NOTES ON THE GEOLOGY OF THE VALLEY OF THE MIDDLE
RIO GRANDE.

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INTRODUCTION.

The following statements are based partly on observations made during a trip from Eagle Pass to Edinburg by row-boat in the months of May and June, 1889, and partly on work in the region between Del Rio and Eagle Pass during the summer of 1891.*

A portion of the area having been described by Dr. R. A. F. Penrose, Jr., in the first annual report of the Geological Survey of Texas, in the present article I propose to confine myself to that part of the river between San Felipe creek, near Del Rio, and Webb bluff, three miles below the southern line of Maverick county. A line joining the two

*The greater portion of the section above Eagle Pass was made in company with Mr. J. Owen, who rendered valuable assistance by his accurate knowledge of the region on both sides of the Rio Grande.

points has a direction S. 27° E., and a length of 81.7 miles. The distance by the river is probably half as much more, or one hundred and twenty miles. The general direction of the dip is about S. 45° E., which in this region of very slightly inclined strata makes the section practically follow the dip.

TOPOGRAPHY.

For the distance given, the Rio Grande flows in a valley eroded in Quaternary (or later Tertiary) and upper Cretaceous sediments, and its banks vary in character with the different materials of which they are composed. When the strata are of sufficient hardness, bluffs of from 50 to 100 feet in height are found stretching along on one side or the other of the river, while opposite there is generally only a gentle slope from the water. In places the line of hills drops back some three or four miles from the river, leaving broad fertile valleys. The general nature of the topography, while resembling that of the same formations in central Texas, is characterized by somewhat more angular and stronger lines, due, no doubt, to the difference in climatic conditions. The tributaries which empty into the Rio Grande on the Texas side are mostly small and carry comparatively little water. The principal creeks are San Felipe, Sacatosa, Sycamore or San Pedro, Pedro Pinto, Cow, Texaquito, Las Moras, Elm, Rosita, Willow and Cuero. On the Mexican side, however, there are bold streams which add considerably to the volume of water in the river. Among them are the San Diego, Escondido and San Domingo rivers.

The elevation of Del Rio, according to the Southern Pacific railroad engineers, is 973 feet; that of Eagle Pass, by the same authority, is 762 feet. According to a line of levels run for an irrigating canal, the bed of the river is 120 feet lower at Eagle Pass than at the falls some forty miles above, giving about three feet fall per mile in direct line, or about two feet per mile of river. All of the falls and rapids, which are numerous, are caused by the edges of the harder strata as they are carried under by the dip.

GEOLOGIC STRUCTURE.

LOWER CRETACEOUS.

The town of Del Rio is situated on the *Arietina* clays, which have here a great development. Just southeast of the town there is a conical hill or "mountain" 100 feet, or possibly more, in height, composed of clays and shales and containing great numbers of shells of *Exogyra arietina*, Roemer, *Nodosaria texana*, Conrad, and various other fossils. The hill

is capped by gravel. Toward the south and east rises a scarp composed of the same *Arietina* clays and *Nodosaria* shales.

The deposits of ochre which have been reported from this district occur in these *Arietina* clays in the form of segregations of ferruginous matter in bodies of considerable size but somewhat variable quality.

The clays and shales of the scarp are capped by a fine grained sub-crystalline limestone of creamy white color, semi-conchoidal fracture, and containing many small reddish spots. This limestone is lithologically and stratigraphically equivalent to the *Vola* limestone of the Colorado section, and although no fossils have been found, it is referred to that horizon on these grounds alone. It is the highest bed of the lower Cretaceous in this locality.

UPPER CRETACEOUS.

The Val Verde Flags.—The lower Cretaceous materials continue to a point $2\frac{1}{2}$ miles south of Del Rio, where the *Vola* limestone is overlain by a softer flaggy limestone. The contact observed in this locality was so small in area and so covered that no conclusion could be reached regarding the conformity of the two beds. Where it has been observed in other localities it shows little, if any, unconformity. The lime flags can be followed to Sacatosa creek, 6 miles southeast of Del Rio, where they are well developed. They are grayish-white in color, laminated to flaggy in structure, and separated into bands by laminated clays. The lower strata contain considerable bituminous matter and the remains of fishes. The higher beds of this locality are also sufficiently bituminous to give off a fetid odor when struck with a hammer. The principal fossil here is *Inoceramus*, the species of which have not yet been determined. These flags can be followed from this locality down Sacatosa (?) creek to the Rio Grande, and down the Rio Grande to Sycamore creek, forming a bluff 25 to 75 feet in height along the river the entire distance, so that we have an exposure some six miles in length along the line of section, with a dip apparently not less than 100 feet to the mile.

These bluffs are in Val Verde county, and for that reason I have named the flags the *Val Verde flags*. They are tolerably uniform in structure from base to top, the principal variation being in thickness. In places they are shaly, but are commonly flags of various thicknesses, frequently showing on a transverse surface alternate parallel laminæ of white and yellow. Their weathered surfaces are from light yellow to reddish, and in some places beds of deeper yellow or even orange hue are found. Moderate amounts of oxide of iron occur, and at one place a quantity of calcite was observed crystallized similarly to that which I

have described from Anderson county.* In some localities, especially on the Mexican side, the ferruginous coloration appears on the flat surfaces of the flags in beautiful grainings, many specimens of which can be seen in Eagle Pass and Porferio Diaz. The only fossils which I found were different species of *Inoceramus*, except toward the top where a few small ammonites were seen; but it is possible that others may be obtained on closer examination.

A thin seam of lignitic matter was observed in the flags at the mouth of Sycamore creek, on the southern side of the bluffs.†

The Pinto Limestone.—Sycamore creek flows at the base of the Val Verde bluffs, which at its mouth turn sharply northeastward and, after running back from the river for several miles, turn southeastward again, and then run back toward the river, leaving a valley along the Texas side some 4 miles or more in width. At the southeastern point of the bluff on Sycamore creek the contact of the Val Verde flags with the base of the overlying chalky limestone is found. The difference in the physical character of the two limestones is very marked. The flags show their laminated character throughout, while the overlying limestone is of earthy texture and without any perceptible lamination. The beds of the upper limestone vary in thickness from one to three feet or more and are separated by bands of laminated limy shales. The thickness of the overlying limestone at this point is not more than 12 or 15 feet. The fossils observed belong to the genera *Inoceramus* and *Ammonites*.

These bluffs, in common with all others in this vicinity, are capped with 20 to 30 feet of gravel or chalky conglomerate belonging to the Reynosa beds.

Crossing the valley we find the bluffs at its southern margin on Pinto creek to be of chalky limestones separated by limy clays in bands from one to two feet in thickness, the whole exposure being about 30 feet in height. The only peculiarity noticed was numerous grooves cut in the limestone, extending diagonally across the present creek bed and very nearly in the general direction of the flow of the Rio Grande,

On the Mexican side of the river, between these two points, a long line of bluffs appears, showing the limestone resting on the flags with apparently a slight difference in dip between them, the dip of the flags being seemingly somewhat greater than that of the overlying limestone. At the southern extremity of this line of bluffs the limestone is in heavier beds (three feet or over) and rises to a height of 40 feet or more above the river. Some cavities of considerable size have been weathered in it.

* 2d Ann. Rep. Geol. Surv. of Texas, 1890, p. 305.

† Mr. Owen informs me that these flags attain a very much greater thickness toward the southwest in Mexico.

Opposite the extremity of the line of bluffs, on the Mexican side and a short distance above Piedro Pinto creek, the Rio Grande turns abruptly westward, and for a quarter of a mile flows in rapids over the edges of underlying limestone. It is here that the water is to be taken out for irrigating the valley north of Eagle Pass, which contains about forty thousand acres of irrigable land. The exposures of the limestone continue from here to Las Moras creek, a total distance of 15 miles from its first appearance. The following sections will show its character:

Cow Creek Section.

	Feet.
1. Thick-bedded limestones, with interbeddings of clay shales and nodules of altered pyrites	40
2. Similar limestones in thinner beds.	35 or 40
<i>Fossils.</i> — <i>Inoceramus</i> , <i>Gryphæa</i> , <i>Ammonites</i> , <i>Baculites</i> , of undetermined species; fossils sometimes ferruginated.	

Texaquito Creek Section.

1. Gravel, with calcareous cement (Reynosa beds)	
2. Bowldery limestone containing numerous shells of <i>Exogyra ponderosa</i> , Roemer	6
3. Chalky limestone	6
4. Softer limestones of similar character, with several species of <i>Inoceramus</i> and other fossils	6
5. Yellow bowldery limestone in beds separated by bands of limy clay; the limestone becomes more chalky in appearance toward the base (upper <i>Gryphæa</i> bed, characterized by <i>Gryphæa aucella</i> , Roemer, which is very abundant toward the base, but disappears toward the top)	16
6. Harder limestone, much broken, with shales and limy clays	25
7. Obscured by later gravel	20
8. Limy clay, with great numbers of shells of <i>Exogyra costata</i> and <i>Inoceramus</i> , sp. und	
9. Yellow limy shales, with same fossils as number 8, and containing ferruginous seam	4
10. Clayey limestone, with a large <i>Ammonites</i> (14 inches in diameter), <i>Nautilus</i> , sp. nov., and immense <i>Inoceramus</i> shells. This limestone is bedded in strata twelve to fourteen inches in thickness and strongly jointed. The compass bearing of joint planes is N. 20° E., and the lines contain oxide of iron. The <i>Inoceramus</i> here, as elsewhere, is preserved in two ways: In one they are simply molds showing the outer form of one or both shells; in the other, shell fragments and sometimes entire shells occur. Specimens were measured having a length of 15 inches.	25

Las Moras Section.

1. Gravel, chalky limestone, with some iron pyrites. <i>Inoceramus</i> of several species, <i>Nautilus</i> , <i>Ammonites</i> , <i>Baculites</i> , etc., to creek	4
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This section is at road crossing of the creek, half a mile from the Rio Grande. At the mouth of the creek the limestone passes under the water, and just below is succeeded by the beds of the Eagle Pass division. The contact is covered by river drift, but may be found further up the creek.

Throughout the entire range of this chalky limestone the conditions of deposition seem to have been quite similar. The beds become somewhat more massive but broken toward the top. They are separated by limy shales at the base, then by calcareous clays, then by purer clays, and finally by calcareous clays again. *Inoceramus* and *Ammonites* seem to be the only fossils ranging entirely through the Val Verde flags and Pinto limestone, and the occurrence of *Exogyra ponderosa* and *E. costata* so far down in the Pinto limestone is worthy of note.

The Eagle Pass Division.—Immediately overlying the Pinto limestone there is a great series of clays, sands and greensands, with more or less impure limestone and beds of coal, to which I propose to give the name *Eagle Pass division*. This name was suggested for a portion of these deposits by Dr. C. A. White in 1887, and I now extend it to cover the entire series of deposits lying above the Pinto limestone and below the Webb bluff beds. It has a surface exposure along our line of section of nearly sixty miles. It comprises a number of more or less distinct members which may be described separately.

Upson Clays.—The basal member consists of yellow clay containing calcareous nodules of septarian character, the crevices or septæ of which are filled with dogtooth spar. These nodules occur in large geodic forms scattered through the clays, and contain *Exogyra ponderosa*, Roemer. Numbers of specimens of these fossils are found in geodes as well as on the hillsides, where they have been left by the disintegration of their matrix. The nodules or geodes seem to occupy pretty definite horizons, and sometimes form benches on the hillsides. The uppermost member of this series, as I observed it, is a clay shale.

San Miguel Beds.—Resting on the clay shales, which form the upper member of the Upsen clays, there is a deposit of sandstone, thin to heavy bedded, separated by bands of clay, and containing seams of glauconitic material with many fossils, as well as occasional heavy beds of clay, especially toward the top. I have called this deposit the *San Miguel beds* from the locality at which it was first observed by Dr. Comstock and myself. In the Rio Grande section it first occurs in the hills north of Carter's ranch, where the hills show exposures of it from 75 to 100 feet in height. The exposures are excellent for several miles south of this point, and a very rich fauna, which is now being studied, was secured.

In the upper portion I found *Exogyra ponderosa*, and great numbers of other shells not yet determined. Above this the sandstone becomes more calcareous, and in places is compacted and contains calcareous nodules. Three miles south of Carter's ranch we found the teeth and bones of a saurian in the concretions. The materials overlying this become more clayey, as will be seen by the following section, made some 10 miles north of Eagle Pass:

Section near Eagle Pass.

	Feet.
Sand and silt.....	8
Sandstone	2
Clays displaying cone-in-cone structure.....	6
Sandstone with laminæ and nodules of calcite.....	1
Clay, to base.....	8

Above this there are sands with lime and greensand containing many casts of fossils, *Inoceramus* and other bivalves, together with numerous gasteropods. This continues to a point about 8 miles north of Eagle Pass, below which these strata are soon covered by the next newer series of deposits.

The Coal Series.—This series comprises the ferruginous shales, brown calcareous shales, brown calcareous clays, heavy bedded sands, shales, sands, and yellow clay which accompany the coal seam worked at the Hartz and other mines.

The exposures along the river above the Hartz mine show the following strata underlying the Reynosa beds of gravel and limestone:

Section near the Hartz Mine.

	Feet.
Brown calcareous clays.....	40
Ferruginated shales.....	40
Uncompacted sands*.....	20
Shale	20
Heavy bedded sands.....	30
Yellow clay†.....	20
Coal†	4
Purple shale†.....	6
Sand to river†	

Just south of the Hartz mine there may be seen the only disturbance of any considerable extent which was noticed in the entire section north

* Western extremity of coal seam.

† Exposed just above Hartz mine.

of Eagle Pass. This is a fault with a downthrow toward the north of about 60 feet.

Half a mile below the bridge across Elm creek the following section was observed:

Section on Elm Creek.

	Feet.
Sand	12
Gravel	1 to 4
Nodules of oxide of iron	$\frac{1}{2}$ to 1
Sand	2
Chocolate clays, with interbedded iron nodules	3
Cross-bedded sandstone	1
Blue clay	1
Sandstone containing clay inclusions, some glauconite, and regularly stratified iron nodules	3
Clays with very thin seam of coal	

Above the bridge a deposit of shaly sands occurs, containing ferruginous sandstone seams which in places pass into a lean iron ore and form a stratum of eight to twenty inches in thickness. The sandstone has a very shaly appearance on weathering. Overlying this there are beds of laminated yellow clays, followed by darker beds with a very thin seam of coal.

Immediately above the laminated clays lies the stratum containing cannon-ball concretions, which, with the overlying sands carrying great quantities of silicified wood, form one of the most persistent and easily recognizable horizons of the series. There are numerous excellent exposures of the latter on Seco creek.

Convent Hill Section.

	Feet.
Gravel (Reynosa beds)	
Yellow clays and sands	30
Calcareous nodules, highly ferruginous, imbedded in clay	1 to 2
Bituminous shales with $\frac{1}{2}$ -inch seam of coal, to river	

Above these beds are found a series of brown or buff sandstones, semi-indurated, calcareous, and containing fossil shells of *Inoceramus*, *Exogyra ponderosa*, etc.

The entire section from these sandstones to the lower San Miguel sandstones is shown in a general way in the following record of a boring made for artesian water on the top of the hills just northeast of Eagle Pass:

Eagle Pass Artesian Well Section.

	Feet.
1. Soil and subsoil	14
2. Yellow clay	26
3. Bluish clay	50
4. Sand with some gravel	110
5. Black shale; six inches coal	60
6. Clayey sand	70
7. Gray sand	30
8. Sand; small gravel	60
9. Sand	20
10. Gray slate	30
11. Dark shale	55
12. Coal	6
13. Dark shales	9
14. White sand; gas	40
15. Black shale	150
16. Sand and shale	15
17. Black shale	135
18. Sand and shale; gas	15
19. Dark soft sand and shale	75
20. Hard gray sand; salt water	10
21. Gray shale	50
22. Gray sand	10
23. Calcareous clay	370
24. Dark clay	102
Total	1,512

This is important as giving us the relative dip of the beds. The coal seam which crops out 5 miles above Eagle Pass is found here at a depth of 525 feet, while at 1,512 feet the heavy sandstones which were noted 3 miles north of Carter's ranch, or 15 miles above Eagle Pass, have not yet been reached. The estimate of dip at 100 feet to the mile is therefore seemingly not at all excessive.

The materials below Eagle Pass are somewhat different from those above. The sandstones are harder and the clays have a blue or greenish hue; the lime, instead of being in the form of geodes or septaria, is intermingled with the sand, or forms separate strata; and the fossils are much more plentiful than in any other division except the San Miguel beds. I propose to call this deposit the *Escondido beds*.

Escondido Beds.—The last exposures of the Coal series beds on the river are at Porferio Diaz, where a greenish sandy clay with glauconite was observed, and a mile below, on the same side of the river, where there is a similar bed of sandy clay with indurated boulders, streaks of lignite, impressions of leaves (grasses), and logs of silicified wood. At the mouth of Escondido river similar clay was seen, and a mile below there was

found a series of sandy clays capped by sandstones, with an indurated glauconitic layer containing small oysters and other fossil forms. This sandstone is the same as that capping the hills at Eagle Pass and is the lowest stratum of the Escondido beds.* Passing down the river this sandstone thickens and shows ripple markings in places, and has an apparent dip of at least 2°. The exposure is a mile in length, and consists of sandstones alternating with clays. Fossils are very abundant and well preserved, consisting of *Ammonites* (*Placenticerias*), oysters and other bivalves, and several gasteropods. Similar exposures continue for 4 miles below Eagle Pass. Above these come other blue clays and thin sandstones with many oysters.

At Fortress bluff, 6 miles below Eagle Pass, the exposure has a height of 60 feet, and is composed of sandstones with seams of sandy clay interstratified. The first of the great oyster beds occurs here in strata six inches to a foot in thickness. Similar exposures continue to the bluffs 10 miles from Eagle Pass. The sandstones at this locality are highly calcareous and contain several beds of oyster shells.

From this point to the falls of the Rio Grande, just above the Webb county line, the exposures are but repetitions one of another—brown, buff, blue, or green clays, with sandstones, sometimes friable and sometimes so indurated as to be semi-quartzites. Abundant fossils, consisting of *Ammonites* (*Placenticerias*), oysters and gasteropods, are found. The rapids (or falls of the Rio Grande), which continue almost to the line between the two counties, are formed by the edges of some of these ammonite-bearing beds as they pass below water level. From this point to Webb bluff, a distance of 3 miles, no fossils were found; but there was no change in the lithologic character of the rock materials, nor could the clays at the base of the Webb bluff section be distinguished in any way from those observed at the rapids above.

Webb Bluff Section.

	Feet.
Gravel	
Sandstone, white and glistening, with mica and some little iron; calcareous sandstones; clay with cannon-ball concretions; and small seam of granhamite	30
Greensand marls with many Tertiary fossils; nodules of carbonate of lime; specks of glauconite	7 to 8
Stiff, plastic dark greenish or blue clay, jointed	10

We have therefore only 3 miles in which there can be any room for deposits intermediate between strata containing fossils of recognized and

* From Mr. Owen's examinations I learn that this is a very persistent bed throughout Maverick county and is easily recognizable. It is about five hundred feet above the coal seam, and is therefore valuable as a definite horizon from which to work in prospecting for the coal.

decisively marine Cretaceous forms and those containing marine Eocene forms. The average dip does not exceed 100 feet per mile, and we saw nothing in any of the exposures on either bank of the river in this space to indicate a change until we reached Webb bluff itself. The entire appearance of the upper portion of this bluff was so different from that of the materials we had been examining for the three previous days that it was remarked even before we landed.

The upper Cretaceous Section.—If the estimated dip of 100 feet per mile can be relied on (and no evidence was found in the field work to cast any doubt upon it) the section as given would have a total thickness of over eight thousand feet, of which the upper Cretaceous deposits constitute about 7,800 feet, divided as follows:

	Feet.
Eagle Pass division { Escondido beds	3,300
Coal series	900
San Miguel beds	800
Upson clays	700
Pinto limestones	1,500
Val Verde flags	600
	<hr/> 7,800

It may not be prudent, however, to rely implicitly upon the apparent dip in such materials as form the Escondido beds, because faulting might occur in places and be entirely unnoticed in such an examination as we could make. It is therefore possible that future work may somewhat reduce the estimate here given.

REYNOSA BEDS.

In May, 1889, I observed along the line of the Southern Pacific railway between San Antonio and Eagle Pass a deposit usually consisting of a larger or smaller quantity of gravel cemented by a very porous or tufaceous limestone. In some places the gravel seemed to be entirely missing and only the limestone present. The same deposit was noticed north of Eagle Pass on our visit to the coal mines, and we found it forming the summits of the hills at many localities along the river during our voyage from Eagle Pass to Edinburg. The thickness of this deposit as noted was from 3 to 30 feet, and in some instances it was overlain by the yellow silt flanking the Rio Grande. At the town of Reynosa (in the Mexican state of Tamaulipas) and opposite Edinburg in Texas we found a much larger and firmer deposit of limestone—the same indeed which was designated in the report of the Mexican boundary survey Cretaceous limestone. Our examinations resulted in finding

in it such fossils as *Bulinus alternatus*, Say, and in showing that it is stratigraphically higher than the Fayette sands. Dr. Penrose described it in the first annual report of the geologic survey of Texas under the name of the Reynosa limestone. The connection between this Reynosa limestone and the tufaceous lime and gravel, however, was not recognized until the past summer. Mr. J. A. Taff of the Texas survey, in his examination along the line of the Texas-Mexican railway between Corpus Christi and Laredo, observed the same lime and gravel with *Bulinus alternatus* overlying the Fayette sands at various places. I joined his party in Cotulla, and during my work with them up the valleys of the Nueces and Leona rivers I found many exposures of the gravel and lime and of the firmer limestone already described in such connection as to prove conclusively that they are mere local variations of one and the same deposit. I therefore extend the name Reynosa to include the entire series of deposits for the present. These deposits cover a very large area in western Texas and extend into Mexico. In places the limestone reaches such thickness and hardness as to be used as building material, as in the district south of Porferio Diaz, at Reynosa, and elsewhere. As nearly as we have been able to ascertain, these beds seem to be in part at least the equivalents of the *Equus* beds described by Professors Cope and Leidy in southwestern Texas. They appear to rest unconformably upon the underlying beds of Cretaceous, Eocene and Neocene age. While the connection of the Reynosa beds with the Lafayette formation toward the east has not been determined by actually tracing one into the other, their similar stratigraphic position above the Fayette sands and beneath the coastward clays of the Port Hudson (Columbia formation of McGee) is strong evidence in favor of their being different phases of the same formation.

CORRELATION OF RIO GRANDE AND COLORADO RIVER SECTIONS.

<i>Rio Grande Section.</i>		<i>Colorado Section.</i>	
Neocene.....	Reynosa beds.....	Lafayette (?)	
Eocene.....	Webb Bluff Tertiary	Eocene	
Upper Cretaceous	{ Eagle Pass division	{ Escondido beds....	(Wanting)
		{ Coal series	(Wanting)
		{ San Miguel beds...	Glauconitic beds
		{ Upson clays.....	<i>Ponderosa</i> marls
		Pinto limestone	Austin limestone
Lower Cretaceous	{	Val Verde flags	Eagle Ford shales
		<i>Vola</i> limestone.....	<i>Vola</i> limestone
		<i>Arietina</i> clays.....	<i>Arietina</i> clays