* and *Ostrea Marshii.*
	A. Trinity Division.	Best developed in Pike County, Arkansas, and Bosque County, Texas. Represented in Kansas by the Cheyenne sandstone; at Pyramid Mount, New Mexico, by the yellow and white sandstone; and at Kent, Texas, by sandstone called Paluxy.

Resting on the New Red sandstone or the Palezoic series according to different parts of the country.

Cambridge, Massachusetts, May, 1897.