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EMIL BÖSE AND O. A. CAVINS

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CRETACEOUS AMMONITES FROM TEXAS AND NORTHERN MEXICO

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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FOREWORD

The late Dr. Emil Böse, the senior author of this publication, was born at Hamburg, Germany, in 1868. After taking his Doctorate at Munich in 1893 he became geologist of the Mexican Geological Survey where he served from 1898 to 1915. He contributed a large part of the geological studies preliminary to and to the actual direction of the program of the Tenth International Geological Congress held in Mexico in 1906.

From 1915 to 1917 he served as geologist for the Bureau of Economic Geology of the University of Texas. From 1917 to 1922 he was engaged in consulting problems in oil and water in Mexico, Texas, Oklahoma and New Mexico. From 1922 until the time of his death he was employed by the Richmond Petroleum Company of Mexico, S. A., as geologist, continuing his investigations in the geology of Mexico and southern Texas and working in more detail areas with which he was already somewhat familiar. During most of this latter period he worked with the junior author.

The present publication has grown out of the desire to record the results of the interesting geological studies of an area, which considering its proximity to Texas and the amount of economic geological examination which it has undergone, is poorly represented in the literature. The publication is based on the long experience of Dr. Böse in Mexico and Texas prior to 1922, reinforced by the more or less detailed studies with the junior author during the period from 1922 to the date of Dr. Böse's retirement to his deathbed.

By training and experience Dr. Böse was eminently fitted to report on the geological and paleontological problems of Mexico. He was regarded by the foremost geologists of the world as the best informed geologist on Mexican geological problems in addition to being an authority on ammonites in general and those of the Cretaceous in particular. Trained under Karl Zittel, he had done some good work in the Alps before going to Mexico, where a virgin geological field awaited him.

His field work in Mexico and areas adjacent to it gave him a great deal of first-hand information, the results of which are given in this publication.

On September 9, 1927, Dr. Böse was seriously injured in an automobile accident at Sabinal, Texas, while this publication was on press. He was confined to his bed and died the following eighth of November. It is greatly to be regretted that Dr. Böse was unable to see the publication through to its finished form. The proof reading devolved upon the junior author, who accepts the responsibility for any typographical errors and here wishes to thank the staff of the Bureau of Economic Geology for their kind and efficient aid.

O. A. CAVINS.

Most of the investigations recorded in this bulletin were made by the authors while in the employ of the Richmond Petroleum Company of Mexico, S. A., by whom permission to publish has been very generously extended. The Bureau of Economic Geology is very glad to be the medium of publication of this extended contribution to the geology of southern Texas and northern Mexico and acknowledges its indebtedness both to the authors and to the company. It is believed that the publication will be useful in a large way to geologists and to the petroleum industry and other industries based on the geologic sciences.

E. H. SELLARDS.

THE CRETACEOUS AND TERTIARY OF SOUTHERN TEXAS AND NORTHERN MEXICO*

BY EMIL BÖSE AND O. A. CAVINS

INTRODUCTION

In a recent paper the senior author[1] has summarized the Jurassic and Cretaceous stratigraphy of the mountains between the Sierra de Parras and Monterrey, Nuevo Leon, Mexico, a territory which was practically unknown geologically up to that time. During the years 1923 to 1926 we have had an opportunity to study in some detail the stratigraphy of the Cretaceous, and partly also of the Tertiary, in the low land east of the Sierra Madre Oriental, from the region north of Tampico to that northwest of Piedras Negras, Coahuila (opposite Eagle Pass on the American side), and this gives us an opportunity to clear up a number of points which so far have remained in doubt.

The literature on this region is not very plentiful and mostly refers to reconnaissance trips, such as the one made by José G. Aguilera described in Bulletins 4–6 of the Instituto Geológico de México, or the publications of Dumble by the California Academy of Science. Others were dedicated to an entirely different object and treat the stratigraphy in a secondary way, as the studies of ore bodies in the San Carlos Mountains, Tamaulipas, by Kemp and Finlay. Paleontological papers referring to these regions have been published only by T. W. Stanton and by L. W. Stephenson, who have shown us the existence of an entirely new rudistid fauna representing either the uppermost Turonian or the Emscherian (Coniacian) and the Santonian.

Recently certain papers were published which aim to elucidate the stratigraphy of parts of this region. W. A. Ver Wiebe[2] tries to give an idea of the stratigraphy in the region of the oil fields near Tampico and to the south of that

*Manuscript submitted September, 1927; published April 1928.
[1]E. Böse, 12.
[2]W. A. Ver Wiebe, 93.

city, but unfortunately he does not base his subdivision on paleontology.

The same may be said of the essay by Ben Belt,[3] who also gives a subdivision of the beds of the same region. To a certain degree this applies also to a paper published by Richard A. Jones on the so-called Salado Arch between Laredo and Rodriguez, Nuevo Leon.

All these recent authors, as well as Dumble, make systematic subdivisions of the Cretaceous and Tertiary of the region, but unfortunately use only local names for the different beds, and do not try to correlate them with the universally recognized horizons; a discussion of the faunas of the different beds is entirely neglected.

Thus there was much left to be done and, as we had the good fortune of discovering a number of fossil localities with characteristic faunas, the following pages may contribute a little to the knowledge of the subdivision and the change of facies of the Cretaceous and Tertiary in the region here described.

Several gentlemen have kindly assisted us by lending us fossil material; for this we have to thank Messrs. P. H. Bohart, L. C. Shelton, and G. H. Keeley, of the Mexican Gulf Oil Company; Messrs. A. H. Noble and W. S. Adkins, of the Aguila Petroleum Company; Dr. Brändlin, of the Crédito Petrolero, and Mr. Griffith, of the Espuela Oil Company, all in Tampico. We also want to express our thanks to Dr. Carl Burckhardt, of Mexico City, for the determination of a number of Jurassic fossils, and to Mr. Juan D. Villarello, director of the Instituto Geológico de México, for his kindness in having put at our disposition the collections and the library of the Geological Survey of Mexico.

In some of the expeditions Mr. J. B. Orynski has taken active part, and to him we owe the collection of many fossils and the measuring of beds especially in the region north and northwest of Lampazos, Nuevo Leon.

For the determination of the fossils and the conclusions drawn from them the senior author of this publication, Dr. Emil Böse, is responsible.

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[3]Ben C. Belt, 5.

GENERAL TOPOGRAPHY OF THE REGION

In the state of Tamaulipas and Nuevo Leon, Mexico, the highly folded and overthrust masses of the Sierra Madre terminate toward the east in a rather abrupt face. From the foot of these mountains a slightly hilly country extends east toward the Gulf of Mexico and is divided into two portions in the south by the Sierra de Tamaulipas and farther north by the Sierra de San Carlos. North of these latter mountains, plains and hills undivided by a central range form the country east of the Sierra Madre. Still farther north the Sierra de Ramones, which may be considered as the southern end of the Sierra de Picachos, causes the plains and hill country to become much narrower; and still farther northeast the Sierra de Vallecillo takes the place of another portion of it. But north of the Sierra de Lampazos and the Sierra de Vallecillo the hilly country expands again toward the west and is limited there by the Mesa de Cartujanos and the Sierra de Pajaros Azules; it ends practically in the valley through which the Monclova-Piedras Negras Railway runs; the low land becomes restricted to a narrow strip east of the Burro Mountains and limited there by the Rio Bravo (Rio Grande).

This description of course states only the most general features of the region; there exist numerous more or less well defined ridges and rows of hills which cannot be named here, but on the following pages we shall always indicate the location of the different points of which we are speaking. Still we must briefly describe some of the topographical features. On almost every map, we find in the region between the country of Guerrero, Tamaulipas, and the northern boundary of the State of Nuevo Leon, a very distinct ridge called Ceja Madre (Ceja means brow, and in this part of the country is usually applied to a distinct ridge of the scarp type of hills). In reality this name here applies to different ridges and is not at all the name of one distinct topographical element; where one ridge dies out, another one takes the name if it lies more or less in the same direction. In other words, the Ceja Madre consists of a number of ridges and as we shall see later on, part of it is formed of Cretaceous, and another part of Tertiary formations.

STRATIGRAPHY

The region discussed here is formed mainly by the Cretaceous and Tertiary, and in a much lesser degree by intrusives and eruptives.

In the southern portion, up to Monterrey, Nuevo Leon, there is no doubt that the Cretaceous is underlain by Jurassic, of a normal facies in the central portion of the Sierra Madre, but in the eastern part of the Sierra Madre it exists in a coastal facies, consisting mostly of reddish sandstones, conglomerates, with even small coal seams, some limestone, and white gypsum. Characteristic sections of this coastal facies may be seen west of Victoria, Tamaulipas, on the road to Jaumave; north of Victoria in the Cañon de Caballeros; in the region of Galeana, Nuevo Leon, and to a certain degree also in the valley south of the Cañon de Santa Catarina near Monterrey, Nuevo Leon. North and east of Monterrey the marine Jurassic possibly disappears entirely, but the lowest portion of the Cretaceous is nowhere exposed there; this problem has been discussed by the senior author of this paper.[4]

South of Victoria the normal facies of the Jurassic probably extends farther east. At least in the deep well Altamira No. 11 of the Mexican Gulf Petroleum Company an ammonite was found below the lower Cretaceous, which was determined by Dr. Carl Burckhardt as a *Kossmatia*, nearly related to one from the upper Portlandian of San Pedro del Gallo, Durango, and this makes it probable that the Portlandian is represented in its normal facies, while farther north this horizon is always the first to show signs of the proximity of the continent.

CRETACEOUS

Since the extension of the region here discussed is more than seven hundred and fifty kilometers in length, we have to

[4]E. Böse, 12.

expect that different changes of facies will be found in the different beds. Therefore it will be difficult to discuss the stratigraphy in the entire extension as a whole, as the horizons do not change their facies all at the same place. We prefer to give a stratigraphic subdivision of one region first, and then discuss the changes of the horizons elsewhere. As the northernmost part has the most complete development of the Cretaceous we shall begin with it.

NOMENCLATURE

The history of stratigraphy has shown that at first local names for the different beds are used in different regions, but as the number of those local names begins to increase and to make it difficult to understand their correlation, a universal nomenclature must be introduced. The most practical one would be of course an entirely paleontological subdivision based on the occurrence of certain genera and species, but as beds of the same age have proved to contain different species in different countries, even where the facies is about the same, stratigraphy has begun to develop two different ways. One is to name the zones not after a species but after a certain group of species or a subgenus, and another one to apply, at least to the larger stages, names that can be used anywhere although even those names were originally local ones.

It is quite evident that the correlation of different beds can only be based on the comparison of the faunas, especially where a great change of petrographical facies takes place. Experience has shown that ammonites are by far the best index fossils, as they change rapidly from one bed to another, and as their groups never have a very long life. Echinoderms can be considered as second best to rely on for stratigraphical subdivision, although they are generally much less abundant. Among the Pelecypoda only a smaller number of genera supplies good index fossils, the best being the Caprindae and Rudistidae, the Inocerami, and Trigoniae; while oysters and their relatives are the cause of much confusion, and a comparison of groups of them on different continents is practically out of the question.

Wherever we have found ammonites there has not been any difficulty in the determination of the age, and fortunately ammonites are rather abundant in the beds of the region here discussed.

In Europe and most other parts of the earth the Cretaceous has been subdivided generally into two great groups: Infracretaceous and Supracretaceous.

These have been further subdivided in the following way:

I.	Maestrichtian		Supracretaceous
	Campanian		Supracretaceous
	Santonian		Supracretaceous
	Coniacian or Emscherian		Supracretaceous
	Turonian		Supracretaceous
	Cenomanian		Supracretaceous
	Albian		Infracretaceous
	Aptian		Infracretaceous
	Barremian	Neocomian	Infracretaceous
	Hauterivian	Neocomian	Infracretaceous
	Valanginian	Neocomian	Infracretaceous
	Berriasian	Neocomian	Infracretaceous

In the United States also two large groups have been distinguished, but no general names have been introduced. Unfortunately these two groups do not coincide with those of Europe, which have been accepted in most of the other countries. Taking as an example the subdivision of the Texas Cretaceous we find:

II.	Navarro beds	Upper Cretaceous	
	Taylor marls	Upper Cretaceous	
	Austin chalk	Upper Cretaceous	
	Eagle Ford shales	Upper Cretaceous	
	Buda limestone	Washita division	Comanchean
	Del Rio clay	Washita division	Comanchean
	Georgetown formation	Washita division	Comanchean
	Edwards limestone	Fredericksburg division	Comanchean
	Comanche Peak limestone	Fredericksburg division	Comanchean
	Walnut clays	Fredericksburg division	Comanchean
	Paluxy formation	Trinity division	Comanchean
	Glen Rose formation	Trinity division	Comanchean
	Travis Peak formation	Trinity division	Comanchean

Stages:	Zones:	In Texas:
Albian	Zone of Hoplites div.sp., Caprinidae and Rudist beds Zone of Parahoplites cfr. milletianus d'Orbigny	- - - - - Edwards limestone to Glen Rose beds
Aptian Gargasian	Zone of Dufrenoya texana Burckhardt	Travis Peak f.
Bedoulian	Zone of Requienia sp. div.	Trinity sand?
Barremian	Not fossilerous	
Hauterivian	Zone of Leopoldia and Astieria aff. sayni Kilian	Missing
Valanginian	Zone of Astieria astieri and Thurmannia thurmanni Pictet	
Berriasian	Not fossiliferous	
Jurassic	(Portlandian)	Missing

It should be kept in mind that our studies are not detailed in every part but more of the nature of reconnaissance work, although some places have been studied in detail so far that the sequence of the beds could be determined; there is always the possibility that certain horizons may have escaped us and that later on faunas may be found in beds which we could not study in favorable places; but even our incomplete collections enable us to establish a subdivision into well characterized horizons. We shall always indicate where our studies are incomplete and where further investigations should be made.

We shall now describe the different horizons studied in northern Mexico.

INFRACRETACEOUS (Berriasian to Barremian inclusive)

The lower Cretaceous is not exposed in the region between Lampazos and Piedras Negras and it probably does not exist there. We are here giving the data of the region of Monterrey because farther south we shall have to indicate certain changes of facies.

Near Monterrey and especially on the south side of the valley immediately south of the Cañon de Santa Catarina, on the land of the Hacienda de los Nogales, we found above the sandstones and conglomerates of the Portlandian (Jurassic) a mass of gray medium bedded limestone (without angular unconformity) which has not yielded any fossils. As such a limestone occurs frequently between the upper Portlandian or the "Boundary Beds" of C. Burckhardt and the Valanginian, we have considered this mass as representing the *Berriasian*, which is known to exist in other parts of northern Mexico, where Burckhardt has been able to find a fauna.

Above this we find at least some 150 meters of gray marls, weathering yellowish and alternating with thin bedded limestones; these beds contain a great deal of limonite produced from pyrite; often we find fragments of *Astieria* of the *A. astieri* group, *Neocomites neocomiensis, Thurmannia thurmanni, Kilianella* cfr. *lucensis*, etc., mostly preserved as limonite which originally was pyrite. The fauna is rather poor but sufficient to show that these beds represent the *Valanginian*.

Above these beds occur thin bedded gray limestones, at least some hundred meters thick. We have not been able to find any fossils, but our time was limited and we did no more than walk across these beds. As similar beds elsewhere in northern Mexico are known to contain Hauterivian and Barremian fossils we suppose that these thin bedded gray limestones represent the *Hauterivian* and *Barremian*. We shall later on see that at least the lower one of these formations is represented farther south by fossiliferous deposits.

The studies of Carl Burckhardt have shown that all over northern Mexico the deposition of beds was uninterrupted from the Oxfordian to the Portlandian (Jurassic) and from the Berriasian to the Barremian, the only exception being the region north of Torreon, Coahuila, where the Jurassic continent existed and where the Aptian lies on Permian or other older rocks. The Valanginian is almost everywhere quite fossiliferous; the Berriasian has rendered faunas only in some places although there is no doubt that it is represented by certain beds; a Hauterivian fauna also has been proven to exist in different places while the Barremian is generally sterile, but the beds which represent it have afforded characteristic ammonites in different localities.

MESOCRETACEOUS (Aptian to Cenomanian inclusive)

Aptian.—The lowest beds of the Mesocretaceous, the Aptian, are exposed in this region only in the Sierra del Burro near Piedras Negras; they are probably not very different from those of the mountains between Monterrey and Saltillo.

This locality of the Sierra del Burro lies in the valley of San Vicente, where dark gray somewhat shaly limestones and shales contain fragmentary *Douvilleiceras* of the *D. martini* group, and numerous *Toxaster*. In the Sierra del Agua de las Cabras (Hacienda de la Babia) near El Melon and at Puerta del Tapon we find that these limestones are underlain by red clays which have not yielded any fossils. These clays may represent the Bedoulian and the limestones of San Vicente certainly belong to the *Gargasian.*

In the region of Saltillo and Monterrey, the series is much more nearly complete, and contains a great number of fossils. There the base of the Mesocretaceous is formed by gray hard thick bedded limestones containing *Requienia* and *Monopleura.* These beds certainly represent the *Bedoulian* or lower Aptian; no fossils have so far been found which could be determined specifically.

Above these beds we find a series of reddish to gray marls and thin bedded black limestones about 30 meters thick, which in the Cañon de Vallas on the Hacienda de Saucillo near Saltillo contain a large and very well preserved fauna, consisting mostly of ammonites. We collected the following species:

Hamites cfr. *tropicalis* Meunier
Puzosia cfr. *matheroni* d'Orbigny
Puzosia sp.
Uhligella cfr. *zurcheri* Jacob
Uhligella aff. *zurcheri* Jacob
Neocomites (?) sp.
Dufrenoya aff. *furcata* Sowerby

Dufrenoya texana Burckhardt
Dufrenoya nov. sp. var.
Parahoplites n. sp. aff. *P. consobrinus* Sinzow
Parahoplites aff. *melchioris* Anthula
Acanthoplites n. sp. aff. *A. crassicostatus* d'Orbigny
Acanthoplites n. sp. aff. *A. gargasensis* d'Orbigny
Acanthoplites cfr. *uhligi* Anthula
Acanthoplites n. sp.
Acanthoplites sp. div.
Douvilleiceras cfr. *buxtorfi* Jacob
Douvilleiceras n. sp. aff. *D. buxtorfi* Jacob
Douvilleiceras aff. *D. buxtorfi* Jacob
Douvilleiceras aff. *D.cornueli* d'Orbigny
Douvilleiceras cfr. *delagoense* Krenkel
Douvilleiceras martini d'Orbigny
Douvilleiceras martini var. *occidentale* Jacob
Douvilleiceras cfr. *martini* d'Orbigny
Douvilleiceras cfr. *pretiosum* d'Orbigny
Douvilleiceras n. sp. aff. *D. pretiosum* d'Orbigny
Douvilleiceras subnodosocostatum Sinzow
Douvilleiceras subnodosocostatum var. *pusillum* Sinzow
Douvilleiceras n. sp. aff. *D. subnodosocostatum* var. *pusilla* Sinzow
Douvilleiceras tschernyschewi Sinzow
Douvilleiceras cfr. *tschernyschewi* Sinzow
Douvilleiceras cfr. *volgense* Vasiliewsky
Douvilleiceras aff. *wilfridi* Burckhardt
Douvilleiceras n. sp.
Ancyloceras cfr. *matheroni* d'Orbigny
Vola cfr. *morrisi* Pictet
Toxaster sp.
Rhynchonella nuciformis Ooster

Carl Burckhardt[7] found years ago a very similar, although less rich, fauna in the canyon of Fernandez of the Rio Nazas in the State of Durango, west of Torreon, Coahuila. His description of the fauna has been published lately;[8] we were permitted to make use of his originals and his manuscript text for which we are indebted to Dr. Burckhardt himself and Ing. Juan D. Villarello, Director of the Instituto Geológico de México (Geological Institute of Mexico).

Burckhardt has recognized that these beds represent the *Gargasian* (upper Aptian) and that they correspond to the

[7]Carl Burckhardt, 13.
[8]Carl Burckhardt, 15.

Trinity division (Travis Peak) of Texas, where a few ammonites have been cited which belong to Burckhardt's new genus *Dufrenoya* (group of *Hoplites furcatus* auct.) and especially to the group of *Dufrenoya furcata* Sow. Kilian[9] has identified the form found in the Trinity beds of Coombes Hollow, Travis County, Texas, with *D. furcata* Sowerby, but Burckhardt says that it is a somewhat different species, and calls it *Dufrenoya texana*. A plaster cast of Kilian's original from Coombes Hollow, Texas, existing in the collection of the Instituto Geológico de México shows that the figure given by Lasswitz is entirely wrong in the details of ornamentation. Burckhardt also shows that to the group of *D. furcata* belongs the fossil described by Cragin[10] under the name of *Hoplites roemeri*, which was found in the Dinosaur beds of Cow Creek, Travis County, Texas. *Dufrenoya texana* Burckhardt occurs in the Gargasian both of Rio Nazas, Durango, and the Cañon de Vallas, Coahuila.

According to an ammonite find recently made by us, we can state that similar beds exist also in the Cañon del Barril, near Mina Reforma, in the mountains east of Sierra de San Marcos and southeast of Cuatro Ciénegas.

The Mexican fauna shows a great affinity on the one hand with that from Russia described by Sinzow, and on the other hand with the corresponding fauna of southern France and Switzerland; although most of the species are different, practically all the groups are represented by forms nearly related to those of the above mentioned countries.

A characteristic feature is the abundance of *Dufrenoya*, among which we find forms which cannot be distinguished from the European index fossil *D. furcata* Sowerby or from the somewhat different form *D. furcata* d'Orbigny of France, which generally is confused with the species first described in England.[11]

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[9] W. Kilian, 41; R. Lasswitz, **44**; Burckhardt, **15**, pl. ix, figs. 2, 3.

[10] F. W. Cragin, **22**, p. 134, pl. xliv, figs. 4, 5.

[11] Gayle Scott, **70**, p. 119, takes *Dufrenoya furcata* d'Orbigny (not Sowerby) in much too wide a sense; it is impossible to unite *D. roemeri* Cragin with *D. furcata*, as has been shown by Burckhardt. Scott accepts the generic name of *Parahoplites* for this group, although it is quite distinct from it; even if the name *Dufrenoya* should have escaped him, although it had been used by his own master (Kilian, **42**, pp. 34, 35, 37) and by many others, he should at least have discussed the name proposed by Spath: *Stenhoplites*. Spath accepts *Dufrenoya* now for *D. dufrenoyi* and retains *Stenhoplites* for *Hopl. furcatus* Sowerby (Spath, **82**, p. 147).

A further characteristic is the great number of different *Douvilleiceras*, among which we find the European index fossils *D. martini* d'Orbigny, *D. subnodosocostatum* Sinzow, and *D. buxtorfi* Jacob. The occurrence of *Uhligella zurcheri* Jacob, or at least a very nearly related form, is of interest, although this species is also found in a horizon which is a little higher in the column, as we shall see farther on.

Somewhat different from the European form is the fossil which we hâve called *Acanthoplites* aff. *gargasensis* d'Orbigny, because in this species (there seems to be quite a number of species belonging to the same group) the ventral portion never shows the furrow which is generally seen in the European form; but Kilian mentions that in some individuals this furrow is absent and the ribs cross the venter without interruption, as is true in all individuals examined by us.

In general this species develops to a much greater size than the European forms, except *Douvilleiceras*, but in part this may be explained by the circumstance that most of the fossils of the upper Aptian in southern France are preserved as pyrite casts where the outer whorls may have been destroyed. In the Valanginian fauna of Symon, Zacatecas-Durango, one can often observe that only the internal whorls are preserved as pyrite, while the rest is calcareous and is easily destroyed.

The fauna shows that the Mexican beds represent the upper Aptian or *Gargasian* of the universal nomenclature. The horizon can easily be overlooked in strongly folded mountains because it often is covered by debris of the massive Albian limestone.

This horizon seems to be present in different places of northern Mexico. We have already cited the locality of Sierra del Burro, opposite Del Rio, Texas, and that of the Cañon del Barril near Cuatro Ciénegas in Coahuila. Recently the senior author of this paper discovered a bed with numerous *Douvilleiceras* and *Dufrenoya* nearly related to those of the Cañon de Vallas, in a locality about three miles north of Cuchillo Parado, and also near the Aurora mine near Cuchillo Parado, in the State of Chihuahua. The same beds exist also at Puerto Berrendo, Coahuila, although there we have not yet found the ammonite bed but only the horizon with pelecypods.

Albian.—The lowest beds so far discovered in the region between Lampazos and Piedras Negras are thick bedded, hard limestones of gray to black color, containing nodules of black chert; they are over 500 meters thick. In the Sierra de Lampazos these rocks are not very fossiliferous but at some places contain *Hoplites* related to *H. rudis* Parona and Bonarelli. We find them in the deep canyons near Lampazos, Nuevo Leon, and on the top of the mountains at Minas Viejas near Villaldama, Nuevo Leon. The rock and its fauna change somewhat farther west in the Sierra de Bustamante and in its northern geological continuation, the Sierra de Pajaros Azules, where the gray thick bedded limestone has a somewhat lighter color and begins to contain great quantities of *Caprina* and related genera. Caprinidae become still more abundant farther west and south, as in the mountains between Monterrey and Saltillo. In the Burro Mountains the Albian resembles somewhat that of Texas, although it becomes in general more calcareous; it carries the same fossils and among them a great number of Caprinidae and *Praeradiolites.* These beds are very well exposed in the canyon between Hacienda San Miguel and the Rancho San Vicente where the whole series from the Gargasian to the upper Albian is exposed.

Upper Albian (or Vraconnian).—In Mexico we find generally above the thick bedded limestone which certainly represents the lower part of the Albian, a series of thin bedded gray limestones containing nodules and long lenses of black chert. Frequently they contain silicified ammonites, of which the most important are *Oxytropidoceras* of the *O. acutocarinatum* group and *Pervinquieria* of the *P. inflata* group (*P. aguilerae* Böse). *Turrilites* related to *T. bergeri* and others and numerous other open whorled forms occur. These beds were formerly called Vraconnian, a rather doubtful term, but the recent works of Spath have made it possible to show that they are really upper Albian.

In another part of this work the senior author will show that the lowest part of these beds with *Oxytropidoceras acutocarinatum* corresponds to the upper bed of the English middle Albian, the *cristatus* zone or bed VIII of Folkestone, while the higher beds with *Pervinquieria whitei* Böse and *P. burckhardti* Böse correspond to the higher Albian, or in other words to the *orbignyi* and *varicosus* zones respectively (beds IX and X of Folkestone). In general the upper Albian has been considered as Vraconnian, but in this section the natural division seems to begin with the *cristatus* zone, and therefore we consider the *cristatus* zone as the base of the *upper Albian* and abandon the term Vraconnian.

On the west side of the Sierra de Bustamante and west of the Sierra de Pajaros Azules we find the thin bedded gray limestones with long lenses of black chert. They are not everywhere fossiliferous, but in some places the main forms can be found.

In the Sierra de Lampazos this horizon is developed in a different manner: it consists of reddish-gray marls and thin bedded limestones, about 100 meters thick. These contain at many places *Oxytropidoceras* of the *O. acutocarinatum* (Shumard) Marcou group and of the *O. belknapi* Marcou group in large fragments, *Turrilites* of the *bergeri* group, and numerous large but badly preserved *Macraster* probably belonging to *M. elegans* or *M. aguilerae* Böse.

Above these beds we find thin bedded limestones alternating with marls, about 150 meters thick. They contain frequently large *Pervinquieria* of the group of *Pervinquieria trinodosa* Böse, but no careful collections have been made thus far. Similar beds are found on the east side of the Sierra de Pajaros Azules but no determinable fossils have been found there. It is very probable that these marls and limestones include the Cenomanian.

On the flank of the Sierra del Burro, Coahuila, west of Del Rio, Texas, this horizon is represented by a series of thin bedded limestones which contain the fauna of the lower Georgetown beds. As fossils do not seem to be very frequent and our time was very limited, we did not try to subdivide these limestones.

Toward the west and south of the Sierra del Burro the already very calcareous Georgetown beds of Del Rio become replaced by hard limestone which has not yet been subdivided. The senior author of this publication found over twenty years ago in such limestone a bed with *Gryphea washitaensis* Hill in the hills near the station of Bermejillo, Durango; recently we discovered such a bed with *G. washitaensis* in a narrow canyon about fifteen kilometers west of the ranch Piedra de Lumbre (west of Cuatro Ciénegas) on the old road to Acatita, Coahuila. These *Gryphea* beds are similar to those of the Cerro Muleros near Ciudad Juarez and to the Denton beds in northern Texas, but they are converted into hard limestone and specimens can be found only where these limestones are strongly weathered. The locality will be mentioned again in our chapter on the Turonian.

Cenomanian.—The senior author of this paper will show in another chapter that the base of the Cenomanian in Texas and northern Mexico is to be found in the uppermost Georgetown beds. On the flank of the Sierra del Burro in Coahuila (opposite Del Rio, Texas) the uppermost Georgetown is represented by thin bedded limestones and marls, the first of whitish-yellow, the latter of bluish-gray color. The limestones contain a great number of *Acanthoceras cunningtoni* Sharpe, a characteristic Cenomanian group, and *Turrilites brazoensis* Roemer. They are accompanied by a great number of *Holectypus limitis* Böse. A little lower there is a bed with numerous *Kingena wacoensis* Roemer. We consider these beds as the lower Cenomanian.

Above these beds we find the so-called Del Rio clay; this consists in the region of Del Rio and opposite on the Mexican side, of gray marls and clays weathering brown in its lower portion, while in the upper part thin beds of sandy limestone appear and become rather frequent toward the highest portion of the horizon. The whole thickness of these beds is not over fifty meters. The lower portion of the Del Rio clay contains an abundance of *Exogyra arietina* Roemer, but this species is by no means absent in the upper portion where it often forms thin beds. In the middle and upper portions *Nodosaria texana* Conrad is very common. In the upper portion we find here also *Gryphea marcoui* Hill and Vaughan, and *Exogyra cartledgei* Böse. In Texas the Del Rio clay often contains a great number of pyrite ammonites; these are rather rare on the flank of the Sierra del Burro, but we have found there a few specimens of *Mantelliceras brazoense* Böse, of *Scaphites subevolutus* Böse, *Turrilites bosquensis* Adkins, and *Engonoceras bravoense* Böse.

Toward the south the Del Rio clay begins to change in facies on the flank of the Sierra del Burro. In the exposure on the Rio de la Muralla on the road from Villa Acuña to San Carlos we have not found a single *Exogyra arietina*, but a great number of *Gryphea marcoui* and *Exogyra cartledgei*. Still farther south and west on the ridge between Orégano and San Carlos the Del Rio clay changes into a gray blue, almost blackish marl, which does not contain a single *Exogyra arietina* but quite a number of other species:

Stoliczkaia aff. *dispar* d'Orbigny
Engonoceras bravoense Böse
Gryphea mucronata Hill
Exogyra cartledgei Böse
Vola subalpina Böse
Lima wacoensis Roemer
Hemiaster calvini Clark[12]
Leptarbacia argutus Clark
Phymosoma cfr. *volanum* Cragin

The position of these beds below the Buda limestone does not leave any doubt that they represent the Del Rio clay notwithstanding their different fauna and petrographical aspect.

Still farther south the Del Rio clay changes more and more; the clay becomes reduced to a thickness of about twenty meters, then to about ten meters and between Remolino and El Macho it disappears entirely. The upper beds

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[12]Jules Lambert in Gayle Scott, 70, p. 184, says that the real *Hemiaster calvini* Clark has no peripetalous fasciole. This is certainly an error of observation of Clark or is due to badly preserved material. All the *Hemiaster* of the Buda limestone which I have seen have a peripetalous fasciole, and our specimens from the Del Rio clay show it too. Our specimens are very similar to the one figured by Gayle Scott., l.c, pl. ii, fig. 3, under the name of *Palhemiaster ex, cfr. comanchei* Clark.

of the Del Rio change into very calcareous marls, which toward the south gain in thickness and become harder until they are very thin bedded limestones in the region of the Hacienda de la Babia. Between Remolino and El Macho they are still somewhat softer than the Buda limestone, but for only a short distance. At El Pensamiento the thin mass of clay contains a number of badly preserved pyrite ammonites, among which we found a well preserved fragment of *Turrilites bosquensis* Adkins. The senior author of this work will show in another chapter why we consider the Del Rio clay as middle Cenomanian or perhaps as lower Cenomanian in the European sense.

On the flank of the Sierra del Burro, Coahuila, the Del Rio clay in its normal as well as in its calcareous facies is always overlain by the Buda limestone. The Buda is here more calcareous than in Texas, and consists of gray to whitish brittle limestone with a very few thin marly layers. It is rather unfossiliferous but some beds contain quite a number of ammonites. A very good locality exists in a dry canyon opposite Remolino about two kilometers from the river on the road to Orégano. There we found the following species:

Budaiceras mexicanum Böse
Mantelliceras mantelli Sowerby
Mantelliceras laticlavium Sharpe var. *mexicanum* Böse
Euhystrichoceras remolinense Böse

Budaiceras is a characteristic ammonite for the Buda limestone in Mexico as well as in Texas, where it has been described by Shattuck and by Lasswitz under the name of *Barroisiceras;* it has nothing to do with this upper Cretaceous genus. Lasswitz also described it as *Schloenbachia.* The new genus belongs to the *Acanthoceratinae* and is probably derived from *Acanthoceras* itself or from Stoliczkaia. The two species of *Acanthoceras* prove that the Buda limestone belongs decidedly to a higher zone of the Cenomanian, and as no ammonites are yet known from the upper portion of Buda limestone, it is very probable that it represents the whole upper Cenomanian, *i.e.*, the zone of *Mantelliceras mantelli* and *Acanthoceras rotomagense.*

This is the highest bed of the Cenomanian in the region of the Sierra del Burro; it is overlain by the Turonian. Farther south we have not yet been able to distinguish the Cenomanian faunally. It seems to be represented by a sterile limestone in the Sierra de Pajaros Azules and especially so in the Sierra de Lampazos near Minas Viejas and Villaldama, Nuevo Leon, but these regions have not yet been studied in detail. Still farther south the Cenomanian seems to be contained in the series of sandy and argillaceous marls with thin beds of sandy limestone, or in the thin bedded black limestone which in its lower portion carries an upper Albian fauna.

To the west, near Ojinaga, Chihuahua, the upper Cenomanian exists certainly in the facies of the Buda limestone, which consists of cream-colored, fairly hard limestone; Messrs. Gonzalo Vivar and H. Izazumi of the Geological Institute of Mexico have collected there a very well preserved specimen of typical *Budaiceras*.

SUPRACRETACEOUS (Turonian to Maestrichtian inclusive)

Turonian.—This horizon is in general very uniform lithologically, but in some parts of northern Mexico it can be subdivided into two (or even three) easily distinguished zones: the Salmurian and the Ligerian, possibly also the Angoumian. The first Salmurian fauna was found by Dr. Ernst Angermann and by Dr. E. Haarmann at the Cerro del Macho on the Hacienda del Mohóvano (Coahuila-Chihuahua) and its age recognized and its fauna described by the senior author[13] of this work. A new locality was discovered some years ago by Messrs. O. A. Cavins and R. C. Stoner, and was revisited by us recently. This locality is much more important than the first one discovered, because it shows a section through the lower beds and the Salmurian. The place is on the old road from Acatita to Cuatro Ciénegas, in a narrow canyon some fifteen kilometers west of the ranch of Piedra de Lumbre.

[13]E. Böse, 10.

Above the thick bedded dark gray limestones of the lower Albian we find thin bedded limestones which contain numerous *Gryphea washitaensis*. These are covered by badly exposed gray gypsiferous shales and marls with thin and some thick beds of limestone. We have found in these shales only a *Crioceras* and another ammonite as yet undescribed, but it seems that the shales correspond to the lowest horizon of Haarmann and very probably represent the Cenomanian.

The shales are covered by gray thin bedded somewhat marly limestones which readily weather into irregular pieces with sharp edges; the limestone is somewhat nodular in the upper part: it has a thickness of about twelve meters. Then follows a more marly gray nodular limestone at least fourteen meters thick, which passes into a harder nodular limestone of some sixteen meters thickness, forming steep bluffs. It seems to be covered by gray shales.

We collected mainly in the lower limestone and found the following species:[14]

Vascoceras angermanni Böse
Vascoceras aff. *adunense* Choffat
Vascoceras cfr. *mohovanense* Böse
Vascoceras n. sp.
Fagesia haarmanni Böse
Fagesia n. sp., aff. *haarmanni* Böse
Fagesia n. sp.
Neoptychites n. sp.
Puzosia aff. *austeni* Sharpe
Hoplitoides aff. *mirabilis* Pervinquière
Hoplitoides n. sp.
Acanthoceras (?) sp.
Metoicoceras cfr. *whitei* Hyatt
Metoicoceras sp.
Inoceramus labiatus Schlotheim

The base of the highest limestone contains numerous echinoderms, probably belonging to *Hemiaster*, and some ammonites not yet determined.

These beds unmistakably represent the Salmurian in a facies similar to that of northern Africa and Portugal. It

[14]These determinations are provisional and not complete.

is interesting in that it constitutes a locality much farther east than the original one; we do not know as yet how far this facies extends toward the east, as this horizon can be easily overlooked where the topographic conditions are not favorable and fossils are few. Very frequently we find a not very thick mass of thicker bedded limestones at the base of the Turonian, but so far no fossils have been found in it. The shales which cover these limestones probably represent the Ligerian and Angoumian, that is the whole remainder of the Turonian.

In the region between Lampazos and Piedras Negras the Turonian consists mainly of black thinly laminated limestone and black shales, alternating with beds of thin bedded black limestone. In some places it is more calcareous as for example west of Del Rio, and at others it is more shaly. At the foot of the Sierra de Pajaros Azules near the abandoned ranch of Santa Rita Mr. J. B. Orynski and the senior author measured a thickness of 326 meters, mostly shales, which appears to be the average in this region.

This horizon represents apparently the whole Turonian; the higher parts are often entirely barren of fossils. Near Margaritas in the region of Villa Acuña, Coahuila (opposite Del Rio, Texas) the upper portion of the Turonian is represented by whitish marls and marly limestone; in these we found a slightly compressed but in general well preserved specimen of *Prionotropis woolgari* Mantell var. *mexicana* Böse. This species occurs in Europe in a rather high horizon of the Turonian but has often been confounded with a related one, described by Petrascheck under the name of *Acanthoceras* crf. *Woollgari* to which most of the specimens belong which in Central Europe have been cited as *P. woollgari* from the lower Turonian. It is very possible that the whitish marls which appear above the Eagle Ford shales in some parts of Texas and northern Mexico and which generally have been regarded as Austin chalk represent in reality the upper Turonian.

The Turonian, which corresponds in age to the Eagle Ford shales of Texas[15] and the Benton formation of the Rocky Mountains, occurs in the hills near the station of Peyotes[16] and continues north along the flank of the Sierra del Burro. To the south the formation continues in the Lomas de Peyote to within a few miles north of Puerto Calzones, where it disappears under the Austin chalk. It forms a row of hills at the eastern foot of the Sierra de Pajaros Azules and also an isolated anticline south of the Ojo de Agua near the Hacienda de Encinas.

At Lampazos we find the Turonian forming a horseshoe-shaped row of hills accompanying the northern outline of the Sierra de Lampazos, it being separated from the middle Cretaceous (Albian to Cenomanian) by a circular valley, or farther south by a row of topographical depressions. It is well exposed on both the east and west side of the Sierra de Lampazos and the Sierra de Minas Viejas. It is also well exposed on the west side of the Sierra de Bustamante and in some places on the east side. It appears around the whole Sierra de Vallecillo but is not everywhere exposed in all its thickness. In the whole district mentioned these beds carry the same fossils, mainly *Inoceramus labiatus, I, hercynicus,* and related species, and the petrographical nature of the beds varies but little.

Coniacian (Emscherian).—This horizon so far has never been distinguished in northern Mexico, the cause being probably that it is petrographically very similar to the beds above it; it has been included in the very general name of Austin Chalk or San Juan limestone (Dumble). Its thickness is about three hundred meters as measured by J. B. Orynski and the senior author, near Hacienda de Encinas on the road from Lampazos to Hermanas near Puerto de

[15]Gayle Scott, 70, p. 100, says that in northern Texas *Acanthoceras rotomagense* is found at the base of the Eagle Ford shales. In this case these basal beds should be separated from the Eagle Ford shales and be considered as upper Cenomanian. This is another case which shows that the use of local names for petrographical units only serves to produce confusion. It is very possible that these basal Eagle Ford shales belong really to the Woodbine sands and represent the Buda limestone of southern Texas which is unknown in north Texas.

[16]The fossils found at this locality have been described by E. Böse in Bol. 30 of the Instituto Geológico de México, 1913.

Guerra. West of Piedras Negras (at Jimenez) it consists of a cream colored to white, rather hard limestone which in some beds contains large specimens of the group of *Inoceramus undulatoplicatus* Roemer, which is nearly related to the group of *Inoceramus digitatus* of Europe; our specimens are generally very much larger than those figured by Roemer from Texas. Dr. E. Haarmann discovered years ago the locality at "Nacimiento de Escondido" near Morelos, Coahuila, and brought a large specimen; but in this same locality the senior author of this paper measured several still larger specimens with a longitudinal diameter of 120 centimeters, and these shells were not complete; some must have had a length of more than 1.5 meters! The rocks contain also other *Inocerami*, not yet described, and locally *Mortoniceras*, apparently of the group of *M. margae* Schlüter.

The Coniacian is generally covered in this region; we find it on the northeast side of the Sierra del Burro, on the Peyotes hills; near Hacienda Encinas at the foot of the Sierra de Pajaros Azules. In this latter region it does not consist of the cream colored limestone as near Piedras Negras but rather of whitish marls with thin beds of gray limestone and carries few fossils; only the base is still composed of a thin mass of the cream colored limestone.

This horizon certainly continues into Texas, where the lower portion of the Austin chalk frequently contains *Inoceramus undulatoplicatus* and poor specimens of the *Mortoniceras margae* group. Farther south, in Coahuila, it becomes more and more shaly as can be seen in the region of Cuatro Ciénegas and in the valley of Monclova, which is the southernmost point yet known at which the Coniacian appears in the facies of the lower Austin chalk.

Santonian.—This stage occurs in Mexico in two different horizons which can also be easily distinguished petrographically. The lower horizon, the middle Austin chalk of Texas and northern Mexico, consists of a whitish chalky marl and chalky limestone; the upper horizon is a dark gray shale (Taylor marls) with a few beds of whitish gray, thin-bedded limestone at the base; this latter part has been considered generally as the upper portion of the Austin chalk in Texas.

The lower Santonian consists of a white to gray chalky limestone with beds of hard gray limestone and light gray marls. A suitable place to measure the thickness has not been found, but it is probably not over one hundred meters and possibly even less. The horizon is very fossiliferous; the most common fossils are: *Mortoniceras texanum* Roemer and related members of the group, *Pachydiscus flaccidicosta* Roemer, *Baculites* sp., large undescribed *Inoceramus* related to *I. regularis* d'Orbigny; locally it contains great numbers of echinoderms, small *Exogyra*, *Gryphea* sp., etc. The frequency of *Mortoniceras texanum* shows that the horizon represents the lower Santonian. We have never found a single *Placenticeras* in these beds although several species of this genus have been cited from Texas.

The horizon is very well developed in the Rio de San Rodrigo near Piedras Negras, and still better in the Arroyo del Tecolote and Arroyo Blanco near Jimenez, Coahuila, where it contains an enormous number of fossils, especially ammonites. Some of the *Pachydiscus* there measure over 1.5 meters in diameter and ammonites of a diameter of between one-half meter and one meter are quite common. This horizon makes up the southern portion of the Lomas de Peyote near Puerto de Calzones; there it contains *Mortoniceras texanum* and numerous *Inocerami*. It also forms the low hills farther south between Rancho del Pescado and Villa de Juarez, Coahuila, where it carries the same fossils.

We find another exposure to the north of Villa de Juarez, between this town and La Angostura; south of Villa de Juarez, the lower Santonian is well exposed in the Loma de San Juan or Loma de la Laja and still farther south in the Loma Blanca. At all these localities we have found well preserved specimens of *Mortoniceras texanum;* in the Arroyo Ócano between La Laja and Loma Blanca we found also *Pachydiscus flaccidicosta.* Well preserved *Inocerami* are common at all these localities.

Lower Santonian occurs also at Hacienda de Encinas at the foot of the Sierra de Pajaros Azules, with its characteristic fossils, and a locality which contains exceptionally large *Inocerami* can be found near Encinas on the road to Puerto de Guerra near the crossing of a little creek.

We have mentioned above that the Loma de San Juan or Loma de la Laja consists of lower Santonian and contains frequent *Mortoniceras texanum* and large well-preserved specimens of *Inoceramus* aff. *regularis* d'Orbigny. This is the type locality of Dumble's *San Juan limestone*[17] which thus in this region proves to belong to the lower Santonian and to represent the middle portion of the Austin chalk of Texas.

Upper Santonian.—Above the lower Santonian we find a series of dark gray shales alternating with thin beds of gray limestone. Higher in the column these latter disappear and we find only dark gray shales with some intercalations of gray concretionary limestone beds weathering to a rusty brown. The horizon could not be measured anywhere but cannot be far over 300 meters thick.

The shales contain sometimes numerous specimens of *Exogyra ponderosa* Roemer and less frequently *Placenticeras syrtale* Morton and related forms (Loma del Gato, north of Progreso; Loma de Hermanas, east of the road from Progreso to Agua Dulce; Arroyo de la Pasta at one kilometer from Las Esperanzas, Coahuila; Arroyo del Sauz, between Esperanzas and Barroterán). In the lower beds (Arroyo Blanco near Jimenez, Coahuila) occurs an *Inoceramus* of the *I. regularis* type but different from similar forms of the lower Santonian. Near Vallecillo, Nuevo Leon (two miles from town at old shaft on the road to Tortillas), the junior author of this paper discovered several specimens of *Gaudryceras kayei* Forbes preserved as limonite casts.

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[17]Dumble, **30**, p. 170.

In addition to the ammonites, we found in these beds:

Anchura johnsoni Stephenson at Esperanzas
Morea reticulata Stephenson at Esperanzas
Ostrea cfr. *sloani* Stephenson at Esperanzas
Exogyra ponderosa Roemer at Esperanzas. Loma del Gato, Hermanas station
Cyprimeria n. sp. at Esperanzas
Alectryonia falcata Morton north of Loma del Gato
Inoceramus sp. north of Loma del Gato
Micrabacia cribraria Stephenson at Esperanzas

The frequency of *Placenticeras syrtale* and related forms proves, as will be shown in another chapter by the senior author, that these beds belong to the Santonian, as such forms are known in Europe only in Santonian age and as the *Placenticeras* of lower and higher beds have an entirely different character. These beds certainly correspond to the Taylor marls of Texas.[18] We consider these beds as upper Santonian because they lie on the beds with *Mortoniceras texanum*. In this region we have not found any *Mortoniceras* in these beds, but in the region of Ojinaga, Chihuahua, where these beds occur in a somewhat different facies, a *Mortoniceras* related to *M. texanum* but certainly different from it occurs together with *Placenticeras sancarlosense* Hyatt, which is a form nearly related to *P. syrtale*. The *Exogyra* which occurs together with *P. sancarlosense* and *P. planum* is probably different from *E. ponderosa* but very similar to it.

Dumble has called the beds discussed here Papagayos shales although his type locality lies much farther south in the Sierra Ramones. His determination is right in so far as the Papagayos shales have to be considered as including a somewhat different facies of the upper Santonian, as will be shown in another chapter.

These beds are widely distributed in the country discussed in this report, but are mostly covered by alluvium. Under the name of Upson clay they appear near El Moral west

[18]Gayle Scott, 70, p. 111, does not give the slightest proof for his opinion that the Taylor marls should be considered as Campanian; they lie on lower Santonian and the natural conclusion from this would be to regard them as upper Santonian.

of Piedras Negras; in the southern portion of the Lomas de Peyote they are generally covered but can be seen between Rancho del Pescado and Villa de Juarez, Coahuila.

These beds are very well exposed near Esperanzas, Coahuila. Aguilera has considered them as part of the Fox Hills group, mainly relying on the presence of *Micrabacia* and *Sphenodiscus*. But his *Micrabacia* is not that of the Fox Hills beds and belongs to the species *M. cribraria* Stephenson and his *Sphenodiscus* is probably a worn *Coahuilites*, certainly not a *Sphenodiscus*, and may not even come from the vicinity of Esperanzas. The Fox Hills beds exist also in the Arroyo de la Pasta, but they lie on the beds with *Placenticeras syrtale* and contain numerous *Exogyra costata* Say. That the *Micrabacia* does not belong to these younger beds is shown by an exposure in the Arroyo del Sauz between Esperanzas and Barroterán where they occur together with *Placenticeras syrtale* and *Exogyra ponderosa;* while in the Arroyo de la Pasta they occur certainly below the main bed with *Placenticeras syrtale* and together with *Anchura johnsoni* Stephenson.

Good exposures of our beds with *Placenticeras syrtale* and *Exogyra ponderosa* exist at the Loma del Gato and farther north in the valley of the Arroyo del Gato; also in the Loma de las Hermanas, all of which localities lie between Villa de Progreso and Cerro de Jabalí, a basalt plug with a large lava field, at the foot of which lies the Rancho de Agua Dulce.

The lower portion of these beds is exposed near the Rancho de la Laja and also in the Rio de Lampazos near the Rancho de la Ciega. The middle portion of the shales is well visible in the bed of the Rio de Lampazos on the crossing of the road from Lampazos to San Patricio. The badly exposed shales in the so-called Lomas de San Antonio east of the Loma de San Juan (or de la Laja) and especially near Peñitas may belong to the higher beds, discussed in the following paragraph, although Dumble includes them in his Papagayos shales. Good exposures are also found south of Vallecillo, Nuevo Leon, but we shall speak of these in another chapter.

In most of the other localities of the region discussed here, the shales are badly exposed, as for example on the Arroyo del ócano between El Paso de los Padres and Rancho de San Carlos, and are covered with young alluvium or conglomerates.

Campanian.—This division contains near Lampazos at least two different horizons: the lower part consisting of brackish water beds, the upper part of shales with *Exogyra costata* and *Gryphea vesicularis*. As the lower beds certainly form a local facies of what in other parts is considered as shales belonging to the *Exogyra costata* beds, we have decided to designate them as *Tulillo beds*, which name should not be considered as the name of a horizon but as that of a local facies. We shall see that farther north in the region of Piedras Negras, Mexico, and Eagle Pass, Texas, these beds are replaced by marine deposits at least in part, and that the upper *Exogyra costata* beds appear there in a brackish water or lagoon facies, called the Coal series. We shall first discuss the southern region between Lampazos, the Rio Nadadores, and the Ceja Madre.

Tulillo beds.—Above the shales of the upper Santonian we find in this region a series of sandy shales with beds of soft and hard sandstones. All these are of a dark to yellowish color, and some are gray on fresh fracture. Many of these sandstones form rather thick masses but pass into the sandy shales laterally. The sandstones are mostly medium to thin bedded, but thick and hard beds occur. The entire thickness of these beds is not much more than one hundred meters.

One of the best exposures of these beds is in the Arroyo del Tulillo, about 7.5 miles northwest of Lampazos, where they contain a fauna rich in specimens but poor in species. The fauna is decidedly a brackish water deposit, as is shown by the preponderance of *Melania*, *Corbicula*, *Corbula*, and others. This is probably the locality from where C. A. White[19] obtained the fauna which in 1883 he considered as of Laramie age. He cited from this point: *Ostrea glabra*,

[19]C. A. White, 85, pp. 207–209.

Anomia micronema, *Brachydontes regularis*, *Corbicula occidentalis*, *Corbula subtrigonalis*, *Melania wyomingensis*, and *Odontobasis buccinoides*. There is no doubt that the fossils collected by us and by Mr. J. B. Orynski are very similar to the species cited by White, but they are by no means identical with them. The locality has been mentioned also by Aguilera in 1897.[20] He cites the same general locality as White and the same species, but does not mention White's paper, of which he had no knowledge at that time. He also considers the beds of Laramie age, nothwithstanding that at that locality they plainly underlie the beds with *Exogyra costata*.

In the Arroyo de Tulillo we can distinguish three different zones: a lower sandy shale with soft and hard sandstones containing a great number of fossils, mostly gastropoda; above these lie dark and reddish shales with sandstone beds containing exclusively large oysters similar to *Ostrea glabra;* still higher we find carbonaceous shales with thin seams of coal, containing mainly bivalves *(Corbicula, Corbula)* and above these a bed of rather hard sandy limestone replete with gastropoda, mainly *Melania*, and some bivalves. Above these we find alternating beds of hard sandstone and sandy shale, the sandstones predominating, carrying mostly large smooth oysters, very thick and massive beds of coarse reddish sandstone and a series of thin and thick bedded sandstone alternating with sandy shaly beds. The fossils collected in the lower portion of this series are certainly similar to the species White identified them with in 1883, but they are not identical with them. The big oysters can scarcely be distinguished from *Ostrea glabra*, and the large *Anomia* will probably have to be considered as *Anomia micronema* or as a predecessor of this species. But the *Corbicula* is certainly different from *C. occidentalis* and the *Corbula* from *C. subtrigonalis*. The former one seems to be nearer to *Corbicula cyteriformis*. The *Melania* which is so abundant in this locality is quite different from *M. wyomingensis* and the *Odontobasis* cannot be identified with

[20]José G. Aguilera, 3, p. 141.

O. buccinoides. We did not find anything which could be compared with *Melania insculpta* Meek cited by Aguilera.

The similarity between these fossils and those of the Laramie beds is not very astonishing despite the difference of age; it is well known that species from brackish water deposits do not change very much and that beds of quite different age contain often more or less the same groups of pelecypoda and gastropoda. We simply have to recognize the fact that brackish water fossils in general cannot be used to determine the exact age of beds.

Fortunately the position of these rocks shows us that they lie well below the beds with *Exogyra costata* (exposed in the neighboring Mesa de Cartujanos) and still farther below the horizon with *Sphenodiscus lenticularis,* which belongs to and is covered by the marine beds of the Escondido division, the Maestrichtian. These beds thus belong to the base of the *Campanian.*

We found another locality where the brackish water fossils, especially *Melania* n. sp., are extremely abundant. This locality is about three kilometers east of the Rancho del Pescado on the road to Laguna de Leche, in Coahuila. The country west of Rancho del Pescado seems to be underlain by the shales of the Santonian (Taylor marls). Immediately east of the Rancho del Pescado we find sandy shales and thin bedded sandstones with ferruginous concretions; then follow to the east and slightly dipping toward that same direction sandstones and sandy shales, which locally carry undetermined fossils in calcareous concretions. At three kilometers from the ranch we find thin beds of limestone in brownish shales, which are composed almost entirely of brackish water fossils, mainly *Melania* idential with that of the Arroyo de Tulillo; these weather out and the well preserved shells can be collected by the hundreds. Above these beds we find more or less thick bedded gray and reddish sandstones, also very slightly east dipping and composing the next four miles. Then we see them covered by sandy shales and gray thin bedded soft sandstones carrying a great number of *Gryphea vesicularis, Exogyra costata* and a large smooth oyster. This locality plainly confirms our determination of the age of the brackish water beds, *i.e.*, that they lie below the beds with *Exogyra costata* and form the beginning of the Campanian. We shall later on see that farther north our brackish water beds are replaced by marine beds which actually carry *Exogyra costata* and other fossils.

Dr. T. W. Stanton had the kindness to call our attention to the fact that C. A. White compared his fauna principally to that found in Rock Springs and Point of Rocks in Montana and that those beds also lie below the Fox Hills division. We do not presume that the orogenic movement took place exactly during the same time in both northern Coahuila-Nuevo Leon and Montana, but if there was any difference it must have been rather small. That this emersion in northern Mexico is of greater importance than has been thought so far, will be shown in another part of this paper.

The Tulillo beds are by no means restricted to the two places mentioned above, although these are the only ones where brackish water faunas have been found so far. Part of the sandstones may even be marine, and there may have been an oscillating movement like that in the Escondido beds of the same region. The brackish Tulillo beds extend from near Candela to near Laguna de la Leche and from there southward. The formation which Dumble has considered as Eocene and highest Cretaceous west of Rodriguez and between Rancho del Pescado and Laguna de la Leche is the Tulillo beds. These are well exposed in the Arroyo del Reparo which empties into the Rio Salado a few miles above the station of Rodriguez, Nuevo Leon; there the Tulillo beds overlie the shales of the upper Santonian (Taylor marls). In the upper portion of the Arroyo del Reparo, that is, above the crossing of the road from Rodriguez to Lampazos, we find the Tulillo beds all the way for about three miles to where an old road to La Mesa station of the National Railways crosses the creek. About half way between these points we found a sandstone which contains numerous *Inocerami* similar to *I. vanuxemi;* it appears to belong to the lower portion of the Tulillo beds which here therefore are still marine. The higher portion does not seem to contain fossils in this section. At the road crossing mentioned above the Tulillo beds are resting on the upper Santonian (Taylor marls) which carries there only *Inocerami.* On the railway line east of La Mesa at kilometer 1210–1211 we find the Tulillo beds well expressed unfossiliferous. They continue toward the south here as well as south of Mojina station and are found again south of the Chancaca hills, where they likewise rest on the Taylor marls.

East of the Salado River the Tulillo beds probably exist just west of the station of Huizachito, at least sandstones and sandy shales similar to them seem to occur below the beds with *Exogyra costata* and *Gryphea vesicularis,* but as will be shown later this zone is very limited, since a little farther west the younger beds appear again. South of the railway line we find the Tulillo beds on the left bank of the Salado River at a ranch about 6.7 kilometers from Rodriguez, and again forming all the hills between El Parreño and the valley of Escalera, where they are well exposed in the Loma de la Oracion. They seem to disappear toward the south but in reality they become very shaly and carry fewer sandstones in the so-called Ceja Chica; a good exposure exists near Tortillas on the road to Santa Celia. Their continuation farther south will be discussed in another chapter.

Marine Upper Campanian.—In the region south of the Rio Nadadores and east of the country near the ranch of Longoria the upper portion of the Campanian is marine and can be divided in two horizons:

A. Gray sandy shales and argillaceous shales with sandstone and sandy limestone containing numerous *Exogyra costata, Gryphea vesicularis* and a large smooth oyster.

B. Calcareous sandstones and hard sandy dark blue limestones with thinner beds of sandy shales rarely containing *Exogyra costata* and locally numerous gastropoda.

This is only a very general lithological subdivision, because these conditions change locally. In the Mesillas north of Lampazos, Nuevo Leon, the upper portion of the Campanian is very shaly; the last beds with *Exogyra costata* are found about 50 meters below the base of the Maestrichtian (Escondido beds) which begin with a hard sandy limestone, a few meters of shale and another hard sandy limestone carrying everywhere the new genus *Coahuilites*. These last fifty meters seem there to be without fossils. At the Mesa de Cartujanos the main portion of the shales with *Exogyra costata* lies at the foot of the mesa (where the only road to the top begins to ascend) but *E. costata* occurs again about 250 meters higher and there we find it associated with *Sphenodiscus lenticularis,* especially in the beds of hard bluish sandy limestone. Above these shales, in the hard beds occurs *Coahuilites* but probably also in shales in other places; Messrs. Shelton and Keeley, then geologists of the Mexican Gulf Oil Company, found a loose specimen at Rincon de las Casas, but the rock shows that it comes from the higher beds (Maestrichtian-Escondido beds). They collected in the same place *Exogyra costata* and a small *Sphenodiscus intermedius* Böse which probably fell from a higher bed.

As we have already said, the two horizons cannot be distinguished everywhere partly because of changing facies, partly from poor exposures. But in general we can easily follow the broad zone of the upper marine beds of the Campanian, especially in the east, from the Rancho Azulejo toward the south. The fossils, especially *Exogyra costata* and in most places also *Gryphea vesicularis,* occur first on the main road from Azulejo to Longoria and also on the Tanque del Macho on the so-called Ceja del Macho.[21] The first locality lies a little south of the place where the road from Tanque del Macho enters the main road. We found a *Sphenodiscus lenticularis* a little above the beds with *Exogyra costata* between the Tanque del Macho and the main road. The same zone exists a few kilometers west of Laguna de la Leche on the road to Rancho del Pescado. From there it goes south and is poorly exposed east of the Rancho de Anguila on the hills where the road from Anguila

[21]The Eocene fossils which Dumble cites from the Ceja del Macho necessarily must come from some other place, as no Eocene exists within ten miles of this place.

goes down to the Tanque del Llano. From here we can follow the beds through the plains where they are exposed between the tank and the Rancho de San Edmundo. They continue on the road from here to Rancho Perico and carry fossils everywhere; they also appear on the road from Las Cuatas to El Perico. The zone is very broad and fossiliferous; we see it composing the hills west of El Perico which reach the railway a little east of the station Camaron; we also can follow it from El Perico to Huizachito station and find abundant fossils on the hills between the two places. These fossils appear also on almost all the cuts of the railway between the stations of Camaron and Huizachito, proving that the zone is extremely broad here. This is due to a very low and very wide anticlinal bending of the beds which can be detected from the line Anguila-Cuatas to that of Camaron-Huizachito and even farther south almost to Escalera. This rather unimportant anticlinal folding has been considered as a broad arch by Richard Jones[22] but in reality it is so flat that it might almost be considered as a wide terrace. No proof for the anticlinal nature of this slight structure has been really given so far, although its existence has been presumed by several geologists. Only in one place, near Anguila, the existence of an anticline can be really proven stratigraphically, because we find west of the *Exogyra costata* beds and lying on them a zone of Escondido beds containing a rich fauna of gastropods and pelecypods and quite a number of *Sphenodiscus* of the group of *S. prepleurisepta* Böse. On the east side of the *Exogyra costata* beds we find no Escondido beds south of Las Cuatas, but there we find a succession of the Tertiary, and a narrow strip of Escondido beds may be covered. The anticline disappears certainly south of the railway.

We can follow the beds with *Exogyra costata* and *Gryphea vesicularis* south of the railway. We find the fossils near Huizachito station on the abandoned road to La Escalera; we also find them forming low hills accompanying the shales with *Enclimatoceras* below the Eocene sandstones of the Ceja Madre near the windmill of Tinajas and the low hills

[22]Richard Jones, 40.

south and southwest of the place called Las Coloradas west of Rancho de Cuevas. At the bank of La Escalera fragments of *Gryphea vesicularis* and *Exogyra costata* occur in the earth of which the dam is built. Here the zone seems to become narrower and no anticlinal bending can be found in it; all the beds dip east in normal succession. South of Escalera we find the beds again near the road from Santa Celia to El Sauz with abundant fossils, and likewise on the road from Rancho Gutirrez to Tortillas; the zone can probably be followed through to the road from Tortillas to El Sauz, at least the fossils appear on this road about two kilometers north of the Rancho El Aguila.

West of the Rio Salado we find the beds with *Exogyra costata* at the foot of the Mesillas, especially on the south, southeast and southwest side. Toward the south they are eroded and do not appear anywhere. They occur farther west at the foot at the Mesa de Cartujanos, but seem to be eroded toward the south. They occur in many places between San Patricio and Rancho Jabalí.

Development of the Campanian near Piedras Negras.—We have already indicated that the conditions of deposition in the Campanian were different farther north in the region of Piedras Negras and Barroterán. There we can also subdivide the Campanian into two horizons which do not entirely correspond in age to those distinguished near Lampazos. These two horizons are:

A. Beds of calcareous sandstone, partly very conglomeratic, sandy shales and sandy limestones, all of gray to brown color. This series has been called the San Miguel beds by Dumble and lies on the upper Santonian which in this region was called the Upson clays by Dumble.

B. Yellow sandstone and sandy shales which contain several coal seams. This series has been called the Coal series by Dumble, and Olmos formation by Stephenson.

We thus see that here the marine portion is found in the lower part of the Campanian, while the upper portion is a lagoon deposit.

The San Miguel beds.—These beds carry frequently *Exogyra costata;* a good locality is near the Arroyo de las Navajas on the road from Piedras Negras to El Moral; another one exists near Esperanzas less than a kilometer from the railway station in the Arroyo de la Pasta. In this last place, which was known to Aguilera, we collected mainly *Exogyra costata* and a number of poorly preserved gastropoda. Near the Arroyo de las Navajas we found a large *Placenticeras* which we determined as *P. whitfieldi* Hyatt. It is entirely without ornamentation and therefore very different from all the *Placenticeras* found in the Santonian. We also found there a number of *Exogyra costata* Say, *Ostrea saltillensis* Böse, *Brachydontes* aff. *regularis* White, *Pholadomya* sp. and *Liopistha bella* Stephenson.

This lower portion of the Campanian is scarcely 100 meters thick; it is generally badly exposed and in this region mostly covered by the sandstone of the upper portion.

The Coal Series.—There is little to say about the Coal series. It seldoms contains determinable fossils. Some leaves have been found in the mines of Las Esperanzas and we collected a small number of brackish water fossils, mainly *Corbicula*, which are so poorly preserved that they could not be determined. At Las Esperanzas a good section through these beds can be seen only in the coal mines, while the lower beds are very well exposed in a creek near the abandoned mine of Nogales. The thickness could not be measured because in most places the cover of Escondido beds is missing near Esperanzas. The Coal series is well developed in the vicinity of Piedras Negras and also in the Sabinas basin; a third locality exists farther south in the basin of Lampacitos, Coahuila, on the railway from Piedras Negras to Monclova.

Campanian north of Rio Nadadores.—As we have seen in the foregoing paragraph, the Campanian has in the north a lagoon deposit in its upper portion and a marine one in the lower part; in the region of Lampazos it has a brackish water deposit in the lower portion and a marine one above. The region where these two provinces of facies come together would therefore be of interest. Unfortunately the Campanian of the Sabinas basin as well as that of the Piedras Negras basin is covered by the Maestrichtian to the south; thus the change of facies cannot be followed out without interruption.

Notwithstanding these unfavorable conditions we have been able to find at least part of the zone of transition north of the Rio Nadadores in the region around Villa de Progreso, Coahuila. Here we find the Taylor marls (upper Santonian) covered by sandy shales with thin to medium bedded sandy limestone and brown sandstones; the exposures are not very good in general because all the mesas are covered by a rather thick recent conglomerate. These sandy beds seem to be entirely sterile and therefore may be lagoon deposits from the bottom to the top. Only in the very highest part of the Loma de los Narizones near Progreso we have found a number of large *Sphenodiscus lenticularis* Owen in sandy calcareous dark gray limestones. This shows that the shaly sandy bed between them and the Santonian must correspond to the *Exogyra costata* beds, although we have not found a single *Exogyra costata* in this region.

A good cross section through the higher beds of the Campanian in this region is exposed in the old railway cut near the Rancho de Lobos. We find there hard sandy limestones and sandy shales with plant remains, small oysters and shark teeth. That these beds are beginning to become again marine is shown by the rare occurrence of a *Pecten*. These beds are badly exposed also on the south side of the Rio Nadadores in the Lomas del Comal where they are covered by lower Escondido beds containing a great number of *Coahuilites sheltoni* Böse. Thus we find in the zone of transition sandy beds without fossils that might prove them to represent the *Exogyra costata* beds, but their position between the upper Santonian and the beds with *Sphenodiscus lenticularis* and *Coahuilites sheltoni* shows us that these sterile beds which appear so different from the Tulillo facies as well as from the San Miguel beds or the upper *Exogyra costata* beds, represent in reality the Campanian in the whole and form a region of transition between the two provinces of facies. Unfortunately a belt of Maestrichtian separates these transition beds also to the south from the fossiliferous *Exogyra costata* beds of the region of Lampazos.

Age of the Exogyra costata beds.—Our reasons for regarding the *Exogyra costata* beds as Campanian are, first, because they lie on the upper Santonian and are covered by the Escondido beds which undoubtedly are Maestrichtian, second, because we find in these beds at the base *Placenticeras whitfieldi* which is nearly related to the group of *Ammonites bidorsatus* Roemer, although it does not show the peculiar ornamentation of this group, which Hyatt separated from *Placenticeras* under the name of *Diplacmoceras*. But the suture of this species is nearer related to that of *Ammonites bidorsatus* which occurs in the lower Campanian of Europe; it has also the concave venter with continuous ridges on the shoulders. We have also to take into account the occurrence of *Gryphea vesicularis* in the upper part of the *Exogyra costata* beds. We have never found it in the lower portion even where the lower portion is entirely marine. This is rather conclusive, because *Gryphea vesicularis* occurs in Europe always in the higher Campanian up to the base of the Maestrichtian. We do not pretend that the Mexican *Gryphea vesicularis* is really identical with the European or the Asiatic form, but there is no character which distinguishes it specifically, which may be due to its simple form. Nevertheless *Gryphea vesicularis* is such a characteristic form that the occurrence of this group must be regarded as important for the determination of the age.

Orogenic movements during the Campanian.—Although this chapter treats only of the stratigraphy of the Cretaceous in the north, we must call the attention here to the orogenic movements which began in the Campanian and ended with the folding of the Mexican continental mountain system during older Eocene time.

We have seen that the Campanian near Lampazos is composed of brackish water beds in its lower portion. As the upper Santonian (Taylor marls) are evidently marine, this means that at the beginning of the Campanian an emerging movement of the bottom of the sea took place. This movement began in the southeast and we shall see later on that it caused the uplift of a long island or even a continent on the present coastal plain of Tamaulipas and Nuevo Leon, while in the region of Lampazos it produced the deposition of brackish water beds on the coast line. This uplift progressed toward the north during older Campanian time almost as far as the present course of the Rio Nadadores; then the bottom of the sea began again to sink in the region of Lampazos where the beds of upper Campanian were deposited as marine shales at shallow depth as the frequency of sandy beds and the occurrence of the large thick shelled oyster forms, *Exogyra costata* and *Gryphea vesicularis*, show.

At the same time the lower Campanian was marine farther north in the region between Piedras Negras and Barroterán, as is shown by the fossils which indicate the existence of a shallow sea. During the upper Campanian an uplift of the sea bottom followed which caused the deposition of the sandstones with the coal seams, probably a lagoon deposit on the coast. How far this movement extended toward the west cannot be ascertained at the present time. It is possible that the Rattlesnake Beds in West Texas belong to the coast line, but the age of these beds is not well enough known. The lagoon deposits of Sabinas and Barroterán extend certainly farther west to the valley of La Soledad, which belongs to the Rancho de San Blas. Farther west the conditions are not known in detail, but we know that on the boundary line of the States of Coahuila and Chihuahua the Campanian consists mostly of sandy rocks. It is not known how far the movement extended toward the south, but it certainly did not go any farther than the line from Monclova to Monterrey, as from there southwards the Campanian seems to be marine everywhere. Thus for the present we have to say that during the lower Campanian the bottom of the sea was uplifted in the region of Lampazos and then sank again in the upper Campanian while farther north it began to rise up during the latter part of Campanian time. We shall later on see that during the Maestrichtian another immersion followed in the north, while in the south an emersion began and continued until after the beginning of Eocene time.

Maestrichtian.—We consider as Maestrichtian those beds which in general have been designated as Escondido beds. We have not been convinced by the arguments of A. de Grossouvre[23] to the effect that, because an ammonite of the group of *Mortoniceras delawarense* had been found in the Eagle Pass beds, the *Sphenodiscus pleurisepta* should be considered as coming from the lower Campanian. This determination has been made without taking into account the actual conditions in the field. The Eagle Pass beds contain the Campanian (San Miguel beds, Coal series) and the Maestrichtian (Escondido beds) and there is nothing to prove that the *Mort. delawarense* comes from the same horizon as *Sphenodiscus pleurisepta.*[24]

We consider as the base of the Maestrichtian (Escondido beds) the hard sandy limestone (below) gray sandy shale (in the middle) and thick bedded gray sandy limestone (above), which form the lowest rim rock in the Mesillas northeast of Lampazos. This rim rock is not thicker than some ten meters; it lies about fifty meters above the highest bed with *Exogyra costata* and is separated from it by thin-bedded sandstone and sandy shales. The rim rock contains almost everywhere specimens of a new ammonite genus which will be called *Coahuilites* Böse; it occurs both in the hard rock and in the shales. The species found in it are *Coahuilites sheltoni* Böse and *Coahuilites orynskii* Böse. The first specimens of the new genus were discovered by Mr. Shelton, formerly geologist of the Mexican Gulf Oil Company, who told us about the locality, which lies about five kilometers south of the ranch of Alamo Viejo in an old railway cut (this railway has never been finished.) E. Böse, O. A. Cavins, J. B. Orynski and R. C. Stoner collected at this locality several times and were able to obtain a number of well preserved specimens. Böse and Orynski found the same genus and species later at different points of the rim

[23]A. de Grossouvre, **36**, p. 22.

[24]I have collected very carefully in all the beds of the Escondido formation, from the very lowest to the highest portion, but have never found a single *Mortoniceras!* I have also inspected different collections made by other geologists and these contained no *Mortoniceras.*—E. Böse.

rock of Mesillas, which showed that the ammonite may be used as an excellent index fossil.

The Escondido beds (Maestrichtian) are in general a sandy facies. They consist of different beds of shale, sandy shales of gray color, reddish and yellowish sandstones and conglomerates, gray to red sandy limestones, often almost composed entirely of fossil shells, and calcareous sandstones and conglomerates. Not all these beds are entirely marine; in the south the upper portion becomes brackish, as will be shown later on.

We have been able to subdivide the Maestrichtian in the region between Lampazos and Piedras Negras into five different horizons as follows, beginning at top:

A. Zone of *Sphenodiscus pleurisepta* Conrad
B. Zone of *Coahuilites cavinsi* Böse
C. Zone of *Sphenodiscus intermedius* Böse
D. Zone of *Sphenodiscus lenticularis* Owen
E. Zone of *Coahuilites sheltoni* Böse

As we have already said, we find at the base a horizon about ten meters thick consisting of thick bedded sandy limestone and sandy shales and containing *Coahuilites sheltoni* and *Coahuilites orynskii*. The most common form is *Coahuilites sheltoni* which we found in several specimens in the first hard ledge around the Mesillas near San Patricio, Nuevo Leon. Together with it occurs *Coahuilites orynskii.* Much richer is the locality on the old railway cut, already mentioned, about five kilometers south of Rancho del Alamo Viejo, where the shales contain a great number of specimens of *C. sheltoni.*

Above this horizon we have not found any ammonites, but we have not made more than one reconnaissance trip through the upper beds of Mesillas. We found the next higher horizon with ammonites on the road from Lampazos to Encinas in the upper portion of the valley of El Oro. These fossiliferous beds occur below and in a bluff of sandstones about twenty meters above the first thick bedded sandstones of the Maestrichtian, which are underlain by shales containing *Exogyra costata* about fifty meters below the upper boundary of these shales. No *Coahuilites* was found in the lower sandstones probably because of poor exposure. The fossiliferous beds above these lower sandstones which are separated from the higher ones by a series of sandy shales correspond thus to our horizon D. They contain numerous *Sphenodiscus lenticularis* Owen and also a *Belemenitella* and a great number of gastropods and bivalves not yet determined. A little higher we found *Sphenodiscus intermedius* Böse at the same locality.

We have found this same horizon on the Loma de los Narizones near Villa de Progreso, and on the Ceja del Macho of the Rancho Azulejo. It probably exists also on the Arroyo del Jabalí near the Rancho del Jabalí but the *Sphenodiscus* found there were so badly preserved that an exact determination was not possible.

The next higher horizon is well exposed in a low mesa near the old road from Rancho El Oro to Rancho del Jabalí near the crossing of the abandoned road from Rancho del Jabalí to San Patricio. This horizon is formed by gray sandy shales and more or less thick bedded gray hard sandy limestones weathering brown. These sandy limestones are generally quite sterile but in some places we find nests of fossils in them which contain a great number of well preserved specimens of *Sphenodiscus prepleurisepta* Böse and *S. intermedius* Böse; in the softer beds just below the highest sandy limestone these ammonites weather out in some places, especially on the east side of the mesa. This horizon we have called our horizon C. We find it again north of the Mesillas on the top of a little hill of sandstone with *Sphenodiscus prepleurisepta* Böse at the side of the road from San Patricio to Alamo Nuevo, at 27.3 kilometers N 15° W of San Patricio.

We find the same horizon also much farther north near the goat ranch of Campo de la Rosita not very far from the coal mines of Saltillito. Most of the very hard ledge of sandy limestone seems to be entirely sterile there, but lenses contain numerous specimens of *Sphenodiscus intermedius.* The exact distance of this locality from the beds with *Exogyra costata* could not be determined at this place but there is no doubt that it lies considerably above them, although still in the lower portion of the Maestrichtian. The same horizon with *Sphenodiscus intermedius* exists also on the Rancho Azulejo on the road to Amole ranch.

The middle portion of the Maestrichtian is formed by our horizon B. This consists of very hard siliceous sandy limestones intercalated in beds of gray sandy shale. It contains a group of *Coahuilites* which is quite different from that occurring at the base of the Maestrichtian; we have called this species *Coahuilites cavinsi* Böse. It occurs in several beds, the lowest of which lies about ten miles from Villa de Progreso on the road to Rancho Santa Cruz at the place where the road crosses the first bluff of very hard sandy limestone below the above mentioned ranch. The same beds seem to exist on a little mesa west of where the old road from Santa Cruz to Rancho de los Garcia crosses the main road from Villa de Progreso to Saltillito. A higher bed which contains the same species exists at the point where the old road from Santa Cruz to Rancho de los Garcia leaves the mesa of Santa Cruz and descends over a bluff into the next valley. This bed is almost a hundred meters higher than the first one, but the ammonites belong to the same species.

Above this horizon sandstones and sandy shales carrying mainly oysters and plant remains begin to predominate in the region between Lampazos and Barroterán. These beds which were probably deposited in lagoons or at least very near the coast, are very well exposed in the highest parts of the Mesa de las Cruces (south of Aura and west of Rancho de Santa Cruz) where they carry beds of large oysters and plant remains; these seem to be the youngest beds exposed in this region just south of the valley in which the Monclova-Piedras Negras Railway runs. We find similar beds in the upper portion of the Mesa de Cartujanos near Lampazos; the large bluff below the rim contains beds of large oysters, and above it we find sandstones and conglomerates with many plant remains, some shark teeth and small oysters.

It is safe to say that these beds are the brackish water representative of the highest marine beds on the Rio Grande, well exposed in different creeks between Guerrero, Coahuila and the Rancho de Cerrito Prieto. These highest beds consist mostly of gray, slightly sandy shales; they constitute our horizon A. They contain at least two species of *Sphenodiscus: S. pleurisepta* Conrad and *S. aberrans* Böse. The numerous *Sphenodiscus* with ornamentation which have been cited from lower beds, certainly do not belong to *S. pleurisepta*, but to those other species cited above: *S. intermedius, S. prepleurisepta,* and possibly even to *Coahuilites*.

At the Arroyo Caballero near Cerrito Prieto on the Rio Grande the highest marine beds of the Maestrichtian are covered unconformably by sandy and shaly beds of the Eocene Midway, as has been described on the American side by Stephenson and other authors. This Eocene did not go any farther inland, and we do not find it anywhere farther west. The deposition of marine and brackish water beds ended in the region between Saltillito and Mesa de Cartujanos with the highest Maestrichtian and the land then definitely emerged from the sea until the present times.

The thickness of the Maestrichtian is probably not less than 250 to 300 meters (Mesa de Cartujanos and Mesa de las Cruces) where it is entirely preserved, but in other places it becomes reduced in thickness and it is even missing in part of this region. The reason therefore is another orogenic movement which formed the main Mexican continent and which in the north began during the Maestrichtian. As toward the north and east the Cretaceous is everywhere covered by early Eocene, in most places by Midway, we can observe there how the Maestrichtian in the form of the Escondido bed becomes more and more reduced until it disappears entirely.

We have already seen that on the Rio Grande near the Hacienda de Cerrito Prieto the marine beds with *Sphenodiscus pleurisepta* are unconformably overlain by marine Midway. The base of this Maestrichtian begins a few kilometers below Piedras Negras, a little south of the mouth of the Rio Escondido, and this is certainly the region where its marine facies reaches the greatest thickness.

A little farther south and west we find at the old abandoned ranch of Saucillo, shales and sandstones containing *Ostrea cortex* in great numbers in the bed of the Arroyo Saucillo (or Juanes), and above these in the little mesa just above the creek we find a red sandstone containing *Venericardia alticosta*. No *Sphenodiscus pleurisepta* has been found in this part, but farther upward in the same creek, where the road from Rancho Azulejo to Rancho Amole crosses it, we find in the bottom of the creek a lens full of fossils, mainly different species of *Inoceramus*, but also quite a number of *Sphenodiscus intermedius* Böse; this place lies about 7.8 miles from Rancho Azulejo. On the same road but only 4.5 miles from Rancho Azulejo we found other specimens of *Sphenodiscus intermedius* Böse in a rather hard and very fossiliferous, somewhat sandy limestone. Unfortunately the beds below this limestone are covered, and no section of strata between the limestone and the *Exogyra costata* beds could be obtained.

On the road from Tanque del Macho to Longoria we found above the beds with *Exogyra costata* first thin to medium bedded sandy limestones with numerous gastropods and some bivalves; above these, a sandy clay with *Sphenodiscus lenticularis* Owen. The exposures are not very complete on this road. Farther on following the road from Rancho Azulejo toward Longoria we cross again the beds with *Exogyra costata*, but the following part is much covered. At about one and one-half miles northwest of the Rancho de Longoria we find a little mesa, where a hard gray sandy limestone covers a gray sandy shale; this latter contains *Sphenodiscus* which could not be determined specifically. Farther on, after passing Longoria where we could not find any fossils, we find another mesa half a mile east of the road and about two miles from Longoria; a thick bedded calcareous sandstone forms the rim rock and is underlain by gray sandy shales; these are very imperfectly exposed but notwithstanding this we were able to collect several *Sphenodiscus* cfr. *pleurisepta* Conrad. The rocks of this mesa are the highest ones of the Maestrichtian. They dip down toward a broad valley which runs toward the Laguna de la Leche. This valley contains shales and clays of the Midway containing *Venericardia alticosta;* they lie on the above mentioned sandy limestone or calcareous sandstone of the Maestrichtian and are covered on the opposite side of the broad valley by the characteristic red and gray coarse sandstone and conglomerate of the Wilcox division of the Eocene.

The conditions on the abandoned road from Anguila to Cuevas Pintas and Porvenir are very similar. The Escondido beds are not very well exposed but reach to near Cuevas Pintas; they are covered by sandy shales and sandstones which near the earth tank of Cuevas Pintas contain *Venericardia alticosta;* from there on toward Porvenir we find mainly the coarse sandstones and shales of the Wilcox division.

Here the thickness of the Maestrichtian has already begun to diminish. Very little farther south near Anguila only small areas of the Maestrichtian are left. We find it one mile southeast of the Rancho Anguila on the east side of the Arroyo Camaron; it consists there of medium to thick bedded hard brownish calcareous sandstones, sandy shales and sandy limestones. These contain numerous gastropods, pelecypods and quite frequently also *Sphenodiscus* related to *Sphenodiscus pleurisepta.* Still farther south near San Edmundo, the Maestrichtian seems to be entirely absent, or if present, it is reduced to a few meters, there being a very small interval between the sandy shaly beds with concretions containing *Enclimatoceras vaughani* representing the Midway and the beds with *Exogyra costata.* From here on south the Maestrichtian is certainly missing entirely and the Midway often containing quite numerous *Enclimatoceras vaughani* in the ball-like concretions, lies immediately on the beds with *Exogyra costata,* all along the Ceja Madre south of the National Railway to Laredo.

Farther west the conditions are different. We have already seen that the Maestrichtian is very well developed in the region between Barroterán and Lampazos south to the

Mesa de Cartujanos. We find it again in the mesa near San Antonio de Afuera, where it carries numerous *Sphenodiscus;* this hamlet lies on the road from Candela to Monclova. The Maestrichtian continues southward with some interruptions caused by erosion to the Cerro de la Popa east of Reata, where it gains a great thickness but consists almost entirely of thick bedded sandstone. Still farther south we find it all over the country from Paredon to Saltillo forming a large basin of upper Cretaceous. It contains *Sphenodiscus* in several places (Arizpe west of Paredon; Cerro de la Cruz at Ramos Arizpe near Saltillo). But these belong only to *S. lenticularis,* the upper beds being probably continental or lagoon beds and only containing scattered oysters and plant remains.

The age of the Escondido beds is clearly defined by the preponderance of *Sphenodiscus,* which in part *(S. prepleurisepta, S. intermedius, S. pleurisepta)* is so similar to the European species from the Maestrichtian *(Sphenodiscus binkhorsti* Böhm) of northern Europe that a doubt about the identity in age can scarcely persist. Quite significant is also the occurrence of *Parapachydiscus* cfr. *colligatus* which is also known in the Maestrichtian of Limburg. No Campanian ammonites have ever been found in the Escondido beds.

CHANGES OF FACIES IN THE CRETACEOUS BETWEEN LAMPAZOS AND TAMPICO

We have already indicated that the changes of facies between Lampazos, Nuevo Leon, and Tampico do not occur in all the beds in the same district; thus, while we may find an abyssal deposit in the Albian, we have a deep water deposit in the Cenomanian and a shallow sea in the upper Cretaceous. It will therefore be necessary to consider each age for itself and afterwards describe how the different orogenic movements occurred in different parts of the region. We use here the same subdivisions we have introduced in the northern portion of the country and in Texas and then shall be able to compare the various districts. In general we shall pay most attention to the area between the foot of the Sierra Madre and the coast of the Gulf of Mexico, but we shall have to discuss also certain developments in the high mountains themselves.

Infracretaceous (Berriasian to Barremian, inclusive).—No Infracretaceous has been discovered so far in the country between the foot of the Sierra Madre and the Gulf coast. In the Sierra Madre itself, where older beds are exposed no *Berriasian* fauna has been found so far. On the other hand, the *Valanginian* is well represented in different places. We have already spoken of the Valaningian near Monterrey; we find it also in the region west of Saltillo and east of this town. In the Valle de Potosí and on the Cerro de Potosí, at Rincon de las Alazanas and in a number of other places east of Saltillo, its existence was discovered several years ago by the senior author of this paper. There it consists of gray shales alternating with thin bedded gray limestones containing numerous ammonites. Many of these are preserved in the form of limonite or pyrite.

Much nearer the region discussed here we found the Valanginian at Galeana (thirty miles west of Linares). There the Valanginian is represented in its lower part by medium and thin bedded limestones of gray color with intercalations of gray marls. The limestones frequently carry *Thurmannia thurmanni* Pictet, and related species. Above these we find a mass of coarse red sandstones and conglomerate apparently entirely sterile, but covered by a series of sandy gray shales and sandstones which carry numerous *Astieria* apparently mostly of the group of *A. astieri* d'Orbigny. The fossils are not especially well preserved, because the matrix is sandy but sufficiently well for the determination of the group. These beds must have been deposited near the coast, especially those of the middle part which are entirely of a shore line origin, but later a new submersion must have followed during the deposition of the sandy shales with *Astieria* which terminated with a formation of thin bedded limestones with interbedded gray marls and shales. These latter ones represent certainly the upper portion of the Neocomian.

We have not been able to find fossils in these limestones, but slightly farther west in the Cañon de Pozos on the land of the Hacienda Ciénega del Toro, we observe dark limestones and shales which contain numerous *Astieria* and *Leopoldia* and very probably represent the *Hauterivian.* This same horizon probably exists also near Miquihuana, Nuevo Leon, where Hill found a number of ammonites; some of these seem to belong to *Astieria sayni* group and it is very possible that these sandy beds also belong to the Hauterivian.

Barremian fossils have not been found anywhere in this region, but no detailed studies have been made.

Mesocretaceous (Aptian to Cenomanian, inclusive).—Much better represented than the Infracretaceous is the Mesocretaceous, although the very lowest beds do not seem to be exposed between the Sierra Madre and the Gulf coast.

Aptian.—On the road from Ciudad Victoria to Jaumave between the ranch La Mula and Mina, José G. Aguilera found years ago some specimens of a *Puzosia*, which belongs to the group of *Puzosia liptoviensis* Zeuschner. It must have been found in the reddish beds of the base of the middle Cretaceous limestones; at least its lithological character leads to this conclusion. This group which is very common in the region of western Zacatecas occurs in beds which either represent the very highest Barremian or the lowest Aptian. Above these beds we find limestones with *Requienia* and *Monopleura* which certainly represent the lower Aptian or Bedoulian.

The upper Aptian or Gargasian has not yet been found in this region, except at the place near Saltillo mentioned in the first chapter. In the region of the Sierra de San Carlos in Tamaulipas the upper Aptian does not seem to be exposed, but as beds exist there which belong to the lowest Albian, it is very possible that more detailed examination may show its existence even there.

Albian.—In the Sierra Madre we find thick bedded gray limestones resting on the upper Aptian where this is developed. In the western portion they carry Caprinidae and certain Rudistidae indicating thus the existence of rather shallow water. These fossils cannot be separated from their matrix in general, but in some places, as in the Gruta de Garcia near Monterrey, they weather out, or in other places, as near Las Palmas, at the foot of the Sierra del Abra, they can be found isolated. These limestones carry generally nodules of dark chert, but the fossils are never silicified.

A different kind of limestone is found in a long and rather narrow zone which begins in the north in the Sierra de Lampazos and continues southward in the most eastern portion of the Sierra Madre, at least until Ciudad Victoria but probably still farther south. These are rather black or at least very dark limestones in thick to medium beds. They carry frequently strongly ornamented *Hoplites* probably belonging to groups found in the deep canyons near Lampazos, in the highest parts of the Sierra de Minas Viejas, especially on top of the high mountain near the mines; farther south we find them on the west side of the canyon east of Villa de Santiago which leads toward Cadereita. Similar forms occur also in the black limestone near Ciudad Victoria. Thus there seems to exist a whole zone of Albian limestone which occupies the front ranges of the Sierra Madre from Lampazos to north of Xicotencatl and does not in general carry any Caprinidae but contains strongly ornamented *Hoplites* of the Albian. The age of these beds cannot be doubtful, as they are covered practically everywhere by beds which contain *Oxytropidoceras* of the group of *O. acutocarinatum* Shumard, which represents the upper bed of the middle Albian. The existence of strongly ornamented ammonites and the absence of Caprinidae and Rudistidae[25] in general make it evident that we have here the deposits of deeper waters.

We find much better collecting conditions in the San Carlos Mountains in Tamaulipas, where intrusive rocks have lifted up the middle Cretaceous, and this as well as erosion

[25]The limit between the deeper and the shallow sea is of course not the same in every bed of the lower Albian on such a long tract; the Caprinae extend a little farther east in some beds than in others, and the zone of dark limestones enters farther into the main mountains in some places than in others, but in general the distribution is rather uniform and the zone is comparatively narrow.

has made possible the observation of the older beds of this series. These beds had been considered as practically barren of fossils by former authors as Furman Kemp, Finlay and Dumble.

As we have already remarked, no Aptian has been discovered in this region; in the lower portion of the limestones we find a series of yellowish to reddish and gray colored thin bedded limestones, with a peculiar porcelain fracture; these contain a number of ammonites mostly rather compressed. We find these beds in the Cañon de San Nicolas in the Sierra de San Carlos. In two localities we discovered the following fossils:

First locality:

Puzosia aff. *P. mayoriana* d'Orbigny
Uhligella jacobi Burckhardt
Uhligella cfr. *jacobi* Burckhardt
Parahoplites milletianus d'Orbigny
Parahoplites aff. *P. milletianus* d'Orbigny
Hamites cfr. *virgulatus* Brongniart

Second locality:

Belemnites sp.
Hamulina sp. nov.
Crioceras sp.
Puzosia matheroni d'Orbigny
Puzosia sp.
Uhligella zurcheri Jacob
Uhligella sp.
Parahoplites aschiltaensis Anthula
Parahoplites aff. *melchioris*
Acanthoplites aff. *A. janneli* Parent
Acanthoplites sp.
Douvilleiceras bigoureti Seunes
Douvilleiceras sp.
Inoceramus cfr. *anglicus* Woods.

We do not intend to say that the species named are really identical with the European ones, but they are so near them that they belong at least to the same groups. The list shows that these beds evidently represent the so-called horizon of

Clansayes, or the lowest Albian. In former years several authors considered this horizon as belonging to the Aptian, but Jacob has shown that the Clansayes horizon really forms the base of the Albian, and his views have been generally accepted. Similar beds were discovered in Zacatecas by Burckhardt before 1906 and called by him "Parahoplites beds."

Above these beds we find in the Cañon de San Nicolas as well as in the Cañon de Montezuma between Aguamiel and Montezuma (three miles northwest of San Nicolas) thick bedded gray limestones which contain a fauna of ammonites and some bivalves and brachipods. The following fossils were collected:

First locality in Cañon de San Nicolas:

Hamites cfr. *attenuatus* Sowerby

Second locality in Cañon de San Nicolas:

Hamites attenuatus Sowerby
Puzosia sp.
Oxytropidoceras aff. *O. acutocarinatum* (Shumard) Marcou
Oxytropidoceras n. sp. aff. *O. multifidum* Steinmann
Oxytropidoceras roissyi d'Orbigny (a little lower than the rest)
Rhynchonella aff. *apicalis* Pictet

A much richer fauna was discovered by us not quite two miles from San Carlos on the road to La Gavia in the southern part of the San Carlos Mountains. There the thick bedded limestones form the brow of the terrace which skirts the side of the mountains and above we see only the thinner bedded limestones and shales. The following fauna was collected here:

Belemnites sp.
Phylloceras velledae Michelin
Hamites simplex d'Orbigny
Kossmatella agassizi Pictet
Desmoceras (Beudanticeras) beudanti Brongniart
Latidorsella latidorsata Michelin
Puzosia n. sp. aff. *P. kiliani* Fallot
Puzosia cfr. *mayoriana* d'Orbigny
Puzosia n. sp. aff. *nolani* Fallot

Puzosia aff. *provinciale* Parona et Bonarelli
Uhligella aff. *U. rebouli* Jacob
Uhligella n. sp. aff. *U. walleranti* Jacob
Uhligella n. sp.
Acanthoceras cfr. *camattei* d'Orbigny
Acanthoceras sp.
Engonoceras sp. nov.
Oxytropidoceras cfr. *roissyi* d'Orbigny
Homomya sp.
Epiaster sp.

In a bed which rests on these ammonite beds we found numerous specimens of *Inoceramus* aff. *concentricus* Parkinson.

Similar beds occur also between Aguamiel and Montezuma but the conditions for collecting are not very favorable; we found only *Puzosia* cfr. *mayoriana* d'Orbigny and *Inoceramus* aff. *concentricus* Parkinson.

The fauna of San Carlos is entirely new for North America, although some of its elements seem to occur in the so-called Horsetown beds of California; but those beds contain also other and higher horizons, which makes a comparison rather difficult. In Texas this horizon is represented by the beds above the Glen Rose and includes probably also the Edwards limestone which contains mainly Caprinidae and Rudistae, while the few ammonites so far have not been satisfactorily described. This fauna corresponds exactly to the middle Albian of Europe and the composition of the elements found near San Carlos reminds us strongly of the Albian of the Balearic Islands described by Fallot and that of certain regions of southern France and northern Africa.

A very characteristic feature is the preponderance of forms which show very little ornamentation; the only exceptions are the fragment of *Oxytropidoceras roissyi* and that of a large *Acanthoceras*. The *O.* cfr. *roissyi* can scarcely be distinguished from the European species and is decidedly different from the *O. acutocarinatum*. The main part of the fauna belongs to the family of the Desmoceratidae: *Desmoceras* s.s., *Uhligella, Puzosia, Latidorsella,* while other genera are less frequent. Among the bivalves a species very similar to the characteristic *Inoceramus concentricus* is quite common.

According to Kilian, Fallot, and others this kind of a fauna indicates a deep sea deposit. They have tried to show that the bathyal and abyssal portion of a geosyncline is inhabited by a smooth fauna with little or no ornamentation (stenotherm forms of E. Haug). In such a fauna strongly ornamented forms may be found, as these are transported by currents of the sea, as in the same manner we find the smooth species sometimes in the deposits of a shallower water. This explanation can be well applied to this region of Mexico. We already know that toward the southwest and west the Albian is composed mostly of reef building Caprinidae and Rudistae, as is also true in Texas (Edwards limestone), but that these Caprinidae are practically missing in the region east of a line drawn from Lampazos, Nuevo Leon, through Villa de Santiago, Iturbide and Llera (south of C. Victoria). How far this zone continues toward the south is not yet known, but on the railway between San Luis Potosí and Tampico the Caprina limestones are found far to the east in the lower limestone of the range between El Abra and Ebano. These Caprina limestones certainly were formed in a region of shallow water, these animals being reef builders.

Somewhat different is the fauna of the Cañon de San Nicolas, where ornamented elements like *Oxytropidoceras roissyi*, *O. acutocarinatum* and *O.* aff. *multifidum* occur. These two latter forms are probably a little higher than the first one. The frequent occurrence of a *Rhynchonella* indicates rather shallower water.

The same limestones occur much farther north in Nuevo Leon in the Sierra de Papagayos near Ramones and carry a very similar fauna. According to the descriptions of Dumble this author may have included both the San Carlos and the Sierra de Papagayos limestones in his San Juan limestone.

In the northern part of the country the Albian limestones are always characterized by thick nodules of black chert; toward the south and east the character of the beds changes considerably. We found Albian limestones exposed in the Sierra de Tamaulipas, especially in the deep Cañon del Diablo and the side canyons of the Cañon de Panales. Those limestones are more or less white or at least of a light gray color, and the chert nodules also show a whitish or gray color. Near the so-called Piedra de Agua in the Cañon del Diablo the thick bedded limestone is full of sections of large ammonites but we were not able to separate a single one from its matrix. A few specimens collected by the junior author in the Cañon de los Panales were rather poorly preserved, but among them we found a characteristic South American form of the Albian, the *Acanthoceras prorsocurvatum* Gerhardt. The transition beds between the Albian and the Aptian, that is the horizon of Clansayes or lower Albian, seem present also; the junior author collected in the Cañon de los Panales some rather poorly preserved fossils:

Puzosia cfr. *kiliani* Fallot
Acanthoplites aff. *crassicostatus* d'Orbigny
Uhligella sp.
Inoceramus cfr. *anglicus* Woods.

The rocks which contain these fossils are similar to those of the lower Albian of the Cañon de San Nicolas.

At the same latitude but farther west in the mountains of Ciudad Victoria the Albian limestones show exactly the same character as in the north, that is, dark gray bedded limestones with nodules of black chert.

Upper Albian.—This formation, which formerly was included in the term Vraconnian by the senior author, consists of thin bedded gray limestones with nodules and long lenses of black chert, very often secondarily but strongly folded, mostly in the form of knee folds, while the thicker bedded middle Albian limestones do not partake in this kind of deformation but present only the larger features of the tectonics.

These extremely characteristic beds contain everywhere *Pervinquieria* of the group of *P. inflata* Sowerby and a great number of open whorled ammonites: *Turrilites*, *Crioceras*, *Hamites, Ancyloceras, Anisoceras* and others. These beds are extraordinarily uniform all over northern and central Mexico and have been found in almost every part of the states of Zacatecas, Nuevo Leon, Tamaulipas and Coahuila. Fossils of the above mentioned character occur on the road west from Ciudad Victoria to Jaumave, especially on the long serpentines of the road above Ciudad Victoria. In the San Carlos Mountains this horizon is also very well developed; the characteristic thin bedded gray limestones with their long thin lenses of black chert lie immediately above the middle Albian. They are not thicker than 100 to 125 meters. In Texas these beds are represented by the lower Georgetown beds and in California by part of the Horsetown beds both of which carry the characteristic *Pervinquieria* of the *P. inflata* group.

In the Sierra de Tamaulipas these beds are difficult to distinguish from the middle Albian, as they also have a whitish color, but they are probably represented in the thin bedded limestone at the top of the series.

These beds belong certainly to deeper water deposits but are not of abyssal nature, which means that after the time of the middle Albian, the bottom of the sea rose again all over northern Mexico. This movement continued during the Cenomanian, as we shall see in the following paragraph.

Cenomanian.—The Cenomanian proper is not very well represented in this part of the country, that is, no fauna of this age is known, but above the Albian in Nuevo Leon, Coahuila and Tamaulipas occurs a series of sandy shales and limestones alternating with thin bedded limestones and argillaceous shales and marls, mostly of gray color and weathering yellowish. Although these beds, which are not thicker than 100 to 160 meters, have not yet rendered any fauna, their position between the upper Albian and the Turonian leaves no doubt with respect to their age. It is possible that to them belongs also the lowest part of the shales which the senior author formerly has included in the Turonian, that is, those which carry a great number of fish remains and especially bones, but as yet we have not had any paleontological proof for this opinion.

These beds, which possibly were also included in the San Juan limestone by Dumble, occur in the Sierra de Papagayos but are often covered by débris. On account of the softer nature of their rocks they generally form slight depressions in the spurs of the mountains, the front part being composed of the somewhat harder limestones of the base of the Turonian.

We found beds of this age in every part of the Sierra Madre we entered. They are well developed on the road from Linares to Galeana near Iturbide and in the syncline west of this latter town; they can also be observed on the road from Ciudad Victoria to Jaumave, especially near the end of the canyon which leads down to the Rancho de la Mula. In the Sierra de San Carlos and in the Sierra de Tamaulipas these beds are often covered by the débris of the Turonian, but show generally as a terrace between the upper Albian and the Turonian.

The nature of these beds shows clearly that they were deposited in rather shallow water, but another sinking of the bottom of the sea may have taken place during the upper Cenomanian if the above mentioned dark thin bedded limestones and shales with bone remains really belong to them.

Supracretaceous (Turonian to Maestrichtian, inclusive). The Supracretaceous of this region compared with that of the country between Lampazos and southern Texas shows still greater changes than the Mesocretaceous. The facies of the beds from the Turonian to the Santonian are different in their lithological character and their fauna is generally very poor or quite different from that of the northern province. The Campanian and Maestrichtian, on the other hand, were never deposited in the region between the Sierra Madre and the Gulf Coast, while the former at least exists in the Sierra Madre itself and contains generally the same fauna as in the more northern region. We shall discuss the different horizons in the following paragraphs.

Turonian.—The lowest portion of the Supracretaceous is made up of black, brown and gray shales, shaly and laminated black limestone, thin bedded limestone of the same color, and locally, especially in the lower and upper portions, medium bedded black and very bituminous limestone. The shales and the shaly limestones carry pyrite in granules and even in crystals. The thickness of this horizon varies between 250 and 350 meters. While in some parts, as for example west of Ciudad Victoria, these beds are quite calcareous, in other localities, as near Montemorelos, where Dumble did not distinguish them from his Papagayos shales, they are quite argillaceous and contain only a very few beds of thin limestone.

The fauna of these beds is not rich in species but in individuals. We find great numbers of *Inoceramus labiatus* Schlotheim and *I. hercynicus* Petraschek, rarely an entirely compressed ammonite *(Prionotropis?)* and some *Ostrea lugubris* Conrad. Fish scales and bones are very frequent; sometimes whole skeletons of fishes are found, especially in the lowest portion of these beds which, as above stated, may belong to the Cenomanian.

Wherever we have seen this horizon we could always collect the characteristic fossils above cited. The main fossil-bearing localities from north to south are: east side of the Sierra de Papagayos near Ramones *(Inoceramus labiatus, I. hercynicus)*; south of Montemorelos at Los Ahorcados *(I. hercynicus)*; Cañon de Santa Rosa, west of Linares *(Inoceramus hercynicus)*; in the San Carlos Mounttains near El Palmar at the upper end of Cañon de San Nicolas near the well (fish skeleton and *Inoceramus hercynicus)*; in the Sierra de Tamaulipas, on the east side near Rancho del Tigre *(I. labiatus)*; on the west side near San Francisco *(I. hercynicus, I. opalensis* Böse); near Piedras Negras, Tamaulipas, at Cueva del Leon *(I. hercynicus, I. labiatus)*; near Los Angeles *(I. hercynicus, I. labiatus, Ostrea lugubris, Prionotropis* (?)); in the center of the Sierra de Tamaulipas at La Zaga between Los Angeles and Los Venados *(I. labiatus, I. hercynicus)*; in the Sierra Madre west of Ciudad Victoria in the Cañon de Tamatan near Peñuela *(I. labiatus)*; on the road to Jaumave near the Rancho de la Mula *(I. labiatus, I. hercynicus)*.

By both lithology and fossils this horizon is easily identified all over northern and central Mexico; it has been found in numerous localities after its occurrence was first shown at Parras in 1905 by the senior author; it now has been found in the states of Chihuahua, Coahuila, Durango, Zacatecas, Nuevo Leon, Tamaulipas, San Luis Potosí, Hidalgo, Puebla, and elsewhere. Certain parts of it are extremely uniform petrographically, especially the brown and black shales and the thinly laminated limestone, although there is a difference in the different elements of the horizon, because in some localities it is more calcareous and in others more shaly.

The Turonian of our southern region is scarcely different from the beds described in the former chapter which exist between Lampazos and southern Texas. We find it almost everywhere along the flanks of the Sierra Lampazos, the Sierra de Vallecillo, the Sierra de Mamulique, the Sierra de Picachos, which mountain ranges form the connection between our northern area and the one described here. In the region of Tampico these beds have been included in the so-called San Felipe limestones, although they are certainly very different from the upper part of this so-called formation, both as to lithology and fauna.

Coniacian and Lower Santonian.—The rocks above the Turonian are very poor in fossils and therefore a subdivision is at some places impossible, especially in the northern portion of the territory described here. We already know that in the region south of Monclova in Coahuila the whitish limestones and marls which represent the Coniacian and lower Santonian (Austin chalk) become more and more shaly until they are entirely represented by gray shales which cannot be petrographically distinguished from those of the upper Santonian (Taylor marls); this change can be seen west of Cuatro Ciénegas in the region between this town and Rancho de la Zacatosa. A similar change occurs toward the west in the State of Chihuahua, where near Ojinaga the Coniacian (with *Peroniceras* aff. *subtricarinatum* and *Proplacenticeras* aff. *fritschi)* is represented by reddish sandstone and sandy shales and the lower Santonian by gray sandy marls.

In the southeast we observe that the Austin chalk becomes very thin at Vallecillo and probably does not represent more than the Coniacian. This marly limestone disappears toward the south and is replaced by gray shales. The lower portion of these shales and marls which carry rare thin beds of gray limestone weathers in a peculiar manner, forming elliptical nodules on the surface of the beds; where the beds form a bluff as along a stream it is practically impossible to recognize the bedding planes. We observed these beds in the Papagayos Mountains near Ramones; Dumble includes them in his Papagayos shales. The lower 100 meters seem to be absolutely barren of fossils. We presume that they represent the Coniacian.

The middle part, which still weathers to elliptical-shaped nodules on the surface of the bedding planes, carries locally very characteristic *Inoceramus* of the *I. balticus* Böhm group *(I. crippsi* Auct.). Such were found for example on the road to Carmen and on that to Cañas, northeast of Linares, Nuevo Leon. These *Inocerami* are probably identical with a form quite frequent in the lower Santonian (zone of *Mortoniceras texanum* Roemer), the middle portion of the Austin chalk of the northernmost Mexico and Texas.

This southern facies extends also to the west; we find the same gray shales lying immediately on the Turonian in the wide valley of Jaumave, west of Ciudad Victoria.

Before we enter into a discussion of the stratigraphic and facies conditions of the Coniacian and lower Senonian in the Sierra Madre we must first see how the facies changes toward the south and east.

At Ciudad Victoria, especially in the big quarry near Tamatán, we see that above the Turonian dark shales and limestones occur thin to medium bedded white limestones interbedded with gray shales weathering into elliptical nodules on the bedding planes and entirely similar to the lower "Papagayos shales," that is similar to the lower portion of the shales which we observed farther north in the region of Linares and Lampazos. This shows that here the lower portion of the great mass of upper Cretaceous shales is beginning to be replaced by white limestone. Toward the east the first equivalent of those lower shales occurs in the Sierra de Tamaulipas. Beginning south of the main mountains of the Sierra de San Carlos and continuing south into the Tamaulipas range proper, the whitish limestone above the Turonian becomes thicker, and from the Mesa de Solís (the highest range on the road from Ciudad Victoria to Jimenez) on eastward, these thin bedded white limestones do not show much shale in their lower hundred meters, and only at the top do thin bedded white limestones begin to alternate with beds of normal gray ("Papagayos") shales. In this region and farther south near the main road from Ciudad Victoria to Soto la Marina through Villa de Casas, where the base of these limestones is exposed, the white limestones are about 135 meters thick. These are probably the limestones referred to by Dumble as San Juan limestone in the Tamaulipas range, but as this name has been applied to a number of different beds from the Albian upwards, it would be better not to use it. Also the name of San Felipe limestone has been applied to these white limestones, unfortunately also this latter name has been used rather indiscriminately for formations which represent the Turonian as well as the Coniacian and part of the Santonian. It would be best to use a new name for these white limestones of the Sierra de Tamaulipas which lie immediately on the Turonian; we propose to call them *Solis limestones*, not in the sense of a local name of a horizon but as a local name for a facies comprising the Coniacian and lower Santonian. It is a creamy-white to light gray limestone, mostly thin bedded, but containing some medium and even some thick beds of the same character; in general they do not contain many chert nodules but in some parts light gray chert lenses occur; some of these beds, especially just above the Turonian, show a very characteristic green color. The limestone is not very hard and has a kind of porcelain fracturing. It resembles very much the lower portion of the Austin chalk near the Rio Grande and is probably of the same age, that is, the Coniacian and lower Santonian.

We have not been able to find a single fossil in the main portion of the Solis limestone; but one finds very commonly fragments of very thick *Inoceramus* in it, just as they occur in the lower Austin chalk. In the uppermost part where the limestone begins to alternate with shale we found an enormous *Inoceramus* with a diameter of at least half a meter which seems to be identical with those that so frequently occur in the zone of *Mortoniceras texanum* of the middle Austin Chalk in northernmost Mexico. The same fossil occurs also in the same zone in the shales interbedded with thin limestones at the Puerto de Jora west of Cuatro Ciénegas, which represent the zone of *Mortoniceras texanum* Roemer. There is scarcely any doubt that the Solis limestone represents the lower and part of the middle Austin chalk, that is: the Coniacian and the lower Santonian; a subdivision is not possible as no characteristic fossils have been found in the lower portion.

Still farther south the facies of the Coniacian and lower Santonian changes again. In the region of Chocoy there exists a series of thin bedded gray limestones, interbedded with shales in its upper portion. These beds have been designated as San Felipe limestones, but have not been distinguished from the Turonian below them. A Turonian fossil, the *Inoceramus hercynicus* Petraschek, has been found in a well of the territory known as Aguacate y Paciencia, near Topila, south of Tampico, below the main mass of the San Felipe limestone.

This San Felipe limestone is certainly a facies of the same horizon to which belongs our Solis limestone. From the upper portion of the San Felipe limestone Stephenson[26] has described the interesting *Durania manuelensis* which he considers representing the upper Austin chalk. His form is certainly not lower Santonian, as *Durania* never gets as high as that, but represents probably the Coniacian and upper Turonian where the genus described here is developed in Europe. Stanton[27] has described another fossil from the San Felipe beds of the Sierra del Abra, under the name of *Sauvagesia degolyeri.* He says that in size, form, general appearance, and minute structure this species is very much

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[26]Stephenson, 89, p. 12, pl. xv.

[27]T. W. Stanton, 86, p. 45, pl. xcvi.

like an undescribed *Sauvagesia* from the upper part of the Brownstown marl near White Cliff, Arkansas. As the Brownstown marl lies on the Turonian, it is entirely possible that it corresponds to the San Felipe beds and also belongs to the Coniacian or at the utmost to the lower Santonian. As we shall see later on, there are other reasons why we should consider the San Felipe beds as Coniacian and not higher than lower Santonian, if we take into account the age of the overlying "Papagayos" shales.

Upper Santonian.—We have already seen that in the north near Linares and the Sierra de Papagayos the Turonian is covered by a thick mass of gray shales, the lower portion of which is lithologically a little different from the upper one, and we have tried to show that the lower portion is nothing but a shaly facies of the Coniacian and lower Santonian, represented in other parts by the Austin chalk (in the north) and by the Solis limestone and the San Felipe beds (in the south). We shall now discuss the upper portion of this mass of shales. This upper portion is also of gray color but of a little darker shade and the shales weather into a uniform mass of long splinter-like pieces and can be considered as a fissile shale. These beds can be followed from the Sierra de Vallecillo where they carry *Gaudryceras kayei* Forbes south to the Sierra de Papagayos. At Vallecillo these shales lie above the somewhat reduced Austin chalk and toward the east are covered by the Tulillo facies of the beds with *Exogyra costata.* Their age is therefore well determined as Santonian. These upper shales do not seem to carry any fossils in the south, at least we have never found any as far south as Tampico, with one exception which will be discussed a little farther on. These shales which near Tampico have been divided into Papagayos, Mendez and Velasco shales carry numerous foraminifera, but these do not give us any proof of the real age of the beds and are only useful for local purposes.

On both sides of the Sierra de Tamaulipas we find the Solis limestone overlain by gray shales which certainly correspond to the upper shales farther north. On the west side of this mountain range these shales seem to have a thickness of at least some 1200 feet (no actual measuring being possible). These shales have yielded no fossils so far, except some thin shelled small oysters. This makes a determination of the real age almost impossible, especially as they are not overlain by younger Cretaceous but by upper Eocene (Ocala limestone) near Abasolo, Tamaulipas.

But fortunately fossils exist farther south near Rayon in the upper portion, the so-called Mendez shales. Dr. Braendlin, formerly chief geologist of the Crédito Petrolero in Tampico, had the kindness to show us fragments of a saurian which he collected near Rayon. Together with this animal he found a number of other fossils, among which we recognized the upper valve of *Coralliochama g.-boehmi* Böse; together with it were found numerous fragments of *Sauvagesia* belonging to species described by the senior author from the Cardenas division and by Stephenson from Chocoy, Tamaulipas. Thus there is no doubt that at least the upper part of the shales, which are generally called Papagayos shales or Mendez shales, correspond in age to the Cárdenas division, that is, to the *Coralliochama* beds of this division, and later on we will show that these beds are older than Campanian, which means that they belong to the upper Santonian. The discovery of *Coralliochama g.-boehmi* in these shales is thus of the greatest importance; the specimen was somewhat corroded on the upper side and showed the characteristic coral-like structure, which by someone had been taken for bone structure and the specimen had been regarded as part of the saurian. But the lower side shows the teeth of the hinge very well preserved and does not leave any doubt about the generical position of the fossil. Thus we see that in the south near Tampico the upper Santonian occurs in a shallow water facies carrying Rudistids and Caprinas, while in the north its rocks were probably deposited in a somewhat deeper water, although not very far from the coast, as is indicated by the occurrence of the thick shelled oysters *(Exogyra ponderosa)*, and by the frequency of concretionary limestones which generally carry ammonites. But before we can discuss the distribution of the different facies of the Senonian we shall have to consider the composition of these beds in the Sierra Madre, west of the region so far discussed. Before we enter into this discussion we shall have to say a few words about the very highest Cretaceous beds in the region south of Vallecillo and north of Tampico.

In the northern portion of this area we find above the upper shales of the Santonian a series of hard gray calcareous sandstones in very thick beds but alternating with somewhat sandy shales. This series is nowhere very thick, but as it is rather constant and can be followed almost to Tampico and generally represents the top of the Cretaceous in this region, it will be described here. The series consists of thick bedded gray calcareous sandstone alternating with sandy shale; the upper portion consists of thin bedded shaly sandstone, and sandy shale, sometimes like the so-called paper shales. The thick bedded sandstones occur on the hill near the cemetery of Linares and form a long hogback north of the road from Linares to Burgos near the ranchos of El Indio and El Mulato. Similar rocks occur above the shales west of Guadalupe la Joya and on the road from Guadalupe la Joya to General Teran, just northwest of Palo Blanco.

In the southern portion of this area we find similar sandstones and sandy shales near La Coma, about thirteen miles south of Ciudad Victoria forming the very youngest part of the rocks deposited in this region. These sandstones are certainly not of marine origin; they contain a great number of plant remains and worm tracks of different kinds.

Still farther south we find similar sandstones and sandy shales forming the highest beds in the region of Magiscatzin; they are folded in the same way as the underlying shales.

There is no doubt that these sandstones and shales lie everywhere conformably on the shales of the upper Santonian and that they belong to the Cretaceous. The overlying Midway in the north is of different character and always carries marine fossils. In the south we have never seen a place where these beds are covered by Tertiary. They have sometimes been confounded with the lower Tertiary; Dumble, for example, seems to consider these beds at Padilla, east of Ciudad Victoria, as Tertiary, but they are far away from the Cretaceous-Tertiary contact, and the Tertiary begins with entirely different rocks: namely, the shales and coral reefs of the Ocala limestone.

The determination of the age of these upper sandy Cretaceous beds is impossible as long as no characteristic fossils have been found in them. They cannot be much younger than the upper Santonian, if they do not simply form the uppermost beds of this age. This latter theory is the most probable one; we have seen that in the region of Lampazos the lower portion of the Campanian is represented by the brackish water deposit of the Tulillo facies (lowermost beds of the horizon with *Exogyra costata* Say) and that these beds continue south but become more and more shaly toward the south, thinning out at the same time, until near Tortillas they are represented by a few beds of sandstones in the shales. From here to the south a representative of the Campanian (beds with *Exogyra costata)* is entirely unknown and no *Exogyra costata* has been found between the foot of the Sierra Madre and the Gulf coast.

Thus, while in the north and west, that is, in the region of Piedras Negras and Eagle Pass, a submersion took place during the beginning of the Campanian and another one at the beginning of the Maestrichtian (Escondido beds) which suffered a short interruption at the beginning of the Eocene, we find that farther south in the region between Huizachito and Tortillas, only a submersion followed in the upper Campanian and that during the time of the Maestrichtian no deposition followed. Still farther south the bottom of the sea began to rise at the end of the upper Santonian and neither Campanian nor Maestrichtian was ever deposited there. It is thus quite natural that the upper Santonian ended in this region from Tortillas to Tampico with the deposition of brackish water and non-marine sandstones and sandy shales. In the north this interruption of deposition lasted until the lower Eocene, the existence of which is known from Tortillas to east of Linares; in the central portion the interruption lasted until the upper Eocene which between Jimenez and Abasolo at least rests in the form of Ocala limestone with its characteristic *Oligopygus* on the shales of the upper Santonian; while still farther south the lower Oligocene (Vicksburg formation) seems to cover the Cretaceous. Thus the farther south we go, the longer the interruption of deposition lasted but it seems to begin everywhere at the same time, the end of the upper Santonian.

The Supracretaceous in the Sierra Madre.—Before we can discuss the distribution of Cretaceous facies in northeast Mexico and the sequence of orogenic movements, we first have to see what happens in the Sierra Madre during the time from the Turonian to the Maestrichtian.

Several years ago the senior author of this paper called attention to the fact that in the Sierra Madre east of Saltillo, no beds younger than Turonian seem to exist, while west of this town the whole upper Cretaceous is represented. He left the question open as to whether this was to be explained by erosion or by non-deposition.

We can add now that the conditions observed east of Saltillo prevail also in that part of the Sierra Madre which lies south of the region mentioned, as far as the beginning of the broad valley of Tula. We may also add that south of the Sierra de Parras, or south of the great synclinal basin between Torreon, Coahuila, and Saltillo, the Turonian is still present in its normal facies, but that above the beds with *Inoceramus labiatus* sandstones and sandy shales are found which represent either the upper Turonian or the Coniacian or both together. It is as yet doubtful if the Santonian and Campanian are represented at all, but the Maestrichtian seems to be entirely absent. About the regions farther south nothing definite is known, but it seems that with exception of the Turonian no Supracretaceous was deposited.

There are different conditions in the basin of Tula and in the Sierra Madre east of it. Near Tula we find the oldest beds to consist of a gray rather hard limestone which contains *Coralliochama* and *Biradiolites* in its upper beds. Above this limestone we find a series of about 300 meters of shales and sandy shales in which no fossils seem to occur. These shales are covered by sandy shales, sandy limestones and sands which carry a great number of *Gryphea vesicularis* and *Exogyra costata.* These beds are covered by sands which so far have not rendered any fossils.

The occurrence of *Gryphea vesicularis* at the lower part of the upper beds may indicate that a part of the underlying barren shales belongs to the Campanian, because *G. vesicularis* seems to appear mainly at the base of the upper Campanian. Anyhow there is no doubt that the Campanian is represented here by marine beds.

Farther east, in the region of Cárdenas and Canoas, the conditions change again. There we find that the base is formed by a medium to thick bedded limestone which is excellently exposed in the Cañon de Tamazopo, where it carries *Sauvagesia* in its middle and lower part and *Coralliochama* and *Biradiolites* in its very uppermost beds. This limestone is covered by sandy shales, sandstones and shales carrying echinoids, *Orbitoides,* and especially the rich fauna of Cárdenas consisting mainly of *Coralliochama g.-boehmi* Böse, numerous *Biradiolites,* and *Actaeonella* which have been described by the senior author in Bulletin 24 of the Instituto Geológico de México. These beds are especially well exposed east of Cárdenas. They are covered by younger rocks consisting of sandstones, calcareous sandstones, sandy limestones and sandy shales which contain numerous *Exogyra costata* in the lower portion and *Gryphea vesicularis* and *Exogyra costata* in the upper portion. This can be observed at Cárdenas itself, where the upper portion begins with the shales carrying a large smooth oyster. The same upper beds occur also in the syncline of Canoas where they form its youngest part.

The beds of Cárdenas with *Coralliochama* were not separated by the senior author in his original description from the upper beds with *Exogyra costata,* but his later studies in the field showed clearly that there are two different formations present; this statement was made by him in his Bulletin 42 del Instituto Geológico de México.

There cannot be any doubt that the upper horizon with *Exogyra costata* and *Gryphea vesicularis* represents the

Campanian and thus the lower beds must be the Santonian; this is confirmed also by the character of the fauna and this is the reason why in 1906 the senior author of this paper considered the Cárdenas section as lower Senonian.

For a long time the petroleum geologists of Tampico have confounded the limestone in the Tamazopo Canyon with the limestones of the Albian-Cenomanian and this has unfortunately caused the widespread use of the name Tamazopo (usually spelled Tamasopa in oil publications) limestone for rocks that are entirely different and much older. In the Tamazopo Canyon the base of this limestone does not seem to be exposed; the soft beds of the Turonian are probably covered with débris and with the soil of tropical vegetation. But a little farther southeast of Xilitla the whole succession is very well visible. There the limestones of the Albian-Cenomanian appear at the base; they are covered by fossiliferous Turonian which has been cited by the senior author in 1910, and this Turonian is overlain by gray limestones representing the real Tamazopo limestone. Thus the Tamazopo limestone evidently represents the Coniacian and possibly the upper Turonian, but this cannot be decided until the *Sauvagesia* and other Rudists contained in it have been studied. But the real succession of beds in this region is evident:

Sandstones, shales, and sandy limestones with *Exogyra costata* and *Gryphea vesicularis.*	Campanian
Shales, sandstones, and limestones with *Coralliochama g.-boehmi, Actaeonella* and *Trochactaeon* div. sp., etc.	Santonian
Gray limestone with *Sauvagesia* in the Tamazopo Cañon (Tamazopo limestone).	Coniacian
Black shales, thinly laminated black and brown limestone, thin bedded black limestone with numerous fishes and *Inoceramus labiatus, I. hercynicus*, etc.	Turonian
Thin and thick bedded gray limestone with silicified ammonites in the upper part.	Cenomanian-Albian.

The difficulty in this region has always been the change of facies in a relatively short distance. We see now that the limestone at Tula which probably extends quite a way farther west and south to Cerritos and Guadalcazar belongs to the upper Cretaceous, representing the Tamazopo limestone, that is, the Coniacian and possibly the upper Turonian, while the shales above it, well exposed in the Sierra de Tula, correspond to the Santonian or the Coralliochama beds of Cárdenas, possibly in their upper portion also to the base of the Campanian, while the upper Campanian at least is very well represented by the shales, sandstones and sandy limestones with *Exogyra costata* and *Gryphea vesicularis.*

On the other hand, when we advance farther east from the Cañon de Tamazopo we find in the Cañon de Micos another gray limestone with chert nodules which do not seem to occur in the greater part of the Tamazopo limestone. The limestone of the Micos Canyon carries few fossils which can be recognized, especially a *Gryphea* which belongs to some species of the *G. pitcheri* group, but it is clearly covered by Turonian with *Inoceramus labiatus*, and this proves that the limestone of the Micos Canyon belongs to the series of Albian-Cenomanian limestones. We should expect above the Turonian the Tamasopo limestone but it certainly is not developed here and in its stead occur thin bedded limestones alternating with shales. This part is not well exposed; in the Valley of Valles which follows east of the Cañon de Micos we find gray shales very similar to the Taylor marls and the so-called Papagayos beds; in these beds C. L. Baker and the author found several years ago a large *Inoceramus* of the *I. balticus* group, but rather large and very similar to those occurring in the Taylor marls.

From Valles to the east the conditions are clearer. There we find below these shales which certainly correspond to the Coralliochama beds of Cárdenas (although the fauna is entirely different), and represents the Santonian, a series of whitish thin bedded limestones from which Stanton has described his *Saucagesia degolyeri.* These white limestones, which have been called the San Felipe beds, thus represent the Tamazopo limestone, that is, the Coniacian and possibly also the Turonian; at least the lower Turonian is not known in this special place, although the senior author of this paper has found a thin mass of Turonian shales showing a few *Inoceramus labiatus* at the base of the white limestone and above the thick bedded limestone of Las Palmas which correspond to the Albian-Cenomanian. The region is strongly disturbed and only very detailed work could clear up the exact succession of the zones; but in general the stratigraphic subdivision does not leave much room for doubt. The base of the Abra range is formed by Albian limestones which may include also the Cenomanian; the lower Turonian is poorly represented by its common facies carrying the usual fossils and may in part be replaced by the so-called San Felipe beds which in their upper part correspond to the upper Turonian and the Coniacian. The following shales in the Valley of Valles are the Santonian in the facies of Taylor marls or Papagayos shales; no Campanian has so far been observed in this valley.

On the other hand the San Felipe beds correspond to the Tamazopo limestone, this latter one being probably a real reef facies in a shallow sea. That the upper part of the Papagayos shales of Rayon, which have been distinguished under the name of Mendez shales, corresponds to the Coralliochama beds of Cárdenas and thus to the Santonian, we have seen already. Here also we have a deposit formed near the shore with part of it certainly formed of Rudistid reefs in the west near Cárdenas Canoas, while farther east shales were deposited which probably were more distant from the actual shore but in their younger portion begin to show the effect of a rising sea bottom through the presence of Rudistids there. We shall later on show this emersion became complete and resulted in the formation of a continent or at least a long island in the region between the Sierra Madre and the Gulf coast.

THE PROVINCES OF FACIES DURING THE CRETACEOUS IN NORTHEAST MEXICO

Most of what we have to say on this subject is already contained in the foregoing pages, but a brief summary may make the conditions clearer to the reader who is not well acquainted with the geology and topography of northern

Mexico. In an earlier paper the senior author has shown[28] that during the late Jurassic times and early Cretaceous a continent was formed in part of northern Mexico, where the Aptian lies on older rocks, partly marine Permian, partly rocks of undetermined age as in Acatita on the flank of the Sierra de Sobaco. East of the continent in the Sierra de San Marcos (south of Cuatro Ciénegas) the Aptian is underlain by red sandstones and conglomerates of unknown age, but very little farther east at El Barril in the vicinity of the Mina Reforma, immediately east of the Sierra de San Marcos, we found below the Aptian limestones (with *Douvilleiceras)* a series of red and green sandstones and sandy shales of great thickness at the bottom of which we discovered a shore fauna containing mainly *Exogyra* and some *Vola*, which proves that the Neocomian is represented here by a marine deposit which was formed not very far from the coast line. This fauna was studied in detail by Dr. C. Burckhardt, who recognized its Neocomian age. Still farther east in the region of Saltillo and Monterrey we find marine Neocomian overlying sandy coast deposits of the Portlandian, the uppermost Jurassic, while the Kimmeridge appears in the marine facies with numerous ammonites. Still farther east we find coal seams in the upper part of the Jurassic and also sandy shales, and at Galeana the Jurassic contains great masses of gypsum, while the lower Neocomian is in part sandstone and conglomerate and in part marine, carrying ammonites.

We know that the Jurassic-Neocomian continent existed all over Texas except a small region in the southwest (Malone). The sandy facies in the upper Jurassic and even the lower Neocomian in the region of Galeana and Aramberri make it probable that either the Jurassic-Neocomian continent bent toward the south from eastern Texas or that it sent out a long peninsula or a series of islands into the region east of the Sierra Madre of Mexico at least as far south as Ciudad Victoria. A detailed study of this portion of the Sierra Madre would probably give additional evidence concerning the orogenic movements during Jurassic and

[28]Böse, 12.

Neocomian times, the distribution of facies and the probable extension of the continent or islands.

We know that during the Aptian the Cretaceous sea began to extend from the south into northern Mexico and then into Texas, Oklahoma, Arkansas and Kansas and that during Albian and Cenomanian times a shallow sea left its deposits over this vast region. We know also, that at the end of the Cenomanian a slight orogenic movement took place in Texas, which caused in the north the formation of sands and sandy shales during the uppermost Cenomanian (Woodbine sands) and an unconformity between the Buda limestone and the Eagle Ford shales in the south (Austin). There is a possibility that the lowermost Turonian, the Salmurian, may be missing in a great part of Texas, but it is also possible that in some parts the upper portion of the *rotomagensis* zone was not deposited. This problem can only be solved by a detailed study of the faunas of the uppermost Buda limestone, the Woodbine sands and the lowermost Eagle Ford beds. These latter beds have been generally considered as the representatives of the Turonian, but new discoveries make it probable that the lower portion really belongs to the upper Cenomanian.

We shall now discuss the range of facies of the Cretaceous a little more in detail. We can abstain from the consideration of the Neocomian as this occurs only sporadically in the Sierra Madre and central Mexico, while in the coastal region of Nuevo Leon and Tamaulipas it is not exposed.

In Texas the upper Aptian (Gargasian) is represented by the Travis Peak beds, a part of which is considered as the Trinity division. This is made evident by the occurrence of *Dufrenoya* in several species as has been shown by C. Burckhardt[29] who cites from Texas: *Dufrenoya texana* Burckhardt, *D. justinae* Hill, *D. roemeri* Cragin and *D. hoplitoides* Lasswitz. From a collection made by Prof. F. L. Whitney in Austin which he has kindly shown to the senior author it is shown that these *Dufrenoya* are by no means rare in the Travis Peak beds of Texas. The beds below this zone seem to be mainly the Trinity sands, about the age

[29]C. Burckhardt, 15, p. 17.

of which nothing definite can be said on account of the absence of characteristic fossils; it is of course possible that they represent the lower Aptian, *i.e.*, Bedoulian. They rest on much older beds of different age and were deposited during the first transgression of the Cretaceous sea in Texas.

Farther south the conditions change. In the Sierra del Burro, just south of Del Rio, Texas, but in Mexican territory, the upper Aptian (Gargasian) appears in the form of shaly and sandy dark gray limestones which contain *Douvilleiceras* and numerous *Toxaster*. Their base is not here exposed but very little farther south in the Sierra de Agua de Cabra on the Hacienda de la Babia we see below them red clay, well stratified. Its base is not exposed but farther west these beds seem to lie on old rocks in the Sierra del Carmen. Still farther south in the region of the Rio Nazas west of Torreon, Coahuila, Burckhardt[30] found the upper Aptian (Gargasian) resting on Caprina beds which in their upper portion certainly represent the Bedoulian (lower Aptian) while the lower Requienia beds may even be as old as the Barremian.

Similar conditions exist near Saltillo where a rich Gargasian fauna was collected in the Cañon de Vallas, Hacienda Saucillo. There the Gargasian beds with *Dufrenoya* and *Douvilleiceras* cover limestones with Caprinidae, and in the lower portion Requienias predominate. Unfortunately the base of these beds is not exposed but we know that in all this region the Neocomian up to the Hauterivian exists in a marine facies carrying ammonites, while the uppermost Jurassic (Portlandian) is represented by sandstones of a shore deposit. The conditions are probably similar in the region of the Rio Nazas, as upper Jurassic and Neocomian are very well represented at San Pedro del Gallo in Durango, the upper Jurassic being entirely marine there.

Much farther north and west lies another locality with Gargasian, near the town of Cuchillo Parado in Chihuahua, where *Dufrenoya* accompanied by *Douvilleiceras* occurs in a rather narrow zone of shales. There the lower Aptian is possibly represented by sandstones with shales and some

[30]C. Burckhardt, **15**, pp. 47, 48, and table at p. 54.

limestones carrying a small *Exogyra*, but the age of these beds cannot be proven otherwise than that they lie below the bed with *Dufrenoya*. All the beds below those with the small *Exogyra* consist of sandstones, shales with gypsum and similar rocks.

The facies of the upper Aptian (Gargasian) is rather uniform all over northern Mexico and is not very distinct from the Travis Peak formation in Texas, except perhaps through a little darker color. It is very probable that the Gargasian will be found to exist all over northern Mexico and that it forms a single province with Texas.

Much less is known about the basal beds of the Albian in northern Mexico, and less in Texas. Burckhardt[31] cites from the Rio Nazas in the limestone above his Gargasian: *Parahoplites* of the *P. milletianus* group, *Parahoplites* similar to *P.* cfr. *bigoti* Perv., *Douvilleiceras* cfr. *clansayense* Jacob and *D.* of the group of *D. bigoureti* Seunes. He considers these beds as the representatives of the Clansayes beds of France, the base of the Albian. He cites similar beds from the State of Mexico (San Gaspar) from where he describes *Uhligella mexicana* Burckhardt which is related to *U. dupiniana* d'Orb. and *U. walleranti* Jacob. He also supposes that the same beds exist at Mazapil in Zacatecas from where he described in another work *Parahoplites* cfr. *milletianus* d'Orb. *P.* aff. *aschiltaensis* Anthula and *Douvilleiceras* sp. Similar beds exist also according to Burckhardt in San Pedro del Gallo in Durango, where they carry *Douvilleiceras* cfr. *nodosocostatum* d'Orbigny.

Burckhardt's Clansayes beds of the Nazas are certainly the same which we consider as the base of the Albian in the Sierra de San Carlos. We have already seen that the fauna is the same only richer in the San Carlos Mountains, but even the character of the rocks appears to be very similar. What Burckhardt says about the lithological character of these beds in the Nazas region can be applied also to the San Carlos Mountains. He says that the former limestones occur in thin beds, are well stratified, sometimes laminated, of light gray color or often of a coffee-with-milk color, and

[31]C. Burckhardt, **15**, p. 52 and table at p. 54.

that the limestone alternates with beds or intercalations of black chert. The only difference is the frequency of this chert and the fact that his ammonites are often silicified.

Burckhardt considers his Gargasian as a neritic facies, and the underlying Bedoulian as a reef facies. The Clansayes beds he considers as a bathyal facies. All this applies also to our beds near Saltillo and the basal Albian beds of the Sierra de San Carlos. The Bedoulian is certainly a reef facies, the Gargasian a neritic one and the basal Albian is a bathyal deposit.

In Texas the development seems to be somewhat different. If the Trinity sands really represent the Bedoulian they occur doubtless in a shore facies; but the Gargasian (Travis Peak) may very well be neritic. On the other hand, the next higher Glen Rose beds, which according to a few ammonites which the senior author saw in the collection of Prof. Whitney may very well represent the Clansayes beds, belong certainly to a near shore facies taking into account that Gastropoda and Pelecypoda, many of which show a very heavy shell, predominate in these beds.

Considering the few data we have about the distribution of the base of the Albian (Clansayes beds) we can say little about the limitation of facies. The Texas Glen Rose is a near shore deposit, but in the mountains a short distance south of the Rio Grande (Sierra del Burro) the Glen Rose beds become much more calcareous and seem to have been deposited in deeper waters. In Chihuahua (Cuchillo Parado) we have not found the fauna of the Clansayes beds, and it is possible that they are represented by the thin to medium bedded black limestones alternating with shales which lie above the Gargasian. They certainly appear different from the beds farther east. There is scarcely any doubt that the basal Albian is represented by deep sea deposits in northern-central Mexico (Zacatecas, Durango, and possibly Coahuila) but farther east in eastern Coahuila it seems to be deposited in a reef formation (Saltillo), while still farther east in Tamaulipas we find again a bathyal facies.

The middle Albian is very little known in central and northern Mexico. In Texas it is probably represented by the Walnut clays and Comanche Peak limestone which carry different forms of *Oxytropidoceras* but have to be considered as a near shore deposit, and by the Edwards limestone which is a reef facies in many parts. In northern Mexico near the Rio Grande we find a similar development in the Sierra del Burro, but the beds are much more calcareous. A little farther south we find a reef facies occupying the whole space of the middle Albian, practically all over northern Mexico containing everywhere Caprinidae and Rudistidae. At La Encantada near Placer de Guadalupe in Chihuahua a red marl with many ammonites is intercalated in these reef beds. In the mountain ranges of eastern Coahuila and western Nuevo Leon we find the same reef facies on the west side of the wide valley through which the National Railway runs between Monterrey and Lampazos; the same kind of Caprina limestone continues farther south in the mountains between Monterrey and Saltillo. We find that these limestones extend westward in the State of Coahuila into the State of Chihuahua and even Durango. Toward the south this facies ends in the Sierra de Jimulco and the Sierra de Parras. South of it we find an entirely different facies in northern Zacatecas which consists of thin bedded limestones carrying very few fossils. This is certainly a bathyal facies according to the few ammonites which have been found. They have much less thickness than the limestones of the reef facies. The lower portion of these limestones carries *Oxytropidoceras* aff. *acutocarinatum* (Shumard) Marcou, cited by C. Burckhardt from Mazapil and therefore belonging certainly to the middle Albian.

Thus we have an enormous province of shallow sea deposits beginning in Texas (and possibly farther north) covering the greater part of that state and continuing toward the south in the states of Coahuila, part of Nuevo Leon, part of Chihuahua and part of Durango. To the south the sea becomes deeper in the State of Zacatecas and possibly in San Luis Potosí (Catorce). The western boundary of the shallow sea is not known in Mexico; it seems that shallow deposits exist in Sonora (Arivechi) and there is certainly a reef facies of this age in Lower California which has been discovered by the senior author of this paper on an expedition through Lower California together with Dr. E. Wittich. There the Caprina reefs occur in different places in eruptive tuffs of andesite (submarine eruptions) and the fossil are partly metamorphosed into epidote by the effect of the later intrusions.

The eastern boundary of this shallow water reef facies lies more or less in the valley through which runs the National Railway from Lampazos to Monterrey, the east side of this valley being composed of dark thick bedded limestones carrying *Hoplites* strongly ornamented. Farther south the boundary line must lie in the east flank of the Sierra Madre where similar dark limestones with similar *Hoplites* occur. From Monterrey to Villa de Santiago and north of Montemorelos the boundary line may lie more or less in the valley of Villa de Santiago; from there on south it certainly lies in the mountains, the lower part of the Sierra Madre being composed of the black limestones with few ammonites. This bathyal deposit probably continues farther south than Ciudad Victoria, possibly to Llera.

Thus we have a bathyal sea deposit south of the reef facies and east of it. We might expect to find farther east another reef facies if the emersion movements noted in the Neocomian continued into the middle Cretaceous. Instead of this we find a still deeper sea to the east in Tamaulipas, in the north (Sierra de San Carlos) as well as in the south (Sierra de Tamaulipas). Here the sinking of the bottom of the lower Albian sea was followed by another downward movement, which produced the abyssal deposits with the characteristic ammonites of San Carlos which are so similar to the fauna of the abyssal deposits of the middle Albian of the Balearic Islands of Spain, described by Fallot. We do not know the whole extension of this facies, which certainly constitutes a province entirely different from all the others of the middle Albian known so far in northern Mexico and Texas. It certainly exists in all the Sierra of

San Carlos and the Sierra de Tamaulipas, but these end in the plains in the north as well as in the south; east of them we find the Cretaceous covered by Tertiary. There is a possibility that this facies may be found in the Sierra de Vallecillo, but as yet we have no proof of it.

The shallowness of the deposits in northern Mexico, Texas and continguous states indicates the existence of a continent in the northwest during the middle (and upper) Albian. This is confirmed by the fact that to the south and east bathyal and even abyssal seas existed. This continent will have to be found in northwestern Texas and northern New Mexico and in the Rocky Mountain region, where the Cretaceous begins with probably Cenomanian deposits (Dakota sandstone and equivalents).

The upper Albian of Texas and northern Mexico is better known than the middle portion. In northern Texas we find it represented by the Duck Creek marls, the Fort Worth limestone, the Denton, Weno and Pawpaw beds, although these latter two beds, or at least the Pawpaw, may be considered possibly as transition beds between the Albian and the Cenomanian. In southern Texas the upper Albian is represented by the lower portion of the Georgetown beds. All these formations are characterized by the preponderance of the genus *Pervinquieria* (=*Inflaticeras*=*Subschloenbachia*). This genus is especially common in the Duck Creek and the Fort Worth beds, while below these it is substituted by *Elobiceras* and in the higher formations it becomes more and more rare. It may even continue into the Cenomanian but is extremely rare in these upper beds. The Georgetown beds have not yet been subdivided as carefully as those of northern Texas but it is probable that there too the same conditions will be found.

All these beds were deposited in shallow water, as is indicated by the nature of the rocks and the fauna as far as this is known. In southern Texas these beds begin to become more calcareous, especially near the Rio Grande. This is still more evident on the Mexican side in Coahuila, where the Georgetown beds a short distance south of the Rio Grande become entirely calcareous. Wherever the upper

Albian has been distinguished in Coahuila it occurs as thin bedded gray limestone with long lenses of black chert and nodules of chert and contains silicified but mostly small ammonites among which forms of *Pervinquieria* of the group of *P. inflata* are the most important. A characteristic of these beds is that they always contain a great number of open whorled ammonites like *Turrilites, Hamites, Ptychoceras, Anisoceras* and others. A rich fauna from these beds has been described by the senior author of this publication[32]; only very few of the species cited from Mazapil may belong to the middle Albian; all of those from Camacho, Zacatecas are certainly upper Albian. Beds of this kind, mostly carrying the characteristic fauna, are widely distributed all over northern Mexico. We find them in the Sierra Mojada of Chihuahua, in the Sierra de la Paila of Coahuila, in the mountains between Saltillo and Monterrey, in northern Zacatecas (Camacho, Fresnillo), in northern San Luis Potosí (Catorce). In part these beds may be represented by thicker bedded limestones without fossils or even with Caprinidae but these places have not as yet been studied in detail.

In northwestern Mexico in the Cerro de Muleros the beds belonging to the upper Albian are composed of marls and thin bedded limestones very similar to those of western Texas and were certainly deposited in shallow waters. A somewhat similar condition exists farther east, in northern Nuevo Leon. There in the Sierra de Lampazos these beds occur in the form of thin bedded limestone alternating with gray marls and containing the characteristic *Pervinquieria* of the *P. inflata* group.

Thus again we find a neritic facies in the north in Texas and the very northernmost part of Mexico, while from there on south deeper, bathyal deposits predominate and are rather uniform all over northern and central Mexico. They occur in this form also in the east on the east flank of the Sierra Madre and even in the Sierra de San Carlos and the Sierra de Tamaulipas. This means that in the coastal region between the Sierra Madre and the Gulf coast the sea

[32] E. Böse, 11.

bottom began to rise again and that instead of the abyssal deposits of the middle Albian we find bathyal deposits in the upper Albian. Excepting the Turonian these upper Albian beds are probably the most uniform Cretaceous deposits in Mexico, which means that all central and northern Mexico at this time was covered by a relatively deep sea, while toward the north the water was much shallower and as has been mentioned above surrounded a continent in the region of the Rocky Mountains.

The conditions during the Cenomanian seem to be quite different. In Texas the Cenomanian begins in the north with the Main Street beds, contains the Grayson marls, and the Woodbine sands. A characteristic for the base of the Cenomanian is the occurrence of the large *Turrilites brazoensis* Roemer in the Main Street beds. Unfortunately the faunas of the Main Street and the Grayson marls have not been described as yet in detail but we know that they correspond to those of the upper Georgetown and the Del Rio clay in the south which have rendered characteristic ammonites. From the Woodbine sands Gayle Scott[33] has described *Acanthoceras rotomagense*, but his figured specimen is certainly not *A. rotomagense* although it is a Cenomanian form. In southern Texas the Cenomanian consists of the upper portion of the Georgetown beds, the Del Rio clay, the Buda limestone and a calcareous bed which so far has been considered as belonging to the Eagle Ford shales. This latter bed contains a great number of ammonites, of which the senior author has seen a number in a collection made by Prof. W. S. Adkins, of Austin. They belong to *Acanthoceras* and possibly *Mantelliceras* and seem to be all upper Cenomanian forms.

In southernmost Texas and northernmost Mexico, that is, in the region of Del Rio and that of the Sierra del Burro, Coahuila, the upper Georgetown beds frequently carry *Acanthoceras* of the *A. cunningtoni* group together with the characteristic large *Turrilites brazoensis*. The higher Del Rio contains *Mantelliceras (Submantelliceras* Spath) of the *M. martimpreyi* group, *Turrilites brazoensis* and a number

[33]G. Scott, 71, p. 617, pl. xxii, figs. 1, 2.

of other ammonites among which the new *Scaphites subevolutus* is extremely similar to the Cenomanian *S. evolutus* Pervinquière. We fiind in this bed also two new species of *Stoliczkaia.* The next higher bed, the Buda limestone, is mainly characterized by the occurrence of the new genus *Budaiceras,* probably a form restricted to America. This genus is characteristic for the Buda limestone and has been found in many places. Lasswitz[34] has described under the generic name of *Schloenbachia* quite a series of species which really belong to *Budaiceras;* these species are: *Schl. roemeri, Schl. roemeri* var. *harpax, Schl. roemeri* var. *elegantior, Schl. frechi, Schl. frechi* var. *curvata, Schl. evae.* To *Budaiceras* belongs also *Barroisiceras haberfellneri* Lasswitz (non v. Hauer).[35] Prof. W. S. Adkins has studied these forms at Breslau and has photographed the originals; he has been kind enough to furnish a series of these photographs to the senior author, and these pictures show clearly that those ammonites are neither *Schleonbachia* nor *Barroisiceras* but *Budaiceras.* Shattuck has described two forms of *Budaiceras* from the Buda limestone of Texas under the name of *Barroisiceras texanum* and *B. hyatti.*[36] These forms also have nothing in common with the real *Barroisiceras* of the Coniacian and belong really to the new genus here described.

In northernmost Mexico *Budaiceras* is quite common everywhere that the Buda limestone has been distinguished. It occurs in the region of Ojinaga in Chihuahua and in different places on the flank of the Sierra del Burro in northern Coahuila. In this latter place it is accompanied by some upper Cenomanian forms: *Mantelliceras mantelli, M. laticlavium* and *Euhystrichoceras remolinense* (nearly related to *E. nicaisei* Coquand). These ammonites as well as the *Codiopsis texana* Whitney (scarcely distinguishable from *C. doma)* and *Cottaldia rotula* Clark (extremely similar to *C. bennettiae* Cotteau) prove that the Buda limestone represents the upper Cenomanian, that is the *Mantelliceras man-*

[34]R. Lasswitz, pp. 27–29.
[35]R. Lasswitz, **44,** 1904, p. 28, pl. viii, fig. 3.
[36]Shattuck, **75,** p. 35, pl. xxv, figs. 1, 2.

telli beds. If the highest beds with *A. rotomagense* are represented also in the Buda limestone this will have to be proven in Texas, and also what relation exists between the Buda limestone, the lower Eagle Ford beds which carry numerous *Acanthoceras* and the Woodbine sands. The difference in age of these three deposits must be extremely small.

All these deposits of the Cenomanian of Texas and northernmost Mexico are either neritic or shore beds. The Woodbine sands certainly indicate a new orogenic movement in North America, that is, the transgression of the upper Cenomanian over parts of the continent which existed during all the time from the Albian to the upper Cenomanian. There is scarcely any doubt that the Dakota sandstone corresponds in age to the Woodbine sands although its fauna is rather poor. With the deposition of the Dakota sandstone an immersion begins over vast parts of the old continent in central North America and from this time on the Cretaceous sea invades a country where no older Cretaceous beds had ever been deposited. This sea persisted during the Turonian, Coniacian, Santonian, Campanian, and at least part of the Maestrichtian.

In most parts of northern Mexico the Cenomanian is very insufficiently known. Burckhardt cites an *Acanthoceras* cfr. *laticlavium* from San Pedro del Gallo and a *Turrilites* cfr. *costatus* from Mazapil. The first one comes from limestones interbedded with marls, the second one from the thin bedded black limestones below the Turonian. At the Cerro de Muleros the lower Cenomanian is represented by a red sandstone and the upper by light gray limestones and marls which contain *Hemiaster calvini* Clark and *Exogyra whitneyi* Böse. This is practically all we know about the Cenomanian fauna of northern Mexico. We have already mentioned that above the upper Albian exist marls and thin bedded limestones, often also sandy beds, especially in the region of the Sierra Madre between Monterrey and Saltillo and farther south and east; the same is the case in Tamaulipas. In northern Nuevo Leon, in the Sierra de Lampazos and its southern continuation, these beds are mostly thin bedded limestones and marls, but we have not found any characteristic fossils in these beds. On the boundary line of Chihuahua and Coahuila Haarmann has collected a small number of species in a gray to yellowish marl below the Salmurian, which may represent the Cenomanian; they contain *Metoicoceras*, *Hemiaster*, and a number of gastropoda and pelecypoda. In another place in Coahuila west of Cuatro Ciénegas and about fifteen kilometers west of Piedra de Lumbre we have found gray marls or shales below the Salmurian, but the beds are so poorly exposed that fossils could not be collected. On the whole we can only say that the Cenomanian in northern Mexico seems to represent a period of rising sea bottom, but that these beds never have been studied in detail and that a discussion therefore is practically impossible.

The conditions in the Supracretaceous are quite different. Unfortunately the faunas and subdivision of this age are very little known in Texas, and our conclusions with respect to that state must remain rather indefinite. There is no doubt that part of the Eagle Ford shales represent the Turonian. Characteristic fossils as *Inoceramus labiatus* Schlotheim and *Prionotropis woollgari* Mantell have been cited from these beds.

In northern Mexico the Turonian is much better developed. In two places we know the base of the Turonian, the Salmurian, with its characteristic ammonite fauna, *Fagesia*, *Vascoceras*, *Neoptychites* and other genera. From the Cerro del Macho on the Hacienda del Mohóvano on the Chihuahua-Coahuila line this fauna has been described by the senior author of this publication;[87] although a still richer locality fifteen kilometers west of the Rancho de Piedra de Lumbre, west of Cuatro Ciénegas in Coahuila, has not yet been studied in detail, it is not to be doubted that a number of the species are identical with those from the Cerro del Macho. At both localities the beds consist of light gray limestones and marls, and these as well as the fauna indicate a neritic facies.

[87] E. Böse, 10.

In Texas these beds are unknown as yet, but they have been discovered recently in Montana[38] where they contain different species of *Vascoceras*. In Mexico they may be found in the limestones which occur frequently at the base of the Turonian but which so far have not yielded any fossils. In many places these beds are covered by the débris of the younger shales and limestones.

The greater mass of the Turonian in northern Mexico consists of black shales, thinly laminated black limestones and thin to medium bedded black limestone. They generally carry *Inoceramus*, especially of the groups of *I. labiatus* and *I. hercynicus;* rarely a badly preserved ammonite is found which probably belongs to *Prionotropis* or *Acanthoceras*.

In northernmost Mexico, on the flank of the Sierra del Burro, these dark shaly beds are covered by whitish marls and thin bedded marly limestones, and in these we collected a *Prionotropis* which scarcely can be distinguished from the European *P. woolgari* Mantell. These beds certainly represent here the upper Turonian.

In general we can say that the facies of the Turonian is extremely uniform all over northern and central Mexico. The beds found in Coahuila are in no wise different from those of Nuevo Leon, Chihuahua, Zacatecas, San Luis Potosí, Tamaulipas or even Hidalgo. It seems that a sea of rather uniform depth covered all northern and central Mexico at this time. This sea cannot have been very deep, but it was certainly less shallow than the Cenomanian one. In earlier times *Inoceramus* was taken as a characteristic proof of deep sea deposits, but the frequent occurrence of oysters (*Ostrea lugubris* Conrad) in these beds shows that the Turonian was deposited in relatively shallow waters. While the Turonian is extremely uniform in northern Mexico a great change of facies begins to appear in the higher beds and also a greater variety in their distribution.

The Coniacian has been very little studied in Texas and northern Mexico and still less in the Rocky Mountain region.

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[38] J. B. Reeside, 65.

Part of the Austin chalk in Texas has always been considered as Coniacian. Unfortunately the great confusion caused by the paper of R. Lasswitz[39] has only served to make the question more difficult. As we have already said, his *Barroisiceras haberfellneri* certainly is a *Budaiceras* and comes from the upper Cenomanian (Buda limestone). His *Schloenbachia kiliani* is a *Pervinquieria* from the Duck Creek beds and his *Schloenbachia austinensis* is also a *Pervinquieria* from the Georgetown beds; both belong to the Albian (we owe these notes to the kindness of Prof. W. S. Adkins of Austin who studied the originals of Lasswitz). No decidedly Coniacian ammonites have so far been described from Texas, although several have been cited. The only fossil which can be considered as representing the Coniacian is *Inoceramus undulatoplicatus* Roemer, which belongs to the group of *I. digitatus* and is mostly found in the Coniacian.

In Mexico we have at least two places where real Coniacian has been proven to exist. One of these is about four kilometers from Ojinaga, Chihuahua, opposite Lajitas, Texas, where the senior author of this publication discovered *Peroniceras* aff. *subtricarinatum* d'Orbigny and *Proplacenticeras* cfr. *fritschi* de Grossouvre, in a reddish sandstone underlying the shales of the Santonian. The other locality is far to the south, at Zumpango del Rio in the State of Guerrero, and was described by C. Burckhardt.[40] This latter locality shows also shore deposits and contains numerous ammonites belonging to *Barroisiceras* and *Peroniceras*.

In the northern portion of northeast Mexico the Coniacian is represented by the lower beds of the Austin chalk, that is white limestones and marls which carry frequently *Inoceramus undulatoplicatus* Roemer. They carry also ammonites but these are very badly preserved. Most of them belong to *Mortoniceras (emscheris ?)* but no *Peroniceras* or *Barroisiceras* have been so far discovered. These beds are found in northern Coahuila on the west to the boundary line with Chihuahua, in the middle as far south as Cuatro Ciénegas where they become shaly and gray; also near

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[39]R. Lasswitz, 44.
[40]C. Burckhardt, 14.

Monclova but south of this town they begin to be replaced by gray shales. We have seen them in the east of Coahuila in the region from Piedras Negras to Lampazos, and still farther south to Vallecillo, but there they disappear very soon farther south and become replaced by gray shales.

Thus we can say that the Austin chalk facies of the Coniacian extends through central and southern Texas and northern Mexico as far south as a line from approximately Vallecillo to Cuatro Ciénegas, and west to the boundary line of the States of Coahuila and Chihuahua. Farther west this facies is replaced by a shore deposit consisting of red sandstones and sandy shales.

Toward the south we find the Coniacian represented by gray shales which so far could not be separated from the Santonian shales. This facies is known to exist as far south as the synclinal basin between Saltillo and Torreon in the center of the country and from Vallecillo south to the region west and northwest of Jimenez, Tamaulipas; they are known to exist also west of Ciudad Victoria in the broad valley of Jaumave.

A different facies of the Coniacian is found south of the synclinal basin of Saltillo-Torreon, in northern Zacatecas, where the Turonian is covered by gray to yellowish sandstones and sandy shales, which contain mainly *Inoceramus* of the Emscher type. In Tamaulipas the shales of the Coniacian are replaced by light colored limestones which facies we have called Solis limestone. These beds extend from south of the Sierra de San Carlos to the southern end of the Sierra de Tamaulipas. This facies is similar to that of the lower Austin chalk in the north.

Still farther south we find that gray thin bedded limestones with gray marls take the place of the light colored Solis limestone. This new facies is characterized by the occurrence of not very frequent Rudistids, especially *Sauvagesia* and *Durania*. This facies extends southeastward to the region of Tampico and to the Sierra del Abra. It cannot be considered as a reef facies, as it does not form thick masses of reef limestone, but it is certainly a deposit in shallow water.

West of the Sierra del Abra we find the real reef facies of the Coniacian in the Tamazopo Cañon (the true Tamazopo limestone) and in its representative at Xilitla and in the region between Tula and Cerritos. There rudistids are very frequent, at least in the upper beds, while they are rather rare near Xilitla and in Tamazopo Cañon.

Thus we find in the north a province covering at least the greater part of eastern Texas and some of northern Mexico where white limestones and marls, a shallow water deposit, represent the Coniacian; to the west it is replaced by a shore deposit consisting of sandy masses, and to the south a uniform mass of gray shales barren of fossils. These shales extend over the center of Mexico where they are replaced by sandy deposits in Zacatecas. This makes it probable that a land mass existed farther west and south, perhaps in the region of the so-called Sierra Madre Occidental and even farther west. In Lower California the Coniacian does not seem to be represented, as the lowest beds of the Supracretaceous seem to be those which contain *Coralliochama orcutti* White, and which very probably represent the Santonian.

On the east side of Mexico we find south of the shale facies again a deposit of light colored limestones, similar to those of the lower Austin chalk, and farther south these are replaced by gray limestones and marls with rudistids, a shallow water deposit. West of this province a reef facies appears and it is very probable that still farther west we may find either a sandy facies or a land mass, but we have no data about the development of the upper Cretaceous in southern and central San Luis Potosí, where we would have to expect them. The result is thus, that during the Coniacian time northern and central Mexico was covered by a generally shallow sea with rudistid reefs in some parts and neritic deposits in others.

During the period of the lower Santonian a deposition similar to that of the Coniacian prevailed in Texas and northern Mexico. Since the time of Roemer it has been known that the lower Santonian is represented by part of the Austin chalk in Texas. This is the middle part of what has been called Austin chalk and it carries frequently *Mortoniceras texanum* Roemer as well as many other fossils, most of which have not yet been described. This facies continues into northern Mexico, where we find it from the international border on the flanks of the Sierra del Burro south to Monclova and to Lampazos. Farther south these marly and calcareous beds are replaced by gray shales which up to the present do not even permit of separation into lower and upper Santonian, and therefore will be treated together.

In the west near Ojinaga the lower Santonian is represented by gray to yellow shales which carry *Mortoniceras texanum* Roemer but which are not very fossiliferous; they also carry a number of *Inoceramus* of the group of *I. balticus* Boehm (*I. crippsi* Auct.). These shales are everywhere somewhat sandy, but contain layers of limestone. They represent a very shallow water deposit. The upper Santonian appears in Texas under the name of Taylor marls. These contain mainly *Exogyra ponderosa* Roemer, *Placenticeras syrtale* Morton, *Pl. guadalupae* Roemer and related species. The *Placenticeras,* which also occur in the corresponding beds of northern Mexico, are important for the determination of the age of these beds, in so far as they belong to the strongly ornamented forms which are characteristic of the upper Santonian of Europe. *Placenticeras syrtale* has often been cited from European beds, but none of the figured specimens is really identical with the American species. We cannot see why Gayle Scott[41] should consider the Taylor marls as Campanian; he does not give the slightest reason for this opinion and the character of the *Placenticeras* should have proven to him that they cannot come from the Campanian. We may add here that probably the so-called upper Austin chalk, which is very marly and contains only a few limestone beds, also belongs to the upper Santonian, as it seems to be the main horizon for *Placenticeras guadalupae* Roemer. The large *Exogyra* which is so frequent in this bed has been confounded with *Exogyra ponderosa* but it is really an entirely different species as the senior author of this publication has shown already in

[41]G. Scott, 70, pp. 110, 189.

1917.[42] Scott is very much given to considering all species in a very broad sense, an idea which has been abandoned long ago by most modern palaeontologists. Judging from other examples in his paper we would suppose that Scott will consider the European forms which have been described as *Placenticeras syrtale* and *guadalupae* as identical with the American species of this name. Thus we can still less understand why he should consider the Taylor marls as Campanian.

In northernmost Mexico the upper Santonian is developed in the form of shales of gray to dark color which carry *Placenticeras syrtale* and *Exogyra costata*. These shales should not be called Taylor marls, because they do not contain marls but are shales throughout, with some beds of limestone and locally thin sandy limestone layers in the upper portion. This facies with the characteristic fossils is found all over northern Mexico as far west as the boundary line of Chihuahua and Coahuila and as far south as the Sierra de Parras, without any considerable change in facies. Toward the west in Chihuahua (region of Ojinaga) these shales become very sandy and contain a number of limestone beds; they are of a much lighter color than those of Coahuila. They contain numerous *Placenticeras* of the *syrtale* and *guadalupae* groups, also *P. sancarlosense*, *P. planum* and others. In the same beds is a large *Mortoniceras* which is extremely near to *Mortoniceras texanum* without being identical with it. The beds contain frequently a large *Exogyra* which some geologists consider as *E. ponderosa* Roemer; but it is certainly distinct and should be considered as a different species. We thus see that in the west there exists a near-shore facies, just as in the Coniacian.

We do not have any data about the beds which represent the Santonian in northern Zacatecas, although there can be little doubt that the horizon exists in that region, if we consider the great thickness of the sandstones and sandy shales above the Turonian. It is very probable that there too we shall find a shaly or sandy shale deposit.

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[42]E. Böse, 9.

In southern Coahuila we have not been able to distinguish the lower Santonian from the upper; the shales are not very fossiliferous and carry mainly *Exogyra ponderosa* and some *Inocerami*.

Still more difficult is the situation south of Vallecillo, Nuevo Leon. We have already seen that in this region, at least as far as the southern end of the Sierra de San Carlos, the Coniacian and the whole Santonian are represented by a thick mass of gray shales. The lower part carries locally *Inoceramus* of the *balticus* group which are probably identical with those of the lower Santonian, but the upper fissile shales are entirely barren. Evidently the conditions of deposition were extremely uniform from the beginning of the Coniacian to the top of the Santonian. The only change we find is the sandstone which forms the uppermost beds of these shales. These sandstones and sandy shales indicate that in this region the deposition of marine beds ended with the Santonian; no younger beds of the Cretaceous have ever been found from Agualeguas to the south. We shall discuss this feature still farther on.

Southward from the south end of the San Carlos Mountains, the lower Santonian is probably represented by the transition beds between the Solis limestones and the overlying shales, while these latter ones probably constitute the rest of the Santonian. No fossils except foraminifera seem to have been found in these shales to a little northwest of Tampico in the region of Rayon, where Dr. Braendlin collected in them *Coralliochama boehmi* and a number of fragments of *Sauvagesia* and *Biradiolites*. Unfortunately we have not had an opportunity to visit this locality, but there is not the slightest doubt but that there a colony of rudistids was developed. These allow us to synchronize these beds with those of Cárdenas. Similar rudists have been described by Stephenson from these shales in the region of Chocoy. The rudistids of Rayon and Chocoy do not seem to have formed reefs, while they certainly did this in some beds of the region of Cárdenas; this is especially the case in the upper portion near this last mentioned town from where also come the greater part of Rudistids and *Actaeonella* as well as the other gastropods collected and described by the senior author of this publication.

Thus we probably have a moderately deep sea all over northern Mexico except the western part; this deeper sea continues south in the east to the region of Tampico. From here to the west we find first shales with moderately large *Inoceramus* in the valley of Valles, and then near Canoas marly and sandy beds and even sandstones in the lower portion, and marly and reef limestones in the upper part still farther west near Cárdenas. In the country around Tula, which lies still farther to the west, we find these shales becoming very sandy in most parts and entirely barren of fossils. Here also we should expect to find a shore line or shore line deposits in San Luis Potosí, or a continent, but as we have said above, this part of the country is practically unknown.

It is very possible that a continent stretched through western Chihuahua, Durango, and Zacatecas during the time from the Turonian to the upper Santonian, and it may have existed also on the west coast of Mexico at least in the northern part. In Lower California the beds with *Coralliochama orcutti* lie partly on the Albian (or at least the middle Cretaceous) and partly on a Cretaceous intrusive mass of monzonite; they are evidently shore deposits. In one place near Santa Catarina the senior author of this publication together with Dr. E. Wittich observed a conglomerate which had the same aspect as the young conglomerates of the Reynosa formation, but it carried large *Puzosia* in the cementing matrix. The intrusive mass of monzonite which forms the highest mountains of Lower California was formed during the time between the Albian and the Santonian and may have had some connection with the supposed continent on the mainland. How far this western Santonian reaches to the south is not known as yet; it certainly does not exist on the coast of Colima where the Cretaceous beds seem to end with the upper Cenomanian. So far no Santonian has been found farther south in Mexico.

The Campanian is represented in Texas by the Navarro beds; we can conclude this mainly from its position between the Santonian and the Maestrichtian, on the Rio Grande.

Part of the Navarro beds may even belong to the Maestrichtian, *Sphenodiscus lenticularis* having been cited from them. The main characteristic fossils from these beds seem to be *Exogyra costata* Say and *Gryphea vesicularis* Lamarck. Unfortunately we do not know in which horizon the *Sphenodiscus lenticularis* Owen has been found and neither do we know the exact position where *Gryphea vesicularis* has been found in the Navarro beds. Gayle Scott thinks that the Navarro beds belong to the very highest Campanian and the Maestrichtian. He does not give any very good reason other than that according to him *Gryphea vesicularis* and *Alectryonia larva*, which too is cited from the Navarro beds, occur in Europe always in the transition beds between the Campanian and the Maestrichtian. Nobody of course can prove that the *Gryphea vesicularis* of Texas and northern Mexico is really identical with the European species, and still less this can be said about the *Alectryonia larva*, the identification of which seems rather doubtful. The conditions are probably similar in Texas and northern Mexico and there we have already seen that the basal beds with *Exogyra costata* carry *Placenticeras whitfieldi* which resembles forms of the lower Campanian, and which is cited by Udden also from corresponding beds in the Chisos Mountains. We have also seen that *Exogyra costata* has been found in the lower as well as in the upper portion of these beds and that *Gryphea vesicularis* seems to be limited to the upper part, but that it lies always below the beds with *Coahuilites* and those with *Sphenodiscus lenticularis*. As the Taylor marls in northern Mexico represent the San tonian, there does not seem to be any reason why the beds with *Exogyra costata* should not be considered as the representatives of the Campanian. If a line has to be drawn between the Campanian and the Maestrichtian this line should certainly be placed below the beds where entirely new forms of ammonites begin to appear, that is, *Coahuilites* and *Sphenodiscus*.

On the whole the Navarro beds of Texas do not seem to be very different from the beds with *Exogyra costata* in northern Mexico, except those beds which contain *Sphenodiscus* *lenticularis* and which should be separated from the Navarro beds and receive a proper name, because they certainly represent a younger formation, the beginning of the Maestrichtian. The rocks are shaly and sandy and thus similar to those of northern Mexico, they were deposited in a very shallow sea and not very far from the shore.

In the central part of the state of Coahuila the normal facies of the Campanian can be followed as far south as the Sierra de Parras, the region south of this high mountain range not being well known.

Toward the west, in Chihuahua, we do not know very much about the Campanian, but can say that near Ojinaga the beds above the Santonian are extremely sandy and conglomeratic; the fauna is completely unknown; these conglomeratic beds begin to appear near the boundary line of the states of Chihuahua and Coahuila. These beds cannot have been deposited very far from a shore. We have seen that in the region of Piedras Negras-Eagle Pass, Barroteran-Sabinas, Saltillito, Lampacitos the lower portion of the Campanian is marine while the upper part, the Coal series, is a lagoon or brackish water deposit. An outlier of this facies exists still a little farther west between Aura and San Blas. The names of the localities cited here give approximately the whole extension of this brackish water facies of the Campanian, unless it extends farther west in Texas, which is very probable in the Chisos Mountains according to Udden's description of this region. There the lower Campanian seems greatly to resemble that of Piedras Negras, and according to Udden, carries *Exogyra costata* as well as *Placenticeras whitfieldi*, while the higher beds are certainly shore deposits.

Farther south and east we find that the lower Campanian is represented by brackish water beds, consisting mainly of thick bedded sandstones and some shales and sandy limestones which carry the characteristic brackish water fauna of the Tulillo facies. The distribution of the typical Tulillo facies seems to be limited to the region between the Mesa de Cartujanos, the Rio Nadadores and the Laguna de la Leche. Here the upper Campanian is everywhere characterized by a great number of *Gryphea vesicularis* Lammarck and *Exogyra costata* Say.

The Tulillo facies of the Campanian continues south along the Rio Salado and in the region between this river and the mountains of Lampazos to about a line some little distance south of Escalera-San Ambrosio; from here on the lower portion becomes more and more shaly and the sandstones are reduced to a few beds. It must be remarked that here already the lower Campanian is marine carrying *Inocerami* from the Arroyo del Reparo (near Rodriguez, Nuevo Leon) to the south. The upper Campanian does not change as far south as the Rancho del Aguila on the road from Tortillas to El Sauz. In this latter region the whole Campanian is again marine.

From this part to the south an emersion must have followed at the end of the Santonian, because the Campanian disappears entirely and has not been found anywhere on the coastal region between the Sierra Madre and the Gulf coast at least from Parás south to Tampico.

But we find the marine Campanian again in the Sierra Madre itself, at least as far north as the valley of Tula, Tamaulipas, and as far south as Cárdenas and Ciudad del Maíz in San Luis Potosí. The beds which carry *Exogyra costata* and in the higher portion also *Gryphea vesicularis* are very sandy in this region and thus indicate deposition near the coast. There is scarcely any doubt that a communication existed between the Campanian of San Luis Potosí and that of Saltillo, but the intervening territory is almost unknown; it may be that the beds were destroyed in the Sierra Madre itself by erosion, but they should be found somewhere east or west of the National Railway. It is probable that a continental area existed in the central part of the country during the Campanian time, but a long arm of the sea must have extended itself between this continental area and the continental uplift of Tamaulipas, at least to the south of the railway from San Luis Potosí to Tampico.

We come now to the youngest period of the Cretaceous, the Maestrichtian. We have already seen that the greatest marine development of the Maestrichtian is to be found on the Rio Grande, mainly on the Mexican side, between this river and Lampazos. In Texas mainly the lower portion of the Maestrichtian seems to be present, those beds which contain *Sphenodiscus lenticularis* Owen; only near the Rio Grande in the region of Eagle Pass all the Maestrichtian is present but not very well exposed at most places. What part of the Maestrichtian is represented by the so-called Pulliam formation cannot as yet be decided, as the only fossil of these beds seems to be the *Ostrea cortex* which may occur anywhere in the Maestrichtian, while forms extremely similar to it may be even found in the Campañian.

The rich ammonite fauna of the Maestrichtian between the Rio Grande and Lampazos enables us to subdivide it into five distinct zones, and this subdivision allows us to study the regression of the Maestrichtian sea in regions farther south. We have already seen that the marine development of the whole series exists only near the Rio Grande; near Saltillo and at the Mesa de Cartujanos the uppermost beds are decidedly brackish water deposits or were laid down right on the coast. That is, the beds with *Sphenodiscus pleurisepta* are represented by oyster beds and conglomerates with plant remains, small oysters and some shark teeth.

Southeast of Piedras Negras the Maestrichtian thins out and the last deposit is found near the Rancho de Anguila, while a little farther east near the Rancho de San Edmundo the Maestrichtian is entirely missing and the Midway rests directly on the Campanian.

But the Maestrichtian extends much farther south from the region of Lampazos. It is generally preserved only in the large synclines while on the intervening anticlines it is entirely eroded. We find it well exposed in the large syncline of San Antonio de Afuera and San Antonio de Adentro between Candela, Coahuila, and Monclova, Coahuila. It consists there of sandy shales, sandstones and thick bedded, hard sandy limestones, which frequently carry *Sphenodiscus* *lenticularis* in the lower portion and other indeterminable *Sphenodiscus* in the upper part. It is several hundred meters thick, and appears to be very similar lithologically to the rocks of the Mesa de Cartujanos.

We find the Maestrichtian again in enormous mass, mostly consisting of sandstones in the upper portion, while the lower beds show limestones, also sandy, which carry *Sphenodiscus lenticularis,* in the region of La Popa, in a syncline which forms a high mountain between Reata, Coahuila, and Bustamante on the railway line from Lampazos to Monterrey, lying opposite to Villaldama. The base of the Maes trichtian here lies on the Campanian with *Exogyra costata.* The upper portion seems to consist of continental or shore deposits.

Still farther south we find the Maestrichtian developed as shales with beds of calcareous sandstones and sandy limestones, in the region of Paredon. West of Paredon, Scalia discovered some *Sphenodiscus lenticularis* in beds of large oysters near the former station of Arizpe. The same beds are found at many places between Paredon and south of Saltillo. The senior author of this publication has described the *Sphenodiscus lenticularis* from the Cerro de la Cruz at Ramos Arizpe near Saltillo. These beds overlie the Campanian, which everywhere carries *Exogyra costata* in great numbers. In the Mesa de Guajardo west of Saltillo the Maestrichtian is very well exposed but all the portion above the beds with *Sphenodiscus lenticularis* and those above them with oysters seem to be entirely continental or at the utmost shore deposits. The upper, mostly green and reddish, sandy beds are very characteristic and can be found all over the region of Saltillo to near General Cepeda.

Thus we see that while on the Rio Grande near the town of Guerrero, Coahuila, the Maestrichtian is marine from the bottom to the top, it soon begins to become brackish in the upper parts and the farther south we go, the less marine it becomes in the upper beds, until the region of Saltillo where we find only the lowermost portion, with *Sphenodiscus lenticularis* and *Inocerami,* developed as marine deposits, while everything above it seems to be shore deposit or even continental. These upper beds are by no means unimportant, but have a thickness of at least some four hundred meters. There is a bare possibility that the sandy shales which at Tula, Tamaulipas cover the beds with *Exogyra costata* and *Gryphea vesicularis* may represent the Maestrichtian in a shore facies, but so far no fossils have been found in them. Considering the data we have at the present time the Maestrichtian sea ends south of the line of Saltillo-General Cepeda.

Our knowledge of the distribution of continents and ocean in North America during Maestrichtian time is very limited, and there is little hope that a real reconstruction of these conditions will ever be possible. West of Eagle Pass in the Chisos Mountains the Maestrichtian may be represented by the Tornillo beds and by higher deposits described by Udden. As they do not carry any fossils, these beds are probably not marine and an emersion may have followed after the time of the lower Campanian. But from the different *Sphenodiscus* cited and described by Hyatt, we know that at least the lower portion of the Maestrichtian exists in a marine facies into the Rocky Mountain region as a part of the Fox Hills formation. We also know that these same beds extend into Texas and possibly Arkansas. But marine Maestrichtian must exist also in the Mississippi basin and farther north. In what manner these different seas were connected and divided can scarcely be shown at the present time. In Mexico the Maestrichtian certainly dies out toward the south and is limited to a not very wide area in Coahuila.

TERTIARY

It is not our intention to give a detailed study of the facies distribution of the Tertiary over northeast Mexico; before this can be done a detailed study of the faunas will have to be made and their distribution will have to be studied in the field. But we cannot get to any conclusion about the time of mountain building in the region discussed here, without taking into account at least that part of the Tertiary which overlies directly the Cretaceous.

We can distinguish two entirely different provinces of the lower Tertiary on the northern Gulf coast of Mexico; unfortunately our data about the region between these two provinces are very limited, but they are sufficient for the present purpose.

THE NORTHERN TERTIARY PROVINCE

Along the Rio Grande and between this river and the Cretaceous mountain of northern Mexico in Coahuila, Nuevo Leon and Tamaulipas, the Tertiary is developed in the same manner as in southern Texas, and can be subdivided in the same way:

Frio clay
Fayette sandstone
Claiborne group:
  Yegua formation
  Cook Mountain formation
  Mount Selman formation
Wilcox group:
  Bigford formation
  Carrizo sandstone
  Indio formation
Midway formation

We have found this subdivision to persist at least as far south as an east-west line through Los Herreras, a station of the railway between Monterrey and Matamoros (opposite Brownsville, Texas). This subdivision has been studied carefully by several authors and the results of these as well as those of his own studies have been united in an excellent work of A. C. Trowbridge[43] to which we have only to make the objection that his thicknesses are probably too small. The similarity of our beds on the Mexican side with those described by Trowbridge is so great that we can simply refer to his work. Instead of repeating here the well known facts we shall give only a very general summary of the marine and non-marine beds which compose this Eocene and then enter into a short discussion of the Cretaceous-Eocene contact.

[43]A. C. Trowbridge, 92.

The Eocene begins in this region with the marine beds of the Midway. This group is overlain by the non-marine Wilcox group, which carries mainly plants. This may be either a continental deposit, in favor of which determination speaks the cross-bedding of the sandstones in almost every part, or it may be partially a shore deposit, but there is no doubt that an emersion took place at this time. The Wilcox group is followed by the marine strata of the Claiborne group, which indicates a sinking of the continent below the waters of the ocean. At the end of this age another rising of the sea bottom is indicated in the Yegua formation, which carries only oyster beds, while the overlying Fayette sandstone carries mainly plants. The youngest bed of the Eocene developed here, the Frio clay, contains sparingly oysters and wood.

Marine Oligocene is entirely missing in southern Texas and northern Mexico, while the Miocene seems to be represented by the thin formation of Oakville sandstone.

We are mainly interested in the beds which lie immediately on the Cretaceous. We may remark here, that no outliers of marine Tertiary are known in Mexico south and west of the Cretaceous-Eocene contact and neither is Cretaceous known within the area of the Tertiary.

The unconformable contact between the highest marine beds of the Maestrichtian and the Midway in Maverick County, Texas, two miles north of the Webb County line has been studied by different geologists; the corresponding locality on the Mexican side is found near the Rancho de Cerrito Prieto southeast of Guerrero. This contact can be followed from the mouth of the Arroyo del Caballero near Cerrito Prieto southwards almost without interruption, as has been stated in another chapter of this publication. We find an excellent contact between Maestrichtian beds and Midway in the broad valley south of Longoria, where the shales of the Midway with *Venericardia alticosta* overlie the calcareous beds of the Maestrichtian with *Sphenodiscus* sp.

Farther south the Midway shales which carry large round and flat calcareous concretions with *Enclimatoceras* *vaughani* Gardner[44] overlies the Campanian (beds with *Exogyra costata* and *Gryphea vesicularis)*. We find this same succession also farther south; the Midway with its characteristic concretions is very well exposed all along the west side of the so-called Ceja Madre between the station of Huizachito on the National Railway and the road from El Sauz to Guerrero. It carries *Enclimatoceras vaughani* in different places, especially at a point south of the windmill called Tinajas, where *Enclimaticeras* is quite frequent. On all this tract the Midway overlies the Campanian which contains *Exogyra costata* and *Gryphea vesicularis.*

South of Tortillas conditions begin to change. We have not made detailed studies in the region immediately south of this place, but from about Parás the Eocene begins to lie directly on the Santonian, that is, shales of the "Papagayos" type. Exposures are not very good in this region, but in general the Midway seems to form the base of the Eocene here also. It is certainly exposed near Cerralvo on the road from this place to Loma Bonita, and on the Los Herreras road, and carries *Venericardia alticosta.*

South of this place we have not many data, but northeast of Linares we still find marine lower Eocene covering the Santonian; a good exposure exists near Guadalupe la Joya, where the Eocene carries *Venericardia alticosta* and *Ostrea* cfr. *pulaskensis.*

East of Cruillas on the road to San Fernando we found a series of sandstones, tuffs, and conglomerates with pebbles and blocks of intrusive material resting on the Cretaceous. Fossils are rather scarce and not very well preserved, mostly as casts. The conglomerates are interbedded with volcanic tuffs or at least with very fine-grained volcanic material, which at many places contains oysters and *Anomia.* The oysters are very like the upper valve of *Ostrea divaricata.* In the hard sandy layers between the conglomerates we found fragments of *Pecten*, casts of *Turritella, Pyrula, Natica, Olivella, Arca, Cardium*, etc., none of which are well enough

[44]Gayle Scott, **70**, p. 114, expresses the rather astonishing opinion that *Enclimatoceras uhlrichi* from the Midway is specifically identical with *Hercoglossa danica* Schlotheim from the European Danian. This opinion has already been refuted by Dr. Julia Gardner and does not need to be discussed any further.

preserved for specific determination. The petrographic character and location led us to consider these beds as Eocene until better fossils found might give an exact idea of the age of the beds. We have found no similar beds farther south.

THE SOUTHERN TERTIARY PROVINCE

A great change of facies sets in near the town of Jimenez in Tamaulipas. While in the northern province no marine Oligocene is known, this formation covers a great part of the territory in the south. But the Tertiary series does not begin with it, for in the northernmost part of this province the Oligocene is underlain by some uppermost Eocene, which is entirely different from anything known in Texas. We shall have to describe these beds a little more in detail than those of the north.

UPPER EOCENE

In the region of Jimenez-Abasolo, Tamaulipas, the Santonian is covered directly by upper Eocene. The lowest beds are formed by a gray shale weathering yellow and containing a great deal of secondary gypsum, distributed in small crystals within the shale. These shales occur west of Encinal at Casa Blanca (west of the road from Jimenez to San Fernando), where they do not contain any fossils. A similar shale occurs at Encinal containing some corals and agglomeration of very small orbitoides-like foraminifera, also some larger forms. The shales exist also at the Ceja de los Caballeros farther south and compose probably all the low territory on the road from here to Abasolo where the weathered clay near the road contains a great deal of the gypsum crystals and shows the same color as the weathered shales.

East of Abasolo these shales are exposed on the road to Buenos Aires at the foot of the Cerros del Aire. These hills rise steeply out of the plain and are composed of a white coral reef limestone, rather imperfectly bedded, at least in parts. The white limestone is everywhere full of corals but contains also a number of echinoderms and orbitoidal foraminifera. We collected in the limestone the following fossils:

Oligopygus n. sp.
Agassizia sp.
Gryphostrea sp.
Scaphander sp.
Orbitoidal foraminifera *(Lepidocyclina ocalana?)*
Corals

The most important among these fossils is the *Oligopygus* n. sp. It is very similar to the different species of this genus described from the upper Eocene of the southeastern United States. *Oligopygus wetherbyi* de Loriol from the Ocala limestone or synchronous beds (upper Eocene) is very similar in shape, but it is easily distinguished by the position of the periproct, which is much nearer to the margin in the Mexican species. The form of the transverse depression around the peristome is similar to that of *Oligopygus floridanus* Twitchell from the Ocala limestone (upper Eocene) but here the periproct is much nearer to the peristome than in the Mexican species. Still more similar is *Oligopygus haldermanni* Conrad from the Ocala limestone but in this species the periproct is much nearer the margin than in the Mexican species and the height of the species seems to be generally greater. The form of the transversal depression around the peristome and the form of the latter itself seem to be very similar. This new species cannot be identified with any of the described American species but is closely related to all of them.

Another related form is *Oligopygus ovumserpentis* Guppy from the Eocene of the Antillean region. Jackson cites it under the name of *Echinolampas ovumserpentis* Guppy from the Eocene of St. Bartholomew, Magazique and Matanzas, Cuba, the Cambridge formation of Jamaica, and from the San Fernando formation of Trinidad. This species seems to be quite variable according to the descriptions and figures of Cotteau and Jackson. It is easily distinguished from the Mexican species, because its periproct is quite near the margin.

The new species here mentioned also varies very much with respect to its dimensions, but the general character, especially the shape, the position of the apex, and that of the periproct, the deep transversal depression around the peristome are always the same.

It seems that the genus *Oligopygus*, of which very few species are known, is found only in the very highest Eocene. In reality *Oligopygus* seems to be very common in the highest Eocene according to the investigations of C. W. Cooke[45], and as far as our present knowledge goes, the genus is entirely limited to this horizon. Not very long ago Clark and Twitchell[46] cited all three species of American *Oligopygus* from the Vicksburg group (lower Oligocene) and only *O. haldermanni* also from the Ocala limestone which at that time was considered as Oligocene; this made the exact determination of the age of the Mexican reef limestone difficult, but in a letter of January 29, 1924, Dr. C. Wythe Cooke confirmed our original view and told us that none of the three American species of *Oligopygus* occurs in the Vicksburg group but that all of them were found in the Ocala limestone.

The second of our species is a very incomplete *Agassizia* which could not be compared with any other.

A third species, *Gryphostrea* sp. is nearly related to *G. subeversa* Conrad and to *G. eversa* Deshayes (from the Eocene of Paris), and is of great stratigraphic interest. It seems that *Gryphostrea* is restricted to the Eocene and occurs in the Ocala limestone (cited by Cooke in the paper mentioned above). Dall presumes that the genus may be found even in the highest Cretaceous *(G. vomer* Say) but has never found it in the Oligocene beds.

It seems that the orbitoidal foraminifera found by us in the same beds belong either to *Lepidocyclina ocalana* Cushman or to a nearly related species; this form occurs only in the upper Eocene (Ocala limestone) and confirms our determination of the age of these beds.

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[45] C. W. Cooke, 20.

[46] W. B. Clark and M. W. Twitchell, 18, pp. 166–170.

Our conclusion is thus that the gypsum clays with the interbedded large coral reef of the Cerros del Aire have to be considered as upper Eocene and as the Mexican representative of the Ocala limestone of the southeastern United States.

OLIGOCENE

The Oligocene forms a long and broad zone running nearly north-south and parallel to the coast. In the northern portion of the area it forms part of the flank of the large anticline south of the San Carlos Mountains, where it begins to overlap the Eocene and covers this so completely that with the exception of the highest Eocene beds none of the deposits of this epoch can be observed between the upper Cretaceous and the Oligocene.

The Oligocene makes up the region between the Cerros del Aire and the Sierra de Maratines as well as at least the western portion of this latter range of hills. Farther toward the south we find it composing the Sierra de San José de las Rusias and the valley and hills west of this range.

Lower Oligocene.—We have been able to distinguish several horizons in the lower Oligocene. East of the Cerros del Aire we find a wide topographical depression evidently filled with soft beds, probably shales. These shales are visible at the east foot of the Cerros del Aire and contain there large *Lepidocyclina*.

The next part of the depression is covered by alluvium, but about four miles east of the Cerros del Aire we find some very low hills which have produced a number of fossils. We shall call these beds the *Echinolampas* zone. The beds composing this horizon consist of gray argillaceous shales containing at the base irregular calcareous concretions, partly composed of small orbitoidal foraminifera but also enclosing other fossils, mainly echinoids and some Pectens. The same fossils occur also in the shales themselves. The higher portion of the beds contains a number of thin and hard, rusty weathering limestone beds, mainly containing large *Lepidocyclina* similar in shape to *L. mantelli* or *gigas*, but also some of the echinoids found in the lower beds. The following fauna was collected in these beds:

Echinolampas n. sp. I
Echinolampas n. sp. II
Macropneustes aff. *mexicanus* Kew
Macropneustes n. sp.
Clypeaster sp. A. Kew
Pecten sp.
Lepidocycina sp.

The fauna of these beds is not very large although most of the species are represented by a number of well preserved specimens.

Echinolampas n. sp. I has a certain similarity with *E. appendiculatus* Emmons from the Castle Hayne limestone (upper Eocene) of North Carolina. Especially the young specimen of sp. I is rather similar to the middle Atlantic border form, but it grows much larger, is less pointed posteriorly, the apex lies nearer to the anterior margin, the periproct is nearer the inferior surface and the peristome is less elliptical and more pentagonal-elongate. With respect to shape it has a certain similarity with *Echinolampas clevei* Cotteau from the Eocene of St. Bartholomew and from Matanzas, Cuba. It is less elongate, the apex lies much nearer to the anterior margin and the ambulacra seem to be still a little narrower. All the rest of the *Echinolampas* described from the Antillean region have more petaloid ambulacra and the apex is more centrally located. *Echinolampas aldrichi* from the lower Oligocene (St. Stephens limestone, Alabama, and Vicksburg limestone, Mississippi) has an entirely different shape.

Echinolampas n. sp. II is a form which in its shape resembles somewhat *Echinolampas castroi* Cotteau from the Eocene of Matanzas, Cuba, but the ambulacra of the Antillean species are much more petaloid, the apex lies much less in front, while the position of the periproct seems to correspond to that of species II. There is no form described from the Tertiary of the United States which resembles it.

Macropneustes aff. *mexicanus* belongs to a species extremely near to the one of this name described by Kew from the hill at the extreme north of La Puerta range at Topila, where it occurs together with a *Clypeaster* sp. A (Kew). We shall see that this latter species seems to occur also at the Cerros del Aire locality. *Macropneustes mexicanus* is especially characterized by its curved petals. We observe these in our specimens; in the original the ambulacra I and V are considerably longer than ambulacra II and IV. The same is the case in our specimens. The only and rather slight difference we find between our form and Kew's is that the greatest height in most of our specimens is a little greater in comparison with the antero-posterior diameter, but in one specimen even the relation of height and length is exactly the same as in the type specimen. There does not seem to exist any species in the Antillean region or in the United States which is very nearly related to *Macropneustes mexicanus* Kew. In *M. antillarum* Cotteau the anterior pair of petals (II and IV) are slightly curved, but the posterior ones are entirely straight (the specimen figured by Jackson, **39**, pl. XV, fig. 1, under this name, certainly belongs to some other species); the anterior furrow is much deeper than in *M. mexicanus*. What Kew figures as *M. antillarum* (from Tuxpam and from an unnamed locality No. 33 which according to the map of Dumble lies south of Tuxpam and south of the Fubero Railway) is somewhat similar to *M. mexicanus* but easily distinguished from it through its less curved ambulacra II and IV and the entirely straight I and V; it shows a deep indentation of the anterior ambitus, while our species is only slightly excavated. The species of Kew is also different from *M. antillarum* Cotteau, although more nearly related to it than the specimen figured by Jackson. The main difference lies in the position of the apex which is much more anteriorly placed in Kew's specimen than in that of Cotteau, and in the relations of the dimensions. While Jackson's specimen is too narrow and a little lower than the type, Kew's specimen approaches this more in width but is much too thick, as Jackson has pointed out.

Our species *Macropneustes* n. sp. is very similar to *M. mexicanus* Kew, but the greatest height is less in comparison with the antero-posterior diameter and the paired ambulacra II and IV are practically of the same length as the posterior I and V. The upper surface curves gently toward the anterior margin while in *M. mexicanus* this curve has a much shorter radius; the anterior furrow seems to be still shallower in *M.* n. sp. than in *M. mexicanus.*

At the same locality we found only four fragments of *Clypeaster.* It is very possible that they represent two different species. Two fragments show an extremely sharp margin, while a third one has a rounded and rather thick margin. The fourth fragment represents only the region of the five petals and probably belongs to the same species as the last mentioned. The second species seems to be identical with *Clypeaster* sp. A of Kew.[47] The author unfortunately does not describe this species and only figures it. We cannot find any difference between this species and that from our locality. In the fossil list made up by Dickerson and Kew this species is cited from the Rancho Salitre and from the La Puerta range near Topila; the explanation of the plates does not say from where the figured specimen comes; in the text (loc. cit., p. 218) the species is not mentioned as occurring at Rancho Salitre, but in its stead the authors cite an unfigured *Clypeaster* sp. b which in the above cited list is mentioned only from "Hills four miles north of San Rafael" and from a place "Three miles directly west of Larios, Veracruz." We may mention here that *Clypeaster* sp. A has not been found by us at Rancho Salitre. Species A Kew resembles our species with regard to the pointed anterior part, the length and width of the petals, the breadth of the poriferous zones and their relation to the interporiferous zone, the distance between the ends of the poriferous zones at the termination of the petals, the thick margin and the longitudinal cross section of the shell. There can be no doubt about the identity of the two forms.

The occurrence of *Macropneustes* aff. *mexicanus* and *Clypeaster* sp. A makes it very probable that the beds collected by us are the same as those of La Puerta range near Topila.

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[47] Dickerson and Kew, 23, pl. xxiii, fig. 2; pl. xxiv, fig. 2.

As the species found by us are new or known only from another locality the age of which is not yet satisfactorily established it is rather difficult to say what horizon our fauna represents. We have seen that all the nearest relatives seem to belong to the highest Eocene of the United States and of Cuba, but the occurrence of large orbitoidal foraminifera which resemble *Lepidocyclina mantelli* and *L. gigas* and the position above the horizon with *Oligopygus* shows that the fauna corresponds to the basal beds of the Oligocene. Taking into account that faunas of echinoids are not known from a lower Oligocene bed in the Antillean region it is not surprising that we cannot cite any nearly related forms from those islands. In the southern United States the genera *Echinolampas* and *Macropneustes* are apparently very rare in the lower Oligocene and the few forms cited from it and the upper Eocene are very different from ours with the sole exception of *Echinolampas appendiculatus.* But the younger faunas of the United States and of the Antillean region do not contain any species which might be considered as very near relatives of the forms found by us. It seems that our fauna is entirely restricted to the coast of northern Mexico; that there are no very near relations with the southern United States which can be explained in part by the distance and probably the difference of climate; the fauna lived near the coast and in shallow waters and therefore probably developed in a locally different way. But we shall see that the still younger beds of Salitre are of such a character that their Oligocene age cannot be doubted, and this confirms the view that the present zone belongs to a very low zone of the Oligocene.

East of the locality where we found the *Echinolampas* horizon the ground is covered with alluvium, but at the base of the Maratines hills there again appear rocks of the lower Oligocene which have yielded a fauna. We first discuss the best locality of these beds which exists near and at the Rancho Salitre, visited years ago by Cummins and Sands, whose collection was determined and partly described by Dickerson and Kew. These two authors cite from this locality the following species:

Agassizia clevei Cotteau
Clypeaster sp. A (according to their text: Clypeaster sp. b.)
Clypeaster sp. ind.
Lovenia dumblei Kew
Ostrea sp.
Pecten gatunensis Toula
Pecten condylomatus Dall
Pecten sp.
Ficus mississippiensis Conrad
Melongena sp.
Natica sp.

At this locality we have been able to distinguish two different beds, of which the lower one seems to have escaped the attention of Cummins and Sands for the fossils of this bed do not seem to be mentioned by Dickerson and Kew.

North of the houses of the Rancho Salitre we find a yellow clay bed which at different points contains a great number of fossils, partly as casts, and partly with the shell. We shall call this bed the Zone of *Clypeaster* aff. *douvillei* Stefanini. In the bottom of the shallow creek near the houses of the ranch, and especially in the upper branches of the creek a little north of the ranch house we find a bed of yellow clay, mostly sandy and containing pebbles of different sizes. The bed is locally composed almost entirely of small *Lepidocyclina* with fragments of *Pecten*, echinoderms and other shells; in other parts the foraminifera are less frequent and the shells are very well preserved. There are about twenty feet of these clays exposed but the base is nowhere visible. From this bed we collected the following species:

Clypeaster aff. *douvillei* Stefanini
Pygorhynchus aff. *gouldii* Bouvé
Eupatagus aff. *floridanus* Clark
Schizaster n. sp.
Cidaris sp.
Pecten n. sp. aff. *gatunensis* Toula
Arca sp.
Xenophora conchyliophora Born
Natica sp.
Neverita sp.
Cypraea sp.

Pyrula sp.
Olivella cfr. *collecta* Dall
Conus cfr. *designatus* Dall
Scaphander sp.
Lepidocyclina sp.

The most common and most important fossil of this bed is the *Clypeaster* aff. *douvillei* Stefanini.[48] It is a rather small form for this genus and very well characterized by its sharp and thin margin, the almost perfect low conical form and the narrow petals. We have found only one form which is very similar to it and this is *Clypeaster douvillei* Stefanini. The specimen on which Stefanini founded his species comes from the "white limestone of Jasper County, Mississippi" with *Lepidocyclina mantelli.* This latter species according to Dr. C. W. Cooke is an index fossil of the Marianna limestone, that is, the middle bed of the Vicksburg group of the lower Oligocene. The dimensions of our *Clypeaster* are practically the same as those of *Cl. douvillei;* it resembles it also in the low conical shape and the sharp and thin margin. The type has a little greater height than our specimen of about the same size, but even this remains within the boundaries of variability of our species. The main distinctive character seems to be that the interporiferous zones in the petals seem to be limited on the outside by lines which are a little curved while in *C. douvillei* they are practically straight. Clark and Twitchell include *C. douvillei* in *C. rogersi* Morton[49] and say "that the former species appears to be *C. rogersi* with relatively thin margin and subconical surface, such as the writer has found to grade into the more typical representative of the species." Comparing the figures of *C. rogersi* with those of *C. douvillei* it seems to be utterly impossible that both belong to the same species; comparing the measurements (after making the necessary corrections, because these are misprinted in both the text of Clark and Twitchell and of Stefanini!) one finds that the height of *C. rogersi* is greater than that of *C. douvillei;* the sharp and thin margin of the

[48]G. Stefanini, **87**, p. 682, pl. xxii, fig. 1a–c; p. 698.
[49]Clark and Twitchell, **18**, pp. 136–139, pl. lxiv, figs. 2, 3.

latter species cannot very well grade into the thick and rounded one of the former species. In our 33 specimens this character never changes while the dimensions and the form of the outline of the margin vary to a certain degree.

According to Clark and Twitchell (loc. cit., p. 138) *Clypeaster rogersi* occurs both in the Jackson formation (upper Eocene) and in the Vicksburg group (lower Oligocene). but Dr. C. Wythe Cooke in his paper on the correlation of the Vicksburg group and in the above mentioned letter to us states that in reality this species never occurs in the upper Eocene and is restricted to the Vicksburg group. No *Clypeaster* is known in the Eocene of the United States.

The specimens which we have called *Pygorhynchus* aff. *gouldi* is only a fragment, and the species to which it belongs will be discussed in our description of the fauna of the higher bed at Rancho Salitre.

Eupatagus aff. *floridanus* Clark is very nearly related to the American species of this name, which according to its author comes from the Vicksburg group (lower Oligocene) of Florida, but may really come from the upper Eocene. Our species resembles especially Fig. 2 on pl. 82 of Clark and Twitchell, which is considered as the type. Unfortunately there is again a number of misprints in the text as well as in the explanation of the plates. The measurements given in the text do not refer to the letters in the explanation of the plates and those in the paragraph about the locality. Measuring the figures we see that the type specimen should be called C (pl. lxxxii, fig. 2), that of fig. 1 on pl. xxxliii should be called A, and fig. 2 of the same plate should be B. The general shape of one of our smaller specimens is very similar to that of the type specimen, but the angle between the ambulacra II and IV seems to be a little larger, while that between the ambulacra I and V is possibly a little smaller. One of our larger specimens is a little thicker in the posterior region than the type and resembles in this respect more fig. 1 on pl. lxxxiii, but the form of the petals is quite like that of the type, while the ambulacra of both specimens on pl. lxxxiii are much longer than those of the type. The position of the peristome seems to be like that of the type, but the smooth band on the lower surface is perhaps somewhat broader in our species. In general our specimens are a little more pointed posteriorly than *Eupatagus floridanus*. Notwithstanding these differences both forms are very nearly related.

Schizaster n. sp. is represented by a single specimen. None of the species described from the Tertiary of the United States is very similar to it. The nearest relative seems to be *Sch. scherzeri* Gabb from the Miocene of Costa Rica. It is also similar to the *Sch. scherzeri* Kew from the Oligocene of Tuxpam, Veracruz.

Cidaris sp. is only represented by a few fragments and some spines; a determination or comparison with other species is impossible.

Pecten aff. *gatunensis* Toula is a rather characteristic form, but not very closely related to any described from the United States. There is a certain resemblance with *Pecten gatunensis* Toula, but the Mexican species does not have the broad and smooth submargin and the lines which limit the ears of the right valve on the upper outside meet at an angle at the umbo, while in the Panama species they form a straight line. Our species is a little broader than high; the right valve is more convex than the left one. While in the right valve the ears stand at an angle as mentioned above, their upper outline forms a straight line in the left valve. The ears are subequal, the anterior one of the right valve being a little larger than the posterior one; the byssus notch is very shallow. The anterior ear of the right valve shows about 5-6 rather faint riblets, the posterior one has only three on its lower portion while the upper part is smooth. The ears of the left valve show 4 to 6 very faint riblets respectively. The submargins are narrow and smooth, each valve has about 22 to 23 ribs these are a little more rounded on the right valve but slightly flattened on the top, while on the left valve about eight ribs near each margin are very flat on the top and those in the center rounded. The interstices are much narrower than the ribs on the right valve, while they are about as wide as the ribs on the left valve. Very fine concentric lamellae cross both ribs and interstices. The markings on the inner side of the valves correspond to the ornamentation of the outside; they are very strong near the margin but faint on the remainder.

The other fossils found in the bed are not of any stratigraphic importance.

Clypeaster aff. *douvillei* finds its nearest relative in the Vicksburg formation, probably in the middle portion of this horizon of the lower Oligocene. *Eupatagus* aff. *floridanus* has a certain similarity to *E. floridanus* which has been cited from the Vickburg group by Clark and Twitchell, but which according to a communication from Dr. C. Wythe Cooke does not occur in this horizon and belongs to the upper Eocene. Taking into account that *Clypeaster* aff. *douvillei* is a very near relative of *Cl. douvillei*, that the bed contains also very numerous *Lepidocyclina of* a rather small species, and that our horizon is relatively high above the typical upper Eocene, there does not remain any doubt that this clay bed belongs to the lower Oligocene.

The next higher beds at Rancho Salitre consist of coarse grained sandstone, sandy clays and not very coarse conglomerates. These beds are equally very fossiliferous, and most of the fossils collected by Cummins and Sands probably came from them. These beds will be called: Zone of *Agassizia inflata.*

The beds of this zone are well separated from the underlying clay, although the contact is visible only near the ranch houses and is covered by débris and pebbles in the upper branches of the creek. These pebbles come partly from the upper bed but in greater number from the Reynosa conglomerate which covers the older beds on top of the hills. The lower portion of our zone seems to be generally coarse sandstone while the higher beds are more conglomeratic. They are very calcareous and therefore much harder than the lower clay bed. We collected the following fossils near the houses of the ranch:

Agassizia inflata Jackson var.
Clypeaster sp. b. Kew and Dickerson
Clypeaster n. sp.

Pygorhynchus aff. *gouldi* Bouvé
Pygorhynchus aff. *alabamensis* Twitchell
Ostrea sp.
Pecten aff. *gatunensis* Toula
Pecten div. sp.
Arca sp.
Conus cfr. *designatus* Dall
Melongena (?) sp.

In a bed farther south, 2.1 miles south of Rancho Porvenir in a creek crossed by the road from Rancho Salitre to Rancho Repelo we found a small fauna which apparently corresponds to that of the zone of *Agassizia inflata.* The species found are:

Clypeaster n. sp. aff. *Cl.* sp. n. Kew and Dickerson
Pygorhynchus n. sp. aff. *alabamensis* Twitchell
Cidaris sp.
Pecten n. sp. aff. *gatunensis* Toula
Arca sp.
Conus sp.
Olivella cfr. *collecta* Dall
Natica sp.
Lepidocyclina sp.

These fossils come from a yellow sandy clay, but at the same locality exist hard sandstones and conglomerates. In the clay beds exist numerous corals of very large size Farther south a coral reef develops in these beds and forms the hills just west of El Repelo. The reef consists of white limestones often full of large corals, sometimes almost structureless, as in recent coral reefs.

The upper bed of Rancho Salitre is characterized by the frequency of an *Agassizia* which scarcely can be distinguished from the Eocene *Agassizia inflata* Jackson of the Antillean region. Jackson[50] has already remarked that the species called *Agassizia clevei* Cotteau by Kew is much nearer related to the species *Agassizia inflata.* This latter species comes from the Eocene of St. Bartholomew while *Agassizia clevei* occurs in the upper Oligocene of Anguilla. Our form seems to hold a place between the two species, but is nearer related to the Eocene form. The height of our

[50]R. T. Jackson, 39, p. 96.

species in relation to the length is about the same as in *A. inflata* while the transverse diameter is a little greater. But the difference is small. The curve of the anterior slope from the apex to the margin is generally a little stronger, but we have specimens which in this respect cannot be distinguished from the type. We have called this form *Agassizia inflata* Jackson var. but a comparison with the material of the Eocene may show that it is really a new species.

Our *Clypeaster* sp. b a. Dickerson is certainly a new species. Our species resembles the one figured by Kew and Dickerson with respect to the outline of the ambitus, especially in the constriction in front of the interambulacra between Am. I-II and Am. IV-V which gives the fossil a decidedly pentagonal contour. Our form is less rounded on the anterior side, and more pointed. The margin of our species is rounded but decidedly much thinner than that of *Clypeaster* sp. A Kew (probably the one which was compared to the fossil from Rancho Salitre by Kew and Dickerson). Comparing the two, the margin of our form appears almost sharp; it is certainly much thinner than that of Kew's species even in specimens much larger than the figured one. The petals of our species are quite similar to those of *Cl.* sp. A Kew; they are tumid and rise above the surface, as they seem to do in Kew's specimen. The poriferous zones are possibly a little narrower than in the above cited species and it may be that the petals close a little more, but these differences are small. Our species resembles the *Clypeaster* sp. which we found in the zone of *Echinolampas* east of the Cerros del Aire and cited above, but the petals close a little more and the margin is much sharper.

Our species resembles to a certain degree some of the forms described as *Clypeaster rogersi* Morton, but the region occupied by the petals forms a steeper cone above the rest of the upper surface, the zones of pores are narrower and the interporiferous zone has stronger curved sides. Our species is much narrower than *Cl. rogersi.* No other *Clypeaster* described from the Tertiary of the United States is similar to our species. All the *Clypeaster* described and figured from the Antillean region have a much thicker margin and the petals seem to be generally much broader. In outline our species resembles most *Clypeaster oxybaphon* Jackson but the margin of this species is extremely thick and the cone formed by the region of the petals does not seem to rise above the height of the margin.

Our species is much larger than *Clypeaster rogersi* Morton and in this respect resembles those of the Antillean Oligocene, our largest complete specimen measures about 100 mm. in length.

Clypeaster sp. n. of the upper bed of Rancho Salitre is distinguished from the preceding form by its more rounded pentagonal outline; the petals are not tumid and scarcely rise above the rest of the surface; they are long and narrow. The margin is thin but not sharp. No American species seems to be very nearly related to this form.

Pygorhynchus off. *gouldi* Bouvé resembles the type of this species from the lower Oligocene (Vicksburg group) of Florida in outline and height as well as in the position of the apex, but the petals of our form seem to be a little more elongated and the peristome larger. Our form has certain relations also to *Pygorhynchus alabamensis* Twitchell from the lower Oligocene (upper part of the St. Stephens limestone) of Alabama and Georgia, but this latter species is lower in height, the apex lies nearer to the center and the outline is more circular.

Still nearer to the group of *Pygorhynchus alabamensis* Twitchell is the one we have called *P.* aff. *alabamensis;* the similarity can be seen especially in the dimensions and the outline of the ambitus, but in our form the position of the apex is much nearer to the front.

Another species belonging to the groups of *Pygorhynchus alabamensis* and *P. gouldi* is our *Pygorhynchus* n. sp. aff. *alabamensis* Twitchell from the beds near Porvenir. It is much higher and much more evenly curved on the posterior side of the upper surface than *P. gouldi,* while it may be distinguished from *P. alabamensis* by its greater height and the more anterior position of the apex.

Cidaris sp. from the same locality is represented only by an undeterminable fragment.

Pecten n. sp. aff. *gatunensis* Toula is the same as that in the lower bed but occurs in the upper sandy deposit in generally much larger specimens. This apparent difference may be caused only by the circumstance that the larger specimens in the clay bed are mostly fragmentary or broken to pieces, but the large specimens from this bed, we found, reach the size of the medium sized ones of the higher beds. There is no specific difference between these forms.

Pecten n. sp. aff. *gatunensis* Toula from the beds near Rancho Porvenir is very similar to that from Rancho Salitre but is specifically different. It is strongly convex especially in the upper half of the right valve, while the flatter left valve shows a kind of swelling a little below the umbo. The upper outline of the ears forms a straight line in both valves and not a wide angle in the right valve as in the *Pecten* aff. *gatunensis* from Salitre. The number of ribs is the same as in this latter species but they are entirely flattened in the right valve and a little broader and very flat in the left valve. The ears do not seem to be different from those of the species which occurs at Rancho Salitre.

The occurrence of three *Pygorhynchus* which are all nearly related to *P. alabamensis* and *P. gouldi* of the lower Oligocene of the United States, and the frequency of an *Agassizia* which can scarcely be distinguished from the *Agassizia inflata* of the Eocene of St. Bartholomew and occupies a position between this Eocene and a nearly related Oligocene form, make it evident that these beds too belong to the lower Oligocene. If we consider that the difference in age between the clay bed and the conglomerates cannot be very great and remember that also *Clypeaster* sp. b Kew a. Dickerson and *Eupatagus* aff. *floridanus* of the lower bed have very near relatives in the Vicksburg group of the Oligocene, there can scarcely remain any doubt that our two zones represent the Vicksburg group and probably not the very lowest part of it.

Considering the different faunas in the zones of *Echinolampas*, of *Clypeaster* aff. *douvillei* and of *Agassizia inflata* var. there does not remain any doubt that all of these belong to a portion of the lower Oligocene. Most of the Echini have their nearest relatives either in the highest Eocene of the United States or the Antillean region, or in the lower Oligocene of the United States; so our beds can be regarded as the representatives of the Vicksburg group of the southern United States.

Similar beds to those which we have called *Echinolampas* zone exist north of Soto la Marina; there we found a mile west of the road to Abasolo the same kind of large orbitoidal foraminifera and together with them in a clay two fragments of *Macropneustes* which according to their curved petals belong to the group of *M. mexicanus* Kew.

The fossils from other similar beds of lower Oligocene age of this region north of Soto la Marina have not as yet been sufficiently studied, and those localities have to be left out of consideration for the present time. Most of those fossils are *Lepidocyclina* of different kinds and pelecypoda.

The middle and upper Oligocene seem to be represented by sandy, calcareous beds with oysters and limestones with different kinds of pelecypoda, but we could not find anything determinable.

What seems to be the highest part of the Oligocene was found 1.4 miles east of Santa Rosalia, on the road from Jimenez to Loreto. The main part of the beds seems to be calcareous shale or marl with beds of large almost smooth oysters. In these beds we found a geode which contains a well preserved *Aturia,* probably a new species. The large oyster of this horizon seems to be specifically identical with that of the oyster beds which occur near Rancho Viejo on the road from San Fernando to Cruillas.

LOWER MIOCENE

Rocks which appear to be of Miocene age were found on the crossing of Arroyo Chorreras (road from Jimenez to San Fernando) and in the river bed of Rio Conchos at El Salto, 2.7 miles above San Fernando. Another locality which may represent the same beds exists at a distance of about four miles east of Santa Rosalia (road from Jimenez to La Mision, Santa Rosalia, and Loreto).

At Arroyo Chorreras we find a soft light colored somewhat clayey sandstone which contains:

Ostrea divaricata Lea var. *rugifera* Dall
Pecten n. sp. aff. *P. oxygonum* Brown and Pilsbry
Pecten n. sp. aff. *P. madisonius* Say var. *sayana* Dall
Pecten cfr. *oxygonum optimum* Brown and Pilsbry
Turritella sp.

This small fauna does not present any very characteristic species. *Ostrea divaricata* Lea var. *rugifera* Dall is not limited to a single horizon. The form we found may very well be separated from the type, as it is rather small although quite similar to the species figured by Lea. The ribs of the right valve divaricate in the same manner as those of the type, the left valve is smooth; all of our shells have a kind of halfmoon shape.

Pecten n. sp. aff. *P. oxygonum optimum* seems to belong to this group, but the secondary ribbing and the ears are different.

Pecten n. sp. aff. *P. madisonius* Say var. *sayana* Dall is certainly different from the type; it is somewhat oblique, the ribs are higher and more numerous (16) and the shell more convex.

Pecten cfr. *oxygonum optimum* Brown and Pilsbry is similar to the form found at El Salto on the Rio Conchos and is probably related to the type from the Gatun formation. The many crab shells found at this locality seem to belong at least in part to *Callianassa* or related genera, as far as they could be determined in the field. It is to be noted that in the West Indies most of the numerous crab shells have been found in the lower Miocene.

At El Salto on the Rio Conchos above San Fernando we found a sandy clayey indurated bed which contains many fossils mostly of the nature of casts, with the exception of the Monomyaria, some gastropods and few fragments of Echini. We collected the following fauna:

Pecten madisonius Say var. *sayana* Dall
Pecten n. sp.
Pecten aff. *oxygonum optimum* Brown and Pilsbry

Nodipecten n. sp. aff. *N. condylomatus* Dall
Cardium gatunensis Toula
Cardium sp.
Arca sp.
Turritella subgrundifera Dall
Terebra gatunensis Toula
Oliva sp.
Scutella sp.

Apparently this fauna exists also about four miles east of Santa Rosalia but the exposures are very bad and no complete specimens could be secured from the rather hard shell limestone. We found some characteristic fragments which seem to belong to:

Pecten madisonius Say var. *sayana* Dall
Nodipecten n. sp. aff. *N. condylomatus* Dall

The fauna of the locality in the river bed of Rio Conchos at El Salto seems to be very similar to that which was found by Cummins near San Fernando and from which Dickerson and Kew cite the following fauna:

Arca sp.
Arca trinitaria Guppy
Cardium gatunense Toula
Clementia cfr. *dariena* Conrad
Meretrix sp.
Macoma sp.
Ostrea sp.
Pecten gatunensis Toula
Pecten cfr. *gatunensis* Toula
Pecten condylomatus Dall
Pecten levicostatus Toula
Amphissa sp.
Olivella sp.
Turritella sp.

This fauna reminds us strongly of that of Gatun which belongs to the lower Miocene according to Vaughan, although Toula originally thought that it was still younger.

Of our fauna collected at El Salto the most important species is *Pecten madisonius* Say var. *sayana* Dall which in the United States occurs in the Miocene of the Chipola beds and of Maryland. The species is so characteristic that there is no doubt about its determination.

Pecten n. sp. has a very convex and slightly inequivalve shell which is not quite equilateral. The valves are considerably broader than high; the greatest convexity is near the umbo which is sometimes turned over rather suddenly toward the hinge line. The surface of each valve is covered by sixteen to seventeen strong ribs, which are rounded and broader than the interstices; both ribs and interstices are covered by riblets. Fine concentric lamellae cause a kind of scaly ornamentation both on the ribs and the interstices between these. The submargins are relatively broad, covered with very faint riblets and often appear almost smooth; they are strongly convex in such a manner that between them and the ears a deep furrow is formed. The posterior ears show six to seven moderately strong riblets, but the upper portion is smooth; the anterior ears are larger the byssal notch is not very deep; the anterior ears are covered by strong riblets. This species is very characteristic and large, but does not seem to have been previously described.

Pecten aff. *oxygonum optimum* Brown and Pilsbry is very similar to the type described by Brown and Pilsbry from the Gatun beds. We have only four specimens, but they seem to be very similar to the one figured by those authors although perhaps a little narrower and more like the specimen from the Antillean region figured by C. W. Cooke. *P. oxygonum* Sowerby has never been well figured and therefore a comparison is difficult; the type seems to be a much smaller shell than the variety from Panama.

Nodipecten n. sp. aff. *N. condylomatus* Dall is surprisingly similar to this species but has a greater number of ribs (14); it is also related to *Nodipecten articulosus* Cooke but this one has only 8 to 11 ribs and the nodules are more evenly distributed. In our species the nodules of one specimen are rather faint on the majority of ribs but very strong on two of them; there is only one row of nodules which exists at the place where the valve suddenly bends over and produces from the side the appearance of a side view of the knuckles of a hand. On the other specimen there are two rows of nodules but none of them very prominent. *Pecten condylomatus* Dall occurs in the lower Miocene (Chipola beds) and *P. articulosus* has been found in the Oligocene of Cuba.

Our *Cardium* cfr. *gatunense* Toula is represented by a few casts, but is very similar in shape and ornamentation to the type. There exist still other species of *Cardium* in our collection from the same place.

Turritella subgrundifera Dall appears to be identical with the species originally found in the Chipola marls; we collected a dozen specimens and all seem to agree in every detail with the type as far as ornamentation goes; the only difference seems to exist in the size, our specimens being in general smaller than the type, but none of them shows the aperture; it is possible that they are only fragments of much longer shells.

Terebra gatunensis Toula agrees in every respect with the type and also with the specimens described by Brown and Pilsbry from the Gatun formation.

We found fragments of a large echinoderm, which according to the shape of the petals, the branching ambulacral furrows on the lower side and the pillars near the margin in the interior, the smooth low conical upper surface, the very broad poriferous zones which almost close at the end of the petal do not leave any doubt that they belong to *Scutella.* A specific determination is impossible, but as *Scutella* is practically unknown in the Oligocene of the Atlantic Coast, although some species have been described from the middle and upper Eocene, and is equally unknown in the Oligocene of the Antillean region, while the genus is found frequently in almost every Miocene deposit of the earth, its existence in many fragments at our locality makes it still more probable that these beds belong to the Miocene. Our little fauna seems to represent the beginning of the Miocene and to correspond in age to the Chipola beds and to the Gatun formation of the Isthmus of Panama.

In the hills where the Miocene beds of Santa Rosalia exist, a great part of the ground is covered by caliche or by sand and other débris. Now and then we find a shell rock in the creek bed, as for example, near the Rancho Magueyes, or as on the top of a hill west of the Hacienda Buena Vista, but most of this rock is real coquina from which no determinable fossils could be separated. *Pecten* beds similar to those of the San Fernando deposits exist also at the Rancho Temascal and between this ranch and Panales on the road from Temascal to La Misiọn and Jimenez. No good material could be secured here. Nearer to the coast a thick cover of sand hides all the rocks from view.

CHANGES OF FACIES IN THE TERTIARY BETWEEN TEXAS AND TAMAULIPAS

We have seen that in the region of the Rio Grande the Cretaceous is covered directly by the Midway. First it is the Maestrichtian in the north which underlies the lower Eocene; then the Campanian, and at last in the region south of Parás it is the Santonian. This condition continues to about the region of Linares, Nuevo Leon. Unfortunately we have not had any opportunity to study there the beds which overlie the lower Eocene. It is very well possible that the first marine Oligocene and possibly marine upper Eocene will be found farther north, but we have no data of our own with respect to that country.

In the region southeast of Cruillas, Tamaulipas, we see that the lower and middle Eocene has disappeared entirely and that upper Eocene of the character of the Ocala limestone of the United States overlies directly the Santonian. This Eocene zone does not seem to go very far south, as in the region of San José de las Rusias the Santonian seems to be directly covered by lower Oligocene, which probably overlaps all the Eocene beds.

North of Jimenez most of the Eocene seems to become overlapped first by the lower Oligocene and this in its part by lower Miocene which corresponds in its character partly to that of the United States Miocene (Chipola beds) and partly shows already elements of the southern facies so well developed on the Isthmus of Tehuantepec, Central America, and the Isthmus of Panama.

Toward the south the Oligocene is well developed in the region of San José de las Rusias and continues south of

Tampico into the State of Veracruz (Tuxpam). From there on the Miocene seems to develop more and more and it certainly overlaps the Oligocene in southern Veracruz, where near Santa Maria Tatetla it lies directly on the Cretaceous. This Miocene deposit has formerly been taken as Pliocene by the senior author of this publication who described its fauna, but is now taken for Miocene by most of the American paleontologists who have described the faunas of Central America. On the Isthmus of Tehuantepec the lower Miocene (formerly considered as upper Miocene by the senior author of this publication and as younger neogene by Toula) becomes very thick and takes a wide distribution.

The main differences between Texas-northern Tamaulipas and central-southern Tamaulipas are these: in the northern region we find a relatively not very thick mass of marine lowest Eocene the Midway lying unconformably over different beds of the Cretaceous; above these beds we find a thick mass of either shore or more probably continental beds, the Wilcox; then follow near-shore alternating with lagoon or continental deposits during the Claiborne and Jackson ages; the Oligocene is missing, the marine Miocene exceedingly reduced. In the southern province we find very little Eocene and that of the youngest beds of this age, then a mighty development of shallow water and partly near-shore deposits with coral reefs, representing the lower Oligocene, followed by a shore deposit of middle and upper Oligocene and at last quite important shallow water deposits of older Miocene age.

Farther south no Eocene with the exception of the somewhat doubtful Chicontepec sandstones is known, but the Oligocene appears in a great extension as shallow water deposit, but seemingly becomes more and more overlapped by deeper water deposits of the lower Miocene in the facies of the Gatun beds. Still farther south in Chiapas Eocene and lower Oligocene appear again in great thickness.

CONTINENT- AND MOUNTAIN-BUILDING MOVEMENTS IN NORTHERN MEXICO DURING CRETACEOUS AND TERTIARY TIMES

The senior author of this publication has shown in his paper on the "Vestiges of an ancient continent in northeast Mexico," that during upper Jurassic and Neocomian time a continent existed in the central portion of northern Mexico and we have adduced a few more facts confirming his former observations. On the following pages we shall now try to show in what manner the distribution of water and land changed in younger times and how at last the continent rose out of the sea and the immense mountain mass of northern Mexico was formed. The material for this discussion is already given in the foregoing chapters and in practically all cases we can refer to them for the necessary data.

In lower Aptian times an immersion (transgression) all over northern Mexico took place and the sea covered not only the continental part of northern Mexico but also the regions east and west of it which had been continuously under the ocean during the Jurassic and the Neocomian. This sea advanced even farther to the north and covered the greater part of Texas. The continent persisted mainly in parts of New Mexico and the Rocky Mountain region.

During the lower Aptian time the sea in northern Mexico was shallow, in Texas it was probably entirely a near-shore deposit. During upper Aptian (Gargasian) time the sea probably deepened slightly but the deposits in Mexico as well as in Texas remained neritic.

During Albian time we find a shallow sea over the greater part of northern Mexico and all Texas, but the continent persisted in the same region where it was during the Aptian in North America. The Mexican shallow sea possibly reached as far as the present Pacific Ocean during Albian time, and rudist and Caprina reefs were formed in many places. South of the present Sierra de Parras the bottom of the ocean was deeper, and the same may be said of the east in the region where today the front ranges of the Mexican Sierra Madre Oriental appear. During the middle Albian there was even an abyssal sea or at least channel in the region of the present Tamaulipas. Here a rise of the sea bottom followed during the upper Albian which continued during Cenomanian time, probably all over northern Mexico except the western part. In the north, in Texas and Oklahoma, Arkansas and Kansas, the sea showed little changes and was mainly shallow up to the Cenomanian.

In northwestern Mexico probably a continent or a number of islands was formed during the Cenomanian in connection with the rising of the sea bottom in the rest of the country. Our data about this movement are still very limited but it seems that Cenomanian did not exist in lower California and probably not in Sonora. In Chihuahua we find on the Cerro Muleros the lower Cenomanian developed as sandstone and the upper Cenomanian is formed by marls and limestones in its lower part while the upper portion is represented by a thick mass of quartzitic sandstone.

This movement initiated in the Cenomanian becomes more pronounced during the Turonian. The beds which represent this horizon on the Cerro Muleros are sandy. On the west coast of Mexico no Turonian is known to exist, and in Lower California it is certainly absent. The conditions are probably similar in California, Turonian does not seem to be present there unless in the very northernmost portion of the State. Thus it appears as very probable that during the Turonian a continent or a long island extended from north of San Francisco, California, all the way south along the Pacific Coast of Lower California and of the mainland of Mexico.

On the other hand the Turonian sea extended over a great part of North America covering even the former continent of the interior basin. It existed in Kansas and from there down over eastern Texas and all over central and eastern Mexico almost as far as the City of Mexico and probably even farther south. In Mexico the condition of depth in this sea seems to have been rather uniform.

Our knowledge of the Coniacian in Mexico and Texas is rather limited and here we shall have to treat it together with the Santonian, the distribution of land and sea seeming to have been rather similar during both ages. In the east the Coniacian-Santonian sea covered the interior Basin of North America. It also covered eastern Texas and most of northern Mexico with the exception of the western part. In Chihuahua and Zacatecas both the Coniacian and the Santonian become sandy, which may indicate an extension toward the east of the Cenomanian-Turonian continent. But in the west a transgression of the Santonian (and possibly the Coniacian) sea followed which extended over part of California and Lower California. The existence of conglomeratic and sandy Coniacian in southern Mexico, in the State of Guerrero, makes it probable that the movement extended as far south as this locality, but we have to take into account that this locality lies east of the Archean mass which probably formed a long island or a series of islands during middle Cretaceous time.

In eastern Mexico the conditions of deposition during Coniacian and Santonian time were rather uniform and indicate deeper water even in the lower portion, south of Vallecillo.

But mighty orogenic movements began during the Santonian. In the south near Tampico the upper part of the Santonian begins to show the development of rudists which had their predecessors already in the Coniacian and possibly upper Turonian in this region, while in the lower Santonian they seem to be missing. West of Tampico reef limestones began to form during the Coniacian and possibly in the upper Turonian (Tamazopo limestone proper) ; after this time sandy deposits were laid down in a very shallow sea but soon were followed by rudist reefs also in the Santonian, especially farther to the west. This makes it probable that a Santonian continent extended eastward in this region as far as San Luis Potosí, but here we lack the necessary data. It is possible that the continent of the Santonian in the northwest of Mexico extended farther east in the south and occupied central and western Mexico in about the latitude of the city of San Luis Potosi.

Still greater changes occur during Campanian time. The continent in northwestern and central Mexico probably persisted while in east Texas and northern central Mexico at least as far south as the Sierra de Parras a shallow sea extended which probably was in connection with an arm between Tampico and San Luis Potosí. All the deposits of this sea are shaly-sandy and include real sandstones and sandy limestones.

We have already described the changes of level in the sea bottom in northernmost Mexico during Campanian time, where in the region of Lampazos the bottom of the ocean rose during the lower Campanian and formed the brackish water deposits of the Tulillo facies, while farther north a marine facies persisted during this time and the emersion took place during the upper Campanian. We have also indicated that a similar movement took place in the Rocky Mountain region and caused the deposition of brackwater beds during different parts of the Campanian (Laramie movements). But in Mexico this movement was limited to a relatively small area. Much more important was the continent building movement in east Mexico during the Campanian.

We have seen that from the west to the east the Campanian is overlain first by the Maestrichtian and then by the lower Eocene in the north and that south of Parás the Campanian is absent and the lower Eocene lies direct on the Santonian. This latter formation ends from there on toward the south generally with sandy beds. In other words from about Tortillas to Tampico and possibly farther on, a land mass emerged from the water of the ocean at the beginning of the Campanian and an island or even a continental mass was formed on the present coast of Tamaulipas and may have extended far to the east into the present Gulf of Mexico and toward the west possibly as far as a north-south line through Saltillo. No Campanian is known in the Sierra Madre east of Saltillo-Monterrey as far south as the northern beginning of the Tula, Tamaulipas, basin. Even if the Campanian was eroded in part of the Sierra Madre Oriental, and the narrow folds in which the region is laid do not make this theory very probable, the coastal region of Tamaulipas certainly never was covered by the Campanian sea and we may add that this part of the country remained continental in its main portion up to the present time; this thus is *the oldest part of the Mexican continent in the east.* We shall soon see that the folding which built the mountains in this area is older than the one which formed the main sierras of Mexico.

In the west the continent of the Santonian probably subsided all along the Pacific Coast and probably the Sierra Madre Occidental although this territory is obscured in most of its parts by enormous masses of young eruptive rocks but there is scarcely any doubt that Campanian was never laid down in western Chihuahua, Sonora, Durango and Sinaloa. Farther south wherever Cretaceous is known it is older than Santonian on the Pacific Coast and even in southern and central Mexico as far south as the Isthmus of Tehuantepec.

As far as our present knowledge goes we can say that the continent building in Mexico probably began in the south after Turonian time and that in the north the extreme west was lifted above the water during the Cenomanian and continued to be continental in its greater part from there on while an open sea covered all the territory to the east of that continent, until the end of the Santonian, but that at the beginning of the Campanian a continent was formed in the east in the northern part of the present states of Nuevo Leon and Tamaulipas while the sea persisted in the central part between these two land masses of the west and east.

During the Maestrichtian the sea between the two northern land masses became narrower and narrower; all western and central Coahuila and everything south was lifted out of the water and only a relatively narrow arm of the sea persisted during earlier Maestrichtian from Texas to the region of Saltillo, while later on but still during the Maestrichtian the uplift began in the south in such a manner that from Saltillo north the land advanced slowly during this period, until during the last part of the Maestrichtian only the region on the Rio Grande was still below the level of the sea.

It was probably during this period that the large, wide and very low anticline was formed which goes in a north-south direction through Tamaulipas and forms the Sierra de San Carlos and the Sierra de Tamaulipas. It is even probable that the intrusions of the Sierra de San Carlos belong to this period, as their rocks are found in the Eocene near Cruillas. The complicated structure of the Sierra de San Carlos is entirely due to those intrusions, the original form of the dislocation was clearly that of a broad and low anticline as can be seen in the area surrounding those mountains.

The older movement which caused the folding of the Tamaulipas range was followed by a much stronger one which produced the main mountain mass of the Sierra Madre Oriental and the country west of it. Anyone who has seen both the Tamaulipas range and the Sierra Madre Oriental in the north of the country will have been surprised by the difference of the tectonics. Wherever we can study the foot of the Sierra Madre we find that it is either overfolded, the last fold being overturned or overthrust over the less disturbed beds which belong to the Tamaulipas folding. The complicated folding ends at the foot of the Sierra Madre, from there on to the east we find the simple folding of the Tamaulipas structure. This Tamaulipas fold seems to have formed the continental block against which the rest of the western country was pushed during the folding.

We may go even farther in our conclusions and consider the so-called Salado Arch in the north as the virtual although much younger continuation of the Tamaulipas fold. It is of course not the same structure but it takes structurally its place together with the low folds of the Vallecillo anticline and farther north with the low structures between the Rio Salado and the Sierra de Pajaros Azules. This later structure is entirely of the kind which constitutes the east foot of the Sierra Madre farther south; it is an overturned anticline but it does not show any overthrusts over the territory farther east. On the contrary this younger movement extended to the Rio Salado where we find very peculiar folds on the west side, one flank of which is always exceedingly steep, often vertical, while on the east side of the Rio Salado we find only the low Salado Arch.

It is even possible that this older folding continued still farther in later times and that the Salado Arch has to be considered as the continuation of the very broad and low anticline of the Lomas de Peyote and the Sierra del Burro. Everybody who has seen the Sierra del Burro consisting of a very simple and low and wide fold, and also the contiguous mountains of the Sierra de la Babia which are strongly overturned anticlines will have been surprised by this contrast. One may think that this low fold is the result of an enormous intrusion, but when we follow the fold to the south, this appears rather improbable. There may be an intrusive nucleus in the main part of the Sierra del Burro, but it is very well possible that the fold was existing before this intrusion took place and was only heightened by it.

These last speculations cannot be proven at the present time, but there is no doubt there about the surprising difference in tectonics between the folds in the Sierra de la Babia, the Sierra de Pajaros Azules with the low hills east of it and on the other hand the low and broad structures of the Sierra del Burro, the Lomas de Peyote and the Salado Arch.

To a certain degree we are able to determine the age of the main mountain folding in northeast Mexico, that is, the Sierra Madre Oriental. The folding began probably in the Maestrichtian, at least the rising above the level of the sea certainly commenced during this period as we have shown before. We have only to consider that the Sierra de Pajaros Azules lies between two Maestrichtian basins in which the upper part is already lagoon deposit or continental, while farther south the upper part of the Maestrichtian becomes entirely continental. But the main folding occurred certainly in the Eocene. The evidently short period between the upper Maestrichtian and the Midway was scarcely long enough to allow time for the complicated folding of the eastern Mexican mountains. But we find that after the Midway we have in Texas and northernmost Mexico a long period of continental depositions and shore line beds which indicates a series of orogenic movements, small certainly in this special region, but very possibly a result of more important ones at some distance.

This agrees with what we observe in central Tamaulipas. There the first Tertiary laid down on the Cretaceous is upper Eocene. These beds are only slightly dipping toward the east, the same as the Oligocene. There must have been an interruption of Tertiary deposition here during lower and middle Eocene. This makes it extremely probable that *the main folding of the Sierra Madre occurred during lower and middle Eocene.* We know that the formation of the main continent in the north took place during the Maestrichtain, while in Tamaulipas the uplift began and ended during the Campanian. Near the Rio Grande the continent rose above the waters certainly during the earliest Midway, as is shown by the unconformity between the Maestrichtian in marine facies and the marine Midway. The actual folding of the main mass of the Mexican mountain ranges followed then a little later during the Wilcox and probably Claiborne and Jackson time.

The Oligocene is nowhere very much folded all along the coast of Tamaulipas and even Veracruz and it only exists in marine facies in the coastal part east of the strongly folded mountain ranges. This proves that the main folding must have ended before the Oligocene was laid down. There still followed some slight uplift in Miocene times, but this cannot be compared to that of the Oligocene and is scarcely noticeable in the south, the central part of the State of Veracruz. Conditions begin to change south of the Isthmus of Tehuantepec in Chiapas and Central America, where stronger folding took place during the later Tertiary.

CRETACEOUS AMMONITES FROM TEXAS AND NORTHERN MEXICO

BY EMIL BÖSE

INTRODUCTION

In the preceding paper many ammonites have been cited, several of which belong to new genera. Unfortunately a description of all the different faunas is impossible at the present time; especially, the ammonites from the Aptian and Albian will have to be described later. But a description of the ammonites from the Cenomanian up to the Maestrichtian will be given in the following pages, since these are especially important for the subdivision of the northern Mexican Cretaceous and for its correlation with beds in Texas.

As the correlation of the Texan as well as the Mexican beds requires discussion which would not very well fit in with the content of the first of these papers I have considered it practicable to unite these chapters into a paleontological part. The recent work of Spath has made it possible to correlate the Mexican and the Texan beds of the middle Cretaceous with those of Europe and other continents, while, heretofore, especially the limit between the Albian and the Cenomanian had remained somewhat vague, and most modern authors on Mexican and Texan stratigraphy tried to avoid a decision by using the rather indefinite term Vraconnian for local strata which appeared to belong to the doubtful beds between real Cenomanian and Albian. The term Vraconnian was also used by Pervinquière in northern Africa, showing that even in Europe the succession of the different beds was by no means exactly known. But since Spath has in a number of publications demonstrated the real succession of Albian and Cenomanian ammonites in England and South Africa, there is no reason why we should not abandon indefinite terms and describe the local zonation, which, as now known, surprisingly resembles that of Europe and northern Africa.

The material discussed in the following pages was partly collected by W. S. Adkins, partly by O. A. Cavins and myself. For the Del Rio Clay I owe an excellent collection to my friend, Professor W. S. Adkins.

The ammonite fauna of the Del Rio and the Buda is practically unknown, although a few species have been described or cited. Until a short time ago even the relations between the middle Cretaceous of southern and northern Texas was unknown, and it is through the patient studies of W. M. Winton and W. S. Adkins that we now know, more or less, which beds in the south correspond to the well-subdivided middle Cretaceous of northern Texas.

But the real importance of those many beds can be understood only when the faunas, and especially the ammonites, have been compared with those of other countries where a subdivision in accordance with the universal classification has already been established. Probably because of our ignorance of the composition of most of the faunas and especially the Cephalopoda, a discussion of the age of the Texas Cretaceous has been long continued without decisive results and for the beds below the Woodbine sands even a general local name, the Comanchean was created; rather unnecessarily because the Comanchean is not a natural division. We have long known that its lowest member represents the upper Aptian, and that the rest must contain the Albian and probably the Cenomanian, although the existence of this latter stage has often been doubted, and the slight unconformity which seems to exist at the base of the Eagle Ford shales has been given a greater importance than it really deserves.

The studies of Adkins and Winton have shown that the Paluxy and Glen Rose beds of the north represent the Travis Peak and Glen Rose beds of the south; that the Goodland limestones and the Walnut clays of the north correspond to the Edwards limestone, Comanche Peak limestone and Walnut clays of the south, and that the Georgetown formation of the south is represented by at least seven northern beds: Kiamichi clays, Duck Creek limestones, Duck Creek marl, Fort Worth limestones, Denton, Weno and Pawpaw formations; that the Del Rio clay of the south represents at least part of the Main Street and Grayson formations, while the upper Grayson has not been definitely identified in the southern region, nor has the Buda limestone of the south been exactly correlated with a horizon of the north. To this problem belongs also the determination of the stratigraphic position of the Woodbine sands and its relations to southern beds.

Since H. Douvillé[51] has studied the Rudistids and Caprinas of the Edwards limestone, we know that the main mass at least is of Albian age; this refers to central Texas, because the Edwards limestone in one sense only is a stratigraphic horizon, and in another it is the name of a facies, which farther to the south and west contains more formations than the Albian. Since the studies of Douvillé, the overlying Georgetown beds, Del Rio clay and Buda limestone have mostly been considered as containing the Vraconnian and Cenomanian or part of these. The Eagle Ford shales have for a long time been regarded as Turonian, until lately Gayle Scott[52] claimed that the lower portion represented the Cenomanian.

A subdivision of the Georgetown beds has not yet been undertaken. Adkins recognized that it contains probably the Pawpaw, certainly the Weno and Denton in its upper portion, the Fort Worth limestone in the middle and the Duck Creek formation in the base. The representation of the Kiamichi clays has not yet been found everywhere in southern Texas.

In our present study we have especially treated the ammonite fauna of the uppermost Georgetown (on the Rio Grande, Mexican side), the Del Rio clay and the Buda limestone. For the determination of the age of this part of the so-called Comanchean, the careful study of the Weno and Pawpaw fauna by Adkins[53] and the detailed description of the echinoderms of the Buda limestone by F. L. Whitney,[54] are of great help.

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[51]H. Douvillé, **24**, p. 387

[52]Gayle Scott, **70**, p. 106

[53]W. S. Adkins, **1**.

[54]F. L. Whitney, **98**.

THE AGE OF THE WENO AND PAWPAW BEDS

Adkins cites from the Weno beds the following Cephalopoda:

Nautilus texanus Shumard
Nautilus sp.
Engonoceras sp.
Engonoceras serpentinum Cragin
Ancyloceras bendirei Adkins
Schloenbachia wintoni Adkins
Schloenbachia sp. aff. *inflata* Sowerby
Schloenbachia sp.
Helicoceras (?) sp.

From the Pawpaw formation he cites:

Nautilus texanus Shumard
Nautilus sp.
Stoliczkaia aff. *dispar* d'Orbigny (= *S. adkinsi* Böse)
Flickia boesei Adkins
Acanthoceras worthense Adkins
Acanthoceras sp. aff. *suzannae* Pervinquière
Hamites tenawa Adkins and Winton
Hamites sp. aff. *armatus* Sowerby
Scaphites hilli Adkins and Winton
Scaphites sp. aff. *worthensis* Adkins and Winton
Baculites comanchensis Adkins
Turrilites worthensis Adkins and Winton
Turrilites sp. b. Adkins and Winton
Turrilites sp.
Schloenbachia wintoni Adkins
Mortoniceras sp.
Mortoniceras worthense Adkins
Engonoceras sp.
Engonoceras serpentinum Cragin
Puzosia sp.
Lytoceras sp. aff. *marut* Stoliczka
Hamulina worthensis Adkins

The first comparison of the two lists gives the impression that these are certainly two different zones but not very much removed in age. Unfortunately not all the species are described and figured and thus we can get only an inadequate idea of the character of the fauna. The mention of a *Schloenbachia* aff. *inflata* which would be a *Pervinquieria*,[55] and the character of all the *Pervinquieria* described and figured leave scarcely any room for doubt that the beds represent part of the upper Albian.

The so-called *Mortoniceras*[56] *worthense* is in reality a *Neokentroceras* and Adkins has already seen the great resemblance with *Neokentroceras spinosum* Pervinquière.

Pervinquieria wintoni belongs to the *P. inflata* group and also *P. wenoensis*. Adkins has already seen the similarity between his *Acanthoceras (Mantelliceras) worthense* and *Acanthoceras (Mantelliceras) martimpreyi* Coquand which has been called at least in part a Vraconnian form in northern Africa by Pervinquière, but which certainly occurs also in the lowest Cenomanian of that country and recently has been cited from the lowest Cenomanian of England by Spath.[57] *Turrilites worthensis* Adkins and Winton belongs to the group of *T. wiesti* or *T. acutus*. *Lytoceras* is not figured but the observation that it is comparable to *Lyt. marut* Stoliczka makes it probable that this species belongs to *Kossmatella;* a species of this group appears also in the upper Albian of Mexico. Adkins has already called attention to the occurrence in the Pawpaw beds of *Flickia boesei*, which is generically scarcely different from *Flickia simplex* Pervinquière from the so-called Vraconnian of northern Africa. Spath's studies of the ammonite succession in the English Albian and Cenomanian[58] as well as his descriptions of the faunas of southern Africa and their comparison with the English Albian, greatly help us in locating the boundary between the Albian and the Cenomanian in Texas and Mexico. According to Spath[59]

[55]Dr. L. F. Spath has called to the attention of Professor W. S. Adkins that the names *Subschloenbachia* Spath and *Inflaticeras* Stieler should be replaced by *Pervinquieria* Böhm, as Joh. Böhm (N. Jahrb. f. Min., Geol. u. Pal., 1910, II, p. 152) has proposed this generic name for the group of *Schloenbachia inflata* Sowerby. Adkins has communicated this fact to me.

[56]The name *Mortoniceras* should of course be abandoned for Albian or Cenomanian ammonites, as *Mortoniceras* is an upper Cretaceous form and should be limited to the group of *Mortoniceras texanum* Roemer. Gayle Scott uses *Mortoniceras* for the most different genera of the middle Cretaceous and follows herein the bad example given by Pervinquière.

[57]L. F. Spath, **82**, p. 143.

[58]L. F. Spath, **81**, **82**.

[59]Spath, **79**, p. 285, pl. xxv, fig. 4; p. 304.

Pervinquieria trinodosa Böse would represent one of the very highest zones of the Albian, that is, zone XI of Price at Folkestone, while the group of *Oxytropidoceras acutocarinatum* occurs in the top of the middle Albian, or the zone VIII of Price at Folkestone. Thus our division 2, or beds with *Oxytropidoceras bravoense* Böse would correspond to the top of the middle Albian, the *cristatus* beds of England. To the same beds would correspond those of La Encantada near Placer de Guadalupe in Chihuahua with *Oxytropidoceras* aff. *acutocarinatum.* Spath[60] cites a fragment from the *cristatus zone,* that is, bed VIII of Price, which is comparable with *O. multifidum,* the nearest species to *O. acutocarinatum.* To this, one should add according to Spath, the occurrence of *Dipoloceras* n. sp. (Böse) which he compares with his *Dipoloceras* n. sp. He calls attention to the fact that the large specimens of the American species do not show much of an outer tubercle while the small specimens scarcely show any inner tubercle. I can add that all these specimens are casts and therefore in part corroded; this is probably the reason why the tubercles do not show as they would in better preserved specimens. But the cross section is entirely different from *Dipoloceras* n. sp. Spath. This horizon being as low as bed VIII of Folkestone makes it sure that in Mexico the beds in which Carl Burckhardt found his *Oxytropidoceras* cfr. *acutocarinatum* must also belong to the highest bed of the middle Albian and represent a much lower zone than the fauna from Camacho in Zacatecas, which certainly corresponds mainly to bed XI of Price at Folkestone, that is, the upper Albian, to which also belongs *Pervinquieria aguilerae* Böse from Catorce, San Luis Potosí. As we have seen in the first part of this publication, a species very near the type of *Oxytropidoceras,* that is, *O. roissyi,* occurs in the San Carlos Mountains in a bed still a little lower than *O. acutocarinatum.*

In Texas the group of *Oxytropidoceras acutocarinatum* occurs very frequently in the Kiamichi and lower Duck Creek beds in the north, which places these beds in the upper part of the middle Albian. In south Texas the genus

[60]Spath, **80**, p. 99.

seems to be contained in the lowest portion of the Georgetown. This puts the Edwards limestone of that region pretty far down in the middle Albian. The lower Albian must be represented by the Glen Rose beds which I suppose will prove to be the Clansayes horizon and correspond to the *Parahoplites* beds of Burckhardt and our Clansayes beds of the San Carlos Mountains in Tamaulipas.

To the foregoing I may add that in 1918 I found and recognized *Elobiceras* in the Duck Creek beds (lower portion) of Denison in north Texas. These beds would correspond according to Spath's subdivision[61] to zones IX and X of Folkestone, and as the upper Duck Creek beds contain already *Pervinquieria* it is probable that they and the Fort Worth beds represent bed XI of Folkestone.

Spath[62] cites *Pervinquieria kiliani* Lasswitz from bed XII of Folkestone; unfortunately we do not know from which horizon this species was collected in Texas.

Spath determines my *Schloenbachia burckhardti* and *Shl. whitei* as belonging to his new genus *Prohysteroceras*, which I doubt is more than a branch of subgenus of *Pervinquieria*. Certainly my two forms are very similar to Spath's *Proh. wordiei*[63] and appear to belong to the same group. Spath considers his *Proh. wordiei* as a late form corresponding more or less to forms of bed XII of Folkestone, that is, the upper *rostrata* or post-*rostrata* bed. But this would place our two species too high, as they are lower than *Pervinquieria trinodosa* Böse. Their horizon corresponds therefore probably to the main layer of *Prohysteroceras*, that is, bed IX or X of Folkestone.

We return now to northern Texas. Adkins[64] compares my horizon 6 of Cerro Muleros with the Denton, Weno and Pawpaw beds. But this is based on no ammonite fauna. The *Pervinquieria* of the Weno beds certainly belong to *P. inflata* group but may be of a little higher type than our *P. trinodosa* which does not seem to occur any more in the Weno beds. Adkins and Winton cite *P. trinodosa* from the

[61]Spath, **82**, p. 140.
[62]Spath, **81**, p. 76.
[63]Spath, **80**, p. 105; p. 143, pl. iii, fig. 4.
[64]Adkins, **1**, pp. 41, 42.

Duck Creek beds but this appears to be a misinterpretation. Gayle Scott cites it from the lower Duck Creek, but his species[65] has nothing to do with my *Pervinquieria trinodosa.*

I suppose that the Denton beds belong either to bed XII or XIII of Folkestone, because they appear to be not very much older than the Pawpaw beds and these represent certainly either bed XIII or even the transition beds between the Albian and the Cenomanian. We have already indicated that Adkins' *Mortoniceras worthense* and probably also his *Schloenbachia* sp. belong to the group of *Neokentroceras spinosum* Pervinquière. This would place the beds in bed XIII of Folkestone. But still more significant is the occurrence of *Mantelliceras (Submantelliceras?) worthense* Adkins in the Pawpaw beds. There is no doubt that, as Adkins has already pointed out, this species is a very near relative of *Mantelliceras martimpreyi* Coquand. Spath cites *Mantelliceras martimpreyi* from the lowest beds of the English Cenomanian[66] together with *Mantelliceras couloni* d'Orb. This might induce us to consider the Pawpaw beds as lowest Cenomanian. But Adkins cites also a *Stoliczkaia* aff. *dispar* from these beds, and according to the common opinion this would make these beds uppermost Albian. But Spath[67] cites *Stoliczkaia* as occurring in the lower Cenomanian as well as in the upper Albian. Gayle Scott lays entirely too much stress on the stratigraphic importance of *Stoliczkaia*, but that this genus first occurs in the uppermost part of the Pawpaw beds is certainly characteristic. Scott cites *Stoliczkaia* even from the Buda limestone, although there is not the slightest doubt, as we shall see, that this horizon belongs to a rather high zone of the Cenomanian.

The most important fossil in the Pawpaw beds is the *Mantelliceras worthense* Adkins, which belongs to the group of *M. martimpreyi.* Unfortunately the stratigraphy of Pervinquière is not quite exact, and as Spath has remarked,

[65]Gayle Scott, **70**, p. 127, pl. iii, fig. 1.
[66]Spath, **82**, pp. 143, 144.
[67]Spath, **82**, p. 145.

his Vraconnian certainly is sometimes upper Albian and sometimes lower Cenomanian. But from his two descriptions of *M. martimpreyi* we can see that this group appears in the uppermost Albian as well as in the Cenomanian, where it occurs together with *Mantelliceras mantelli* and *M. villei.*

Now we have the same condition in Texas. We find the group of *M. martimpreyi* for one part in the Pawpaw beds, and for another in a much higher one, the Del Rio clay. The species which occur in these two horizons are not identical although Adkins cites his *Acanthoceras worthense* also from the Del Rio clay, but this is certainly only a provisional determination and as we shall show in the palaeontological description of our *Mantelliceras wacoense* and *M. brazoense* these species are certainly different from the lower *M. worthense.* It is remarkable that these species which apparently belong to the same group do not follow each other immediately, and that between them exists an ammonite fauna which contains entirely different genera.

Thus it seems to be the right solution of the problem to consider the Pawpaw beds as the very uppermost Albian, that is, the *dispar* zone of Spath or bed XIII of Price (Folkestone), and the overlying beds as the base of the Cenomanian.

If we now review what has been said in the foregoing pages we come to a correlation of the Texas beds which seems to be quite natural although our results have still to be regarded as provisional:

Pawpaw beds	post-rostrata	bed XIII
Weno beds } Denton beds {	post-rostrata	bed XII
Fort Worth beds	lower rostrata	bed XI
Duck Creek beds	prerostra	bed IX a. X
Kiamichi beds	cristatus	bed VIII
Goodland	(?)	(?)

These faunas are for the most part still unknown and undescribed. I have placed the Fort Worth limestone in the lower *rostrata* zone on account of a very characteristic fossil figured by Winton[68] from this bed and named *Schloenbachia* aff. *inflata;* it is apparently identical with *Pervinquieria aguilerae* Böse.

For the subdivision of the Muleros region this subdivision would mean that the bed with *Pervinquieria trinodosa* is to be correlated with the Fort Worth beds, while bed VI of Muleros would represent the Denton, Weno and Pawpaw beds, if none of these is missing or represented by the overlying sandstone. We thus come to the same result as Adkins.

THE AGE OF THE UPPER GEORGETOWN BEDS

On the Mexican side of the Rio Bravo we have found in the uppermost beds of the Georgetown formation and immediately below the Del Rio clay:

Turrilites brazoensis Roemer
Acanthoceras cunningtoni Sharpe

They occur together with a great number of *Holectypus limitis* Böse and a little lower still more abundant *Kingena wacoensis* Roemer. Adkins considers these latter beds as the uppermost Georgetown, those above them which contain *Turrilites brazoensis*, as the lowest portion of the Main Street formation. These beds certainly are not still Albian but real Cenomanian, as is proven by the occurrence of the extremely characteristic fossil *Acanthoceras cunningtoni* Sharpe or at least a member of this group, which may be regarded as the vicariating species in America as is certainly the var. *cornuta* Kossmat the vicariating form of *A. cunningtoni* in India. This form is certainly Cenomanian and not Albian. It is not quite as common in our beds as *Turrilites brazoensis* which is certainly also of Cenomanian character and quite different from anything known in the Albian. As *Turrilites brazoensis* occurs in the Main Street formation, the Georgetown beds and in the slightly different beds in northern Mexico I regard it as the index fossil for the lower Cenomanian of Texas and northern

[68] W. M. Winton, **99**, p. 55, pl. vi, fig. 2.

Mexico. The group of *T. brazoensis* is not restricted to the upper Georgetown, but is found also higher; we collected one in the Del Rio clay which is smaller in size than the *T. brazoensis* of the upper Georgetown beds but is extremely similar in its form and ornamentation; this specimen was found in the Del Rio clay of the hills between Orégano and San Carlos (region of Jimenez, Coahuila, Mexico). Whitney[69] figures a fragment from the Buda limestone of Texas which seems to belong to this group. It is of course possible, if not probable, that these higher forms are really different species but they belong to the same group. In northern Texas *Turrilites brazoensis* has not been found outside of the Main Street beds according to Adkins and Winton.

It may seem surprising that we cite the main layer of *Kingena wacoensis* Roemer from the base of the beds with *Turrilites brazoensis* and *Acanthoceras cunningtoni,* while Adkins and Winton[70] mention it as a zone fossil above the horizon with *Turrilites brazoensis* and separated from it by a zone with an unnamed *Alectryonia.* This shows only that the so-called zones in north Texas are only of a very relative and local value. Brachiopoda are in general not very good zone fossils and should be used with great caution. Still more surprising it is that in the Main Street formation of northern Texas the main horizon of *Turrilites brazoensis* lies above the one with *Exogyra arietina* Roemer, but this shows that the Exogyras also are not good fossils for the subdivision of small zones. Adkins and Winton remark in another place that *Kingena wacoensis* occurs near the base of the Main Street division (l. c. p. 79) and the *Exogyra arietina* is common in the Main Street limestone and in the base of the Grayson marls (l. c. p. 66). In the Mexican region *Holectypus limitis* Böse, *Acanthoceras cunningtoni* Sharpe and *Turrilites brazoensis* Roemer occur in the same bed, and with them rather rare specimens of *Kingena wacoensis* Roemer, but the main layer of the latter species is below the bed with ammonites, which is not over tnree meters thick; the *Kingena* bed is a calcareous marl, and the

[69]Whitney, **97**, p. 24, pl. xii fig. 1.
[70]Adkins and Winton, **2**, p. 30.

ammonite bed above it is a blue gray soft shale. It may be well to include the *Kingena* bed in the Cenomanian but no characteristic ammonite so far has been found in it which would decide the question.

THE AGE OF THE DEL RIO CLAY

Adkins has tried to subdivide the Del Rio clay into a lower zone with *Exogyra arietina* Roemer and one with *Nodosaria texana* Conrad. He finds a zone of abundance of *Nodosaria texana* above the zone with *Exogyra cartledgei* Böse.[71] Here again I must warn against generalization. We have collected at the Tinaja de la Huerfaca (road from Villa Acuña to El Colorado) *Exogyra cartledgei* in abundance at the very top of the Del Rio clay just below the Buda limestone and far above the main layer of *Nodosaria texana.* Adkins and Winton themselves have already remarked that *Nodosaria texana* itself is by no means a horizon marker, and that it occurs in quite a number of their horizons, although locally it may be found in a limited zone. All those zones which Adkins and Winton have studied with so much care and patience are certainly of great local value, often over a large area, but for the determination of the age and for a comparison with cross sections of the same beds in distant localities they are not of much use.

The Del Rio clay is at best a rather thin deposit, generally not over 45 meters thick, and it is still doubtful if a subdivision will be possible which can be compared to those of other countries. We shall cite here the ammonites which so far have been found in it:

Tetragonites brazoensis n. sp.
Turrilites bosquensis Adkins
Turrilites brazoensis Roemer var.
Baculites aff. *baculoides* Mantell
Stoliczkaia uddeni n. sp.
Stoliczkaia aff. *dispar* d'Orbigny
Mantelliceras brazoense n. sp.
Mantelliceras wacoense n. sp.
Scaphites bosquensis n. sp.

[71]Adkins, 1, p. 18.

Scaphites subevolutus n. sp.
Engonoceras bravoense n. sp.
Adkinsia adkinsi nov. gen. n. sp.
Adkinsia sparsicosta n. sp.
Adkinsia tuberculata n. sp.
Adkinsia bosquensis Adkins sp.
Adkinsia semiplicata n. sp.

These 16 species of ammonites form quite a characteristic fauna, which should make a determination of the age rather simple. Most of these species occur in the lower portion of the Del Rio clay, while *Engonoceras* and the two *Stoliczkaia* seem to belong to the upper portion.

We have to exclude from the discussion the five species of *Adkinsia*, a genus so far not found anywhere else, although intimately related to *Flickia*. But even this latter genus is so rare, that it is not of much stratigraphic importance. It is only of negative value in so far as a real *Flickia* has been found by Adkins in the Pawpaw clay, which is older than our beds.

Of little importance are also the two *Stoliczkaia*, the generic determination of which is not entirely without doubt, in so far as the suture is unknown. In Europe *Stoliczkaia* is generally cited from the uppermost Albian just below the base of the Cenomanian, but Spath[72] cites its existence in the lower Cenomanian as well as in the uppermost Albian. It has often been cited as being accompanied by *Pervinquieria* of the *inflata* group but we have not found a single form of this group in the Del Rio clay; Adkins cites several *Schloenbachia* from the fauna described here (South Bosque River in McLennan County, Texas) but I have not found a single one among his material. I collected a very singular "*Schloenbachia*" in the Del Rio clay west of Del Rio but it is only a small fragment and appears to be different from anything else I have seen. But even the occurrence of a *Pervinquieria* or related genus would not surprise me very much, since Pervinquière cites from the Cenomanian of Algiers *Pervinquieria inflata* from the zone

[72] Spath, 82, p. 145.

of *Acanthoceras martimpreyi* (Aumale) together with *Mantelliceras mantelli.* In the region here discussed, the *Stoliczkaia* lie certainly above the Albian and even above the bed with *Acanthoceras cunningtoni.*

Much more significant are *Mantelliceras brazoense* and *M. wacoense.* These two species belong to the group of *Mantelliceras martimpreyi* Coquand. We find the first representative of this group in *Mantelliceras worthense* Adkins. This species is common in the Pawpaw formation, and Adkins even cites it from the Del Rio clay. But this is certainly an error due to a preliminary determination. His species is different from both *M. brazoense* and *M. wacoense,* although all of them belong to the group of *M. martimpreyi.* There is a great possibility that in northern Africa there exist similar conditions, and that different species of the group of *Mantelliceras martimpreyi* occur in different horizons. In his studies in Tunis Pervinquière cites *M. martimpreyi* from the base of the Cenomanian[73] while in the explanation of his figures and in the general stratigraphic part of his work he calls this base of the Cenomanian by the name Vraconnian. The nearly related forms *M. aumalense* and *M. suzannae* are also cited from the Vraconnian. In Algiers Pervinquière cites *Mantelliceras martimpreyi* from a zone above the Vraconnian and as occurring together with *Acanthoceras villei, Mantelliceras mantelli, Forbesiceras lagilliertianum* and *F. obtectum,* certainly all Cenomanian species; in this horizon according to Pervinquière *M. suzannae* and *Pervinquieria inflata* also occur. These are the conditions at Aumale. At Berroughia we find *Mantelliceras martimpreyi* and *M. aumalense* first above the Vraconnian together with *Euhystrichoceras nicaisei* Coquand; then follows a zone with *Coelopoceras africanum, C. haugi,* and *Acanthoceras (Eucalycoceras)* cfr. *newboldi,* certainly all Cenomanian forms. Still higher is another zone with *Turrilites bergeri* var. *numida,* and above this we find again *Mantelliceras martimpreyi* together with *Euhystrichoceras nicaisei.*

[73]Pervinquière, **57**, p. 296.

It seems probable that not all of the Vraconnian of Tunis may be really considered as upper Albian, but that part of it really belongs to the lower and middle Cenomanian. In Algiers the *M. martimpreyi* group certainly goes high up in the Cenomanian and there exist conditions similar to those in Texas and northern Mexico, that is, the so-called *Mantelliceras martimpreyi* and *M. aumalense* will have to be divided into more species.

This is confirmed by the observation of Spath in England. He[74] found "*Schloenbachia* associated with *Mantelliceras couloni* d'Orbigny and *M. martimpreyi* Coquand and allied species and with two new genera, both represented by unnamed Warminster species, namely, *Submantelliceras* gen. nov. (type *Acanthoceras aumalense* (Coquand) Pervinquière. . . .) and *Euhystrichoceras* gen. nov. (type: *Mortoniceras? nicaisei* (Coquand) Pervinquière." This shows that *Mantelliceras martimpreyi* certainly occurs likewise in the Cenomanian of England, and *Euhystrichoceras* together with it, while we find this latter genus in a little higher horizon, the Buda limestone.

We shall now see what light the other ammonites of this bed will throw on its age. *Tetragonites brazoensis* belongs to the group of *T. timotheanum*. Forms of this group are cited from the Vraconnian and the Cenomanian. Pervinquière cites *P. timotheanum* from the zone just below his higher zone with *Mantelliceras martimpreyi* and above the zone with *Coelopoceras*, that is, from the Cenomanian. In Tunis he cites it from the Vraconnian. In India it occurs in the upper Albian, as at Camacho, Zacatecas, Mexico. Thus it seems that this group occurs both in the Albian and the Cenomanian.

Turrilites bosquensis Adkins is related to the groups of *T. acutus* Passy and *T. wiesti* Pervinquière, especially the first named. The differences between *T. bosquensis* and *T. acutus* lie altogether in the existence of a small row of tubercles on the region around the umbilicus; I have mentioned in the description of the species that I do not consider this difference as very important, the general character being that of *T. acutus*. Pervinquière cites this species

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[74]Spath, 82, p. 143.

from the Cenomanian of Batna and *T. wiesti* Pervinquière from the Vraconnian of Tunis. His two main cross sections of Algiers (Aumale and Berroughia) do not seem to contain any form closely related to ours.

Turrilites brazoensis is a form far removed from almost every species so far known, but more nearly related to Cenomanian forms than to Albian. Stoliczka thought he had found it in the lower Utatur group of India, but Kossmat has proved that this Indian species, which he calls *Turrilites spinosus,* is quite different from *T. brazoensis.* So far this type seems to represent an entirely American group. It is mainly interesting to us on account of its occurrence being limited to the beds between the zone with *Acanthoceras cunningtoni* and the Buda limestone.

Baculites baculoides is a widely distributed form of the Vraconnian and Cenomanian. In Tunis it occurs in the Vraconnian according to Pervinquière. In Algiers it is found in two very different horizons: the Vraconnian and in the zone of *Discoidea forgemoli,* a rather high zone of the Cenomanian, where it occurs together with *Acanthoceras rotomagense* and *Euhystrichoceras nicaisei.* At Berroughia it occurs in the lowest Cenomanian together with *Mantelliceras martimpreyi, M. aumalense* and *Euhystrichoceras nicaisei.* It is easily understood that a form with so little ornamentation and practically no possibility of changing its form must be found in different horizons; and it is quite possible that not all these individuals belong to the same species, but that their simple form does not allow us at present to separate them. However it might be very interesting to study the forms of different horizons with respect to their sutures, with the expectation that they change their suture from one horizon to another; such a difference seems to exist, judging from the sutures published by different authors, but only a very good and large collection of material would permit of such a study.

Scaphites bosquensis n. sp. belongs clearly to the group of *Sc. aequalis,* but differs from the type. We have shown that this group has a very long life and that it is by no means characteristic for a single horizon.

The case of *Scaphites subevolutus* n. sp. is quite different. This is a very strange species; there is probably no other *Scaphites* which shows such an evolute form. The nearest relative is *Scaphites evolutus* Pervinquière which occurs in the zone with *Discoidea forgemoli*, rather high in the Cenomanian, together with *Acanthoceras rotomagense, Turrilites costatus* and *Euhystrichoceras nicaisei.*

The two species of *Stoliczkaia* cannot be identified with any European or Indian form; *Stoliczkaia dispar* always occurs at the top of the Albian, but we have already seen that Spath cites the genus also from the lower Cenomanian. The American species show a slight difference in their ornamentation; they do not show the characteristic divergence between the primary and the intercalated ribs; therefore it is not altogether impossible that we have here a different genus, possibly a descendant of *Stoliczkaia.* Unfortunately the suture is not known and thus an exact determination of the genus is impossible.

Engonoceras bravoense n. sp. is a very interesting form in so far as it does not resemble any known American form. *Engonoceras* is a very common genus in the Albian and Cenomanian of northern America but the only species which might have a certain resemblance with *E. bravoense* is the one figured by Adkins from the Pawpaw beds as *Engonoceras* sp. and his figures are unsatisfactory, the description not quite complete and the suture practically unknown; at least no details can be distinguished in the figures. Adkins' remark that the species is entirely smooth and the venter concave makes it possible that this is a predecessor of *E. bravoense,* although in *E. bravoense* we never see a concave venter; it is always flat even in the smallest specimens. The Old World *Engonoceras* is rather an exceptional form and most of the species described under this name are of a somewhat doubtful generic position and may originate from a different tribe. Spath[75] thinks that his *Engonoceras iris* from the lower Albian is the only real *Engonoceras* known in Europe and that those cited by de Loroil *(A. ebrayi)* and Grossouvre *(A. pedernalis)* belong to other genera. But in

[75]Spath, 83, p. 508.

northern Africa there occurs a species called *Engonoceras thomasi* by Pervinquière, which doubtless is an *Engonoceras* and is extremely similar to this form. It occurs in the Cenomanian of Foum el Guelta in Tunis. It seems to to be exceedingly rare and the only specimen known is of small size. We have called attention to the fact that *E. bravoense* may represent a higher stage of development in the genus *Engonoceras* and we may add that the same can be said of the African species. The exceptional position of *E. bravoense* among the American species and its similarity with the African form, which also stands entirely by itself in the Old World fauna, gives it a certain significance with respect to the age of the American beds.

After this short discussion of the character of the Del Rio fauna we shall try to determine the age of these beds. We have seen that the Pawpaw fauna of the north presents an uppermost Albian character and represents probably the very highest beds of this horizon. Unfortunately the fauna of these beds has not yet been described from southern Texas and northern Mexico, but we know that the lower Del Rio clay including the uppermost part of the Georgetown beds represents the Main Street beds. Their fauna in northern Texas is as yet very little known, but we have seen that in northern Mexico an ammonite of the group of *Acanthoceras cunningtoni*, a characteristic Cenomanian fossil occurs together with characteristic Main Street fossils, such as *Turrilites brazoensis* Roemer, *Holectypus limitis* Böse and *Kingena wacoensis* Roemer. This establishes the fact that the Cenomanian is in part represented by the Main Street beds.

In the higher portion of the column, the Del Rio clay, we do not find many species which could not occur as well in the upper Albian as in the lower or middle Cenomanian. We have seen that *Mantelliceras brazoense* and *M. wacoense* belong to the group of *M. martimpreyi* which according to Pervinquière occurs in Africa in the Albian as well as in the Cenomanian, while Spath has found it in the English Cenomanian. The same can be said of most of the other forms; they all have their nearest relative in northern Africa in the Albian and Cenomanian except *Scaphites subevolutus* n. sp. and *Engonoceras bravoense* n. sp. which find their nearest relatives only in the African Cenomanian.

So far no specifically Albian ammonite has been found in the Del Rio clay; especially *Pervinquieria inflata* is absent and only *Stoliczkaia* could possibly be claimed as a high Albian form, but we have seen that it also occurs in the lower Cenomanian, and that our *Stoliczkaia* is not identical with *St. dispar* or any of the Indian species, and its generic position is not quite certain. The very characteristic *Scaphites subevolutus* and *Engonoceras bravoense* give the American fauna a decidedly Cenomanian aspect. It is certainly not a high Cenomanian fauna, as there are still many reminiscences of the upper Albian in it, but the facts that *Adkinsia* appears here as a new form probably derived from the Albian genus *Flickia,* and that *Scaphites subevolutus* belongs to a group which is absent from the Albian and that the same may be said of *Engonoceras bravoense,* give us the right to consider this fauna as lower Cenomanian in the European sense. Taking into account that below this fauna occurs a form which is distinctly Cenomanian *(Acanthoceras cunningtoni)* we may be allowed to distinguish in this region these latter beds as lower Cenomanian and the Del Rio clay as middle Cenomanian.

THE AGE OF BUDA LIMESTONE

Before we discuss the general subdivision upper Albian and Cenomanian in Texas and in northern Mexico, we have to review the small but extremely important ammonite fauna of the Buda limestone. This fauna consists of:

Budaiceras mexicanum n. gen., n. sp.
Mantelliceras mantelli Sowerby
Mantelliceras laticlavium Sharpe var. *mexicanum* n. var.
Euhystrichoceras remolinense n. sp.

Adkins[76] cites from the Buda limestone also *Tissotia* sp., but I have never seen anything similar to *Tissotia* in the Buda limestone and cannot confirm or reject his assertion.

[76]Adkins, 1, p. 44.

This fauna is small but extremely characteristic. There appears again in a new genus of a rather wide distribution geographically but restricted to the Buda limestone: *Budaiceras*. Several species of this genus have been described under the generic name of *Barroisiceras* and others under the name of *Schloenbachia*. Thus Shattuck described *Barroisiceras texanus* and *B. hyatti;* Lasswitz described *Schloenbachia roemeri, Schl. roemeri* var. *elegantior, Schl. roemeri* var. *harpax, Schl. evae, Schl. frechi, Schl. frechi.* var. *curvata, Barroisceras sequens* and *B. haberfellneri.* All of these belong to *Budaiceras* and have nothing to do either with *Schloenbachia* or with *Barroisiceras*. Gayle Scott[77] even reaches the most surprising conclusion that the two species described by Shattuck belong to *Stoliczkaia*. He even cites a *Stoliczkaia dispar* from the Buda limestone or its representative in northern Texas according to Scott's idea, the Grayson marls. But what he figures under the name of *Stoliczkaia dispar* from the upper Grayson marls certainly does not belong to this species, but may be one of the *Stoliczkaia* occurring in the Del Rio clay. *Budaiceras* is a much younger form than *Stoliczkaia* but may have been derived from it.

All the other species found in the Buda limestone are characteristically Cenomanian. *Mantelliceras mantelli* is a distinctly Cenomanian form and occurs mainly in the lower and middle European and African Cenomanian. Pervinquière cites a somewhat doubtful form of this group from the lower Cenomanian of Tunis and two young specimens from the zone of *Solarium vatonnei* of Aumale in Algiers, which also represents the lower Cenomanian and where this species occurs with *Mantelliceras martimpreyi*. In India *Mantelliceras mantelli* occurs also in the lower Cenomanian, while in Europe it is found mainly in the lower and middle Cenomanian and is rather rare in the highest beds, the zone of *Acanthoceras rotomagense*.

The occurrence of a member of the group of *Mantelliceras (Sharpeiceras) laticlavium* is also of great importance; our specimen is a little different from the type, but

[77]Gayle Scott, **70**, p. 87.

we have not enough material for the creation of a new species. It shows all the main features of the group and cannot be easily confounded with any other form. *Mantelliceras* is generally a rare species and its occurrence is always important for the determination of the age of the bed. In Europe this species occurs generally together with *Mantelliceras mantelli.* In India it was found in the middle Utatur group, the so-called *Acanthoceras* horizon, which corresponds to the Rotomagian of Europe. Above these beds lies the upper Utatur group, which certainly does not belong any more to the Cenomanian and represents the Salmurian, that is, the lowest portion of the Turonian, resembling in many respects the fauna of the Salmurian of Mohóvano, Coahuila, which I described several years ago.

A very interesting species is *Euhystrichoceras remolinense* n. sp. It is different from anything so far described in northern America, but its similarity with *Mortoniceras? nicaisei* (Coquand) Pervinquière is quite striking. Spath[78] found a species belonging to this group, in the lower Cenomanian of Warminster, and has created a new genus *Euhystrichoceras* for the type: *Mortoniceras? nicaisei* (Coquand) Pervinquière. The form is certainly different from *Pervinquieria* as well as *Schloenbachia* and, of course, also from *Mortoniceras.* Therefore the new genus is accepted here. The Algerian individuals are very small, and Pervinquière's species contains a number of varieties which seem to be quite different from each other. He says that the species is very common in different horizons of the Cenomanian; but in his work on Tunis he says that the species occurs there in the Vraconnian, adding that his specimens are too badly preserved for illustration. Thus all his figured specimens come from the Cenomanian of Algiers. He cites the species from the zone with *Mantelliceras martimpreyi* and *Solarium vatonnei* and again from the zone with *Discoidea forgemoli* and *Turrilites costatus* which also contains his *Acanthoceras rotomagense* var. *hippocastanum.* Both beds represent the Cenomanian and the latter one is certainly upper Cenomanian. These remarks refer to

[78]Spath, 82, p. 143.

Aumale. At Berroughia *Euhystrichoceras nicaisei* occurs in the Zone 1 of Ph. Thomas, that is, immediately above the Vraconnian, and again in Zone 4, which is the highest zone of the Cenomanian of that region.

Of the four species found in the Buda limestone one belongs to a new genus and the other three belong to groups which occur in the lower and upper Cenomanian. It may be surprising that no representative of the *Acanthoceras rotomagense* group has been found, but this group even in India is represented not by the typical *rotomagense,* but by *A. turneri* White, a species which occurs also in the Chico beds of California (Mt. Diablo), and by *A. newboldi,* which Spath regards as a different genus, his *Eucalycoceras;* this latter species occurs also in Europe in the middle and upper Cenomanian and has been there determined as *A. rotomagense, A. naviculare, A. cenomanense* and others, according to Kossmat.

In northern Africa conditions seem to be similar, for at least Pervinquière says that *A. rotomagense* is by no means common; he himself cites only 8 specimens from Tunis and among these he includes *A. turneri* White. In Algiers the type seems to be absent, for at least Pervinquière cites only the var. *hippocastanum* and *A.* cfr. *newboldi.*

Taking into consideration that so far we have found only four species of ammonites, it is not very surprising that the group of *Acanthoceras rotomagense* should be missing. Even as it is there cannot be any doubt that the Buda limestone represents upper Cenomanian. If we consider also the echinoderms, our determination of the age is entirely confirmed by the occurrence of *Codiopsis texana* Whitney[79] which can scarcely be distinguished from the Cenomanian *Codiopsis doma* Agassiz of Europe. From Whitney's excellent description of his species we can scarcely find a reason for a separation from the European species, if we accept all the variations figured by Cotteau. *C. texana* is a little more pentagonal and not quite so elevated as the type, and the sides are not quite so straight; these are the only differences indicated by Whitney. There is no doubt that

[79]Whitney, **98**, p. 7 (91), pl. iii (17), figs. 1–4; pl. vi (20), fig. 2.

C. texana belongs to the group of *Codiopsis doma.* Whitney also cites *Cottaldia rotula* Clark which is very similar to *C. bennettiae* Cotteau from the Cenomanian of Europe. These forms confirm our determination of the age of the Buda limestone.

We should also consider that our ammonite fauna does not come from the higher beds of the Buda limestone but from a rather low horizon; it is very possible that the higher beds may furnish still more Cenomanian ammonites, and contain perhaps the zone of *Acanthoceras rotomangense.* Whitney also distinguishes two portions in his Buda limestone which do not seem to carry the same species of echinoderms.

GENERAL OBSERVATIONS ON THE SUBDIVISION OF THE CENOMANIAN IN NORTHERN MEXICO AND SOUTHERN TEXAS

In the preceding chapter we have considered the Weno-Pawpaw fauna as the top of the Albian. Adkins himself is inclined to regard his fauna as lower Cenomanian. It cannot be doubted that the term Vraconnian has been used in a somewhat ambiguous form, as has been stated by Spath in different papers, and it may be better to abandon it altogether and accept the division in Albian and Cenomanian, but this question will have to be decided in Europe. Pervinquière's Vraconnian certainly includes different horizons; Spath [80] supposes that it contains his topmost Albian (horizons XII and XIII) and also at least two Cenomanian horizons. This conclusion is certainly justified by the list of ammonites which Pervinquière (l. c. Tunis, p. 417, 418) cites from his so-called Vraconnian. Pervinquière himself cites a number of species from the Albian and others which are doubtless Cenomanian.

The fauna of northern Africa is of the greatest importance for the study of those of Texas and northern Mexico. Adkins has already called the attention to the fact that his Weno and Pawpaw faunas are nearly related to the fossils described from the Vraconnian of Tunis and Algiers. We

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[80] Spath, **80**, pp. 157–158.

have indicated in the description of our fossils, that most of our types are very similar to species from northern Africa. The following table will make this still more evident:

Mexico and Texas	Algiers	Tunis	Other Countries
Upper Georgetown:			
Turrilites brazoensis Roemer	----	----	
Acanthoceras cunningtoni Sharpe	----	C	Europe (C), India (C)
Del Rio Clay:			
Tetragonites brazoensis n. sp.	C	V	*T. timotheanus* Mayor
Turrilites bosquensis Adkins	C	----	*T. acutus* Passy
Turrilites brazoensis Roemer var.	----	----	
Baculites aff. *baculoides* Mantell	C	V	
Stoliczkaia uddeni n. sp.	----	----	
Stoliczkaia aff. *dispar* d'Orbigny	----	V	C and V Europe
Mantelliceras brazoense n. sp.	C	V	*M. aumalense* Coquand
Mantilliceras wacoense n. sp.	C	V	*M. martimpreyi* Coquand
Scaphites bosquensis n. sp.	CV	V	*Sc. aequalis* Sowerby
Scaphites subevolutus n. sp.	C	----	*Sc. evolutus* Pervinquière
Engonoceras bravoense n. sp.	----	C	*E. thomasi*
Adkinsia adkinsi n. sp.	----	----	
Adkinsia sparsicosta n. sp.	----	----	
Adkinsia tuberculata n. sp.	----	----	
Adkinsia bosquensis Adkins	----	----	
Adkinsia semiplicata n. sp.	----	----	
Buda Limestone:			
Budaiceras mexicanum n. sp.	----	----	
Mantelliceras mantelli Sowerby	C	C	C in Europe
Mantelliceras laticlavium Sharpe	C	C	C in Europe
Euhystrichoceras remolinense n. sp	C	V	*E. nicaisei* Coquand

C=Cenomanian.
V=Vraconnian.

This table shows how many of the American species or ones nearly related to them occur in the Cenomanian of Algiers and in the so-called Vraconnian of Tunis. If we take into account that just the most common of these species which have rare or no relatives in other parts have them in northern Africa, as *Mantelliceras wacoense, M. brazoense, Scaphites subevolutus, Engonoceras bravoense, Euhystrichoceras remolinense,* the similarity becomes still more evident. To this we may add *Adkinsia* which has its nearest relative in *Flickia.* Unfortunately for most of those species we do not know the exact horizon in northern Africa, except where they are cited from Algiers.

I do not want to suggest that these forms which are similar to northern African species prove that they came from there. It is very possible that those forms evolved from ancestors living in American waters, as there seems to be parallel development of ammonites in corresponding beds and in corresponding succession all over the earth. None of our species can really be identified with African or European or Indian species; there is always a more or less slight difference, even in those where we have accepted the name of the species, as is also the case in those species from India which have been identified with European types. There may be one or the other which is really specifically identical, but it is generally an exception. Those species that are of a very simple form may often seem identical, because the features which can vary are not of a very distinctive character. But just such forms which are characteristic for a certain region as e.g. *Engonoceras, Coahuilites, Sphenodiscus, Budaiceras* for North America, *Tissotia* and its relatives for the Old World are great exceptions in other regions and give a special character to the different faunal provinces. Many ammonites have been determined as belonging to one of these local genera, but in most cases it has been necessary to create new genera for them.

I do not want to suggest that such migrations from one continent to another have not taken place, but I want to insist that the occurrence of related forms in two very widely separated localities does not justify the conclusion that necessarily there must have existed a migration from one to the other. Such isolated finds have often served as a reason for the construction of marine communication and even of entire continents along which those forms had to wander from one place to the other. Ammonites were free swimming animals and many theories have been advanced to explain why similar forms are found almost everywhere, but when we come to regard animals like Rudistae and

Caprinidae all those theories seems to lose their value, even that of the transportation of larvae. One of the most surprising facts is the occurrence of *Gryphea vesicularis* all over the earth. Is this really one species developed in one single region?

In our case it is safest not to suggest marine communications through which the different foreign elements may have come, as long as we do not know the different faunas of the Cretaceous which succeeded each other in North America; many of these apparently strange forms may turn out to have originated here and to have developed from older forms already existing in this region.

A question still remains to be answered: does the Buda limestone represent the very highest Cenomanian or is there another bed missing? So far we have not found a representative of *Acanthoceras rotomagense* nor one of *Schloenbachia varians*. This may be due to the fact that we still know very little of the fauna of the Buda limestone which in its higher levels may still contain many surprises for us. It has often been stated that in Texas the Eagle Ford shales which certainly correspond to part of the Turonian lie unconformably on the Buda limestone and that there must be a hiatus in the faunas. This hiatus may consist in the absence of the very highest Cenomanian or of the very lowest Turonian (Salmurian). This latter horizon has been found in at least two different places of western Coahuila, but has not been discovered in the eastern part or in Texas. For the present time the question where the hiatus is, in the highest Cenomanian or in the lowest Turonian or in both, cannot be answered; first we have to know the fauna of the Eagle Ford shales in Texas, which is practically unknown, and also the fauna, especially the ammonites, which occur in the higher beds of the Buda limestone.

THE STRATIGRAPHIC SIGNIFICANCE OF THE UPPER CRETACEOUS AMMONITES OF NORTHERN MEXICO

The upper Cretaceous of northern Mexico, that is the beds from the Turonian up, contains mostly a pelecypod and gastropod fauna, and very few ammonites have been cited from them. Ammonites are by no means common except in a very few horizons, but they give us a much better foundation for a systematic subdivision of the beds than all the rest of the fossils. Mr. Cavins, Mr. Orynski and the author have tried to collect as many ammonites as possible during the time we worked in this region; unfortunately these fossils are rather rare and we did not have time to search systematically for them. But even the small number found (although some zones are quite rich in individuals) allow us to correlate our beds in a much more exact manner than before. Some of the new species and genera will be described on the following pages, that is, those which are really important for a new subdivision; the rather rich fauna of the middle Austin chalk could not be described, but as this horizon contains several characteristic species that are well known and allow a correlation with European beds, this work can be left for a later period.

TURONIAN AMMONITES

Several years ago I described the fauna of the lowest Turonian, the Salmurian, which had been collected by Dr. E. Angermann and Dr. E. Haarmann on the Rancho del Mohóvano on the boundary line of Coahuila and Chihuahua. During the last year O. A. Cavins and I visited a locality about 15 kilometers west of the ranch Piedra de Lumbre on the old road to Acatita (region of Cuatro Ciénegas, Coahuila) where Mr. Cavins had found in 1921 a locality with numerous ammonites. These also proved to be Salmurian and to contain the common genera *Fagesia, Vasoceras, Hoplitoides* and others, a list of which was given in the first part of this work. The fauna has not yet been studied in detail, but the age of the beds is well established and shows that in the west there exists a facies which contains a fauna characteristic of the lowest Turonian of Portugal and northern Africa. It seems that in eastern Coahuila this fauna does not exist, or at least it has not been found so far, even where the lowest part of the Turonian is exposed.

We have always found the Turonian to consist of black laminated limestones and black shales which carry everywhere *Inoceramus labiatus* Schlotheim and *I. hercynicus* Petrascheck; ammonites are rare and always compressed in such a manner that the form of the cross section could not be determined. Those which have been found seem to belong to the group of *Priontropis schlueterianus* Laube et Bruder.

Last year Mr. Cavins and I found an ammonite in whitish marls covering the common black and brown shales of the Eagle Ford shales at the Margaritas ranch near Villa Acuña, Coahuila. The ammonite doubtless belongs to the group of *Prionotropis woollgari* Mantell and is so little different from the type that I have determined it as a variety of this species, without supposing that it belongs to the same species; it may be of different origin and when more material has been found will certainly deserve a specific name.

For a long time it has been known that a form similar to *Prionotropis woollgari* exists in the Benton group of the Rocky Mountain region; it was discovered and described by Meek and cited again by Stanton from his Colorado group. It is not quite the type of the species but a variety which can scarcely be separated from it and is certainly a vicariating form.

The same species is said to exist also in Texas, but has never been described or figured. Cragin[81] cites "*Schloenbachia*" *woollgari* and says that Taff found it in a limestone immediately above the Buda limestone. This position makes the determination very doubtful, as *P. woollgari* is known to occur always in a rather high horizon of the Turonian while in the lower part this group is represented by a different form cited by Petrascheck as *Acanthoceras* cfr. *woollgari* to which most of the specimens belong which have been cited from Central Europe as *P. woollgari*. There also occurs *P. schlueterianus* which is a near relative of *P. woollgari.*

In the upper Turonian of Mexico so far no determinable ammonite has been found, and our discovery is therefore of importance as it makes it probable that the whitish marls

[81]Cragin, 22, p. 243

or limestones immediately above the dark beds with *Inoceramus labiatus* represent the upper Turonian. Our specimen will be described and figured in the following part of this work.

CONIACIAN AMMONITES

The existence of the Coniacian in Mexico was established some time ago by Burckhardt, who described an ammonite fauna from Zumpango del Rio, in the State of Guerrero. In northern Mexico this horizon has so far not been distinguished, and in Texas it has been cited by Lasswitz but he could not prove his assertions and mixed the faunas of the most diverse beds calling the result "Emscher." We have already indicated that his *Barroisiceras haberfellneri* is a *Budaiceras* and comes from the Cenomanian.

For a long time I have observed that the well known *Inoceramus undulatoplicatus* Roemer, which belongs to the group of *I. digitatus*, everywhere occurs at the base of the Austin chalk, both in Texas and northern Mexico, and that it is found below the zone with the typical *Mortoniceras texanum* Roemer. I therefore have always supposed that the lower Austin chalk represents the Coniacian. So far I have not been able to collect together with it a well determinable ammonite although often I have found associated with it *Mortoniceras* of the *M. emscheris* type. In northern Mexico *I. undulatoplicatus* seems to have its main layer in the base of the Austin chalk, although it rises up to the horizon with *Mortoniceras* aff. *texanum* Roemer.

Lately I was able to find a *Peroniceras* aff. *subtricarinatum* d'Orbigny in a sandy limestone occurring as geodes in a red sandstone and sandy shale, in the northern part of Chihuahua about four kilometers south of Ojinaga near the road to Chihuahua. This horizon lies quite a deal below the Santonian with *Placenticeras sancarlosene* Hyatt, and in addition carries *Proplacenticeras* aff. *fritschi* de Grossouvre and pelecypoda and gastropoda. These two ammonites make it entirely certain that this horizon represents the Coniacian. It is a facies completely different from that of the Austin chalk, but almost the whole upper Cretaceous of Chihuahua differs considerably from that of Texas and is much more similar to that of the Rocky Mountain province. In Chihuahua the beds are in general sandy, and only a small part is somewhat similar to the Austin chalk but represents in reality a higher portion of the Santonian. In the paleontological part of this work we have indicated that this *Peroniceras* is very characteristic and that it resembles externally *P. subtricarinatum* but that the suture is different from that figured by Drescher. In this respect our specimen resembles much more that of *P. moureti* Grossouvre and *P. westphalicum* Grossouvre (Schlüter?). All these species are restricted to the Coniacian, as in general is also the genus *Peroniceras*.

Not less characteristic is our *Proplacenticeras* aff. *fritschi* Grossouvre, a form described from the Coniacian of France. Similar to it is also *Proplacenticeras orbignyianum* Geinitz, equally from the Coniacian, which is related in a certain degree to the so-called *"Placenticeras" memoria-schlönbachi* Laube et Bruder from the Turonian and Cenomanian. Similar forms do not seem to have been found in the North American Turonian and Cenomanian. Ammonites do not seem to be very rare at the locality south of Ojinaga as these two were found when I simply walked across the beds, and it is very possible that a larger fauna will be discovered there later on.

SANTONIAN AMMONITES

In northern Mexico as well as in Texas the Santonian can be divided in two parts: the lower Santonian represented by the upper portion of the Austin chalk which possibly can be divided into two horizons, and upper Santonian represented by the so-called Taylor marls which in Mexico are not marls but typical shales.

The upper Austin chalk contains especially at its base *Mortoniceras texanum* Roemer and *Pachydiscus flaccidicosta* Roemer, besides many other ammonites. Yabe and Shimizu[82] have lately tried to prove that Roemer figured two

[82]Yabe and Shimizu, **102**, pp. 27–30, 1923.

different species under the name of *Mortoniceras texanum*, and they separate from the type Roemer's figure 1d under the name of *Mortoniceras roemeri* Yabe et Shimizu. I doubt very much that this species is valid, because the inner whorls of *M. texanum* have entirely different cross sections from that of the mature animal. Many specimens in the Austin chalk are deformed, mainly compressed laterally, and thus often appear to be quite different from the type of the species to which they belong. No doubt there are more *Mortoniceras* in the Austin chalk than the species described by Roemer, but his small specimen may very well belong to his type. Anyhow this question cannot be decided through the comparison of the figures but only through a study of the originals.

The group of *Mortoniceras texanum* characterizing the European Santonian and therefore the Austin chalk has been recognized as the representative of the Santonian in Texas. We have found this species in a number of localities in northern Mexico (Nuevo Leon and Coahuila) where it always occurs high above the base of the Austin chalk; especially rich are the beds of the San Juan Hills which have been called San Juan limestone by Dumble, although petrographically as well as faunally they are surprisingly like the typical Austin chalk of Texas. Other localities are the hills between La Laja and the Rio de Lampazos and the hills near the Cerro del Barril northwest of Villa de Juarez, Coahuila. The fauna of the middle Austin chalk in the Arroyo del Tecolote and in the Arroyo Blanco near Jimenez in Coahuila is extremely rich.

A representative and possibly also the type of *Mortoniceras texanum* occurs also farther west in the state of Chihuahua south of Ojinaga, where we find it in well preserved specimens together with *Placenticeras sancarlosense* and an *Exogyra* very similar to *E. ponderosa* Roemer, but probably belonging to a somewhat different species. We have already remarked that these beds lie above the sandstones with *Peroniceras* and *Proplacenticeras*.

While the Austin chalk is calcareous and marly, the Taylor marls above it are entirely shaly, at least in northern

Mexico, and contain only here and there concretions of limestone which frequently enclose fossils. Ammonites are generally not very common and belong almost always to *Placenticeras.* Hyatt cites several species from the Taylor marls of Texas and a greater number from the San Carlos beds of west Texas and Chihuahua. Unfortunately the San Carlos beds have not been studied in detail and nothing is known about the distribution of the different species found there. I have already mentioned that south of Ojinaga, Chihuahua, in the light colored sandy beds above the Coniacian I have mainly found *Placenticeras sancarlosense* and *Pl. planum* Hyatt. It is possible that the other species belong to a higher horizon. In Coahuila at Las Esperanzas we collected in the upper portion of the Taylor marls a great number of *Placenticeras syrtale* Morton. The different species cited by Aguilera from this place all seem to belong to *Pl. syrtale.* His *Schloenbachia belknapi* is an undeterminable fragment; the sutures which are partly visible are not those of *Schloenbachia* or *Oxytropidoceras;* the specimen may be a deformed *Pachydiscus.* Aguilera cites also a *Sphenodiscus* from Las Esperanzas. This specimen is very much corroded but the suture shows clearly only one adventive lobe in the external saddle and the specimen therefore cannot be a *Sphenodiscus.* I suppose that it is a much corroded *Coahuilites;* according to an old label it does not come from Las Esperanzas but from Candela in Coahuila, and as *Coahuilites* occurs near this place in the Mesa de los Cartujanos and in the Mesa de San Antonio between Candela and Monclova, it is very possible that it came from one of these places and by mistake got into the collection from Las Esperanzas.

In the localities farther south, in the Arroyo del Gato and its neighborhood (north of Rancho de Los Garcias, Loma del Gato, and Loma de Las Hermanas) we also found only *Placenticeras syrtale* Morton, mostly in fragments. *Exogyra ponderosa* Roemer is of course frequent everywhere. *Inoceramus* of the *I. balticus* Böhm group is quite common, but well preserved specimens are rare. So far it has not been possible to collect sufficient material for an exact determination of the species.

The frequency of *Placenticeras* s. s. makes it evident that the Taylor marls correspond to the Santonian, and as they overlie the lower Santonian with *Mortoniceras texanum* Roemer they have to be considered as the representative of the upper Santonian. Grossouvre calls these beds the zone of *Placenticeras syrtale* in France, but as has been stated already by Hyatt, the real *Pl. syrtale* does not exist in Europe. Hyatt has discussed most of the species cited under this name and shown that they are different forms. He calls *Pl. depressum* Hyatt part of the form cited by Grossouvre[83] and Schlüter[84] as *Placenticeras syrtale*. This species is extremely similar to *Pl. guadalupae* Roemer, as has been seen already by Grossouvre and Schlüter and confirmed by Hyatt. The differences are so small that one might consider those specimens as varieties of *Pl. guadalupae* if they were found together with the type, and they are certainly the vicariating European representative of the American group. Unfortunately the exact stratigraphical position of the type in Texas is not known; near the waterfall of the Guadalupe River from where Roemer described his type only the highest Austin chalk and the Taylor marls occur; but I have seen specimens said to come from the Taylor marls of Texas which certainly belong to the typical *Pl. guadalupae*.

The species described by Schlüter[85] as *Ammonites syrtalis* var. *polyopsis* has been called *Pl. schlueteri* by Hyatt;[86] this species is very similar to the American *Pl. syrtale*. It is less involute and the inner row of tubercles is farther removed from the umbilicus than in the American species. That the cross section is more oval than the type would not be such a great difference, as that of the American species also becomes more oval in the later stages. Thus *Pl. schlueteri* Hyatt probably has to be considered as the vicariating European representative of *Pl. syrtale* Morton.

Pl. polyopsis Dujardin[87] from the Santonian of the Touraine is also a species which at least in its larger specimens

[83]Grossouvre, **35**, p. 128, pl. vi, fig. 2; pl. vii, fig. 1.
[84]Schlüter, **69**, p. 46, pl. xiv, figs. 9, 10.
[85]Schlüter, **69**, p. 46, pl. xiv, figs. 1, 2.
[86]Hyatt, **38**, p. 239.
[87]Dujardin, **29**, p. 232, pl. xvii, fig. 12.

is quite similar to *Pl. syrtale* in its ornamentation, but its suture is unknown. The ornamentation is more like that of *Pl. syrtale* than in *Pl. schlueteri*, especially the position of the umbilical row of tubercles. I do not doubt that the species may also be considered as a European representative of the American group of *Placenticeras syrtale*.

The existence of these forms in the European Santonian which, although not identical with the American species, are sufficiently similar to allow a conclusion with respect to the age, confirms our opinion that the Taylor marls of northern Mexico and Texas represent the Santonian. The oldest *Placenticeras* of Europe occurs in the upper Turonian, that is, if *Pl. memoria-schlönbachi* Laube et Bruder really belongs to the genus *Placenticeras*, which appears to be at least doubtful. The original suture indicated in the figure given by Laube and Bruder[88] is not very convincing. Petrascheck has later united this species with *Amm. lewisiensis* and *Amm. bicurvatus* Geinitz[89] which occur in the uppermost Cenomanian of Saxony. The suture has a certain similarity with that of *Placenticeras* but is by no means typical and probably belongs to a different genus.

The first species which are at least nearly related to the genus *Placenticeras* are probably *Ammonites orbignyanus* Geinitz and *Placenticeras fritschi* Grossouvre. But they are by no means typical *Placenticeras* and have little in common with the type of this genus, especially as far as the ornamentation is concerned; the suture is more like that of *Placenticeras*. Spath[90] has created the new genus *Proplacenticeras* for *P. fritschi* Grossouvre, and to this genus belongs certainly also *Ammonites orbignyanus* Geinitz.

A good drawing of the suture of this latter species has been given by Sturm[91] which is much better than the one published by Drescher.[92] The suture of *Proplacenticeras*

[88]Laube und Bruder, **45**, p. 221, pl. xxiii.
[89]Petrascheck, **59**, p. 132, text fig. 1.
Geinitz, **32**, p. 39, pl. xiii, fig. 4 (ex parte).
Geinitz, **33**, p. 112, pl. iv, fig. 2.
Geinitz, **34**, p. 188, pl. xxxiv, fig. 3.
[90]Spath, **84**, p. 79.
[91]Sturm, **91**, p. 58, pl. iii, fig. 4.
[92]Drescher, **28**, p. 330, pl. viii, fig. 1.

fritschi which Sturm unites with *Pr. orbignyanum* is very well preserved and well reproduced in the figures of Grossouvre.[93] Hyatt also unites these two species, but it seems that the French species has a somewhat different ornamentation. The main difference between these older species (the group of which so far had not been found in America) and those of the Santonian consists in the circumstance that the older forms seem to have a smaller number of auxiliary lobes and saddles. I have already remarked that this group occurs also in America and that to it belongs the species which I found south of Ojinaga together with *Peroniceras* aff. *subtricarinatum* d'Orbigny; the form is quite like that of the young *Propl. fritschi* and the suture also seems to have been quite similar, even to the very broad first adventive saddle.

All these older species are very different from those of the Santonian. We have seen that both the groups of *Pl. guadalupae* and *Pl. syrtale* have their representatives in Europe and it is very possible that similar forms will be found also in India. Hyatt has already called attention to the fact that the *Placenticeras tamulicum* Forbes[94] will probably have to be divided into two different species. The flatter form may be related to *Propl. fritschi* (Stoliczka l. c. pl. 48; Kossmat, l. c. pl. 22, fig. 1a only); the ornamentation has a great similarity with that of the French form and the suture has apparently a smaller number of auxiliary saddles.

Quite different is the thicker form (Stoliczka, l. c. pl. 47, figs. 2, 2a) of which unfortunately no side view has been given. This form is quite similar to *Pl. syrtale* Morton and its suture shows the broad first adventive saddle and the extraordinarily deep first lateral lobe of the *syrtale* group. It seems to possess many more auxiliary lobes than the other form. To which group the suture given by Kossmat belongs cannot easily be said, as we do not know the form and sculpture of the specimen.

All these Indian species come from the upper Trichinopoly group which is considered as lower Senonian and

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[93] Grossouvre, **35**, p. 124, text fig. 52, pl. v, figs. 1, 2.

[94] Stoliczka, **90**, p. 90, pl. xliv, figs. 1, 2; pl. xlviii, fig. 1.
Kossmat, **43**, p. 174 (78), pl. xxii (8), fig. 1.

which may very well contain both the Coniacian *(Peroniceras dravidicum* Kossmat) and the Santonian; the lower Trichinopoly group contains a Turonian fauna according to Kossmat (l. c. pp. 133, 134).

There is no doubt that those forms of *Placenticeras* which are nearly related to *Pl. syrtale* and *Pl. guadalupae* occur only in the Santonian of Europe and that all higher or lower forms are quite different from the species found in the Taylor marls and corresponding beds. We can therefore consider these as the representative of the upper Santonian.

Great confusion is apt to be caused by the opinions expressed by Gayle Scott[95] with respect to the age of the Austin chalk and the Taylor marls in Texas. He cites on p. 109 *Barroisiceras haberfellneri* accordingly to him identical with *Amm. dentacrinus* Roemer (misprint for *Amm. dentatocarinatus* Roemer?) as occurring together with *Mortoniceras texanum;* thus fossils from the Coniacian would be found mixed with Santonian forms in Texas. Then he cites from the upper Austin chalk, *Exogyra ponderosa* Roemer, although I have shown long ago[95*] that this *Exogyra* from the upper Austin chalk is very different from *E. ponderosa* and should be given a different name, a distinction which has been recognized also by other authors. From these upper beds or the lower Taylor marls he cites *Pl. syrtale* Morton. From the Taylor marls themselves he does not cite a single *Placenticeras* (p. 110). On p. 118 where there seem to be at least two misprints in the vertical lines, he cites again the ammonites from the Coniacian together with those from the Santonian but cautiously designates the Austin chalk as Coniacian and Santonian. But here he now unites the zone which according to him contains *Pl. syrtale,* with the Taylor marls and puts these in the Campanian, although no form like the *Pl. syrtale* has ever been discovered in real Campanian of Europe. On p. 189 he puts these beds with *Pl. syrtale* back into the Austin chalk and considers them as Santonian and the Taylor marls as Campanian. He also cites quite a number

[95]Gayle Scott, 70, pp. 107–111, 118, 189.
[95*]Böse, 9.

of "paleontological" zones from the Coniacian to the Campanian, just as if these had ever been established in Texas, and he even says on the same page that his researches have brought him to establish these correlations. From his text one sees that Scott evidently never studied either the fauna or the stratigraphy of these beds and that his subdivision is entirely based on theoretical speculations. That he accepts Lasswitz's determination of *Barroisiceras haberfellneri* which is really a *Budaiceras* and comes from the Cenomanian shows how much we can rely on Scott's "paleontological zones." This kind of stratigraphy is apt to mislead such readers as do not know the real conditions in Texas, especially if such "correlation" should be accepted by a textbook.

In the first part of this publication we have already shown that farther south the Santonian is represented by part of the Cárdenas division in San Luis Potosí, which contains *Coralliochama*, a number of rudistids, *Trochactaeon*, *Cerithium* and other fossils, which like the Taylor marls in the north is overlain by beds with *Exogyra costata* and *Gryphea vesicularis* and which rests on a limestone that contains *Sauvagesia* and other rudistid forms. In my first publication I have erroneously united the *Coralliochama* beds with those with *Exogyra costata*, but later investigations have shown me that the *Coralliochama* beds lie below those and represent a lower horizon which certainly corresponds to the Taylor marls. The age of the limestome below the *Coralliochama* beds corresponds probably to that of the Austin chalk and is also Santonian or in part Coniacian and perhaps upper Turonian; these limestones lie at Xilitla on the Turonian beds with *Inoceramus labiatus*. Such a rudistid and Caprinidae facies also probably exists in Texas in the so-called Anacacho limestone, but its fauna has not as yet been described. The rudistids appear to be generally very small and rare.

CAMPANIAN AMMONITES

The Campanian is certainly represented by the beds with *Exogyra costata*[96] which corresponds to the Navarro beds of Texas, but are much less fossiliferous. These beds are mostly shaly but contain layers and beds of sandy limestone and in places even real sandstones and conglomerates where the facies is normal in northern Mexico. The fauna is very poor; in general only *Exogyra costata* and *Gryphea vesicularis* are found in quantities; although in some places like that near El Mitote (Laguna de la Leche) we found also frequently *Turritella trilira* Conrad and *Turritella vertebroides* Morton, *Crassatellites* aff. *vadosus* Morton, *Vetericardia* aff. *subangulata* Wade; all these occur in the upper portion of the beds. In the lower part of the formation we found at the Arroyo de las Navajas between Piedras Negras and El Moral: *Ostrea saltillensis* Böse, *Brachydontes* aff. *regularis* White, *Pholadomya* sp. and *Liopistha bella* Stephenson. Ammonites are absent almost everywhere. Only recently Mr. Cavins and I found a *Placenticeras* in the lower portion of the San Miguel beds which belongs to the horizon with *Exogyra costata*, at the Arroyo de las Navajas mentioned above, and this *Placenticeras* is very different from the species found in the Santonian. I have identified it with *Pl. whitfieldi;* although our specimen is not very well preserved it shows all the characteristic features of the group of *Pl. whitfieldi* Hyatt. This species comes from the Fort Pierre group, which probably includes several horizons. It is difficult to say if this group belongs to the Santonian or if it contains a part of the Campanian. The overlying

[96]I cannot understand how Mr. Bruce Wade (The fauna of the Ripley formation on Coon Creek, Tennessee, p. 57) evidently attributes to me the absurd idea that *Exogyra costata* originates in the Buda limestone and ranges up through the Navarro formation. I have never said such a thing and Mr. Wade must not have read carefully what I said in my publication "On a new Exogyra from the Del Rio clay and some observations on the evolution of Exogyra in the Texas Cretaceous." I only suppose, that the tribe from which *Exogyra costata* came has its first representative in the Buda Cenomanian and that other forms belonging to this tribe occur in the higher formations, from which at last developed the *Exogyra costata* of the Navarro beds. Against this not even "the best authorities on the Cretaceous of the United States" can say anything, unless they prove that *Ex. costata* belongs to a different tribe.

Fox Hills beds may in part still belong to the Campanian, but in part represent the Maestrichtian.

I must call attention to the peculiar sutures in *Pl. whitfieldi*, the absence of tubercles on the vental shoulders, although Hyatt says that such are present in the neanic stage (they "are more perceptible to the touch than to the eye") and to the sharp edges on the narrow venter, which even appears to be slightly concave. Similar characters seem to appear in the *Placenticeras* of the lower Campanian in Europe, that is, in those forms which belong to the group of *Ammonites bidorsatus* Roemer.[97] Externally these forms differ from the typical *Placenticeras* of the Santonian through a concave venter with continuous ridges on the shoulders and a very peculiar tuberculation on the sides which rises toward the venter in older specimens; the younger whorls appear to be smooth.

A good figure of the sutures of these peculiar forms has been given by Schlüter.[98] It shows that the suture contains very much ramified elements which are much longer than the common lobes and saddles of *Placenticeras*. This is confirmed by Grossouvre[99] who found similar although very small forms in the lower Campanian of France; his figure of a suture of these animals shows already the strongly ramified and long saddles and the long and divergent branches of the siphonal lobe.

Hyatt considers these forms are generically different from *Placenticeras*, but I find that the suture has such a similarity with that of *Pl. whitfieldi* that a generic distinction cannot well be made. Hyatt calls his genus *Diplacmoceras* (type: *Ammonites bidorsatus* Roemer) and separates it mainly on account of the ornamentation. I cannot find that this genus has very much external resemblance with *Engonoceras*, as Hyatt claims, for the nodules are quite different from those of *Engonoceras* and the concave venter certainly does not resemble that of the common *Engonoceras*. The very narrow venter is certainly also present in *Pla-*

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[97]Roemer, **66**, p. 88, pl. xiii, fig. 5.

[98]Schlüter, **69**, p. 51, pl. xv, figs. 6–8.

[99]Grossouvre, **35**, p. 137, text fig. 55.

centiceras whitfieldi, and when we compare the sutures, we find that those of *Ammonites bidorsatus* are quite similar to those of *Pl. whitfieldi,* as Hyatt shows them in his fig. 1 of plate 46, although that specimen is much larger than Schlüter's form. This may explain why the sutures of *Pl. whitfieldi* are much more ramified than those of the Westphalian species.

It appears to me that our species is nearly related to the European form although it does not show the peculiar ornamentation, but it has the compressed discoidal form, the narrow venter and the elongated saddles and lobes. The age is probably the same, as we have found examples of *Pl. whitfieldi* just at the base of the beds with *Exogyra costata,* and the European form appears in the lower part of the Campanian.

The main fossil found almost everywhere in the Campanian beds of this region in the lower as well as in the upper portion, is *Exogyra costata* Say; in the upper beds occurs *Gryphea vesicularis* mostly in great abundance. In all our region I have never found *Exogyra costata* lower than the beds above the Taylor marls or the upper Santonian, and only in one place I have found an occasional specimen in the higher beds, the Maestrichtian or Escondido beds; the main layer is certainly in the beds between the Maestrichtian and the upper Santonian, that is the beds with *Exogyra costata* which are synchronous with at least part of the Navarro beds of Texas.

When I first studied the upper Cretaceous fauna of southern Coahuila in 1904 I thought that *Ex. ponderosa* and *E. costata* occurred together at some places, but I have found this to be an error due to the development of both the Santonian and Campanian as very similar shales. Those specimens which are really *Exogyra costata* are everywhere in a higher horizon than *Ex. ponderosa;* that is also true at Parras, Coahuila, and in the vicinity of Monterrey, Nuevo Leon, as later studies have shown me. Near Ramos Arizpe, Coahuila, some 20 kilometers from Saltillo, *Exogyra costata* does not occur together with *Sphenodiscus lenticularis,* but is a little older; only in the Mesa de Cartujanos have I rarely found a specimen of *Ex. costata* together with *Sphenodiscus lenticularis*. But in general *Ex. costata* is restricted to the beds below those with *Sphenodiscus lenticularis*, at least where the species occurs in great numbers.

In the region between Lampazos, Esperanzas and Piedras Negras the zone of *Exogyra costata* offers some difficulties for the stratigraphy in that it appears in different facies. In the south near the Mesa de Cartujanos and as far east as the Rancho del Pescado and Laguna de la Leche the lower portion of these beds is represented by a brackish water facies containing mainly *Melania* aff. *wyomingensis*, *Corbula*, *Corbicula*, large oysters and other fossils. But even in this region one finds especially near Rodriguez, Nuevo Leon, some beds with marine fossils, mainly *Inoceramus* of the *I. regularis* d'Orbigny group. This brackish water facies was considered by C. A. White and J. G. Aguilera as a representative of the Laramie formation. But near the Mesa de Cartujanos in the Arroyo de Tulillo, which was the locality known to White and Aguilera, one sees clearly that these beds lie below shales with a great number of *Exogyra costata*. Still better is the cross section betwen Rancho del Pescado and Tanque del Mitote near Laguna de la Leche, where the *Ex. costata* beds quite plainly cover the beds with *Melania* aff. *wyomingensis*. In all this region only the upper beds consisting mostly of shales with intercalated beds of sandy limestones contain a great number of *Exogyra costata* and these beds are overlain directly by the Maestrichtian with *Coahuilites sheltoni*. These upper beds have always numerous specimens of *Gryphea vesicularis*; this is in accordance with the European conditions where the *Gryphea vesicularis* occurs in its typical form only in the upper Campanian.

The conditions begin to change at the Rio Nadadores in the north, where the upper *Exogyra costata* beds become brackish; at least here they contain only remnants of wood and oysters, and locally shark teeth and very rarely a *Pecten*. The lower portion of the beds is much covered and even where they are found in the form of shales, they do not seem to contain any fossils.

The conditions become clearer farther to the north in the region of Las Esperanzas and Piedras Negras. Here we find the lower portion of the *Ex. costata* beds developed in a marine facies, which at Esperanzas lies directly on the beds with *Placenticeras syrtale.* The *Ex. costata* beds frequently contain *Ex. costata* and a number of gastropods and oysters. But the upper portion of the series is non-marine and consists of sandstones and shales which contain the coal seams, some palm leaves and brackish water pelecypods.

The conditions near Piedras Negras are very similar. At the Arroyo de las Navajas lie the lower *Ex. costata* beds, containing *Ex. costata* in great numbers and a little below their main bed *Placenticeras whitfieldi,* on the shales of the Upson clays, which frequently contain *Exogyra ponderosa,* especially in their middle part. In this region the lower *Ex. costata* beds or San Miguel beds as they have been called, are rather thin, and the sandstones and shales which represent the upper portion of the *Ex. costata* beds contain the coal seams.

MAESTRICHTIAN AMMONITES

The Maestrichtian of this region has proven to be much richer in ammonites than any other locailty along the Rio Grande, but the ammonites are limited to four genera: *Parapachydiscus, Coahuilites, Sphenodiscus* and *Baculites.* At the base just above the beds with *Exogyra costata* we find a horizon about 10 meters thick which contains only *Coahuilites.* The most common form is *Coahuilites sheltoni* which we found in a few specimens in the first hard ledge around the Mesillas near San Patricio. Together with it occurs *Coahuilites orynskii.* Much richer is the locality on the line of the old partly constructed railway, about five kilometers south of the Rancho del Alamo Viejo, where the shales have been well exposed in the railway cut; quite rich is also a locality between the two mentioned above, also on the old railway line, a kilometer south of the only gate.

In a somewhat higher horizon we find the first *Sphenodiscus* which belongs to *Sph. lenticularis.* The best locality is near the direct road from Lampazos to Encinas in the upper portion of the valley of El Oro. The beds contain also numerous bivalves, gastropods and a *Belemnitella;* they lie a little above the lower sandstones of the Maestrichtian. No *Coahuilites* has been found in this place, probably because the lower beds are not well exposed; but there is no doubt that the *Sphenodiscus* beds lie above the first sandstones which overlie the *Ex. costata* beds, and which generally contain the *Coahuilites sheltoni.*

Somewhat higher we find another horizon between Rancho de Jabalí and Rancho del Oro (and also just above the *Sph. lenticularis* zone in the Valley of El Oro) which contains the first ornamented *Sphenodiscus;* we have called the two species: *Sphenodiscus intermedius* and *Sph. prepleurisepta.* This horizon lies considerably above the *Exogyra costata* beds which exist in the saddle through which passes the old road from Rancho Jabalí to Lampazos; above them we find a whole series of sandstones which near the Rancho Jabalí itself contain *Sph. lenticularis,* while the sandstone and shale beds above these have not produced any fossils. This does not mean that they do not contain any, but the fossils are distributed in lenses more than in beds. On the small mesa at the side of which the old road from Jabalí to El Oro passes and around which another one goes to Realitos, most of the sandstone and sandy limestone is without fossils; only now and then one finds a lens which contains dozens of ammonites. In other beds of the formation the conditions are similar and the discovery of fossils is partly a question of luck, where the beds are not well exposed. *Sphenodiscus prepleurisepta* was found also north of the Mesillas on the top of a little hill of sandstone at the side of the road from San Patricio to Alamo Nuevo. The horizon lies quite a distance above the *Coahuilites sheltoni* bed but still belongs to the lower part of the Escondido beds of the Maestrichtian.

Sphenodiscus intermedius is a common form in a locality much farther north, near Campo de la Rosita, not very far from the coal mines of Saltillito. It occurs there also in lenses in a very hard sandy limestone and is accompanied by a large *Baculites* somewhat similar to *B. ovatus* Say. This horizon lies considerably above the beds with *Exogyra* *costata*, which here are represented by the sandstones with coal seams, but it belongs evidently to the lower portion of the Maestrichtian.

In about the middle of the Maestrichtian but only in the northern portion of this region we find a second series with *Coahuilites*. It is a different group from that at the base of the Maestrichtian. We have called this species *Coahuilites cavinsi*. Wherever it is found it occurs in numerous specimens but it is difficult to separate from the matrix which consists mostly of a very hard siliceous sandy limestone. We find the first bed about 10 miles from Progreso on the road to the ranch Santa Cruz where we cross the first hard limestone ledge below the above mentioned ranch. This bed corresponds probably to that of another locality on the old road from Santa Cruz to Rancho de Los Garcias, on a little mesa just before the road crosses the main road from Progreso to Saltillito. In both localities the species occurs in great numbers. On this same old road exists a higher bed which also contains very numerous *Coahilites cavinsi;* it is well exposed where the road from Santa Cruz leaves the mesa of the same name and descends rather abruptly into the next valley. There is no doubt that this bed is at least some 50 meters higher than the first one, but the species is entirely the same. It seems that above this horizon sandstones begin to predominate and that these were deposited either in lagoons or very near the coast, because we mainly find in them remnants of wood and large oysters.

There are quite different conditions near the Rio Grande, where the uppermost beds of the Maestrichtian are entirely marine and carry a great number of *Sphenodiscus*. One of the best localities is in the vicinity of the Arroyo del Caballero near the Hacienda de Cerrito Prieto, a point which has already been mentioned in the literature by Dumble. I visited this locality first in February, 1913, and found principally *Sphenodiscus pleurisepta*, but also a large fragment of *Parapachydiscus* cfr. *colligatus*. There occurs also a new species of *Sphenodiscus* which I describe here under the name of *Sph. aberrans*.

So far *Sphenodiscus pleurisepta* has not been found in the vicinity of Progreso or farther south. An ornamented *Sphenodiscus* occurs in the Mesa de los Cartujanos but it belongs to *Sph. intermedius* and comes from a lower horizon than *Sph. pleurisepta.* It is very probable that the upper Maestrichtian there and in the Mesa de las Cruces (different from Mesa de Santa Cruz) which contains beds of large oysters and shows rather coarse conglomerates with plant remains, small oysters and shark teeth in the uppermost beds, corresponds to the marine beds with *Sphenodiscus pleurisepta* and *Sph. aberrans* on the Rio Grande at the Arroyo del Cabellero. The Eocene sea did not reach very much south and west of the Rio Grande and did not cover the upper beds of the Maestrichtian between the coal mines of Saltillito and the Mesa de Cartujanos, which makes the determination of the highest beds of this latter locality somewhat doubtful. At the Arroyo del Caballero the Midway lies unconformably on the beds with *Sph. pleurisepta;* the highest beds of the Maestrichtian are marine in this place and the missing formation may have belonged to the time of the Danian or the lower portion of the Eocene or both.

It has often been observed that the *Sphenodiscus pleurisepta* is a very near relative of *Sphenodiscus binkhorsti* Böhm which occurs in the Maestrichtian of the Dutch and Belgian Limburg. Binkhorst himself even believed that his species was identical with the one found on the Rio Grande and united them under the name of *Ammonites pedernalis.* The similarity has been confirmed by Böhm, Grossouvre and by Hyatt. This latter author describes another species from Maestricht which he calls *Sph. konincki.* He distinguishes it mainly on account of the suture and does not give a picture of the ornamentation.

Real *Sphenodiscus* have been found in Europe only in the Maestrichtian; the American species of this genus occur only in the Escondido beds and the Fox Hills group. What has been considered as *Sphenodiscus* in India *(Sphenodiscus acutodorsatus* Noetling) does not belong to this genus, which never has entire saddles. Hyatt places it in the genus *Indoceras* which seems also to be impossible, as the external saddle is divided in three parts. *Sphenodiscus acutodorsatus* should be placed in a new genus. Only *Sph. sira* Forbes from India belongs really to our genus and is related to *Sph. lenticularis* as Kossmat shows.

The new genus *Coahuilites* finds its nearest relative in *Libycoceras ismaeli* Zittel, especially in its form and ornamentation, but the suture is quite different showing entire saddles in *Libycoceras*. Related is also *Indoceras baluchistanense* Noetling but the ornamentation is different and the saddles are entire. The similarity in the three genera consists in the fact that the external saddle is divided into only two branches, while in *Sphenodiscus* it has three. It is very characteristic that in Europe, Africa and India forms are developed among the Maestrichtian ammonites which to a certain degree are similar in the ornamentation and in the simple suture, and that in some groups the external saddle is divided by two, in others by three branches, just as happens in the Escondido beds of Texas and northern Mexico. Such forms have never been found in lower beds.

Of a certain stratigraphic importance is also the occurrence of *Parapachydiscus* cfr. *colligatus* in the lower as well as in the upper beds of the Maestrichtian of this region. The specimens are very similar to those of the Maestrichtian of Limburg.

In northern Mexico the unornamented *Sphenodiscus*, that is, those which belong to the group of *Sph. lenticularis* Owen, seem to occur only in the lowest Maestrichtian; the same is probably the case in Texas where *Sphenodiscus lenticularis* has been cited from the Navarro beds; their horizon should be ascertained and separated from the others under a special name. We know that part of the Navarro beds corresponds to our beds with *Exogyra costata* which represent the Campanian, while those above them with *Sphenodiscus lenticularis* belong to the oldest Maestrichtian.

DESCRIPTION OF GENERA AND SPECIES

ALBIAN

Lately I received through the kindness of my friend, Professor W. S. Adkins, of Austin, Texas, two fossils from the Albian. These have a certain importance for a comparison with the European representatives of the beds of Texas and Mexico although they do not come from those beds which have been treated in the foregoing pages. One of them is a *Stoliczkaia* which shows that this genus is appearing in America at exactly the same period where it is known to occur first in Europe and Asia. The other is not an ammonite but a very characteristic *Inoceramus,* which belongs to a group the representative of which we have cited as occurring in Tamaulipas; it occurs in Texas in a bed which corresponds to the one which in Europe contains the corresponding variety of the group. Thus this characteristic form confirms our correlation given in the foregoing chapters.

FOSSIL FROM THE EDWARDS LIMESTONE

INOCERAMUS (Actinoceramus) SUBSULCATIFORMIS N. SP.

Plate XVIII, Figures 1–5

In the Edwards limestone, about twenty feet below the top of this division, my friend, Professor W. S. Adkins, found a very uncommon *Inoceramus;* he recognized its similarity with *Inoceramus concentricus* Parkinson var. *subsulcatus* Wiltsh.[100] and asked me to describe and figure it, as its occurrence in the Edwards limestone has a certain bearing on the determination of the age of this bed. After I had cleaned and prepared the specimen, the similarity to the English species became still more evident, especially in the form of the beak of the left valve and the hinge line. As the specimen is rather well preserved and possesses both valves I do not hesitate to name and describe it, although only this single individual has been found so far.

[100]Woods, **100**, pl. xlvii, figs. 15–20; **101**, p. 4, figs. 10–18 on page 3.

Description.—Shell small of oblong contour, higher than wide, asymmetrical, inequivalve, the left valve being larger and more convex than the right one. Hinge line straight and very short. Both valves are smooth in the upper portion and show strong radial folds in the lower one. The seam is straight only in the upper third and strongly plicated on the rest, the ribs of one valve corresponding to the interstices of the other.

Left valve.—High oblong, oval in the lower portion, beak well pointed, strongly bent over the hinge line and twisted forward. In the front part below the beak appears a smooth and concave semilunar area limited by a slight curved fold; the back portion of the beak is evenly curved toward the hinge line and the seam. The surface of the valve is smooth in and below the umbonal region; this smooth portion has an oblique form, beginning in front near the beak and reaching diagonally down toward the posterior side. This smooth portion shows only fine concentric lines of growth which in their shape do not follow parallel to the outline of the smooth portion but are more or less parallel to the general outline of the valve. In the lower portion the valve shows nine radial folds or ribs, the posterior ones of which are very inconspicuous. The anterior rib begins near the beak and ends at the seam, enclosing the semilunar area mentioned above. The next rib begins a little lower but is very strong and much longer than the first one. In the same manner follow two more ribs, each of them beginning a little lower than the other and ending at the border of the valve. Then almost in the middle portion we see two much shorter and rather low ribs which may represent an individual irregularity. On the posterior part we find four more ribs, all shorter than on the anterior portion and mostly less strong; the last two are very short and low.

Right valve.—High oval, beak lying far toward the anterior portion, slightly twisted forward, not very prominent, situated below and a little forward of the beak of the left valve. Hinge line short and straight and lying behind the beak. Valve not quite as evenly convex as the left one but showing a much greater convexity in the anterior portion, while the posterior side is flattened. The area corresponding to that of the left valve is not very clearly defined, but in this region the shell bends strongly toward the seam and a very faint swelling curves from the beak to the place where the corresponding fold of the left valve reaches the seam. The upper portion of the valve is smooth and shows only concentric lines of growth which follow parallel to the outline of the smooth portion. On the lower third of the valve we find eight short but partly strong ribs or folds which correspond to the interstices between the ribs of the left valve.

Dimensions:

Height of shell	30.5 mm.	(1)
Width of shell	22.0 mm.	0.72
Thickness of shell	17.5 mm.	0.57
Thickness of left valve	9.5 mm.	0.31
Thickness of right valve	8.0 mm.	0.26
Height of right valve	26.0 mm.	0.85

Relation to other species.—As Adkins had already recognized, this species is surprisingly similar to *Inoceramus concentricus* var. *subsulcata* Wiltsh. Woods regards these forms as a variety of *Inoceramus concentricus* Parkinson, and their outline is certainly very much like that of *I. concentricus.* But the appearance of strong folds on the lower portion of the shell gives it a different character and it might be better to regard these forms as a different species. Its value would probably be as good as that of *Inoceramus sulcatus* Parkinson which is distinguished from the *I. subsulcatus* forms only through the greater number (?) of folds and the circumstance that these begin on the beak itself, while in the *I. subsulcatus* there is always a smooth zone of varying size on the beak and often below it; sometimes this zone becomes so small that it can be scarcely distinguished.

This species which at first view seems to be identical with *I. subsulcatus* is distinguished by minor points. First, the outline of the shell is not quite as asymmetrical as

I. subsulcatus and especially the very characteristic wing on the posterior side which we find in *I. concentricus* as well as in *I. subsulcatus,* is practically missing in our specimen. In both *I. concentricus* as in *I. subsulcatus* the line from the point of the peak to the posterior portion of the left valve shows always a decided inflection which in some specimens may be very slight but always seems to be present. This inflection is missing in our specimen and the corresponding line is entirely straight. This makes our left valve appear much more symmetrical. On the other hand our specimen is much more slender than *I. subsulcatus,* while this later species is always rather broad. The right valve is much more similar to that of *I. subsulcatus* and the smooth part resembles surprisingly the right valve of a typical *I. concentricus.*

There can be no doubt that this species is the American vicariating form of the European *Inoceramus subsulcatus.* We have already expressed the opinion that the Edwards limestone corresponds to the middle Albian, and the occurrence of this species would correspond to that of the European form which is found in the middle and upper Albian.

In the first part of this publication we have remarked that in the Sierra de San Carlos, Tamaulipas, we found numerous specimens of a species intimately related to *Inoceramus concentricus* in a zone just above the middle Albian. We have the same question there as here; the *Inoceramus* of the Sierra de San Carlos is so similar to the English *I. concentricus,* that one scarcely knows how to distinguish them, but still there is a certain difference in the outline which is difficult to describe but which is evident to the eye. There is no doubt that both forms belong to the same group and doubtless formerly one would have united them in the same species, possibly as a variety, but modern paleontologists prefer to separate what can be distinguished, especially when the different forms come from very distant localities, and to establish groups or subgenera or genera composed of different but intimately related species.

This happens here also; in the case of the *I.* aff. *concentricus* of Tamaulipas we have numerous specimens which on the whole are all a little different from the English type, although one or the other specimen seems to be almost entirely like some variety of the European type. In the present case where we have only one specimen, we can see that it is a little different from all the varieties of the European form as far as these have been figured and therefore we prefer to consider it as a different species although certainly belonging to the group of *Inoceramus subsulcatus* Wiltsh.

Number of specimens: One.

Age: Middle Albian, Edwards limestone, twenty feet below the top.

Locality: Valley Mills-Coryell City road, one and one-half miles southwest of Valley Mills, near point of entrance onto uplands, Bosque County, Texas.

AMMONITE FROM THE PAWPAW BEDS

STOLICZKAIA ADKINSI N. SP.

Plate XVIII, Figures 9–17

We have already seen in the discussion of the age of the Del Rio clay and the Buda limestone, that some authors have laid too much stress on the occurrence of *Stoliczkaia*, especially the group of *Stoliczkaia dispar*, in drawing the division line between the Albian and the Cenomanian. We have seen that Spath has found *Stoliczkaia* in the lower Cenomanian and we concluded that therefore the occurrence of this genus in our Del Rio clay is not very surprising, and that it does not mean that these beds have to be regarded as Albian. Gayle Scott cites the occurrence of *Stoliczkaia* even from the upper portion of the Grayson marls which he correlates with the Buda limestone, and he even identifies this *Stoliczkaia* with *St. dispar* d'Orbigny. He[101] does not really describe this form, but figures a specimen from the upper Grayson marls and identifies it with *St. dispar*. There

[101]Gayle Scott, **70**, p. 141, pl. iii, figs. 5, 4.

is scarcely any doubt that his species has nothing to do with the real *St. dispar*, because it has too many and too curved ribs and the interstices are too narrow. It may very well be a *Stoliczkaia* but of a different type than *St. dispar*. I cannot very well understand why he says that he distinguishes *Stoliczkaia dispar* from *Ammonites martimpreyi* and that in this he is of the same opinion as Pervinquière. The two species belong decidedly to very different genera, one being a *Stoliczkaia* and the other a *Mantelliceras*.

Professor Adkins discussed with Dr. Spath in London the question of the age of the Pawpaw beds and later on he did the same with me. He saw that both of us had come independently to the conclusion that the Pawpaw beds represent the highest Albian (bed xiii of Folkestone) and he concluded that if we were right a real representative of the group of *Stoliczkaia dispar* might be found just above the beds with *Neokentroceras worthense* (Adkins). Thus he lately visited the Glen Garden Country Club locality at Fort Worth in search of such a form. He had the good luck to find a pyrite fossil which seemed to be extremely similar to *St. dispar*. Professor Adkins had the kindness to send me this specimen and to ask me to study and to describe it, and as the find is of certain importance I insert here the description of the ammonite:

Description.—The fragment discovered by Professor Adkins belongs to a discoidal shell; it is compressed on the flank and its whorls are of an elliptical cross section, much higher than broad; the outer whorl covers about one-half of the preceding one. The flanks are slightly flattened but still curved, the venter is strongly rounded. The umbilicus is moderately wide and its wall is steep but not vertical.

The ornamentation consists of nine ribs on one-fourth of the whorl and thus probably of some thirty-five on the whole whorl. Of the nine ribs four begin at the umbilical wall and show a slight radial swelling on the umbilical border. Between the first two primary ribs (counting from the mouth backward) there is one intercalated which begins in the ventral third of the flank. Between the second and third primary rib we find three intercalated ribs, the first and third of which begin in the ventral third of the flank while the one between them begins in the umbilical third of the flank. Between the third and fourth primary rib there is again only one intercalated rib which begins in the umbilical third of the flank, but the fourth primary rib of this side does not reach the umbilical wall on the opposite side and appears there as an intercalated rib, while the real fourth primary rib of the opposite side is an intercalated one on the side described above. This seems to be an exception but as the fragment is not much more than one-third of a whorl it is impossible to say if this condition is not characteristic for the species. In general none of the secondary ribs shows a swelling at its beginning, but they grow soon in breadth and thickness and on the venter the secondary ribs cannot be distinguished from the primary ones. The primary ribs are almost straight and radial on the flank but on the venter they bend decidedly toward the front. The secondary ribs are not parallel with the primary ones on the flank, but become so later on on the venter. Thus there is always a divergence of direction between the lower part of the primary and secondary ribs. All the ribs thicken somewhat on the venter. The interstices are much wider than the ribs.

Suture.—The suture is very well preserved on our fragment. The siphonal lobe is wide and deep, ending in two branches, between which we see the almost trapezoidal siphonal saddle. The external saddle is broad and high and of an almost quadrangular outline. Its upper part is divided by two shallow and narrow secondary lobes into three short branches, the one on the ventral side being much broader than the other two; the secondary lobe nearer to the umbilical side is deeper than the other one and it may be expected that in a larger specimen the difference would be still more considerable. On the sides of this saddle we find only small incisions. The first lateral lobe is only about one-third as wide as the external saddle and very deep, much more so than the siphonal lobe; it is decidedly bifid. The first lateral saddle is only about half as wide as the external saddle and of about the same height; it does not show a distinct division into various branches in the upper part, but only slight incisions and its upper outline is more rounded than that of the external saddle; one of the incisions is a little deeper than the others; the saddle appears as a little asymmetrical. The second lateral lobe is shallow and narrow, only one-third or one-half as deep as the first one, but it is also bifid. The second lateral saddle lies almost on the umbilical border, is very low and rounded with a few slight incisions. The first auxiliary lobe is half as deep as the second one and bifid. What now follows can be considered either as two auxiliary saddles with a slight auxiliary lobe between them, or as a broad auxiliary saddle divided by a relatively deep secondary lobe; the two branches of this saddle are rounded triangular and entire.

Dimensions:

Height of last whorl	13.3 mm.
Width of last whorl	9.9 mm.
Diameter of umbilicus	7.7 mm.

Relation to other species.—The species which resembles ours most is *Stoliczkaia dispar* d'Orbigny. A comparison with the figures given by Pictet et Campiche[102] shows that the ribs in the smaller specimens have similar bends to ours, although perhaps not quite as strong, but we must take into account that the specimen from Fort Worth is much smaller than any of the Swiss variety figured by Pictet. All these have a greater number of ribs than the individual from Texas and these ribs seems to be somewhat thicker and the interstices narrower in the Swiss specimens; but especially fig. 1 and the inner whorl of fig. 3 of Pictet show a great general similarity with *Stoliczkaia adkinsi* n. sp. One might say that our specimen resembles very much the large fragment figured by Pictet in his fig. 4; even the aspect of the venter is almost the same with the ribs curving forward, while the form of the ribs on the flank is astonishingly like those in the Texas specimen. Even the suture of this specimen

[102]Pictet et Campiche, **61**, p. 264, pl. xxxviii.

resembles that of our species still more than that of Pictet (fig. 1) and that of the Indian variety. The suture (fig. 4c of Pictet) is much less dissected than that of the much smaller specimen (fig. 1c of Pictet) and thus resembles that of our species. The wide and subquadrangular external saddle shows an inclination to subdivision into three branches and the adventive lobes which divide it are much shallower than in the other Swiss and the Indian suture. Very similar to that of our species is also the rather stout and little incised first lateral saddle of Pictet's fig. 4c, which in its somewhat asymmetrical form resembles also that of our specimen. The same can be said of the second lateral saddle. Quite similar is also the first auxiliary saddle with its two triangular rounded points. It can be well imagined that a small specimen of this Swiss variety may have a suture entirely like that of our individual. I do not doubt that fig. 4 of Pictet will have to be regarded as a different species from fig. 1 of Pictet. Which of these corresponds to the original of d'Orbigny cannot be said without a study of the French form; d'Orbigny's species appears rather different from all the others figured as belonging to the same species.

I owe an excellent photograph of the Indian representative of *Stoliczkaia dispar* to Professor Adkins (the original type from Vienna). A comparison with our species is rather difficult on account of the difference in diameter, but one can see that in general the resemblance is very great. In the Indian specimen the interior whorls are not very clearly visible, but it seems that there too the number of intercalated ribs between the primary ones is smaller than on the large outer whorl but all the ribs seem to be perfectly straight while in the specimen from Fort Worth they bend forward on the venter. In the Indian specimen the ribs are certainly narrower than on our fragment, but the difference is not very great. The number of ribs is possibly a little greater in the Indian specimen. The suture is in general very similar, but in the Indian specimen the first lateral lobe seems to lie nearer the venter than in ours, while the saddles are a little more dissected. These differences may be caused by the greater age of the Indian specimen and perhaps by the greater thickness of the venter, because there too the second lateral saddle lies on the umbilical border. Our species is evidently different from the Indian form and also from the European one, but it may very well be considered as the vicariating American representative of the group.

From the *Stoliczkaia* forms of the Del Rio clay this species is distinguished by the much greater number of ribs which are less straight and thinner. It is distinguished from that described by Scott by the apparently smaller number of ribs, the wider interstices and the narrower ribs.

Scott lays great stress on the circumstance that *Stoliczkaia dispar* occurs always just at the dividing line between the Albian (Vraconnian) and Cenomanian. Notwithstanding this, he finds the same species in the Pawpaw beds, the Del Rio clays and the Buda limestone or its representative. This seems to be quite a range for such a characteristic index fossil. Either this species has such a wide range and then it is useless as an index fossil for the finer subdivision of the strata, or there exist different species of the same genus, and then there is no reason why some of them should not occur in the Albian and others in the lower Cenomanian. In this latter case, which seems to be an established fact, only the finding of *Stoliczkaia dispar* s. s. would be decisive for the division of Albian and Cenomanian, but it is very doubtful if really the same species should be found in different and widely separated provinces, so that we can only hope to find species which belong to the same group. *Stoliczkaia adkinsi* n. sp. is certainly nearer to the real group of *St. dispar* than any other so far found in North America and therefore it can be considered as important for the determination of the division line between the Albian and Cenomanian, the more so as other elements of the different faunas allow us to come to the same result.

Number of specimens: 1.

Age: Highest Albian, Pawpaw clay.

Locality: Glen Garden Country Club at Fort Worth, Texas.

CENOMANIAN

AMMONITES FROM THE UPPER GEORGETOWN BEDS

TURRILITES BRAZOENSIS ROEMER

Plate I, Figure 1

1849 *Turrilites brazoensis* Roemer, **67**, p. 45.
1852 *Turrilites brazoensis* Roemer, **68**, p. 37, pl. iii, fig. 2.
1901 *Turrilites brazoensis* Hill, **37**, pl. xxxvii, fig. 3a.
1913 *Turrilites brazoensis* Whitney, **97**, p. 24, pl. xii, fig. 1.
1920 *Turrilites brazoensis* Adkins a. Winton, **2**, p. 45, pl. vii, figs. 14, 15.

This large species is found, mostly as fragments, in all the beds from the uppermost Georgetown to the Buda limestone, or at least all these beds contain *Turrilites* which are very nearly related to *T. brazoensis*, if they are not specifically identical with it. The group reaches its largest size in the upper Georgetown and decreases much in size in the upper two zones, where it is also much less frequent. Roemer figured only a fragment of a large whorl, and even this figure seems to be somewhat schematic.

Description.—Shell large, sinistral, turriculate, slender, with whorls of a subrectangular to subquadrangular cross section. Volutions separated from each other by deep seams.

The ornamentation consists of four rows of tubercles. The foremost row lies on the umbilical border or near it; it consists of high, radially lengthened tubercles, about seventeen to a volution. The second row lies on the front shoulder of the whorl and is just visible at the seam, half of it being covered by the next larger whorl; the tubercles of this row are larger than those of the first row, with a more rounded top and also lengthened radially oblique. They stand in pairs with those of the first row and are connected with them by slight elevations in small specimens and by rather broad and high ribs in the larger ones. Between the second and third rows exists a broad concave band, which in the smaller specimens is generally smooth, but in the very large whorls is crossed by faint elevations connecting the tubercles of the second and the third row. The tubercles of the third row are very sharp, high, oblique and spirally lengthened; they form the shoulder of a shelf on the flank, the other shoulder of which is formed by the fourth row of tubercles. The third row consists of about thirty tubercles on a whorl and the fourth row has the same number. The tubercles of the fourth row are a little smaller than those of the third row, but similar in form and extension. In the smaller whorls these two rows are separated by a concave and smooth space. One cannot say, as Adkins and Winton do, that the tubercles of the third and fourth row alternate, although it appears thus on small whorls, because in large whorls they are connected obliquely by thin but elevated ribs. The tubercles of the fourth row extend on the slanting space of the back end of the flank in an equal number of strongly sigmoidal ribs or plaits which do not correspond in number to the tubercles of the second row of the next smaller volution. Adkins and Winton mention a fifth row of tubercles, but I cannot find a real fifth row; what these authors mean are probably the ends of the plaits mentioned above, which in smaller specimens become somewhat obliterated on the slanting space of the backside of the flank, and which are a little more prominent near the seam toward the next smaller volution.

I have not been able to find a well preserved suture on any of our specimens, but the suture figured by Adkins and Winton shows that there is no difference in character between this species and that of other Cenomanian forms. The species stands by itself and can scarcely be compared to any known form of the Cenomanian age. It may be related to *Turrilites bosquensis*, but it is almost impossible to compare such a small form with the giant species *T. brazoensis* so long as no young whorls of the latter species have been found.

Number of specimens: 5.

Age: Lower Cenomanian, upper Georgetown beds, Del Rio clay (Buda limestone).

Localities: Arroyo del Tule, 50 kilometers from Villa Acuña; 2.5 kilometers from San Lorenzo on road to San

Miguel from Villa Acuña, Coahuila (upper Georgetown beds); 4.9 kilometers from Rancho Orégano on tunnel to San Miguel and San Carlos, region of Jimenez, Coahuila, Mexico (Del Rio clay).

ACANTHOCERAS CUNNINGTONI SHARPE VAR.

Plate II, Figure 1; Plate III, Figures 1–3

1853 *Ammonites cunningtoni* Sharpe, **74**, p. 35, pl. xv, fig. 2.
1858 *Ammonites cenomaniensis* Pictet et Campiche, **61**, p. 195, pl. xxv, fig. 4.
1863 *Ammonites cunningtoni* Pictet, **60**, p. 51, pl. v.
1898 *Acanthoceras cunningtoni* var. *cornuta* Kossmat, **43**, p. 18 (125), pl. v (16), fig. 1.
1907 *Acanthoceras cunningtoni* Pervinquière, **57**, p. 277, pl. xv, fig. 1.

A very large specimen of a diameter of more than two hundred mm. and several fragments of a very large and characterictic *Acanthoceras* were found just below the beds with *Exogyra arietina* and together with numerous *Turrilites brazoensis* and *Holectypus limitis* at the top of the Georgetown beds, immediately above the bed where *Kingena wacoensis* becomes most numerous. Unfortunately all the specimens are very large and no inner whorl has been found, but the ornamentation is so characteristic that there can be no doubt about the group to which these specimens belong.

Description.—This variety has about fourteen ribs on the last whorl which cross the flank radially, show a strong swelling just above the umbilical border and terminate in a long almost spine-like tubercle (pl. iii, figs. 1–3) at the side of the venter. The venter is smooth and convex but in the last part shows a slight keel-like elevation in the middle. Our specimens are compressed and therefore show a rectangular cross section (pl. iii, fig. 3) which is higher than broad, but part of the smaller portion of the whorl demonstrates that the whorl is at least subquadrangular; this part shows also that the subumbilical swelling probably developed from nodules on the internal volutions.

The suture is not very plainly visible on our specimens, but parts of it can be seen in different places. One recognizes the narrow and deep siphonal lobe, the broad external saddle which is divided by a deep adventive lobe, the deep and somewhat irregularly bifid first lateral lobe (pl. ii, fig. 1) and the relatively narrow and low first lateral saddle; the rest of the suture seems to be much lower than the elements mentioned here.

Affinities.—With respect to its ornamentation this specimen stands between the type and *Acanthoceras sussexiense* Sharpe,[103] and in its cross section it resembles this latter species still more, but the strong tubercles at the side of the venter have more resemblance to those of *A. cunningtoni.* On our larger specimen all these long spine-like tubercles are broken off and it cannot be seen whether they really developed from a double row of nodules. Kossmat mentions that in the English original the middle row of tubercles on the venter is replaced by a keel-like elevation which is scarcely perceptible; such an elevation seems to exist also on the venter of our specimen.

Pictet unites with *A. cunningtoni* also *A. sussexiense* Sharpe (non Mantell), but this seems to be impossible, although we know that the Cenomanian *Acanthoceras* vary greatly. The number of ribs is much greater and the cross section is different. Quite different also are the specimens which Pictet unites with this species, but especially his specimen in St. Croix (**61**, pl. xxv, fig. 4) is very similar to our form. Rather more different is the var. *cornuta* from India, described by Kossmat, especially with respect to the spine-like tubercles at the side of the venter, which in his variety (or species) take a more wing-like form.

Altogether it cannot be doubted that the form belongs to the group of *A. cunningtoni*, a species which characterizes the Cenomanian in England, France, Switzerland, North America, and India.

Number of specimens: 3 (fragments are quite common in some places).

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[103]Sharpe, **74**, p. 39, pl. xv, fig. 1.

Age: Lower Cenomanian (upper Georgetown beds).

Localities: Arroyo del Tule, 50 kilometers from Villa Acuña; cliff 2.5 kilometers from San Lorenzo on road from Villa Acuña to headquarters ranch of San Miguel, Coahuila, Mexico.

AMMONITES FROM THE DEL RIO CLAY

TETRAGONITES BRAZOENSIS N. SP.

Plate I, Figures 2–7

Among the material from McLennan County, Texas, I found in a single specimen of a typical *Tetragonites* which at the first view resembles very much *T. timotheanus* Mayor, but a closer investigation showed that it differs in several points, especially the form and the size of the umbilicus. As in these smooth forms the cross section, the umbilicus and the suture are the only elements which can vary and be compared, and as the difference between the species must be very small, I decided to describe this form as distinct from *Tetragonites timotheanus*, taking into account that even species like *T. timotheanus* from the Vraconnian and *T. epigonum* Kossmat from the Santonian are so little different that they might be easily confounded, at least in certain stages of growth. There can be scarcely any doubt that the younger forms of *Tetragonites* are derived from the group of *T. timotheanus*, and there certainly will be found similar species in the beds between the Santonian and the Vraconnian. Pervinquière[104] cites for example a *T. timotheanus* from the Cenomanian of Berroughia in Algiers, and that from the Zone No. 3, far above the Vraconnian. Thus it is not very surprising that we find a similar form in the Texas Cenomanian, and as it presents several distinguishing features we are justified in considering it as a distinct species.

Description.—Shell discoidal, thick, with inflated whorls of quadrangular-oval cross section, much wider than high. The flanks are very slightly rounded and somewhat flat-

[104]Pervinquière, 58, pp. 17, 18.

tened; the venter is almost flat and the border between the venter and the flank is strongly curved, which altogether gives it its subquadrangular cross section. The last whorl embraces four-fifths of the preceding one. The umbilicus is very narrow and deep, the umbilical walls are vertical, but the umbilical border is rounded. Ornamentation does not exist; the cast is entirely smooth; there are no constrictions on our specimen.

The suture is very similar to that of *T. timotheanus* Mayor. The siphonal lobe is narrow and deep, ending in two long branches between which rises a high and tapering siphonal saddle. The external saddle is high and slender, with a great number of incisions. The first lateral lobe is deep, a little less so than the siphonal one, moderately wide, and clearly bifid. The first lateral saddle is lower than the external one but similar in shape, ending also in three branches. The second lateral lobe is similar to the first one, but shallower; it is also decidedly bifid. The second lateral saddle is similar to the first one but much lower; it terminates in three branches, the external one of which is much smaller than the others. The first auxiliary lobe is narrow, similar to the lateral ones but much simpler and shallower; it is clearly bifid. The first auxiliary saddle is very broad and low, ending in two equal branches; it lies on the umbilical border. The second auxiliary lobe is very small and trifid. The second auxiliary saddle is small and pointed; these last two elements lie on the umbilical wall.

Dimensions:

Diameter	11.4 mm.	(1)
Width of the last whorl	6.9 mm.	0.61
Height of last whorl	5.7 mm.	0.50
Diameter of umbilicus	1.9 mm.	0.17

The nearest relative of this species is *Tetragonites timotheanus* Mayor,[105] which is easily distinguished from this form by the presence of strong oblique constrictions.

[105]Pictet et Roux, **62**, p. 259, pl. ii, fig. 6; pl. iii, figs. 1, 2.
Kossmat, **43**, p. 133 (37), pl. vii (3), figs. 11, 13.
Pervinquière, **57**, p. 74, pl. iii, figs. 24–26.

These are always present in small individuals and should be visible in our specimen, which is excellently preserved. We may call attention to the fact that *Tetragonites zacatecanus*[106] from the upper Albian of Camacho, Zacatecas, Mexico, also lacks those constrictions (furrows). The American species is much broader and more rounded in its cross section than *T. timotheanus*, the flanks are less flattened and the cross section on the whole less subquadrangular. The umbilicus is much narrower and in this regard resembles more *T. zacatecanus* Böse. The suture is quite similar to that of *T. timotheanus* but Kossmat's figure shows differences, especially in the first lateral saddle which appears to end in four branches, while in this species there are only three. In the original figure of Pictet we find also that the saddles end in four branches. A similar arrangement appears in the suture drawn by Pervinquière, although there it is not quite as conspicuous as in the above cited ones. *T. brazoensis* has only two auxiliary lobes, while *T. timotheanus* has at least three. These differences are very small but quite characteristic, and taken altogether they are sufficient to distinguish the species from *T. timotheanus*. We have already pointed out that *T. zacatecanus* does not show the furrows on the whorls; it is not improbable that this species may be the predecessor of *T. brazoensis*. No *Tetragonites* is known from the Albian of Texas.

It has been shown by different authors that the group of *Tetragonites timotheanus* Mayor has a worldwide distribution. It has been found in Switzerland, France, Tunis, Madagascar, India, Sakhalin, Vancouver, and California, everywhere apparently in the uppermost Albian and the Cenomanian. The age is not very easy to determine in every place, but it seems that the main horizon is the upper Albian. Pervinquière has cited this species from the Cenomanian of Algiers and from a horizon which cannot be very near the base of this formation. This occurrence would thus correspond to that of the species here described.

Number of specimens: 1.

[106]Böse, 11, p. 126, pl. ix, figs. 11–17.

Age: Lower Cenomanian, Del Rio clay.

Locality: No. 966 (W. S. Adkins), east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas.

TURRILITES BOSQUENSIS ADKINS

Plate I, Figures 8–23; Plate II, Figures 2–18; Plate III, Figures 4–10; Plate IV, Figures 1, 2

1920 Adkins, 1, p. 76, pl. iii, figs. 3, 7.

This species was well described by Adkins and needs only a few observations, especially with respect to the suture, which was not completely known to that author.

The description of Adkins applies also to our new material. We may add that the number of tubercles in each whorl and row varies between 13 and 17, but 14 seems to be the number in most of the specimens. Adkins says that the third row of tubercles (counting from the posterior part) lies at the exact margin between the volutions and is therefore covered. This is an error of observation, because in every specimen which I have seen, the third row of tubercles shows very plainly just above the seam, and they can be very well distinguished also in the figures given by Adkins. He also says that the tubercles on the third row are more closely spaced and more numerous than in the two first rows. This is equally an error; the tubercles are more closely spaced because the spiral on which they stand is smaller than those of the other two rows, but the number of tubercles is the same. Adkins has very well remarked that the tubercles of the third and fourth row are connected pair-wise by an obsolete radial ridge. We have to add that from every tubercle of the fourth row starts a sharp radial rib toward the umbilicus and disappears at the umbilical border.

Of the suture Adkins has seen only part of the siphonal lobe and a portion of the external saddle. On the flank only the siphonal lobe, the external saddle and part of the first lateral lobe appear. What Adkins took to be the first lateral lobe is the adventive lobe of the external saddle. I have been able to see the sutures on quite a number of specimens and to even draw one of them all around the whorl. On the flank we see the greater part of the siphonal lobe, although its internal branch is covered; it ends in two branches, between which we still see on the flank the relatively high siphonal saddle. The following external saddle is high and extremely broad, covering the greater part of the flank; it is divided by an adventive lobe about half as deep as the siphonal one. Now follows the deep and broad first lateral lobe divided by a small adventive saddle into two branches; part of this lobe is still visible on the flank, part of it is covered by the next larger volution; it is not quite symmetrical, one of the branches being bifid, the other trifid. Then follows the first lateral saddle, about half as high and half as broad as the external one; it is divided by a shallow adventive lobe into two parts and resembles in its general form the external one. This first lateral saddle lies in a small specimen on the zone occupied by the fourth row of tubercles and its corresponding radial ribs; in a larger specimen its external branch occupies the smooth space between the third and fourth row of tubercles, while the internal branch lies on the fourth row and its ribs; in a still larger specimen its external branch lies partly on the smooth zone mentioned and partly on the fourth row of tubercles, while the internal branch occupies the zone of ribs. The following second lateral lobe is bifid in the larger specimens but apparently pointed in a small individual, the only one which shows the whole suture; it is not as deep as the first lateral, and rather inconspicuous. The following second lateral saddle is broad and asymmetrical but considerably lower than the first one. Now follows a deep but narrow trifid lobe, strongly oblique backwards. This lobe should be considered as the antisiphonal lobe. On its internal side follows a high asymmetrical saddle divided into two branches by a shallow adventive lobe; it is about as high as the second lateral one and I consider it as the second lateral of the other side of the suture. It has a twisted form on account of the spiral winding of the whorl. Each of its branches is divided into two parts by smaller adventive lobes. There follows a rather narrow and oblique trifid lobe which I consider as the first lateral lobe of the dorsal side of the suture. Next to it we find a high and undivided saddle which of course must be the first lateral saddle. Adjoining it we see a deep although not very broad lobe which is evidently the first lateral lobe of the dorsal side of the suture, because it is followed by a high saddle divided by a shallow adventive lobe into two branches, this being certainly the external saddle of the dorsal side of the suture. The next lobe is the siphonal lobe described above. The only part of doubtful interpretation is the extremely broad second lateral saddle of the dorsal side, but as the lobe which divides it is much smaller than the following one I have regarded it as an adventive one.

At first view one might be inclined to take this *Turrilites* as belonging to the group of *T. acutus* Passy, but this species has only three rows of nodules. One might doubt if the fourth row on the umbilical side could be considered as so important that one should regard it as sufficient for the separation of two groups. If it was not for this fourth row I would not hesitate to consider this form as belonging to the group of *T. acutus* as described by Pervinquière[107] from the Cenomanian of Algiers which it otherwise resembles very much. But we know that there exist two different forms of *Turrilites*, one of which has three rows of tubercles and the other four. Pervinquière and the author[108] have already discussed the question of *Turrilites wiestii* Sharpe and *T. acutus* Passy; there does not seem to remain much doubt about the identity of the two; but Pervinquière[109] has already described a form with four rows of tubercles from the so-called Vraconnian of Tunis which he named *T. wiestii?* Sharpe. He rectified this determination in his work on Algiers and considered his Tunisian form as different from *T. wiesti* which he united with *T. acutus*. I have also described a form with four rows of tubercles

[107]Pervinquière, **58**, p. 51, pl. v, figs. 8–11.
[108]Böse, **11**, pp. 151–154.
[109]Pervinquière, **57**, p. 98, pl. iv, figs. 13–14.

under the name of *T. wiesti* Pervinquière (non Sharpe) from the upper Albian of Camacho, Zacatecas, where there also occurs a *Turrilites* with three rows of tubercles which I have described as *T.* aff. *acutus* Passy. Thus it seems that in northern Africa as well as in Mexico there are two groups of *Turrilites,* one with three, the other with four rows of tubercles.

Externally this species is much more similar to *T. acutus* Passy than to *T. wiesti* Pervinquière, on account of the angularity of the whorls and the deep furrows in which the seams lie. Pervinquière says that the sutures of the two African forms are different. This is certainly the case, but his sutures have been taken on specimens of very different size, and in general I find that the two sutures are quite similar. Pervinquière took his *T.* cf. *wiesti* later on as a variety of *T. bergeri* on account of the suture, but I find that the suture of this last species[110] is quite different and resembles much more that of *T. costatus.* The form of the first lateral lobe in *T. wiesti* Pervinquière is certainly different from that of *T. acutus* and resembles more that of *T. morrisi* Sharpe, as Pervinquière himself figures it.

The suture of *T. bosquensis* evidently resembles that of *Turrilites acutus* in a general way but differs for example with respect to the size of the adventive saddle in the first lateral lobe, which in the African species is much higher; especially in the smaller individuals of the American species this saddle becomes rather insignificant. The form and breadth of the external saddle is quite similar to that of the African form; the rest of the suture is unfortunately unknown in the latter species.

On the whole we can say that this species has certainly a near relationship to *T. acutus,* but that it is evidently a different species. I repeat that I do not consider the existence of the fourth row of tubercles on the umbilical side as something very important; all the other species with four rows of tubercles or more show these on the flank and have an entirely different character.

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[110]Pictet et Campiche, 61, III, pl. lviii, fig. 5.

Number of specimens: Several hundred.

Age: Lower Cenomanian, Del Rio clay.

Localities: Loc. 965* on Aquilla Creek, first east-west road north of the Tokio-Gholson pike; Loc. 964, east bank of South Bosque River, two miles south of South Bosque, near Bickle No. 2 well; Loc. 966, east side of Santa Fe track, 4.5 miles southeast of McGregor, McLennan County; Loma de la Cruz, south of Del Rio, Texas; south of Villa Acuña, Coahuila, Mexico; east of Reed Plateau, two miles south of Terlingua, West Texas.

BACULITES CFR. BACULOIDES MANTELL

Plate III, Figures 11–14; Plate IV, Figures 3–11

1822 *Hamites baculoides* Mantell, **46**, p. 123, pl. xxiii, figs. 6–7.
1840 *Baculites baculoides* d'Orbigny, **54**, p. 562, pl. cxxxviii, figs. 6–11.
1876 *Baculites baculoides* Schlüter, **69**, p. 139, pl. xxxix, figs. 14–15; pl. xl, fig. 1.
1907 *Baculites baculoides* Pervinquière, **57**, p. 92, pl. iv, figs. 7–8.
1910 *Baculites baculoides* Pervinquière, **58**, p. 21.
1923 *Baculites baculoides* Böse, **11**, p. 156.

Among our material there are three fragments of *Baculites* which I cannot distinguish from *Baculites baculoides* Mantell. The cross section is elliptical and the constrictions are very little oblique and the distance between them is like that in the specimens described by Pervinquière from Tunis.

The suture is entirely like the one figured by Pervinquière, but as our specimens are small, the antisiphonal lobe is very small, like one of the adventive lobes in the saddles. Pervinquière remarks that this is true also in small specimens from Algiers.

Baculites baculoides is common in the Vraconnian as well as in the Cenomanian of Europe and north Africa.

Number of specimens: 3.

Age: Lower Cenomanian, Del Rio clay.

*These localities are described in Adkins' *Geology of McLennan County.* Univ. Texas Bull. 2340 (1924).

Localities: Loc. 964, east bank of South Bosque River, two miles south of South Bosque, near Bickle No. 2 well; Loc. 966, east side of Santa Fe track, 4.5 miles southeast of McGregor, McLennan County, Texas.

STOLICZKAIA UDDENI N. SP.

Plate IV, Figures 12–15

Among the material from the Del Rio clay of McLennan County there are two ammonites which very probably belong to *Stoliczkaia* and which are different from the species described below. According to information from Professor W. S. Adkins this species is by no means rare in the upper portion of the Del Rio clay. Although it was not possible to make the suture visible, the generic position does not seem to be doubtful, and the species is certainly new.

Description.—Shell discoidal, evolute, with whorls of oval cross section, higher than broad. The outer whorl embraces about one-fourth of the preceding one. The flanks are flattened, the venter well rounded. The umbilicus is moderately wide; its walls are steep, almost vertical, but the border is well rounded.

The ornamentation consists of about twenty-one ribs on the venter, most of which on the largest whorl begin on the umbilical wall, while the rest begin above the umbilical border. In the smaller whorls the long ribs which begin on the umbilical wall alternate with short intercalated ones which begin in or above the middle of the flank. All the ribs cross the venter. They are always entirely straight and radial; they are narrow and high in the smaller whorls and rounded and broad in the largest whorl. The interstices are always much wider than the ribs.

Dimensions:

	I	
Diameter	42.6 mm.	(1)
Width of last whorl	18.2 mm.	0.43
Height of last whorl	21.6 mm.	0.50
Diameter of umbilicus	12.0 mm.	0.28
Width of penultimate whorl	9.9 mm.	0.23
Height of penultimate whorl	14.6 mm.	0.34
Umbilicus of penultimate whorl	6.6 mm.	0.13

II

Diameter	32.0 mm.	(1)
Width of last whorl	13.6 mm.	0.43
Height of last whorl	13.5 mm.	0.43
Diameter of umbilicus	7.5 mm.	0.23
Width of half whorl back	9.5 mm.	0.30
Height of half whorl back	1.5 mm.	0.36

From the species described by Pictet et Campiche[111] as *Stoliczkaia dispar* d'Orbigny our form is distinguished by the much smaller number of ribs in the younger individual. In *St. dispar* the intercalated ribs are generally two or three, while in this form there is never more than one intercalated rib. Another difference is that the ribs do not carry nodules in a stage where the *St. dispar* shows them, and the venter does not become flattened in the very smallest whorl. The peculiar divergence between the main ribs and the intercalated ones which according to Kossmat[112] exists in all European, Indian, and West African specimens of *St. dispar*, does not appear on this form. I do not attach much importance to the difference in dimensions as these seem to vary quite considerably in *St. dispar*, and also as our specimens are a little deformed.

Number of specimens: 2.

Age: Lower Cenomanian, Del Rio clay upper portion.

Locality: Loc. 951, McLennan County, Texas.

STOLICZKAIA AFF. DISPAR D'ORBIGNY

Plate V, Figures 1–8

1840 *Ammonites dispar* d'Orbigny, **54**, p. 143, pl. xlv, figs. 1, 2.
1860 *Ammonites dispar* Pictet et Campiche, **61**, p. 264, pl. xxxviii.
1863 *Ammonites dispar* Stoliczka, **90**, p. 85, pl. xlv, figs. 1, 3.
1875 *Stoliczkaia clavigera* Neumayr, **49**, p. 933.
1888 *Hoplites dispar* Choffat, **16**, p. 69, pl. ii, figs. 5–9.
1898 *Stoliczkaia dispar* Kossmat, **43**, p. 194 (98), pl. xxiv (10), figs. 2, 3.
1907 *Stoliczkaia dispar* Pervinquière, **57**, p. 388, pl. xii, figs. 9, 10; pl. xvi, figs. 19–23.

Among our Mexican material there are several ammonites which externally resemble *Stoliczkaia dispar* very much.

[111]Pictet et Campiche, **61**, p. 264, pl. xxxviii.
[112]Kossmat, **43**, p. 195.

Unfortunately none of these specimens shows even a trace of suture, and all of them are slightly deformed. The generic determination is therefore not quite certain.

Description.—Shell discoidal, compressed with whorls of elliptical cross section, much higher than broad. The outer whorl covers less than half the preceding one, in the largest specimen even less, at least in the oldest part. The flanks are flattened, the venter is strongly rounded. The umbilicus is moderately wide, its border well rounded, the walls steep but not vertical.

The ornamentation consists of about eighteen broad and straight ribs, most of which begin at the umbilical border, although some seem to be stronger than others in this place. A few ribs are intercalated and begin above the umbilical border. All the ribs swell toward the venter and cross it. They are separated by much wider interstices.

This description refers to the largest specimen we possess, but there are some smaller ones which probably belong to the same species. The largest of these shows the following features: Shell discoidal, very compressed laterally, consisting of whorls of subrectangular cross section, much higher than broad. The flanks are completely flat, which in part may be due to pressure; the venter is also flattened, which gives the form the subrectangular cross section, the curve between flank and venter being rather angular. The umbilicus is moderately large, its walls are steep but not vertical, the border is rounded.

The ornamentation consists of very low and broad ribs; these are rather faint near the umbilical border where most of them begin, but become stronger on the upper half of the flank, show a very slight tubercle where the flank joins the venter, cross the venter becoming very low. There are several intercalated ribs which begin about in the middle of the flank; at the venter they cannot be distinguished from the main ribs. The ribs are not quite straight but bend slightly forward. The nodules on both sides of the venter are especially well developed on the posterior part of the whorl, while toward the last portion they begin to disappear.

A still smaller specimen of which only some fragments were found is distinguished through its curved ribs; they cross the venter and show on both sides of it a row of small nodules (pl. v, figs. 6 and 8).

Dimensions:

	I		II	
Diameter	71.7 mm.	(1)	36.9 mm.	(1)
Width of last whorl	16.8 mm.	0.23	7.6 mm.	0.21
Height of last whorl	28.3 mm.	0.39	15.3 mm.	0.41
Diameter of umbilicus	22.1 mm.	0.31	9.8 mm.	0.27

Generic position.—We can judge only from the form of the specimens, which certainly resembles that of *Stoliczkaia* more than that of any other genus. The small specimens figured by Pervinquière from Tunis are very similar to our small specimens, while our medium sized one corresponds in a certain degree to the interior whorls of fig. 3 and perhaps still more of fig. 5 of Pictet et Campiche. Our largest specimen is a little different from the large specimens figured by Stoliczka and by Kossmat, but it seems to belong to the same genus. I doubt that we have the true *Stoliczkaia dispar*, for it may be a different species of the same genus. *Stoliczkaia dispar* has been cited from California by Anderson[113] but as there is no real description given and the specimens were not figured the occurrence remains doubtful. The same has to be said of the *Stoliczkaia dispar* cited by Lasswitz,[114] although this author gives a figure of the side view and does not show the venter. This author, whose unreliability has been mentioned by different paleontologists, does not give a real description, and the suture which he figures is quite different from that of the typical *Stoliczkaia*.

Number of specimens: 5.

Age: Lower Cenomanian, Del Rio clay.

Locality: 4.9 kilometers from Rancho Orégano on road to San Miguel and San Carlos, near Jimenez, Coahuila, Mexico.

[113]Fr. M. Anderson, 4, p. 106.

[114]Lasswitz, 44, p. 19, pl. iv, (16), fig. 1.

MANTELLICERAS WACOENSE N. SP.

Plate V, Figures 9–25; Plate VI, Figures 1–4

Description.—Shell discoidal, moderately involute, with whorls of rectangular cross section, with ventral corners cut off, always much higher than wide. The flanks are flattened, the venter is flat or very slightly convex but appears concave on account of the ventral rows of tubercles. The upper one-fourth of the flank forms a well accentuated angle with the rest of the flank as well as with the venter. This gives the cross section of the whorl the appearance of a rectangle with the upper corners cut off. The outer whorl covers two-thirds of the preceding one. The umbilicus is moderately narrow and not deep; its border is well rounded, its wall is steep but not vertical.

The ornamentation consists of ribs and tubercles. There are about twenty ribs on small individuals and some twenty-eight on large ones. In the smaller specimens about ten ribs begin at the umbilical border carrying there a high and pointed tubercle, in the largest one about sixteen. The other ribs are either very faint near the umbilical border, or begin in the middle of the flank. All the ribs become rather faint on the middle of the flank; in general they have a sigmoidal form and in the last fourth of the flank bend decidedly forward. Each rib, principal as well as intercalated ones, bears two nodules on the upper fourth of the flank, forming thus two rows of nodules, one of which accompanies the venter and the other goes parallel to it where the flank bends suddenly toward the venter. The number of tubercles is the same in both rows and corresponds to the number of ribs. While the umbilical tubercles are slightly elongated radially, those of the following ventro-lateral row are almost pointed; the tubercles of the ventral row are elongated spirally on the latest part of the outer whorl of the largest specimen but practically pointed on the inner whorls and on the smaller specimens. In the small individuals the ribs do not cross the venter or are at least very faint there, but in the large specimen they form low swellings on the venter.

The interstices between the ribs are wider than these; they are remarkably uniform on the upper half of the flank and cross the venter in the largest specimen, while in the small ones they die out at the ventral row of tubercles.

Suture.—The suture consists of four saddles and four lobes (five of each if we count the last auxiliary saddle as two). The siphonal lobe is deep, relatively narrow but occupies the whole breadth between the two rows of ventral tubercles. It is bifid with two long branches at the base, between which we observe a high somewhat tapering siphonal saddle. The external saddle is of a general rectangular outline; a moderately deep adventive lobe divides it into two branches, of which the one on the umbilical side is a little taller than the ventral branch; this is the case in the largest specimen, while in the smaller ones the difference in height is so small that it can be scarcely noted. The first lateral lobe is bifid, extremely deep and narrow; it ends in two long branches. The first lateral saddle is as high as the external one, but very narrow and slender. The second lateral lobe is regularly bifid and very shallow; it is not half as deep as the first one. The second lateral saddle is broad and low, has a number of very shallow adventive lobes; in the smaller specimens the second lateral lobe becomes irregularly trifid in the larger whorls, and the second lateral saddle shows only one adventive lobe. The first auxiliary lobe of the large specimen is pointed or perhaps trifid; then follows a broad and low auxiliary saddle divided by an adventive lobe into two equal parts; one might consider this saddle as two, but one can distinguish its development from a simple saddle with a slight indentation on the top to the well divided form in the large whorl. The next auxiliary lobe is deep and narrow and is followed by the first half of a low and broad auxiliary saddle.

This is a typical *Mantelliceras* or even *Acanthoceras* suture, and can be seen in practically every Cenomanian species of this genus; the features that the bifid lobes develop from trifid ones and that in the mature form the umbilical branch of the external saddle is a little higher than the ventral branch, and that the first lateral saddle is even a little higher than the external one, are very characteristic.

Dimensions:

	I	
Diameter	19.5 mm.	(1)
Width of last whorl	8.1 mm.	0.42
Height of last whorl	9.9 mm.	0.51
Diameter of umbilicus	4.2 mm.	0.22

	II		III	
Diameter	13.6 mm.	(1)	13.9 mm.	(1)
Width of last whorl	5.3 mm.	0.39	5.9 mm.	0.42
Height of last whorl	6.7 mm.	0.49	7.5 mm.	0.54
Diameter of umbilicus	2.6 mm.	0.19	2.4 mm.	0.17

	IV		V	
Diameter	10.8 mm.	(1)	9.9 mm.	(1)
Width of last whorl	4.2 mm.	0.39	4.0 mm.	0.40
Height of last whorl	5.2 mm.	0.48	5.0 mm.	0.51
Diameter of umbilicus	1.8 mm.	0.17	2.0 mm.	0.20

Among the known American species *Mantelliceras worthense* Adkins is certainly the nearest related one. Adkins[115] even cites this species from the Del Rio clay of the region where our specimens come from; I suppose therefore that he confused our species with *Acanthoceras worthense* in his preliminary determinations. There is no doubt that these are two distinct species. In the first place the dimensions are quite different; if we compare our individual III (diameter 13.9 mm.) with Adkins' I and II (diameter 14.9 and 13.8 mm.) we note at once the difference:

	Mantelliceras wacoense n. sp.	*Mantelliceras worthense* Adkins	
	III	I	II
Diameter	1	1	1
Width of last whorl	0.42	0.40	0.36
Height of last whorl	0.54	0.40	0.43
Diameter of umbilicus	0.17	0.09	0.07

Our species is much higher with respect to the diameter and to the width of the whorl, and the umbilicus is much wider than in *Mantelliceras worthense*. From the description of Adkins we know that his species has only one row of

[115]Adkins, 1, p. 57.

tubercles near the venter and that the latero-ventral row is either missing or very faint, as seems to be in his figures. Also the suture shows some difference; Adkins' suture is not taken from a mature individual, but even as it is, it is easily distinguished from that of this species. The external saddle has not quite the rectangular forms as in *M. wacoense* and the umbilical branch is much narrower. The first lateral lobe is much wider and shorter than that of *M. wacoense,* the first lateral saddle much more slender, the second lateral lobe much deeper.

Thus we have no doubt that *Mantelliceras worthense* is an older form and that it is a decidedly different species. We shall later on see that it is distinguished also from the species next to be described. It is very possible that both the younger forms developed from *Mantelliceras worthense.*

Gayle Scott describes *Mantelliceras worthense* Adkins under two names: *Acanthoceras martimpreyi* Coquand[116] and *Acanthoceras aumalense* Coquand.[117] This identification is entirely impossible. There is a great similarity between *Mantelliceras worthense* and *M. martimpreyi* but they are certainly different species as shown by the description of Adkins. The fossil determined by Scott as *Acanthoceras aumalense* is certainly not this animal; it lacks the characteristic broad venter of this latter species and the rectangular cross section of the whorl, and its ribs are too distinct on the lower part of the flank.

Adkins has already called attention to the similarity of *Mantelliceras worthense* to *M. martimpreyi* Coquand[118] and the related species *M. aumalense* Coquand[119] and *M. suzannae* Pervinquière.[120] These three species, especially the first two, are also very similar to *M. wacoense* n. sp. *Mantelliceras martimpreyi* has a greater number of ribs, the smooth zone of the venter is much wider, the umbilicus has a greater diameter, the suture of the mature form is different in details, the branches of the external saddle being equally

[116]Gayle Scott, **70**, p. 137, pl. i, figs. 7, 8.
[117]*Ibid.*, **70**, p. 139, pl. i, fig. 9.
[118]Pervinquière, **57**, p. 289, pl. xvi, figs. 1–5, 16–18; **58**, p. 41, pl. iv, figs. 2–10.
[119]*Ibid.*, **57**, p. 296, pl. xvi, figs. 6–11; **58**, p. 42, pl. iv, figs. 11–19.
[120]*Ibid.*, **57**, p. 298, pl. xvi, figs. 12, 13; **58**, p. 42, pl. iv, figs. 30, 31.

high, and the whole saddle somewhat more slender; the first lateral saddle is more slender and the second lateral saddle still more so, while the second lateral lobe is distinctly trifid and not bifid as in ours. Especially different are the younger specimens from those of our species, their ribs are more falciform and more numerous and the rows of tubercles near the venter are less distinct and not so prominent. Still less similar is *M. aumalense* on account of its broad venter and the rectangular cross section of the whorls, although there is a certain relationship through the vanishing of the ribs on the lower part of the flank. The dimensions are more like those of *M. wacoense,* only the inflated form which is not figured must be quite different. The suture is similar to that of our smaller individuals, only the first lateral saddle is much more slender than in our individual of the same diameter.

Quite different is *M. suzannae* on account of the cross section of the whorl, the extremely broad zone between the ventral nodules, the completely flat flanks and the great difference between height and width of the whorl; the suture is also quite different in details, the different elements being in general much more slender.

There is no doubt but that our species belongs to the group of *Mantelliceras martimpreyi,* but it is certainly specifically different. Still more similar to the African form is *Mantelliceras worthense* Adkins, which comes from a horizon somewhat older than ours. The three African forms occur in the Vraconnian of Tunis according to Pervinquière, but in Algiers they have been found in higher horizons, that is, above the beds with *Pervinquieria inflata* and together with *Mantelliceras mantelli* and *A. villei* at Aumale which certainly represents Cenomanian beds. At Berroughia these forms seem to occur in the middle Cenomanian and without doubt above the Vraconnian. It seems that the Tunisian Vraconnian of Pervinquière may contain part of what in Algiers is considered as Cenomanian.

Number of specimens: 5.

Age: Lower Cenomanian, Del Rio clay.

Locality: East side of Santa Fe tracks, 4.5 miles south of McGregor, McLennan County. Texas.

MANTELLICERAS BRAZOENSE N. SP.

Plate VI, Figures 5–43

There is a very common species among our material, which is found at almost every Del Rio locality at which Adkins collected. Unfortunately no mature specimen was found, but some fragments of larger whorls give us an idea of its ornamentation and mature suture. The dimensions seem to vary but little.

Description.—Shell discoidal, moderately involute with whorls of high trapezoidal cross section, always higher than broad, the greatest width lying at the umbilical border. The flanks are flat but are slightly bent over toward the venter in the last fourth of their height. The venter is flat or slightly convex but appears concave on account of the ventral rows of tubercles. The outer whorl covers about two-thirds of the preceding one. The umbilicus is narrow but not deep, its wall is steep but not vertical; the umbilical border is well rounded.

The ornamentation consists of about twenty-eight ribs on the largest whorl fragment, and of some twenty in small specimens. About five ribs begin at the umbilical border in a rather faint tubercle; all the other ribs begin above the first third of the flank, where they are faint, in small specimens scarcely visible. They grow quickly stronger and develop a faint nodule at three-fourths of the height of the flank; from there on the ribs bend suddenly forward and disappear at a row of very pointed tubercles; these are a little spirally elongated, very sharp, and steep toward the venter, the border of which they form. While the ventral row of tubercles is very well pronounced, the latero-ventral row is scarcely noticeable, and often developed only as a row of slight swellings, which cannot even be called nodules. In the typical individuals there are three or four ribs intercalated between the main ribs; in the smallest individual all the ribs begin in the second third of the height of the flank, and the lower third is entirely smooth. Near the venter all the ribs are equally strong. The interstices between them are not much wider than the ribs. In the largest fragment there is a slight indication of the ribs passing the venter in the form of low transversal swellings separated by very shallow and rounded furrows.

Suture.—The sutures are quite similar to those of *Mantelliceras wacoense* n. sp., but show some differences in the detail. The siphonal lobe is deep and narrow, occupying the width of the venter; it ends in two long lateral branches and has a rather high somewhat tapering siphonal saddle at the bottom. The external saddle is divided in two branches of almost equal width by a not very deep adventive lobe; both branches are strongly indented; they are almost of the same height. In one suture of the largest fragment, there seems to exist an irregularity and the umbilical branch appears much longer than the ventral one. In the smaller specimens the umbilical branch is very slightly longer than the ventral one. The first lateral lobe is very deep and narrow and much incised; it ends in two points in the large specimen as well as the smaller ones. The first lateral saddle is strongly incised, undivided and not quite as slender as the umbilical branch of the external one, but quite as high. The second lateral lobe is about half as long as the first one, narrow, much incised and ends also in two points in the largest as well as in medium sized whorls, but in the smallest whorls it becomes trifid or pointed. The second lateral saddle is slender at the base and broad above; a short adventive lobe divides it into two symmetric branches. On the large fragment it is incised, but in the medium whorls it is almost massive and only shows an indentation in the middle of the top. The first auxiliary lobe seems to be trifid or irregularly bifid in the largest suture; in the medium sized whorls it ends in a single point. The first auxiliary saddle is divided by a very narrow but rather deep adventive lobe; it is not as broad as the second lateral one. The second auxiliary lobe is not easily distinguished. The first auxiliary lobe lies on the umbilical border; the first auxiliary saddle and the second auxiliary lobe lie on the umbilical wall.

Dimensions:

	I		II	
Diameter	14.6 mm.	(1)	14.3 mm.	(1)
Width of last whorl	5.6 mm.	0.38	5.2 mm.	0.36
Height of last whorl	7.3 mm.	0.50	7.1 mm.	0.50
Diameter of umbilicus	2.8 mm.	0.19	3.0 mm.	0.21

	III		IV	
Diameter	13.7 mm.	(1)	12.7 mm.	(1)
Width of last whorl	5.1 mm.	0.37	5.0 mm.	0.39
Height of last whorl	6.6 mm.	0.48	6.0 mm.	0.47
Diameter of umbilicus	2.8 mm.	0.20	2.0 mm.	0.16

	V		VI	
Diameter	12.6 mm.	(1)	12.0 mm.	(1)
Width of last whorl	4.6 mm.	0.37	4.6 mm.	0.38
Height of last whorl	6.5 mm.	0.52	6.1 mm.	0.51
Diameter of umbilicus	2.2 mm.	0.17	2.1 mm.	0.18

	VII		VIII	
Diameter	11.5 mm.	(1)	11.2 mm.	(1)
Width of last whorl	4.9 mm.	0.43	4.8 mm.	0.43
Height of last whorl	5.5 mm.	0.48	5.9 mm.	0.53
Diameter of umbilicus	2.4 mm.	0.21	1.5 mm.	0.13

	IX		X	
Diameter	9.3 mm.	(1)	8.2 mm.	(1)
Width of last whorl	3.6 mm.	0.39	3.0 mm.	0.37
Height of last whorl	4.1 mm.	0.53	4.1 mm.	0.50
Diameter of umbilicus	1.5 mm.	0.16	1.4 mm.	0.17

The nearest form to this one is probably *Mantelliceras worthense* Adkins,[121] but the dimensions are very different, as one can see from a comparison of our individuals I and III with I and II of Adkins (compare these in our description of *Mantelliceras wacoense* n. sp.). This new species has much higher whorls, although the width is almost the same, and the umbilicus is much larger. The suture is also quite different, the umbilical branch of the external saddle is much broader, the whole saddle has a quadrangular form, the first lateral lobe is narrower and deeper, the first lateral saddle is broader. Much more similar seems to be the suture figured in pl. iv, fig. 4 of Adkins which does not very

[121]Adkins, 1, p. 93, pl. i, figs. 11–13, 15–17, 20–25; pl. iv, fig. 4; pl. iii, fig. 5.

well tally with the text figure 13. In the plate we see that the external saddle is much more like a quadrangle, although it seems to be differently incised; the first lateral lobe is certainly deeper and narrower; the first lateral saddle is quite similar to that of this species; the second lateral lobe is not quite as deep and the second lateral saddle seems to be of a different shape, especially lower, and the first auxiliary lobe not cut in quite so deep. Still we see that on the whole the suture is of the same type as in *M. brazoense* and differs only in details. The ornamentation is very similar, although Adkins does not mention the latero-ventral row of swellings which accompany the line where the flanks bend strongly toward the venter, but in his figures one can see that such swellings exist also in the species which he has described. It is very possible that both *Mantelliceras wacoense* and *M. brazoense* developed from *M. worthense*.

This species is of course also related to *Mantelliceras martimpreyi* and *M. aumalense*, especially to this latter one. The main difference is the much broader venter in this last species and probably the greater number of ribs, but the cross section is rather similar, especially with respect to the flat flanks, and the ornamentation is not very different. Quite similar is the ornamentation, especially the partial disappearance of the ribs on the umbilical side of the flank and the very slight swelling of the ribs at the point where they bend strongly forward. In *Mantelliceras martimpreyi* the ribs are much stronger and the cross section is not so rectangular.

Mantelliceras suzannae on the other hand has a still more rectangular cross section of the whorl, and the venter is comparatively broader. In all the three African species the suture is very similar to that of *M. brazoense* and there is no doubt that they belong to the same group.

Number of specimens: About 30.

Age: Lower Cenomanian, Del Rio clay.

Localities: Loc. 966, east side of Santa Fe track, 4.5 miles south of McGregor; Loc. 964, east bank of South Bosque River, two miles south of South Bosque near Bickle well No. 2; Loc. 955, on Aquilla Creek, first east-west road north of the Tokio-Gholson pike; all in McLennan County, Texas. Near Villa Acuña, Coahuila; on road from Rancho Orégano to San Carlos, near Jimenez, Coahuila, Mexico.

SCAPHITES BOSQUENSIS N. SP.

Plate VII, Figures 1–6

Description.—Shell subglobular, inflated, with whorls much wider than high, and of broad oval section. The flanks are very convex, the venter is very broad and evenly curved, much less convex than the flank. The last whorl embraces the preceding one almost entirely. The umbilicus is very deep, its border rounded; it is rather wide for the group. The umbilical wall is vertical.

The ornamentation consists of about sixty ribs on the venter which partly start from the umbilical border, partly bifurcate from ribs that start at that region; but the bifurcation does not always begin at the umbilical border, sometimes it occurs on the flank. On the umbilical border and the flank the ribs are strongly inclined forward, on the venter they curve very slightly forward. The ribs are very fine and are separated by interstices still a little narrower. No tubercles can be observed on the ribs.

The siphonal lobe is narrow and deep, ending in two long branches, between which a high and narrow siphonal saddle exists. The external saddle is broad and high, divided into two branches by a rather deep adventive lobe; the branches carry other and smaller incisions; the umbilical branch is rather inclined toward the umbilicus. The first lateral lobe is deep and narrow, ending in a long point; it is irregularly trifid. The first lateral saddle is much lower than the external one, broad and divided into two branches by a shallow adventive lobe. The rest of the suture could not be distinguished.

Dimensions:

Diameter	8.1 mm.	(1)
Width of the last whorl	9.3 mm.	0.90
Height of last whorl	2.7 mm.	0.33
Diameter of umbilicus	2.6 mm.	0.32

Scaphites bosquensis n. sp. belongs to the group of *S. aequalis* but differs from the original type by its ornamentation and by its relatively much greater width and the wide umbilicus. The species has some similarity with *S. hilli* Adkins and Winton.[122] In this latter species the undivided ribs on the umbilical border are long, while such are not developed on our specimen. The suture is different. The adventive lobe which divides the external saddle is much deeper than in *S. bosquensis*, the first lateral lobe is much broader and clearly bifid. There is no doubt that in larger specimens of this species the first lateral lobe will also become bifid, but in our individual, which is a little larger than the one from which the suture illustrated by Adkins is taken, the first lateral lobe is not yet in a mature stage, while this is the case in the fossil from the Pawpaw beds.

In another place[123] I have already called the attention to the fact that the group of *Scaphites aequalis* has a long life; it appears in the Vraconnian, has its greatest development in the Cenomanian and appears in isolated forms still in the Turonian and Coniacian.

Number of specimens: 1.

Age: Lower Cenomanian, Del Rio clay.

Locality: Loc. 964, east bank of South Bosque River, two miles south of South Bosque, near Bickle No. 2 well, McLennan County, Texas.

SCAPHITES SUBEVOLUTUS N. SP.

1924 *Scaphites* aff. *evolutus* Pervinquière, Adkins, Geol. McLennan County, pp. 56, 57.

Plate VII, Figures 7–30; Plate XVIII, Figure 8

Description.—Shell discoidal, very evolute in the internal whorls but becoming less so in the largest whorl. Whorls with oval cross section, wider than high in the mature whorl, but higher than wide in the smaller whorls. The flanks are well rounded, the venter shows a still stronger

[122] Adkins and Winton, 2, p. 37, pl. vii, figs. 3–6.
Adkins, 1, p. 79, pl. ii, figs. 1-12.

[123] Böse, 11, p. 165.

curvature in the mature whorl, while in the small whorls the curvature is the same on the flank as on the venter. The outer whorl covers more than half the preceding one (diameter 14.4 mm.) while in the next similar specimen (11.1 mm.) the outer whorl scarcely covers more than one-tenth of the preceding one; in the smallest individual (5.0 mm.) the whorls barely touch each other. The umbilicus is very wide in the smallest individual (about one-half of the diameter) and much narrower in the oldest one (about one-third the diameter). The umbilical wall is steep in the smaller whorls, but not deep; in the largest whorl it becomes vertical and the umbilicus appears rather deep.

The ornamentation is very characteristic. The three smallest whorls are entirely smooth; the first half of the fourth whorl carries about nine more or less elevated ribs, separated by wide interstices; the venter remains smooth (pl. vii, figs. 24, 29, 30). The next whorl shows twenty strong ribs, slightly sigmoidal; on the venter they curve strongly forward and become thin. Between them we find here two to four thin ribs intercalated, but these appear on the highest part of the flank and are of the thickness of the main ribs on the venter. The ornamentation remains the same from here on, but the ribs become stronger and the secondary ones reach down to the upper third of the flank. The primary ribs are here very prominent but narrow and separated by wide interstices; the secondary (and on the venter also the primary) ribs are thin but sharp and are separated by interstices about as wide as the ribs.

Suture.—The siphonal lobe is narrow and deep; it ends in two long branches and has between them a high and broad siphonal saddle. The external saddle is high and broad; a shallow but narrow adventive lobe divides it into two main branches which show a number of small incisions. The first lateral lobe is narrow and deep, about as long as the siphonal one; it ends in an irregularly trifid form with one long branch extending below the others, which gives it the appearance of being pointed. The first lateral saddle is slender and high, almost as much as the external one; it ends in two prongs. The second lateral lobe is narrow and very shallow; it is not quite half as deep as the first one; it is funnel shaped and ends in a rounded point. The second lateral saddle lies on the umbilical border; it is oblique triangular but rounded at the top. There follows an oblique and very shallow and narrow funnel shaped auxiliary lobe and a small triangular equally oblique auxiliary saddle on the umbilical wall. The suture of the small whorls is essentially the same, although the different elements become simpler; the first lateral lobe appears very broad and shallow and becomes trifid; all the branches are of about the same length. The auxiliary lobe and saddle begin to develop in the fifth whorl.

Dimensions:

	I		II	
Diameter	14.4 mm.	(1)	11.1 mm.	(1)
Width of last whorl	6.4 mm.	0.44	3.7 mm.	0.33
Height of last whorl	6.1 mm.	0.42	4.5 mm.	0.41
Diameter of umbilicus	4.6 mm.	0.32	4.7 mm.	0.42

	III		IV	
Diameter	9.3 mm.	(1)	8.8 mm.	(1)
Width of last whorl	3.0 mm.	0.32	3.3 mm.	0.38
Height of last whorl	3.5 mm.	0.38	3.6 mm.	0.41
Diameter of umbilicus	3.8 mm.	0.41	3.3 mm.	0.38

	V		VI	
Diameter	7.6 mm.	(1)	5.0 mm.	(1)
Width of last whorl	2.7 mm.	0.36	2.0 mm.	0.40
Height of last whorl	2.9 mm.	0.37	1.6 mm.	0.32
Diameter of umbilicus	2.9 mm.	0.37	2.5 mm.	0.50

Generic position.—From its ornamentation and the circumstance that the smaller the whorls are, the less they cover the preceding ones, the species has all the appearance of a very evolute *Scaphites*, that is, the coiled part of it, while the hook is missing. But the suture which in general is quite that of a *Scaphites* has a first lateral lobe which is apparently irregularly trifid, while the first lateral lobe of *Scaphites* is always bifid. It is probable that the suture is not quite mature, as is also to be supposed on account of the last whorl not covering enough of the preceding one for a mature *Scaphites*. We know that the lobes of this genus develop from the trifid form into irregularly trifid and then by the faster growth of one of the branches, which to that stage was much shorter than the longest one, become bifid. We see in the smaller whorls of this species that the first lateral lobe is decidedly trifid with branches of equal length; it is therefore to be presumed that in a later stage the first lateral lobe will become bifid.

Notwithstanding this doubt about the generic position of the species, I have not hesitated to name it, first because it is one of the most widely distributed forms of the Del Rio clay and very common at every locality, and second on account of its great similarity with a species from the Cenomanian of Algiers, north Africa. It fits in so well with the rest of the fauna that it could not be very well left unnamed, the more so, as the species is very characteristic and easily distinguished from all others.

Relation to other species.—The very nearest relative of this species is *Scaphites evolutus* Pervinquière[124] from the Cenomanian of Aumale in Algiers, north Africa. As its name indicates this form is also very evolute for a *Scaphites* although not quite as much as is this new species. The ornamentation is very similar, but the number of ribs may be still greater in the African individuals. The whorls are more inflated and rounded, and much broader than high. The umbilicus is considerably narrower than in the American form. The suture is very similar in general with exception of the bifid first lateral lobe and the somewhat more slender external saddle.

Quite similar also is *Scaphites peroni* Pervinquière[125] especially the suture figured by Pervinquière in his text figure 11. But the ornamentation is not as regular as in *S. subevolutus* or in *S. evolutus*.

Both the African species occur in rather high zones of the Cenomanian. *Scaphites evolutus* is frequent in the upper Cenomanian zone with *Discoidea forgemoli* and *Turrilites costatus*, which also carries *Acanthoceras rotomagense* var. *hippocastanum*, at Aumale; *S. peroni* occurs in

[124]Pervinquière, **58**, p. 25, pl. ii, figs. 3–9.

[125]*Ibid.*, **58**, p. 26, pl. ii, figs. 10–16.

zone No. 3 of Berroughia which is also high in the Cenomanian.

Number of specimens: About 30.

Age: Lower Cenomanian, Del Rio clay.

Localities: Loc. 966 east side of Santa Fe track, 4.5 miles south of McGregor; Loc. 964, east bank of South Bosque River two miles south of South Bosque, near Bickle No. 2 well; Loc. 955 on Aquilla Creek, first east-west road north of the Tokio-Gholson pike, all in McLennan County, Texas. Foot of Reed Plateau, two miles south of Terlingua in West Texas.

ENGONOCERAS BRAVOENSE N. SP.

Plate VII, Figures 31–35; Plate VIII, Figures 1–8

Engonoceras is one of the most common genera in the Del Rio clay everywhere I have searched for fossils on the Mexican side of the Rio Bravo in the vicinity of Villa Acuña (opposite Del Rio, Texas). In Texas it is not at all rare as is shown by the collection made by Adkins. All the specimens seem to belong to the same species which is different from any so far described.

Description.—Shell discoidal, flattened with entirely embracing whorls, the last whorl being much higher than half the diameter of the shell. The whorl has the form of a high triangle cut off at the point in the small individuals, but becomes elongated oval in the larger ones. Therefore the greatest width is near the umbilical border in the small specimens and near the middle of the flank in the large ones. The flanks are perfectly flat in the small individuals and slightly curved in the large ones. The venter is perfectly flat and bordered by two very sharp edges in the small specimens; in the large ones it becomes first slightly rounded but still showing the edges, which are not very sharp, and then becomes entirely rounded showing neither a flat space nor edges. This is mainly the case on the living chamber. The umbilicus is narrow and shallow. The species has no ornamentation at all; it is entirely smooth.

Suture.—The suture is strongly inflected and often asymmetrical, as is so frequently the case in *Engonoceras*. The siphonal lobe is broad and shallow, ending in two branches which are very oblique; between them is an extremely low siphonal saddle. The external saddle is divided by four adventive lobes, unless the small one nearest to the venter is considered when it is even divided by five adventive lobes. In the distinction of external saddle and first lateral lobe the usage of Joh. Böhm is followed, although it is not always easy to say which is the first lateral lobe. It is certain that the adventive lobes change in the same species in number and even in the same individual. Thus a small specimen in the collection shows on one side four adventive lobes and on the other only three. The two largest specimens on the contrary have as many as six adventive saddles. As long as the species were few in number, the definition of Böhm was justified, i.e. that *Engonoceras* has four adventive saddles, but the figures of Hyatt prove that the number of adventive saddles may change. In *Engonoceras subjectum* Hyatt[126] five or even six adventive saddles can be counted. Hyatt avoids the question by not accepting the definition of Böhm and by counting simply the whole number of saddles and lobes. I consider as the first lateral lobe the one which is deepest, and from which on toward the umbilicus the lobes are notably shallower than those toward the venter. I consider the small lobes near the venter, which may change in number and sometimes are two and sometimes only one, as secondary incisions which do not count as adventive lobes.

In this manner I find on our two largest specimens three adventive saddles which are entire and a fourth one which is divided into three secondary saddles in the largest specimen, and into four in the second largest individual. This number is never reached in one of the small specimens; there three entire saddles and another one divided by a small secondary lobe are generally distinguished. As all specimens come from the same horizon and do not differ in shape, I consider the number of secondary incisions as irrelevant. The lobes are partly bifid and partly irregularly trifid. All the auxiliary lobes (five in the larger specimen as far as they could be counted) seem to be all bifid; the first lateral

[126]Hyatt, **38**, p. 168, pl. xxi, figs. 2–6; pl. xxii, figs. 1–5.

lobe is bifid and also the second one; the secondary incisions of the external saddle seem to be all trifid. The saddles are all entire with exception of the first auxiliary saddle which is divided by a small secondary lobe; this is the case in even very small specimens. The form of the saddles and lobes changes somewhat where the sutures are very crowded, which happens only from the first lateral lobe toward the umbilicus. There the saddles become lower and apparently broader and the lobes still narrower than in general. All the lobes are much narrower than the saddles; the narrowness of the lobes is a characteristic feature of the species.

Dimensions:

Diameter	20.0 mm.	(1)
Width of last whorl	3.7 mm.	0.19
Height of last whorl	11.3 mm.	0.57
Diamter of umbilicus	1.6 mm.	0.09

Relation to other species.—This species is rather exceptional among the American members of the genus; it is distinguished by the narrow lobes and the great number of incisions on the umbilical branch of the external saddle. There is a certain similarity in the specimen which Hyatt considers as *Engonoceras uddeni* Cragin,[127] but this species has a row of nodules on both sides of the venter. This species is entirely smooth, which also gives it a special position among the American *Engonoceras*. As most of the other species of this genus come from a lower horizon this species may represent a higher stage of development. It cannot be said that it leads over to *Metengonoceras*, as this genus according to Hyatt occurs in the Fredericksburg (Albian) as well as in the Eagle Ford shales (Turonian) or partly upper Cenomanian. Spath[128] separates these latter forms from *Metengonoceras* under the new genus *Epengonoceras*. There is a very great similarity between this species and *Engonoceras thomasi* Pervinquière[129] from the Cenomanian of Foum el Guelta in Tunis. The form of this African

[127]Hyatt, **38**, p. 159, pl. xix, figs. 1–6.
[128]Spath, **83**, p. 508.
[129]Pervinquière, **57**, p. 202, pl. ix, fig. 6.

species is practically the same as *E. bravoense*, perhaps a little thicker, and within the umbilicus slightly wider. The suture is also very similar, showing the high saddles and narrow deep lobes. The umbilical branch of the external saddle is subdivided by a small secondary incision very similar to that of the smaller individuals of our species. The lobes are perhaps a little more serrated in the African form but certainly not very much. Even the curvature of the suture resembles that of this new species.

Pervinquière insists in this place as well as in others that the method of Joh. Böhm in dividing the genera by the number of adventive saddles in the external saddle is of very doubtful value. He would be certainly right, if the genera were separated only on account of this feature, but I cannot see that anyone would be able to confound *Engonoceras* with *Knemiceras*, as the form of the saddles is quite different, not to speak of the external form of these genera. Still less similar are *Placenticeras* and *Knemiceras*, at least as far as real *Placenticeras* are concerned. The generic position of most of the European and African forms from the Vraconnian and Cenomanian cited as *Placenticeras* appears to me as very doubtful; they are certainly different from the real *Placenticeras* of the Santonian and Campanian.

Number of specimens: About 20.

Age: Lower Cenomanian, Del Rio clay.

Localities: Small pyrite specimens from Loc. 966, east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas. Larger calcareous specimens from different places near Del Rio and Villa Acuña, Coahuila, especially from near the road between Rancho Orégano and San Carlos, and on the road from Villa Acuña to San Gregorio in the valley of the Rio Zorrilla, Coahuila, Mexico.

ADKINSIA NOV. GEN.

(Genotype: *Adkinsia adkinsi* Böse)

In 1920 Adkins[130] described and figured under the name of *Flickia*(?) *bosquensis* a clydonitic ammonite which on ac-

[130]Adkins, 1, p. 87, pl. i, fig. 4; pl. iv, fig. 11.

count of its simple suture he compared in first line with *Flickia* Pervinquière and also with *Neolobites* Fischer. Having at that time found only one specimen he could not very well create a new genus for this form, although he was able to indicate the main features which distinguish this ammonite from the typical *Flickia*. Later he found a number of different specimens evidently belonging to the same group and this material he kindly turned over to me for a more detailed study.

A careful examination of the material has shown that at least four forms in addition to the one described by Adkins can be distinguished, differing in ornamentation and in the details of the suture, but all having a number of features in common which unite them in a well circumscribed group. Thus I have not hesitated to establish a new genus *Adkinsia* for these forms notwithstanding the similarity of the suture with that of *Flickia*. My reason for this is the decidedly different ornamentation of *Adkinsia*, a slight difference in the suture and the different age. While the real *Flickia*, represented in Texas by *Flickia boesei* Adkins, occurs in the lower third of the Pawpaw beds, *Adkinsia* has been found only in the middle Del Rio clay, which according to Adkins corresponds to the base of the Grayson marls. This means that the layer of *Flickia* is about 15 to 20 meters lower than that of *Adkinsia*. Between them is the Main Street fauna with the characteristic *Turrilites brazoensis* Roemer. I do not doubt that the numerous zones in the upper middle Cretaceous distinguished in north Texas are mainly of local value, but the greater subdivisions made there are certainly real stratigraphic zones as in the present case. When the ammonite fauna of the Pawpaw beds is compared with that of the Del Rio clay (or lower Grayson marls), a great similarity between them is found, but they are not identical. Many of the ammonites of the Del Rio clay evidently have their ancestors in the Pawpaw beds, which makes these two formations appear to be intimately related, while the ammonite fauna of the higher Buda limestone is quite different, although the rest of the fauna is rather similar.

It has been shown that notwithstanding the similarity of the ammonite fauna the Pawpaw beds represent the highest Albian, while the Del Rio clay belongs to the upper portion of the lower Cenomanian. Thus there can be no doubt that *Flickia boesei* Adkins is a relatively much older form than the species belonging to the new genus *Adkinsia;* so far these two genera never have been found in the same bed. The conditions are, probably, that *Flickia,* a very aberrant form, living in Pawpaw time, changed its character during the short Main Street time, and from it developed *Adkinsia* in lower Grayson time; it would not be astonishing if the main branch *Flickia* persisted up to the Grayson time but so far it has not been found in this zone, although Adkins[131] cites an ammonite aff. *Flickia* from the middle Grayson marl. But his indications are rather vague (small, keelless) and do not establish the occurrence of *Flickia* in this higher bed with any degree of certainty.

The relation between these beds and the European zones has already been discussed. Here we are only interested in the fact that in Texas *Flickia* is older than *Adkinsia.*

Definition of the genus.—Shell discoidal, more or less inflated, generally rather involute, with whorls of elliptic cross section, generally broader than high, but also sometimes higher than broad. The flanks are curved, mostly a little less than the venter which is well rounded. No keel exists on any of the species. The umbilicus is moderately narrow and deep; its walls are more or less steep. The umbilical border is always rounded.

The umbilical border shows 8-12 sharp nodules; in the interior whorls these nodules are very faint but from a certain point on they become very prominent. They are generally elongated radially. From these nodules an equal number of ribs starts; these are mostly curved or bent forward and become very faint near the venter, although in some cases they cross the venter as very low and indistinct swellings.

Suture.—The suture is extremely simple, consisting of three lobes and three saddles. All the saddles are entire

[131]Adkins 1, p. 57.

show any great resemblance to *Adkinsia* or to *Flickia*, and it is practically impossible to prove to whàt tribe these two genera belong.

ADKINSIA ADKINSI, N. GEN., N. SP.

Plate VIII; Figures 9–14

Description.—Shell discoidal, rather involute, with whorls of high elliptical cross section, higher than broad. The flanks are rather slightly curved, the venter is strongly curved and well rounded. The outer whorl covers about half of the preceding one. The umbilicus is narrow, moderately deep; its walls are not very steep, although their curvature is stronger than that of the flanks.

The ornamentation of this species consists of about 12 very slight, tubercle-like thickenings on the umbilical border; they are scarcely perceptible. Near the end of the outer whorl two of these become more prominent and appear as radially elongated, very low tubercles extending into very low forward-curving broad ribs which disappear near the venter.

Suture.—The suture is clydonitic as in the related genus *Flickia.* It consists of a siphonal, two lateral lobes, the external saddle and two lateral saddles, the second one of which is also completely visible, part of it being on the steep part of the umbilical wall. The siphonal lobe is wide, covering the greater part of the venter and has a very low siphonal saddle. The external saddle is moderately broad, a little wider than the siphonal lobe; it is well rounded and a little steeper on the ventral side than on the umbilical flank. The first lateral lobe is narrow but deeper than the siphonal one; it is slightly asymmetrical, the umbilical side being quite vertical, while the ventral one is more slanting. The first lateral saddle is about half as high as the external one and is not well rounded but has a rather rectangular form with rounded corners. The second lateral lobe is shallow, much less deep than the first one but about as wide; it is well curved, like a section of a circle. The second lateral saddle is low, somewhat angular, but less so than the first lateral saddle; half of it lies on the umbilical wall. The following lobe is visible only in a small part, most of it belonging to the internal part of the suture.

Dimensions:

Diameter	12.3 mm.	(1)
Width of last whorl	5.4 mm.	0.44
Height of last whorl	6.0 mm.	0.49
Diameter of umbilicus	2.9 mm.	0.24

Relation to other species.—This species, of which only one very well preserved specimen has been found, is entirely different from the rest of the forms which belong to the new genus. To a certain degree it forms the transition to *Flickia*, as it appears almost smooth at first view; but the angular form of certain parts of the suture, and the existence of slight tubercles and ribs does not leave any doubt that this form belongs really to *Adkinsia*. It differs from all the other species through its compressed form, its narrow umbilicus, the very inconspicuous ornamentation and the outline of the suture. *Adkinsia bosquensis* Adkins is much more inflated and has a wider umbilicus and much more prominent ribs; unfortunately Adkins does not give a figure of the front nor of the venter, nor the relations of the dimensions; all this because his specimen was somewhat mutilated; this makes a comparison with this species rather difficult, but there does not remain any doubt about their being different species.

Number of specimens: One.

Age: Lower Cenomanian, Del Rio clay.

Locality: Loc. 966 east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas.

ADKINSIA SPARSICOSTA N. SP.

Plate VIII; Figures 15–20

Shell discoidal, moderately involute with whorls of not very highly elliptical cross section, considerably broader than high. The flanks are moderately curved, the venter is strongly curved and well rounded. The outer whorl covers a little less than half the preceding one. The umbilicus is not very narrow but deep, its walls are moderately steep and their curvature is stronger than that of the flanks.

The ornamentation consists of 10 well defined narrow ribs, inclined forward, separated by much wider interstices. In the interior whorls these ribs are very short and only slightly elongated tubercles and not very prominent. At the beginning of the last whorl they become prominent but are first nothing but tubercles, then they grow little by little in length and the last four even cross the venter while the interstices appear as shallow and broad furrows across the venter. The ribs begin at the umbilical wall, appear first narrow and high, but broaden on the flank and are broad and well rounded on the venter.

Suture.—The sutures have in general the character of other species of the genus, but differ in their details. They consist of three lobes and three saddles. The siphonal lobe is very broad, funnel like, the flanks are not very steep and the siphonal saddle at its bottom is very low. The upper portion of the lobe covers practically the whole width of the venter. The external saddle is at the bottom almost as broad as the siphonal lobe but narrows strongly toward the top; still it is well rounded there; its ventral flank is much steeper than the umbilical one. The first lateral lobe is deeper than the siphonal one but not quite as broad; it is well rounded at the bottom and but very slightly asymmetrical, the umbilical flank being a little steeper than the ventral one. The first lateral saddle is only half as high as the external one, but is almost as broad; it is very slightly angular with well rounded corners. The second lateral lobe has a very peculiar form, its bottom being practically straight and forming a broken angle with the sides which are curved. This peculiarity is especially evident in the smaller sutures but exists also in the later ones where the straight part ascends slightly toward the ventral flank. The second lateral saddle is very small and low, but broad at the bottom narrowing toward the rounded top, the umbilical flank being steeper than the external one. This saddle lies entirely on the umbilical wall. The next lobe is only half visible, the other half belonging to the internal suture. The sutures are widely separated in the older part of the last whorl, but crowd together in the external portion of it.

Dimensions:

Diameter	15.6 mm.	(1)
Width of last whorl	6.6 mm.	0.42
Height of last whorl	6.0 mm.	0.38
Diameter of umbilicus	4.9 mm.	0.31

Relation to other species.—This species, of which only one specimen has been found which is excellently preserved, is easily distinguished from all the others described here, and also from *Adkinsia bosquensis* Adkins. The narrow ribs which in a later stage cross the venter, are not found in any other species; its umbilicus is much wider than that of *Adkinsia adkinsi*. Its suture is more rounded than that of most of the other species and the straight bottom of the second lateral lobe is very characteristic. The general form of the shell is less inflated than *A. bosquensis* Adkins or *A. tubercalata* n. sp., but much more than *A. adkinsi* n. sp.

Number of specimens: One.

Age: Lower Cenomanian, Del Rio clay.

Locality: Loc. 966, east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas.

ADKINSIA TUBERCULATA N. SP.

Plate VIII, Figures 21–26

Shell discoidal, somewhat involute with whorls of elliptical cross section, broader than high. The flanks are a little less curved than the venter, the curve of the latter one being quite strong, but the venter is well rounded. The outer whorl covers almost half of the preceding one. The umbilicus is narrow, not very deep, its walls are moderately steep and the border rounded. The umbilical border appears prominent on account of the sharp nodules beginning abruptly on it.

The ornamentation consists of about 10 nodules which begin abruptly on the umbilical border; the four innermost ones of the outer whorl are scarcely discernible and very low, but the next three forward are quite prominent and high, but very little elongated and inclined forward. The last three nearest to the mouth begin less abruptly; they are narrow, high and sharp and can be considered as narrow ribs which disappear before they reach the external third of the flank. They are decidedly inclined forward. These ribs are separated by very wide interstices with a well rounded bottom.

Suture.—The sutures are well separated from each other in the inner part of the whorl, but in the one nearer to the mouth they crowd together in such a way that in some places they touch each other, that is, the first lateral lobe of the front suture touches the first lateral saddle of the one behind it. But this kind of distribution is by no means regular; the suture nearest to the mouth is well separated from the next one, then follow backwards five sutures which touch each other in the way described; they are succeeded by two behind them, which are well separated from them and from each other; the next two following backwards touch each other as described above, but are well separated from those behind as from those in front. All the rest of the sutures following behind are well and rather widely separated from each other. The sutures consist of three lobes and three saddles, as in all other species of the genus. The siphonal lobe is very narrow and very deep, containing a relatively low siphonal saddle, which is a little higher than in most of the other species. The flanks of the siphonal lobe are almost vertical. The external saddle is a little broader than the siphonal lobe, very high and well rounded at the top, while the flanks are practically vertical. The first lateral lobe is extremely narrow, somewhat oblique, a little asymmetrical with almost parallel sides and slightly deeper than the siphonal lobe; the bottom is inclined toward the umbilical side, its deepest part lying nearest to the umbilicus. The first lateral saddle is broader than the external one but considerably lower; it is somewhat angular and asymmetrical at the top and the external flank is steeper than the umbilical one. The second lateral lobe is very shallow, scarcely half as deep as the first one; it is well rounded on the bottom and the sides are not very steep. The second lateral saddle is similar to the first one but smaller; it just reaches to the umbilical seam; it occupies the umbilical wall.

Dimensions:

Diameter	15.0 mm.	(1)
Width of last whorl	7.2 mm.	0.48
Height of last whorl	6.8 mm.	0.45
Diameter of umbilicus	4.0 mm.	0.27

Relations to other species.—The nearest related species is probably *Adkinsia bosquensis* Adkins, but its suture is very different, the first lateral lobe being much wider than in this species, the external saddle broader and lower. Also the ornamentation is different, the tubercles of *A. bosquensis* being much broader and stronger than in this species. A comparison of dimensions is not possible because Adkins does not give them and they cannot be measured in his figures. Two of our specimens are considered as being probably identical with *Adkinsi bosquensis* Adkins, although the suture does not seem to be entirely the same as the original; in their description we shall mention the difference with *A. tuberculata.*

Number of specimens: One.

Age: Lower Cenomanian, Del Rio clay.

Locality: Loc. 964, east bank of South Bosque River, two miles south of South Bosque near Bickle No. 2 well, McLennan County, Texas.

ADKINSIA BOSQUENSIS ADKINS SP.

Plate IX, Figures 1–6

1920 *Flickia* (?) *bosquensis* Adkins 1, p. 87, pl. i, fig. 4; pl. iv, fig. 11.

Among the material from McLennan County, Texas, there is one large and one small specimen, which seem to agree rather well with the form described by Adkins as *Flickia* (?) *bosquensis.* There are small differences, but they may be due to difference in age or to variation; they are certainly not sufficient to allow a specific separation. They will be discussed later.

Description.—Shell discoidal but inflated, somewhat involute with whorls of elliptical cross section, much broader than high. The flanks are almost as much curved as the venter, the latter being very well rounded. The outer whorl covers about one-third of the preceding one. The umbilicus is narrow and deep, its walls are very steep although not quite vertical, the border is rounded, but appears very prominent on account of the sharp nodules beginning on it very abruptly.

The ornamentation consists of about 8 nodules which begin at the umbilical border. The first three nodules (the farthest backwards) on the last whorl (and all on the smaller whorls) are not very prominent and more like indistinct thickenings on the umbilical border. The following five nodules nearer the mouth are very sharp with a vertical wall toward the umbilicus; they are pointed but flatten out toward the flank forming a kind of triangular low rib which is very narrow and well defined at the beginning but broadens at once and forms a triangular field on the flank which becomes lower toward the venter and disappears before it reaches the venter. The front side of these ribs is much steeper than the back side. They cross the venter very indistinctly forming a kind of low swelling on it which somewhat breaks the uniform curve of the shell and makes it appear bumpy. But the last rib clearly crosses the venter and is limited on both sides by a shallow furrow, strongly bent forward and connected with the interstice between the last and the next rib back of it. The interstices between the nodules are wide with a well rounded bottom, but generally die out in the last third of the flank, with the exception of the last ones.

Suture.—The suture consists of three lobes and three saddles. They are well separated in the inner part of the last whorl but crowd together in the portion nearest to the mouth where the first lateral lobe almost touches the external saddle of the preceding suture. This is only the case in the last sutures and the pair behind it; all the rest of the sutures are widely separated. The siphonal lobe is not very deep and has vertical sides; the siphonal saddle at its bottom is moderately high. The external saddle is high and a little broader than the siphonal lobe; its umbilical flank is not quite vertical, the top is well rounded. The first lateral lobe is much deeper than the siphonal one with a well rounded bottom and almost vertical sides. The first lateral saddle is much lower than the external one; in the smaller part of the whorl it is almost half as high. In the last part of the outer whorl it is only slightly narrower than the external one, but in those of the sutures farther back it is relatively much narrower. The second lateral lobe is wide above and narrows toward the bottom which is rather straight and gives the lobe an angular aspect; it is much wider than the first lateral saddle, especially in the sutures nearer to the mouth. The second lateral saddle is low and narrow with slanting flanks; it lies entirely on the umbilical wall. The following lobe is only partly visible and not very distinct.

Dimensions:

Diameter	14.9 mm.	(1)
Width of last whorl	8.2 mm.	0.55
Height of last whorl	5.7 mm.	0.38
Diameter of umbilicus	3.8 mm.	0.26

There is another but small specimen which seems to belong to the same species. It is in general very similar in form to the larger one, but the nodules scarcely begin to develop on the largest whorl where it shows two distinct sharp tubercles with a slight indication of broadening into a triangular rib. The number of tubercles seems to be the same as in the larger specimen. The suture is exactly the same as in the smaller whorl of the larger ammonite. The siphonal lobe is perhaps a little wider relatively, but the external saddle is still wider than the siphonal lobe. The first lateral lobe and the first lateral saddle are very similar to those of the larger specimen, the second lateral saddle is very low and rounded; it lies entirely on the umbilical wall. The following lobe is only partly visible and not very distinct.

Dimensions:

Diameter	8.1 mm.	(1)
Width of last whorl	4.3 mm.	0.53
Height of last whorl	3.3 mm.	0.41
Diameter of umbilicus	1.4 mm.	0.17

It is thus seen that even the dimensions are not very different with the exception of the width of the umbilicus, but it is known that all these forms grow spirally in such a way that the umbilicus becomes wider.

Relations to other species.—Comparing the present description and illustrations with those of Adkins, it is seen that there is scarcely any difference. Especially the form of the nodules and ribs is astonishingly alike. Comparing Adkins' figure 11 on plate iv it is observed that near the end of the whorl the rib seems to be accompanied by a shallow furrow which crosses the venter, although this is not mentioned in the description. The suture is also very similar, only the external saddle in Adkins' specimen apears to be a little broader. The first lateral lobe is very similar to that of this species; in the text figure of Adkins it appears broader than on the photograph of the plate. These differences may be slight errors in drawing. According to the text figure the second lateral saddle cannot be seen in Adkins' specimen, but it appears very clearly there in the older suture; it may seem to disappear in those nearer to the aperture on account of the steep wall on which it lies; this is at least the impression which the photograph on the plate gives. Adkins gives no dimensions in his description, probably on account of the poor state of preservation of the fossil. As the umbilicus seemed to be a little wider than in our specimen, notwithstanding that Adkins' ammonite is certainly a little smaller, I have tried to measure the diameter and the umbilicus on the figure of plate I and the result was: the relation of diameter to umbilicus equal to 1:0.25. Of course this does not prove that the result is exact because Adkins' figure is rather poor, but it shows at least that the difference cannot be very great.

This species differs from *Adkinsia tuberculata* n. sp. by its more prominent tubercles, the broad triangular ribs, the lower external saddle and shallower lobes. It is much more distinct from all the other species described here, in ornamentation as well as in dimensions and sutural elements.

Number of specimens: Two.

Age: Lower Cenomanian, Del Rio clay.

Localities: Larger specimen from Loc. 964, east bank of South Bosque River, two miles south of South Bosque near Bickle No. 2 well, McLennan County, Texas. Smaller specimen from Loc. 966, east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas.

ADKINSIA SEMIPLICATA N. SP.

Plate IX, Figures 7–12

Shell discoidal, moderately involute, with whorls of elliptical cross section, broader than high. The flanks are slightly, the venter very strongly curved and the latter is well rounded. The outer whorl covers about four-fifths of the preceding one. The umbilicus is narrow, rather deep, its walls are vertical, but the border is well rounded; it appears sharp on account of the steepness of the umbilical wall.

The ornamentation is very simple and consists mainly of about 8 nodules which begin abruptly on the umbilical wall. The first five (counting from behind) are scarcely discernible, but the next three are very prominent, pointed on the umbilical wall but elongated radially in the form of a broadening rib, which disappears before the upper third of the flank. The backside of the ribs appears steeper than the front side. The rest of the flank and the venter are absolutely smooth. The interstices between the ribs are very wide and show a well rounded bottom.

Suture.—The sutures appear at different distances from each other but they never touch each other. They consist of three lobes and three saddles like all the other species of this genus. The siphonal lobe is moderately wide, not very deep, has vertical sides and at the bottom a relatively high siphonal saddle. The external saddle is very broad and low, but well rounded and symmetrical, both sides being quite steep. The first lateral lobe is not very broad, very shallow and has a rather straight bottom, which gives it an appearance of angularity; it is not quite as deep as the siphonal lobe. The first lateral saddle is very low, not half as high as the external one; it is truncated on the top, that is, the top is practically straight and shows angular corners. The second lateral lobe is very narrow and quite angular with a straight bottom. The second lateral saddle is very low and small with a straight top which gives it a quadrangular shape. The following auxiliary lobe is only half visible. The second lateral lobe lies on the umbilical border, the second lateral saddle entirely on the umbilical wall.

Dimensions:

Diameter	11.6 mm.	(1)
Width of last whorl	5.9 mm.	0.51
Height of last whorl	5.3 mm.	0.46
Diameter of umbilicus	2.3 mm.	0.20

Relation to other species.—This species stands almost by itself, not so much on account of its ornamentation which to a certain degree resembles that of *Adkinsia bosquensis* Adkins, as with regard to the suture. The different elements of the suture are extremely low and therefore appear much broader than in the other species. With the exception of the siphonal lobe and the external saddle they have a decidedly angular outline, which distinguishes the species from all the others. *Adkinsia adkinsi* n. sp. has also rather angular lobes and saddles, but all these are quite asymmetrical while in this species they are practically symmetrical.

Number of specimens: One.

Age: Lower Cenomanian, Del Rio clay.

Locality: Loc. 966, east side of Santa Fe track, 4.5 miles south of McGregor, McLennan County, Texas.

AMMONITES FROM THE BUDA LIMESTONE

EUHYSTRICHOCERAS REMOLINENSE N. SP.

Plate IX, Figures 13–15

A very interesting species occurs in the Buda limestone of El Remolino in Coahuila, near the town of Jimenez. It is absolutely different from any other American species so far described, and at first view one might think it a real *Schloenbachia*, but the venter is quite different. The only really near relative of this species is the African *Mortoniceras? nicaisei* (Coquand) Pervinquière, as will be shown later on.

Description.—Shell discoidal, evolute, with whorls of oval cross section, broader than high. The flanks are slightly flattened, the venter is strongly convex and carries a strong keel (the keel is broken off in most parts of the specimen studied, only in the inner portion of the whorl one notes that it is high). The outer whorl covers more or less half the preceding one. The umbilicus is shallow and moderately wide, its walls are steep, and the umbilical border well rounded.

The ornamentation consists of about 12 main ribs which begin on the umbilical wall and at a short distance from the umbilical wall form a nodule-like, radially elongated swelling which cannot very well be called a tubercle. At this point these ribs bifurcate in the smallest part of the whorl, and both branches curve strongly forward, especially near the venter. Between these bifurcated ribs an intercalated rib is generally found which sometimes begins below the middle of the flank, especially in the portion of the whorl nearer to the mouth, and at other places it begins on the umbilical wall but carries no nodule-like swelling. On the venter the ribs are very uniform. In the part of the whorl farthest away from the mouth the ribs stop rather suddenly at a little distance from the keel, almost giving the impression of a slight nodule at the end; on the part nearer to the mouth they die out at the keel. The preceding whorl shows very strong nodules above the umbilical border.

The specimen is slightly deformed by pressure, which gives it a somewhat oval shape and which makes it difficult to measure the dimensions. I therefore have measured the specimen once near the end of the whorl (I) and another time a quarter of a volution backwards (II).

Dimensions:

	I		II	
Diameter	34.9 mm.	(1)	25.1 mm.	(1)
Width of last whorl	13.7 mm.	0.39	12.8 mm.	0.51
Height of last whorl	11.6 mm.	0.33	10.0 mm.	0.40
Diameter of umbilicus	11.5 mm.	0.33	8.5 mm.	0.34

Relation to other species.—I have already remarked that this species does not seem to be very nearly related to any European or American form. But in the African Vraconnian and Cenomanian occurs a form which surprisingly resembles this one: *Mortoniceras? nicaisei* (Coquand) Pervinquière[135] for which Spath[136] has created the new genus *Euhystrichoceras,* regarding as the type figures 18 and 19 on plate VI of Pervinquière's work on Algiers. The original figure of Coquand is quite different from this species, showing more and thinner ribs and an entirely different cross section. Pervinquière has figured co-types of Coquand's species, preserved in the Museum of Budapest, and a specimen from Aumale which corresponds closely to Coquand's original figure. But he unites with this species a much more inflated form from Algiers (figures 16–19 of plate VI, Algiers, none from Tunis has been figured) and this one resembles ours surprisingly. I very much doubt if the two north African forms really belong to the same species. The differences between this inflated form and the Mexican species consist in details of ornamentation. The African form has more intercalated ribs and the main ribs are a little more regular than in this species, especially with respect to the nodules.

Pervinquière calls his species doubtfully *Mortoniceras,* but according to modern conceptions it is quite different from this genus and also from *Schloenbachia* or *Pervinquieria.* It is certainly not a *Mortoniceras,* which name should be restricted to forms with an undulated keel belonging to the group of *Mortoniceras texanum* Roemer. Spath is therefore justified in creating a new genus for this form.

Pervinquière compares the species with *Pervinquieria inflata,* but the resemblance is rather slight; it is certainly nearer to *Schloenbachia varians* with which it has been several times confused.

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[135]Coquand, **21**, p. 323, pl. xxxv, figs. 3–4.
Pervinquière, **57**, p. 235, pl. xi, figs. 13–15.
Ibid., **58**, p. 65, pl. vi, figs. 6–19.

[136]Spath, **82**, p. 143.

Pervinquière says in his work on Tunis that *E. nicaisei* occurs there in the Vraconnian, adding that his specimens are too badly preserved for illustration. All his figured specimens in the Tunis work as well as that on Algiers therefore come from this latter country, and were found in the Cenomanian. Pervinquière cites the species from Aumale in two different horizons of the Cenomanian, first from the zone with *Mantelliceras martimpreyi* and *Solarium vatonnei*, and second from the zone with *Discoidea forgemoli* and *Turrilites costatus*, which also contains his *Acanthoceras rotomagense* var. *hippocastanum*. Both beds are undoubtedly Cenomanian, and the second one may very well represent upper Cenomanian. At Berroughia the species occurs in Zone 1 of Ph. Thomas, which lies immediately above the Vraconnian, and again in Zone 4 which is the highest Cenomanian developed in that locality. As his species comprises at least two different forms, one cannot know which of them belongs in the different zones or whether both occur together. It is quite important that a form belonging to the same group has been found in England by Spath; according to the figures he refers to, it must be the inflated form and it occurs at Warminster in the earliest Cenomanian together with *Mantelliceras couloni* d'Orbigny and *M. martimpreyi* Coquand. It is of course quite possible that members of the same group occur also higher in the Cenomanian.

Number of specimens: One.

Age: Upper Cenomanian, Buda limestone.

Locality: Opposite El Remolino, two kilometers from Rio San Rodrigo in dry cañon near road to Orégano, region of Jimenez, Coahuila, Mexico.

MANTELLICERAS MANTELLI SOWERBY

Plate X, Figures 4, 5

1814 *Ammonites mantelli* Sowerby, **78**, vol. I, p. 119, pl. lv.
1854 *Ammonites mantelli* Sharpe, **74**, p. 40, pl. xviii, figs. 4–7.
1859 *Ammonites mantelli* Pictet et Campiche, **61**, p. 200, pl. xxvi.
1863 *Ammonites mantelli* Pictet, **60**, p. 41.
1863 *Ammonites mantelli* Stoliczka, **90**, p. 81, pl. xli, figs. 2, 3; pl. xlii, figs. 2, 3.

1871 *Ammonites mantelli* Schlüter, **69**, p. 12, pl. v, figs. 1–8; pl. vi, figs. 1, 2, 11.
1875 *Ammonites mantelli* Geinitz, **34**, p. 279, pl. lxi, figs. 1, 2.
1897 *Acanthoceras mantelli* Kossmat, **43**, p. 23 (130), pl. iv (15), fig. 4.
1903 *Mantelliceras mantelli* Hyatt, **38**, p. 114.
1907 *Acanthoceras mantelli* Pervinquière, **57**, p. 288, pl. xvi, fig. 18(?).
1911 *Mantelliceras mantelli* H. Douvillé, **27**, p. 299.

It is not proposed to cite here the complete synonymy of this species which for the older works is given by Pictet and Campiche; I only mention here descriptions important for the identification of specimens.

Mantelliceras mantelli has been cited from all over Europe, northern Africa, Persia, India and other parts of the world, but so far has not been known in America. I have several specimens which show all the characteristics of the group and which are so similar to the European and Indian varieties, that I do not think it practicable even to distinguish them as an American variety, as long as the English originals have not been newly described and figured. In general, the species of *Acanthoceras* and *Mantelliceras* are considered as very variable, but a careful study may show that in reality there exist more species than we actually know. The determination here thus does not mean that this species is actually identical with that represented by the original of Sowerby, but that it belongs to this group.

Description.—Shell discoidal, rather involute, the outer whorl covering about one-half of the preceding one; cross section of the whorl subrectangular (with the external corners cut off) in the inner volutions, but oval in the last portion of the largest whorl, flattened in the part farther backwards. Venter decidedly flattened in the smaller whorls, but somewhat rounded near the end of the largest whorl. The whorls are higher than broad, especially in the internal volutions of the animal.

The ornamentation consists of about 34 ribs on the last whorl, part of which originate on the umbilical border, and start from a nodular swelling; the others are intercalated and do not always reach the umbilical border. In the posterior part of the last whorl there are noted two rows of tubercles on the ribs, one of which limits the flat part of the venter, and one at the place where the flank joins the venter. This last row disappears soon, while the one bordering the flat portion of the venter goes on much farther, but at last disappears also, and then the venter becomes entirely rounded. All the ribs cross the venter without getting fainter. The ribs are broad and rounded; in the posterior portion of the last whorl and the preceding volutions the interstices are much narrower than the ribs, but in the last part they are as broad as these.

The suture could not be entirely observed but the characteristic feature of the group, the siphonal lobe which is longer than the first lateral, could be well distinguished.

Dimensions:

Diameter	117.9 mm.	(1)
Width of last whorl	43.6 mm.	0.37
Height of last whorl	50.7 mm.	0.43
Diameter of umbilicus	25.0 mm.	0.21
Width of penultimate whorl	21.4 mm.	0.18
Height of penultimate whorl	24.3 mm.	0.21

The specimens studied are very similar to the European and Indian ones; the ratio of dimensions agrees very well with those given by Kossmat. There is no feature which distinguishes these specimens from the typical forms.

Ammonites mantelli has been made the type for the genus *Mantelliceras* by Hyatt,[137] which name has been accepted by most of the modern authors. The main difference from *Acanthoceras* is the absence of a median row of tubercles on the venter. This genus is distinguished from *Sharpeiceras* Hyatt only through more dissected suture and especially through the abnormally long first lateral lobe of the latter genus. But Kossmat unites *A. laticlavium* (type of *Sharpeiceras)* with *M. mantelli* in the same group. Quite a number of genera have been split off from the old genus *Acanthoceras*, and some of these like *Rauliniceras* Douvillé

[137]Hyatt, 38, p. 113.

and *Mantelliceras* Hyatt are certainly good genera, but some of the rest like *Sharpeiceras* and *Calycoceras* are of rather doubtful value. *Mantelliceras mantelli* characterizes the Cenomanian, but according to Schlüter is rare in the upper Cenomanian, the *Rotomagense* beds.

Number of specimens: Three.

Age: Upper Cenomanian, Buda limestone.

Locality: Two kilometers from Rio San Rodrigo at El Remolino in dry cañon near road to Orégano, region of Jimenez, Coahuila. About 4 kilometers south of Tinaja de la Huérfana on road from Villa Acuña through Rancho San Geronimo to El Colorado, Coahuila, Mexico.

MANTELLICERAS LATICLAVIUM SHARPE VAR. MEXICANUM

Plate X, Figure 6; Plate XI, Figure 1

1854 *Ammonites laticlavius* Sharpe, **74**, p. 31, pl. xiv, fig. 1.
1863 *Ammonites mantelli* Stoliczka, **90**, p. 81, pl. xlii, fig. 1.
1871 *Ammonites lacticlavius* Schlüter, **69**, p. 18, pl. vii, figs. 4–8.
1895 *Acanthoceras laticlavium* var. *indica* Kossmat, **43**, p. 199 (103), pl. xxiv (10), figs. 5, 6. **II**, p. 24.
1903 *Acanthoceras laticlavium* Choffat, **17**, p. 25, pl. iv, fig. 3; pl. vii, fig. 1.
1903 *Sharpeiceras laticlavium* Hyatt, **38**, p. 111.
1904 *Acanthoceras laticlavium* H. Douvillé, **26**, p. 239, pl. xxi, fig. 3.
1907 *Acanthoceras laticlavium* Pervinquière, **57**, p. 301, pl. xiv, fig. 4.
1910 *Acanthoceras laticlavium* Pervinquière, **58**, p. 79, note.

This well known and characteristic group occurs in many places in the Cenomanian; it is cited from England, Germany, France, Tunis, Algiers, Persia, Mozambique and India. The specimen studied is very similar to the original species, especially with respect to the ornamentation, the ribs being practically as numerous as in the English type, but always two start from an umbilical tubercle. The tubercles are perhaps a little less pronounced at the umbilicus and in the row on the flank which lies a little nearer to the umbilicus than to the external row. The two rows which accompany the venter on each side are quite like those of the type, but they number twice as many tubercles as the umbilical row. The suture could not be distinguished in every part, but it shows the strong dissection of the saddles and the extremely deep first lateral lobe with its two long branches which are much deeper than the siphonal lobe. The main difference is in the cross section of the whorl which in the Mexican variety is much higher than in the type, and in the circumstance that the ribs are slightly inclined forward. On account of the narrower venter the flat zone between the two rows of ventral tubercles appears narrower than in the type. The involution is the same as in the type, that it, the outer whorl covers the preceding one only to the second row of tubercles, counted from the venter. The ribs begin on the umbilical wall, as they do in the type; they show a prominent nodule on the umbilical border, from which nodules generally two ribs start, a second row a little below the middle of the flank, a third one at the connection of the flank with the venter and a fourth one at the side of the venter, consisting of high, sharp, spirally prolonged tubercles; the space between them on the venter is smooth, almost concave.

Dimensions:

Diameter	119.8 mm.	(1)
Width of last whorl	?38.0 mm.	0.32
Height of last whorl	54.8 mm.	0.46
Diameter of umbilicus	36.3 mm.	0.30

These dimensions are not quite like those of the original nor like those measured by Schlüter, but they coincide well with those of *Mantelliceras laticlavium* var. *indica* Kossmat; the width seems to be a little greater, but this measurement is not quite exact. It differs from the Indian variety through the more numerous ribs and the fact that these are a little inclined forward.

The differences from the type do not seem sufficient for the creation of a different species, at least not until more material is found. There is no doubt that the Mexican specimen belongs to the group of *Mantelliceras laticlavium* and that it is very similar to the type.

Mantelliceras laticlavium var. *byzacenica* Pervinquière is probably a different species, although it may belong to the group of *M. laticlavium;* the ribs are very different, being much more numerous; the nodules on the umbilical border are less numerous and the row on the flank seems to be entirely missing, as is also the latero-ventral row, the species showing in total only two rows of tubercles, one on the umbilical border and a ventral one, which has twice as many tubercles.

M. laticlavium is in general rather a rare species everywhere and occurs together with *M. mantelli* as is the case also in our locality.

Number of specimens: One.

Age: Upper Cenomanian, Buda limestone.

Locality: Two kilometers from Rio San Rodrigo at El Remolino in a dry canyon near the road to Orégano, region of Jimenez, Coahuila, Mexico.

BUDAICERAS NOV. GEN.

(Genotype: *Budaiceras mexicanum* Böse)

The most common ammonite in the Buda limestone everywhere is one which cannot be grouped in any of the described genera. Shattuck[138] figured two species of this form under the generic name of *Barroisiceras* (?), although the genus has only a very distant similarity with that group and the suture is entirely different. Lasswitz cites its species partly as *Schloenbachia*, partly as *Barroisia*, and supposes that the species come from the Coniacian.

As the new genus is known from widely separated localities both in Mexico and Texas and seems to be characteristic of the Buda limestone it certainly deserves a new generic name.

Definition.—Shell discoidal, moderately evolute with whorls covering about one-fourth to one-half of the preceding one, much higher than broad, of helmet-shaped to oval cross section. The flanks are flattened, the venter is slightly sharpened in the mature whorls but is rounded on the living chamber. The umbilicus is moderately wide and shallow, its border is well rounded and its walls are not very steep.

[138]Shattuck, **75**, p. 35, pl. xxv.

The ornamentation of this genus is very characteristic. The flanks are covered by about 20 to 25 low and broad, almost straight ribs in the mature whorls; these begin on the umbilical border where they are rather narrow but broaden immediately and disappear on the side of the venter in a slight nodosity which is scarcely distinguishable on the living chamber. On the roof-like venter we observe a great number of small spirally somewhat elongated nodules which are much more numerous than the ribs. These disappear on the anterior part of the largest whorl.

The ornamentation of the inner whorls changes considerably. In very young specimens the ribs are decidedly falciform, some of them do not reach the umbilical border, they are steep on the back side and slope toward the front. They broaden on the upper part of the flank and end in a well defined broad spirally elongated tubercle. The center of the venter shows a row of spirally lengthened low and sharp tubercles which together appear somewhat like an undulated keel; here the number of these tubercles seems to coincide with that of the ribs. The venter is a little flatter and less roof-like.

In the next stage the ribs straighten but are still a little falciform. They are not yet as broad as in the mature whorl and carry still the broad tubercle at the end near the venter, which becomes roof-like. The nodules on the ventral mid-line become much more numerous than the ribs and the nodules are more rounded and not so much elongated. This changes in the still larger and mature whorls where the nodules become again lengthened, very thin and rather sharp. All the ribs reach the umbilical border.

Suture.—The suture consists of a moderately broad and not very deep siphonal lobe with two short branches between which rises a small trapezoidal siphonal saddle. The external saddle is high and very broad, it is divided by a more or less shallow adventive lobe and shows a number of more or less deep incisions. The first lateral lobe is sometimes shallower and sometimes deeper than the siphonal one; it is relatively wide but this changes with the different species; it is bifid in the larger sutures but trifid in the very small specimens; its branches are not very long. The first lateral saddle is much narrower than the external one but about as high; it is very little dissected and has a small adventive lobe which divides it into two parts. The second lateral lobe is very much like the first one only shallower and narrower, it is also bifid in the large whorls and apparently irregularly trifid in the smallest specimen. The second lateral saddle has only one shallow indentation in the middle, the branches are well rounded, it is very low, about half as high as the first one and lies almost on the umbilical border. The first auxiliary lobe is built after the model of the second lateral, although very shallow and broad above; it is distinctly bifid. The first auxiliary saddle is entire and low. The second auxiliary lobe, which is very plain on a specimen from Shoal Creek near Austin, lies on the umbilical wall, is bifid and very small. The second auxiliary saddle which could be seen on the same specimen, is relatively wide, divided by an indentation, but its umbilical side belongs to the internal suture.

The suture has a certain similarity to that of *Acanthoceras:* the broad and very little dissected external saddle, the bifid lobes which develop from trifid stages, the relatively narrow first lateral saddle resemble to a certain degree features of the characteristic *Acanthoceras* line. But the saddles and lobes are much less dissected and the lobes are narrow but have no long branches.

If the ornamentation is observed it is found that the young specimens show a distinct resemblance with *Acanthoceras* on account of the two rows of tubercles at the side of the venter and the middle row on the venter itself. In the larger specimens this similarity becomes lost.

This genus shows a surprising resemblance to some *Pulchellia*, especially to *Psilotissotia* not only in the suture, but also to a certain degree in the sculpture. Comparison with *Psilotissotia mariolae* Nicklès[139] shows that the suture is extremely similar to that of this genus, although there are more auxiliary lobes. The character of the lobes espe-

[139]Nicklès, **50**, p. 11, pl. i, figs. 7–9; pl. iii, fig. 5.

cially as well as that of the external saddle is quite like those of this genus. But also the sculpture shows the broad ribs ending at the venter in a tubercle, and on the venter is found a keel covered with small tubercles. Of course the entirely involute form of the *Pulchelliadae* is different.

It is thus concluded that *Budaiceras* belongs to the family of the *Acanthoceratinae* and that it is derived from *Psilotissotia* through either *Acanthoceras* or possibly *Stoliczkaia*.

There is also a certain similarity with *Barroisiceras* at least in the ornamentation, but the suture of this genus[140] is much more reduced and the keel is quite different from the row of nodules of the present genus. Therefore the determination of the genus as *Barroisiceras* by Shattuck is untenable.

Barroisiceras haberfellneri Lasswitz (non Hauer)[141] is also a typical *Budaiceras*. Professor W. S. Adkins has photographed the original at Breslau and has kindly given me a copy. This shows better than the somewhat beautified figure of Lasswitz that the species has all the characters of *Budaiceras* and certainly comes from the Buda limestone.

Part of the species of this genus were placed by Lasswitz in the genus *Schloenbachia*. I have already shown in my Monograph on Cerro Muleros that Lasswitz regards as *Schloenbachia* forms which are foreign to it and that he entirely misinterprets the original definition. To *Budaiceras* belong the following species of Lasswitz: *Schloenbachia roemeri* Lasswitz[142] with its varieties(?) *harpax* and *elegantior;*[143] *Schl. evae,*[144] *Schl. frechi*[145] and its variety(?) *curvata.*[146] Prof. Adkins has photographed all of these original specimens and the pictures show that all of them belong to *Budaiceras*, and they certainly do not come from the Coniacian but from the Buda limestone. It is very prob-

[140]Grossouvre, **35**, p. 51, text figure.
Solger, Ammonitenfauna d. Mungokreide, text figures 53–70.
[141]Lasswitz, **44**, p. 28, pl. viii, fig. 3.
[142]*Ibid.*, **44**, p. 27, pl. vi, fig. 3.
[143]*Ibid.*, **44**, p. 27, pl. vi, fig. 4 (harpax); p. 28, pl. vi, fig. 5 (elegantior).
[144]*Ibid.*, **44**, p. 29, pl. viii, fig. 2.
[145]*Ibid.*, **44**, p. 28, pl. vi, fig. 6.
[146]*Ibid.*, **44**, p. 28, pl. vi, fig. 7.

able that his *Barroisiceras sequens* belongs also to *Budaiceras*. None of the fossils which Lasswitz cites from Shoal Creek near Austin can come from the Coniacian, as this formation does not exist there.

Geographic distribution.—*Budaiceras* seems to be limited to the Buda limestone of Texas and northern Mexico. I have seen quite a number of specimens from Shoal Creek at Austin, Texas; Shattuck cites the genus from Little Bear Creek, Hays County, Texas. I have collected a number near Remolino and a single specimen much farther west on the road from San Gregorio to El Colorado in the Sierra del Burro, Coahuila, Mexico. Messrs. Gonzalo Vivar and H. Izazumi collected a well preserved specimen at Arroyo de las Mangas near Lajitas, region of Ojinaga, Chihuahua, and another in the Sierra Grande near Ojinaga, Chihuahua, Mexico. This shows that the species is found north and south of the Rio Grande and always in the same bed, that is, in the limestone above the Del Rio clay and below the Eagle Ford shales.

BUDAICERAS MEXICANUM N. GEN. N. SP.

Plate IX, Figures 16–23; Plate X, Figures 1–3

Shell discoidal with whorls higher than broad of oval cross section, moderately evolute; the outer whorl covers about one-fourth of the height of the preceding one and grows rapidly in height. The flanks are flattened, the venter is roof-shaped in the larger whorls but becomes rounded in the last stage. In very small specimens the venter is more flattened and not so roof-like. The umbilicus is wide and shallow, its border well rounded and its wall curved and not steep.

The ornamentation consists of about 20 low and broad, almost straight ribs in the mature whorls; in somewhat smaller whorls they are slightly bent with the convex side to the front. In very small individuals they are slightly falciform. On the large mature individuals the ribs begin on the umbilical border where they are narrow, but they broaden quickly on the flank and disappear suddenly at the side of the venter in a slight nodosity which is scarcely distinguishable on the living chamber. On the inner whorls the ribs begin very thin and sharp on the umbilical wall, broaden above the umbilical border and end in a rather broad, spirally lengthened tubercle. Not all the ribs begin at the umbilical wall in this stage, some begin in the middle of the flank and some on the umbilical border, but near the venter they are entirely uniform. On the center of the roof-like venter there is a row of small slightly elongated nodules or tubercles; these are much more numerous than the ribs on the mature whorl but disappear entirely on the living chamber. On the next smaller stage of the volutions the ribs are still rather straight and the upper tubercles at the side of the venter are still very pronounced; the ribs are not quite as broad as in the mature stage; the venter is roof-like. The row of nodules is more numerous than the ribs and the nodules are more rounded and scarcely elongated spirally. In the smaller individuals the ribs are falciform, terminate in a very pronounced tubercle at the side of the venter and are steep at the posterior side and slope gently toward the front side. The venter is less sharp and not very roof-like; the row of tubercles in its center shows the same number of tubercles as ribs. These tubercles are considerably lengthened and almost give the impression of a granulated keel. The space between them and the lateral tubercles is smooth and slightly undulated.

Suture.—The suture consists of a moderately broad and not very deep siphonal lobe with two short branches at the bottom between which rises a small siphonal saddle. The external saddle is very broad and little scalloped but rather high; a small adventive lobe divides it into two parts. The first lateral lobe is much deeper than the siphonal one; it is relatively broad, bifid in the mature suture, but trifid in the young stage; it has no long branches. The first lateral saddle is much narrower than the external one but about as high; it is always a little bent toward the umbilical side; it is not much dissected but shows a small adventive lobe in the top. The second lateral lobe is very much like the first one, only shallower and narrower; it is bifid in the mature suture and trifid in the immature. The second lateral saddle has only one very shallow indentation in the middle, the branches are well rounded; it lies on the umbilical border and is very low and narrow. The first auxiliary lobe is quite similar to the second lateral but much smaller and shallow; it is bifid. The first auxiliary saddle is entire and very low. The second auxiliary lobe could not be very well distinguished, it lies on the umbilical wall. There is probably another auxiliary saddle.

Dimensions:

Diameter	77.0 mm.	(1)
Width of last whorl	18.5 mm.	0.24
Height of last whorl	27.9 mm.	0.36
Diameter of umbilicus	23.2 mm.	0.30

Relation to other species.—The two species with which this species can be well compared are *Barroisiceras* (?) *texanum* Shattuck and *B. hyatti* Shattuck.[147] They certainly belong to the same genus but are specifically different. *B. texanum* has a very different cross section in a later stage of the whorl, the ribs are more numerous and the tubercles at the end of the ribs are not as pronounced as in our specimen. *B. hyatti* has much broader and straighter ribs and the cross section appears to be quite different. The description of both species is rather poor and the illustrations do not show many details.

A detailed comparison with the species figured by Lasswitz under the name of: *Barroisiceras sequens, B. haberfellneri, Schloenbachia roemeri,* with the varieties *harpax* and *elegantior, Schl. evae* and *Schl. frechi* with the variety *curvata,* is quite impossible, as we have no photographs of the keel side nor a good description; we can only state that all these belong to *Budaiceras.*

No European species so far described are very similar to this one. The young specimens resemble somewhat certain *Psilotissotia* forms.

[147]Shattuck, **75**, p. 35, pl. xxv, figs. 1, 2 (the explanation on the plate is erroneous).

Number of specimens: About 20.

Age: Upper Cenomanian (Buda limestone).

Localities: Two kilometers from Rio San Rodrigo at El Remolino in dry canyon near road to Orégano, region of Jimenez, Coahuila. About 4 kilometers south of Tinaja de la Huerfana on road from Villa Acuña through Rancho San Gregorio to El Colorado, Coahuila, Mexico.

AMMONITE FROM THE UPPER TURONIAN

PRIONOTROPIS WOOLLGARI MANTELL N. VAR. MEXICANA

Plate XI, Figures 11, 12

1822 *Ammonites woollgari* Mantell, **46**, p. 197, pl. xxi, fig. 16; pl. xxii, fig. 7.
1828 *Ammonites woollgari* Sowerby, **78**, pl. dlxxxvii, fig. 1.
1854 *Ammonites woollgari* Sharpe, **74**, p. 27, pl. xi, figs. 1, 2.
1876 *Prionocyclus (Prionotropis) woolgari* Meek, **47**, p. 455, pl. vii, figs. 1–3; pl. vi, fig. 2.
1893 *Prionotropis woolgari* Stanton, **85**, p. 174, pl. 42, figs. 1–4.
1902 *Acanthoceras woollgari* Petrascheck, **59**, p. 149, figs. 7–8.

There is no doubt but that the present specimen belongs to the group of *Prionotropis woollgari*, but it is not entirely identical with the English species. In the latter one, which is best represented by the figures of Sharpe, the ribs seem to be more numerous in the interior whorl and they are always inclined forward and seem even to be curved in the small volutions. In the present specimen the ribs are straight and entirely radial, except the last ones which cross the venter and bend forward. The ribs seem to be thicker and more rounded and corresponding to this the nodules on the umbilical border are thicker and more rounded. The involution seems to be the same as in the English specimens, the outer whorl covering only the uppermost part of the preceding one and leaving the lowest latero-ventral row of nodules half visible. In the inner whorls the ribs begin at the umbilical seam where they commence with a round strong nodule. Later on the ribs begin at the umbilical border where also the nodule develops and in the last portion of the outer whorl the nodules and with them the beginning of the ribs lie outside of the umbilical border, until at last the nodules disappear entirely and the ribs bifurcate on the venter. These conditions are similar in the English type: on the venter we find three rows of sharp nodules, elongated spirally; one lies in the center and the other two on the side of the venter. The central row forms a kind of serrated keel in the largest whorl. There is another row of tubercles on each side of the venter at the place where the ribs end; these tubercles are not sharp but rounded; they seem to form enormous spine-like projections in the last part of the outer whorl, where they are all broken off in the specimen studied. There the sharp tubercles at both sides of the venter disappear or better said, merge with the large lateral nodules.

In the English type the ribs increase in number from one whorl to the other, especially in the inner volutions. This is probably the case also in the present specimen although the greater part of the inner volutions is not preserved. In the English species the ribs on the outer whorl number about 14, the same as in the Mexican species, but in Sharpe's specimen the ribs are practically uniform and the distances between them seem to grow steadily. In the Mexican specimen the ribs are rather irregular in the last whorl. While in the English type the ribs correspond always to the three nodules on the venter, this is not the case here; in several instances there is no rib on the flank although the sharp nodules on the venter continue regularly. In this feature, the specimen studied resembles the large individuals of *Prionotropis schlueterianus* Laube and Bruder.[148] In this species ribs are missing where the sharp nodes on the venter exist, and sometimes the ribs bifurcate on the center while in other places they unite in the large nodule and separate again on the venter.[149] *Prionotropis schlueterianus* is much more involute, the outer whorl covering mostly the nodules at the end of the ribs; the ribs are more numerous and the umbilical nodules are mostly missing. *Prionotropis schlueterianus* has often been confounded with *P. woollgari*

[148]Laube u. Bruder, **45**, p. 236, pl. xxix, figs. 2, 3.
Petrascheck, **59**, p. 150, pl. x (4), fig. 3; pl. xi (5), fig. 3; pl. xii (6), fig. 1.
[149]*Ibid.*, **59**, pl. xii, fig. 1.

and on the European continent seems to be rather more common than the English type, which also occurs mostly in a higher horizon, although Petrascheck cites *P. schlueterianus* also from the Strehlener Pläner. Spath[150] cites *Prionotropis woollgari* from the base of the Angoumian.

From the United States Meek described a form which he identified with *Prionotropis woollgari.*[151] Petrascheck has remarked that this identification is not quite without doubt, but the American form belongs certainly to the group of *P. woollgari* and not to *P. schlueterianus;* it may be necessary to consider the American form as a variety or even as a different species, but the differences between it and the European type are very small. The main difference seems to be that the umbilical nodules are not quite as accentuated as in the English form.

With respect to the genus it is evident that *Ammonites woollgari* is the type of this genus, since Meek[152] cites the only English form in his definition of the genus. I cannot understand how Petrascheck[153] made the misinterpretation that Meek considered *Ammonites carolinus* as representative of the genus; Meek says expressly that he considers Mantell's species as the type of *Prionotropis,* and merely mentions *A. bravaisianus* and *A. carolinus* as very closely resembling specimens of the typical form. Petrascheck asserts that Meek identified *Prionotropis woollgari* with *Pr. carolinus,* but this is certainly not the case.

Number of specimens: One.

Age: Upper Turonian, white marls above the Eagle Ford shales.

Locality: First ranch about one kilometer from houses of Margaritas near Rio Bravo on road Piedras Negras to Villa Acuña, 24 kilometers from Jimenez, Coahuila, Mexico.

[150]Spath, **84**, table at p. 80.

[151]Meek, **47**, p. 455, pl. vi, fig. 2; pl. vii, fig. 1.

[152]*Ibid.*, **47**, p. 453 and note.

[153]Petrascheck, **59**, p. 149.

AMMONITES FROM THE CONIACIAN

PROPLACENTICERAS AFF. FRITSCHI GROSSOUVRE

Plate X, Figures 7–9

1894 *Placenticeras fritschi* de Grossouvre, **35**, p. 124, text figure 52; pl. v, figs. 1, 2.
1926 *Proplacenticeras fritschi* Spath, **84**, p. 79.

Together with *Peroniceras* aff. *subtricarinatum* I found in the Coniacian of Chihuahua near Ojinaga an ammonite which greatly resembles *Proplacenticeras fritschi* de Grossouvre. It is only a fragment and not very well preserved, but there is scarcely any doubt that it belongs to the group which is so characteristic of the Coniacian of Europe and to which also *Placenticeras orbignyianum* Geinitz belongs.

The fragment preserves almost half a whorl and the cross sections of several smaller whorls. The shell must have been discoidal with a relatively wide umbilicus for the genus; the cross section of the whorl is trapezoidal, much higher than wide; the greatest width lies at the umbilical border. The flank is flattened but slightly curved, the venter is flat with rather sharp edges, but narrow. The umbilicus is moderately wide and deep with steep, but not vertical, walls; the umbilical border is rounded but well pronounced. It seems that the umbilical border carried nodules; the rest of the surface shows no ornamentation and is entirely smooth.

The suture is not well preserved but the elements are quite clear. The siphonal lobe is wide and deep, with a relatively high median saddle and two long branches which form an angle of about 90 degrees. The external saddle is divided into three adventive saddles by two adventive lobes. The first adventive saddle is very broad and had at least one deeper secondary lobe in the middle of the top. The first adventive lobe is narrow and deep. The second adventive saddle is narrower than the first one and shows a number of small incisions at the top and on the side. The second adventive lobe is deeper than the first one and has a number of short branches. The third adventive saddle is lower than the second one, shows several incisions on the top side and is constricted in the middle. The first lateral lobe is much deeper than the adventive ones and has a number of short branches. The first lateral saddle rises higher than the third adventive one, has a small secondary lobe in the middle of the top and is very asymmetrical, the umbilical side being much higher than the ventral one; it shows a number of short incisions in the upper part and is constricted in the middle of the stem. The second lateral lobe is very short, wide at the bottom and narrow at the top, with a number of short branches at the bottom. The second lateral saddle is short and broad, with four or five short incisions at the top. The first auxiliary lobe lies on the umbilical border, but its form cannot be distinguished; there are probably two more saddles and two lobes on the umbilical wall. The first and second adventive saddle of the external saddle are poorly preserved, but it seems that the small ramifications at the top were more like those of the other saddles.

The sutures of the fragment are certainly very similar to those of *Proplacenticeras fritschi* and the number of elements seems to be also the same. In addition, the general form of the suture is quite like that of the French form: a line connecting the tops of the saddles goes strongly backwards from the venter to the first lateral lobe, and from there on runs across the rest of the flank radially but in a slight curve, just as one notes this on de Grossouvre's plate v, figure 1a. The elements of the suture seem to resemble still more those of *Pl. orbignyanum* Geinitz, as it is figured by Sturm;[154] but in form the fragments resemble more *Propl. fritschi*, its cross section being thicker at the umbilical border than the form from Saxony and Silesia.

The group of *Proplacenticeras orbignyanum* Geinitz, to which *P. fritschi* belongs, is very characteristic and is found only in the upper Turonian and the Coniacian. It contains forms with very slight ornamentation or none, a venter without nodules, slightly curved flanks and a trapezoidal cross section. The suture is in general like that of the real

[154]Sturm, **91**, p. 58, pl. iii, fig. 4.

Placenticeras of the Santonian, but is perhaps a little more simplified and has a smaller number of auxiliary lobes and saddles. Thus Spath is quite justified in proposing the new genus *Proplacenticeras* for *P. fritschi*, although he does not give a definition of it, and only names this species as the type. This genus is at least as good as *Diplacmoceras* which Hyatt created for the Campanian *Placenticeras*, which incidentally Spath cites from the uppermost Santonian.

The group of *Proplacenticeras orbignyanum* probably leads back to the so-called *Placenticeras memoria-schlönbachia* Laube and Bruder, which has been described from the Turonian[155] and Cenomanian[156] of Bohemia and Saxony. The suture of these forms is very imperfectly known. Of the type we know only part of the suture and not the external saddle. The species which Petrascheck described under the name and which occurs in a deeper horizon, the uppermost Cenomanian, has also an imperfect suture which reminds us somewhat of that of *Proplacenticeras orbignyanum*, especially in the sudden rising of the top line of the saddles in the first lateral saddle and the exceedingly asymmetrical form of the latter one. These forms are quite different from the typical *Placenticeras;* they show only very small nodules on the umbilical border and a very narrow venter, which Geinitz even took for a sharp venter. The suture has apparently two adventive lobes in the external saddle, but the character of the elements and the sudden rise of the top of the saddles from the first lateral saddle on, give it a very different aspect from that of the typical *Placenticeras*. It may be remarked that a similar line can be seen sometimes in young specimens of typical *Placenticeras*, e.g., *Pl. bolli* Hyatt.[157] If the suture of *Pl. memoria-schlönbachi* was better known one would probably be justified in creating a special genus for these forms. Petrascheck says that *Proplacenticeras orbignyanum* occurs in Saxony and Bohemia in the upper Turonian. *Propl. fritschi* comes from the Coniacian of France.

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[155]Laube u. Bruder, **45**, p. 221, pl. xxiii, fig. 1.

[156]Geinitz, **34**, p. 188, pl. xxxiv, fig. 3.
Petrascheck, **59**, p. 132, text figure 1.

[157]Hyatt, **38**, pls. xlii and xliii.

Number of specimens: One.

Age: Coniacian.

Locality: About four kilometers south of Ojinaga near the more western road to Chihuahua, Mexico.

PERONICERAS AFF. SUBTRICARINATUM D'ORBIGNY

Plate XI, Figures 2–4

1840 *Ammonites tricarinatus* d'Orbigny, **54**, p. 307, pl. xci, fig. 1.
1850 *Ammonites subtricarinatus* d'Orbigny, **55**, Vol. II, p. 121.
1894 *Peroniceras subtricarinatum* de Grossouvre, **35**, p. 94, pl. x, figs. 1–3; pl. xi, fig. 1.

About four kilometers south of Ojinaga, Chihuahua, near the bed of the large creek, in brownish to reddish sandstones and sandy shales which form a row of little hills, I found a fragment of a *Peroniceras*. These beds lie below the marls with *Placenticeras planum*, *Pl. sancarlosense* and *Mortoniceras* aff. *texanum*. The fragment is not much over one-fourth of a volution, but is well enough preserved for a determination of the group. It is very evolute, the cross section of the whorl is subquadrate, the venter is slightly curved and shows a median keel with two lateral keels separated from it by two well preserved furrows; the lateral keels are lower than the median one. The ornamentation consists of straight and rounded ribs in radial position, which at the umbilical border begin with a tubercle and end in a strong tubercle at the shoulder of the venter; one of the ribs begins above the middle of the flank. The flanks are flattened. The umbilical wall is very steep, the umbilical border is rounded.

The suture is not quite completely visible; the siphonal lobe could not be distinguished but the broad external saddle divided by a deep secondary lobe can be seen in almost all its parts; the deep first lateral lobe, the relatively broad first lateral saddle, the shallow second lateral lobe and the small second lateral saddle are quite visible.

Although the general form is that of *Peroniceras subtricarinatum*, the suture is different from the one figured by Drescher.[158] The first lateral saddle is much broader than

[158] Drescher, **28**, p. 331, pl. viii, figs. 2–4.

in the form from Silesia and there is no auxiliary saddle visible. The suture resembles much more that of *P. moureti* de Grossouvre,[159] although this form has a much greater number of ribs.

It is rather astonishing that forms so similar in their external features as *Peroniceras subtricarinatum, P. dravidicum, P. westphalicum* and *P. moureti* should have such different sutures. I am not sure that the *P. westphalicum* of Grossouvre[160] is really identical with the form described by Schlüter; the ribs seem to be too sharp and the umbilical nodules too strong and the latero-ventral tubercles not numerous enough. But *P. westphalicum* Grossouvre is certainly extremely similar to *P. subtricarinatum* and the suture seems to be entirely different from that published by Drescher and copied by Schlüter. It resembles entirely that of *P. moureti* and also the present species. *P. dravidicum* has quite a different suture,[161] the second lateral saddle is not independent but an oblique branch of the first one and the first auxiliary lobe is deeper than the first lateral one; this is at least the interpretation of Kossmat. One might doubt that the suture drawn by Drescher is exact, but Kossmat remarks that he has compared also the sutures of a large specimen of *P. subtricarinatum* in the collection of Bonn, and there apparently has found the same number of lateral and auxiliary lobes as Drescher. Thus it seems that the suture of *Peroniceras* varies considerably.

Number of specimens: One.

Age: Coniacian.

Locality: About four kilometers south of Ojinaga near the western road to Chihuahua, Mexico.

AMMONITES FROM THE UPPER SANTONIAN (TAYLOR MARLS)

GAUDRYCERAS KAYEI FORBES

Plate X, Figures 10–14; Plate XI, Figures 5–10

1845 *Ammonites kayei* Forbes, **31**, p. 101, pl. viii, fig. 3.
1865 *Ammonites kayei* Stoliczka, **90**, p. 156, pl. lvii, fig. 1.
1879 *Ammonites jukesi* Whiteaves, **96**, I, pt. 2, p. 111, pl. xiii, fig. 3.

[159]De Grossouvre, **35**, p. 101, fig. 39.
[160]*Ibid.*, **35**, p. 98, pl. xii, figs. 1–4.
[161]Kossmat, **43**, p. 190 (94), pl. xxiii (9), fig. 3.

1895 *Lytoceras kayei* Steinmann, **88**, p. 86, pl. v, fig. 5.
1895 *Lytoceras (Gaudryceras) kayei* Kossmat, **43**, p. 124 (28), p. 162 (66), pl. xvi (2), fig. 5; pl. xvii (3), fig. 2.
1902 *Lytoceras (Gaudryceras) kayei* Anderson, **4**, p. 83.
1907 *Lytoceras (Gaudryceras) kayei* Pervinquière, **57**, p. 69, pl. iii, fig. 20.

Shell extremely evolute with very little embracing whorls, the smaller specimen shows seven volutions. Whorls of kidney-like cross section, much broader than high, greatest width at the umbilical border. In a fragment of a larger whorl the height of the cross section is scarcely much less than the width, the form of this cross section is more high oval and not kidney-like. In the inner whorls the flanks are strongly curved and can scarcely be distinguished from the venter which is broad and curved. The umbilicus is extremely wide and its walls curve uniformly into the flank; on the first six whorls the walls of the umbilicus can scarcely be distinguished. In the large fragment the flanks become flatter and the venter is much stronger curved; the umbilical wall is steep, although low. The only ornamentation of the specimens consists of four constrictions on each whorl, which are strongly bent forward but little curved forward. No ribs can be seen as all the specimens are casts of limonite.

The suture could not be followed entirely but what can be observed is quite similar to the one given by Pervinquière.

Dimensions:

	I		II	
Diameter	21.0 mm.	(1)	18.0 mm.	(1)
Width of last whorl	8.2 mm.	0.39	7.6 mm.	0.42
Height of last whorl	5.4 mm.	0.26	4.0 mm.	0.22
Diameter of umbilicus	11.3 mm.	0.54	9.3 mm.	0.52
Width of penultimate whorl	6.1 mm.	0.29	5.7 mm.	0.32
Height of penultimate whorl	3.7 mm.	0.18	2.9 mm.	0.16
Diameter of umbilicus of penultimate whorl	8.4 mm.	0.40	8.0 mm.	0.44

I have identified the specimens with *Gaudryceras kayei* on account of their very characteristic form, although the fine sculpture of the surface is not preserved. It is difficult to compare their dimensions with those so far given in the literature, because the relation of the dimensions changes considerably with the diameter and most of the published dimensions refer to either larger or smaller individuals. The dimensions of a specimen measured by Steinmann refer to an individual of almost the same diameter as those studied.

	Steinmann's form	Mexican form
Diameter	1	1
Width of last whorl	0.333	0.39
Height of last whorl	0.289	0.26
Diameter of umbilicus	0.533	0.54
Width of penultimate whorl	0.231	0.29
Height of penultimate whorl	0.178	0.18

These measurements show that the Mexican form has broader volutions although the dimension of the umbilicus is almost the same.

Comparing the north African form which is nearest to this one in diameter and the smallest one from India with our two individuals we find:

	Mexican form		Indian form	African form
	I	II	(12.6 mm.)	(25 mm.)
Diameter	1	1	1	1
Width of last whorl	0.39	0.42	0.40	0.38
Height of last whorl	0.26	0.22	0.24	0.32
Diameter of umbilicus	0.54	0.52	0.56	0.52

In this instance also it is seen that the Mexican form is a little wider and less high. The different forms certainly belong to the same group, but they may be specifically different. The Indian form occurs in the Valudayur beds which according to Kossmat would be of upper Senonian (Campanian) age, and Steinmann considers the Quiriquina beds of Chile as of the same age. In Tunis the form occurs in the Santonian, as in Mexico, but Pervinquière[162] cites *Gaudryceras kayei* from the Maestrichtian of Algiers, but is somewhat doubtful about the specific determination and

[162] Pervinquière, **58**, p. 13.

seems to think that it might belong to *Gaudryceras valudayurense* Kossmat.

Anderson cites *L. kayei,* unfortunately without giving an exact description, dimensions or figures, from Mt. Diablo in California; the exact horizon is unknown.

Thus it seems that forms belonging to the group of *Gaudryceras kayei* occur in every bed of the Senonian, from the Santonian to the Maestrichtian, and that notwithstanding its characteristic figure it cannot be used for the determination of the age of the beds.

Number of specimens: Four.

Age: Upper Santonian (Taylor marls).

Locality: Old shaft two miles from Vallecillo on road to Tortillas, Nuevo Leon, Mexico.

PLACENTICERAS SYRTALE MORTON

Plate XII, Figures 1–7

1834 *Ammonites syrtalis* Morton, **48**, pl. xvi, fig. 4.
1903 *Placenticeras syrtale* Hyatt, **38**, p. 205, pl. xxvii, figs. 15–17; pl. xxviii, figs. 1–6.

This species is quite abundant in the Taylor marls of Las Esperanzas, Coahuila, and occurs there in different beds. Aguilera has cited these forms as *Placenticeras placenta* and *P. intercalare,* which are very nearly related to this species, but the differences cited by Hyatt can also be observed in our specimens. Aguilera cites also *Pl. stantoni* from this place, but I have not seen any specimen which could be identified with this species and Aguilera's specimens in the Instituto Geológico de México are fragments of large whorls which I consider as *Pl. syrtale.* Most of the specimens found by us are fragments of whorls of different sizes, only a very small and two very large specimens are complete, but there the sutures could not be prepared.

I identify our specimens with *P. syrtale* on account of their form and especially on account of the very characteristic first lateral lobe. Our smallest specimen (diameter 72 mm.) shows the following features: Shell discoidal, whorls much higher than broad, the greatest width of the smallest portion of the outer whorl lies near the umbilicus, the cross section is almost sagittal, but truncated on the venter; the venter is very narrow and shows on both sides a row of small tubercles which alternate on both sides, and between these the venter is slightly depressed. The umbilicus is narrow and deep with rather steep walls. The ornamentation consists of about 9 nodules on the umbilical border and about 14 nodules at four-fifths of the height of the flank. All these nodules are very small at this stage of the species, at least on the shell, but in the parts where the shell has been removed they appear stronger. The small tubercles on the shoulders of the venter are very numerous. In this specimen the suture could not be made visible.

In a somewhat larger fragment which is entirely silicified (height of the whorl 38 mm.) the cross section changes rapidly and appears almost hexagonal, but truncated above. The greatest width is still a little above the umbilical border, the umbilical wall is steep, the venter is narrow and flat between the rows of small alternating tubercles on the shoulders. The umbilical nodules appear a little lengthened radially and bent forward; the second row of tubercles on the flank are farther distant from the venter. The number of tubercles in both rows does not seem to be much greater than in the small specimen, but they are much more prominent. This specimen shows the suture in part; the first adventive saddle of the external one is very much broader than the other two and the first lateral lobe is much deeper than the adventive lobes of the external saddle. The number of auxiliary saddles is 5 or 6. A still larger fragment (height of the whorl 45 mm.) shows the same characters as the one here described.

A much larger fragment (diameter 133 mm., height of the whorl 59 mm.) shows the changing of the ornamentation, and of the form. It is much higher than broad, the cross section is almost oval, the tubercles on the shoulders of the venter are very low and less numerous, the venter is still flat but begins to become slightly rounded. The nodules above the umbilical border are much smaller than in the specimens described above, they are lengthened radially but with a strong inclination forward. The tubercles on the upper portion of the flank are very indistinct and lie at two-thirds the height of the flank. The umbilical wall is less steep than in the smaller individuals. This specimen shows the whole suture which is very characteristic. The siphonal lobe is very broad and shallow, the two branches form an angle of at least 150 degrees; between them appears an extremely low and broad siphonal saddle. The external saddle is very broad and is divided into three adventive saddles by two adventive lobes. The first adventive saddle is very broad and shows a great number of very short branches. The first adventive lobe is moderately deep and has a number of very short branches; it is bifid. The second adventive saddle is almost as high as the first but much narrower and minutely digitate. The second adventive lobe is similar to the first one and of the same length and width. The third adventive saddle is divided into two parts by a narrow secondary lobe which is a little deeper than the rest of the incisions; both branches are digitate. The first lateral lobe is very characteristic; it is much deeper and wider than any of the adventive ones, it is trifid and has a number of short branches, it is very little asymmetrical. The first lateral saddle is as high as the third adventive one of the external saddle; it is divided into two branches by a thin and shallow secondary lobe which is a little deeper than the rest of the incisions; both branches are minutely digitate. The second lateral lobe is only half as deep as the first one, it is bifid and has a number of short indentations. The second lateral saddle is a little lower than the first one but very similar in outline; it is also divided into two parts by a shallow secondary lobe. There are six auxiliary saddles and seven auxiliary lobes; the first four of these saddles are all divided by a slight secondary lobe and most of them show digitation in both branches; the last two are entire; four of these saddles lie on the umbilical wall. The auxiliary lobes are similar to the second lateral one but simpler, the last two or three appear to be entire and rounded.

A still larger fragment shows the same suture, but here the cross section of the whorl (height of the whorl 87 mm.) is still more rounded and the venter although still distinctly flattened becomes rounded. Both rows of nodules on the flank are still visible but very low and the nodes very far apart. The nodules on the ventral shoulders are scarcely distinguishable, but this may partly be a result of corrosion.

This species belongs certainly to *P. syrtale*, although the original figure of Morton appears to be quite different. But Hyatt's reproduction of the type is quite similar to our small specimens. The sutures of the type correspond especially well with those of our specimens, although our fossils are much larger. Hyatt remarks that Morton's original specimen is probably a dwarf. Hyatt has given a better figure of this original and has also published a drawing of the suture. This picture shows the extraordinarily long first lateral lobe and its characteristic form, quite similar to that of our larger specimens. Very characteristic is also the broad tree-like first adventive saddle of the external saddle. The suture is different from that of all the other *Placenticeras;* the only one which has a certain similarity is that of *P. sancarlosense* Hyatt, which shows also the broad and tree-like first adventive saddle, but the first lateral lobe is different.

I doubt very much that the specimens figured by Hyatt as *P. syrtale* var. *halei* can be regarded as a variety of this form, it is probably a different species. All of the saddles have much slenderer stems; the first adventive one is to a certain degree similar to that of *P. syrtale*, but the adventive lobes are too deep and the first lateral lobe not deep enough compared with the second adventive lobe and the second lateral. The form of the first lateral saddle is also quite different from that of the type.

P. syrtale has often been cited from Europe but there does not seem to exist a single species in that continent which can be identified with *P. syrtale*. In America it seems to be rare, or at least the only typical specimens described are those figured by Hyatt and unfortunately the exact horizon is not known. Our specimens occur in the higher portion of the Taylor marls, the upper Santonian.

Number of specimens: About 30.

Age: Upper Santonian (Taylor marls).

Localities: Arroyo de la Pasta, one kilometer from Las Esperanzas coal mines; Arroyo del Sauz in the vicinity of Las Esperanzas; Loma de las Hermanas, east of the road from Progreso to Agua Dulce; Loma del Gato, west of the road from Progreso to Agua Dulce; all in the State of Coahuila, Mexico.

AMMONITE FROM THE CAMPANIAN (LOWEST BEDS WITH EXOGYRA COSTATA)

PLACENTICERAS WHITFIELDI HYATT

Plate XIII, Figures 1–3

1876 *Placenticeras placenta* Meek, **47**, pl. xxiv, fig. 2 (pars).
1903 *Placenticeras whitfieldi* Hyatt, **38**, p. 221, pl. xlv, figs. 3-16; pl. xlvi; pl. xlvii, figs. 1–4.

A single specimen of a large *Placenticeras* was found near a bed with *Exogyra costata* in the San Miguel beds of the vicinity of Piedras Negras, Coahuila. This was the only one I have been able to find and as ammonites are rare in those beds, the find is of importance. Fortunately the species is quite characteristic and the sutures could be prepared although they are somewhat corroded.

Description.—Shell discoidal, compressed laterally, involute with whorls much higher than wide of an almost sagittal cross section truncated above. The flanks are almost flat, especially in the inner volutions, and very slightly rounded in the largest whorl; the greatest width lies at the umbilical border in the small whorls and a little above this place in the largest whorl. The venter is very narrow even in the large whorls, it is entirely flat or even a little concave in the smaller whorls and completely flat in the largest whorl; it is limited by sharp edges on both sides. The umbilicus is relatively narrow, its walls are very steep, almost vertical, but the umbilical border is rounded. There is no ornamentation either on the umbilicus, the flanks or the venter.

Suture.—The siphonal lobe is broad and shows long arms; the siphonal saddle between these branches is relatively high for the genus. The external saddle is divided into three adventive saddles by two adventive lobes. The adventive saddles are high, slender and divided into many long branches; the adventive lobes are narrow and bifid. The first lateral lobe is long and narrow ending in a point and therefore trifid. The first lateral saddle is high, ending in three or four long branches. The second lateral lobe is relatively broad but only half as long as the first one. The second lateral saddle is short, and broad, but shows a number of branches. Of the auxiliary lobes only three could be well distinguished, they are all trifid and much smaller than the lateral ones. The fourth auxiliary lobe lies on the umbilical border and there are at least two more on the umbilical wall. The auxiliary saddles are short and similar to the second lateral one; those on the umbilical wall could not be very well distinguished.

All the saddles and lobes appear here probably too broad and too short, because the sutures are a little eroded; on a small part of the inner whorl where the cast is better preserved, one can see that the terminals of the saddles are longer than they are shown here and the lobes are more complicated.

Our species is very characteristic on account of its very compressed high whorls, the exceedingly narrow venter even in a large whorl, the deep and narrow umbilicus, and the complete absence of ornamentation; also by the slender and long saddles of the suture. It is in every respect very similar to *Placenticeras whitfieldi* and I do not doubt that it belongs to this species. In the only drawing of a larger suture figured by Hyatt on his plate XLVI the sutures appear still more complicated and the saddles and lobes longer, but this may be due to the circumstance that the sutures of our specimen are less well preserved. The form of our individual is entirely the same as that of *Pl. whitfieldi* which has also the absence of ornamentation in typical specimens. There is no other American species with which this one can be compared. *Pl. whitfieldi* occurs in the Fort Pierre group of the Rocky Mountain section; our own specimen has been found in the base of the beds with *Exogyra costata*.

Haug considers the Fort Pierre group as Maestrichtian but this cannot be accepted, because the first *Sphenodiscus lenticularis* occurs in the Fox Hills beds, and it seems that this species characterizes the lower part of the American Maestrichtian. The underlying Fort Pierre is therefore probably Campanian. There is no doubt that the *Exogyra costata* beds are overlain by real Maestrichtian and underlain by upper Santonian and thus the Campanian age of our beds can scarcely be doubted. Grossouvre has taken the Escondido beds for lower Campanian but this is certainly wrong as has been shown in another chapter of this publication.

Placenticeras bidorsatum[163] occurs in Europe in the Campanian, especially in the lower portion of it. It is quite different from the species of *Placenticeras* which are found in the Santonian, and Hyatt[164] has created for this group a special genus, *Diplacmoceras*. According to Spath[165] these forms do not occur in the Campanian but in the very highest Santonian, which may be a matter of taste.

Hyatt says that these forms have the external character of *Engonoceras* and the suture of *Placenticeras*. This group develops its ornamentation very late, and appears to be smooth in the inner whorls, while at last there appear nodules below the venter on the flank which little by little rise, until they reach the venter. The suture is quite that of *Placenticeras* although the saddles are very ramified and slender and long. The venter is very characteristic, it is concave and bordered by two sharp edges.

These forms seem to me quite similar to *Pl. whitfieldi* in several aspects. This species also has the concave venter in the small whorls and its suture is also very ramified and the saddles are extremely long. The long branches of the siphonal lobe are also very similar, the flattened form and the deep and narrow umbilicus. I suppose that the younger

[163]Roemer, **66**, p. 88, pl. xiii, fig. 5.
Schlüter, **69**, p. 51, pl. xv, figs. 6–8.

[164]Hyatt, **38**, p. 242.

[165]Spath, **84**, table at p. 80.

species of *Placenticeras* have a tendency to lengthen the saddles and lobes of their suture, to lose all ornamentation and to develop a flat or concave venter with sharp edges. These forms are certainly different from the typical *Placenticeras* of the upper Santonian, and it may be necessary to create a special genus for *Pl. whitfieldi*, as we cannot very well unite it with *Diplacmoceras*.

Number of specimens: One.

Age: Campanian, base of the beds with *Exogyra costata* (SanMiguel beds).

Locality: About 20 kilometers from Piedras Negras near Arroyo Navajas, on road to Jimenez, Coahuila, Mexico.

AMMONITES FROM THE MAESTRICHTIAN (ESCONDIDO BEDS)

COAHUILITES N. GEN.

The type of this new genus is *Coahuilites sheltoni* n. sp., which is dedicated to Mr. Shelton, formerly geologist of the Mexican Gulf Oil Company, who called my attention to the locality where this species is most plentiful.

This new genus is characterized by the following features:

Shell discoidal, higher than broad in its whorls, very involute; in its smallest whorls of a sagittal cross section, in the medium ones of subhexagonal and in the mature form of a subrectangular cross section. The youthful forms show a sharp keel, the medium ones a roof-like venter with a keel-like line in the middle; the mature form has a slightly curved almost flat venter, with relatively sharp shoulders.

Ornamentation.—The ornamentation consists of two rows of tubercles, one near the middle of the flank, and one on the ventral shoulder; the tubercles of the lower row are much less numerous than those on the ventral shoulder, but there is no definite relation between the two. In very young specimens the latero-ventral tubercles become very low, almost undiscernible, and the row on the flanks develops from curved thin ribs which begin above the umbilicus and terminate on the flank.

Suture.—The suture consists of a broad siphonal lobe with two branches forming a very wide angle; the siphonal saddle is very low and broad. The external saddle is divided into two branches by a deep adventive lobe; in the younger species of the genus the ventral branch is divided by a deep secondary lobe into two secondary branches, the ventral one of which is much smaller than the umbilical one and strongly inclined toward the venter.

The different branches of the external saddle are indented by a number of secondary lobes; the saddles have phylloid endings. The first lateral lobe is always deeper than any other one, broad at the bottom and narrow at the top; it is irregularly bifid but develops from a trifid lobe. All the rest of the saddles are slender in the stem and broad at the top; the first and second lateral saddle are generally indented at the top, all the auxiliary saddles are entire. The second lateral lobe and all the auxiliary ones are serrated or bifid.

Generic position.—Externally this genus resembles astonishingly *Libycoceras ismaëli* Zittel.[166] It has the same roof-like venter in the medium sized individuals, the two rows of tubercles, one near the middle of the flank and the other on the ventral shoulder, the latter one with many more tubercles than the inner one on the flank, without a constant relation between the number and position of the tubercles of the two rows; the ventral tubercles are lengthened spirally like those in this new genus. But in the mature stage the genus has a different shape from *Coahuilites;* instead of flattening, the venter becomes much sharper. With respect to the suture there is also a certain resemblance. As in this genus the external saddle is divided by one adventive lobe into two adventive saddles, but all the saddles are entire. The lobes are serrate and not so subdivided in branches of different length. The whole suture is curved and not straight as in *Coahuilites.*

A very similar suture to that of *Libycoceras* occurs in *Indoceras baluchistanense* Noetling,[167] a fact which has been mentioned by different authors. But the ornamentation is entirely different. In the suture we find again the external

[166]Quaas, **63**, p. 302, pl. xxix, figs. 3–7; pl. xxx, fig. 1.
[167]Noetling, **52**.

saddle divided by only one adventive lobe, but here also the saddles are all entire and the lobes serrate; they develop from first bifid and these from trifid lobes in the younger stages of growth.

Another very characteristic ammonite from the Maestrichtian of the region is that which Noetling[168] described as *Sphenodiscus acutodorsatus.* This is certainly not a *Sphenodiscus,* because this genus never has entire saddles. The subdivision of the external saddle reminds one of that in *Coahuilites cavinsi* and *C. orynskii,* in so far as the ventral branch of the external saddle is divided by a secondary lobe and the ventral portion of this adventive saddle is strongly inclined toward the venter. This is never true in a real *Sphenodiscus.* In *Indoceras* the ventral branch of the external saddle is also strongly inclined toward the venter, which fact distinguishes it from *Libycoceras.* Thus there really is here a case similar to that in our region: one species with an undivided ventral adventive saddle inclined toward the venter, and another with a divided adventive saddle, the ventral branch of which is inclined toward the venter.

Hyatt[169] considers *Sphenodiscus acutodorsatus* as *Indoceras,* but his manner of not giving much consideration to the position of the first lateral lobe makes it more difficult to arrive at an exact comparison of different genera. *Sphenodiscus acutodorsatus* should at least be considered as a subgenus of *Indoceras.* Böhm[170] places both *I. baluchistanense* and *Libycoceras ismaëli* in the genus *Indoceras,* which seems to be quite impossible taking into account the development of the shape in both genera. He accepts the determination of *Sphenodiscus* for *Sph. acutodorsatus,* but this is also entirely impossible; if we unite this form with *Sphenodiscus* we should certainly place *Placenticeras* also with *Sphenodiscus.* It is impossible to unite different species in the same genus merely because they show the same number of adventive lobes in the external saddle; this is the reason why forms so different as *Pl. warthi* Kossmat,

[168]Noetling, **51**, p. 76, pl. xxi, fig. 3.
[169]Hyatt, **38**, p. 57.
[170]J. Böhm, **7**, p. 200, table.

Pl. uhligi Choffat and others have been wrongly placed in the genus *Placenticeras*.

From *Sphenodiscus* the new genus is easily distinguished, partly on account of the very characteristic ornamentation which has never left a doubt, even in the field, of the generic position of specimens found in the Escondido beds, although in this region both genera occur more or less in the same beds; and secondly, on account of the suture, which is distinct from that of *Sphenodiscus*, first because the external saddle has only one adventive lobe in this genus and two in *Sphenodiscus*, and second on account of the simpler form of all the saddles from the first lateral on, although this latter difference is not very great nor important.

It is quite possible that both *Coahuilites* and *Sphenodiscus* are derived from the same tribe. *Coahuilites* certainly begins to appear earlier, or at almost the same time, as *Sphenodiscus; C. sheltoni* and *C. orynskii* are older than *Sphenodiscus*, the *Sphenodiscus lenticularis* an unornamented form, occurring always a little higher, while the ornamented forms, *Sph. prepleurisepta* and *Sph. intermedius* appear more or less at the same time with *Coahuilites cavinsi*. They are the last ammonites in the Cretaceous of Mexico (except *Parapachydiscus* and *Baculites)*, and certainly are not younger than Maestrichtian. Quaas regards the age of *Libycoceras* as Danian, but that seems to be an error, because the fauna has much more the aspect of Maestrichtian. Noetling regards the age of the beds with *Indoceras* as Maestrichtian; according to his geological cross section *Indoceras* lies about 800 feet above the beds with *Gryphea vesicularis*.

It is not at all improbable that this genus and *Sphenodiscus* are of the same origin as *Libycoceras* and *Indoceras;* I would rather think that these two genera as well as *Placenticeras* are derived from *Engonoceras*, while as Douvillé[171] indicates, *Libycoceras* and *Indoceras* may find their nearest relatives in *Tissotia*. This latter genus has never been found in northern America, while *Engonoceras* and related genera are exceedingly common. *Hoplitoides* and *Coelopoceras* are

[171]Douvillé, 27, p. 320

both found in North America and may belong to the same tribe.

Geographical distribution.—So far, *Coahuilites* has been found only in northern Mexico, in the region between Candela and the Rio Grande. Among the specimens determined and figured by Hyatt[172] as *Sphenodiscus pleurisepta,* is a small specimen, labeled Rio Pecos, Texas, which in its ornamentation resembles very much a medium sized *Coahuilites* and is certainly quite different from the typical *Sphenodiscus pleurisepta.* Hyatt himself says that the suture is simpler than those of later age. His observation that the first five lateral saddles are all divided makes it possible that this specimen is really a *Sphenodiscus.* Only a closer study of the suture could prove if this specimen belongs to *Coahuilites* or to *Sphenodiscus.*

COAHUILITES SHELTONI N. GEN., N. SP.

Plate XIII, Figures 4–11

Coahuilites sheltoni is one of the most common species of the new genus. So far it has been found well preserved in only three places. In its general character it much resembles other *Coahuilites,* but its suture is different from the others.

Description.—Shell discoidal, very involute, with whorls of an almost subhexagonal elongated cross section, much higher than broad. In the inner whorls the cross section is almost sagittal and very similar to the cross section *Sphenodiscus;* these volutions show also a very sharp keel, but in the larger whorls the keel becomes less prominent and in very large specimens the keel appears as a low ridge on the rather rounded or flattened venter. On the living chamber the keel disappears almost entirely and the venter becomes slightly curved. The umbilicus is very narrow and its wall is not very steep; its border is well rounded.

Ornamentation.—The development of the cross section is in a great way due to the development of the ornamentation. The smallest whorls are practically smooth on the

[172]Hyatt, **38**, p. 62, pl. iii, figs. 7–12.

flanks and these are slightly curved up to the ventral keel. Soon two rows of very low nodules appear on the flank, one at about one-fifth of the height of the flank from the keel, and the other at about the same distance from the umbilical wall. This latter row consists first of thin ribs bent towards the front and covering the umbilical half of the flank. Later on local thickenings of the ribs are formed and these develop into sharp tubercles while the ribs disappear. Then the row of the nodules nearest to the umbilicus begins to change its position and moves spirally farther away from the umbilicus; on larger whorls we find this row often only a little below the middle of the flank. Together with this phenomenon the venter becomes less sharp. The row of nodules near the keel retains its position also in the larger whorls but the venter develops a shoulder on each side of the keel. These shoulders begin to develop in the smaller whorls, but the angle between the shoulders is scarcely more than 60° while in the larger whorls this angle grows to 120° and in the largest specimen to almost 150°. The shoulders are limited by the ventral rows of tubercles.

The row of nodules nearest to the umbilicus consists of about 12 tubercles in the smallest whorls and 7–8 in the larger whorls. The nodules are high and pointed but sometimes slightly elongated radially, apparently the result of their development from radial ribs.

The ventral row consists of 20 nodules in the smaller whorls, and of about 16 in the larger ones. They are also high and pointed but elongated in the spiral direction. There does not seem to exist any fixed relation between the two rows of nodules in number or position of the tubercles.

Suture.—The suture of this species is quite different from others of the same genus. In small individuals (height of the whorl: about 17 mm.) the suture is rather curved, but becomes almost entirely straight in the larger whorls.

The siphonal lobe shows a very low siphonal saddle in the middle; the branches of this lobe extend deep into the base of the external saddle. As in all the *Coahuilites* the external saddle is of a rather complicated structure; a bifid adventive lobe, not quite as deep as the first lateral one, divides into two high adventive saddles of which the one near the keel is not symmetrically divided, while the one toward the umbilicus is divided by a small secondary lobe into two parts, each of which is divided again by a still smaller incision. All the terminations of the secondary saddles are phylliform. The first lateral lobe is deeper than any other one and seems to be asymmetrically bifid, the lowest point being divided into two parts by a small secondary saddle; the suture of smaller whorls shows decidedly that this lobe develops from a trifid one. The lobe is deep, broad, divided into three main branches. The first lateral saddle is about as high as the branches of the external one, but is less stout. It is divided into three phylloidal endings by shallow secondary indentations. The top of the saddle is much broader than the stem. The second lateral lobe is only about half as deep as the first one and decidedly bifid in large whorls, but rather serrated in the small ones. It is almost as broad as the first lateral. The second lateral saddle is divided into two phylloidal terminations by a very shallow indentation; its stem is very slender. There follows about 7 auxiliary saddles until the umbilical border and probably one or two more on the umbilical wall; all these saddles are entire and have a broad phylloidal top, while the stem is slender. The auxiliary lobes are broad, shallow and serrate although there seems to exist an inclination to bifid ending. There is no essential difference in the suture of a whorl of 20 mm. height and one of 40 mm. height, except that in the former the second lateral saddle seems to be entire, while in the larger whorls it has a slight sinus; even the number of auxiliary lobes seems to be more or less the same in both cases.

Dimensions:

	I		II	
Diameter	109.2 mm.	(1)	96.1 mm.	(1)
Width of last whorl	?34.4 mm.	0.32	35.2 mm.	0.37
Height of last whorl	60.6 mm.	0.55	56.3 mm.	0.59
Diameter of umbilicus	5.4 mm.	0.05	5.2 mm.	0.05
Width half a whorl back	29.3 mm.	0.27	25.0 mm.	0.26
Height half a whorl back	43.8 mm.	0.40	31.5 mm.	0.33

	III		IV	
Diameter	87.5 mm.	(1)	71.9 mm.	(1)
Width of last whorl	30.0 mm.	0.34	27.8 mm.	0.39
Height of last whorl	51.2 mm.	0.59	37.9 mm.	0.52
Diameter of umbilicus	4.3 mm.	0.05	3.9 mm.	0.05
Width half a whorl back	21.7 mm.	0.25	17.0 mm.	0.24
Height half a whorl back	32.0 mm.	0.37	30.2 mm.	0.42

	V		VI	
Diameter	54.1 mm.	(1)	54.7 mm.	(1)
Width of last whorl	19.4 mm.	0.36	?16.5 mm.	0.30
Height of last whorl	27.6 mm.	0.51	28.8 mm.	0.53
Diameter of umbilicus	3.5 mm.	0.06	3.5 mm.	0.06
Width half a whorl back	15.0 mm.	0.28	?11.2 mm.	0.20
Height half a whorl back	23.0 mm.	0.43	22.5 mm.	0.41

	VII		VIII	
Diameter	39.1 mm.	(1)	30.9 mm.	(1)
Width of last whorl	10.3 mm.	0.26	8.1 mm.	0.26
Height of last whorl	21.9 mm.	0.53	17.3 mm.	0.56
Diameter of umbilicus	2.0 mm.	0.05	1.6 mm.	0.05
Width half a whorl back	6.7 mm.	0.17	5.3 mm.	0.17
Height half a whorl back	15.2 mm.	0.39	12.0 mm.	0.39

Relation to other species.—This species is distinguished from those described farther on by the smaller number of nodules in the row nearer to the umbilicus and the shape of the venter which does not become quite as flat as in the others. The differences in the relation of dimensions is not very great but the height of the whorls as well as the width is generally a little greater than in other species. The main difference lies in the suture; in our species the ventral branch of the external saddle is undivided, while in both the other species it shows a deep secondary lobe; also the rest of the lobes are of a somewhat different character.

Number of specimens: About 50.

Age: Maestrichtian, base of the Escondido beds.

Localities: About five kilometers south of the Alamo Viejo Ranch, in Coahuila, on the road to San Patricio, region of Lampazos, Nuevo Leon, Mexico, about half way between Alamo Viejo and San Patricio one kilometer south of the gate. Several typical specimens were found on the first ledge about 150 feet above the beds with *Exogyra costata* all along the Mesillas near San Patricio, Nuevo Leon, region of Lampazos. The species seems to be limited to about 10 meters of sandstone and sandy shale and sandy limestone. This bed is crossed by the road from San Patricio to Alamo Nuevo Ranch, and several specimens have been found near the road also.

COAHUILITES ORYNSKII N. SP.

Plate XIV, Figures 1–3

I owe two well preserved specimens of a very characteristic *Coahuilites* to the amiability of Messrs. Noble and Adkins, formerly of the Aguila Petroleum Company. They were collected by the geologists of this company at the foot of the Mesillas near San Patricio, and are different from other specimens found near this locality.

Description.—Shell discoidal, very involute, with whorls of a subrectangular to subhexagonal cross section, much higher than broad when mature. The innermost whorls have an almost sagittal cross section, very similar to that of *Sphenodiscus;* they have a very sharp keel. In larger whorls the keel becomes less sharp, the venter, which in the small whorls passes into the flank without a well defined shoulder, now develops shoulders on both sides and becomes roof-like. At a diameter of less than 65 mm. the venter begins to flatten, the keel begins to disappear and soon the venter is almost flat, only slightly rounded, entirely smooth and with two very distinct shoulders. The umbilicus is very narrow, its wall is not at all steep and the border so little expressed that the wall practically passes imperceptibly into the flank.

The ornamentation consists of two rows of nodules. The innermost whorls are not known in this species, at least with respect to their ornamentation. In the medium sized whorl we observe an inner row of pointed sharp tubercles at about half the height of the flank; this row rises spirally little by little on the flank, and on the living chamber it lies above the middle of the flank. In this species the tubercles of the two flanks alternate with each other, in such a manner that a tubercle of one flank corresponds to an interstice on the other one. There are 9–10 tubercles in each row. Where the venter joins the flank we find another row of tubercles; these are prominent but lengthened spirally and form the shoulder of the venter. These tubercles correspond to each other on both flanks in such a manner that the tubercle of one row stands opposite to one of the row on the other flank. This ventral row consists of 13 tubercles. There is no fixed relation between the row on the flank and that on the ventral shoulder either in number or in position.

Suture.—The suture of this species shows a decided resemblance with that of *Coahuilites cavinsi* described farther on. The siphonal lobe is broad and shallow with two long branches forming a wide angle; between them rises a very low siphonal saddle. The external saddle is divided by a deep adventive lobe into two branches, of which the one nearer to the venter shows a rather deep secondary lobe which causes a bifurcation of this adventive saddle; the ventral branch is strongly inclined toward the siphonal side and terminates in two phylloidal points, while the branch nearer to the flank is parallel to the rest of the saddles and ends in three phylloidal points. The adventive lobe is bifid and shows few incisions. The adventive saddle nearer to the flank is very narrow in the stem and broad at the top; it ends in four phylloidal points. The first lateral lobe is much deeper than the siphonal one and is somewhat irregularly bifid; it is very broad in the lower portion and narrow at the top; it shows a number of incisions. The first lateral saddle is about as high as the external one, very slender in the stem and broad at the top, which shows two phylloidal endings. It is slightly inclined toward the venter. The second lateral lobe is apparently trifid; it is only about half as deep as the first one, broad at the bottom and narrow at the top. The second lateral saddle is low, entire, ending in one large phylloidal termination, slender at the stem and broad at the top. There follow about 7 or 8 auxiliary lobes outside the seam of the umbilicus; all of these are decidedly bifid, broad and shallow. The auxiliary saddles are all entire and have a broad phylloidal top while the stem is much thinner; they are all very low.

The suture is almost straight, the tops of the saddles from the largest adventive saddle of the external one until the last auxiliary one lie on a straight line.

Dimensions:

Diameter	85.6 mm.	(1)
Width of last whorl	27.3 mm.	0.32
Height of last whorl	47.6 mm.	0.56
Diameter of umbilicus	4.1 mm.	0.05
Width of penultimate whorl	16.2 mm.	0.19
Height of penultimate whorl	27.0 mm.	0.32

Relation to other species.—The difference between this species and *Coahuilites cavinsi* are indicated in the description of this latter species. The suture is very similar, but there are minor differences. The main difference lies in the ornamentation, the tubercles on *C. orynskii* being much less numerous, of a different form in the ventral row and of a different position with respect to the height of the flank in the row nearer to the umbilicus.

Externally this species resembles *Coahuilites sheltoni* much more on account of the strong tubercles, but here the inner row is still nearer to the umbilicus and its tubercles do not alternate with those of the corresponding row on the opposite flank. In both the rows on the flank and that on the ventral shoulder the number of tubercles is greater than in the present species. But the greatest difference exists in the suture. In *C. sheltoni* the ventral branch of the external saddle is not divided by a deep secondary lobe and the whole external saddle resembles rather the ventral branch of the external saddle in *C. orynskii.* This difference is so great that the question arises, should not *C. cavinsi* and *C. orynskii* be considered as belonging to a different subgenus of *Coahuilites?* But the external shape and ornamentation and the rest of the suture are so similar that for the present I prefer to unite the three species in one genus.

Number of specimens: Four.

Age: Basal part of Maestrichtian, base of Escondido beds.

Locality: Lowest ledge of hard rock on Mesillas near San Patricio, region of Lampazos, Coahuila-Nuevo Leon, Mexico.

COAHUILITES CAVINSI N. SP.

Plate XIV, Figures 4–8

In the lower portion of the Escondido beds north of the Rio de Nadadores occurs quite frequently a species of this new genus which is distinguished from the other two through its ornamentation and its suture. It seems to always occupy a higher zone and has been found in different places.

Description.—Shell discoidal, compressed laterally, very involute, with whorls of lanceolate cross sections in youth and a subrectangular one in old age. Young specimens have exactly the outline of *Sphenodiscus*, but later on the flanks become flattened and the venter roof-shaped, until at last the venter becomes flattened and slightly curved. In youth the shell is disk-like with a very sharp venter; later on the flanks become flat and almost parallel to each other, while the venter is still sharp but slopes at a larger angle toward the flanks. Near the living chamber the sharp keel of the venter becomes rounded, the angle in which the venter slopes toward the flanks is still much larger and on casts only the slight elevation of the siphon in the middle of the venter indicates where the keel should be; the venter is then entirely rounded. At the same time the flanks become entirely parallel to each other. The umbilicus is very narrow and almost closed. The greatest width of the whorls is a little below the middle of the flanks in the young individuals, and very little above the middle of the flanks in the almost mature ones, but lies in the upper half of the flanks in the living chamber of the mature specimens. The living chamber has about the length of half a whorl.

The ornamentation changes almost as much as the shape, and the cross section. Very young individuals show a row of rather faint tubercles at one-third of the height of the flank. These tubercles are round and slightly pointed, but very low. A second row of still much fainter tubercles appears at two-thirds of the height of the flank which in this case reaches to the keel of the shell, there being no division between the flank and what in later stages would be called the venter. This second row is so faint that it can scarcely be seen but is easily distinguished by the touch. The number of tubercles seems to be more or less the same in both rows, i.e., about 12 to the volution. In a later stage, when the venter becomes roof-like and is well distinct from the flanks, the umbilical row of tubercles rises little by little and takes its place in the middle of the flank; the tubercles are still low but more pointed; they begin to lengthen radially but with a bend toward the front of the animal. At the same time the second row of tubercles (near the venter) becomes very distinct, the tubercles being first pointed and round and more numerous than those of the umbilical row. On mature specimens we count 12 tubercles in the flank row and 20 on the latero-ventral series. The external row of tubercles also rises slowly above the umbilicus and takes the place where venter and flank join. This becomes especially evident on the living chamber where the keel disappears and the upper row of tubercles forms the shoulder of the broad and almost flat venter. Here the tubercles on the flank become clearly lengthened radially but with an oblique direction toward the venter. On the living chamber the tubercles of the latero-ventral row become also lengthened, very oblique and rather sharp. In some places they even seem to send out toward the umbilicus a very faint and falciform rib which disappears in the upper third of the flank, perhaps joining a tubercle of the inner row.

Suture.—The difference in the suture in the specimens described above is much less; the outline of the different elements is practically the same in specimens of 45 mm. in diameter and in such of 100 mm. although the form of the shell is entirely different. The mature suture consists of a very broad and shallow siphonal lobe with two broad branches which form a very large angle; between these rises a broad and low siphonal saddle. The external saddle is low but very broad, it is divided by an adventive lobe into two adventive saddles the ventral one of which is divided by a rather deep secondary lobe; the umbilical adventive saddle is very broad and little dissected, ending in three phylloidal marginals; the branches of the ventral adventive saddle are extremely slender and the smaller one is inclined toward the venter; the adventive lobe which divides the saddle is serrated at the bottom. The first lateral lobe is much deeper than the rest of the lobes but of a very simple structure, ending in a short point and showing small saw tooth-like indentations on the sides. The first lateral saddle is as high as the external one, but very slender and with two phylloidal terminations. The second lateral lobe is half as deep as the first one; it is distinctly bifid, very wide at the bottom and narrow at the top. The second lateral saddle is very low and terminates in two broad leaves. The next three auxiliary saddles are very simple and low, ending in a single broad leaf; the last two auxiliary saddles are broad subquadrangular. The five auxiliary lobes are all very shallow, broad and bifid, with two minor indentations.

Dimensions:

	I	
Diameter	83.2 mm.	(1)
Width of last whorl	23.5 mm.	0.28
Height of last whorl	43.7 mm.	0.53
Diameter of umbilicus	6.0 mm.	0.07
Width of penultimate whorl	.....	.....
Height of penultimate whorl	.....	.....

	II		III	
Diameter	83.0 mm.	(1)	74.4 mm.	(1)
Width of last whorl	22.8 mm.	0.27	20.5 mm.	0.28
Height of last whorl	42.0 mm.	0.51	37.1 mm.	0.50
Diameter of umbilicus	6.0 mm.	0.07	5.8 mm.	0.08
Width of penultimate whorl	13.5 mm.	0.16	.....	.....
Height of penultimate whorl	27.9 mm.	0.34	.....	.....

Relation to other species.—The only species with which we can compare this one is *Coahuilites orynskii* n. sp. The differences are quite evident. In *C. orynskii* the whorls are relatively broader and the greatest width does not lie near the venter but below the middle of the flank; the flank is not so flat, especially on the living chamber, the venter is narrower there. The number of tubercles is much smaller in both rows and the tubercles are stronger, the row on the flank lies much nearer to the umbilicus than in *C. cavinsi*, and its tubercles alternate with those of the row on the opposite flank. The suture also shows differences: in *C. orynskii* the umbilical branch of the external saddle is much more slender and more dissected and it ends in four phylloidal terminations while that of *C. cavinsi* always ends in three. The first lateral lobe is much wider and more dissected; the rest of the saddles are more slender than in *C. cavinsi*. The number of auxiliary lobes is greater (7). A comparison of the dimensions shows the difference of the shape in the two species

	C. cavinsi		*C. orynskii*	
Diameter	83.0 mm.	(1)	85.6 mm.	(1)
Width of last whorl	22.8 mm.	0.27	27.3 mm.	0.32
Height of last whorl	42.0 mm.	0.51	47.6 mm.	0.56
Diameter of umbilicus	6.0 mm.	0.07	4.1 mm.	0.05
Width of penultimate whorl	13.5 mm.	0.16	16.2 mm.	0.19
Height of penultimate whorl	27.9 mm.	0.34	27.0 mm.	0.32

Coahuilites orynskii occurs in a much lower horizon than the species described here, it occurs in the bed immediately above the *Exogyra costata* beds and forms the base of the Maestrichtian. *C. cavinsi* occupies a relatively high position in the Maestrichtian and lies far above the beds with *Sphenodiscus lenticularis* and even above the lowest beds with *Sphenodiscus prepleurisepta*.

Number of specimens: About 30.

Age: Maestrichtian (lower part of the Escondido beds).

Localities: Mesa de Santa Cruz; old road from Santa Cruz to Rancho de los Garcias, between the ranch Santa Cruz and the road from Progreso to Saltillito. Road from Progreso to Santa Cruz, near the latter ranch, about 10 miles from Progreso.

SPHENODISCUS LENTICULARIS OWEN

Plate XIV, Figures 9–11

1852 *Ammonites lenticularis* Owen, **56**, p. 579, pl. viii, fig. 5.
1876 *Placenticeras (Sphenodiscus) lenticulare* Meek, **47**, p. 473, fig. 66 of text; pl. xxxiv, fig. 1.

1903 *Sphenodiscus lenticularis* Hyatt, **38**, p. 71, pl. viii, figs. 1, 2; pl. ix, figs. 1–6.
1903 *Sphenodiscus lenticularis* Solger, **76**, p. 69, text fig. 25; pl. iv.
1913 *Sphenodiscus lenticularis* Böse, **8**, p. 20, pl. i, figs. 1–5.

Sphenodiscus lenticularis is not a rare species in the region between Lampazos and Piedras Negras. It occurs always at the bottom of the Escondido beds and is never found in a higher zone. I have first cited this species from Mexico at a locality near Ramos Arizpe not far from Saltillo, Coahuila, but later on have seen it almost everywhere between that point and Piedras Negras at the base of the Escondido beds. It lies always right above the upper zone of *Exogyra costata* but not in the very lowest bed of the Escondido formation.

Description.—Shell discoidal, very involute with a sagittal cross section, much higher than broad. The flanks are slightly curved in youthful specimens and almost flat in large specimens, the venter is sharp, the umbilicus very small, passing imperceptibly into the flank. On the cast no ornamentation can be found.

The suture is relatively simple. The siphonal lobe is very broad and not very deep, it has two lateral branches which form an angle of about 90 degrees. Between them rises a low and broad siphonal saddle. The external saddle is divided by two adventive lobes into three adventive saddles, which are all very slender in the stem and broad at the top, terminating in phylloidal marginals. This refers to large specimens; in smaller volutions the saddles are stouter. The first lateral lobe is broad and deeper than any other one but not much ramified. The first lateral saddle is stouter than the adventive ones of the external saddle and about as high. The second lateral lobe is much shallower and narrower than the first one, but built after the same model. The second lateral saddle is similar to the first one but much smaller. In a medium sized specimen we count 6 auxiliary lobes all serrated or bifid at the bottom, broad and shallow. The auxiliary saddles are entire, the first and second lateral saddles are indented at the top.

does not seem to be very common, although it has been found in at least two places.

Description.—Shell discoidal, very involute, compressed laterally, with whorls of sagittal cross section in the smaller specimens and more oval cross section in large whorls, much higher than broad. The flanks are curved but show in the umbilical third a flat zone which slants uniformly toward the umbilicus; the outer two-thirds are slightly but almost uniformly curved toward the venter. The venter is sharp in the inner whorls but rounded at a diameter of less than 60 mm. The umbilicus is very narrow but has no walls, the surface of the flank rising from the seam uniformly toward the middle of the flank.

The ornamentation consists of two rows of nodules in the small specimens. One row consisting of about 8 or 9 round nodules which are small but prominent, lies just where the flat or even concave zone near the umbilicus ends below the middle of the flank, the row of nodules dividing the concave zone from the curved part of the flank; this is entirely the same in the largest specimen as in the smallest one. The second row of nodules appears only in the smallest whorl observed, but these nodules are rounded and low and lengthen in the somewhat larger whorl into broad low almost invisible folds, which disappear before they reach the venter. On very large specimens they seem to disappear entirely on the last volution.

Suture.—The suture is rather simple. The siphonal lobe is extremely broad, its two branches are very short while the siphonal saddle between them is very broad and very low. The external saddle is divided into three adventive ones by two adventive lobes. The first adventive saddle is the smallest and is entirely simple, ending in a round leaf, even in a completely mature specimen. The first adventive lobe is deep and broad, it has four teeth-like branches and is bifid. The second adventive saddle is bifid, slender in the stem. The second adventive lobe is deeper than the first, irregularly bifid with four teeth-like branches, each of which is subdivided by very small saddles. The third adventive saddle is high, narrow in the stem but much broader than either of the first two and is decidedly bifid, ending in two very broad leaves. The first lateral lobe is very deep and broad, it has five teeth-like short branches which are subdivided at the end by insignificant saddles; the lobe is much broader below than at the top. The first lateral saddle is very high, about as tall as the third adventive saddle, but more or less as broad; it is bifid, ending in two very broad leaves separated by a narrow and shallow indentation. The second lateral lobe is about two-thirds as deep as the first one, it has four short branches, none of which is subdivided; it is bifid. The second lateral saddle is short and bifid, ending in two broad leaves which are separated by a small incision; in a small whorl this saddle is entire. There are 10 auxiliary lobes and 9 auxiliary saddles. All the auxiliary saddles are entire, becoming very broad, almost subquadrangular near the umbilical border and very narrow on the umbilicus itself; of the auxiliary lobes six are bifid and the first of them has two more teeth-like branches on the side; the rest are entire with a rounded bottom. On a small specimen these differences do not yet appear or at least are not discernible on account of the preservation of the individual, which occurs in a rather coarse sandy limestone.

Dimensions:

	I	
Diameter	95.6 mm.	(1)
Width of last whorl	21.6 mm.	0.23
Height of last whorl	53.5 mm.	0.56
Diameter of umbilicus	7.7 mm.	0.08

	II		III	
Diameter	80.6 mm.	(1)	59.2 mm.	(1)
Width of last whorl	21.6 mm.	0.27	14.2 mm.	0.24
Height of last whorl	42.3 mm.	0.52	30.9 mm.	0.52
Diameter of umbilicus	?6.0 mm.	0.07	5.5 mm.	0.09

Relation to other species.—Externally this species resembles most *Sphenodiscus intermedius*, but the suture is entirely different, the saddles are less subdivided and of different form, as we have explained in the discussion of this latter species.

This species resembles also *Sph. pleurisepta* but the saddles of this latter species are shorter and stouter and the first lateral lobe is not as deep in relation to the adventive lobes of the external saddle. The ornamentation is also different; while in *Sph. pleurisepta* the row of nodules nearest to the venter is stronger in the small specimens and develops in large specimens into broad arcuate ribs, these nodules are very insignificant in this species and practically disappear in large individuals. It seems also that this species is always much smaller than *Sph. pleurisepta.*

Number of specimens: Five.

Age: Lower Escondido beds, lower Maestrichtian.

Localities: Little mesa near road from El Oro Ranch to Jabalí Ranch, a few miles from the latter one. Hill at 27.3 kilometers N 15° W of San Patricio Ranch on road to Alamo Nuevo, region between Lampazos and Villa de Juarez, Coahuila, Mexico.

SPHENODISCUS ABERRANS N. SP.

Plate XVI, Figures 1–3; Plate XVII, Figure 1

Among the material from the highest beds of the Escondido formation I found a number of specimens which are decidedly different from *Sphenodiscus pleurisepta.* The difference exists not only in the shape and ornamentation, but also in the suture.

Description.—Shell discoidal, laterally compressed, very involute, consisting of whorls with a sagittal cross section in the interior whorls and an elongated subrectangular-oval one in the last whorl; the cross section is much higher than wide, the greatest thickness lying in the upper third of the flank. The flank is flattened on the living chamber, but slightly concave in the inner half of the smaller whorls and convex on the external half. The venter is sharp in the inner whorls, becomes rounded in the mature ones and flattened on the living chamber. The umbilicus is very narrow, its border is rounded and the wall is moderately steep.

The ornamentation consists of about 17 broad, rounded ribs which begin at the upper third of the flank where they are thick and high and decrease in height and width toward the venter and disappear a little below the ventral keel. The ribs are radial but slightly inclined forward; they are separated by broad and rounded interstices. On the smaller whorls the ribs begin with a strong nodule. The umbilical two-thirds of the flank are smooth. The shell shows fine lines of growth inclined forward on the flank and curving strongly forward on the venter.

Suture.—The elements of the sutures are extremely simple, especially the lobes, much more so than in any other species described. The siphonal lobe is very broad and shallow and a siphonal saddle can scarcely be distinguished. The external saddle is divided into three adventive saddles by two adventive lobes. The first adventive saddle is very low and simple, ending in two small round leaves; the first adventive lobe is narrow and shallow, irregularly bifid, ending in two very short rounded points; the second adventive saddle is higher than the first and slender; it ends in two phylloidal marginals; the second adventive lobe is much deeper and broader than the first one, serrated at the bottom and ends in two very short points; the third adventive saddle is higher and stouter than the second one and ends in two phylloidal terminations. The first lateral lobe is deeper than the adventive and the siphonal ones, it is also broader than the adventive lobes; it is serrated at the bottom, ending in two short branches. The first lateral saddle is about as high as the third adventive one but a little stouter, ending in two phylloidal terminations. The second lateral lobe is much shorter and narrower than the first one but is in general similar and serrated at the bottom. The second lateral saddle is very short, ends in one phylloidal point and is slender in the middle. The first three auxiliary lobes are very simple, showing only a serrated bottom; the first three auxiliary saddles are entire, ending in a broad and round leaf. The fourth auxiliary lobe is divided by a high and narrow secondary saddle. The fourth auxiliary saddle is relatively broad and divided by an incision. But these particulars exist only on one side of the original, while the other flank does not show any difference in the form of the auxiliary lobes and saddles, except that the saddles near the umbilicus become broader and lower, as is shown in the other suture figured here. The fifth auxiliary lobe shows only an indentation in the middle, while the sixth and seventh are rounded at the bottom. The fifth and sixth auxiliary saddles are entire, the fifth being high and broad, while the sixth is low and narrow.

Dimensions:

	I	
Diameter	115.1 mm.	(1)
Width of last whorl	23.0 mm.	0.20
Height of last whorl	61.7 mm.	0.54
Diameter of umbilicus	5.5 mm.	0.05
Width of penultimate whorl	16.9 mm.	0.15
Height of penultimate whorl	36.2 mm.	0.31

	II		III	
Diameter	106.3 mm.	(1)	100.0 mm.	(1)
Width of last whorl	24.5 mm.	0.22	25.7 mm.	0.26
Height of last whorl	57.0 mm.	0.54	52.5 mm.	0.53
Diameter of umbilicus	5.2 mm.	0.05	5.0 mm.	0.05
Width of penultimate whorl	10.5 mm.	0.10	......	......
Height of penultimate whorl	33.5 mm.	0.32	......	......

Relation to other species.—The nearest species to this one is probably *Sphenodiscus pleurisepta* Conrad which is one of the few that have a decided ornamentation. But while *Sph. pleurisepta* has two rows of tubercles which in very large specimens unite to short ribs approximately on the center of the flank, with very faint indications of elongated tubercles near the venter, we find in this species only one row of ribs on the upper portion of the flank while the lower portion of the flank is smooth and concave. On the smaller whorls the inner nodules are above the middle of the flank. In shape *S. aberrans* resembles the very old individuals of *Sph. pleurisepta* as shown in Hyatt's (loc. cit.) plate IV, but this species preserves a sharp keel much longer and the ornamentation is never as pronounced as in *Sph. aberrans*. The suture is different from that of *Sph. pleurisepta;* the lobes as well as the saddles are much simpler than those of corresponding stages of growth of the form described by Conrad. Especially the adventive saddles of the external saddle appear extremely simple and even reduced in size, particularly the first one which appears almost degenerated.

Number of specimens: Five.

Age: Upper Maestrichtian, highest beds of Escondido formation.

Localities: Four miles northwest of crossing of Arroyo Caballero, Coahuila, on road from Nuevo Laredo to Piedras Negras. Arroyo Caballero downstream from same road, Coahuila, Mexico.

SPHENODISCUS PLEURISEPTA CONRAD

Plate XVII, Figures 2–5

1857 *Ammonites pleurisepta* Conrad, **19**, Vol. I, pt. II, p. 159, pl. xv, fig. 1.
1861 *Ammonites pedernalis* Binkhorst, **6**, p. 23, pl. va, fig. 1.
1898 *Sphenodiscus pleurisepta* Böhm, **7**, pl. vii.
1903 *Sphenodiscus pleurisepta* Hyatt, **38**, p. 59, pl. iii, figs. 7–15; pl. iv; pl. v, figs. 1–3; pl. vi, fig. 6.

Sphenodiscus pleurisepta is a very common species in the highest portion of the Escondido beds. There might be a possibility of distinguishing in the slightly lower beds a variety which has less prominent nodules in the row nearer to the venter, and the venter of which becomes sooner rounded; also the suture seems to be a little different, but my material is not sufficient for a description of this form.

Sphenodiscus pleurisepta has been described and figured by Hyatt in such a detailed manner that we do not need to add anything here.

Number of specimens: About 50.

Age: Upper Maestrichtian (upper Escondido formation).

Locality: Arroyo del Caballero and vicinity near Hacienda Cerro Prieto on the Rio Bravo, Coahuila, Mexico.

PARAPACHYDISCUS CFR. COLLIGATUS BINKHORST

Plate XV, Figure 11

1861 *Ammonites colligatus* v. Binkhorst, **6**, p. 25, pl. vii, 8a.
1890 *Pachydiscus colligatus* Seunes, **73**, p. 6, pl. ii, fig. 4; p. 13, pl. iii, fig. 3.
1893 *Pachydiscus colligatus* de Grossouvre, **35**, p. 202, pl. xxiv, fig. 3 (fig. 1?); pl. xxxiii?
1907 *Parapachydiscus colligatus* Pervinquière, **57**, p. 175, pl. vii, fig. 12.
1908 *Pachydiscus colligatus* de Grossouvre, **36**, p. 28, pls. iv–viii.
1913 *Pachydiscus colligatus* Nowak, **53**, p. 361, pl. xliii, fig. 30; pl. xliv, fig. 39.
1921 *Parapachydiscus* n. sp. aff. *colligatus* Spath, **79**, p. 226.

In the lower portion of the Maestrichtian of Progreso I found a fragment of a *Parapachydiscus* which is either very nearly related to *P. colligatus* or even identical with this species. It is only about one-fourth of a whorl with rounded flank and rounded venter, higher than wide. The form is not very evolute. The ornamentation consists of 11 ribs on the fourth of a whorl; these ribs are thin, not very high, but very distant from each other; one of these ribs does not reach the umbilical border, some seem to bifurcate from slight swellings at the umbilical border. All the ribs are equally strong on the venter which they pass although they become slightly weakened at the grooved siphonal line. The ribs are almost radial and only very little bent forward.

The suture could be observed only in parts, but seems to be rather complicated and quite similar to that figured by Binkhorst.

In general our specimen is extremely similar to those from Limburg, especially to the one in fig. 2, pl. IV of Grossouvre (1908); the number of ribs is perhaps a little smaller, but this seems to change somewhat as can be seen in pl. V of Grossouvre.

Grossouvre includes in his synonymy *P. epiplectus* Redtenbacher [175] and Nowak follows him in this, but as Spath has already indicated, the two species are certainly different.

[175] Redtenbacher, **64**, p. 121, pl. xxviii, fig. 2.

Neither do I believe that *P. freswillensis* Seunes[176] can be considered as belonging to *P. colligatus*, the ribs showing a sinus which is much too strong on the venter and the umbilical nodules being preserved even in the large volutions. Only the specimen figured in fig. 1 of pl. VIII in Seunes (Sous-pyrenéenne) is quite similar or possibly identical with *P. colligatus*.

In 1913 I found a large fragment of *Parapachydiscus* in the Arroyo del Caballero near Hacienda Cerro Prieto, Coahuila, which is extremely similar to *P. colligatus*, but unfortunately this specimen is not accessible to me at the present time. It is important in so far as it shows that this group appears not only in the lower portion of our Maestrichtian but also in the very highest. Spath[177] seems to indicate that *Parapachydiscus* occurs only up to the lower portion of the Maestrichtian, but in this region a member of the group certainly occurs also in the very highest beds.

Number of specimens: One.

Age: Lower Maestrichtian, lower part of the Escondido beds.

Locality: First mesa near road from Progreso to Santa Cruz, Coahuila, Mexico.

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[176] Seunes, **73**, p. 3, pl. i; p. 14, pl. iii, fig. 1.
Ibid., **72**, p. 236, pl. vii, fig. 1; pl. viii, figs. 1, 3 (2?).

[177] Spath, **84**, table at p. 80.

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PLATE III

Figs. 1–3. *Acanthoceras cunningtoni* Sharpe var.—Lower Cenomanian, upper Georgetown beds. Arroyo del Tule, 50 km. from Villa Acuña, Coahuila, Mexico........Page 201

Fig. 1, side view; fig. 2, venter; fig. 3, cross section of same specimen.

Figs. 4–10. *Turrilites bosquensis* Adkins.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas........Page 206

Fig. 4, side view = Pl. II, Fig. 4 (Pl. I, Fig. 8).

Figs. 5–10, sutures.

Fig. 5, flank with part of siphonal lobe, external saddle and part of first lateral saddle; Fig. 10, same, amplified twice.

Fig. 6, flank with part of external saddle, first lateral lobe and first lateral saddle; Fig. 8, same, amplified twice; same specimen as Figs. 5 and 10.

Fig. 7, flank with part of external saddle, first lateral lobe and first lateral saddle; Fig. 9, same, amplified twice; same as Pl. II, Figs, 2, 7, 13.

Figs. 11–14. *Baculites* cfr. *baculoides* Mantell.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas......Page 210

Fig. 11, siphonal side; Fig. 14, side view with external saddle and first lateral lobe.

Fig. 12, siphonal side; Fig. 13, side view, same position as Fig. 14.

Original of Figs. 1–3 at University of California, Berkeley; the rest at the Bureau of Economic Geology, University of Texas, Austin.

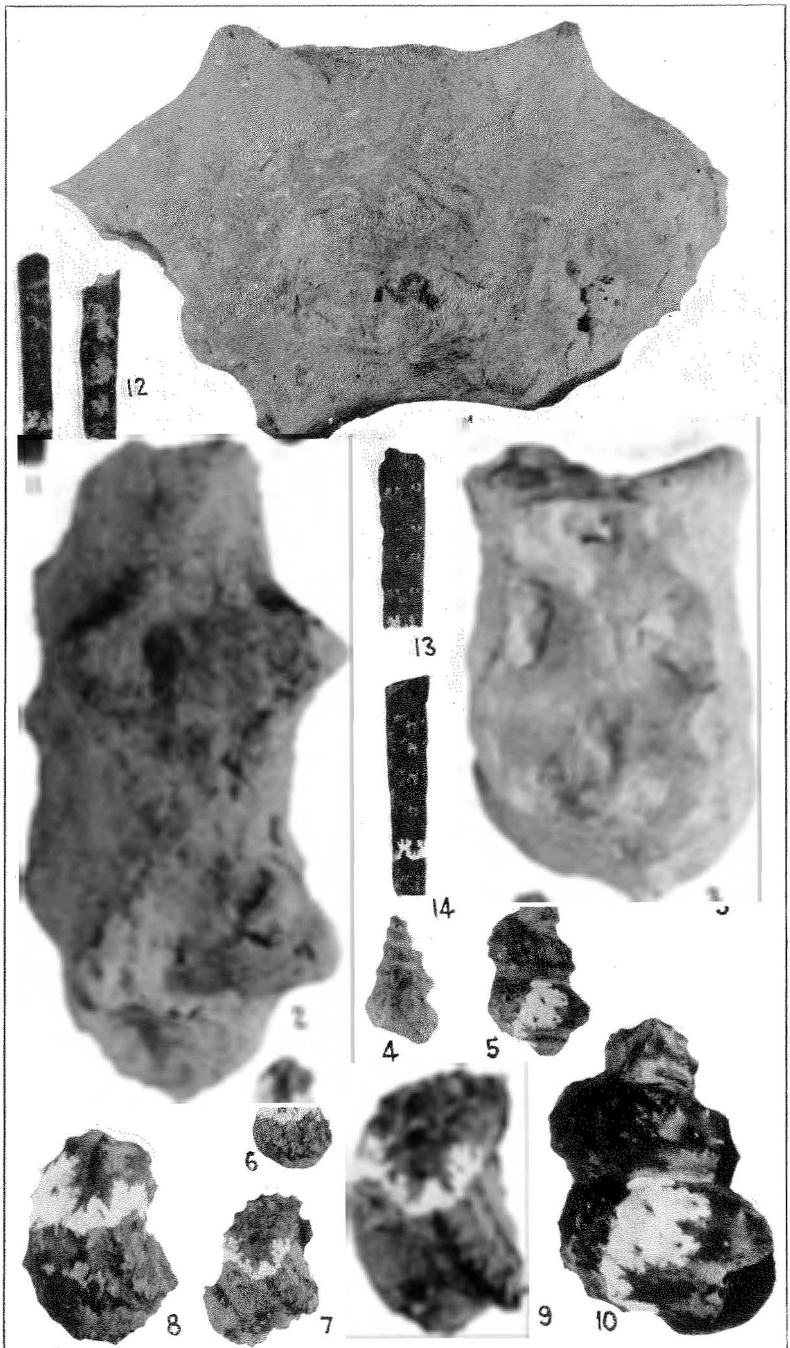
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PLATE IV

Figs. 1, 2. *Turrilites bosquensis* Adkins.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas........Page 206

Fig. 1, internal suture and siphonal lobe (to the right also part of external saddle), amplified twice.

Fig. 2, same specimen, internal suture, from right to left: external saddle, first lateral lobe, and first lateral saddle—all of internal suture.

Figs. 3–11. *Baculites* cfr. *baculoides* Mantell.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas........Page 210

Fig. 3, antisiphonal side, same specimen as Pl. III, Figs. 11, 14.

Figs. 6–11, specimen of Pl. III, Figs. 11, 14, amplified twice.

Fig. 6, siphonal lobe; Fig. 7, siphonal side; Fig. 8, first lateral saddle; Fig. 9, external saddle, first lateral lobe, and first lateral saddle of opposite side; Fig. 10, antisiphonal lobe; Fig. 11, external saddle.

Figs. 4, 5, same as Pl. III, Figs 12, 13, amplified twice.

Figs. 12–15. *Stoliczkaia uddeni* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 951, McLennan County, Texas........Page 211

Fig. 12, side view; Fig. 13, venter of same specimen.

Fig. 14, cross section and venter; Fig. 15, side view.

All originals at the Bureau of Economic Geology, University of Texas, Austin.

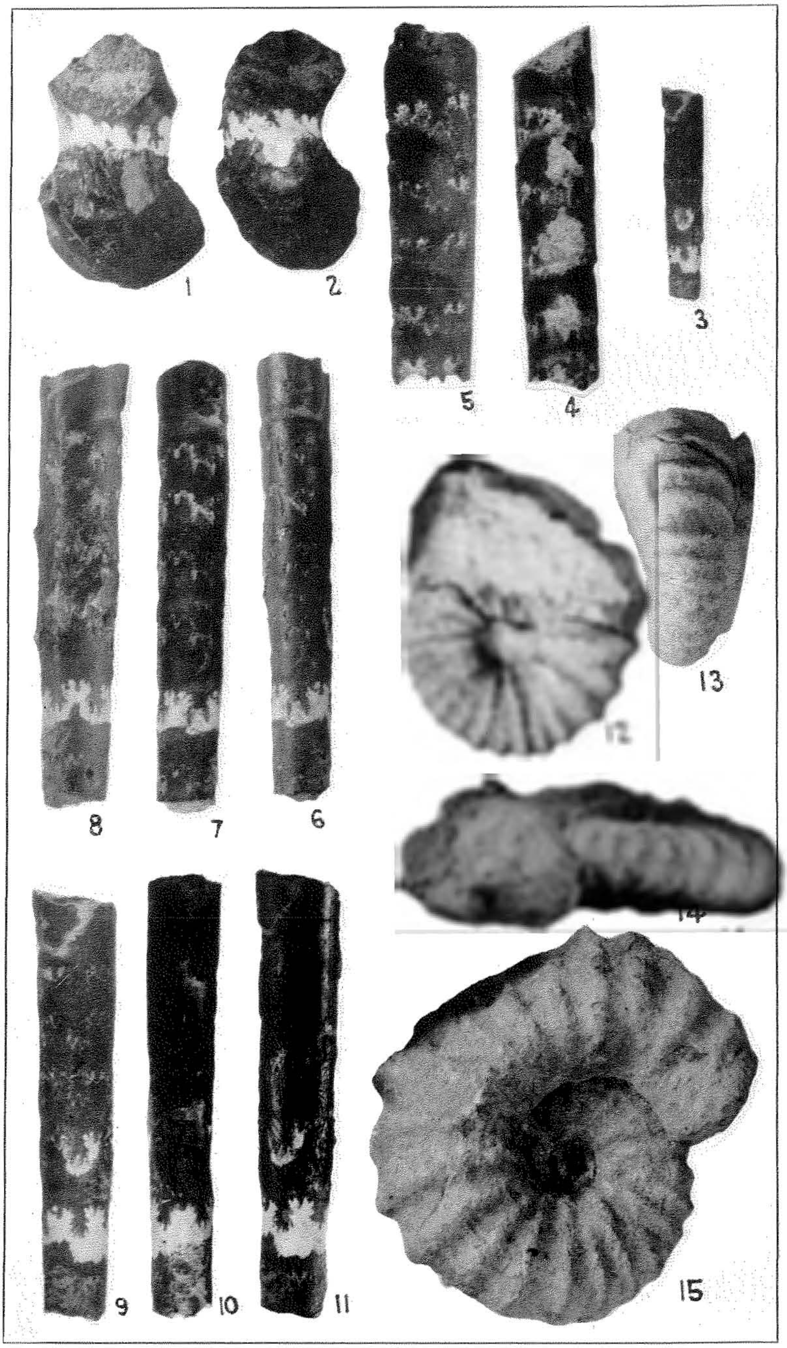

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PLATE V

Figs. 1–8. *Stoliczkaia* aff. *dispar d'Orbigny* sp.—Lower Cenomanian, Del Rio clay. Locality, 4.9 km. from El Orégano on road to San Carlos, region of Jimenez, Coahuila, Mexico.........Page 212

Fig. 1, side view; Fig. 2, cross section; Fig. 3, venter of mature specimen.

Fig. 4, venter; Fig. 5, side view of immature specimen.

Fig. 6, side view; Fig. 8, venter of young specimen.

Fig. 7, side view of still younger specimen.

Figs. 9–25. *Mantelliceras wacoense* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas.........Page 215

Fig. 9, side view with suture; Fig. 10, venter with suture (type).

Figs. 23–25, same specimen (type), enlarged twice.

Fig. 11, cross section; Fig. 12, side view of small specimen.

Fig. 13, side view; Fig. 14, cross section of small specimen.

Fig. 19, side view; Fig. 20, venter of small specimen.

Figs. 15, 16, same specimen, enlarged twice.

Fig. 21, venter; Fig. 22, side view of small specimen.

Figs. 17, 18, same specimen, enlarged twice.

All the originals at the Bureau of Economic Geology, University of Texas, Austin, with exception of Figs. 1–8, which are at the University of California, Berkeley.

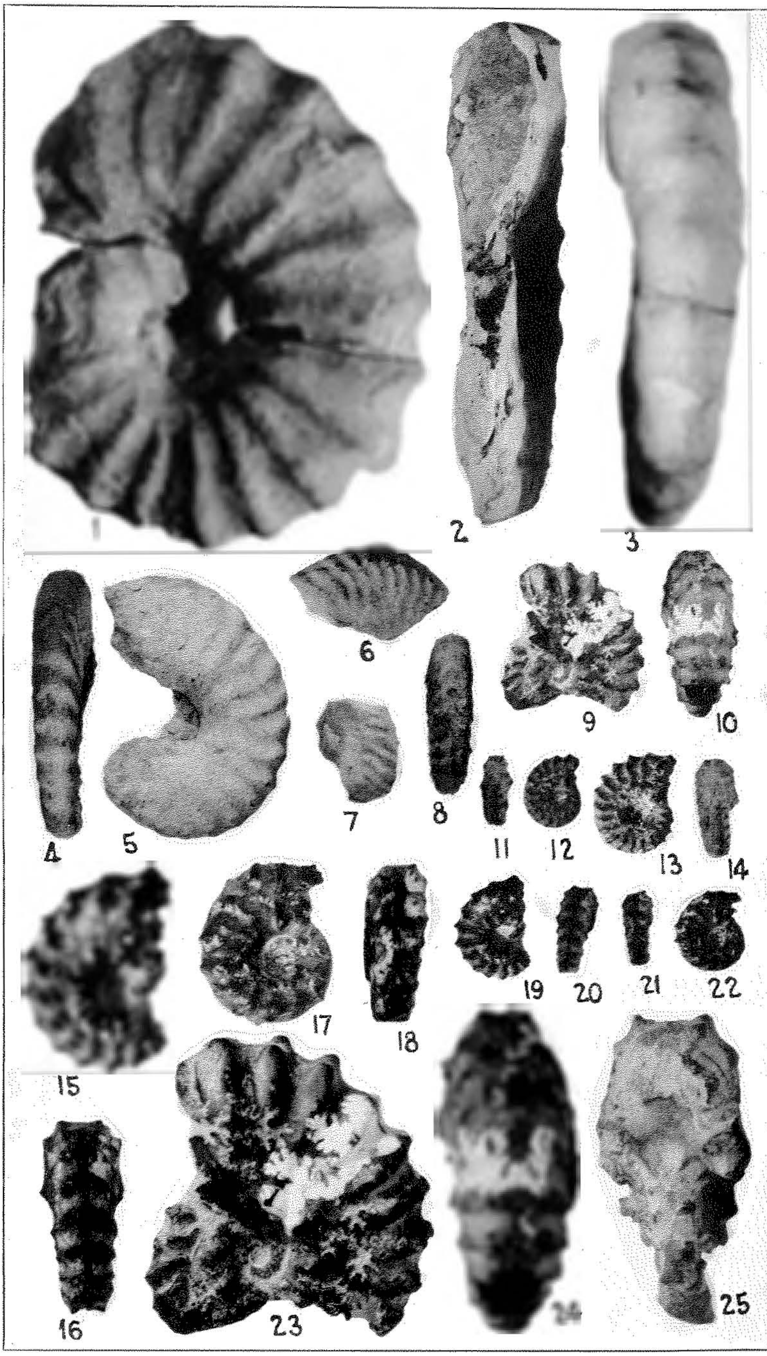
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PLATE VI

Figs. 1–4. *Mantelliceras wacoense* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas........Page 215

Figs. 1, 2, same as Pl. V, Figs. 11, 12, enlarged twice.

Figs. 3, 4, same as Pl. V, Figs. 13, 14, enlarged twice.

Figs. 5–43. *Mantelliceras brazoense* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas........Page 220

Fig. 5, side view; Fig. 6, venter of largest fragment, with suture. Figs. 24, 25, same specimen, enlarged twice.

Fig. 7, side view; Fig. 8, venter, with suture (type).

Figs. 26, 27, same specimen (type), enlarged twice.

Fig. 9, side view; Figs. 40, 41, same, enlarged twice.

Fig. 10, side view; Fig. 11, venter; Figs. 31, 32, same, enlarged twice.

Fig. 12, side view; Fig. 13, cross section; Figs. 30, 33, same, enlarged twice.

Fig. 14, venter; Fig. 15, side view of smallest specimen; Figs. 28, 29, same, enlarged twice.

Fig. 16, cross section; Fig. 17, side view; Figs. 42, 43, same, enlarged twice.

Fig. 18, side view; Fig. 19, venter of fragment; Figs. 38, 39, same, enlarged twice.

Fig. 20, side view; Fig. 21, cross section; Figs. 36, 37, same, enlarged.

Fig. 22, venter; Fig. 23, side view; Figs. 34, 35, same, enlarged twice.

All the originals are deposited in the Bureau of Economic Geology, University of Texas, Austin.

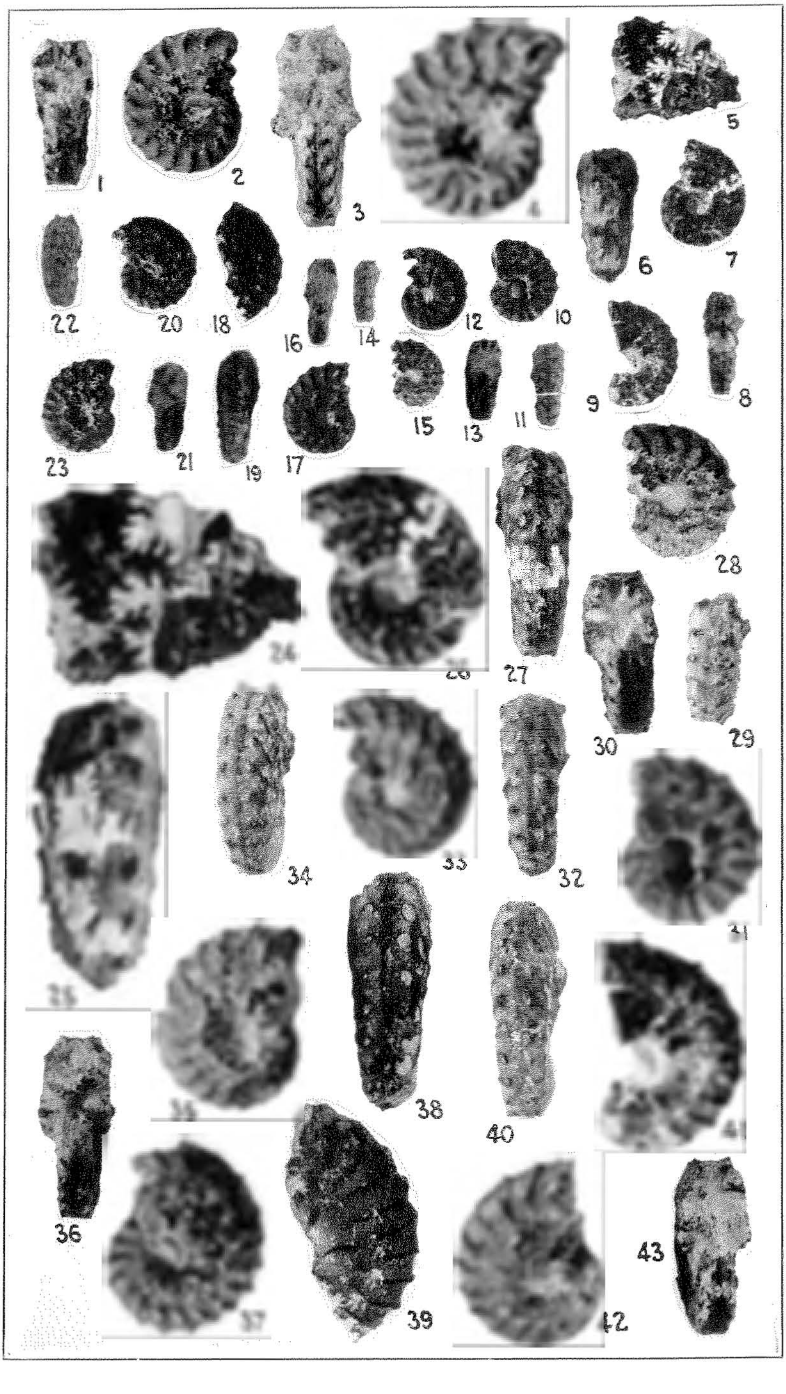
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PLATE VII

Figs. 1–6. *Scaphites bosquensis* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas............Page 224

Fig. 1, side view; Fig. 2, cross section; Fig. 3, venter; Figs. 4–6, same, enlarged twice.

Figs. 7–30. *Scaphites subevolutus* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas............Page 225

Fig. 7, side view; Fig. 8, opposite side, with suture; Fig. 3, venter, with suture; Figs. 23–26, same, enlarged twice (type).

Fig. 10, side view; Fig. 11, venter; Figs. 21, 22, same, enlarged twice.

Fig. 12, side view; Fig. 13, cross section; Figs. 27, 28, same, enlarged twice.

Fig. 14, side view; Fig. 15, cross section; Figs. 29, 30, same, enlarged twice.

Fig. 17, side view; Fig. 19, venter; Figs. 32, 34, same, enlarged twice.

Fig. 16, venter; Fig. 18, side view; Figs. 31, 33, same, enlarged twice.

Fig. 14, side view of very small specimen; Figs. 35, 36, same, enlarged twice, showing the simple ribs at this stage.

Figs. 37–41. *Engonoceras bravoense* n. sp.——Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas............Page 229

Fig. 37, small specimen. Comp. Pl. VIII, Figs. 1–4 (type).

Fig. 38, suture of small specimen; Fig. 41, same, enlarged twice. Comp. Pl. VIII, Figs. 5, 6.

Fig. 39, small pyrite specimen; Fig. 40, same, enlarged twice.

All the originals are in the Bureau of Economic Geology, University of Texas, Austin.


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PLATE VIII

Figs. 1–6. *Engonoceras bravoense* n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas .... Page 229

Fig. 1, same as Pl. VII, Fig. 37, enlarged twice; Fig. 4, cross section of same specimen; Fig. 3, cross section, enlarged twice; Fig. 2, venter, enlarged twice.

Fig. 5, cross section of specimen figured in Pl. VII, Figs. 38, 41; Fig. 6, same, enlarged twice.

Figs. 7, 8. *Engonoceras bravoense* n. sp.—Lower Cenomanian, Del Rio clay. Locality, 4.9 km. from Orégano, on road to San Carlos, region of Jimenez, Coahuila, Mexico .... Page 229

Fig. 7, venter, with siphonal lobe (asymmetrical position), same as Pl. XII, Fig. 8.

Fig. 8, side view and living chamber with suture of large specimen.

Figs. 9–14. *Adkinsia adkinsi* n. gen., n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas .... Page 237

Fig. 12, venter; Fig. 13, cross section; Fig. 14, side view of type; Figs. 9–11, same specimen, enlarged twice.

Figs. 15–20. *Adkinsia sparsicosta*, n. gen., n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas ... Page 238

Fig. 15, venter; Fig. 16, cross section; Fig. 17, side view of type; Figs. 18–20, same specimen, enlarged twice.

Figs. 21–26. *Adkinsia tuberculata* n. gen., n. sp.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas ... Page 240

Fig. 24, cross section; Fig. 25, side view; Fig. 26, venter of type; Figs. 21–23, same specimen, enlarged twice.

Originals of Figs. 7, 8 at University of California, Berkeley; the rest at the Bureau of Economic Geology, University of Texas, Austin.

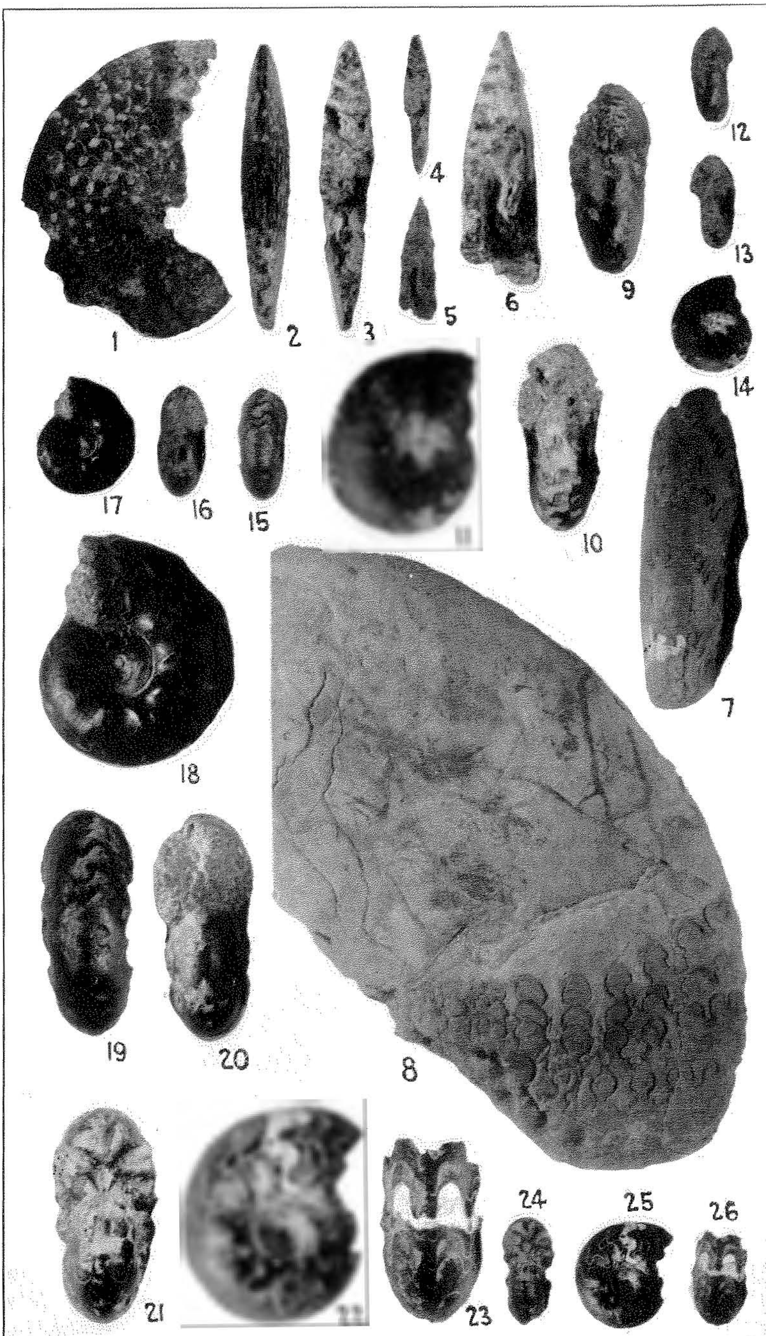
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PLATE IX

Figs. 1–6. *Adkinsia bosquensis* Adkins sp.—Lower Cenomanian, Del Rio clay. Loc. 964, McLennan County, Texas .... Page 242

Fig. 1, side view; Fig. 2, venter; Fig. 3, cross section; Figs. 4–6, same, enlarged twice.

Figs. 7–12. *Adkinsia semiplicata* n. gen., n. sp.—Lower Cenomanian, Del Rio clay. Loc. 966, McLennan County, Texas . Page 246

Fig. 7, side view; Fig. 8, cross section; Fig. 9, venter of type; Figs. 10–12, same specimen, enlarged twice.

Figs. 13–15. *Euhystrichoceras remolinense* n. sp.—Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico.

Fig. 13, side view; Fig. 14, venter; Fig. 15, cross section of type.

Figs. 16–23. *Budaiceras mexicanum*, n. gen., n. sp.—Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico .... Page 247

Fig. 16, side view of small specimen; Fig. 17, venter of same.

Fig. 18, side view of smallest specimen, with immature suture.

Fig. 19, side view; Fig. 20, venter, with rows of nodules.

Fig. 21, first lateral lobe, first and second lateral saddle, and auxiliary lobes.

Fig. 22, siphonal lobe; Fig. 23, external saddle, first lateral lobe, and first lateral saddle of same specimen.

Originals of Figs. 1–12 at the Bureau of Economic Geology, University of Texas, Austin; the rest at University of California, Berkeley.

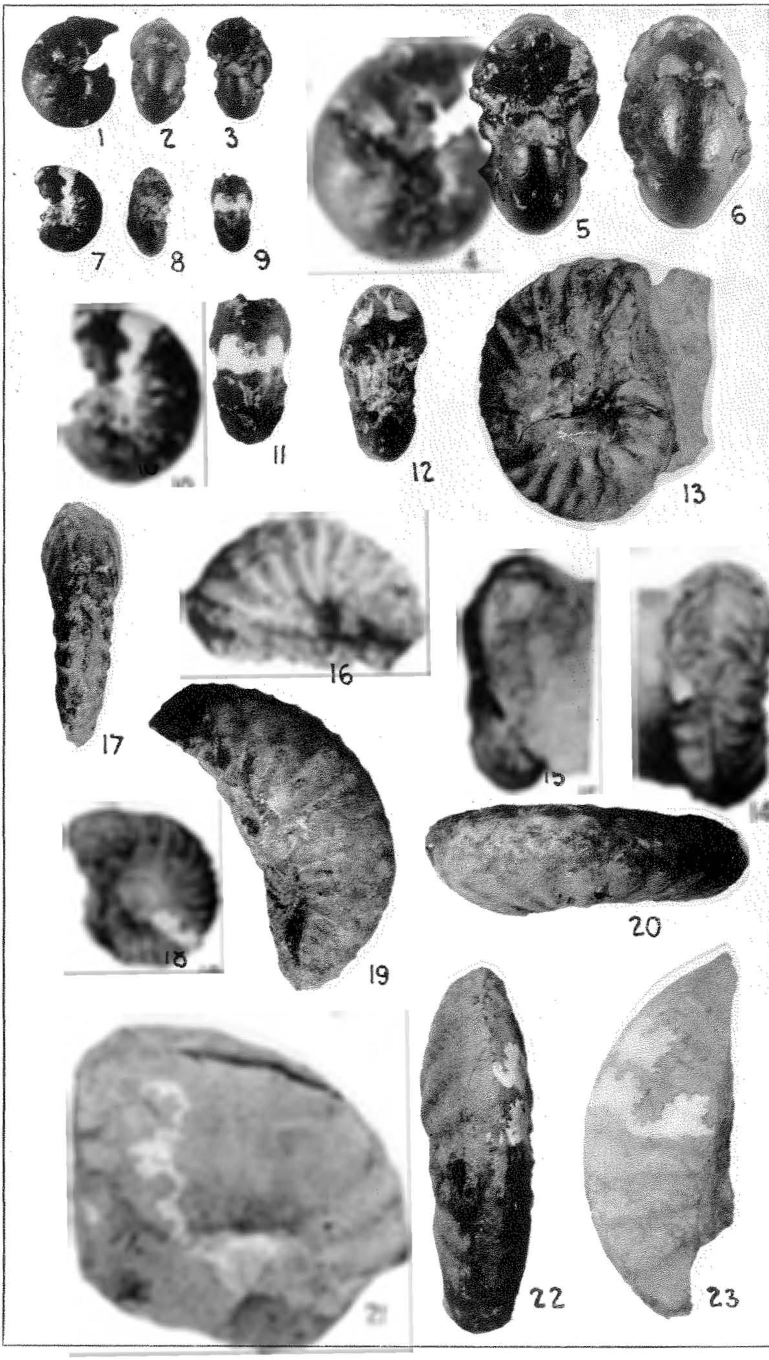
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PLATE X

Figs. 1–3. *Budaiceras mexicanum* n. gen., n. sp.—Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico .... Page 259

Fig. 1, venter; Fig. 2, cross section; Fig. 3, side view of mature specimen (type).

Figs. 4, 5. *Mantelliceras mantelli* Sowerby.—Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico.

Fig. 4, venter and cross section; Fig. 5, side view .... Page 250

Fig. 6. *Mantelliceras laticlavium Sharpe* var., *mexicanum* n. var. —Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico .... Page 253

Fig. 6, venter of specimen of Pl. XI, Fig. 1.

Figs. 7–9. *Proplacenticeras* aff. *fritschi* de Grossouvre.—Coniacian. Region of Ojinaga, Chihuahua, Mexico .... Page 265

Fig. 7, side view; Fig. 8, venter; Fig. 9, cross section.

Figs. 10–14. *Gaudryceras kayei* Forbes.—Upper Santonian, Taylor marls. Vallecillo, Nuevo Leon, Mexico .... Page 269

Figs. 10, 11, side views of different specimens.

Fig. 12, side view of a large fragment; Figs. 13, 14, same specimen, enlarged twice.

All the originals are at University of California, Berkeley.

All figures ⅔ natural size, except Figs. 13–14 which are 1⅓ × natural size.

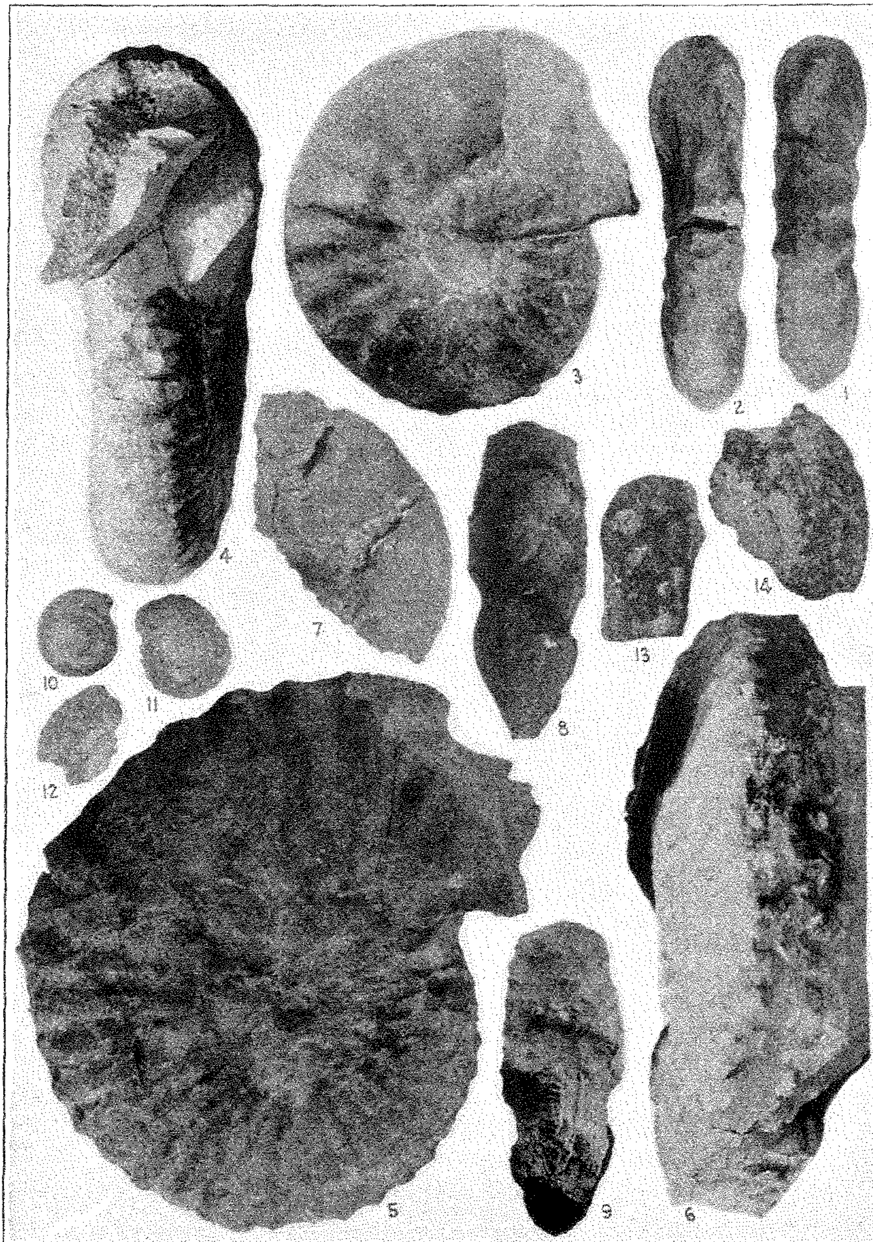
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PLATE XI

Fig. 1. *Mantelliceras laticlavium Sharpe* var., *mexicanum* n. var. —Upper Cenomanian, Buda limestone. El Remolino, region of Jimenez, Coahuila, Mexico .... Page 253

Fig. 1, side view of specimen of Pl. X, Fig. 6.

Figs. 2–4. *Peroniceras* aff. *subtricarinatum* d'Orbigny.—Coniacian. Region of Ojinaga, Chihuahua, Mexico .... Page 268

Fig. 2, venter; Fig. 3, cross section; Fig. 4, side view and suture.

Figs. 5–10. *Gaudryceras kayei* Forbes.—Upper Santonian, Taylor marls. Region of Vallecillo, Nuevo Leon, Mexico .... Page 269

Figs. 5–7, specimen illustrated in Pl.. X, Fig. 10, × 1⅓.

Figs. 8–10, specimen illustrated in Pl. X, Fig. 11, × 1⅓.

Figs. 11, 12. *Prionotropis woollgari* Mantell var. *mexicana*.— Upper Turonian, lowest Austin chalk. Margaritas, near Villa Acuña, Coahuila, Mexico .... Page 262

Fig. 11, side view; Fig. 12, venter.

All the originals are at University of California, Berkeley.

All figures are ⅔ natural size, except Figs. 5–10 which are 1⅓ × natural size.

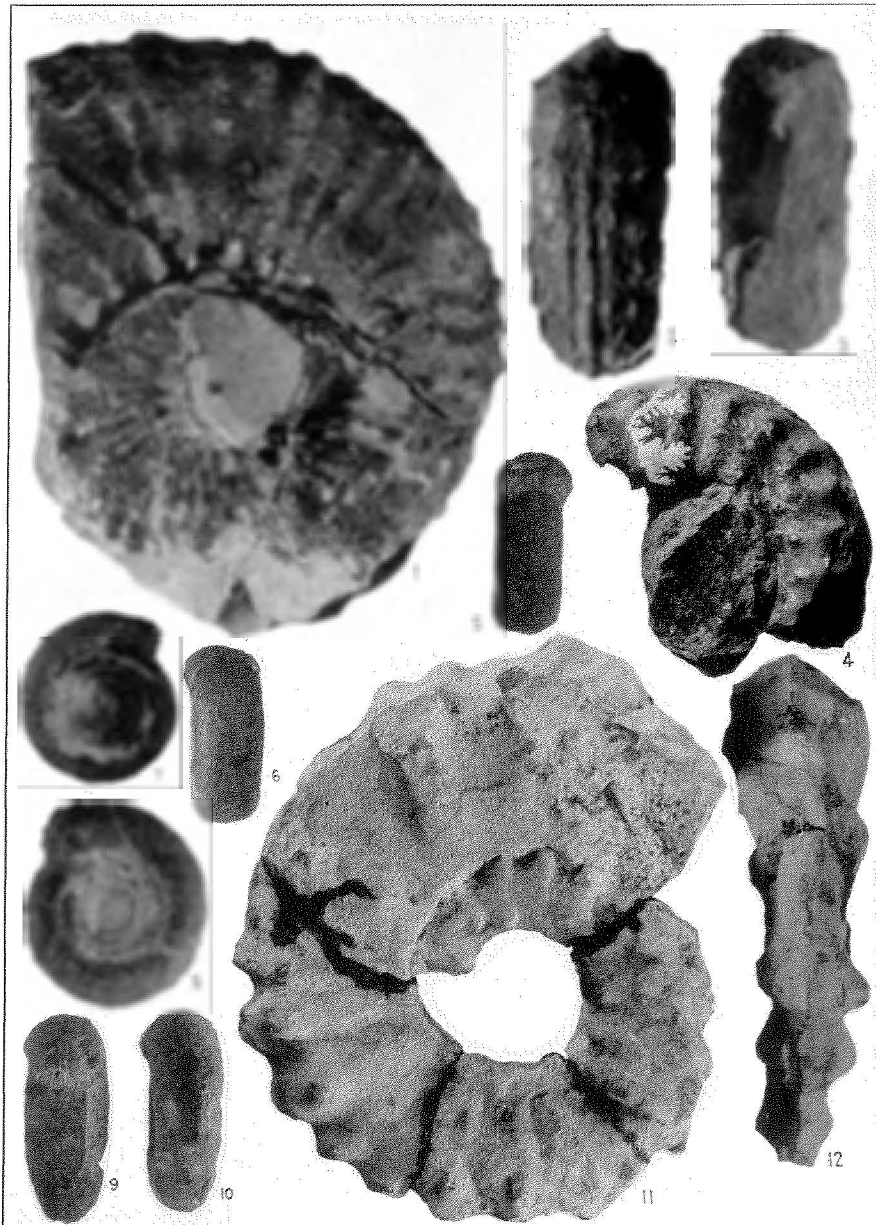
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PLATE XII

Figs. 1–7. *Placenticeras syrtale* Morton.—Upper Santonian, Taylor marls. Esperanzas, Coahuila, Mexico........................Page 272

Fig. 1, suture of large specimen.

Fig. 2, suture of smaller mature specimen; Fig. 3, venter of same.

Fig. 4, venter; Fig. 5, side view of medium-sized specimen.

Fig. 6, side view; Fig. 7, cross section of juvenile specimen.

Fig. 8. *Engonoceras bravoense* n. sp.—Lower Cenomanian, Del Rio clay. Locality, 4.9 km. from El Orégano, on road to San Carlos, region of Jimenez, Coahuila, Mexico........................Page 229

Fig. 8, side view and suture of individual shown on Pl. VIII, Fig. 7.

All the originals are at University of California, Berkeley.

These figures are all ⅔ natural size.

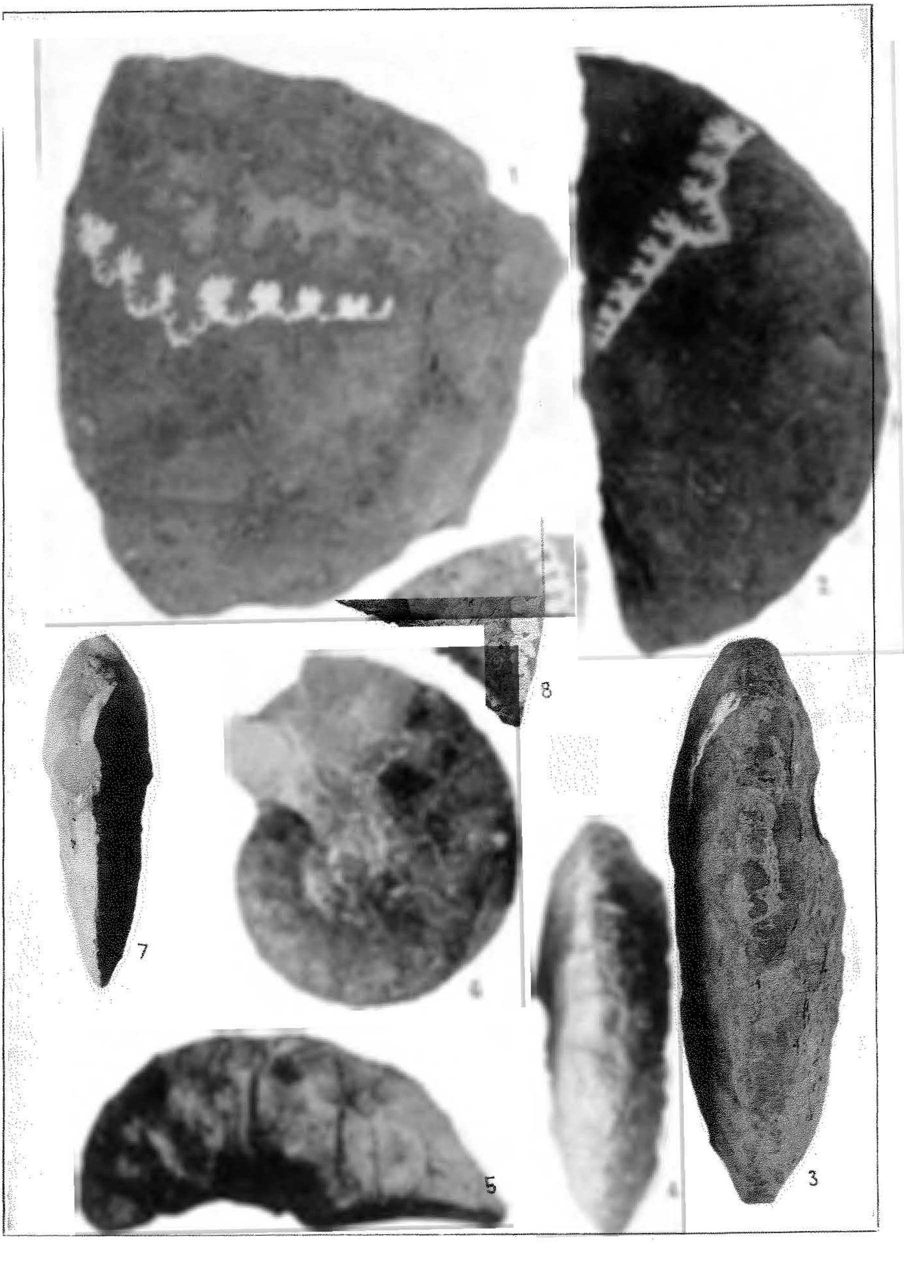
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PLATE XIII

Figs. 1–3. *Placenticeras whitfieldi* Hyatt.—Lower Campanian, lower *Exogyra costata* beds. Arroyo Navajas, region of Piedras Negras, Coahuila, Mexico .... Page 276

Fig. 1, side view and suture; Fig. 2, venter of inner whorl; Fig. 3, cross section of inner whorls of same specimen.

Figs. 4–11. *Coahuilites sheltoni* n. gen., n. sp.—Lowest Maestrichtian, lowest Escondido beds. Locality, 5 km. south of Alamo Viejo, region of Villa de Juarez, Coahuila, Mexico .... Page 283

Fig. 4, side view and suture; Fig. 5, venter of small specimen from north side of Las Mesillas, region of Lampazos, Nuevo Leon, Mexico.

Fig. 6, side view and suture of medium-sized specimen.

Fig. 8, side view and suture; Fig. 9, cross section; Fig. 7, venter and siphonal lobe of mature specimen (type).

Fig. 10, side view of small specimen; Fig. 11, inner whorl, with immature suture, taken from same specimen.

All the originals are at University of California, Berkeley.

These figures are ⅔ natural size.

PLATE XIV

Figs. 1–3. *Coahuilites orynskii* n. gen., n. sp.—Lowest Maestrichtian, lowest Escondido beds. West side of Mesillas, region of Lampazos, Nuevo Leon, Mexico........Page 287

Fig. 1, side view and suture; Fig. 2, cross section and siphonal lobe; Fig. 3, venter and siphonal lobe of mature specimen (type).

Figs. 4–8. *Coahuilites cavinsi* n. gen., n. sp.—Lower Maestrichtian. lower Escondido beds. Rancho Santa Cruz, region of Villa Progreso, Coahuila, Mexico........Page 290

Fig. 4, cross section; Fig. 5, venter; Fig. 6, side view and suture of mature specimen (type).

Fig. 7, side view and suture of small individual.

Fig. 8, side view and suture of other small individual.

Figs. 9–11. *Sphenodiscus lenticularis* Owen.—Lower Maestrichtian, lower Escondido beds. Valley of El Oro, region of Villa de Progreso, Coahuila, Mexico........Page 293

Fig. 11, side view and suture; Fig. 10, cross section; Fig. 9, venter of mature specimen.

Original of Figs. 1–3 at the Bureau of Economic Geology, University of Texas, Austin; all the other originals are at University of California, Berkeley.

All figures are ⅔ natural size.

PLATE XV

Figs. 1–5. *Sphenodiscus intermedius* n. sp.—Lower Maestrichtian, lower Escondido beds. Coahuila, Mexico .... Page 295

Fig. 1, side view of mature form from Campo de la Rosita, region of Villa de Progreso.

Fig. 2, side view; Fig. 3, venter; from small mesa between Jabalí and El Oro, region of Progreso.

Fig. 4, cross section; Fig. 5, side view and suture of mature but small specimen from small mesa between Jabalí and El Oro, region of Villa de Progreso (type).

Figs. 6–10. *Sphenodiscus prepleurisepta* n. sp.—Lower Maestrichtian, lower Escondido beds. Region of Lampazos, Nuevo Leon, and Villa de Progreso, Coahuila, Mexico .... Page 298

Fig. 6, side view and suture of mature specimen; Fig. 9, siphonal lobe and venter of same. From near Rancho Jabalí (type).

Fig. 7, side view and suture of smaller but mature animal; Fig. 8, cross section of same, from 27.3 km. northwest of San Patricio.

Fig. 10, large mature specimen from 27.3 km. northwest of San Patricio.

Fig. 11. *Parapachydiscus* cfr. *colligatus* Binkhorst.—Lower Maestrichtian, lower Escondido beds. From first mesa west of road from Progreso to Rancho Santa Cruz, Coahuila, Mexico .... Page 305

All the originals are at University of California, Berkeley.

These figures are ⅔ natural size.

PLATE XVI

Figs. 1–3. *Sphenodiscus aberrans* n. sp.—Upper Maestrichtian, upper Escondido beds. From Arroyo del Caballero, region of Guerrero, Coahuila, Mexico .... Page 301

Fig. 1, side view and suture; Fig. 2, cross section; Fig. 3, venter of mature but not largest specimen (type).

All figures are natural size.

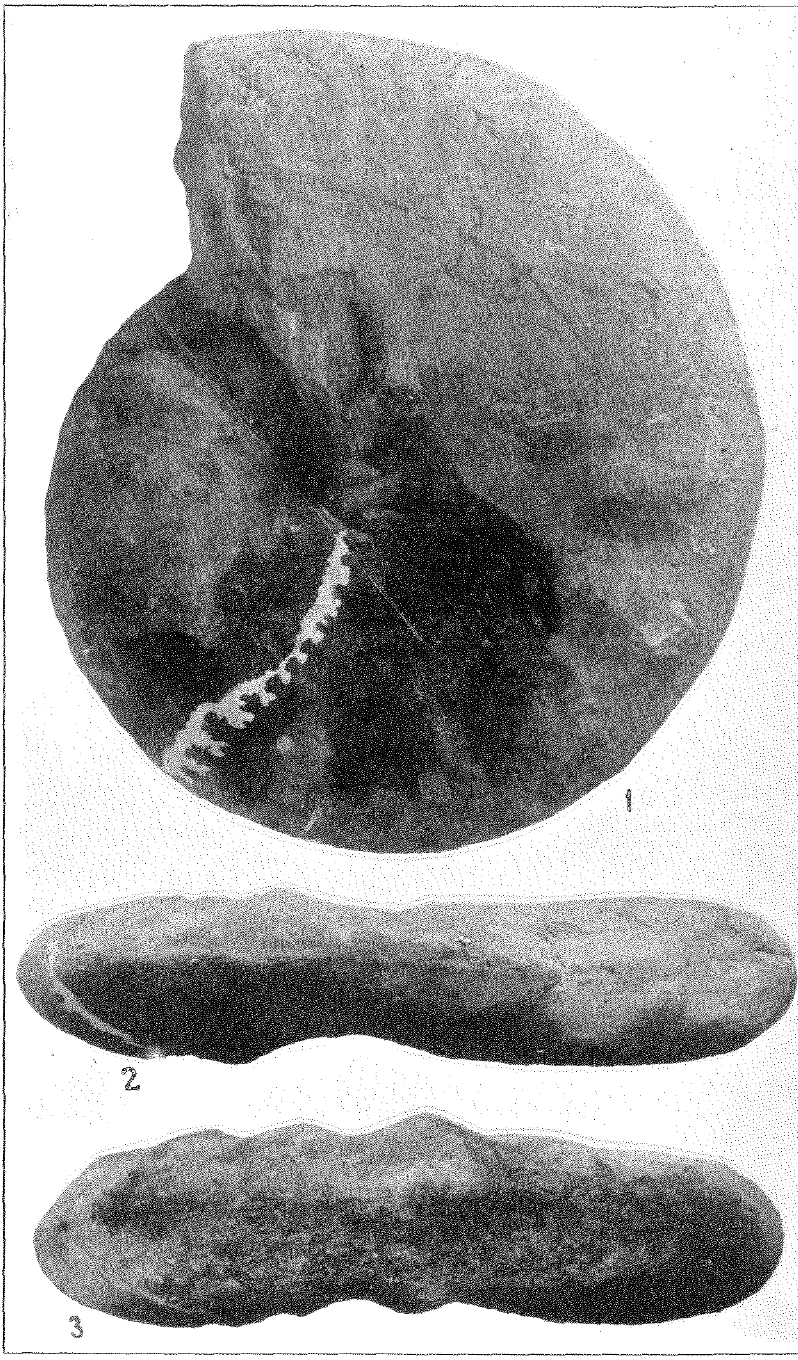
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PLATE XVII

Fig. 1. *Sphenodiscus aberrans* n. sp.—Upper Maestrichtian, highest Escondido beds. From Arroyo del Caballero, four miles northwest of crossing, region of Guerrero, Coahuila, Mexico .... Page 301

Fig. 1, smaller but mature specimen, with suture.

Figs. 2–5. *Sphenodiscus pleurisepta* Conrad.—Upper Maestrichtian, highest Escondido beds. From four miles northwest of crossing of Arroyo Caballero, region of Guerrero, Coahuila, Mexico .. Page 304

Fig. 2, side view, with suture, of medium-sized specimen.

Fig. 3, venter and siphonal lobe; Fig. 4, side view, with suture; Fig. 5, cross section of mature but not largest specimen.

All the originals are at University of California, Berkeley.

All figures are ⅔ natural size.

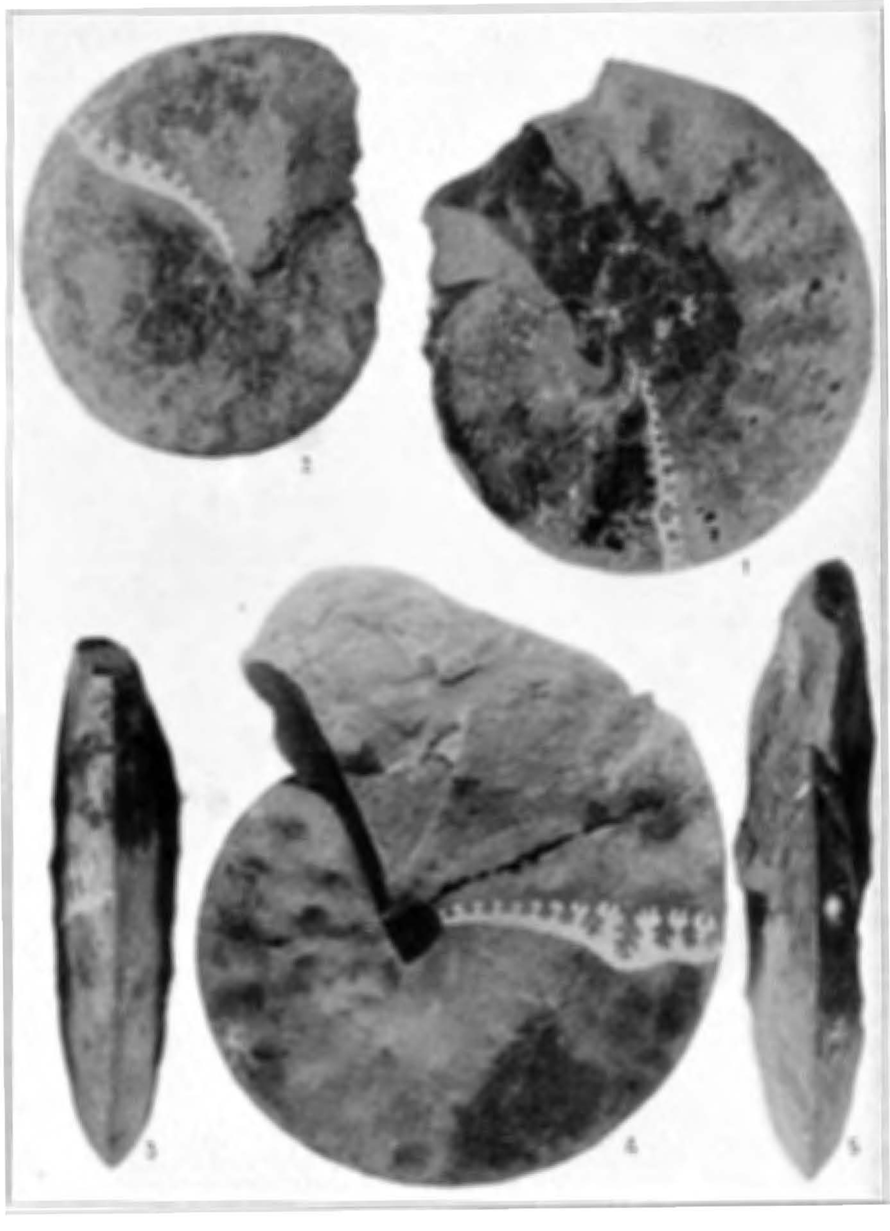

PLATE XVIII

Figs. 1–5. *Inoceramus (Actinoceramus) subsulcatiformis* n. sp., Böse.—Upper Edwards, Bosque County, Texas, about 1.5 miles west of Valley Mills .... Page 189

Fig. 1, end view; Fig. 2, ventral; Fig. 3, dorsal; Fig. 4, right valve and incurved beak of left valve; Fig. 5, left valve showing basal plicae. All natural size; all are views of one specimen, the holotype.

Fig. 6. *Inoceramus* sp. aff. *concentricus* Parkinson (smooth form; inserted for comparison with the plicate species). Left valve, natural size. Comanche Peak, southeast of Leander, Williamson County, Texas (coll. W. S. Adkins) .... Page 191

Fig. 7. *Budaiceras* sp. (Natural size.) Buda, Austin (coll. Prof. Whitney) .... Page 255

Fig. 8. *Scaphites subevolutus* n. sp. Böse. Six individuals, natural size. Del Rio: McLennan County, near McGregor, locality 966 .... Page 225

Figs. 9–17. *Stoliczkaia adkinsi* n. sp. Böse.

Figs. 9–13 are of the holotype, locality 723; Figs. 14–17 of other specimens from near Fort Worth. Pawpaw clay, localities in Tarrant County, as indicated below. Fig. 9, holotype, $\times 2.5$; Figs. 10–12, holotype, natural size, views of flank, venter, and cross section; Fig. 13, holotype $\times 2$; Figs. 14, 15, two individuals, $\times 2.5$, locality 714, southeast of Fort Worth, on Sycamore Creek; Figs. 16, $\times 2.5$, locality 723 (Glen Garden Country Club); Fig. 17, natural size, same individuals as in Figs. 14–16, and another from locality 723 .... Page 193

Originals of all except Fig. 7 are in the collections of the Bureau of Economic Geology, Austin.

NOTE.—This plate was made up recently following, for the most part, verbal instructions given by Dr. Böse. W. S. A.