ART. XXI.—*On Outlying Areas of the Comanche Series in Kansas, Oklahoma and New Mexico*; by R. T. HILL.*

THE Tertiary Plains formations of western Kansas, Texas and eastern New Mexico constitute the summits of extensive levels or plateaus. The eastern border has an average altitude of 2000 feet in Kansas and 2500 feet in Texas.

The Medicine Lodge, Cimarron, Canadian, Red, Brazos, and Colorado rivers originate along the eastern escarpment of the Great Plains and are rapidly destroying them by head-water erosion. These streams are types of the valleys of the rivers of the central denuded region which rise in the eastern margin of the plains, as distinguished from the rivers of the plains such as the Republican and Smoky Hill, which rise and flow upon the plains formations, and from the rivers of the mountains which transect the plains.

The sources of these marginal rivers consist of many digitate branches along the eastern border of the plains. These streams soon cut through the Tertiary formations composing the surface of the plains, down into the underlying red beds of undetermined age, which are the chief components of the underlying floor. These valleys are bordered by mural escarpments of red beds, capped by remnantal patches of the Plains formation between which are preserved occasional patches of the Cretaceous formations.

In proceeding southward the first region of the breaks of the plains with their escarpments of picturesque Red Bed scenery, is the valley of the Medicine Lodge River of Kansas—the so-called "Gypsum Hills" country of many writers.

This region, which lies along the south central border of Kansas in the counties of Harper, Barber, Comanche and Meade, abounds in data throwing light upon the problems of the Pleistocene, Tertiary, Cretaceous and Permo-Trias history. Its geology has been mentioned by earlier writers, especially Professors O. P. St. John† and Robert Hay.‡ The latter has given an interesting and graphic description of the structure and scenery and pointed out the great denudation which preceded the Tertiary sedimentation.

Near the head-waters of this river a thin group of Cretaceous formations lies between the Tertiary and the Red Beds. To the east the Plains formations rest directly upon the Red

* Published by permission of the Director of the United States Geological Survey.

† Notes on the Geology of Southwest Kansas, by O. P. St. John, Fifth Biennial Report. Kansas State Board of Agriculture, Topeka, 1887, Part II, pp. 132, 152.

‡ A Geological Reconnaissance in Southwestern Kansas, by Robt. Hay, Bull. 57, U. S. Geological Survey, 1890.

Beds, the intervening Cretaceous deposits having there been denuded in early Tertiary time.

There has been a diversity of opinion as to the age and affinities of the Cretaceous beds of this region. St. John* referred them with the overlying sandstone to the Dakota, but notes certain dissimilarities of structure and fauna from the Dakota as he had seen it elsewhere.

Prof. Robert Hay† has pointed out their dissimilarity to other outcrops of the Cretaceous, and while judiciously not committing himself, said :

“ With reserve, we are inclined to place the stratum called the shell bed in the Fort Benton group. . . . Before giving up the Dakota age of the sandstones (one bed in particular) I will have to re-examine the region.”

In a later paper,‡ after reviewing subsequent discoveries he says : “ There seems no doubt but that they belong to lower horizons than the Kansas Dakota. There is no reason why the Texas names given to the beds [by Prof. Cragin,] Trinity for the lower sandstone, and Comanche Peak for the upper, should not be permanent.”

Prof. Cragin has written more voluminously upon the region and its formation than any other writer, and he it was who first brought out the important fact that a portion of the beds were of pre-Dakota age,§ and belonged to the lower-lying Comanche Series which has its typical development in central Texas.

It is impossible in this short paper to give all the reference to Prof. Cragin's age determination of these beds, but in general he has classified the Cretaceous deposits into three conspicuous divisions : a basal member which he has named the Cheyenne sandstone ; a group of intermediate shales which he has until lately called the Neocomian shales, and recently terms the Kiowa shales, and an upper sandstone which he calls the Dakota. He has correlated the Cheyenne sandstone with the Trinity sands of Texas and Arkansas, and the Kiowa shales with the Fredericksburg division, and the Dakota with the Dakota. Furthermore, he has generally spoken of the shales as the “ Neocomian shales of Kansas.” As a result of this classification, the Dakota sandstone was supposed in Kansas to rest directly on the beds of the Fredericksburg division, without the interposition of the sediments of the Washita sub-epoch.

* Kansas State Board of Agriculture, Fifth Biennial Report, Part II, pp. 142-144, Topeka, 1887.

† Bull. 57, U. S. Geol. Survey, 1890, pp. 29-30.

‡ Geology and Mineral Resources of Kansas, Topeka, 1893, pp. 12-13.

§ See Bull. Washburn Laboratory of Natural History, vol. i, No. 3, vol. ii, Nos. 9, 10, 11. American Geologist, July, 1894, etc.

The writer naturally felt interested in the extension northward into Kansas of the supposed equivalents of the Comanche series of the Texas region as announced by Prof. Cragin, and in August, 1894, proceeded to the region in company with Mr. C. N. Gould, a promising young local student, and Mr. G. B. Shattuck of the post graduate department of Johns Hopkins University. We made minute studies and sections of the localities in Barber and Comanche counties. The present observations are based upon extensive studies and collections made upon this trip.

Four miles west of Sun City a small remnant of the Cretaceous, hardly 100 feet long, 50 feet broad, and not over 40 feet thick, forms a cap to a Red Bed butte. This is the easternmost Cretaceous formation interpolated between the Red Beds and Tertiary, as seen by the writer on this journey.* This outcrop is the remnantal base of the Cretaceous formations, more fully developed to the westward.

About two miles west, upon the northeast land section of Comanche county, a more extensive and thicker outcrop of the Cretaceous formation occurs. This locality is the "Black Hills" of St. John, Hay and Cragin, so-called from the black color of the shale composing the buttes, as distinguished from the predominant red color of the buttes of the Gypsum Hills region lower down the river. This locality is the easternmost of a continuous series of outcrops exposed from here to west of Belvidere. A minute study was here made of the section, which is as follows, beginning at the bottom :

Section at Black Hills, Northeast Corner of Comanche Co.

I. The Red Beds.

1. Friable beds of finely comminuted sand and clay of intense vermilion color constituting the slopes and base of the butte. Some 400 feet of this formation are exposed. This is the problematical formation known as the Red Beds.	Ft. Ins.
Triassic of various writers.....	300

IIa. The Cheyenne Sandstone.

1. White pack sand, sometimes irregularly cross-bedded, consisting of the loosely or unconsolidated sand known in the Texas region as "pack sand" with occasional fine silicious pebbles. In its upper and exposed portion this sand ultimately becomes ferruginated into light-colored limonitic tints, but sometimes it reveals blotches of vermilion hematitic coloring. The ultimate oxidation, however, is a dark blackish brown. Some kaolinized pebbles were occasionally seen in layers of gravel three inches thick. The total thickness of this formation is	57

* Prof. Hay notes having seen a patch of these beds in the hills north of Sharon, which are thirty miles east of this locality.

	Ft.	Ins.
2. Blue-black sandy clay shale with limonitic seams. This begins rather abruptly above the sandstone, but its sandy nature indicates that it is a transition and not an unconformity, which is further attested by the occurrence upward in these shales of bands of sand similar and identical in material with the lower sandstone. The shale contains crystals of selenite and dicotyledonous leaf impressions	10	
3. The shale No. 2 in its upper part grades by gradual transition into a bed of sand which superficially indurates into a hard series of layers aggregating four feet in thickness. In these sandstones and shales (No. 2) immediately below it were found the dicotyledons to be mentioned later	4	
IIb. The Belvidere Shales.		
4.* A persistent stratum of small Gryphæate oysters superficially resembling the Comanche Peak variety of <i>G. pitcheri</i> . A closer study shows it to be a small form <i>Gryphæa pitcheri</i> Morton (<i>G. dilatata</i> , var. <i>tucumcarii</i> Marcou) imbedded in a sandy shaly matrix not exceeding	1	6
5. A thin white shaly sandstone with plant and molluscan remains		3
6. Thin black sleek paper shale with impressions of mollusca in its lower part	15	6
7. Indurated bed in the shale with occasional minute pebbles	2	
8. Shale like No. 6	4	
9. Sandy induration in shale	2	
10. Shale	5	
11. Indurated shale with Gryphæas	1	
12. Black shale	5	
13. Indurations with var. of <i>Gryphæa pitcheri</i> (<i>G. roemeri</i> Marcou, <i>G. forniculata</i> White), Cyprimeria and Turritella, alternating with shales for a thickness of	20	9
14. Blue shale as above.		
15. Indurated beds with <i>Exogyra texana</i> Roemer, Trigonina, sp. Cyprimeria, Turritella and Gryphæas of large size. The upper horizon of 15 containing vertebrates bones, Lingula, etc. Total of Nos. 15 and 16	17	

* Above this oyster bed to the summit of the section, the formation consists mostly of blue papyraceous shales with occasional indurated bands and presenting many fossiliferous horizons, all of which, however, are portions of the same continuous deposition and fauna.

	Ft.	Ins.
16. Fossiliferous shale.....	16	
17. From No. 16 to the top of the large butte $\frac{1}{8}$ mile to the west the thickness of shale is	32	
Making of blue shale with indurated fossil layers a total of.....	106	

In the shale near the summit of this butte specimens of the large *Gryphæa dilatata* var. *tucumcarii* Marcon, were found.*

As we approach Belvidere the Cheyenne sandstone begins to form the principal slope of the river basin, and west of that village the bed of the river rises until it is upon the Cheyenne sandstones, while some bluffs and castellated remnants of the sandstones are beautifully exposed in the north side of the valley.

Five miles west of Belvidere the railroad has made magnificent cuts into the beds so that they are there seen better than at any other locality. Here the comparatively steep wall of the valley affords a fine section from the old deposition plane of the Great Plains Tertiaries down into the Cheyenne sandstone, the buttes on the south margin of the river valley being remnants of the main body of the plains to the northward. It is here that Prof. Cragin made his Blue Cut mound section,† omitting from it, however, the basal sandstones which are revealed in the floor of the valley near by. Following is the section as measured by Mr. Gould and the writer :

Blue Cut Section.

II. The Cheyenne Sandstone—bottom not exposed.	Ft.	Ins.
1. The Cheyenne sandstones are well shown west of Belvidere in the bluffs on the north side of the river valley, especially in the cliffs of Thompson's Creek. About two and one-half miles west of Belvidere a small creek from the south emptying into the river makes good cuts through the sandstone, showing the same general detail as at Black Hills section.		
2. Sandy shale band above the basal sandstone the same as No. 2 of Black Hills section.....	8	
3. Thin sandstone layers of the plant beds‡ of Nos. 3 and 4 of the Black Hills section.....	6	

* See remarks on this species, p. 38.

† Bull. Washburn Laboratory, vol. ii, No. 11, p. 77, 1890.

‡ These beds constitute a low bench immediately adjacent to the river, and the clay shales succeed them, forming the higher outer slope of the valley. I made a general study of the section to the summit: Mr. C. N. Gould made the succeeding accurate measurements and minute collections.

IIa. Belvidere Shale.		Ft.	Ins.
5. Black or blue shale		26	
6. Oyster bed, sandy matrix			2
7. Black shale		3	6
8. Oyster bed, in shale			8
9. Black shale		1	
10. Oyster bed, in shale			3
11. Black shale		3	
12. Oyster bed, in shale			8
13. Lower part, black shale with much gypsum 3 }		7	
Upper part quite ferruginous 4 }			
14. Oyster bed with much gypsum			8
15. Black shale		5	
16. Oyster bed weathered		1	
17. Black shale weathered		3	
18. Oyster bed, cap on top of cut		2	
19. From top of cut to top of next Gryphæa bed ..		20	
20. To top of next Gryphæa bed		12	
21. To top of next Gryphæa bed		4	
22. To top of next Gryphæa bed		12	
Total,		102	
III. The "Dakota" Sandstone.			
23. A small nipple of nearly black ferruginous sandstone, consisting of coarse oölitic-like grains, and containing stems of plants. This is the character of sandstone generally called Dakota in Kansas			20
IV. Plains Tertiary :			
24. White mortar-like rock with calcareous matrix enclosing fine grains of sand			11

Thirty rods north of the line of the section the Tertiary (No. 24) rests directly on the Belvidere shales, the Dakota (No. 23) having been eroded.

These two sections, taken some miles apart, are sufficient to show the general character of the structure and sedimentation of the beds. They practically agree in thickness and character with the sections of the Belvidere region previously given by Prof. Cragin.*

Reviewing both these sections above the Red Beds (No. 1) and below the Dakota (III), they consist of continuous deposits of shallow marine sedimentation, showing (Ia) a group of the sand beds at the base (the Cheyenne sandstones of Cragin) grading into an upper portion of thin blue and black shales (IIb). These shales resemble lithologically the similar blue and black shales of the Meek and Hayden section as seen in the plains and Rocky Mountains of the northwest, and not those of the beds

* Bulletin Washburn Laboratory, vol. ii, No. 11, pp. 75-76, 1890.

of the Lower Cretaceous of the Central Texas region, which are of a light-colored marly nature.

Although the occurrence of the secondary beds of sandstone, No. 2, 3, and 4, immediately above the main body of that material, is quite persistent both at Black Hills and Blue Cut, Prof. Cragin has not noted its occurrence in his sections of these localities. Whether he failed to observe them, or merely considered them portions of the Cheyenne sandstone to which they logically belong, rather than the shale series above, cannot be stated. That he considered the Cheyenne sandstone and overlying shales a continuous sequence of sedimentation, is clearly shown in his discussion of the Vanheim section, where he finds a band of Cheyenne-like sandstone ten feet thick, intercalated between ninety feet of shale beneath and forty above. The shales overlying No. 4 we call the Belvidere shales from the town near which they can best be seen.*

These formations may be grouped into a generalized section characteristic of the bordering breaks of the Plains in southern Kansas, western Oklahoma, and northeastern New Mexico, which we may appropriately call the Plains section.

This section is as follows:

In this section there are two conspicuous time unconformities, indicative of long periods of erosion, one between the Red

* Since writing this paper Prof. Cragin has proposed the name Kiowa for the shale beds. The name would no doubt have priority over the one herein used by me, but owing to doubt as to which subdivision Prof. Cragin would have included the beds 2, 3 and 4, I prefer to retain for the present the term Belvidere shales. Although the relations of the Cheyenne sandstones and Belvidere shales are transitional, the writer draws the line of demarcation between the Belvidere shales and the Cheyenne sandstone immediately above this highest sandy layer No. 4, in the sections given.

Beds and the Cretaceous—the other between the Cretaceous and the overlying Tertiary.

Owing to the great erosion which took place between the close of the Cretaceous and the deposition of the plains Tertiary (Miocene and later), any or all of the Cretaceous may be missing in some localities as between the Canadian and Brazos; while south of the head of the Brazos the plains Tertiary rests on the limestones of the Fredericksburg and Trinity divisions of the Comanche series instead of the beds of the Washita division to the northward.

Paleontology: The fossil mollusca was submitted to Mr. T. W. Stanton of the United States Geological Survey, and the fossil plants to Prof. F. H. Knowlton, for determination and study. Their reports are included in the following discussion.

The Cheyenne Sandstone.—Prof. Cragin, as before noted, reported the occurrence of one species of a plant from these beds. This he described as *Cycadoidea munita*.^{*} It can be stated that later information concerning the specimens in question, throws doubt as to its occurrence in this identical horizon.

In the lowest sandstone No. 1, only plant stems and small pieces of lignite were found. A well defined flora was found in the sandy shale (No. 2) and the layers (3, 4) immediately overlying the main basal sandstone, and which are genetically related to No. 1, marking the cessation of the initiatory sandy beds of the series; two large boxes of these specimens were collected at Black Hills and submitted to Professor Knowlton, whose appended report speaks for itself. Similar plant remains were observed in the same sand layer near Blue Cut Mound, but night coming on a detailed collection could not be made there.

Report upon a Small Collection of Fossil Plants from Black Hills, near Belvidere, Kansas, collected by Prof. R. T. Hill in August, 1894.

This material has been carefully examined and the following species identified:

Rhus Uddeni Lx.

Sterculia Snowii Lx.

Sassafras Mudgei Lx.

Sassafras cretaceum Newby., var. *obtusum* Lx.

Sassafras, n. sp.

Glyptostrobus gracillinus Lx.

Sequoia sp.

The above species have, according to Lesquereux, the following distribution:

^{*} Bull. Washburn Laboratory, vol. ii, No. 10, p. 65.

Rhus Uddeni Lx.—The locality for this species is simply "Kansas." It is said to have been presented to the U. S. National Museum by the collector, Prof. J. A. Udden, but according to the records it is not now and has never been in this institution. I have lately written to Prof. Udden to find where it came from, and he replies that it is "from the west slope of the Smoky Hill Buttes, near Salemsburg Post Office, Saline county, Kansas."

Sterculia Snowii Lx.—From Ellsworth Co., Kansas, where it is very abundant. It was reported by Mr. W. F. Cummins from the "upper sandstone of the Tucumcari beds, four miles west of Big Tucumcari mountain, New Mexico," and described by him under the name of *Sterculia Drakei*. 3d Ann. Rep. Geol. Survey of Texas, p. 210.

Sassafras Mudgei Lx.—Found on hills along the Salina river, Kansas.

Sassafras cretaceum var. *obtusum* Lx.—Also found on bluffs along the Salina valley, Kansas.

Sassafras n. sp.—This is a small leaf differing from any heretofore described. It, however, approaches to certain well known forms from Kansas.

Glyptostrobus gracillinus Lx.—Found near Sioux City, Iowa, at the mouth of Iowa creek. The collection from near Belvidere contains a number of fairly well preserved examples and there can be no question of its correct identification.

Sequoia? sp.—The collection contains a number of fragmentary cones which appear to belong to this genus. I have not been able to identify them with any known species, and they may be new, although it is hardly safe to found species on such imperfect material.

Indeterminable dicotyledons.—Besides the forms enumerated above, there are a number of fragmentary leaves that it is impossible to determine with satisfaction. They are undoubtedly dicotyledons, but are only fragments with hardly a trace of nervation preserved.

All the above mentioned species belong to the Dakota group as it is usually accepted, but as a matter of fact no detailed stratigraphic work has yet been done with a view to ascertaining the range and association of the fossil plants referred to this formation. It would be natural to suppose that a formation of great thickness and wide areal extent, would have horizons capable of differentiation by means of the fossil plants, but they have not yet been worked out.

If it is shown by stratigraphic and paleontologic data that these leaves come from a horizon lower than that usually recognized as the Dakota group, it would be quite in accord with what should be expected of the Dakota flora. This flora, for years supposed to be the oldest of its type in North America, is made up of a great number of highly differentiated forms, that must have had an anterior period of development. That is, the flora could not have sprung into existence in so abrupt a manner as would seem

to be indicated by previous studies. If more were known of the chronologic sequence of the Dakota flora, it would possibly be found that the plants identified above belonged to lower or older beds. But all that can now be stated is that these species belong to the Dakota group as it has usually been accepted, and have never before been identified outside of it.

Very respectfully,
F. H. KNOWLTON,
Ass't Paleontologist.

(Signed)

III. *The Belvidere Shales*.—The fossils enumerated by Prof. Cragin from these shales, especially in his earlier writings, were determined under difficult conditions, remote from large libraries and typical collections, and his synonymy is greatly in need of revision.

From "the Neocomian shales," (the Belvidere shales)—the shales lying between the "Dakota" (No. IV) sandstone at the top and the highest layer of the Cheyenne sandstone, as above defined, Prof. Cragin in his various papers has reported the following fossils.*

Astrocœnia nidiformis Cragin, 7.	Gervillia sp. allied to G. an-
(? Nereis incognita Cragin, 6.	ceps, 4.
Ostrea anomioides Meek, 2.	Modiola burlingtonensis Whit-
Ostrea franklini Coquand, 4.	field, 4.
Ostrea diluviana Lam., 2, 4.	Inoceramus comancheana
Gryphæa bryani Gabb, 2.	Cragin, 7.
Gryphæa pitcheri Morton, 2, 4.	Inoceramus sp., 3.
" " var. fornicu-	Pinna comancheana Cragin, 7.
lata White, 4.	Cucullæa (Idonearca) terminalis
Gryphæa vesicularis White, 4.	var. recedens Cragin, 6.
Exogyra columbella Meek, 2.	Idonearca? tippana Con., 4.
" flabellata Goldf, 4.	I. vulgaris Con., 4.
" forniculata White, 2, 4.	Limopsis sp., 4
" texana Roemer, 2.	" subimbricatus Cragin, 6.
A. argentaria Mort., 4.	Nucula catherina Cragin, 6.
Anomia tellinoides Mort., 4.	" sp., 4.
Plicatula arenaria Meek, 4.	Trigonia emoryi Conrad, 2, 3.
" senescens Cragin, 6.	Remondia ferrissii Cragin, 4, 6.
Neitheia quinquecostata	Cardita belviderensis Cragin, 6.
Sowerby, 2, 4.	Gouldia sp. "Prof. Marcou
Avicula belviderensis Cragin, 6.	thinks it an Astarte."

* The figures appended to the names in the list refer to the publications of Prof. Cragin in which they have been used, as follows:

1. Bull. Washburn Laboratory, vol. i, No. 3.
2. Bull. Washburn Laboratory, vol. ii, No. 9.
3. Bull. Washburn Laboratory, vol. ii, No. 10.
4. Bull. Washburn Laboratory, vol. ii, No. 11.
5. Invertebrate Paleontology of the Texas Cretaceous, Austin, June, 1893.
6. Neocomian of Kansas, American Geologist, 1894.
7. Colorado College Studies, 1895.

Cardium belvederi Cragin, 3. (Not described.)	Dentalium, 4.
Cardium hillanum Sow. ? 4.	Trochus texanus Roemer, 6.
“ kansaense, 3.	Margarita marcouana Cragin, 6.
(?) “ mudgeii Cragin.	“ (Solariella) Newberryi Cragin, 6.
“ (Nemocardium) biso- laris Cragin, 6.	Neritina sp., 4.
Cyprina ovata M. & H., 2, 3.	Serpula iintrica White, 2.
Tapes belviderensis Cragin, 6.	Vanikoro propinqua Cragin, 7.
Roudaria quadrans Cragin, 4.	Scalaria sp. (?) 4.
Cyprimeria crassa Meek, 2, 4.	Turritella marnochii White (probably T. seriatim granu- lata Roemer), 2.
“ gradata Cragin, 3. (Not described.)	Turritella marnochii White “ typical ” Cragin, 4.
Leptosolen belvederi Cragin, 4. (Not described.)	Turritella marnochii White, var. belvederi Cragin, 4.
Leptosolen otterensis Cragin, 6.	Anchura kiowana Cragin, 7.
Pholadomya ? elegans ? 4.	Globiconcha elevata Shum., 4.
“ sancta sabæ Roemer, 4.	Neritoma marcouana Cragin, 7.
Homomya alta Roemer, 4.	Ammonites acutocarinatus Shum., 3, 4.
Liopistha protexta Con., 4.	A. pedernalis Roemer, 4.
Mactra antiqua Cragin, 6.	Petersia Medicinensis Cragin, 6.
Corbula crassicostata Cragin, 7.	

The large and abundant collections of invertebrate fossils, made by Mr. C. N. Gould and the writer from the shale beds overlying the sandstone from which these fossil plants were collected and grading into them, were determined by Mr. T. W. Stanton, Paleontologist of the U. S. Geological Survey, who reports upon them as follows :

Washington, Jan. 25, 1895.

Mr. R. T. HILL, U. S. Geological Survey.

Dear Sir.—I have the honor to submit the following report on the fossils collected by you last season in southern Kansas.

The collection includes fossils from three different localities, which, according to the labels, are Black Hill, Blue Cut Mound, and hill four miles west of Sun City, Kansas, all of which are in Comanche and Barber counties. The collections from the first two localities are from several different horizons, but as they all evidently belong to one fauna they have all been combined in one annotated list, though the separate lists for each locality and layer are also appended in order that the record may be complete. In connection with the examination I have made a preliminary study of your Washita collection from the Denison section for comparison.

List of Species.

Enallaster sp.—Fragments of an Echinoid referred to this genus by Dr. W. B. Clark. It is not known in beds later than the Comanche series in America.

Ostrea sp.—This species is probably a new form. In size and outline it resembles some specimens of *O. franklini* to which Prof. Cragin referred it, but there are noteworthy differences especially in the beaks and the cartilage pit sufficient for specific separation. This species is very abundant in the shales.

Gryphæa pitcheri Morton.—A few specimens from No. 2 of Blue Cut Mound section seem to belong to this species, though they may be the young of one of the related forms.

Gryphæa forniculata (White).—It is abundant in certain layers. It occurs in the Washita beds at El Paso and the Kiamitia beds of the Washita at Denison and many other places in Texas.

Gryphæa tucumcarii Marcou.—Abundant in the upper part of the section at Blue Cut Mound. It is interesting to note that this form, 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.

Ecogyra texana Roemer.—There are only three specimens in the collection. It is abundant at El Paso in beds that are supposed to be Washita and it also occurs at Tucumcari Mountain, New Mexico.

Plicatula senescens Cragin.—Originally described from this region. The material is not sufficient for critical comparison.

Pecten sp.—A small smooth form like one that occurs in the Paw Paw beds of Denison.

Avicula belviderensis Cragin.

Avicula leveretti Cragin?—Several specimens were collected in the shales of Blue Cut Mound, that agree fairly well with the figure and description of that species from the Kiamitia beds on Duck Creek, Texas.

Inoceramus comancheana Cragin?—Fragmentary impressions of a form closely related if not identical with this species from the Duck Creek beds.

Lithophagus sp. nov.—Abundant burrowing in *Gryphæa forniculata*.

Nucula catherina Cragin.

Nucula sp.—Casts.

Leda sp.—Casts.

Trigonia emoryi Conrad.—This widely distributed species occurs at Tucumcari, El Paso, etc., and seems to have a great vertical range. It is found in the uppermost Washita beds at Denison and is reported from the Fredericksburg.

Cardita belviderensis Cragin.

Cardium mudgei Cragin?

Cardium bisolaris Cragin.

Cardium (Protocardia) *texanum* Conrad.

Roudaria [?] *quadrans* Cragin.—The Museum contains an example of this species collected by Prof. A. Hyatt at Tucumcari.

Cyprimeria sp.—This abundant species is evidently not *C. crassa*, as Prof. Cragin thought. Our collections of the Texan forms of this genus are not yet large enough for a revision of the species.

Cytherea ? sp.—A few casts of an indeterminate Venerid.

Tellina ? sp.

Mastra antiqua Cragin.

Corbula crassicostata Cragin, also occurs in the Paw Paw beds.

Dentalium sp.—Represented by fragments.

Natica sp.—A few small casts.

Turritella sp. related to *T. seriatim-granulata* Roemer.—This abundant species does not exactly agree with Roemer's figure nor with any of the four or five other similar species that have been described from Texas. The group needs careful study with large collection from the entire area in order to determine whether we are dealing with several species or only one or two variable forms. The variety now under consideration occurs at Tucumcari.

Anchura kiowana Cragin.—A small form represented by several imperfect specimens. It is closely related to *Anchura mudgei* White, which occurs in the Paw Paw beds, but is apparently not identical with it.

Trochus texanus Roemer.—Two specimens that are doubtless like the one referred to this species by Prof. Cragin. They are somewhat smaller than Roemer's figure, but agree well in sculpture and form.

Schloenbachia peruviana von Buch.—Two or three characteristic fragments. The species is abundant in the Duck Creek and Kiamitia beds at Denison. It also occurs in the Washita division at El Paso and is said to occur as low as the Walnut clays of the Fredericksburg.

Sphenodiscus sp.—Fragments of a form that differs from *S. pederalis* von Buch in that it has a truncated periphery. *S. emarginatus* Cragin and *S. roemeri* Cragin are both related forms from the Fredericksburg and Trinity divisions, respectively, but they do not agree with each other nor with this form in the details of the septa.

A critical examination of the above list will show conclusively that the beds from which the fossils came belong to the Comanche series and probably to the upper half of that series. To make closer correlation with the subdivisions of the Texas section is more difficult because the association of species is not exactly the same as in any one of those subdivisions and some of the species common to the two regions are known to have a considerable vertical range. Taken altogether, the evidence seems to indicate

about the horizon of the Kiamitia. The absence of limestone in the Kansas section adds another element of difficulty in the correlation, because a fauna occurring in shales is often more closely related to a slightly earlier or slightly later fauna in beds of the same lithologic character than it is to a strictly contemporaneous fauna in limestone or sandstone. That is, differences in local faunas are often in part due to differences in depth of water and in character of the sea bottom.

The similarity of the faunas in Kansas, at Tucumcari, New Mexico, and near El Paso, Texas, will allow greater confidence in correlating the beds at these three places.

Very respectfully,
(Signed)

T. W. STANTON.

List of Fossils from Black Hills, Kansas.

No. 4. <i>Gryphæa forniculata</i>
White. Small specimens—
young or depauperate exam-
ples of this species.	<i>Lamna</i> sp.? A shark's tooth
probably of this genus.
No. 2, 5 and 9, contain indeter-
minate fragments of fossils.	No. 13. <i>Ostrea</i> sp.
<i>Gryphæa forniculata</i> White.
<i>Cyprimeria</i> sp.
No. 6. <i>Corbula crassicosata</i>
Cragin.	Fragments of other forms oc-
curring in Nos. 11 and 15.
<i>Ostrea</i> sp.	No. 15. <i>Gryphæa forniculata</i>
White.
<i>Gryphæa forniculata</i> White.	<i>Exogyra texana</i> Roemer.
<i>Exogyra texana</i> Roemer.	<i>Avicula belviderensis</i> Cragin.
<i>Nucula</i> sp.	" <i>leveretti</i> Cragin?
<i>Cardium mudgei</i> Cragin?	<i>Lithophagus</i> n. sp.
<i>Cardium bisolaris</i> Cragin.	<i>Trigonia emoryi</i> Conrad.
<i>Roudaria? quadrans</i> Cragin.	<i>Cardita belviderensis</i> Cragin.
<i>Cytherea? sp.</i>	<i>Cardium (Protocardia) texa-</i>
<i>num</i> Con.
No. 11. <i>Tellina? sp.</i>	<i>Cyprimeria</i> sp.
<i>Mactra antiqua</i> Cragin.	<i>Tellina? sp.</i>
<i>Corbula crassicosata</i> Cragin.	<i>Natica</i> sp.
<i>Dentalium</i> sp.	<i>Turritella</i> sp. related to <i>T.</i>
<i>seriatim-granulata</i> Roem.
<i>Natica</i> sp.	<i>Anchura kiowana</i> Cragin.
<i>Anchura kiowana</i> Cragin.	<i>Sphenodiscus</i> sp.
<i>Trochus texanus</i> Roemer.	<i>Lamna? sp.</i>
<i>Turritella</i> sp. related to <i>T.</i>
<i>seriatim-granulata</i> Roem.	<i>Reptilian vertebra.</i>
<i>Schlenbachia peruviana</i> von
Buch.	

From Blue Cut Mound, four miles southwest of Belvidere, Kan.

No. 5. <i>Ostrea</i> sp.	No. 6. <i>Ostrea</i> sp.
<i>Avicula belviderensis</i> Cragin.	<i>Gryphæa pitcheri</i> Morton?
<i>Inoceramus</i> sp.	<i>Turritella</i> sp. related to <i>T.</i>
<i>seriatim-granulata</i> Roem.
<i>Corbula crassicosata</i> Cragin.	
<i>Sphenodiscus</i> sp.	

No. 7. Enallaster sp.	No. 13. Ostrea sp.
Pecten sp.	Cytherea? sp.
Avicula.	No. 14. Ostrea sp.
Nucula catherina Cragin.	Gryphæa forniculata White.
Anchura kiowana Cragin.	No. 15. Ostrea sp.
Sphenodiscus sp.	Gryphæa forniculata White.
No. 8. Ostrea sp.	Corbula crassicosata Cragin.
Gryphæa forniculata White.	No. 18. Ostrea sp.
Plicatula senescens Cragin.	No. 19. Ostrea sp.
No. 9. Ostrea sp.	Gryphæa tucumcarii Marcou.
Leda sp.	Small and rather distorted specimens.
Corbula crassicosata Cragin.	No. 21. Gryphæa tucumcarii Marcou.
Impressions of several other Pelecypods.	No. 22. Gryphæa tucumcarii Marcou.
No. 10. Ostrea sp.	Cardium mudgei Cragin?
No. 11. Cardium mudgei Cragin.	Turritella sp. related to T. seriatim-granulata Roem.
Corbula sp.	Anchura kiowana Cragin.
Turritella sp. related to T. seriatim-granulata Roem.	
No. 12. Ostrea sp.	

List of Fossils from hill four miles west of Sun City.

Cardium mudgei Cragin?	Turritella sp. related to T. seriatim-granulata Roem.
Cyprimeria sp.	Anchura kiowana Cragin.
Corbula sp.	

Mr. Stanton reports the following genera and species from the Belvidere shales, at all the localities mentioned:

Enallaster sp.	Cardium (Protocardia) texanum Conrad.
Ostrea sp.	Cyprimeria sp.
Gryphæa pitcheri Morton.	Cytherea?
G. forniculata White.	Tellina? sp.
Exogyra texana Roemer.	Mactra antiqua Cragin.
Plicatula senescens Cragin.	Corbula crassicosata Cragin.
Pecten sp.	Roudaria? quadrans Cragin.
Avicula belviderensis Cragin.	Dentalium sp.
Avicula leveretti Cragin, Texas.	Natica.
Inoceramus comancheana Cragin.	Turritella sp. related to T. seriatim-granulata Roemer.
Lithophagus sp.	Anchura kiowana Cragin.
Nucula catherina Cragin.	Trochus texanus Roemer.
Nucula sp.	Schlenbachia peruviana von Buch.
Leda sp.	Sphenodiscus sp.
Trigonia emoryii Conrad.	
Cardita belviderensis Cragin.	
Cardium bisolaris Cragin.	

The foregoing studies of the flora and fauna by Professors Knowlton and Stanton, aside from my own opinions, dis-

agree with Prof. Cragin's conclusions on the age and position of the Cheyenne sandstone and Belvidere shales, which he referred to the Neocomian in general and to the Trinity and Fredericksburg divisions of the Comanche series in Texas and Arkansas in particular. It is difficult to find a basis for Prof. Cragin's conclusions in the paleontology testimony he himself has presented, as will now be shown.

An analysis of the species at various times reported by Prof. Cragin, from the Belvidere shales, shows the following well-known species peculiar to the greater divisions of the Cretaceous in other regions of the United States.

Ripley, uppermost Cretaceous of Atlantic coastal region :

<i>Neithea quinquacostata</i> Sow.	<i>Modiola burlingtonensis</i> Whit-
<i>Anomia tellinoides</i> Meek.	field.
<i>A. argentaria</i> Morton.	<i>Idonearca tippana</i> Conrad.
<i>Gryphæa bryani</i> Gabb.	<i>I. vulgaris</i> Conrad.
	<i>Liopistha protexta</i> Conrad.
	Eight species.

Montana division (western equivalent of Ripley of Atlantic coast) :

<i>Cyprina ovata</i> M. & H.	<i>Ostrea anomioides</i> Meek.
	Two species.

Colorado Group (middle division of Upper Cretaceous) :

<i>Ostrea diluviana</i> ? Lam. Austin	<i>Cyprimeria crassa</i> Benton (prob-
Chalk.	ably Montana) New Mexico.
	<i>Plicatula arenaria</i> .
	Three species.

Dakota Group :

<i>Cardium kansasense</i> Meek, Salina, Kansas.
One species.

Washita division of the main area of the Comanche series :

<i>Gryphæa forniculata</i> White.	<i>Cardium hillanum</i> Sow. (i. e. <i>tex-</i>
<i>Gryphæa pitcheri</i> Mort.	<i>anum</i> Conrad).
<i>Exogyra flabellata</i> i. e. <i>texana</i> .	<i>Corbula crassicostata</i> Cragin.
<i>Neithea occidentalis</i> Conrad.	<i>Pholodomya sancti sabæ</i> Roemer
<i>Nucula catherina</i> Cragin.	<i>Turritella marnochii</i> White.
<i>Inoceramus comancheana</i> Cragin.	<i>A. acutocarinatus</i> Shum., i. e.
<i>Trigonia emoryii</i> Conrad.	<i>peruvianus</i> de Buch.
	Twelve species.

Species common to Fredericksburg and Washita divisions :

<i>A. peruvianus</i> von Buch.
One species.

Fredericksburg or Middle division Comanche series :

Exogyra texana Roemer. *Trochus texanus* Roemer.
Two species.

Trinity or Basal division :

Homomya alta Roemer. *Ostrea franklini* Coquand.
Cucullæa terminalis Conrad. Three species.

He reports two species which have been found in the Washita of Tucumcari :

Pinna comancheana Cragin. *Cardita belviderensis* Cragin.

Besides the above he gives the following species, so far reported to occur only in these beds. (Total 21 species.)

<i>Astrocœnia nidiformis</i> .	<i>Cardium mudgei</i> Cragin.
<i>Nereis incognita</i> Cragin.	<i>Roudaria</i> ? <i>quadrans</i> Cragin.
<i>Plicatula senescens</i> Cragin.	<i>Tapes belviderensis</i> Cragin.
<i>Avicula belviderensis</i> Cragin.	<i>Pholadomya</i> ? <i>elegans</i> ? Cragin.
<i>Petersia medicinensis</i> Cragin.	<i>Mactra antiqua</i> Cragin.
<i>Remondia ferrissii</i> Cragin.	<i>Leptosolen otterensis</i> Cragin.
<i>Limopsis subimbricatus</i> Cragin.	<i>Neritoma marcouana</i> Cragin.
<i>Cucullæa terminalis</i> , var. <i>recedens</i> Cragin.	<i>Vanikora propinqua</i> Cragin.
<i>Cardita belviderensis</i> Cragin	<i>Anchura kiowana</i> Cragin.
<i>Cardium</i> (<i>Nemocardium</i>) <i>bisolaris</i> Cragin.	<i>Margarita marcouana</i> Cragin.
	<i>M. (Solariella) Newberryi</i> Cragin.

From this list we can now strike out two species, *O. franklini* Coquand, which has been disproved by Stanton, and *Cucullæa terminalis* Conrad, abandoned by Cragin.

A similar analysis of the list of species given by Mr. Stanton results as follows :

He finds none of the eight Ripley species reported by Prof. Cragin, nor any of the forms reported from Montana, Colorado, Dakota, or Trinity divisions.

He finds fifteen forms previously identified in the Washita division of the North Texas region, as follows :

<i>Gryphæa tucumcarii</i> Marcou.	<i>Inoceramus comancheana</i> Cragin.
<i>Gryphæa pitcheri</i> Morton.	<i>Trigonia emoryi</i> , Conrad.
<i>Exogyra forniculata</i> White.	<i>Nucula catherina</i> Cragin.
<i>Exogyra texana</i> Roemer.	<i>Corbula crassicostata</i> Cragin.
<i>Avicula leveretti</i> Cragin ?	<i>Trochus texana</i> Roemer.
<i>Cardium</i> (<i>Protocardia</i>) <i>texanum</i> Conrad.	<i>Schlenbachia peruvianus</i> von Buch.
<i>Cyprimeria</i> sp.	<i>Sphenodiscus</i> sp.
<i>Turritella</i> , related to <i>T. seriatim-granulata</i> Roemer.	Total fifteen.

Common to Washita and Fredericksburg:

Exogyra texana Roemer. *Schlœnbachia peruvianus* von Buch.

Fredericksburg division:

Trochus texanus Roemer.

Mr. Stanton also finds the following species described from Kansas by Cragin, viz.:

<i>Cardium bisolaris</i> Cragin.	<i>Nucula catherina</i> Cragin.
<i>Mactra antiqua</i> Cragin.	<i>Cardita belviderensis</i> Cragin.
<i>Plicatula senescens</i> Cragin.	<i>Corbula crassicostata</i> Cragin.
<i>Avicula belviderensis</i> Cragin	<i>Inoceramus comancheana</i> Cragin.
<i>Roudaria quadrans</i> Cragin.	<i>Anchura kiowana</i> Cragin.
	Total ten.

Tabulating these results, they show:

	Reported by Cragin.	Reported by Stanton.
Uppermost Cretaceous { Ripley species, 8 } --	10	0
Colorado species -----	3	0
Dakota species -----	1	0
Washita species, { Texan, 11 -- } -----	13	15
{ Tucumcari, 2 } -----		
Belvidere species -----	21	10
Common to Washita and Fredericksburg -----	2	2
Fredericksburg species -----	1	1
Trinity species -----	1	0
Species common to other localities, 31		
Peculiar species ----- 21		
Total -----	52	28

When Prof. Cragin first announced the occurrence of *Ostrea franklini* and the Trinity sands in Kansas—before giving the paleontologic details since published—the writer was inclined to accept his conclusions.* But as Prof. Cragin's paleontologic publications progressed, it became my opinion, even without having seen the region, that the Belvidere beds of Kansas represented the writer's upper or Washita division of the Lower Cretaceous section, and not entirely the Fredericksburg and Trinity as asserted by Cragin. This opinion was confirmed after seeing, later, Prof. Cragin's collections at Washburn College.

If distantly situated beds are to be correlated by the law of common species, it is impossible to see upon what ground Prof. Cragin referred these beds entirely to the Trinity and Fredericks-

* See Annual Report Arkansas Geological Survey, vol. ii, 1888, p. 115.

burg. According to the fauna as identified by him and as analyzed above, they could more logically have been referred to the uppermost Upper Cretaceous (the Montana division) than to the Fredericksburg, since the list contains more Ripley-Montana than Fredericksburg species. But the Washita species as enumerated by him far exceed those from all other divisions, and hence upon his own data the beds should have been chiefly referred to this division.

Concerning the alleged Ripley, Montana, Colorado and Dakota species mentioned by Prof. Cragin, it is strange that none of them were found in the collections studied by Mr. Stanton, and we cannot escape the conclusion that they were founded upon erroneous identifications.

Mr. Stanton's studies of the fossils of the Belvidere shales also demonstrate the opinion I have long entertained, that these fossils are largely of the age of the Washita division of my Texas section, and not solely the Fredericksburg and Trinity divisions, as maintained by Cragin. I am glad to have my own conclusions sustained by such an authority, and I fully agree with him that the Belvidere beds represent in general the Washita division and probably the attenuated Fredericksburg as seen in the North Texas section.

There are several points more strongly suggesting this affinity than Mr. Stanton has brought out. Mr. Stanton's diagnosis removes the alleged *O. franklini* from the list of Kansas species, while Prof. Cragin himself has retracted the other Trinity species (*Cucullæa terminalis* Conrad) which he once reported.* The facts eliminate the sole molluscan species upon which Prof. Cragin could correlate these formations with the Trinity division of Texas.

Mr. Stanton also finds in the Belvidere shales two additional species which Cragin himself has recently described from Texas, to wit: *Avicula leveretti*,† of the Washita of Denton county, Texas, and the peculiar *Inoceramus* to which I have called attention in previous writings, as being found only in the Preston beds,‡ and to which Prof. Cragin has recently given the name *I. comancheana*.§ Thus we have common to the Belvidere beds of Kansas and the Preston beds of the Washita division of Texas and Indian Territory the following peculiar species which occur in no other geologic horizon, and seem to intimately connect these beds at the two localities:

* American Geologist, vol. xiv, 1894, p. 3.

† Invertebrate Paleontology of the Texas Cretaceous, Austin, June, 1893, pp. 171-172.

‡ Bull. Geol. Soc. of America, vol. v, p. 332.

§ Colorado College Studies, 1894, p. 53.

Gryphæa forniculata White.
Avicula leveretti Cragin.
Inoceramus comancheana Cragin.

Of the fifteen recognized species common to both the Kansas and Texas regions all occur in the Washita division of Texas and eleven are found only in it. The Fredericksburg fossils reported by him with the exception of one little known fossil hitherto reported only from the Caprina limestone of the Fredericksburg (*Trochus texana* Roemer), are all of species which in Texas also occur in the Washita division. These species are as follows: *Exogyra texana* Roemer, *Sphenodiscus* sp. Cragin, *Schlenbachia peruviana* von Buch, and *Trigonia emoryi* Conrad. In all the writer's years of labor and study of the region he has never seen *Trigonia emoryi* in the beds of the Fredericksburg division, and although so reported by the Texas Geological Survey, he does not believe it occurs there, while it is common, abundant and widely distributed in the beds of the Washita division.

The *Sphenodiscus* from the Belvidere beds may possibly be confused with *S. pedernalis* Roemer, of the Fredericksburg division. A large number of undescribed species belonging to this group of Ammonites occur in the Comanche Series from the Glen Rose through the Washita division. The writer has observed these differences for years and submitted the species to eminent authorities. It can only be said now, as Mr. Stanton has already said, that the *Sphenodiscus* of the Belvidere beds—a figure of which without description has been published by Cragin*—is not *S. pedernalis* of Roemer. On the other hand, some of the Belvidere specimens seem to resemble species occurring in the Denison beds of the Washita division.

This leaves only two undoubted species common to the Fredericksburg and Washita in the Belvidere beds. These are *Exogyra texana* Roemer, and *Schlenbachia peruvianus* von Buch.

Exogyra texana Roemer is found to range upward into the Washita division in New Mexico, in Trans Pecos, Texas, and at El Paso, but the writer, in the course of his extensive observations, has never seen it in Central Texas above the Fredericksburg division. While this form usually has a well defined zone of abundance in the Walnut clays at the base of the Fredericksburg division, it really has a wide vertical range, occurring in the underlying Glen Rose and the upper beds of the Caprina limestone in the Austin region and associated with a Fort Worth fauna at Frontera, three miles west of El Paso.

* The Neocomian of Kansas, American Geologist, 1894, Plate I, fig. 4.

As has been previously shown by Roemer, this species greatly resembles *Exogyra matheroniana*, an allied species, which in Europe also has a wide vertical range and extends as high as the Senonian. It was largely owing to its abundant occurrence in Texas that Roemer made the cardinal mistake of considering the Lower Cretaceous beds to be Upper.

On the other hand, none of the many peculiarly characteristic Fredericksburg species of Texas occurs in the Kansas beds.

Concerning the twenty-three species which Prof. Cragin describes and which have as yet been reported only from the Belvidere shales, the writer believes that many of them are due to the fact that they represent the naturally denser population of the more northern shallower littorals; others will be found to occur in the rich unstudied littoral faunas of the Washita division in North Texas,* while some of them will be reduced to synonyms. They all belong to that group of littoral genera with a wide range and of little value for minute correlation.

The species called throughout this paper *Gryphæa forniculata* White is the same as the one from Comet Creek, Oklahoma, first figured by Prof. Marcou as *Gryphæa pitcheri* Morton,† and later called by him *Gryphæa Roëmeri*.‡ 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. Roëmeri* 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 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.

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*).§

* Since penning these words Prof. Cragin himself has already verified this prophecy by publishing many species from the Denison beds which emphasize this assertion. See Fifth Annual Publication, Colorado College Studies, received April, 1895.

† Geology of North America, Plate IV, fig. 5, 5a, 6.

‡ Proc. Boston Soc. Natural History, 1861, p. 95.

§ Loc. cit., Pl. IV, fig. 1, 1a, 2.

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 called *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.

A lithologic comparison of the Belvidere shales and those of the Washita division, North Texas section, is also of interest. While differing in detail, there is one broad generic resemblance. They are both in general shallower water deposits than the beds of the Fredericksburg division, the shales being blacker and containing beds of littoral sand.

Owing to the underlying Dakota flora of the Cheyenne sandstone there may be doubt in the minds of some whether to assign the Belvidere shale to the Dakota or to the Washita division, but it is difficult in view of the facts presented to see upon what possible ground they could have been referred to the Trinity division.

Prof. Knowlton's determination of the dicotyledonous Dakota flora in the top of the Cheyenne sandstone shows that from a paleontologic standpoint these sandstones have no resemblance to the flora of the Trinity division at Glen Rose, Texas, beds which contains a flora of typical Potomac nondicotyledonous species.† The Cheyenne sandstones are of far later age than the Trinity, and occupy a stratigraphic position at the base of the Washita midway between the Trinity and the Dakota.

These facts being true, Prof. Cragin's assertion that the Dakota sandstone (No. IV of the general section) in Kansas rests directly on the Fredericksburg division without the intervention of the Washita division is also disproved.

Concerning the correlation of the Belvidere beds with the Neocomian, as done by Prof. Cragin, we can only repeat our opinion, founded upon facts previously given, that the Washita division is homotaxially nearer the equivalent of the Gault, and that the lower lying beds of the Trinity division are

* According to Mr. E. T. Dumble, *American Geologist*, November, 1893, pp. 310-312.

† See *Proceedings U. S. National Museum*, vol. xvi, pp. 261-282.

more nearly the nearer equivalents of the Neocomian in the United States.*

The Camp Supply Beds.—There can be little doubt but that the localities of the Cretaceous near Camp Supply reported by Prof. Cope,† and at Comet Creek, reported by Prof. Jules Marcou,‡ represent a portion of the same general sedimentation as the Belvidere beds which Prof. Cragin himself has reported in Northern Oklahoma.

From the beds near Camp Supply Prof. Brown, of the University of Kansas, reports eleven invertebrate species, as follows:

1. Gryphæa§ forniculata White.	7. Plicatula incongrua Cragin.
2. Exogyra texana Roem.	8. Trigonía emoryii Conrad.
3. Ostrea subovata Shum.	9. Trigonía sp.
4. Ostrea quadriplicata Shum. (variety).	10. Turritella seriatim granulata Roemer.
5. Cucullæa terminalis Conrad.	11. Schlenbachia peruvianus von Buch.
6. Neithea occidentalis Conrad.	

Of the nine species named, the following have been reported from the Belvidere shales of Kansas:

1. Exogyra texana Roemer.	5. Turritella seriatim granulata Roemer.
2. Gryphæa forniculata White.	
3. Trigonía emoryii Conrad.	6. Schlenbachia peruvianus von Buch.
4. Cucullæa terminalis Conrad.	

The following are characteristic species of the Washita division of Central Texas:

1. Gryphæa forniculata White.	5. Trigonía emoryii Conrad.
2. Ostrea subovata Shum.¶	6. Schlenbachia peruvianus von Buch.
3. Ostrea quadriplicata Roemer.	
4. Plicatula incongrua Conrad.	

The following species are common to the Fredericksburg and Washita divisions of Texas:

Neithea occidentalis Conrad.	Schlenbachia peruvianus von Buch.
Turritella seriatim-granulata Roemer.	

* Age and Significance of the Trinity Division. Proc. Biological Society of Washington, vol. viii, pp. 17–20, 1893. Bull. Geol. Soc. of America, vol. v, pp. 336–37, 1894.

† Observations on the Geology of Adjacent Parts of Oklahoma and North West Texas, Proc. Nat. Sci. Acad. Phila., 1894, p. 63.

‡ Geology of North America, p. 17.

§ Originally published as *G. pitcheri* Morton. Prof. Brown informs me by letter that it is the form figured by Marcou, i. e. *G. forniculata* White.

|| Originally published as *O. crenulimargo* Roemer by Prof. Brown. He informs me that he now regards it a variety of *Ostrea quadriplicata* Shum.

¶ See remarks on this species by Dr. Benj. F. Shumard, Trans. Academy of Science of St. Louis, vol. i. p. 587. He here states that its horizon is the Washita limestone and gives more light upon it than is contained in his original description of it in Marcy's Report on Red River.

The vertebrata from these beds strikingly resemble those described by Williston and Cragin from the Belvidere beds of Kansas with the exception of two species of Pycnodont fishes belonging to the genera *Uranoplosus* and *Cœlodus*, for which this is a new horizon.*

Concerning these vertebrates Prof. Cope† remarks :

“The three species of Pycnodont fishes were new to science, and they have a Lower Cretaceous facies. *Plesiosaurus* is represented by dorsal vertebræ only, but these are not of the Upper Cretaceous type. I have never found Lepidotid fish remains in the Upper Cretaceous of North America, while they are characteristically Lower Cretaceous and Jurassic in Europe. The only occurrence of Lepidotid fishes so far recognized in North America, is based on some teeth sent by Mr. Charles H. Sternberg in the Dakota sandstone of Kansas, and on the new species, *Macrepistius arenatus*, from the Trinity bed of Texas discovered by Prof. R. T. Hill. (See Journal of the Academy Natural Science, Philadelphia, vol. ix, Part 4). The crocodilion remains are undeterminable.”

From the molluscan species it will be seen that these beds paleontologically more resemble the Washita division than the Fredericksburg. Furthermore, they show the same general association of molluscan species as do the Belvidere shales, and like them differ from the beds of the Central Texas region by containing vertebrates. That they are a southern extension of the Belvidere beds there can be no reasonable doubt.

The Comet Creek Bed.—Little is known concerning the isolated remnant of the Cretaceous formations at Comet Creek, in G county, Oklahoma, the only locality of the Comanche Cretaceous recognized as having been seen by Prof. Jules Marcou in his journey with the Pacific railway explorations.‡ According to this author this locality consists of a single stratum of “Gryphæate limestone” “five feet thick” containing one fossil species, the *G. pitcheri* of Marcou. This species has been found elsewhere only in the Washita division and is especially abundant in both the Belvidere shales of Kansas and the Preston beds of Texas. This is the fossil which Prof. Marcou figures so well as *Gryphæa pitcheri*§ Morton, but for which he himself later suggested the more appropriate name of *G.*

*The species of the genus *Mesodon* from Texas described by Prof. Cope with these fishes, as coming from Texas, belong to the Trinity division.—See New and Little Known Paleozoic and Mesozoic Fishes, Journal Academy of Natural Science, vol. x, Philadelphia, 1894.

†Proc. Phila. Acad. of Nat. Science, loc. cit., 243.

‡See Geology of North America, p. 17.

§He says, Geology of North America, page 38: “The drawings are very exact and were done from nature by Humbert, the most skilful artist for fossils in Paris.”

Ræmeri,* and which White later described as *G. forniculata*, as called throughout this paper.

Inasmuch as these beds lie in the Kansas province, i. e., the region north of the Ouachita system of mountains, and is completely cut off from the Texas region by them, it is reasonable to infer, until the localities can be visited, that the Comet Creek bed is a part of the same general formation as those near by at Camp Supply and Belvidere.

The Tucumcari Region.—The Tucumcari exposures, as we shall call the New Mexican localities of the Cretaceous, are the most isolated of all the Comanche deposits, and, as we have shown, there is no possibility of tracing by stratigraphic continuity their relations with the main Kansas and Texas areas. They are two hundred and fifty miles southwest and west of the Belvidere and Comet Creek localities; about two hundred miles northwest of the nearest Texas localities in the breaks of the Plains on the headwaters of the Brazos, and three hundred miles north of the Kent localities in Trans Pecos, Texas. If there was stratigraphic connection between these localities across the intervening areas, it was forever destroyed by the great pre-Plains erosion, or obscured by the succeeding Plains sedimentation.

Yet paleontology again comes to our aid to show that the small thickness of Comanche Cretaceous preserved in this isolated area was intimately connected with the other outlying areas. It is unfortunate that in the following remarks we have not the benefits of the publication of the results of the field season spent by Prof. Alpheus Hyatt in this region in the year 1889. The writer has seen his collections, however, and has no fear in saying that, when published, they will substantiate the general proposition maintained in this paper. That he and every other modern writer holds these beds to be of Cretaceous age, and not Jurassic, as maintained by Prof. Jules Marcou, is also fully substantiated. We shall not enter into this controversy here. Aside from Prof. Hyatt's unpublished collection, three collections have been made from this region.

1. By Prof. Jules Marcou, who collected two species as follows: *Gryphæa tucumcari* Marcou, later figured by him as *Gryphæa dilatata* var. *tucumcarii*; and *Östrea Marshi* Marcou.

2. A collection made by the writer, April 30, 1891, and now in the collections of Johns Hopkins University, a list of which was published in Science of July 14, 1893.

3. A collection made by members of the Texas Geological Survey, in the summer of 1891, a list of which as identified by Mr. T. W. Stanton of the U. S. Geological Survey, was published on page 208 of the third annual report of that survey.

* Proceedings Boston Society of Natural History, 1861, p. 95.

In addition Prof. Cragin has recognized from the Tucumcari collections of the Texas Survey two species which he had collected from Belvidere, *Cardita belviderensis* Cragin and *Pinna comancheana* Cragin. Mr. Stanton has also identified *Roudaria* [?] *quadrans* Cragin in the Tucumcari collections made by Prof. Hyatt, and *Trigonia emoryi* Con., *Protocardia texanum* Con., *Cardita belviderensis* Cragin, *Tapes belviderensis* Cragin, and *Cyprimeria* sp. from the collection made by the writer.

Counting all these known fossils, we have from the Tucumcari beds the following list of species of invertebrates :

<i>Turbinolia texana</i> [?] Conrad.	<i>P. texanum</i> Conrad.
<i>Ostrea Marshi</i> , as determined by Marcou.	<i>Cytherea leonensis</i> Conrad.
	<i>Pinna comancheana</i> Cragin.
<i>Ostrea quadriplicata</i> Shumard.	<i>Cardita belviderensis</i> Cragin.
<i>Gryphæa dilatata</i> , var. <i>tucumcarii</i> Marcou.	<i>Tapes belviderensis</i> Cragin.
	<i>Roudaria</i> [?] <i>quadrans</i> Cragin.
<i>Gryphæa pitcheri</i> Morton.	<i>Cyprimeria</i> sp.
<i>Exogyra texana</i> Roemer.	<i>Turritella seriatim granulata</i> Roemer.
<i>Plicatula</i> , species undescribed.	
<i>Neithea occidentalis</i> Conrad.	<i>Turritella marnochii</i> White, or <i>seriatim granulata</i> Roemer.
<i>Trigonia emoryii</i> Conrad.	
<i>Protocardia multistriata</i> Con.	<i>Ammonites leonensis</i> Conrad.

These species all come from the impure shaly beds below the highest escarpment of brown sandstone, which we shall elsewhere discuss under the Dakota, and above the unfossiliferous white sands, occupying a vertical range of about 115 feet in thickness.

Of the twenty species enumerated thirteen are also represented in the Belvidere beds, as follows :

<i>Gryphæa dilatata</i> var. <i>tucumcarii</i> Marcou.	<i>Tapes belviderensis</i> Cragin.
	<i>Pinna comancheana</i> Cragin.
<i>G. pitcheri</i> Morton.	<i>Cardita belviderensis</i> Cragin.
<i>Exogyra texana</i> Roemer.	<i>Roudaria</i> ? <i>quadrans</i> Cragin.
<i>Plicatula</i> , species.	<i>Turritella seriatim-granulata</i> Roemer.
<i>Trigonia emoryii</i> Conrad.	
<i>Protocardia multistriata</i> Conrad.	<i>Turritella marnochii</i> White.

The analogy between these fossils and those characterizing the Washita division is so striking that it hardly seems necessary to make comparisons of the species enumerated. The following are peculiar to and characteristic of the Washita division :

<i>Turbinolia texana</i> Conrad.	<i>Trigonia emoryii</i> Conrad.
<i>O. quadriplicata</i> Shumard.	<i>Pinna comancheana</i> Cragin.
<i>G. dilatata</i> var. <i>tucumcarii</i> Marcou.	<i>Cardita belviderensis</i> Cragin.
	<i>Protocardia texanum</i> Conrad.
<i>G. pitcheri</i> Morton (var. not given).	<i>Turritella marnochii</i> White.
<i>Plicatula</i> sp.	<i>Ammonites leonensis</i> Conrad.

Of the remaining six, one, *Cytherea leonensis* Conrad, is a form which is reported in the Mexican Boundary Report from near Leon Springs. The writer has never seen this species *in situ*. *Ostrea Marshii* is a form which Dr. B. F. Shumard calls *O. subovata*, and which he has identified from his "Washita limestone," which is practically synchronous with the whole of our Washita division. Of this species he says:*

"I have before me specimens of *O. subovata* from Fort Washita, several localities in Grayson and McLennan counties, and from Mt. Bonnell, near Austin, some of them in a beautiful state of preservation, and have compared them most carefully with Marcou's figure of *Ostrea Marshii*, in the Geology of the U. S., without being able to detect any difference whatever of specific value. . . . I have also compared my specimens of *O. subovata* with an authentic example of *O. Marshii* from Europe, and regard them as being specifically distinct, as much so as we usually find in closely allied species."

Protocardia multistriata Conrad is a species of *Protocardia* which may occur in both the Fredericksburg and Washita divisions. The writer has specimens from the Denison beds of the Washita division which are indistinguishable from it.

This leaves only three species, *Turritella seriatim-granulata* Roemer, *Exogyra texana* Roemer, and *Neithea occidentalis* Conrad, which may have a common range into both the Washita and Fredericksburg divisions.

The absence of the rich fauna of the Fredericksburg and Glen Rose which constitutes the great thickness of the Central Texas section is conspicuous.

It must be apparent that the fossils from the Comanche Cretaceous at Tucumcari are nearly related to the faunas of the Washita division of North Texas, and to the Trans Pecos and Belvidere regions, and they show certain transitional conditions between the variations seen in the faunas of these extreme localities, such as the occurrence of species so far as known hitherto found in only one of the regions, such as *Turbinolia texana*, of El Paso region, *O. quadruplicata* Shumard, of the Central Texas region, *Ammonites leonensis* Cragin, of the Central Texas and Trans Pecos region, and *Pinna comancheana* Cragin, *Roudaria? quadrans* Cragin, and *Cardita belviderensis* Cragin, of the Belvidere region.

The age of the arenaceous beds underlying the first fossiliferous horizon of Tucumcari is still problematic. In previous papers the writer has noted their lithologic resemblance to the basement arenaceous Trinity littoral of the Comanche series of Texas.

* Trans. Academy of Science, St. Louis, 1860, vol. i, No. 4, p. 587.

The white sands between the Red Beds and Washita fauna are lithologically somewhat different from the Cheyenne sandstones, but it is an interesting fact hitherto unpublished, that they contain dicotyledonous leaves of, at least one species identical with those of the Cheyenne sandstone, the *Sterculea Snowii* of Lesquereux. This specimen was collected by the State Geological Survey, and erroneously described,* as Prof. F. H. Knowlton has shown,† as a new species under the name *Sterculea drakei* Cummins. It was also erroneously published,‡ as having come "From the upper sandstone of the Tucumcari beds four miles west of Tucumcari Mountain, New Mexico, above the bed of blue clay, 'bed F' of Marcou's section."§ Mr. N. F. Drake in a recent letter to Mr. J. A. Taff,|| as announced by the latter before the Geological Society of Washington, April, 1895, stated that he collected this particular specimen, and that it came from the basal sandstone below the molluscan-bearing beds and not from the Dakota above it. It is the writer's opinion that when these basal beds are fully studied, they may be found to represent the initiatory sediments of the Comanche sea upon the Red Beds in this region, like the Trinity sand of Central Texas, the Antlers sands of Southern Indian Territory, and the Cheyenne sandstone of Kansas, all members of the great initiatory littoral formation, marking epochs in the migration of the sea which, during the Comanche epoch, transversed them diagonally northward across the Great Plains Region.

A comparison of the two sections at Tucumcari and Belvidere which the writer has personally studied, reveal some common interesting general features. Both localities show topographic similarity in that they are remnantal buttes in the margins of the Plains. The summits of both sections are the mortar-bed-like rocks of the Tertiary Plains formation resting, through unconformity by erosion, on a sandstone of supposed Dakota age. Beneath this alleged Dakota sandstone in each locality are clay shales with marine fossils of the Washita division; below these molluscan-bearing shales are sands containing the dicotyledonous *Sterculea Snowii* Lesquereux, while the base of each is the Red Beds.

The observable differences between the Belvidere and Tucumcari localities are as follows: *G. dilatata* occurs at the base of the Washita beds at Tucumcari, while at Belvidere it ranges near their summit. The Tucumcari fauna contains above the

* Annual Report, Texas, State Geol. Survey, 1891, p. 210.

† American Journal of Geology, vol. ii, No. 4, p. 372.

‡ Geol. Survey of Texas, Third Annual Report, 1891, p. 210.

§ Ibid, p. 209.

|| We are indebted to Mr. J. A. Taff for permission to use this information.

G. dilatata zone, *Ammonites leonensis* Conrad and *O. quadriplicata* Shumard, characteristic middle and upper Washita species of the Central Texas region, which do not occur at Belvidere. In general association the species of the Tucumcari locality have greater resemblance to that of the uppermost beds of the Washita division of the Central Texas section, while the common forms of the Belvidere beds, such as *Schlaenbachia peruvianus* and *Gryphæa Ræmeri*, are more common to the Preston or basal beds of the Washita. More minute studies of the range of species in the Tucumcari beds is necessary before any positive conclusions on these subjects can be stated.

The seventy-five feet of alleged Dakota sandstone overlying the fossiliferous beds of Tucumcari will be more fully discussed in a future paper.

The outlying beds of the Washita division are also found far southward in the Trans Pecos region of Texas at Kent,* El Paso and as far west as Arivichi in Sonora, where its fauna was reported by Gabb. We cannot here continue the presentation of the minute data concerning them, but they, together with the data we have given concerning the beds in Kansas, Oklahoma and New Mexico, all demonstrate the generalization we have before presented,† that the beds of the Washita division far overlapped interiorward those of the Trinity division. This study has enabled us to classify and understand the significance of the outlying areas of the Cretaceous in Oklahoma, New Mexico, and Trans Pecos, Texas, and their paleontologic relations as shown in the appended table.

The geology of these outlying areas of the Cretaceous preserved in the scarps of the Plains adds greatly to our knowledge of the distribution, variation, paleontology, and history of the beds of the Comanche series and of the progressive oscillatory conquest of the Great Plains region by the sea in Cretaceous time. The Belvidere beds have revealed the following additions to our knowledge of Cretaceous paleontology: First, a lower stratigraphic occurrence of the dicotyledonous Dakota flora than known, whereby we may now say that dicotyledons make their first appearance before the beginning of the Washita sub-epoch, instead of in the Dakota as hitherto believed. Second, a similar downward range in the geologic scale of the Ichthyian vertebrates of hitherto supposed Upper Cretaceous range. Third, intermingling of these plants and fishes with molluscan species and other vertebrates of the Washita division such as has not hitherto been found in the Comanche series.

* See sections by E. T. Dumble, Bull. Geol. Soc. America, vol. vi, pp. 376-388, and American Geologist, vol. xii, p. 309.

† Bull. Geol. Soc. of America, vol. v, p. 332-338.

These beds represent the modified attenuated northern extension of the Washita division and probably a portion of the Fredericksburg division of the Comanche series of Texas, which, as we have previously shown, far overlapped to the northward those of the Trinity division. The beds of the later division have not been found north of the 34th parallel and there is every reason to believe that their original sedimentation did not extend north of this line. Neither are the remarkable limestones and accompanying forms of the great Caprina limestone of southern Texas represented in the outlying areas.

Known Occurrence of Species of the Outlying Areas of the Comanche Series.

	Washita.					Fredericksburg.	Trinity.
	Kansas.	Oklahoma.	New Mexico.	Trans Pecos, Tx.	Central Texas.		
<i>Turbinolia texana</i> Conrad	--	--	×	×	×		
<i>Terebratula wacoensis</i> Roemer	--	--	×	×	×		
<i>Ostrea subovata</i> Shumard	?	×	×	×	×		
<i>Ostrea quadriplicata</i> Shumard	--	×	×	×	×		
<i>Gryphæa forniculata</i> White	×	×	×	×	×		
<i>Gryphæa pitcheri</i> Morton	×	×	×	×	×		
<i>G. dilatata</i> var. <i>tucumcarii</i> Marcou	×	×	×	×	--		
<i>Exogyra texana</i> Roemer	×	×	×	×	--	×	
<i>Exogyra plexa</i> Cragin	--	--	--	×	×		
<i>Plicatula incongrua</i> Conrad	--	×	×	×	--		
<i>Plicatula belviderensis</i> Cragin	×	×	×	×	--		
<i>Lima wacoensis</i> Roemer	--	--	--	×	×	×	
<i>Neithea occidentalis</i> Conrad	--	×	×	×	×	×	
<i>Avicula belviderensis</i> Cragin	×	--	--	--	--		
<i>A. leveretti</i> Cragin	×	--	--	--	×		
<i>Pinna comancheana</i> Cragin	×	--	×	--	?		
<i>Inoceramus comancheana</i> Cragin	×	--	--	--	×		
<i>Nucula catherina</i> Cragin	--	--	--	--	--		
<i>Trigonia emoryii</i> Conrad	×	?	×	×	×		
<i>Cardita belviderensis</i> Cragin	×	--	×	--	--		
<i>Protocardia texanum</i> Conrad	×	×	×	×	×		
<i>P. multistriatum</i> Conrad	--	--	×	×	×		
<i>Cyprimeria species</i>	×	--	×	×	×		
<i>Cytherea leonensis</i> ? Conrad	--	--	×	×	--		
<i>Cytherea</i> sp.	×	--	--	--	×		
<i>Mactra antiqua</i> Cragin	×	--	--	--	--		
<i>Corbula crassicostata</i> Cragin	×	--	--	--	×		
<i>Tapes belviderensis</i> Cragin	×	--	×	--	--		
<i>Roudaria quadrans</i> Cragin	×	--	×	--	--		
<i>Turritella seriatim-granulata</i> Roemer	×	×	×	×	×	×	
<i>T. marnochii</i> White	--	--	--	--	--		
<i>Trochus texanus</i> Roemer	?×	--	--	--	--	×	
<i>Ammonites leonensis</i> Conrad	--	--	×	×	×		
<i>Schloenbachia peruvianus</i> von Buch.	×	×	--	×	×	×	
<i>Sphenodiscus</i> sp.	×	--	--	×	×	×	