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CHARLES D. WALCOTT, DIRECTOR

RECONNAISSANCE

IN THE

RIO GRANDE COAL FIELDS OF TEXAS

BY

THOMAS WAYLAND VAUGHAN

INCLUDING A REPORT ON IGNEOUS ROCKS FROM THE SAN CARLOS COAL FIELD, BY E. C. E. LORD

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CONTENTS.

II.—SAN CARLOS COAL FIELD.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., May 14, 1899.

SIR: I submit herewith for publication a manuscript by Mr. T. Wayland Vaughan, entitled Reconnaissance in the Rio Grande Coal Fields of Texas. This paper treats of two areas, both of which, in addition to the economic considerations, are of scientific interest, inasmuch as they give interesting types of the geology of the localities studied.

The first of the areas embraces that portion of the Lower Rio Grande region lying between Del Rio and Laredo, and treats of a section of the Cretaceous and Tertiary formations and of the relations of the one to the other. This section has been an object of interest for many years, and, as shown in the literature cited by Mr. Vaughan, has been visited by many geologists. As the region is a transition ground between the phases of these formations hitherto considered peculiar to the Rocky Mountain and the Atlantic Coastal plains, respectively, such a section must necessarily throw some light upon the relations of the formations, including the age position of those hitherto ascribed to the Laramie epoch. Mr. Vaughan could hardly be expected to solve completely all the problems of the region in the short period of time during which he was permitted to examine it, but his paper will be a valuable contribution to a progressive series of researches which have been made in that territory.

The second paper treats of the San Carlos coal field in Trans-Pecos Texas. This paper, too, is of great scientific interest, inasmuch as it gives a detailed section of the Cretaceous beds of the Vieja Mountains of the Trans-Pecos region, and also throws light upon the occurrence of interesting volcanic rocks.

Mr. Vaughan has treated the economic features more briefly than he would have done if the determination of the stratigraphic position of these coals had not been the principal object of these preliminary reconnaissances.

Very respectfully,

ROBT. T. HILL,
Geologist.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RECONNAISSANCE IN THE RIO GRANDE COAL FIELDS OF TEXAS.

By Thomas Wayland Vaughan.

INTRODUCTION.

One of the most important economic questions with which Texas has to deal is that of coal supply. Although it embraces 250,000 square miles of territory, and is by far the largest State in the Union, in 1897 it stood nineteenth in the scale of coal producers. For manufacturing enterprises and railroads coal is one of the first requisites; therefore in the following paper an attempt has been made to state all that is known of the coal fields of the Rio Grande region. Two reconnaissance trips made jointly with Mr. T. W. Stanton, under instructions received from Mr. R. T. Hill, during the field season of 1895; a reconnaissance made in 1898 in company with Prof. William L. Bray, of the University of Texas, who was studying the flora of western Texas; and a certain portion of the notes accumulated while mapping the geology of the Brackett quadrangle, as assistant to Mr. R. T. Hill, and later while mapping the geology of the Uvalde quadrangle, serve as a basis for this report, but all available information has been utilized. The fact that this report is, as a whole, the result of reconnaissance work and that it is not based upon a detailed study of the coal fields herein treated, should be emphasized.

Mr. Stanton has determined all of the Cretaceous fossils discovered, except a few Foraminifera, and has contributed his conclusions concerning the age of the beds. The Eocene fossils were determined by the writer.

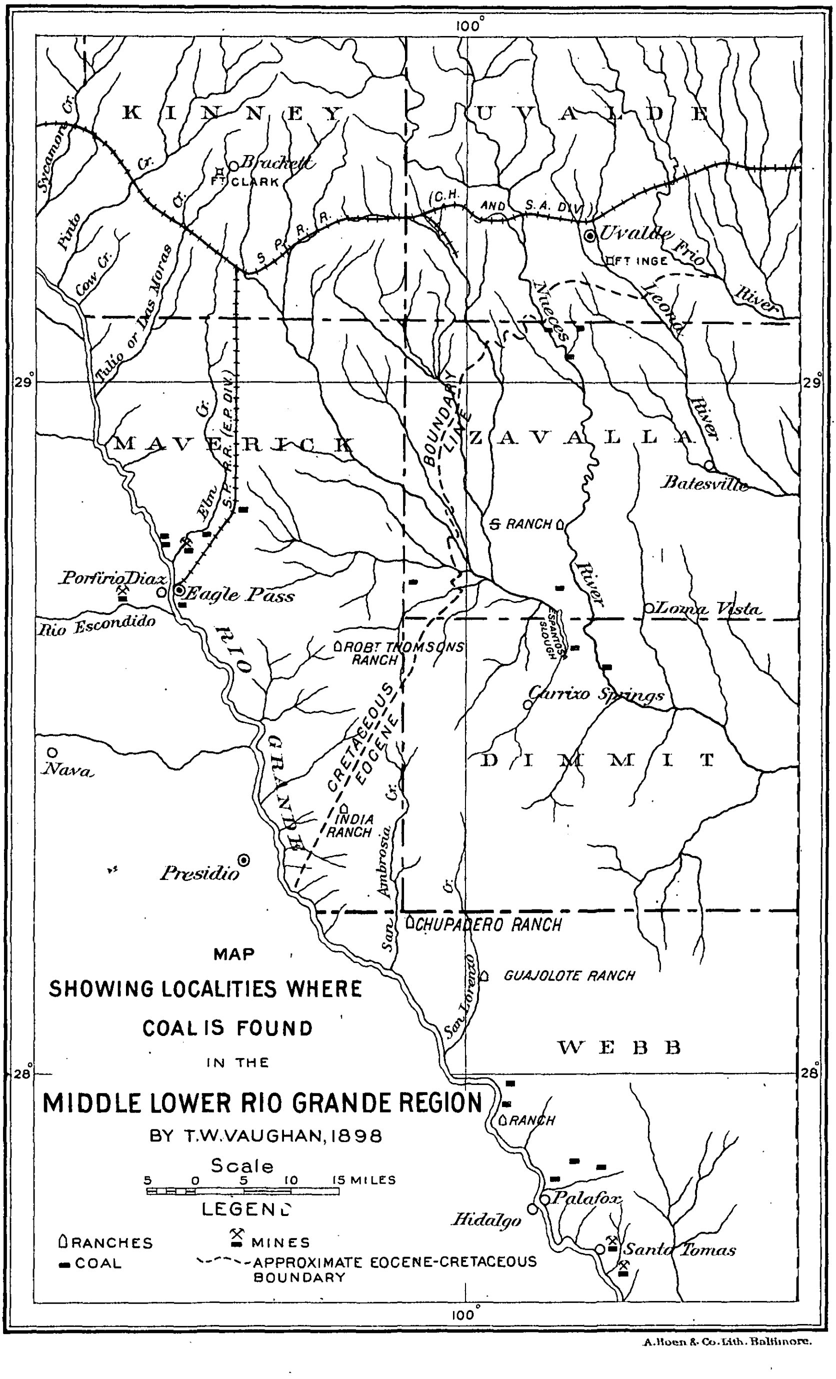
The general plan of the discussion followed is: (1) The general geology of the coal fields and adjoining areas; (2) the distribution of the coal and the present condition of mining; and (3) the physical and chemical characters of the coal.

Several coal-bearing areas have been recognized in the region adjacent to the valley of the Rio Grande in New Mexico and Texas.[1] The

[1] Coal fields of Colorado, by R. C. Hills: Mineral Resources U. S. 1892, pp. 319 et seq.
New Mexico, Its Resources, etc., New Mexico Bureau of Immigration, Santa Fé, 1884.
The Cerillos coal field, by John J. Stevenson: Trans. New York Acad. Sci., Jan., 1890, pp. 105–122.
Mr. T. W. Stanton has made an examination of the White Oaks mine, and informs the writer that the coal there is probably Laramie.

first of these includes a number of isolated or limited districts in New Mexico, to which belong the Cerillos, Bernalillos, and Fort Bayard fields, which are probably of the same age as the so-called "Laramie" coals of Colorado, viz, uppermost Cretaceous and transitional Cretaceo-Tertiary. The second area is situated in the Vieja Mountains, in the vicinity of San Carlos, Texas. These coal beds are of Pierre age. The third area occupies the interior portion of the Rio Grande Plain, and extends from the Santa Rosa Mountains of Mexico to beyond Eagle Pass, Texas. Mines are worked in it near Eagle Pass, Texas, and near San Felipe, Sabinas, Fuente, and Porfirio Diaz, in Mexico. The coal of this area is of Fox Hills age. Associated with it is a fossil plant, *Geonomites tenuirachis* Lx., which also occurs in the "Laramie" coal of New Mexico. The marine fauna is equivalent to that of the Ripley and Navarro beds of the Gulf region and to that of the Fox Hills beds of the Rocky Mountain section. The fourth area is the coal field adjacent to Santo Tomas, Texas. These coals are usually lignites of Eocene age.

In addition to the districts mentioned adjacent to the valley of the Rio Grande, allied beds are found in the Trinidad-Raton district of Colorado and New Mexico and in the White Oaks district of the Sacramento Mountain region of New Mexico.



A. Hoen & Co. Lith. Baltimore.

I.—EAGLE PASS AND EOCENE COAL FIELDS OF THE MIDDLE RIO GRANDE REGION OF TEXAS.

DEFINITION OF THE AREA.

This part of this report is based upon a reconnaissance, made in 1895, of the Rio Grande region from Del Rio, in Valverde County, to Santo Tomas, in Webb County, thence to Uvalde, in Uvalde County; and upon a second reconnaissance, made in 1898, from Cline, Uvalde County, to Eagle Pass, thence up the Rio Grande to Upson, across to Paloma, back to Eagle Pass, and from the last-mentioned place to Carrizo Springs, thence to the Rio Grande at the Webb-Maverick county line. After returning to Carrizo Springs the return journey to Uvalde County was made along the Nueces River. Besides the data accumulated on these reconnaissance trips some data obtained while studying the geology of the Brackett and Uvalde quadrangles have been utilized.

The area is approximately a right-angled triangle, the apex being at Santo Tomas; the hypothenuse, the Rio Grande; the base, a line from Del Rio to Uvalde, and the third side a line from Uvalde to Santo Tomas. It embraces portions of Kinney, Valverde, Maverick, Webb, Zavalla, and Uvalde counties. (Pl. I.)

GENERAL PHYSICAL FEATURES.

These coal fields lie within the geographic province of the Texas region denominated the Rio Grande Plain.[1] This plain is a local modification of the southwestern attenuation of the coastal plain of the Gulf and Atlantic States, comprising a western prolongation of the same up the Rio Grande, included in the angle formed by the convergence of the Balcones escarpment line and the eastern front of the Cordilleran region in Coahuila.

The Texas side of the region is a vast plain, slightly inclined to the southeast, sloping from an elevation of 1,082 feet at Johnstone, Valverde County, to about 600 feet opposite Santo Tomas, or at the rate of about 3 feet to a mile. The streams have cut their beds in this plain and now lie considerably below its former level. The larger of these stream valleys are accompanied by series of terraces. The structure of the Texas portion of the plain throughout the greater part of its extent is that of a gently southeasterly dipping monocline. In the

[1] Hill and Vaughan, Eighteenth Ann. Rept. U. S. Geol. Survey, Part II, 1898, p. 202.

vicinity of Santo Tomas there is a local exception to the usually uniform direction of dip of the strata. Here the dip, instead of being to the southeast, is to the northeast, according to information furnished by Mr. D. D. Davis, superintendent of the Cannel Coal Company's mine. This disturbance is, without doubt, genetically connected with the uplift of the Sierra Santa Rosa of Mexico.

The northern limit of this plain is a great southward-facing escarpment, several hundred feet in height, which has been described[1] under the name "Balcones escarpment." Along its foot is a strip of country

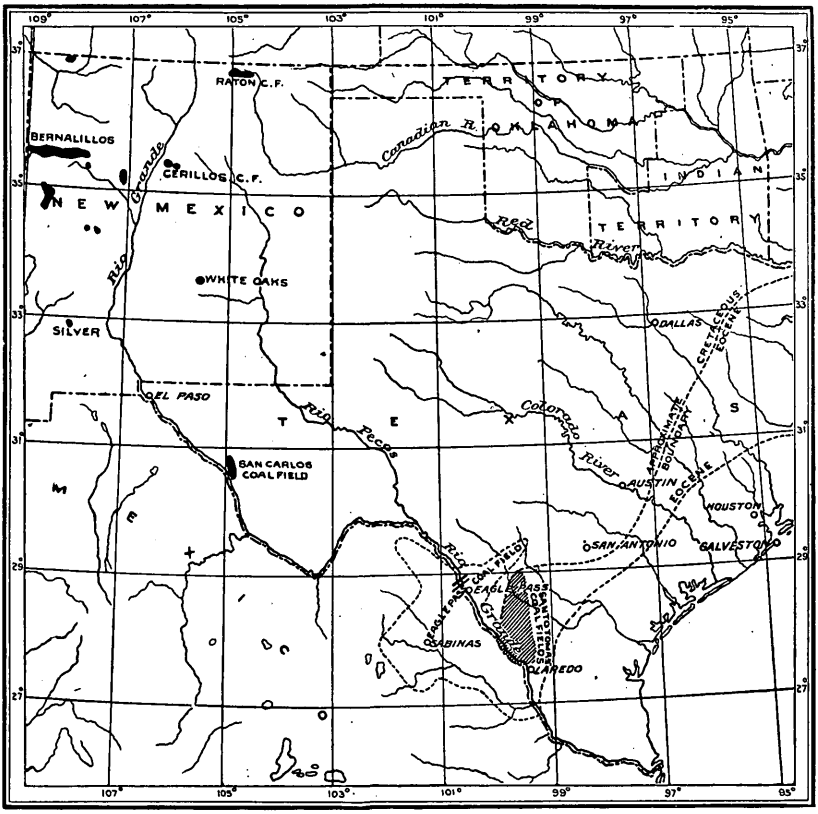


FIG. 1.—Map showing the general position of the Rio Grande coal fields.

from 6 to 15 miles wide, which is broken by faults and in which there has been considerable volcanic disturbance. This scarp is the southern edge of the vast Edwards Plateau. It is composed of practically horizontal limestone strata, and attains an altitude of some 2,500 feet.[2]

The vegetation consists of grasses, which at the time of our visit were mostly dead and dry, and of a variety of prickly plants belong-

[1] R. T. Hill: Am. Geologist, Vol. V, No. 1, Jan., 1890, pp. 17-18; Am. Jour. Sci., 3d series, 1887, Vol. XXXIV, pp. 291 et seq.

[2] The geographic features of the region are more fully described in a paper by Mr. Hill and the writer entitled The Geology of the Edwards Plateau and Rio Grande Plain: Eighteenth Ann. Rept. U. S. Geol. Survey, Part II, 1898, pp. 193-323.

ing to the Leguminosæ, Rhamnacaæ, and Cactacæ, constituting the chaparral of the Mexicans. There are enormous orchards of *Opuntia rafinesquei*, the common prickly pear or nopal of the Mexicans, and tasajillo, *Opuntia leptocaulis*, is often extremely abundant. Of the Leguminosæ, the mesquite and several species of acaciæ are the most common. Lignum vitæ also is a common and characteristic plant. Except along the creeks, where occasionally live oaks grow, there are no trees, unless the mesquite reaches a size sufficient to entitle it to that name. Professor Bray, of the University of Texas, is making a careful study of the flora of western Texas with reference to climatic and other natural conditions. Rains are very infrequent, and the country is not capable of supporting a dense population.

The following table gives the average annual rainfall at some of the more important places,[1] as determined by observations extending through several years:

	Inches.
Fort Clark (Brackett)	24.02
Fort Inge (Uvalde)	25.35
Eagle Pass	25.01
Laredo	19.58

The mean annual temperature is as follows:

	Degrees (F).
Fort Clark	68.8
Fort Inge	68.7
Eagle Pass	72.
Laredo	72.9

January is the coldest month, but the average temperature for that month at any place is rarely as low as 45°. August and July are the hottest months, but the average for these months is rarely as high as 90°. In the summer, in the middle of the day the heat is intense, but at night there is always a refreshing breeze.

DESCRIPTIVE GEOLOGY.

The region as a whole is underlain by a series of rock sheets belonging to the Cretaceous and Tertiary periods, which are covered to a considerable extent by surficial deposits of silt and gravel. The beds will now be described in ascending order.

CRETACEOUS.

RIO GRANDE SECTION.

The Cretaceous strata of the Texas region have been divided into two great subgroups or series, an upper and a lower. These series have been further divided into formations, which are still further subdivisible into individual strata; but for purposes of general discussion the formations are the units of the system of classification.

[1] Climatic conditions of Texas, by Gen. A. W. Greely: Senate Ex. Doc. No. 5, Fifty-second Congress, first session.

LOWER CRETACEOUS (COMANCHE SERIES).

EDWARDS LIMESTONE.

At Del Rio the lowest rocks exposed belong to the Fort Worth limestone, but a short distance above Del Rio, before reaching the mouth of Devils River, exposures of the Edwards (Caprina) limestone are seen. The canyons of the Rio Grande and Devils rivers in this vicinity are cut through it. It is a whitish limestone and occurs in thick ledges.

FORT WORTH LIMESTONE.

Within the breaks[1] of the Rio Grande, on both sides of the railroad where it crosses San Felipe Creek and in the valley of the creek to the north of the railroad, are good exposures of this limestone. Macroscopically it is rather soft, chalky, and argillaceous, and possesses a minutely granular or subflocculent texture. Its color when freshly broken is white or whitish, with a yellowish tinge, due to the presence of ferruginous matter. It weathers to a grayish or yellowish color. The fossils which it contains are frequently ferruginous replacements. Microscopically the limestone is composed of minutely crystalline calcite and much flocculent (argillaceous) material. Foraminifera belonging to the Globigerina and Nodosaria types are present in very great numbers.

Exposures aggregating a thickness of about 40 feet were seen. In its upper part the limestone becomes very argillaceous and passes into a whitish clay which lies at the base of the Del Rio (*Exogyra arietina*) clay.

The Valverde County court-house and jail are built of this limestone. Through it the San Felipe Springs burst forth, the water coming up along a system of joint planes.

The following fossils were obtained near the San Felipe Springs (locality No. 269):

Enallaster texana (Roemer).
Kingena wacoensis (Roemer).
Rhynconella ? sp.
Ostrea (Alectryonia) sp.
Lima, two species, probably undescribed.
Neithea occidentalis Conrad.
Inoceramus sp., small fragmentary specimens.
Nemodon, two distinct species, undescribed.
Cardium sp.
Thracia sp.

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[1] Mr. W J McGee defines break as follows: "The 'break' is the head of a small retrogressive ravine, a minor water course gradually eating its way back into the upland." Twelfth Ann. Rept. U. S. Geol. Survey, p. 434.

What is here called "the breaks" is a much-indented escarpment that constitutes the outer boundary of the Rio Grande Valley, in a restricted sense, and up to which the general level of the Rio Grande Plain extends. The indentation of the escarpment is due to the head-water erosion of numerous small streams which are cutting it away.

Scaphites ? sp., several small distorted specimens that may be Olcostephanus or some other ammonoid genus.
Turrilites brazoensis Roemer.
Nautilus texanus Shumard.

DEL RIO CLAYS.

The top of the breaks of the Rio Grande to the northeast, east, and southeast of Del Rio is formed of the Buda limestone, to be discussed later. The slope is composed of the Del Rio clays. Within the breaks near Del Rio, to the southeast, is a conical-shaped butte, called Lone Hill, also composed of these clays, and they are exposed 20 miles west of Brackett, on the road to Del Rio, where they are overlain by the Buda limestone.

The following is a section exposed at the old ocher mine 2 miles north of east of the Del Rio court-house:

Section at ocher mine 2 miles north of east of Del Rio court-house.

	Feet.
7. Buda limestone capping.	
6. Slope to the edge of the bluff covered with *Exogyra arietina*, a few feet.	
5. Yellowish clay	15
4. Red clay	5
3. Thin indurated sandy layer	½
2. Red clay	10
1. Greenish clays	30

In the lowest stratum are thin, sandy flags containing Equisetum? and *Nodosaria texana*. *Exogyra arietina* is very abundant throughout the section. No. 4 is the bed from which the red ocher has been mined. This ocher is usually a vermilion-colored clay.

The section above described illustrates the lithologic characters of the beds. At the base, along the contact with the Fort Worth limestone, there is a white calcareous clay. Above this bed the clays are usually greenish before weathering. When subjected to atmospheric action they become yellowish. Beds of red clay occur near the top. Frequently the *Exogyra arietina* is cemented into slabs by a sandy ferruginous matrix. The thickness, as determined by the aneroid barometer, is 100 feet.

Although fossils are numerous in these clays, there are but few species. The following are the species collected and the localities whence they were obtained:

Fossils from 20 miles west of Brackett.

Nodosaria texana Conrad.
Pecten, a small undescribed species.

Fossils from old ocher mine on bluff 2 miles north of east of Del Rio court-house.

Nodosaria texana Conrad.
Exogyra arietina Roemer.
Plicatula incongrua Conrad.
Neithea sp., fragments.
Esquisetum?

BUDA LIMESTONE.[1]

Above the Del Rio clays occurs a limestone, which both in its stratigraphic position and its lithologic characters corresponds to the Buda limestone of the Colorado River section at Austin. Macroscopically this limestone is hard, and whitish or yellowish in color when freshly fractured. The fracture is conchoidal or splintery. It is frequently traversed by minute veins of calcite. Upon weathering it becomes yellowish or pinkish; occasionally, on account of the great amount of iron contained, weathered specimens may be incrusted by hematite. Numerous small red or pink blotches characterize the limestone. Microscopically it consists of minute veins and patches of transparent calcite, between which are patches of minutely crystalline granular calcite of dark-gray or brownish color, in which angular transparent pieces of calcite are embedded. The calcite veins are sometimes clouded in appearance, but are lighter in color than the bulk of the rock. No well-preserved Foraminifera were observed, but there are grayish masses of minutely crystalline calcite that show the structure of Foraminifera of the Globigerina type.

Outcrops of this limestone are to be seen northeast, east, and southeast of Del Rio, where it occurs above the Del Rio clays. It is also exposed at numerous places on the road from Brackett to Del Rio, between Sycamore Creek and the latter place.

Measurements of the thickness of the limestone at Del Rio were not obtained, but near Brackett it is about 100 feet thick—a little more than twice the thickness at Austin.

UPPER CRETACEOUS.

DAKOTA DIVISION.

(Absent.)

EAGLE FORD FORMATION.

The Buda limestone is overlain by a series of flaggy, argillaceous limestones, between the beds of which calcareous shaly layers are frequently found. These beds occupy precisely the same stratigraphic position with reference to the Buda limestone below and the Austin chalk above as do the Eagle Ford shales in central and northeastern Texas. The stratigraphic continuity of the beds has been traced from Del Rio, by way of San Antonio and Austin, to Red River, east of Sherman.[2]

As has been shown, these beds thin from Waco southward toward the Rio Grande; the more unctuous and darker-colored shales of the lower portion of the north Texas section disappear, and only the

[1] In accordance with a suggestion of Mr. R. T. Hill, the name Shoal Creek limestone is here changed to Buda limestone, as the former name is preoccupied.

[2] Robt. T. Hill: Am. Jour. Sci., Vol. XXXIV, Oct., 1887, pp. 291 et seq.; Bull. No. 4, Geol. Survey of Texas, Austin, 1889, p. xxvii; Artesian and other underground waters in Texas, New Mexico, and Indian Territory, Final Rept. of the artesian and underflow investigation of the U. S. Dept. Agriculture, 1892, p. 124.

upper or more calcareous, sometimes arenaceous, horizons (called "fish beds" by Shumard, Hill, and others) persist, becoming more accentuated.

The local name "Valverde flags"[1] has been proposed for these beds along the Rio Grande, but there is not sufficient lithologic difference to warrant the use of a separate designation, and the equivalence of the Valverde flags and the Eagle Ford beds has, as stated, been established by actually tracing the beds across the area intervening between the areas to which the two names were originally applied.

Outcroppings of the Eagle Ford flags were seen along the road from Del Rio to Eagle Pass, from a point 3 miles southeast of the former place until the valley of Sycamore Creek was reached, where they were obscured by the débris in the valley. The distance across the area of exposures is about 8 miles.

No estimate was obtained of the thickness of this formation in the vicinity of Del Rio. Dumble has estimated that it is 600 feet thick.[2] Near Brackett it is about 250 feet thick, by actual measurement, so that it would seem that the foregoing estimate is probably too great.

AUSTIN CHALK.[3]

This formation is a soft, chalky, argillaceous, white limestone, containing a little ferruginous matter in the shape of pyritiferous lumps or nodules of marcasite. Sometimes there are alternations of chalky layers and calcareous clays. It presents exactly the same lithologic and paleontologic characters in the middle Rio Grande region that it does in the Colorado River region. A microscopic examination of a specimen of the chalk collected 15 miles from Del Rio, on the road to Eagle Pass, showed its foraminiferal nature; Globigerina, Textularia, and Orbulina were present in very great numbers.

The first exposure was seen about 15 miles from Del Rio, on the road to Eagle Pass. Other exposures were seen as far as Tulío Creek (Las Moras Creek), about 33 miles from Del Rio. Pinto, Cow, and Tulío (Las Moras) creeks flow over the chalk where the Eagle Pass–Del Rio road crosses the streams. On the road from Brackett to Del Rio exposures were seen as far as the first crossing over the Southern Pacific Railroad.

At the crossing over Cow Creek there is an excellent exposure in a bluff, about 25 feet high, composed of layers of chalk, 1 foot or more in thickness, alternating with beds of yellow clay. From this place the following fossils were obtained (locality No. 271):

Cidaris ? sp., a detached plate.
Gryphæa aucella Roemer.

[1] E. T. Dumble: Bull. Geol. Soc. America, Vol. III, 1892, p. 221.

[2] Op. cit., p. 229.

[3] Dumble has used the name "Pinto" for these beds in this region (Bull. Geol. Soc. America, Vol. III, 1892, p. 222), but, as is here shown, there is no occasion for applying a new designation to them.

Avicula sp. Cf. A. linguiformis E. and S.
Inoceramus digitatus Sowerby = I. undulato-plicatus Roemer.
Inoceramus deformis Meek.
Nautilus sp.
Baculites anceps Lam., the form so identified by Roemer.
Pachydiscus flaccidicosta (Roemer).
Mortoniceras texanum (Roemer).
Schloenbachia dentato-carinata (Roemer).

"This is a typical Austin chalk fauna. The species of Inoceramus and Baculites occur also in the contemporaneous Niobrara limestone of the Western interior region." (Stanton.)

From an exposure in Tulío (Las Moras) Creek *Inoceramus digitatus* Sowerby was collected.

No estimate of the thickness of these beds was made. Unfortunately, for some distance below Tulío Creek no exposures of the bed rock were seen, the road being on the wide alluvial terrace flanking the Rio Grande. Dumble estimates that the beds are 1,500 feet thick,[1] basing his estimate upon a dip of 100 feet to the mile.

UPSON CLAYS.

As shown by Dumble,[2] the Austin chalk is overlain by a series of stiff clays, which he calls the Upson clays. The actual contact between the two formations was not observed. The following is Dumble's original characterization of the formation:

> The basal member consists of yellow clay containing calcareous nodules of septarian character, the crevices or septæ [*sic*] of which are filled with dog-tooth spar. These nodules occur in large geodic form 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.[2]

About 2½ miles above Lehmann's house (Upson post-office), near the water level on the Texas side of the Rio Grande, is an exposure only a few feet in thickness.

Section 2 1–2 miles above Upson post-office.

2. Clays that weather grayish yellow or greenish yellow.
1. Clays that are white and chalky on exposure, and seem very like a transition from the Austin chalk to the Taylor marls.

The bluffs on the Mexican side of the river, as could be seen with field glasses, are composed of dark greenish-yellow clays. In places there appear to be indurated layers, but no limestones reminding one of the Anacacho beds.

Lehmann states that a well, bored to a depth of 45 feet, near a slough just south of his house, has its bottom in a stiff, dark-blue clay which

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[1] Bull. Geol. Soc. America, Vol. III, 1892, p. 229.
[2] Op. cit., p. 224.

contains many fossils. Unfortunately none of the fossils were preserved.

An examination of the bluffs of the escarpment bounding the Rio Grande Valley east of Upson was made, but no exposure of the strata beneath the gravel was found. Along the draws was stiff clay, indicating that the gravels rest on a clay foundation.

These observations show that there is no Anacacho limestone along the Rio Grande, but that the equivalent beds have again assumed the character of the Taylor marls of central Texas.

Assuming the dip of these clays to be 100 feet to the mile (the dip of the beds in the vicinity of Eagle Pass) the thickness would be about 700 feet—the estimate made by Dumble (op. cit.).

EAGLE PASS FORMATION.

The name "Eagle Pass beds" was first proposed by Dr. C. A. White, in 1891, in discussing the Cretaceous of the Texas region.[1] Dr. White does not define the formation, but considers it equivalent to the "Ripley" (Navarro of Hill) of eastern Texas, and places it above the Taylor (*Exogyra ponderosa*) marls. Therefore, according to White, the base of the Eagle Pass formation would rest on the top of the Taylor marls, and the equivalent to these marls, the Upson clays, would be excluded from it. Dumble (op. cit.) amplifies the name "Eagle Pass beds" by the substitution of the word *series*, and assigns to this series all of the beds from the Austin to the base of the Eocene. It is better, in the opinion of the writer, to use the name as White first employed it, viz, for those beds extending from the Taylor (Upson) marls or clays to the Eocene. The three subdivisions of Dumble are, however, recognized, but with the reservation that future study may very much modify the nomenclature. As yet no detailed study of the area as a whole has been made, and the present attempt is only to give an idea of the section along the Rio Grande proper, with approximate estimates of the thickness of the formation and a general idea of its variations in the area under discussion.

San Miguel beds.—The following is Dumble's original description of these beds:

> Resting on the clay shales which form the upper member of the Upson 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. * * * 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 the Carter ranch we

[1] Bull. U. S. Geol. Survey No. 82, 1891, pp. 116 et seq.

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 gastropods. 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.[1]

Coming up from the creek valley, about halfway between the ranches of Messrs. Lehmann and Burr, 1½ miles north of Paloma siding, on the Southern Pacific Railroad, one finds sandstone, underlain by clay, exposed in the eastern bluff. The section is similar to that next described, which is seen in coming up from the Rio Grande flat, on the way from the Lehmann ranch to Eagle Pass.

Twelve and a half miles from Eagle Pass, as the road from Upson passes from the silt terrace of the Rio Grande to the plain above the breaks of the river, the following section was observed:

Section 12 1-2 miles from Eagle Pass.

	Feet.
3. Sand and gravel (Uvalde formation).	
2. Soft yellow, grayish, or white calcareous sandstone	40
1. Yellow clay.	

Fossils obtained from No. 2.

Ostrea tecticosta Gabb.
Exogyra costata Say?, upper valve only.
Pecten quinquenarius Conrad.
Cucullæa antrosa Morton.
Crassatella sp.
Cardium carolinense Conrad.
Cardium (Pachycardium) spillmani Conrad.
Legumen planulatum Conrad.
Turritella trilira Conrad.
Anchura rostrata Gabb.

"The above species all occur in the typical Ripley fauna of Mississippi and Alabama. The horizon is about the same as that of the lower marl bed (Navesink formation) of New Jersey." (Stanton.)

Coal series.—This name has been utilized by Dumble (op. cit.) to designate that portion of the Eagle Pass formation which contains the coal beds in the vicinity of Eagle Pass. The following sections will give an idea of the character of the beds.

[1] Dumble, Bull. Geol. Soc. America, Vol. III, 1892, pp. 224, 225.

Section in the Maverick County Coal Company's mine, near Eagle Pass, as given by Mr. George Bregg, former manager of the mine.

	Feet.
7. Sandstone	50
6. Clay	60
5. Sandstone	4
4. Coal	2
3. Clay	94
2. Coal (worked seam)	6
1. Sandstone	14
Total	230

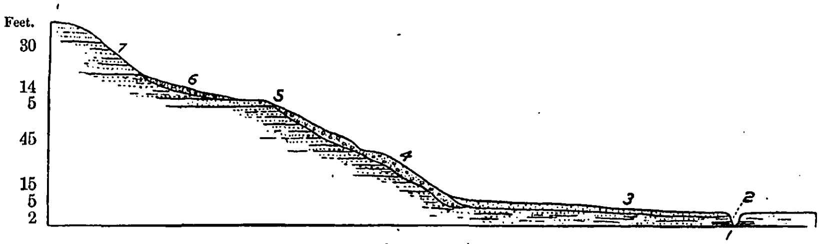


FIG. 2.—Section of hill on east side of Elm Creek, 1 mile above the bridge at the crossing of the Del Rio and Eagle Pass road.

Section of hill on east side of Elm Creek, 1 mile above the bridge at the crossing of the Del Rio and Eagle Pass road.

	Feet.
7. Soft, fine-grained, irregularly bedded sandstone, containing curious elongate tube-like bodies, which stand with their long axes vertical to the stratification planes	30
6. Unexposed gravel-covered slope, the gravel in yellowish sand	14
5. Coarse brown or yellowish sandstone, sometimes with white blotches and containing fossil wood	5–6
4. Sandy slope, a little gravel on the surface	45
3. Alluvial terrace of creek, lower rocks unexposed, alluvium probably underlain by sandstone	15
2. Creek bank, soft, cross-bedded sandstone, with ferruginous concretions	5
1. Yellow clay to bed of creek	2
Total	117

Above the clay apparently the whole section is composed of sandstone like that at the surface in the shaft of the Maverick County Coal Company's mine.

Along Elm Creek, above the bridge, irregularly stratified sandstones and clays containing ferruginous concretions and silicified wood are exposed. There is no constancy in the small beds of sand and clay; they are simply interlocking lenses.

At the old Hartz mine the coal is about 6 feet thick and is both overlain and underlain by clays. From the clays above the coal a specimen of the palm *Geonomites tenuirachis* Lx.—determined by Prof. F. H. Knowlton to be a Laramie species, as it occurs in the coal-bearing Laramie of New Mexico—was collected.

Section at mine No. 1 of the Fuente, Mexico, coal mines on the north bank of the Rio Escondido, 5 or 6 miles west of Eagle Pass.

	Feet.
6. Gravel interstratified with sandy clay resting uncomformably on (5)	15–20
5. Bluish or yellowish carbonaceous clay	5
4. Shaly coal	4
3. Reddish and bluish clay	2
2. Coal (worked seam)	4–5
1. Clay.	
Total	30–36

Near this mine a conglomerate, composed of calcareous pebbles and calcareous cement, covers the surface between the arroyos.

Prospect shaft No. 3 of L. F. Dolch & Co., near coal shaft for mine.

Depth.	Material.	Thickness. Ft.	Thickness. in.
Feet.		*Ft.*	*in.*
0–64	Clay	64	0
64–74	Sandstone	10	0
74–91	Black clay	17	0
91–93	Septaria in clay	2	0
93–96	Hard blue sandstone	3	0
96–100	Very hard brownish clay, with some sand	4	0
100–104	Blue argillaceous sandstone, with some clay seams	4	0
104–120	Dark bluish-black slate	16	0
120–126	Hard sandstone	6	0
126–132	Dark slate	6	0
132–145	Black clay	13	0
145–148	Sandstone	3	0
148–151	Brown clay, rather hard (had to be blasted)	3	0
151	Coal	0	2
151–176	Very hard white sandstone	25	0
176–176½	Bony coal	0	6
176½–181	Clay	4	6
181–182	Brown slate	1	0
182–183	Bony coal	1	0
183–183½	Coal seam	0	6
183½–195	Clay	11	6
195–198	Slate and sandstone	3	0
198–199	Bony slate	1	0
199–201	Sandstone	2	0
201–203	Bone	2	0
203–210	Coal	7	0

Section of artesian well bored on the top of the hill 2 miles northeast of Eagle Pass, between the Uvalde and Carrizo Springs road.[1]

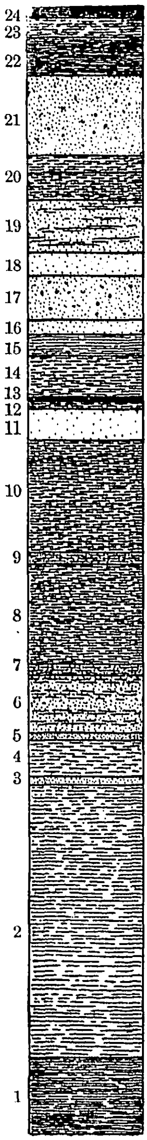


FIG. 3.—Section of Eagle Pass artesian well.

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

Nos. 24 to 8 represent the whole thickness of the Coal series; Nos. 8 to 1 belong to the San Miguel beds.

About 100 feet north of Burr's ranch, 1½ miles northwest of Paloma siding, is an exposure of brownish or greenish-yellow fossiliferous sandstone underlain by clays. The section is of somewhat doubtful stratigraphic position, but it would seem to belong in the Coal series, and probably below the coal horizon. The following fossils have been determined by Mr. Stanton from the collection made here:

Trigonia sp., single cast of a young individual.
Arca? sp., single cast of a young individual.
Cardium eufalense Con.?
Tellina sp.
Cytherea? sp.
Veleda lintea Con.? Common at Corsicana.
Mactra sp.
Corbula sp.
Dentalium sp.
Lunatia obliquata M. and H. Common Ripley species.

[1] Report on artesian waters, etc., for Texas west of ninety-seventh degree of longitude, by Frank E. Roessler, 1890, Senate Ex. Doc. No. 222, Fifty-first Congress, first session, p. 266.

Lunatia sp.
Natica sp. Occurs at Kaufman, Texas.
Fusus sp. Occurs at Corsicana, Texas.
Fusus sp.
Tritonium ? sp. Occurs at Corsicana, Texas.
Trophon ? sp. Occurs at Corsicana, Texas.
Olivella sp.

This fauna seems very closely related to that found 2 miles north of Eagle Pass on the Uvalde road, but *Sphenodiscus pleurisepta*, which usually characterizes the upper beds, is absent. The stratigraphic position of the exposure near the Burr ranch has not been definitely determined, but it would seem to be considerably below the fossiliferous horizons in the bluffs east of Eagle Pass.

From Paloma to Thomson's siding sands and clays outcrop in the draws, and gravel usually caps the hills.

Escondido beds.—Dumble (op. cit.) has proposed the name "Escondido beds" for the sandstones and clays occurring above the Coal series. The following sections and notes describe them. (Pl. II.)

Just east of the railroad, on the eastern side of Eagle Pass, is an escarpment about 90 feet high, the rocks having a strike due north–south magnetic, and a dip 3° E. This escarpment is composed at the top of a few feet of soft, yellowish sandstone, underlain by ledges of hard, brownish, ripple-marked sandstone, which is followed by a slope composed of some clays, but chiefly of soft, yellowish sandstone. The fossils collected on the Uvalde–Eagle Pass road, 2 miles above Eagle Pass, belong in the lower part of the slope of this section (see p. 30). The detail of the section is as follows:

Section on slope near railroad on the east side of Eagle Pass.

	Feet.
5. Soft sandstone	10
4. Hard brown or yellowish sandstone	3
3. Soft yellowish sandstone	1 or 2
2. Ledges of hard sandstone, with some soft sandstone	15
1. Sandy clay and soft, greenish-yellow sandstone to base of escarpment, clays preponderating	60
Total	90

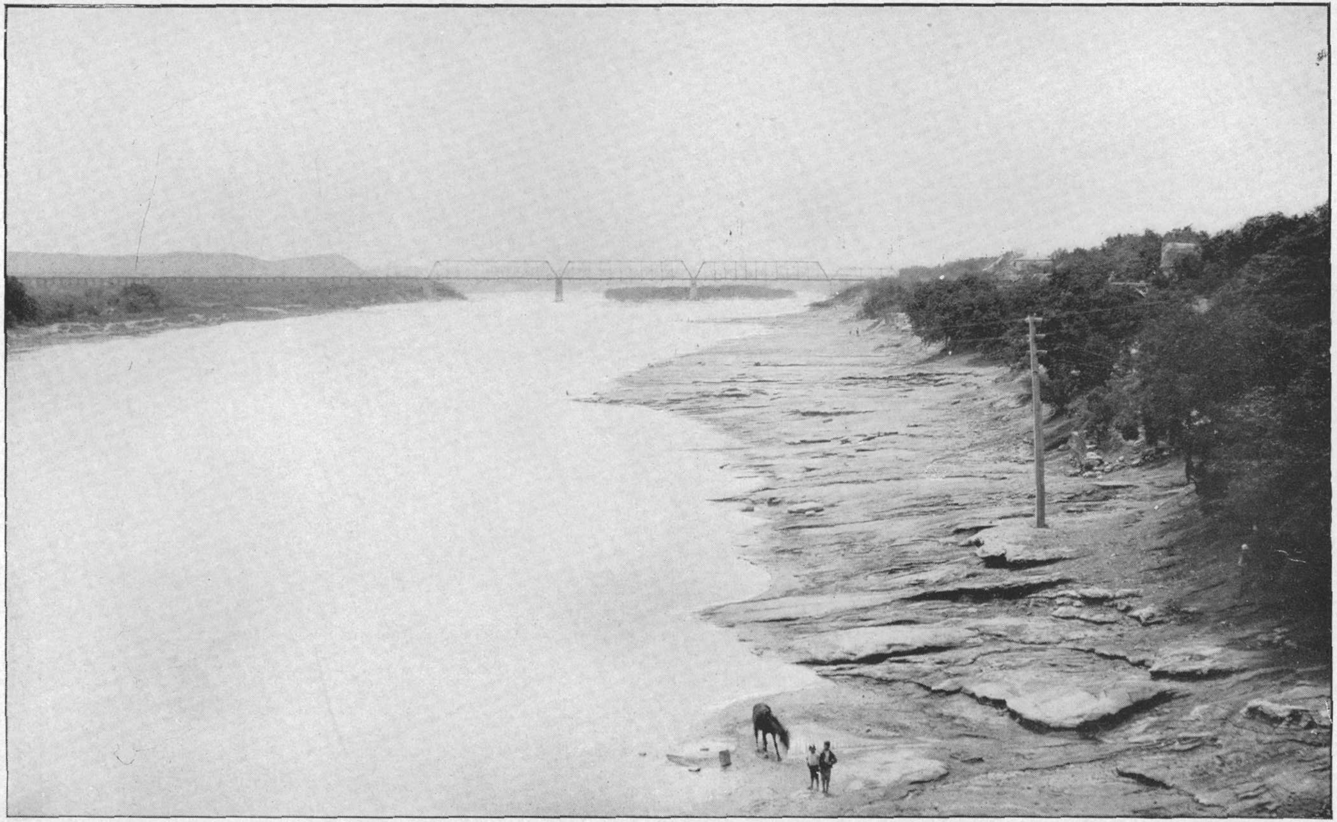
From No. 2 the following fossils were obtained (locality No. 273):

Ostrea, two species.
Anomia sp., a minutely costate species.
Inoceramus cripsi var. barabini Morton.
Cardium sp.
Pholadomya n. sp.
Turritella sp. Cf. T. saffordi Gabb.

"The only species identified in this lot is widely distributed in the Ripley and Montana formations." (Stanton.)

This bed contains an oyster ledge and is the base of Dumble's Escondido beds.[1]

[1] Bull. Geol. Soc. America, Vol. III, 1892, p. 228.



THE RIO GRANDE, FROM MEXICAN SIDE OF THE RIVER, OPPOSITE EAGLE PASS.

Fossils collected 1 1-2 miles southeast of Eagle Pass, on the road to Laredo (locality No. 274).

Anomia sp.
Camptonectes sp.
Lima sp.
Trigonarca cuneata Gabb.
Cardium sp. Cf. C. eufalense Conrad.
Tellina sp.
Corbula sp.
Dentalium sp.
Sphenodiscus pleurisepta (Conrad), a variety in which the abdomen becomes rounded at an early stage.

According to Mr. Stanton, there is in the National Museum a small collection of fossils obtained in the neighborhood of Eagle Pass by Mr. J. Owen. He collected *Exogyra costata* at localities 1 mile southeast and 4 miles east of Eagle Pass. At the first locality he also collected a species of Volutomorpha and other Ripley forms.

Beds composed of brownish sandstone, with occasional beds of fossils, were found along the road to Laredo until about 30 miles from Eagle Pass (about 26 miles in a straight line). The following is a list of the fossils collected, with their localities:

Fossils collected 5 miles southeast of Eagle Pass (locality No. 275).

Ostrea cortex Conrad?, immature specimens.
Arca sp.

Fossils collected 14 1-2 miles southeast of Eagle Pass (locality No. 276).

Ostrea cortex Conrad.

Fossils collected 18 1-2 miles southeast of Eagle Pass (locality No. 277).

Ostrea cortex Conrad.
Anomia sp., same as species from locality No. 273.
Cardium sp. Cf. C. eufalense Conrad.
Mactra sp. Cf. M. warreneana M. and H.
Pholadomya n. sp.
Turritella sp., small casts.
Nautilus dekayi Morton.
Sphenodiscus pleurisepta (Conrad). Typical and abundant.

"The collection evidently belongs to the same subfauna which is more closely related to the Ripley than to any other. The facts that it is in beds that overlie those containing typical Ripley fossils, and that a considerable proportion of the species are peculiar to these beds, are strong indications that we may have here more recent Cretaceous beds than the latest Ripley beds of Mississippi, Alabama, and other portions of the Gulf Coast region." This idea has already been advanced by Mr. Dumble.[1] (Stanton.)

[1] Bull. Geol. Soc. America, Vol. III, 1892, pp. 219-230.

Résumé of characters and thickness of the Eagle Pass formation.

	Feet.
Escondido beds, composed of sandstones and clays, with many fossiliferous horizons, exposed for 26 miles below Eagle Pass	2,600
Coal series, as determined by artesian well bore, which begins in the uppermost bed	900
San Miguel beds, the lower 600 feet of the artesian well bore and the thickness of sandstone exposed in the hills north of the Carter ranch, 15 miles above Eagle Pass (200?)	800
Total thickness of Eagle Pass formation	4,300

RECONNAISSANCE FROM CLINE, UVALDE COUNTY, TO EAGLE PASS.

The road from Cline leads across the Anacacho Mountains to the Beasley ranch, some 10 miles to the south; thence southward to the crossing of the main Eagle Pass–Uvalde road over Chacon Creek. From this point the journey was made along the main public road to Eagle Pass.

The Anacacho formation will receive detailed consideration later. It suffices to say here that in the creek just south of Beasley's house this limestone has dipped beneath clays which initiate the Eagle Pass series.

The whole distance from the first crossing over Mula Creek, south of the Beasley ranch, to the third crossing over the same stream is a silt and gravel flat, with absolutely no bed-rock exposure. The gravel is chiefly flints. The vegetation consists of low, scraggly mesquite bushes, lignum vitæ, and some cats-claw, occasional junco, and some tasajillo (*Opuntia leptocaulis*), with very little grass. The surface of the ground is glazed and checkered by small cracks.

From this crossing over Mula Creek to Chacon Creek the surface is composed entirely of silt and gravel. At the crossing over Chacon Creek the main Uvalde–Eagle Pass road is reached. On the southwest side of the road there is an outcrop, from beneath the silt and gravel, of brownish sandstone, in which is an agglomerate of *Ostrea cortex* Conrad.

Between Chacon Creek and Salado Creek the surface is covered by gravel and silt. About one-fourth of a mile north of Salado Creek is an outcrop of coarse-grained brown sandstone. The following section was observed on the north side of the creek at the ford:

Section at ford on north side of Salado Creek.

	Feet.
3. Thinly laminated, pinkish, purplish, and brown cross-bedded sands	1–2
2. Yellow clay	3–5
1. Hard, yellowish sandstone, containing many fossils, which are difficult to free from their matrix.	

There is an oyster, probably *O. cortex*, besides which Mr. Stanton has identified the following fossils from the collection made at this place:

Limopsis? sp.
Gyrodes petrosa Morton.
Strepsidura ripleyana Conrad.
Pyropsis sp.

These indicate, according to Stanton, the fauna of the Ripley and Navarro beds.

For about a mile after passing Salado Creek the surface is composed of residual sands, with occasional outcrops of yellowish sandstones. For the next half mile there are sands with some gravel embedded in them. For the next 5 miles the soil is usually argillaceous, or a mixture of sand and clay, and there is a considerable amount of gravel scattered over the surface. In ascending a small hill 5½ miles beyond the Salado crossing many fossils were found in a hard layer of greenish sands, which overlies soft yellowish and greenish sands and clays. Mr. Stanton identified the following species from a collection made at this locality:

Trigonia sp., a small imperfect specimen related to T. eufalensis Gabb.
Cardium sp., a form that is abundant in the Navarro beds at Corsicana, Texas.
Veleda lintea Con.? This also occurs at Corsicana.
Turritella trilira Con. variety.
Baculites ? sp., a crushed fragment.

Mr. Stanton remarks: "The fossils from this locality and those from 11½ miles north of Eagle Pass, near Burr's ranch, and 2 miles north of Eagle Pass are nearly all either identical with or closely related to species that occur in the Ripley fauna of Mississippi and Alabama and in the uppermost Cretaceous beds of Navarro and Kaufman counties, Texas. This fauna has a vertical range of several hundred feet in Alabama."

Six and a half miles below the Salado crossing the foundation of the soil is a yellowish-brown clay. Gravel is scattered over the surface. It is chiefly flint, but there is also a considerable admixture of porphyry, showing that the gravel has been brought down by the Rio Grande.

Although there is not a continuous coating of gravel over the hills from this point (17 miles from the Eagle Pass court-house) to Eagle Pass, gravel occurs, in more or less disconnected patches, the whole distance. The rocks consist of alternations of yellowish flaggy sandstones and clays. From about 11½ to 11 miles north of Eagle Pass *Exogyra costata* was found in considerable abundance in yellowish clays. These clays are both overlain and underlain by soft yellow sandstone. This clay bed, by aneroid barometer measurement, is 50 feet thick. The road runs approximately along the strike of the rocks, and the stratigraphic position of the *Exogyra costata* clays and their associated sand beds seems to coincide with that of the sands and clays forming the top of the escarpment overlooking the Rio Grande Valley, 6½ miles north of Eagle Pass, i. e., the base of the Escondido formation. These beds occur considerably above the coal-bearing horizons. About 2 miles from the court-house is a fossiliferous horizon in clays, a section of which gives the following:

Section 2 miles north of Eagle Pass court-house.

	Feet.
4. Hard brownish sandstone ledge, forming top of the escarpment.	
3. Slope of soft yellowish sandstone, about	20
2. Indurated fossiliferous layer	½–1
1. Yellowish clay.	

Mr. Stanton has determined the following from a collection of fossils made at this locality:

Cardium eufalense Conrad?
Mactra sp. Cf. Mactra formosa M. and H.
Dentalium sp.
Natica sp. Occurs at Kaufman, Texas.
Turritella winchelli Shumard. Occurs at Corsicana, Texas.
Strepsidura ripleyana Conrad.
Undetermined volutoid? Cf. Ancilla cretacensis Conrad.
Volutomorpha sp. Cf. V. gabbi Whitefield.
Sphenodiscus pleurisepta (Conrad).

The conclusion to be drawn from these notes is that the whole of the rocks exposed from the crossing over Chacon Creek to Eagle Pass belong above the Eagle Pass coal and correspond approximately to the base of the Escondido formation.

RECONNAISSANCE FROM EAGLE PASS TO CARRIZO SPRINGS.

From Eagle Pass to Robert Thomson's house, 20 miles east of the city, the bed rock presents the same character that it exhibited in going down the Rio Grande to Santo Tomas. It consists of sandstone and clays; for the last 8 miles before reaching Thomson's ranch clays prevail. The tops of the hills are generally capped by gravels, the sandstone and clays being exposed in the creek valleys and along the slopes.

Four miles east of Thomson's, on the road to Carrizo Springs, a specimen of *Sphenodiscus pleurisepta* was found in yellow clays.

To within 9 miles east of the Thomson place dirty, dark ocher-colored clays form for the most part the surface of the ground; there is some sand in the draws, and gravels occur on the high ridges. No sharp line between the Cretaceous and Eocene was discovered, and no fossils were found in the transition beds.

At about 9 miles east of Thomson's ranch and 16 miles west of Carrizo Springs, a change of geological formation was noticed. The clays above described are here succeeded by fine-grained sandstones containing some mica. There are bands of red iron ore and many bits of hematite. The flora consists mostly of Opuntia, lignum vitæ, some guajillo, some rhamnaceous shrubs, and mesquite. There was no grass, the ground between the cactus and the shrubs being barren.

Although it can not be affirmed with certainty, it is quite probable that this change in the character of the rocks marks the boundary between the Cretaceous and the Eocene.

STUDIES ALONG TURKEY CREEK AND THE NUECES RIVER, THE FRIO AND SABINAL RIVERS, BRACKETT AND UVALDE QUADRANGLES (EASTERN KINNEY COUNTY AND UVALDE COUNTY).

The sections along these streams are described in the discussions of the formations.

ANACACHO FORMATION.

This formation was defined by Hill and Vaughan in the Geology of the Edwards Plateau and Rio Grande Plain, etc.[1] It is the stratigraphic equivalent of the Upson clays of the Rio Grande section, and of the Taylor (*Exogyra ponderosa*) marls of central Texas. It overlies the Austin chalk, and is in turn overlain by sandy limestones, sandstones, and clays. Its component rocks are either hard or soft yellowish limestones or yellow marls, the calcareous constituents being in excess of the argillaceous.

The following section is taken from the report cited above:

Section of the Anacacho Mountains, Kinney County.

	Feet.
II. Anacacho formation:	
8. Scarp-making rock, forming the top of the hill. It is a hard, yellow, subcrystalline limestone. In the top a species of Alectryonia was found. About 30 feet below the top, great numbers of *Gryphæa vesicularis* occur, firmly embedded	60
7. Softer limestone: *b*, Soft, yellow, marly limestone, containing a large species of Cardium, 50 feet; *a*, Soft, white, chalky limestone, containing a species of Turritella with three prominent revolving striæ on each whorl (*T. trilira* Con.?), 30 feet; total	80
6. Hard limestone ledges. The upper 30 feet is brownish, and contains great numbers of *Exogyra ponderosa* firmly embedded near the top. The next lower 20 feet is a yellowish granular limestone with glauconitic specks. This bed forms a platform on the east end of the Anacacho	70
5. Ledges of yellow, ferruginous, not very hard, subcrystalline limestone, forming the lower scarp on the east end of the hill	30
4. Slope composed of marly limestone in the upper part, the lower portion yellow marls with fragments of a very large and coarsely corrugated Inoceramus	20
3. Yellowish limestone, weathering into nodular chunks, iron-stained along the weathering cracks. Contains some poorly preserved fossils—Trigonia (?), Mactra, and a finely-ribbed Lima	10

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part II, 1898, pp. 240, 241.

	Feet.
II. Anacacho formation—Continued.	
2. Soft material containing fragments of a very large Inoceramus	5
1. Thin, very hard, brown, siliceous ledge	3 or 4
Total Anacacho beds	279
I. Austin chalk:	
3. Hard brownish limestone, containing many *Gryphæa aucella*	5
2. Hard chalky limestone	10
1. Unexposed—to bottom of arroyo	20
Total Austin chalk exposed	35
Total Anacacho beds	279
Total here exposed	314

The measurements were made with an aneroid barometer and must be regarded as only approximately correct.

The deposit of asphalt at the Lithocarbon Rubber Company's mine is in the Anacacho limestone. The asphalt-bearing horizon corresponds with the upper part of No. 6, above.

The following is a compilation from a large number of sections made along Turkey Creek, beginning at Cline Mountain, in the Brackett quadrangle, and extending to Wagon Top Butte, in the Uvalde quadrangle.

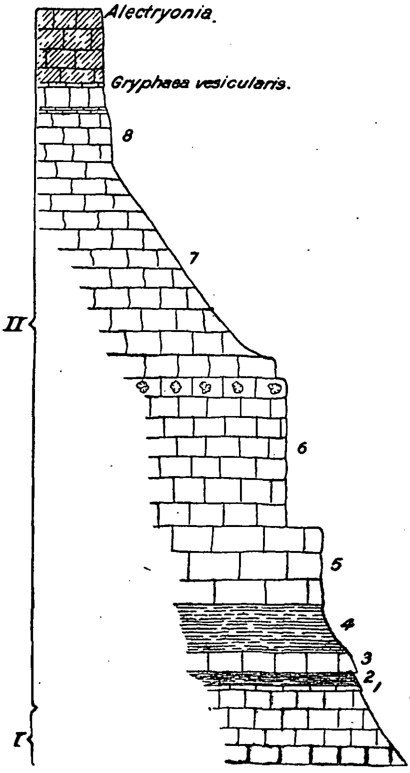


FIG. 4.—Section of the Anacacho Mountains, Kinney County.

Compilation of sections along Turkey Creek.

	Feet.
20. Hard gray limestone. This limestone is coarsely granular, loose textured, and possesses a very rough, honeycombed, weathered surface. It contains an undetermined species of Radiolites or Sphærulites	10
19. Thinly laminated, hard or marly limestone	20
18. Ledges of gray limestone, with honeycombed surface, but not so hard as the uppermost limestone. This bed is not well exposed, so that its detail could not be determined	30
17. Hard, dark-brown, granular limestone	3
16. Light-colored, yellowish, granular limestone in hard, thick ledges. This bed contains specimens of a large Exogyra and a Radiolite; also some pebbles of white and yellow quartz	7
15. Thinly bedded limestone, becoming a thinly laminated, firm, calcareous shale	15
14. Laminated yellow calcareous marl	50

		Feet.
13.	Coarsely crystalline limestone, in thick ledges, containing a species of Radiolite	15
12.	Hard limestone ledge, containing small scattered calcite crystals and shell fragments in a brown matrix	10
11.	Coarsely crystalline yellowish-gray limestone	15
10.	Soft limestone	20
9.	Scarp-forming limestone, several alternations of harder and softer beds about the base	30
8.	Hard limestone with small Gryphæa	10
7.	Soft limestone	20
6.	Soft limestone containing Trigonia sp	10
5.	Thick ledge of yellow limestone	10
4.	Softer, more shaly limestone	20
3.	Thick ledge of granular, argillaceous, ferruginous limestone	5
2.	Softer, rather marly material	15
1.	Ledge of limestone resembling No. 3	5
	Total thickness	320

Base of Anacacho formation and top of the Austin chalk.

The foregoing section must be regarded as only an approximation. Evidently there is considerable variation in the lithologic characters of the sections, frequently making it difficult to correlate from one section to another. The sections were, for the most part, measured with an aneroid barometer, and although it was attempted to check them by the height of the hills as given on the topographic maps, absolute exactness could not be expected.

A carefully measured section along the Sabinal River was not obtained, but from a study from several bluffs, and from several well borings, the general characters of the equivalent beds were discovered, and an estimate of thickness was made. The beds here are intermediate in character between the typically developed Anacacho formation and the Taylor marls. There are beds of limestone showing the same characters as the typical Anacacho, and also rather thick beds of yellow clay of the same character as the Taylor marls. There is more clay than in the vicinity of the Anacacho Mountains, and more limestone than in the central Texas region. These beds near Sabinal are considerably over 300 feet in thickness, probably 400 or more feet.

EAGLE PASS FORMATION IN BRACKETT AND UVALDE QUADRANGLES.

In the Uvalde quadrangle, between Turkey Creek and the Nueces River, the Anacacho limestone is overlain by a brown arenaceous limestone which grades into brown sandstones.

Section at Asphalt Falls, Nueces River.

		Feet.
10.	Flint gravel, lower rocks not exposed	8
9.	Coarse-grained, laminated, and cross-bedded yellow sandstone	2
8.	Soft yellow sandstone and clay	25
7.	*Ostrea cortex* embedded in clay and consolidated to form a firm ledge	2
6.	Laminated, sandy, yellow clays	3½
5.	Soft ledge, composed largely of fragments of oyster shells	1
4.	Soft, laminated, sandy, yellow clays	3
3.	Soft, fine-grained sandstone, frequently beautifully cross-bedded and containing some asphalt	10
2.	Asphalt-bearing sandstone	5
1.	Bluish clays to water's edge	2

10, Pleistocene.
8–9, Eocene?
1–7, Cretaceous.

The area occupied by these sandstones and clays up to the supposed base of the Eocene is very small, being only a mile or two wide, and the writer doubts that their maximum thickness exceeds 100 feet. Along the Frio River they are exposed from place to place from 1 to 2 miles below Engelmann's ranch. About 2 miles, measured in a straight line, below that ranch they dip beneath the Eocene sandstones and clays.

VARIATIONS IN CHARACTER OF THE FORMATIONS IN THE DIFFERENT SECTIONS.

There is very little variation in the formation below the Upson clays—Anacacho formation. The Lower Cretaceous is practically the same in the Uvalde and Brackett quadrangles and westward to Del Rio. This is also true of the Eagle Ford formation and the Austin chalk, but above the latter the variation is great.

Anacacho formation and Upson clays.—The equivalent of these formations in central Texas is, as already stated, the Taylor marls. In the vicinity of Austin these marls are calcareous clays, blue when fresh, but oxidizing yellow, and are about 540 feet thick.[1] In the vicinity of Sabinal clays resembling the Taylor marls and containing the same fossils are exposed along Sabinal River above the town, and have been penetrated by well borings. Here there are numerous thick beds of yellowish limestone interstratified with the clays. When the Anacacho Mountains in the Brackett quadrangle are reached, the clay beds have either entirely disappeared or become very insignificant. Along the Rio Grande the equivalent Upson clays contain, so far as known, no limestone beds, but are composed entirely of greenish or bluish clays which oxidize yellow. These data show that the Anacacho limestone is a purely local development. It is principally an organic limestone, produced by a great luxuriance of testaceous organisms, chiefly mol-

[1] Hill and Vaughan: Eighteenth Ann. Rept. U. S. Geol. Survey, Part II, 1898, p. 240.

lusks. The causes that have brought about the conditions favorable for their growth are not known to the writer.

Eagle Pass formation.—These beds have been shown to possess a total thickness of over 4,000 feet along the Rio Grande. They thin very rapidly to the north, so that the total thickness exposed along the Nueces River, in the Uvalde quadrangle, is only 100 or 200 feet. How much of the formation is buried by the Eocene overlap can not at present be determined, but the decrease in thickness is enormous, as is shown by the fact that the thickness below the lowest *Ostrea cortex* horizon, near Eagle Pass, is some 1,700 feet, while below the same horizon on the Nueces it is probably not more than 100 feet.

These beds are known to be thicker farther to the north than they are along the Nueces River, but how much they are influenced by the Eocene overlap is unknown. These facts reveal an extremely interesting problem—the effect of the Eocene overlap, in regard to which much more data are needed before the problem can be satisfactorily solved.

RELATION OF THE CRETACEOUS TO THE EOCENE.

In order to avoid repetition the details of the basal Eocene will not be described here. They are discussed further on, in the description of the Eocene sections.

Here general statements only will be made.

Rio Grande section.—As has been pointed out by White, Penrose, and Dumble, there is no sharp lithologic line between the Cretaceous and the Eocene. The contact between the two series has not been discovered. The principal result of the writer's work on the Rio Grande was in proving the existence of Eocene fossils some 3 or 4 miles above the Webb-Maverick county line, 6 or 7 miles above where Penrose and Dumble first found such fossils. The fossils obtained here are typical Lower Eocene, and there has been discovered in this region no greater indication of the commingling of faunas than has been found in Alabama or other States, where it has been distinctly shown that an erosion interval occurred between the two series.[1] Because of these faunal relations, it is the writer's opinion that the Cretaceous and Eocene series here were separated by an erosion interval, as is known to be the case elsewhere, and it is quite probable that more extended investigations will subsequently establish the exact contact, though this may not be possible because of the limited number of fossils obtainable and the lack of good exposures.

Between Eagle Pass and Carrizo Springs.—The probable contact between the Eagle Pass formation and the Eocene has already been described (see p. 30). No actual contact was observed. The probable contact is 9 miles east of the Robert Thomson ranch, where the Upper

[1] Harris: Bull. Am. Pal., No. 4, 1896, p. 28.

Cretaceous clays end and sandstones of the Carrizo Springs type are first initiated.

Along the Nueces River.—Here, again, there is indefiniteness, due to the similar lithologic character of the rocks and the dearth of fossils. A detailed section across the contact is given on p. 34 in the discussion of the Eagle Pass formation. The base of the Eocene is placed provisionally at the top of the *Ostrea cortex* ledge, because, (1) on the Frio River, 19 miles farther east, a ledge of these oysters is undoubtedly the summit of the Cretaceous; (2) a short distance below the exposure of this ledge on the river, and stratigraphically above it, a few plant remains were found which Professor Knowlton considers probably Eocene; (3) the strata above this oyster ledge on the Nueces are very similar to strata on the Frio River, known with certainty to be Eocene, or are lithologically identical with those strata. The proof that the writer has located exactly the Eocene-Cretaceous contact on the Nueces is not absolute, but the evidence in favor of the location is strong, and it is doubtful whether the contact will be determined with greater exactness, unless it subsequently becomes possible to make more extended use of the plant remains, which are few and imperfectly preserved.

Along the Frio River.—About 2 miles, in a straight line, below the Engelmann ranch and about a half mile above Myrick's lower apiary, a definite clear-cut contact is revealed. The section exposed is described in detail on p. 51. Evidence of erosion exists in the pebbles of the basal Eocene, but this evidence is not very strong, because of the general lithologic constitution of the rocks (shallow-water sandstones and clays), and because local erosion unconformities or pebble beds might exist almost anywhere. The faunal break is as sharp as a knife's edge. As the Eocene rests on a ledge of the Cretaceous *Ostrea cortex*, to be sure some Eocene fossils are mixed with the oysters along the basal contact, but no Eocene species was found below that ledge, and no Cretaceous species was found above the basal contact. These data prove absolutely that there must have been a break in the sequence of sedimentation long enough to permit a complete faunal revolution.

Although fragmentary, these data sustain the conclusion that there are in the Rio Grande region of Texas no transition beds between the Cretaceous and the Eocene. The respective faunas are absolutely distinct, with as complete a break between them as is known anywhere. The difficulty in differentiating Cretaceous and Eocene rocks lies in the similar lithologic constitution of the two series.

TERTIARY.

EOCENE.

Near India ranch, about 26 miles, in a straight line, below Eagle Pass, the lithologic character of the rocks changes to a coarsely crystalline sandstone of a yellowish or brownish color. The best exposures of this sandstone are seen near Moro ranch well, at Chupadero ranch, and 12¾ miles south of Uvalde on the road to Batesville. The grains are small quartz crystals, which are often cemented together by iron oxide.

RIO GRANDE SECTION.

In the arroyo immediately east of India ranch is a clay containing calcareous concretions. This clay lies below the sandstone to be next described.

From India ranch to San Ambrosia Creek the road to Laredo passes over numerous exposures of ripple-marked brown sandstone, which disintegrates rapidly and forms very poor roads. Between San Ambrosia and San Lorenzo creeks, as there is no covering of more recent deposits, loose sands, derived from the disintegration of the sandstone, constitute the surface. The best exposures of this sandstone are at Chupadero ranch. Here it contains numerous fantastically shaped concretions, and peculiar sandstone pillars are formed by erosion and weathering. When unweathered the sandstone is gray, but upon disintegration it forms coarse, loose, brown crystalline sands. Its thickness, so far as ascertained, is 150 feet. (See fig. 5, p. 53.) It is underlain by clays, and is a well-defined lithologic horizon, apparently what Owen designated the Carrizo sands.[1]

At Chupadero ranch a well sunk into this sandstone yields a permanent supply of water, which is, however, never more than a few feet in depth.

Between Chupadero Creek and San Ambrosia Creek flint gravel forms the capping of the divide.

West of San Ambrosia Creek, going down to the Rio Grande from the divide, dirty, dark-brownish or yellow clays are seen. These pass beneath the sandstone exposed around Chupadero ranch. The bluff on Rio Grande 1 mile above the mouth of San Ambrosia Creek is 40 to 50 feet high and is capped by sandstone; the base is of laminated sands and clay. Three and one-half miles above the mouth of this creek the banks of the river are composed of sandstone and thinly bedded lignitic sands. Specimens of *Venericardia planicosta* Lam. were found in a piece of sandstone from this locality, and a specimen of *Ostrea crenulimarginata* Gabb was picked up near by. These would indicate that the horizon of the beds here exposed is Midwayan Eocene.

[1] First Rept. of Progress of Texas Geol. Survey, 1889, pp. 70-73.

Four and one-half miles above the mouth of San Ambrosia Creek the following section was observed:

Section 4 1-2 miles above mouth of San Ambrosia Creek.

	Feet.
5. Fluvial silt, forming the top of the bluff.	
4. Ledges of soft, yellowish or whitish sandstone	7 to 8
3. Laminated sandy clays, streaks of sand and streaks of clay. The colors are brown, yellow, and purple; the last being caused by carbonaceous matter	3
2. Soft sand bed of a light, grayish-purple color, with darkish sulphur-yellow patches	3
1. Irregularly laminated soft sands, light grayish-green in color and containing much carbonaceous matter	4
Total	18

There is a considerable amount of soft, very pure sand rock along this part of the river. In No. 4 of the foregoing section the ledges sometimes change to thinly laminated sands along the face of a single exposure, as was observed in one instance.

No. 1 of the section is quite thick, changing toward the base into clays of purplish color, due to the presence of carbonaceous matter. These beds are identical, in external appearance, with the lignitiferous Claiborne beds of Louisiana. They are probably 100 feet thick.

It is at about the point where the foregoing section was made that the southern fence of the India ranch pasture is reached. This fence is, according to the statements of a colored cowboy, between three-fourths of a mile and a mile above the Webb-Maverick county line. Just beyond this fence, within the India ranch pasture, hematitic concretions containing *Venericardia alticostata* Conrad and a species of *Glycymeris* (*Pectunculus*) of the type of *G. staminea* (Conrad), were found in the clays. A little farther up the river was a large mass of sandstone resting on the clays and containing beautiful specimens of *Turritella mortoni*. The sandstone was so hard that no attempt was made to get the shells out.

From 1½ to 2 miles above the fence referred to the thinly bedded sands and clays are seen to be underlain by thinly bedded sands, passing downward into thin ledges of soft sandstone.

This has carried the Eocene to a point at least 2 to 3 miles above the Webb-Maverick county line. The horizon of the Eocene is Midwayan. The following five species of fossils were collected:

Turritella mortoni Conrad.
Ostrea crenulimarginata Gabb.
Glycymeris (Pectunculus) sp. indet.
Venericardia planicosta Lam.
Venericardia alticostata Conrad.

Harris has identified, from the Dumble-Penrose collection made 3 miles below the Webb-Maverick county line, fossils that are probably Midwayan, Lower Eocene,[1] but the writer has been unable to obtain a

[1] Dumble: Jour. of Geol., Vol. II, No. 6, 1894, p. 550; Harris: Bull. Am. Pal., Vol. I, 1896, p. 127 (No. 4, 13).

list of the species found there. Harris (op. cit., loc. cit.) says: * * * "we should note the peculiar fauna, Midway, in part, at least, found by Dr. White 18 miles southeast of Eagle Pass. It consists of *Cucullæa macrodonta* (perhaps *saffordi*), Pectunculus, Venericardia [pl. 5, fig. 3]. 'The shelly matter of these species is completely crystallized.' 'The matrix was evidently a calcareous light sand or sandstone.' Harris, Ann. Rept. Geol. Surv. Ark., 1892, Vol. II."

The actual Cretaceous-Eocene contact has not been located along the Rio Grande.

It has been reported that many fossil oysters occur on the high divide between the Chupadero and India ranches, west of San Ambrosia Creek. The writer was unable to make a search for the locality, and did not learn of anyone who had collected specimens from there. He is of the opinion that the section referred to is a bed of *Ostrea crenulimarginata* Gabb, as this species occurs at several places in the basal Eocene of Texas.

The following section[1] of Webb bluff, on the Rio Grande, 3 miles below the north line of Webb County and southeast of India ranch, is from Penrose:

Section of Webb bluff, on Rio Grande.

	Feet.
3. Fine, white, indurated, sandy clay, with dark streaks and specks of lignitic matter	30
2. Greensand marl, with many Tertiary fossils, nodules of carbonate of lime containing glauconitic specks	7–8
1. Stiff, plastic, bluish-black clay, jointed, containing specks of mica	10

Dip of strata, 3° SE.

Dumble subsequently published the same section[2] and stated that it is capped by gravel. Beds Nos. 2 and 3 are the same as the Webb bluff beds of the section by Dumble.

The coarse-grained sandstone seen around Chupadero ranch is overlain near there by a finer-grained laminated sandstone. At Guajolote ranch the coarse-grained sandstone has disappeared, and we have the following section:

Section at Guajolote ranch.

	Ft.	in.
6. Gravel capping (Pleistocene).		
5. Micaceous shale	10	0
4. Ledge of brownish-green micaceous sandstone	2	0
3. Laminated micaceous sandstone	8	0
2. Seam of ferruginous concretions	0	3
1. Massive yellow micaceous sandstone, thickness unknown.		

[1] First Ann. Rept. Geol. Survey of Texas, 1890, p, 41.

[2] Bull. Geol. Soc. America, Vol III, 1892, p. 228; also, Dumble's Report on brown coal and lignite of Texas, Geol. Survey of Texas, 1892, p. 137. In the latter report it is stated that the lowest stratum is Cretaceous.

On the hilltops to the southeast of the Guajolote ranch clays occur above the micaceous sandstones. Ten miles, by road, southeast of this ranch, the following section was observed:

Section 10 miles southeast of Guajolote ranch.

		Feet.
2.	Shaly sandstone, fine grained, laminated, ripple marked in the upper part, and containing obscure or poorly-preserved leaf impressions	20
1.	Thinly laminated sandy clay shale	15

From No. 2 several specimens of leaf impressions were obtained and submitted to Professor Knowlton for determination. He makes the following notes on them:

There is one fine leaf in this lot, but it unfortunately appears to be new. It is a fine, narrow, toothed Celastrus. There is also a small fragment of a palm leaf, but it lacks both apex and point of attachment, and is thus deprived of all characters. There are two or three other fragments of leaves and a large number of stems, possibly of monocotyledons.

The new species of Celastrus appears to resemble most closely a species (*C. rectinervis* Ward) from the Fort Union (Eocene) of Montana. The palm has some resemblance to a Denver species, but as it lacks the essential characters it is impossible to identify it.

One and an eighth mile from the foregoing locality the first outcrop of the Eocene lignite was seen. The rocks in the vicinity consist of micaceous sandstones and clay shales. The dip is about 1° south of east.

From the last-mentioned locality to Santo Tomas the lithologic characters of the rocks are about the same, i. e., they consist of interbedded micaceous sandstones, which vary much in hardness and in color. and of clays or clay shales.

About 8 miles before reaching Palafox poor remains of marine fossils were collected in a micaceous sandstone.

Section of butte 4 miles north of Palafox.

		Feet.
4.	Gravel capping (Uvalde formation).	
3.	Red or brown sandstone	45
2.	Flaggy sandstone	3
1.	Crumbling shales	27

Two and a half miles northeast of Palafox there is an exposure of lignite.

The following are records of two prospect drills kindly furnished by Mr. D. D. Davis, superintendent of the Cannel Coal Company, which has its mines near Santo Tomas.

Prospect drill No. 2, by Cannel Coal Company, northeast of Carbon, about 3 miles southeast of Santo Tomas.

Depth.				Material.	Thickness.	
Ft.	*in.*	*Ft.*	*in.*		*Ft.*	*in.*
0	0–	5	0	Gravel	5	0
5	0–	9	0	Clay and sandstone	4	0
9	0–	10	6	Brown shale	1	6
10	6–	19	0	Yellow sandstone	8	6
19	0–	21	0	Impure coal (Santo Tomas seam)	2	0
21	0–	44	0	Gray shale	23	0
44	0–	45	4	Brown shale	1	4
45	4–	46	0	Coal	0	8
46	0–	56	0	White sandstone	10	0
56	0–	63	0	Gray shale	7	0
63	0–	72	0	Sandstone	9	0
72	0–	75	0	Fire clay	3	0
75	0–	83	0	Sandstone	8	0
83	0–	90	0	Mixed shale and sandstone, marine mollusks	7	0
90	0–	91	0	Limestone (fossil shells)	1	0
91	0–	95	0	Slate	4	0
95	0–	109	6	Sandstone	14	6
109	6–	110	11	Slate	1	5
110	11–	112	10	Coal } San Pedro coal seam	1	11
112	10–	114	10	Clay shale } San Pedro coal seam	2	0
114	10–	116	5	Coal } San Pedro coal seam	1	7
116	5–	130	0	Sandstone	13	7
130	0–	135	0	Slate	5	0
135	0–	139	0	Sandstone	4	0
139	0–	141	0	Slate	2	0
141	0–	156	0	Sandstone	15	0
156	0–	160	0	Slate	4	0
160	0–	164	0	Sandstone	4	0
164	0–	167	0	Slate	3	0
167	0–	206	0	Sandstone	39	0
206	0–	209	0	Slate	3	0
209	0–	225	0	Sandstone	16	0
225	0–	227	0	Clay	2	0
227	0–	230	0	Slate	3	0
230	0–	240	0	Sandstone	10	0
240	0–	269	0	Shale	29	0
269	0–	271	0	Sandstone	2	0
271	0–	281	0	Shale	10	0
281	0–	320	0	Tough shale	39	0

Prospect drill No. 2, by Cannel Coal Company, northeast of Carbon, about 3 miles southeast of Santo Tomas—Continued.

Depth.				Material.	Thickness.	
Ft.	*in.*	*Ft.*	*in.*		*Ft.*	*in.*
320	0–	322	0	Sandstone	2	0
322	0–	328	0	Shale	6	0
328	0–	340	0	Sandstone	12	0
340	0–	356	0	Shale	16	0
356	0–	400	0	Sandstone	44	0
400	0–	404	0	Shale	4	0
404	0–	418	0	Sandstone	14	0
418	0–	424	0	Slate	6	0
424	0–	435	0	Sandstone	11	0
435	0–	446	0	Shale	11	0
446	0–	447	0	Limestone	1	0
447	0–	456	0	Shale	9	0
456	0–	461	0	Sandstone	5	0
461	0–	464	0	Shale	3	0
464	0–	476	0	Sandstone	12	0
476	0–	482	0	Shale	6	0
482	0–	485	0	Sandstone	3	0
485	0–	490	0	Shale	5	0
490	0–	500	0	Sandstone	10	0

Mr. Davis states that the lower sandstones were not very coarse nor were they crystalline. The elevation at the surface, where this drill was sunk, is about 530 feet.

Prospect drill No. 6, at Pilot ranch, 25 miles west of north from Santo Tomas, and 3 1-2 miles from the Rio Grande.

Depth.				Material.	Thickness.	
Ft.	*in.*	*Ft.*	*in.*		*Ft.*	*in.*
0	0–	10	0	Soil	10	0
10	0–	12	0	Gravel	2	0
12	0–	28	0	Yellow shale clay	16	0
28	0–	44	0	Blue shale clay	16	0
44	0–	46	0	Clayey sandstone	2	0
46	0–	68	0	Blue shale clay	22	0
68	0–	74	0	Blue shale clay	6	0
74	0–	74	8	Bony coal	0	8
74	8–	75	0	Brown shale clay	0	4
75	0–	80	0	Blue shale clay	5	0

Prospect drill No. 6, at Pilot ranch, 25 miles west of north from Santo Tomas, and 3 1-2 miles from the Rio Grande—Continued.

Depth.				Material.	Thickness.	
Ft.	*in.*	*Ft.*	*in.*		*Ft.*	*in.*
80	0–	84	0	Brown shale clay	4	0
84	0–	84	10	Coal	0	10
84	10–	85	2	Brown sandstone	0	4
85	2–	90	0	White sandstone	4	10
90	0–	91	11	Coal	1	11
91	11–	92	3	Bone	0	4
92	3–	94	0	Light-brown shale	1	9
94	0–	107	0	Tough shale	13	0
107	0–	117	0	Shale clay	10	0
117	0–	117	6	Bone	0	6
117	6–	118	0	Bony clay	0	6
118	0–	119	0	Bone	1	0
119	0–	125	0	Shale clay	6	0
125	0–	131	0	Sandstone	6	0
131	0–	145	0	Tough shale	14	0
145	0–	149	0	Sandstone	4	0
149	0–	153	0	Clayey sandstone	4	0
153	0–	156	0	Clay	3	0
156	0–	168	0	Shale clay	12	0
168	0–	174	0	Clayey sandstone	6	0
174	0–	176	0	Shale clay	2	0
176	0–	184	0	Sandstone	8	0
184	0–	208	0	Tough shale	24	0
208	0–	208	6	Bony coal	0	6
208	6–	210	0	Clay	1	6
210	0–	215	0	Brown sandstone	5	0
215	0–	216	3	Bony coal	1	3
216	3–	220	0	Brown shale clay	3	9
220	0–	220	9	Brown clayey sandstone	0	9
220	9–	221	0	Coal	0	3
221	0–	227	2	Brown sandstone	6	2
227	2–	228	10	Coal	1	8
228	10–	229	0	Bone	0	2
229	0–	230	8	Striped brown sandstone	1	8
230	8–	232	0	Bony coal	1	4
232	0–	232	6	Bone	0	6
232	6–	236	6	Blue shale clay	4	0
236	6–	236	8	Bone	0	2
236	8–	237	5	Coal	0	9

Prospect drill No. 6, at Pilot ranch, 25 miles west of north from Santo Tomas, and 3 1-2 miles from the Rio Grande—Continued.

Depth.				Material.	Thickness.	
Ft.	*in.*	*Ft.*	*in.*		*Ft.*	*in.*
237	5	238	0	Bone	0	7
238	0	244	0	Sandstone	6	0
244	0	246	0	Brown shale	2	0
246	0	254	0	Brown sandstone	8	0
254	0	255	0	Blue shale clay	1	0
255	0	262	0	Sandstone	7	0
262	0	268	0	Blue shale clay	6	0

Section at the Santo Tomas coal mine (Rio Grande Coal and Irrigation Company).[1]

	Ft.	in.
7. Carbonaceous shale roof; shale soft and requires considerable timbering.		
6. Good coal	0	14
5. Bone	0	4
4. Good coal	0	14
3. Bone	0	6
2. Clay	7	0
1. Sandstone.		

(See fig. 6, p. 54.)

The Cannel Coal Company's mine is about 3 miles below Santo Tomas. Through the courtesy of Mr. D. D. Davis, the manager, the writer was enabled to make the following section:

Section at mine of Cannel Coal Company, 3 miles below Santo Tomas.

	Ft.	in.
8. Clay slate or sandstone	0	14
7. Carbonaceous shale	0	½
6. Good coal	2	0
5. Bone	0	15
4. Clay	2	0
3. Lower bench:		
c. Good coal	0	6
b. Bone	0	2
a. Good coal	0	11
2. Carbonaceous shale	0	3
1. Sandstone	14	0

In this mine there is a small fault, and along the plane of the faulting there is a small sandstone dike.

From prospect drill No. 2, between 83 and 90 feet, Mr. D. D. Davis had obtained and preserved some fossil mollusks, which he presented to the Survey. They were referred to Prof. G. D. Harris for determination. He says they belong to an undescribed fuana, and has not yet furnished any identifications.

[1] Mr. D. J. Roy, manager of this mine, rendered much assistance and showed us many courtesies while we were in Santo Tomas. It was through his kindness that we were enabled to examine the mine.

Dr. C. A. White has collected some fossils near Santo Tomas, but they have not been determined. These specimens, also those from the coal shaft, are poorly preserved.

The dip at Santo Tomas, according to information furnished by Mr. Davis and based upon mine workings, is 2° N. 40° E.

From the sandstone which immediately overlies the coal Mr. Davis had collected several fossil leaves, which he presented to us. Professor Knowlton has examined them, and finds a new species of Juglans, and another species which could not be determined.

From the clays just above the coal (locality No. 280) Mr. Stanton collected some leaves and a Unio. The leaves were too poor for identification. Professor Knowlton states that one looks like a Ficus; he is also of the opinion that the plants from Santo Tomas have a Laramie facies, but does not feel justified in expressing an opinion as to whether they are from the upper or the lower Laramie.

The following is a résumé of the section of the Eocene based on observations and the data accumulated:

Résumé of section of Eocene.

	Feet.
5. The coal beds and the clays and sandstone immediately overlying them were the highest beds seen. Between the two coal seams is a bed of fossils not yet determined	190
4. Below the coal beds is a series of alternations of clay, shales, and sandstones of a thickness of at least	400
3. A series of fine-grained micaceous sandstone	300
2. The coarsely crystalline Carrizo sandstone, with a thickness of at least	150
1. Bluish clays—ascertained by a well boring, below which are more sandstones and clays.	

The fossils reported by Penrose[1] from Webb bluff probably occur below the Carrizo sandstone.

It is evident that the coarse sandstone seen at and near Chupadero ranch has not been reached in the prospect drill at Carbon, near Santo Tomas. It is difficult to correlate the records of the drill at Pilot ranch with the Santo Tomas section. Lithologically the section resembles very much the coal-bearing portion of the Santo Tomas section. In the Pilot ranch drill hole the lower sandstone has not been reached.

The disturbance in the dip at Santo Tomas, together with the extreme similarity in lithologic character of the beds, introduces such complications that reliable estimates of the thickness of the beds and the determination of the number and relative position of the coal seams can not be made until the area has been studied in detail.

The following is taken from Penrose's description of the section along the Rio Grande from Webb bluff to Laredo.[2] The section of Webb bluff has already been given.

[1] First Ann. Rept. Geol. Survey of Texas, 1890, p. 41.

[2] First Ann. Rept. Geol. Survey of Texas, pp. 42 and 43; see also Dumble's Report on the brown coal and lignite of Texas: Geol. Surv. of Texas, 1892, pp. 137-139.

A quarter of a mile below (i. e., Webb bluff) is a bluff 50 feet high of indurated sandy clay, containing mica and ferruginous scales between the strata. Dip 1° south. One mile and a half below are seen similar deposits, but with no fossils, and containing numerous gray calcareous concretions, with veins of brown crystalline calcite. Two miles beyond this, on the Mexican side, is a bluff a quarter of a mile long and 75 feet high, of interlaminated gray sands and chocolate clays, with sulphur and gypsum in places, and occasional ferruginous spots. Hard gray clay-ironstones with leaf impressions are also found. The sand beds are from 1 to 5 feet thick, and the clay is in thin laminæ. Dip undulating from 1 to 5° southeast. The mica and black specks in the sand, the laminæ of chocolate clay, the presence of sulphur and gypsum crystals, all show a strong resemblance to the Tertiary of east Texas. From here to Hardin Ferry, and thence to the mouth of Cavezeras River, are seen similar strata, frequently causing rapids where they cross the Rio Grande. In one place the indurated bluffs encroach on the river until it narrows down to 30 yards. Here the waters have cut a deep channel and rush through at a great velocity. Frequently interbedded glassy ferruginous layers, 1 or 2 inches thick, are found in the sandstone. Three miles below "the Hardin" is a bluff 60 feet high composed of friable sandstones, the harder and softer layers blending into each other and occasionally showing ferruginous patches. Dip 1° south. For 19 miles below this point we pass over identically similar strata, frequently containing calcareous concretions 1 to 3 inches in diameter. These contain seams of crystalline calcite and are of a gray color, weathering brown or red in concentric layers.

Similar strata are seen from here to the San Tomas coal mines. These are situated on the Texas side of the river and at the mouth of San Tomas Creek, about 25 miles by river above Laredo.

For 3 miles below this are seen indurated greenish clays with leaf impressions, broken stems, and specks of lignite. Occasionally seams of chocolate clay and calcareous nodules are found. As usual, the bluffs are capped with pebbles or sand, and dip 2° southeast. Fifteen miles above Laredo is a bluff reaching a maximum height of 40 feet and about 1 mile long. It is composed of interbedded coarse sand, with calcareous nodules, and sandy clay with gypsum and sulphur. The sand grains are red, yellow, white, and gray, and the whole bluff has a greenish appearance, spotted in places by ferruginous matter. Many similar outcrops are seen for 7 miles below, and as the dip is often horizontal, or nearly so, the exposures show simply different parts of the same bed. Eight miles above Laredo is a bluff about 80 feet high and half a mile long, composed of semi-indurated buff sands, with an undulating dip. Similar exposures are seen down the river to Laredo, and in fact that town is built partly on the same beds, which are here succeeded by those of the next division of the Eocene.

This section appears to be quite different from that observed a few miles inland from the river. The very sharply defined Carrizo sandstone appears to be absent, at least its presence was not noted.

RECONNAISSANCE BETWEEN EAGLE PASS AND CARRIZO SPRINGS AND SOUTHWEST OF CARRIZO SPRINGS.

The change from the Upper Cretaceous clays to what is probably the basal Eocene has already been described on page 30.

About 15 miles from Carrizo Springs the sandstone is rather fine grained, of a brown ocher color, and the grains are distinctly crystalline.

Fourteen miles from Carrizo the surface of the ground is formed of deep red sands derived from the disintegration of a hard sandstone. At this locality a very few poorly preserved oysters were found firmly embedded in the sandstone. No specimens good enough for specific determination were obtained.

From here to Carrizo Springs deep, red sands extend the whole distance; the deepest sands are about 8 miles west of the town. There are occasionally more argillaceous beds. The rock whence the sands are derived is, before disintegration, a soft whitish or yellowish sandstone with occasional harder ledges. These are Owen's "Carrizo sands." They are the northward continuation of the sand seam around Chupadero ranch, and are the source whence the water of the artesian wells of the Carrizo Springs vicinity is obtained.

RECONNAISSANCE FROM CARRIZO SPRINGS TO SAN LORENZO CREEK.

From Carrizo Springs to the Richardson ranch, 6 miles east of south of the town, the deep sands are continuous. About opposite the house on the ranch the soil becomes firmer, apparently containing clay enough to make it compact. The tank in Ainsworth's pasture, on the southwest side of the Richardson ranch, has been excavated in clays. Gravel occurs on the summit of the hill near the tank. From this ranch to San Lorenzo Creek clays and compact sandstone are found along the draws, and gravel cappings usually occur on the hills.

NUECES RIVER SECTION.

On the east side of the river, above the coal shaft and just below the Pulliam ranch, at the northern line of Zavalla County, there is exposed a soft, friable sandstone, bluish when fresh, oxidizing yellow, very often possessing a shaly appearance and containing black specks. This sandstone resembles very closely the basal Eocene along the Frio River. A half mile below the Pulliam ranch it passes below the coal seam and possesses a thickness of some 40 feet.

Section through coal seam.

	Ft.	in.
5. Silt and gravel, fluvial	35	0
4. Laminated, brownish, shaly sandstone; contains many carbonaceous specks and a few fossil leaves	2	3
3. Laminated, blue carbonaceous clay	5	0
2. Laminated black clay	1	6
1. Coal, bony at top	2	4
Total	45	9
Eocene exposure	10	9

Professor Knowlton remarks that the leaves from No. 4 are probably Eocene.

Section down high point west side of Nueces River, just below coal shaft.

	Feet.
6. Soft, yellow, friable sandstone; not much soil, vegetation mostly guajillo, very little grass	20
5. Soft sandstone, oxidizing yellow, in ledges, but has a strong tendency to form irregular flags	6
4. Soft white sands, not consolidated, stratification irregular	4
3. Soft laminated sand, containing some clay, about	20
2. Ledge of moderately hard yellow sandstone	1½
1. Shaly sandstone to water's edge in river	8½
Total	60

No. 1 of this section is probably No. 4 of the preceding section.

Section down bluff above the Habey ranch, west side of Nueces River.

	Feet.
2. Coarse-grained, red, ferruginous sands; vegetation *Opuntia rafinesquei, O. leptocaulis*, guajillo, black chaparral, Leucophyllum, Lippia, Yucca (large species), etc	30
1. Soft, coarse-grained, grayish sandstone, oxidizing to deeper colors, in places showing seams of bluish clay	20
Total	50

Section of bluff below the Habey ranch, west side of Nueces River.

	Feet.
5. Soft yellow sandstone ledges with argillaceous partings, about	15
4. Soft yellowish sandstone, fine-grained, laminated, and argillaceous, with layers of coarse-grained sandstone at the top	10
3. Clay, dark colored at the base	6
2. Coarse-grained, laminated, grayish or yellowish sandstone (top of preceding section)	20
1. The same as No. 2 of the preceding section	20

Both 1 and 2 contain occasional streaks of carbonaceous clay.

Section of north end of bluff, east side of Nueces River, just above the McDaniel ranch.

	Feet.
Yellowish shales (contains several coal seams)	40
Laminated soft yellow sandstone	10
Grayish clay shales	10
Total	60

Section of south end of foregoing bluff.

	Feet.
3. Coarse-grained gray sandstone, in ledges, in places very ferruginous, and in other places containing sandy concretions	40
2. Laminated clays and sands, with purple or chocolate-colored streaks, caused by the presence of carbonaceous matter	20
1. Coarse sandstone to water's edge	10
Total	70

Below No. 1 are at least 75 feet of laminated sands and clays with streaks of purple and chocolate.

Section through coal seam.

	Ft.	in.
12. Flaggy clay and sandstone	25 or 30	0
11. Chocolate clays	6	0
10. Coal	1 or 2	0
9. Chocolate clays	3	0
8. Coal	2	0
7. Chocolate clays	6 or 7	0
6. Coarse sand	1	0
5. Chocolate clay and sand	3	0
4. Coal, weathered specimens firm but apparently not very pure; contains considerable sulphur		8
3. Bone		3
2. Chocolate clays	6	0
1. Clays	20	0
Total (about)	80	0

Section of north end of bluff just below the McDaniel ranch, west side of Nueces River

	Feet.
3. Gravel	60
2. Thinly laminated sandy clays and argillaceous sands, and a layer of ironstone; otherwise the beds are whitish	10
1. Soft whitish sands, some clay	10
Total	80

Section of lower (southern) end of foregoing bluff.

	Feet.
3. Gravel capping.	
2. Soft sands and clays, usually laminated, bluish white in color, with sometimes a chocolate tinge	30
1. Hard brownish-yellow or grayish sandstone	7 or 8
Total	38

The estimated total thickness exposed in the above-described sections is between 370 and 400 feet, giving a dip of about 100 feet to the mile to the southeast. Supposing this dip to be continuous to the southern boundary of the quadrangle, there would be a thickness of about 700 feet of Eocene sands and clays within the Uvalde quadrangle along the Nueces River.

There are very few exposures along the Nueces River from the southern margin of the Uvalde quadrangle, about 1 mile south of the "Old 7 D" (Bucklew ranch), to the crossing of the Carrizo Springs–Batesville road over the river. The road is for almost the whole distance on the wide silt flat adjoining the river.

At the S ranch the western bluff and bed of the river are formed of greenish clays, with occasional carbonaceous seams. These clays make an extremely sticky mud, as the writer learned from the sad experience of having the camp wagon bog in it.

Five miles above S 7 ranch and about 7 miles above the crossing of the Carrizo Springs–Batesville road over the river, in a washout leading down to the river, is an exposure of yellow gypseous clays about 20 feet in thickness. Two or 3 feet below the top of this exposure are nodules which upon chemical examination were found to contain small quantities of lime phosphate.

RECONNAISSANCE FROM UVALDE TO CARRIZO SPRINGS, AND FROM CARRIZO SPRINGS TO SANTO TOMAS.

Twelve and three-fourths miles south of Uvalde, on the road to Batesville, crystalline sands, which in all of their characters resemble the Carrizo sandstone, are exposed. Sands of this type mixed with gravel were seen about 7½ miles south of Uvalde, but no exposures of the sands themselves were observed. Around Loma Vista there are exposures of red, angular or crystalline sands. One and a half miles east of north of Loma Vista, in the sandstone hills around Pond's house, some poorly preserved Eocene fossils were found firmly embedded in the sandstone. One species is *Cornulina armigera* (Conrad). This species occurs above the Midwayan, and from it and the facies of some of the other fossils it would seem that the horizon of Loma Vista is Claibornian, the "Lower Claiborne" of Harris.

With the above exception, from Batesville to Loma Vista and from the later place to the crossing over the Nueces River on the way to Carrizo Springs, few or no undoubted exposures below the surficial gravel or creek and river terraces were seen.

At the crossing over the Nueces River there is an exposure, 25 or 30 feet in thickness, of laminated sands and clays, with a seam of poor lignite. Limonitic concretions are abundant.

At Carrizo Springs there are numerous flowing artesian wells, but no very accurate records of the borings were obtainable. The wells vary in depth from 60 to 330 feet. (Pl. IV, *B*.)

Mr. J. W. Campbell, of Carrizo Springs, furnished the following notes on a well that he had bored 3 miles north of the town.

Section of well 3 miles north of Carrizo Springs.

	Feet.
Sandstone	30 or 40
Hardpan and clay (about)	260
Very coarse white sand rock to bottom of the well	6 or 16

The well was not quite completed when the writer was at Carrizo Springs in 1898. It had been bored to a depth of 306 feet, and an abundant and excellent flow of water had been obtained in the coarse white sandstone at the bottom of the bore. Judge George C. Herman, of Batesville, subsequently stated that the boring extended to 380 feet.

Mr. G. G. Cavender furnishes the following record of a well bored on the S. Gobbett survey, eastern bank of the Nueces River, 15 miles from Carrizo Springs:

A. CRETACEOUS-EOCENE CONTACT ON THE FRIO RIVER, 2 MILES BELOW ENGELMANN'S RANCH, SOUTHERN UVALDE COUNTY.

The sandstone floor at the base of the bluff is Cretaceous; the middle and upper portions of the bluff are Eocene.

B. BASAL EOCENE; PORTION OF SAME BLUFF, BUT FARTHER DOWNSTREAM.

Section of well on S. Gobbett survey.

	Feet.
Soil	1
Yellow and red clay	5
Red sandstone, with occasional layers of hard rock	39
Clay (the local "soapstone")	20
Hard rock	28
Soft clay and thin layers of sandstone	16
Sandstone	20
Clay and sand mixed	20
Water-bearing sand	10 or 11
Total	147 or 148

The water rises to within 17 feet of the surface of the ground.

The sandstone around Carrizo Springs is reddish in color, rather coarse-grained, crystalline, and slightly micaceous.

Alternations of sandstone and clay outcrop along the road from Carrizo Springs to Encinal for about 11½ miles from the former village. Here they pass below clays containing calcareous and hematitic concretions. From this locality to Santo Tomas the exposures consist of alternations of sandstones and clays, which often contain calcareous concretions. The sandstones are usually soft and micaceous.

FRIO RIVER SECTION.

(Pl. III, *A* and *B;* Pl. IV, *A*.)

Section across Eocene-Cretaceous contact, 2 miles below the Engelmann ranch and about 5 miles due north of the southern boundary of Uvalde County.

	Ft.	in.
7. Rather soft yellow sandstone An interesting lithologic feature of this sandstone is the occurrence in it of large, oval, sandy nodules, which stand with their long axes vertical. They are from 1 foot to 1 foot 6 inches in length, and vary in diameter from 3 to 7 inches. Sometimes these nodules, when broken across, form sandstone disks. Some of them are more nearly globular.	22	6
6. Soft, yellow, sandy clay, with bluish streaks; some small pebbles in the lower part	2	6
5. Nodules of glauconitic sandstone, usually 6 inches thick; contain a considerable number of small pebbles. In the lower few inches of this layer considerable numbers of *Ostrea cortex* are found. It is in this layer that *Nautilus* n. sp. is found in so great abundance		6
4. Soft, yellow, very argillaceous sands, quite glauconitic. There is a ledge of *Ostrea cortex* just about the top of this layer. A Turritella, probably *T. trilira* Conrad, was also found in it. This bed is the uppermost Cretaceous.		
3. Harder, sandy claystone, whitish blue and yellow in color	1	4
2. Soft, yellow, sandy clay	8	8
1. Sandstone, originally bluish, oxidizes brown and contains fucoidal impressions. In its upper part this stratum becomes softer and more yellowish and is in rather thin ledges	11	9

There are about 25 feet of Eocene strata exposed in the bluff.

Above the oyster (*Ostrea cortex*) ledge are 25 feet of soft sandstone ledges. Farther along downstream, at a still higher horizon, are 30 feet of rather soft sandstone, very massive, and somewhat though not greatly consolidated. Above this sandstone are 6 to 8 feet of soft sandstone ledges. The top is some 40 to 50 feet below the bottom of the section opposite Myrick's lower apiary.

Section of bluff at the Myrick apiary.

	Ft.	in.
13. Cross-bedded and irregularly stratified sandstone or soft unconsolidated sands, white in color but containing streaks of both yellow and red ocher	20	0
12. Sandstone	1	0
11. Blue sandy clay	9	0
10. Thinly laminated sandy shale	1	0
9. Hard, fine-grained, gray sand ledge	1	0
8. Fine soft bluish sands	4½	0
7. Sandy seam	0	4
6. Soft sandy shale, originally blue, weathers yellow	5	0
5. Fine-grained, hard blue sandstone, fossiliferous	0	6
4. Blue sandy shale	1	0
3. Fine-grained bluish sandstone	1	0
2. Sandy shale layer	2	0
1. Soft, whitish or greenish, rather fine-grained sandstone (about)	2	0
Total (about)	48	0

A considerable collection of fossils was made from beds Nos. 4 and 5. The species are characteristic of the Midwayan Eocene.

About a half mile farther downstream an abundant and rich Midwayan Eocene fauna was found. The matrix was a yellow, somewhat argillaceous, and slightly glauconitic sandstone. The commonest species of fossils are:

Venericardia alticostata Conrad.
Cucullæa saffordi Gabb.
Turritella mortoni Conrad.
Turritella humerosa Conrad.

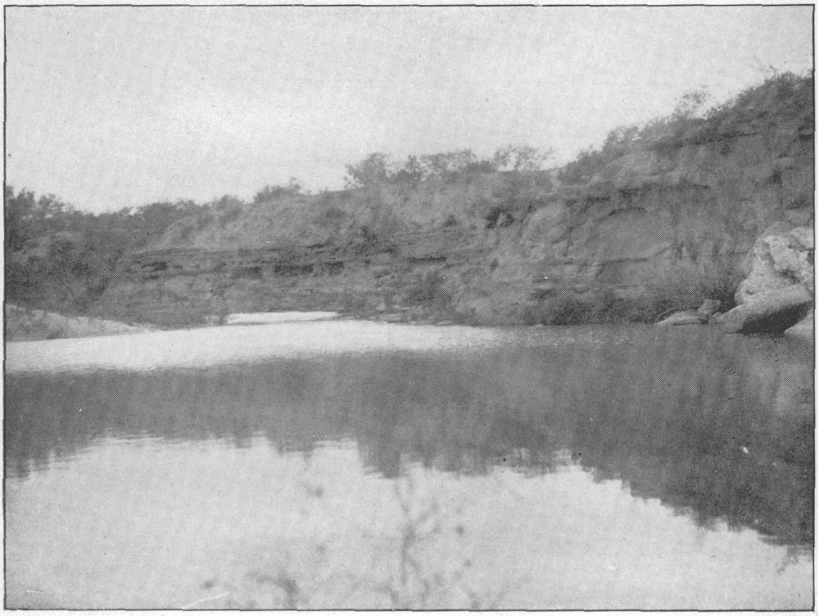
The dip of the rocks is steadily downstream 2° or 3°.

Section of bluff on the Frio River, about 1 mile below the Lewis ranch.

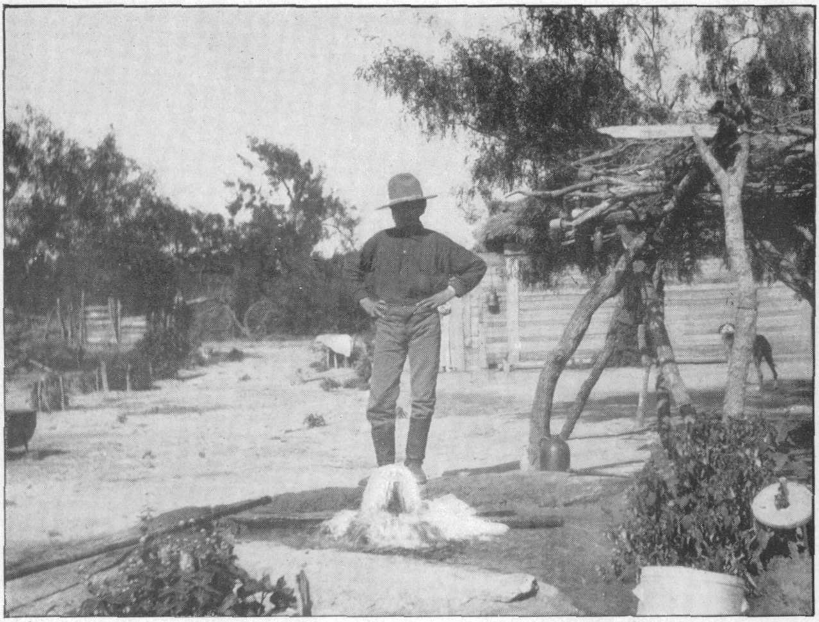
	Feet.
3. Fluvial silt of variable thickness, depending upon the amount of erosion of the rock floor.	
2. Soft white or grayish sandstone, oxidizing brown or yellow, in ledges or laminated; some of it is ripple-marked.	
1. Blue-black clay at base	60

Section of hill below Mexican ranch, on the Frio River below the Lewis ranch.

	Feet.
Capping of flint gravel.	
Coarse-grained gray sandstone, exposed beneath the flint gravel } Flaggy sandstone }	5
Soft shaly sandstone, about	10
Flaggy brown sandstone	5
Soft sandy shales	20
Total	40



A. LOWER EOCENE SANDSTONE, MYRICK'S APIARY, FRIO RIVER, SOUTHERN UVALDE COUNTY.



B. ARTESIAN WELL, DINMAN'S, NEAR CARRIZO SPRINGS.

Section of bluff next lower down on the west side of the Frio River.

	Feet.
6. Coarse-grained brown ferruginous sandstone	20
5. Soft white or yellowish sand	8
4. Clay seam, with thin streak of lignite	7
3. Soft white sands, sandy clay at base	20
2. Sandy shale	2
1. White sandy clay	3
Total	60

The total thickness of the Eocene in the Uvalde quadrangle is probably about 850 feet.

CONCLUSIONS REGARDING THE EOCENE.

From the foregoing discussion of the Eocene-Cretaceous contact, and from the sections of the Eocene, it has already been made evident

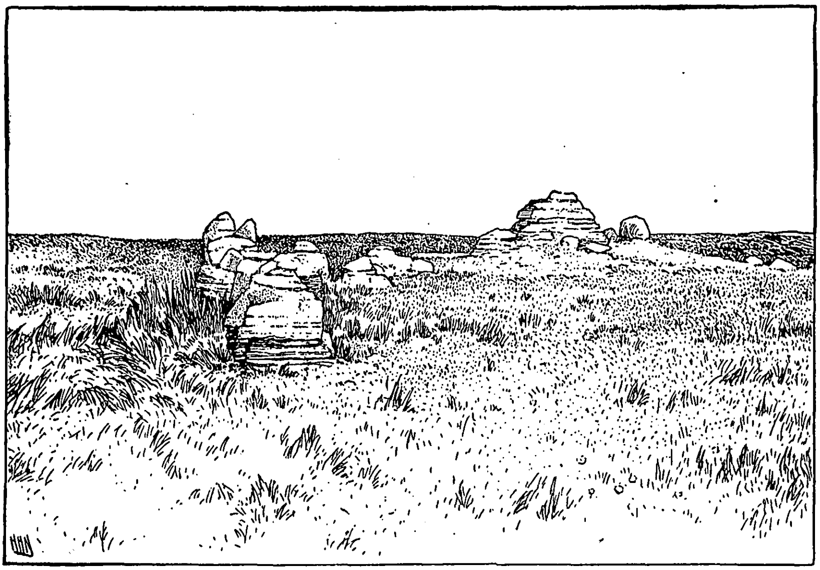


FIG. 5.—Weathering of the Carrizo sandstone at Chupadero ranch.

that there is not yet sufficient data to trace accurately the boundary between the Cretaceous and the Eocene. This boundary crosses the Rio Grande some miles, at least 4 or 5, above the north line of Webb County; it runs northeastward 1 or 2 miles northwest of India ranch, and passes some 16 miles west of Carrizo Springs. From here the boundary continues northeastward, and crosses the Nueces River about the north line of Zavalla County. It continues north of east to the Frio River, crossing that stream 2 miles below the Engelmann ranch, and 5 miles, in a straight line, north of the south line of Uvalde County. The last-mentioned point is the only absolutely determined contact. The others are supposed or inferred from the data at hand.

The whole Eocene strata are sandstones, varying in hardness, coarseness of grain, and amount of contained argillaceous material, and clays, varying in the amount of contained arenaceous material and often containing lignite beds. The actual base of the series in the positively known and inferred localities is sandstone. The immediately succeeding beds may be mostly sandstones, as along the Frio, or there may be much clay, as along the Rio Grande. The variations of the sections can be discovered only by very detailed mapping.

The coarse-grained Carrizo sandstone seems a fairly persistent member. It outcrops around the Chupadero ranch, between India ranch and San Lorenzo Creek, and extends northward on the west side of Carrizo Springs. A very similar sandstone outcrops in the hills around the Turk ranch, in the northwestern corner of Zavalla County,

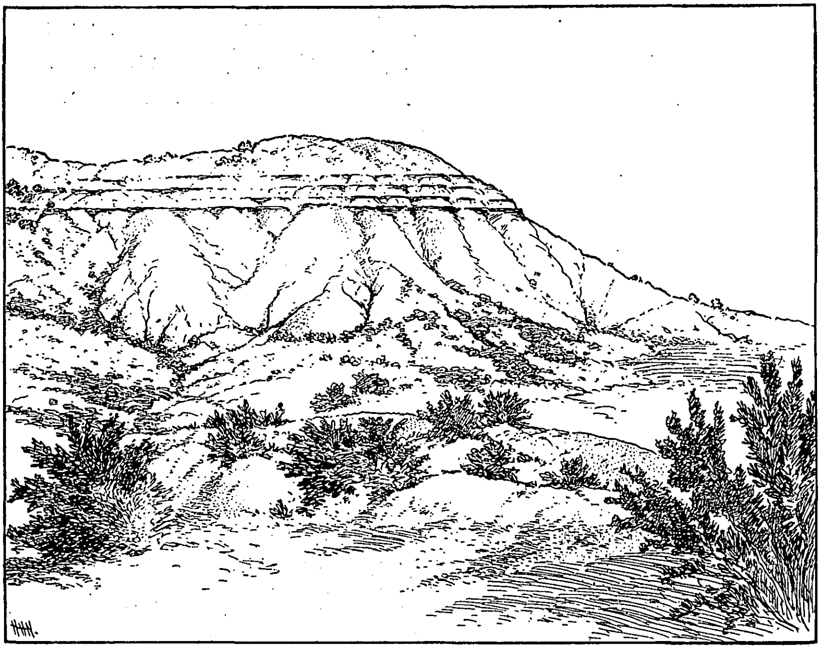


FIG. 6.—Sandstone and clays above coal horizon (Santo Tomas seam) at Santo Tomas.

and near the Habey ranch on the Nueces. It is seen 12½ miles south of Uvalde, between the Leona and Nueces rivers, along the road to Batesville, and apparently extends southward to Loma Vista. It also occurs on the divide in southern Uvalde County, between the Leona and Frio rivers.

Above this sandstone are alternations of finer-grained sandstones and clays, and it is in these sandstones and clays that most of the lignite beds occur.

NEOCENE AND PLEISTOCENE.

The formations of these ages have received so much attention in the paper entitled Geology of the Edwards Plateau and Rio Grande Plain, etc.,[1] that it does not appear necessary to say a great deal here.

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. II.

BLUFF ON RIO GRANDE AT EAGLE PASS, SHOWING THE UPPER PLAIN (UVALDE FORMATION LEVEL) AND THE WIDE SILT TERRACE (COLUMBIA FORMATION LEVEL).

NEOCENE.

In the area that is the subject of this paper the summits and high divides are the remnants of a plain the general features of which have been previously described. This plain was once entirely covered with a surface coating of gravel to which Hill has given the name "Uvalde formation." These deposits form the top of the bluff along the Rio Grande from Del Rio to beyond Santo Tomas, occupying a position 150 to 200 feet above the river and extending eastward far beyond the limits of the area discussed.

PLEISTOCENE.

Below the level of the Uvalde formation several terraces have been developed along the principal stream. The uppermost of this series of terraces usually occurs about 120 feet below the Uvalde formation,

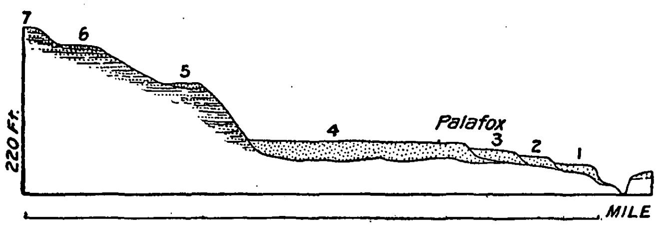


FIG. 7.—Section of bluffs and terraces at Palafox.

at the foot of the bluff forming the walls of the Rio Grande Valley. This terrace is generally several miles wide, and is composed of fine gray calcareous silt. Beneath it are several narrower silt terraces. Terraces occur on all of the other streams, but they will not be described here.

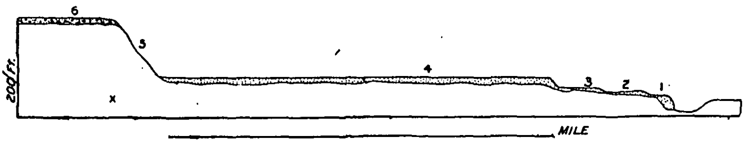


FIG. 8.—Generalized diagram of Rio Grande terraces.

ECONOMIC GEOLOGY.

EAGLE PASS COAL FIELD.

EXTENT.

As stated in the introduction, this coal field lies partly in Texas and partly in Mexico. It extends from Sabinas, Mexico, northeastward to Eagle Pass, crossing the Rio Grande some 5 or 6 miles above the latter town. It continues for more than 8 miles to the north of this town. In the vicinity of Eagle Pass the coal horizon dips at a rather steep angle, and soon plunges beneath the overlying sandstones and clays to a depth too great for profitable working. Concerning the extent of this field in the Santa Rosa district of Mexico, Hill says:[1]

This coal field (the Santa Rosa) is the foundation of the whole valley or plain, and, except where covered by remnants of the later volcanic and conglomerate terrace, it is everywhere exposed. Next to the Sierra Chiquita, or Hog Backs, the coal is

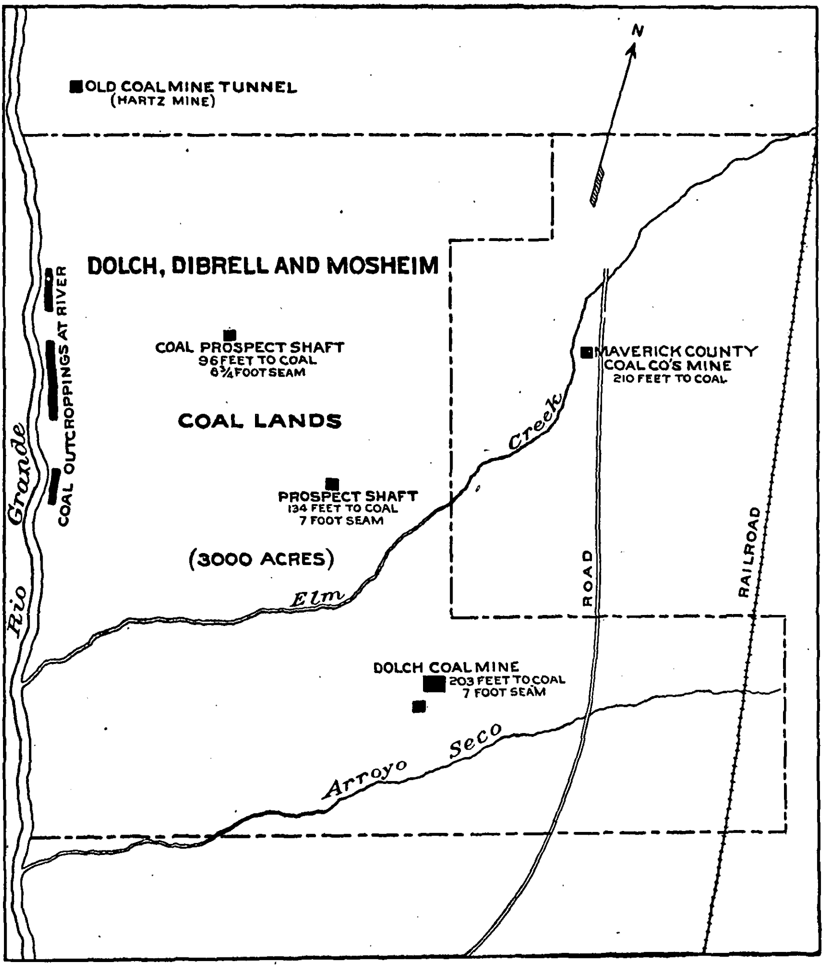


FIG. 9.—Sketch map showing coal mines and prospects near Eagle Pass; furnished by Louis Dolch.

turned up in vertical stratification and is worked within a quarter of a mile of the entries of several mines. The coal beds extend from the foot of the Santa Rosas northward over the entire valley of the Sabinas, and at San Felipe, some 28 miles northeast of the concession, the coals are extensively mined and the product shipped to Texas, New Mexico, and Mexico in enormous quantities. These coals are not to be compared with the imperfect fibrous lignites of eastern Texas or the impure Carboniferous coals of that State, but they are the true Rocky Mountain Cretaceous coals, of anthracite luster, and by far the best fuel in America except the true anthracites of Pennsylvania, ranking higher than the bituminous of the Appalachian region.

[1] Report to the Ministro de Fomento upon the geology of the Santa Rosa mining district.

Owen measured sections of the coal bed at three places in the Hartz coal mine, 5 miles northwest of Eagle Pass. At one place there were 4 feet and 6 inches of good coal, without any division of slate; at another place there were 5 feet and 4 inches of coal, with three divisions of slate aggregating 14 inches, leaving 4 feet and 11 inches of coal; at a third place the stratum was 7 feet and 3 inches thick, with five divisions of slate aggregating 14 inches. This gives a coal stratum with an average thickness of over 5 feet.[1]

The seam mined in the shaft of the Maverick County Coal Company is, according to Mr. George Bregg, the manager, 6 feet thick. He did not state whether there are any divisions of slate or bone. The coal is overlain by clay and underlain by sandstone. The seam in the Fuente mines (Mexico), opposite Eagle Pass, is 4 to 5 feet thick, and is both overlain and underlain by clay. Six feet of coal were passed through in boring the artesian well near Eagle Pass.

Mr. Louis Dolch, of Eagle Pass, furnished the accompanying sketch map (p. 56) showing the location of the prospect shafts sunk for coal.

The following are the detailed sections through the coal seams, given by Mr. Dolch:

Prospect shaft No. 1.

	Ft.	in.
Depth to coal	90	0
Coal	0	29
Slate	0	6
Coal	0	16
Slate	0	4
Coal	0	34
Slate	0	4
Coal	0	4
Total coal and slate	0	97

There are 83 inches of coal, with three divisions of slate.

Prospect shaft No. 2

	Ft.	in.
Depth to coal	134	0
Coal	0	32
Bone	0	13
Coal	0	8
Bone	0	2
Coal	0	24
Total coal and bone	0	79

A total of 64 inches of coal, with two divisions of bone.

[1] First Rept. of Progress of Texas Geol. Survey, 1889, p. 70.

Prospect shaft No. 3 (worked seam).

	Inches.
Coal	28
Bone	6
Coal	16
Reddish clay	3
Coal	10
White clay	2
Coal	18
Total	83

This gives a total thickness of 72 inches of coal, with three divisions of slate. Whether all of this coal is marketable is not known.

Mr. Peter W. Thomson furnishes the following information:

Prospect shaft sunk 6 1-2 miles north of Eagle Pass.

	Ft.	in.
Gravel, sandstone, etc	45	0
Coal	0	7
Slate	0	2
Coal	0	32
Slate	0	2
Coal	0	7
Slate	0	2
Coal	0	7
Slate	0	3
Coal	0	4
Fire clay	0	10
Coal	0	17
Slate	0	4
Coal	0	7
Total coal, slate, and clay	0	104

There are 81 inches of coal, with six divisions of slate or clay.

Prospect shaft sunk in Olmos Creek bottom, 7 miles north of Eagle Pass.

	Ft.	in.
Gravel, sandstone, etc	39	0
Coal	0	26
Slate	0	6
Coal	0	11
Fire clay	0	6
Coal	0	6
Fire clay	0	16
Coal	0	20
Total coal, slate, and clay	0	91

Giving a total of 63 inches of coal, with three divisions of slate and clay.

Prospect shaft 8 miles north of Eagle Pass, on the Southern Pacific Railroad.

	Ft.	in.
Soil, gravel, sandstone, etc	45	0
Coal	0	39
Slate	0	9
Coal	0	15
Slate	0	2
Coal	0	2
Slate	0	7
Coal	0	13
Slate	0	1
Coal	0	10
Total coal and slate	0	98

Here there are 79 inches of coal, with four divisions of slate. The aggregate thickness of the slate, including the valueless 2 inches of coal, is 21 inches.

The writer possesses no data on the chemical properties of the coal obtained in these prospects, and can give no information regarding its quality. It is very evident that the Eagle Pass coal extends farther to the north than any exploitations yet made. "At Thompson's ranch (Olmos siding) the same bed was struck at 150 feet, the level at the surface being a little lower at Breckenridge shaft upon the same property, and the dip balancing the gain. At McKenzie's, farther east, at a lower level topographically, the combined effect of dip and erosion has brought the surface within 20 feet of the coal."[1]

Besides making such observations as were possible, inquiries were made of ranchmen, county surveyors, and other persons who would likely know of the existence of coal beds. Mr. O. P. Hector, county surveyor of Maverick County, states that in a well on his place, 2½ miles below Eagle Pass, coal was struck at a depth of 65 feet, and that the seam is 6 or 7 feet thick.

Mr. Hector was asked whether he knew of any outcrops of coal along Salado, Chacon, Palo Blanco, or Mula creeks. He replied: "No outcroppings of coal along any of the above streams." The Eagle Pass coal extends some distance north of Eagle Pass, at least beyond the Thomson ranch, but because of dearth of exposures and a lack of any records, the actual distance could not be determined. It would seem worth while to prospect farther north. Mr. S. D. Frazier, of Carrizo Springs, in boring a well on the ranch of Simpson and Mangum, in Zavalla County, on Mula Creek 2 or 3 miles above where it empties into Palo Blanco Creek, struck coal at a depth of 120 feet; but the coal is worthless. This coal is probably in the Cretaceous area.

It is certain, however, that the Eagle Pass coal field does not extend to the Nueces River. All of the coal around Eagle Pass occurs below the *Ostrea cortex* horizons, while along the Nueces there is no coal

[1] T. B. Comstock: Second Rept. of Progress of Texas Geol. Survey, Austin, Tex., 1892, p. 53.

below the *Ostrea cortex* ledge. All of the coal (or lignite) along this stream occurs above the oyster ledge and in all probability is Eocene. This coal is discussed under the Eocene coals or lignites (pp. 61 and 62).

One other occurrence of coal is reported in the Eagle Pass formation. Mr. Robert Thomson states that a 4-foot seam of coal was penetrated in a well bored by him on the line between Maverick and Zavalla counties, about 4 miles north of the northern line of Dimmit County. The writer has no further information in regard to this occurrence.

MINES.

Two mines are at present being worked in the Eagle Pass coal bed, in the vicinity of Eagle Pass. One is that of the Maverick County Coal Company, situated on the east side of Elm Creek, 4 miles north of Eagle Pass. A section of this mine is given on page 25. It was opened in 1895. The other mine was opened by L. F. Dolch & Co. in 1898, and is about a mile south of the mine of the Maverick County Coal Company. The shipping of coal from the Dolch mine was begun in January, 1899. It is now owned by the Rio Bravo Coal Company. A section in this mine is given on page 24. The old Hartz mine, about 5 miles above Eagle Pass, on the Rio Grande, was worked on a slope, and is now abandoned.

CHARACTER OF COAL.

Specimens of the Eagle Pass coal were collected, and on them the following notes are based:

The coal is dark, does not air slack, is lustrous or brownish black in color, has a brown streak and subcubical cleavage. Usually no woody structure is apparent.

Two analyses, made by Dr. Peter Fireman, of Columbian University, showed a rather low percentage of water, a ratio of fixed carbon to volatile hydrocarbon of 1.11 and 1.05. The percentage of ash was high.

The following is one of the analyses:

Analysis of Eagle Pass coal.

Moisture	2.50
Volatile hydrocarbon	40.60
Fixed carbon	42.72
Ratio $\left.\frac{F.\ C.}{V.\ H.\ C.}\right\}$	1.05
Ash	14.18
Color of ash	Light brown.
Coke	Coherent, hard.

Penrose gives the following analysis of the Eagle Pass coal:[1]

Analysis of Eagle Pass coal.

	Per cent.
Water	3. 675
Volatile matter	39. 42
Fixed carbon	41. 7
Ash	15. 205
Sulphur	0. 81

The following data concerning some of the coal of the Santa Rosa region are extracted from a paper by Hill,[2] in which he states that, according to Professor Rock, the following is an analysis of that coal:

Analysis of coal from Santa Rosa region.

Moisture	5. 75
Coke	77. 147
Ash	3. 53
Specific gravity	1. 41
By computation this coal should have—	
Fixed carbon	73. 617
Volatile hydrocarbon (approximately)	17. 103
Ratio $\frac{\text{F. C.}}{\text{V. H. C.}}$	4. 3

In the ash, silica and iron predominate. No coal so good as the Mexican article has yet been discovered in Texas.

EOCENE COAL FIELDS.

EXTENT OF THE EOCENE COAL FIELDS, INCLUDING THE SANTO TOMAS FIELD.

The most northern exposure of lignite observed in this region is that in the east bank of the Nueces River at the north line of Zavalla County, about a half mile below the Pulliam ranch. When this locality was visited about 2 feet of coal were exposed. Owen makes the following note on this outcrop:

> Fourteen miles southwest of Uvalde, on the line between Uvalde and Zavalla counties, there is an outcrop of coal in the north bank of the Nueces River. At this place the stratum is 4 feet 10 inches thick, with a 3-inch division of slate in the center.[3]

[1] First Ann. Rept. Geol. Survey of Texas, 1890, p. 98.
[2] Report to Ministro de Fomento upon the geology of the Santa Rosa mining district.
[3] First Rept. of Progress of Texas Geol. Survey, 1889, p. 69.

Dumble states that "the coal has been used by blacksmiths at the fort [Fort Inge] and found to be of good quality."[1]

Going down the Nueces, the next outcrop of coal is in the east bank of the river, just above the McDaniel ranch. The following is a section through the coal seam:

Section through coal seam above the McDaniel ranch.

	Feet.	Inches.
Chocolate-colored clays.		
Coal, not clearly exposed	1 or 2	0
Chocolate-colored clay	3	0
Coal	1	10 or 11
Chocolate-colored clay	6 or 7	0
Coarse sand	0	11
Chocolate-colored clay and sand	3	4
Coal	0	8
Bone	0	3
Chocolate-colored clays	6	0

This exposure is in a weathered bluff, the bottom being about 20 feet above the water in the river, at the time of the inspection. As appliances for digging and obtaining good samples were not at the writer's disposal, no opinion regarding the value of the coal can be expressed.

Mr. M. C. Ott furnished Mr. Hill with the following data: "In a well 3 miles east of the Nueces River, in Uvalde County, on the road from Uvalde to Carrizo Springs, coal was struck in three places; one seam, at a depth of 150 feet, was 5 feet thick."

The writer can not locate this well on any map, and can give no further information concerning the coal than to suggest that it may be the same seam exposed just below the Pulliam ranch.

Coal is reported from the following other localities north of Carrizo Springs: There is, as already noted, an outcrop at the bridge, where the Carrizo Springs-Batesville road crosses the Nueces. There is coal at the mouth of Espantosa Slough, but nothing definite is known concerning it. Mr. S. D. Frazier informs the writer that he struck a 7-foot seam of coal at a depth of 80 feet, in a well bored for Mr. Coleman on Penya Creek.

Santo Tomas coal field.—Probably the foregoing outcrops of coal should be included in the Santo Tomas coal field, but in order to avoid attempts at correlations or suggestions as to equivalence in age, they have been discussed separately. The Santo Tomas coal series will, therefore, be assumed to begin 11 miles below the Guajolote ranch.

Eleven miles by road, southeast of the Guajolote ranch, is an outcrop of coal or lignite. The associated rocks are micaceous sandstones and clay shales. The record of prospect drill No. 6, bored by Mr.

[1] Brown Coal and Lignite, p. 188.

D. D. Davis at Pilot ranch, 25 miles west of north from Santo Tomas, and 3½ miles from Rio Grande, is given on pages 42 to 44. There is another outcrop of coal 2½ miles north of Palafox.

At Santo Tomas there are two mines, that of the Rio Grande Coal and Irrigation Company, which is in the village, and that of the Cannel Coal Company, which is 3 miles southeast of it. The record of the prospect drill bored at the latter mine has been given on pages 41 to 42. In the Cannel Coal Company's mine there are two seams, the upper one being called the Santo Tomas seam (Rio Grande Coal and Irrigation Company), and the lower one, known as the San Pedro seam, being worked by the Cannel Coal Company.

Section of the Santo Tomas seam.

	Ft.	in.
7. Carbonaceous shale roof, soft, requires considerable timbering.		
6. Coal	0	14
5. Bone	0	4
4. Coal	0	14
3. Bone	0	6
2. Fire clay	7	0
1. Sandstone.		

Section of the San Pedro seam.

	Ft.	in.
8. Clay slate or sandstone	0	14
7. Carbonaceous shale	0	½
6. Coal, upper bench	2	0
5. Bone	0	15
4. Clay	2	0
3. Lower bench:		
c. Good coal	0	6
b. Bone	0	2
a. Good coal	0	11
2. Carbonaceous shale	0	3
1. Sandstone	14	0

The following is extracted from Dumble's Brown Coal and Lignite, page 189.

The most northern exposure of this coal observed in Webb County was about 25 miles northwest of Santo Tomas, where a seam of pitch coal was found which was black, massive, dense, and so firm that it does not give a greasy streak with finger nail. No trace of wood structure, subconchoidal fracture.

About 8 miles west of Santo Tomas, at Espada Creek, we find three seams of brown coal.

The upper seam is 12 inches thick, and is a massive pitch coal with conchoidal fracture, very similar to the body of the Santo Tomas coal. It is underlaid by 4 feet of shale, and this by the Santo Tomas seam of coal, which is here 34 inches thick with a 2-inch division of slate. This coal is underlaid by 30 feet of shale, below which is a third seam of brown coal, varying in color from light to dark brown, with many traces of woody structure, impressions of leaves, etc.

MINES.

There are only two mines in the Santo Tomas coal field. They have been mentioned already, and are the Santo Tomas (Rio Grande Coal and Irrigation Company) mine at Santo Tomas, and the mine of the Cannel Coal Company, 3 miles southeast of Santo Tomas. The coal in the Santo Tomas is mined on a slope (tunnel). Work was begun at 31 feet above the level of the Rio Grande, and has been prosecuted through 2,400 feet, to the level of the river. The dip is 2° N., 40° E. The mine has been in operation about fourteen years (1895). The output is from 90 to 100 tons daily, and most of it is sold to the International and Great Northern Railroad.

The Cannel Coal Company take their coal from a shaft. At the time of the writer's visit to the mine (1895) the shaft had been completed, entries driven, and everything was ready for actual mining to begin, but up to that time no coal had been shipped.

CHARACTER OF COAL.

The coal of the Santo Tomas field is hard, lustrous black, with a brown streak and a conchoidal fracture. No woody structure was apparent.

The following analyses were made for the writer by Dr. Peter Fireman:

Analysis of coal from mine of Rio Grande Coal and Irrigation Company.

	Upper bench.	Lower bench.
Moisture	2.26	2.63
Vol. hydrocarbon	48.64	45.67
Fixed carbon	36.15	39.96
Ratio $\frac{\text{F. C.}}{\text{V. H. C.}}$	.74	.87
Ash	12.95	11.74
Color of ash	Yellowish brown.	Brown.
Coke	Coherent, lustrous.	Coherent.

Analysis of coal from mine of Cannel Coal Company.

	Upper bench.	Upper part of lower bench.	Lower part of lower bench.
Moisture	2.70	2.01	2.33
Vol. hydrocarbon	49.99	48.33	49.35
Fixed carbon	37.55	33.15	38.08
Ratio $\frac{\text{F. C.}}{\text{V. H. C.}}$	.75	.68	.77
Ash	9.76	16.51	10.24
Color of ash	Yellowish gray.	Light brown.	Light brown.
Coke	Coherent, hard, partly lustrous.	Partly sooty.	Coherent.

Dumble[1] gives the two following analyses of coals from the Santo Tomas coal field (specimens collected by J. Owen):

Analysis of pitch coal from outcrop 25 miles northwest of Santo Tomas, thoroughly air dried.

	Per cent.
Moisture	2.35
Volatile matter	42.67
Fixed carbon	37.57
Ash	16.55
Sulphur	.86

Analysis of coal from Santo Tomas coal mine.

	Per cent.
Moisture	2.59
Volatile matter	51.05
Fixed carbon	39.01
Ash	7.35
Total	100.00
Sulphur	1.50

[1] Brown Coal and Lignite, p. 190.

Penrose says:[1] "The San Tomas coal is so vastly superior to any of the east Texas lignites that it can not fairly be classed with them." He gives the following analyses of the east Texas lignites and of the Laredo and Eagle Pass coals. They are presented here for purposes of comparison.

Analyses of Texas lignites.

	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Rockdale, Milam County	19.925	52.425	22.000	5.650	1.235
Atascosa County	13.285	59.865	18.525	8.325	2.360
Athens, Henderson County	9.100	42.200	7.375	41.325	0.625
Rusk County	16.825	46.325	31.475	5.375	1.090
Calvert bluff, Robertson County	16.475	58.400	18.675	6.450	1.330
Shelby County	18.260	43.510	29.530	8.700	2.460
Leon County	14.670	37.320	41.070	6.690	0.250
Rockdale, Milam County	13.800	43.550	36.830	5.320	1.350

Analyses of Laredo and Eagle Pass coals.

	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Laredo coal	2.5	51.05	39.1	7.35	1.5
Eagle Pass coal	3.675	39.42	41.7	15.205	0.81

CONCLUSIONS REGARDING THE RIO GRANDE EOCENE COALS.

These coal (or more properly lignite) fields are simply the westward continuation of the great lignitiferous Eocene belt of eastern Texas and the Gulf States as far east as Alabama. The coal beds of the Rio Grande region range in position from Midwayan to Chickasawan. The beds on the Neuces, in northern Zavalla County, are Midwayan, while those around Carrizo Springs and Santo Tomas are Chickasawan.

Although the Eocene contains many lignite beds, most of them are not of economic value for various reasons. They are often thin and impure, and, because of a large content of moisture or because of an unconsolidated mechanical condition, must undergo mechanical treatment by being pressed into briquettes. These questions are discussed by Dumble in Brown Coal and Lignite.[2]

The only place where these Eocene coals are being worked is in the vicinity of Santo Tomas. The coal there is sufficiently hard to need no treatment. In such an investigation as this it is not possible to make

[1] First Ann. Rept. Geol. Survey of Texas, 1890, p. 97.
[2] Geol. Survey of Texas, 1892.

special examination of particular localities. All that can be done is to indicate places and give such data as may be collected under the conditions of the work, as a guide for future detailed examinations.

LITERATURE.

The following annotated bibliography may be of assistance to those interested in the history of geologic investigation in this region:

1857. SCHOTT (Arthur). Substance of the sketch of the geology of the Lower Rio Bravo del Norte: Reports of the Mexican Boundary Survey, Vol. I, Pt. II, pp. 28–48.

This article is a preliminary reconnaissance and contains no detailed stratigraphic work. Schott's observations, taken in connection with the determination of the fossils by Conrad, showed the existence of large areas of Cretaceous rocks in the region covered by his reconnaissance, i. e., from the mouth of the Pecos River to a point between Eagle Pass and Laredo. After personally studying the region, some of the beds in Schott's description will be recognized as those which have since been specifically named. Between the Pecos and Del Rio Schott observed the peculiar buttes formed from the *Exogyra arietina* (Del Rio) clays. He made observations on the coal-bearing beds in the vicinity of Eagle Pass, and noted outcrops of coal near Palafox.

1882. ADAMS (W. H.). Coals in Mexico, Santa Rosa district: Am. Inst. Mining Engineers, Vol. X, pp. 270–273.

The paper of Mr. Adams is one of the first and best descriptions of the Lower Rio Grande coal fields as a whole, although he made erroneous deductions concerning their exact age. From lithological characters he referred the Santa Rosa coal to the Trias, and for similar reasons he referred the Eagle Pass coal to the Permian.

1884. LOUGHRIDGE (R. H.). Report on the cotton production ot the State of Texas: Tenth Census of the United States, Vol. V.

This publication contains several notes on the general geology of the region of the Rio Grande Plain.

1884. COPE (E. D.). A note on the geology of the vicinity of Laredo: Proc. Am. Philos. Soc., Vol. XXI, p. 615.

Cope considered the lignite-bearing beds (the Santo Tomas coals) above Laredo as Laramie, and stated that they are immediately overlain by the Claiborne.

1885. MCGEE (W J). Geological map of the United States: Fifth Ann. Rept. U. S. Geol. Survey.

McGee represents the northern boundary of the Eocene as reaching almost to the twenty-ninth parallel on the Rio Grande, and the southern boundary as crossing that river south of the twenty-eighth parallel and a little east of the ninety-ninth meridian.

1886. HITCHCOCK (C. H.). Geological map of the United States: Trans. Am. Inst. Mining Engineers, Vol. XV.

Hitchcock's map is based on McGee's.

1887.. White (C. A.). On the age of the coal found in the region traversed by the Rio Grande: Am. Jour. Sci., 3d series, Vol. XXXIII, January, 1887, p. 18.

After examining the coal in the vicinities of Eagle Pass and Santo Tomas, and after studying collections of fossils, White concluded that the coal beds were of late Cretaceous age, i. e., Laramie or Fox Hills.

1887. Hill (R. T.). Topography and geology of the cross timbers and surrounding regions in northern Texas: Am. Jour. Sci., Vol. XXXIII, pp. 291–303.

A preliminary map of The Salient Topographic Features of the State of Texas accompanies this article.

1887. Hill (R. T.). The Texas section of the American Cretaceous: Am. Jour. Sci., Vol. XXXIV, pp. 287–309.

On page 290 a map is given which represents, according to then existing knowledge, the areal distribution of the various geologic formations in Texas east of the one hundredth meridian. The Balcones fault is described, and its influence on the topography stated. On page 294 it is stated that the Navarro beds of Texas and the Fox Hills beds of the Northwest meet in the Rio Grande region. On page 302 Hill states that he has good authority for asserting the occurrence of strata of the Washita division "westward to the Rio Grande, beyond Eagle Pass."

1888. White (C. A.). On the relations of the Laramie group to the earlier and later formations: Am. Jour. Sci., Vol. XXXV, pp. 432–438.

This article contains a brief account of a journey from Eagle Pass to Laredo. According to White, the coal-bearing beds at Eagle Pass represent the Fox Hills group of the western section and the Ripley group of the eastern section. The beds containing the Eagle Pass coal pass below the beds containing the Santo Tomas coal. The latter beds are considered of undoubted Laramie age. This so-called Laramie is immediately overlain, in the vicinity of Laredo, by beds containing Claiborne fossils. The upper part of the Laramie is considered of Eocene age.

1888. Hill (R. T.). The Neozoic geology of southwestern Arkansas: Ann. Rept. Geol. Survey of Arkansas, 1888.

On page 101 Hill mentions that the "Rocky Comfort" (Austin) chalk extends from Arkansas to Maverick County, Texas. On the same page it is stated that evidence is found that the Gulf and interior provinces of the Cretaceous unite in the region of Eagle Pass. It is also stated (p. 47) that the Rio Grande is an example of "an old Quaternary valley, filled with sediments cut through by the more recent streams."

1889. Owen (J.). Report in First Report of Progress of the Texas Geological Survey, pp. 69–74.

Although Owen did not apply names to the different beds which he examined, he has given so clear descriptions of them that every bed from the Edwards limestone to the Eocene can be identified. He recognized the relative stratigraphic positions of the Eagle Pass and the

Santo Tomas coal beds, and noted the existence of the sands (Carrizo) which come above the Eagle Pass beds and carry the water supplying the artesian wells at Carrizo Springs.

1889. HILL (R. T.). A preliminary annotated check list of the Cretaceous invertebrate fossils of Texas: Bull. No. 4, Geol. Survey of Texas, Austin, 1889, pp. xii–xxxi, 1–57.

Contains some notes applicable to the Rio Grande region and gives localities for some of the fossils.

1890. PENROSE (R. A. F.). A preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande: First Ann. Rept. Geol. Survey of Texas, pp. 3–101.

On pages 38 to 47 a description is given of a section along the Rio Grande from Eagle Pass to the mouth of the river. The three points of special interest in this paper are:

(1) The description of the plain character of the country.

(2) The ammonites hitherto found at Eagle Pass are shown to occur along the river to near the Webb County line.

(3) The section (page 41) of Webb bluff 3 miles below the north line of Webb County. Here Eocene mollusks were found.

On page 60, in discussing the upland gravel, Penrose states that the gravel along the Rio Grande is frequently cemented, by a calcareous matrix, into a conglomerate. The pebbles of the gravel, or conglomerate, are of "limestone, flint, quartz, chalcedony, agate, black obsidian, red pitchstone, jasper, and porphyry."

On page 62 is a description of the Rio Grande silt. On page 63 the name *Reynosa limestone* is proposed for a hard, white, post-Tertiary rock occurring in the town of Reynosa, 250 miles below Eagle Pass, State of Tamaulipas, Mexico, at an elevation some 50 feet above the Rio Grande.

1890. HILL (R. T.). Classification and origin of the chief geographic features of the Texas region: Am. Geologist, Vol. V, Nos. 1 and 2.

In No. 1 there is an Approximate Map of the Topography and Geology of the Texas Region.

1891. HILL (R. T.). The Comanche series of the Texas-Arkansas region: Bull. Geol. Soc. America, Vol. II, May, 1891, pp. 503–528.

In this paper several allusions are made to the geology of the vicinity of Del Rio. On page 517 the presence of the Fort Worth limestone and the *Exogyra arietina* clays is announced, and on page 519 the occurrence there of an Equisetum and a Nodosaria is made known.

1891. HILL (R. T.). Notes to the geology of the Southwest: Am. Geologist, Vol. VII, pp. 366–370.

On page 366 Hill states that *Nodosaria texana* Conrad, a fossil of the Denison beds, and their southern continuation, the *Exogyra arietina* clays, forms great masses of limestone at Del Rio. On pages 367 and 368 the Tertiary basin of the Lower Rio Grande is described, and the name *Uvalde formation* is proposed for the extensive upland gravel sheet blanketing that region.

1891. HILL (R. T.). Preliminary notes on the topography and geology of northern Mexico and southwest Texas and New Mexico: Am. Geologist, Vol. VIII.

On page 135 "the westward embayment of the Rio Grande from the coast" is described.

1891. WHITE (C. A.). Correlation papers—Cretaceous: Bull. U. S. Geol. Survey No. 82.

On pages 116 and 117 reference is made to the region between Eagle Pass and Laredo. The same opinion that was expressed in the American Journal of Science, Vol. XXV, concerning the presence of Laramie along the Rio Grande below Eagle Pass is reiterated here. Laramie is stated to occur in the valley of the Nueces also. The name *Eagle Pass beds* is used for the beds containing the coal at Eagle Pass.

1891. HILL (R. T.). Notes on the Texas-New Mexican region: Bull. Geol. Soc. America, Vol. III (proceedings of the Washington meeting), pp. 85–100.

Pages 93 to 95 contain a description of the Rio Grande embayment.

1892. DUMBLE (E. T.). Notes on the geology of the valley of the Middle Rio Grande: Bull. Geol. Soc. America, Vol. III, April, 1892, pp. 219–230.

Dumble describes and discusses the section from Del Rio, Valverde County, to Webb bluff, in the northern part of Webb County, and correlates the Rio Grande and the Colorado River section.

1892. HILL (R. T.). On the occurrence of artesian and other underground waters in Texas, New Mexico, Indian Territory, etc.: Final Reports of the Artesian and Underflow Investigations of the U. S. Department of Agriculture.

Accompanying this report is a map showing the general geologic and topographic features of the State. In the text there is a description of the topography of the region. The southern extension of the Edwards Plateau and its termination by the Balcones fault escarpment, which runs east and west, a little north of a line joining San Antonio and Del Rio, is also described. At the foot of this escarpment is the vast level plain which Hill designated the "Rio Grande embayment." Hill states that this plain is covered to a very great extent by surface gravel. The following pages contain statements concerning the Middle Rio Grande region: 58, 63, 65, 66, 67, 68, 74, 76, 88, 91, 92, 119, and 123 to 125.

1892. DUMBLE (E. T.). Report on the brown coal and lignite of Texas: Geol. Survey of Texas.

On the map accompanying this report several outcrops of coal in the Rio Grande region are indicated. Pages 137 to 139 contain a description of the section of the Eocene from a point on the Rio Grande 3 miles below the northern boundary of Webb County to Laredo.

1892. McGEE (W J). The Lafayette formation: Twelfth Ann. Rept. U. S. Geol. Survey.

Reference is several times made in the text to the Rio Grande region. Pl. XXXVIII shows the areal distribution of the Lafayette and Columbian formations of southeastern United States, and represents the upland gravel of the Rio Grande region as Lafayette.

1892. DUMBLE (E. T.). See Second Rept. of Progress Texas Geol. Survey, pp. 7-19.

Contains some general notes.

1892. COMSTOCK (Theo. B.). See Second Rept. of Progress Texas Geol. Survey, pp. 43-54.

Contains notes on the region.

1892. TAFF (J. A.). See Second Rept. of Progress Texas Geol. Survey, pp. 70-77.

1893. HILL (R. T.). The Cretaceous formations of Mexico and their relations to North American geographic development: Am. Jour. Sci., 3d series, Vol. XLV.

"Opposite Del Rio, Texas, the *Exogyra arietina* zone of the Denison beds of the Washita division extends far into Mexico." Pages 320 to 323 give a discussion of the relations existing between the Upper Cretaceous and the Eocene deposits in the Texas-Mexico region from Eagle Pass to Laredo, and the areal distribution of the formations. On page 321 is the following statement: "The Montana-Laramie Eocene portion of the formation occupies the vast synclinal basin of the Rio Grande, east of the great bend, which I have termed the Rio Grande embayment, outcropping beneath the detrital deposits of late Tertiary and Pleistocene age."

Two maps accompany this paper. The first, fig. 2, gives the distribution of known Cretaceous outcrops in Mexico and adjoining portions of Texas. The second is a "Geologic outline of northern Mexico, showing relations of Atlantic Coastal Plain, Cordilleran and Great Plains region." The topography of this map is modified from the map of the Mexican International Railway. It shows the vast distribution of the Tertiary gravel.

1894. HILL (R. T.). Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River: Bull. Geol. Soc. America, Vol. V, March, 1894, pp. 297-338.

On Plate XII a columnar section of the Cretaceous at Del Rio is given. The presence of Caprina limestone, Fort Worth limestone, and *Exogyra arietina* clays is represented.

1894. HARRIS (G. D.). Tertiary geology of southern Arkansas; Ann. Rept. Geol. Survey Arkansas, 1892, Vol. II.

Page 34 contains notes on Eocene fossils along the Rio Grande.

1894. DUMBLE (E. T.). The Cenozoic deposits of Texas: Jour. of Geology, Vol. II, pp. 549-567.

On page 550 the occurrence of Midwayan Eocene fossils on the Rio Grande, near the Webb-Maverick county line, is mentioned. Pages 560 to 562 are devoted to a description of the Reynosa division, which

Dumble correlates with the upland gravel deposit of the Rio Grande embayment, previously mentioned by Hill and Penrose.

1895. DUMBLE (E. T.). Cretaceous of western Texas and Coahuila, Mexico: Bull. Geol. Soc. America, Vol. VI, April, 1895, pp. 375–388.

Pages 383 and 384 contain references to the geology of the region of the Rio Grande Plain.

1895. DUMBLE (E. T.). The soils of Texas; a preliminary statement and classification: Texas Acad. Sci., pp. 25–60.

Several allusions are made to the geology of the Rio Grande region, and data on the soils is given.

1896. HARRIS (G. D.). The Midway stage: Bulletins American Paleontology, Vol. I, No. 4.

Pages 13 and 14 contain a discussion of the basal Eocene along the Rio Grande.

1897. HARRIS (G. D.). The Lignitic stage; Part I, stratigraphy and pelecypoda: Bulletins American Paleontology, Vol. II, No. 9, pp. 198, 199 (6, 7).

In this paper Harris discusses the probable occurrence of the Lignitic Eocene (Chickasawan) along the Rio Grande.

1897. VAUGHAN (T. Wayland). The asphalt deposits of western Texas: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. V (continued); Mineral Resources of the United States, 1896, Nonmetallic products, except coal, pp. 930–935.

This paper describes the occurrence of asphalt in the Brackett quadrangle and along the Nueces River in southern Uvalde County (Uvalde quadrangle).

1898. HILL (R. T.) and VAUGHAN (T. Wayland). Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 199–321.

Contains numerous references to the geology of the Rio Grande region below Del Rio.

II. THE SAN CARLOS COAL FIELD OF TRANS-PECOS TEXAS AND ADJACENT PORTIONS OF THE VIEJA MOUNTAINS.

INTRODUCTORY NOTE.

In August, 1895, the writer was requested by Mr. Robert T. Hill, geologist in charge of the Texas division of the United States Geological Survey, to go to the newly opened coal mines in the vicinity of San Carlos, Presidio County, Texas, in order to ascertain the geologic position of the coal, and if possible obtain samples of it for the Atlanta Exposition. Mr. T. W. Stanton accompanied the writer, for the purpose of studying the paleontology, and to a large extent the field work was carried on jointly. Mr. Stanton furnished the determinations of the fossils collected and his conclusions regarding the horizons to which they belong. Dr. E. C. E. Lord kindly made a careful study of all the lithologic material collected, and the results of his investigations are given in his report on the igneous rocks from the vicinity of San Carlos and Chispa, Texas, which is a part of this bulletin (pp. 88 to 95).

While at San Carlos numerous courtesies were received from the following officers of the San Carlos Coal Company: Mr. S. A. Johnson, president; Mr. Charles Seibert, general manager, and Mr. John J. Maloney, mine superintendent; also from Mr. G. N. Marshall, chief engineer of the Rio Grande Northern Railroad, and Mr. J. E. van Riper, civil engineer. To these gentlemen our thanks are extended.

GEOGRAPHIC POSITION OF LOCALITIES STUDIED.

(Pl. VI.)

Chispa and San Carlos, the places near which our studies were made, are situated in Jeff Davis and Presidio counties, respectively, almost in the heart of the mountainous region of Trans-Pecos Texas. Chispa is on the Southern Pacific Railroad, about 150 miles southwest of El Paso. San Carlos is 26 miles, by rail, almost due south of Chispa, at the terminus of the Rio Grande Northern Railroad, a short road branching from the Southern Pacific Railroad at the latter place. The work on this branch road, which was far advanced at the time the region was visited, has been completed.

Most attention was given to the Vieja Mountains, which are a portion of a range with a trend from west of north to south of east. Beginning at the southern end of this range and going north, it comprises the following mountains: The Chinati, Vieja, Van Horn, Carrito, Diablo, Prietà, and Cornuda. Eagle Mountain lies a short distance west of the axis of the chain, opposite Bass Canyon. The Sierra Blanca are isolated peaks northwest of Eagle Mountain. West of Sierra Blanca is the Quitman system, with a NW.-SE. trend. Beginning at its southeast end and going northwest, it is composed of the Quitman, Malone, Finlay, and Hueco mountains. Still farther west are the Organ Mountains, whose axis extends from north to south. East of the Vieja Mountains are the higher ranges, known as the Guadalupe, Davis, and Chisos groups, which constitute the eastern front of the whole Trans-Pecos mountain region.

The exact localities studied were: (1), The isolated peak, belonging to the Vieja Mountains, 6 miles west of south from Chispa; (2) the vicinity of San Carlos; (3) the western side of the railroad from Chispa summit (the pass between the Van Horn and Vieja mountains) to a point 13 miles from Chispa, going southward toward San Carlos.

LITERATURE.

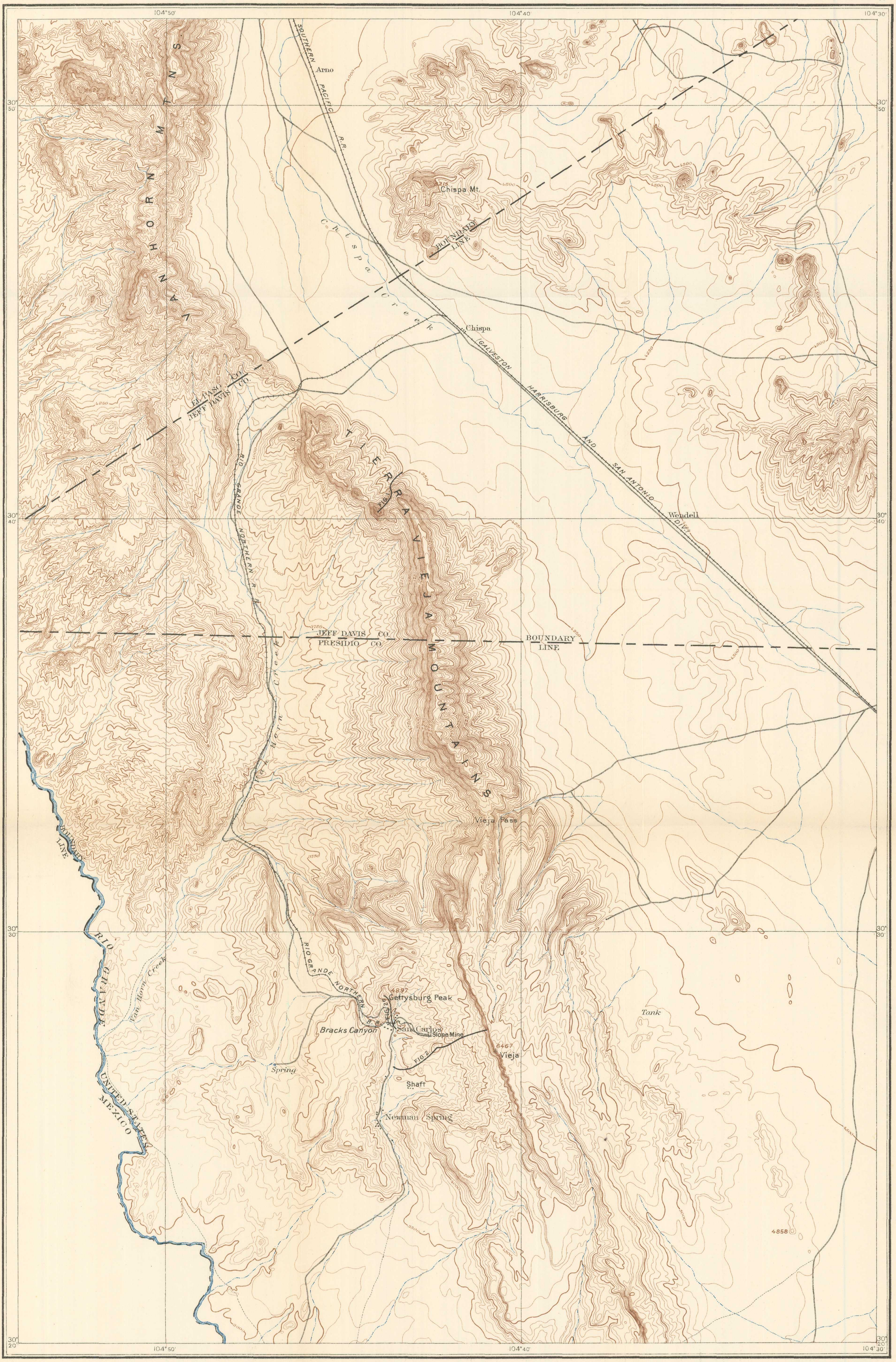
Very little has been written concerning this area. W. H. von Streeruwitz has published a few remarks in the reports of the Geological Survey of Texas. In the fourth annual report of that survey, A. Osann makes some interesting notes on the igneous rocks. On pages 386 and 387, Vol. VI of the bulletins of the the Geological Society of America, E. T. Dumble gives a general section of the Vieja Mountains at San Carlos.

TOPOGRAPHY AND STRUCTURE.

For the details of the topography the Chispa and San Carlos topographic sheets of the United States Geological Survey must be consulted.

Many geologists have noted in Trans-Pecos Texas the peculiar desert valleys or basins, filled with detritus, lying between the mountains of the region, and the abrupt manner in which the mountains rise from them. (Pl. VI.) Chispa, at an altitude of 4,082 feet, is situated in such a basin valley, which is bounded on the south and west by the Vieja and Van Horn mountains, respectively, and on the north and east by outlying westward members of the Davis ranges.

About 6 miles southwest of Chispa there is a saddle or pass, known as Chispa Summit, which separates the Vieja Mountains on the southeast from the Van Horn Mountains on the northwest. The altitude of this saddle is a little less than 4,250 feet. On its southern slope Van Horn Creek rises. This creek flows through a valley, some 5 or 6 miles wide, in a general southerly direction, into the Rio Grande. Its elevation where it passes from the Chispa quadrangle is less than 3,300 feet. On its east side, and subparallel to it, are the Vieja Mountains, the altitude of whose crest varies from 5,250 to a little over 6,000 feet;



TOPOGRAPHY OF THE SAN CARLOS REGION SHOWING LOCATIONS DESCRIBED

Scale

1 ½ 0 1 2 3 4 5 Miles

LITH. BY A. HOEN & CO. BALTIMORE MD.

on its western side, subparallel to it, is a lower range of unnamed mountains whose altitude rarely exceeds 4,250 feet.

For a considerable portion of its length the rocks on the east side of this stream dip toward the Vieja Mountains, and on the west side toward the range on the west. Therefore this creek frequently flows along the very summit of an anticline, of which the Sierra Vieja represents the eastern limb and the unnamed range to the west the western limb. On the southern side of Chispa Summit the dip is southerly. About 2 miles southwest of the summit, and subparallel to the Rio Grande Northern Railroad, there is a narrow ridge with an altitude of approximately 4,500 feet, or some 500 feet above the valley. This ridge is composed of Lower Cretaceous limestone. Along its eastern front there is a fault, with a north-south strike and an easterly downthrow, by which the Benton shales have been brought down about 200 feet below the top of the Edwards (Caprina) limestone, so that now the shales are exposed from the foot of the ridge to a line east of the railroad.

San Carlos, with an altitude of about 3,988 feet, is situated in the basin valley of San Carlos arroyo and is almost entirely enclosed by mountains belonging to the Vieja system. The highest point of the Vieja Mountains, about 7 miles east of the town, is 6,470 feet. (Pls. VII, VIII, and IX.) The summit of the mountain is a little more than 2,700 feet above the valley of San Carlos arroyo. The basin is almost completely surrounded by what the inhabitants call *rim rock*—quartz-pantellerite—which occurs east, south, west, and north of the town. Around the border of this basin the rocks dip away from the center, those along the eastern side dipping toward the east, those on the southern side dipping toward the south, and those on the western and northern sides dipping west and north, respectively. The geologic structure is, therefore, that of a quaquaversal fold or an anticlinal dome. San Carlos arroyo has cut out the top of the dome and made its bed across the southwestern corner, flowing in a southerly direction into the Rio Grande. Just west of San Carlos there is a great fault, pointed out by Dumble,[1] striking north and south, with a westerly downthrow of over 2,000 feet, and bringing the rim rock "nearly to the level of the valley."

Along the foot of the mountains on the west side of San Carlos arroyo, and within a distance of three-fourths of a mile, are five springs, known as Newman's springs. The largest has been gaged, and according to Mr. S. A. Johnson furnishes a supply of 15,000 gallons of water a day. Mr. Johnson stated that he believed when all the springs are cleaned out that they will supply 40,000 to 50,000 gallons a day. The water is of excellent quality.

[1] Bull. Geol. Soc. America, Vol. VI, p. 387.

SECTIONS STUDIED AND NOTES THEREON.

PEAK NEAR CHISPA.

Section of peak belonging to the Vieja Mountains 6 miles west of south of Chispa.

(Pl. VII; Pl. XI, fig. 1.)

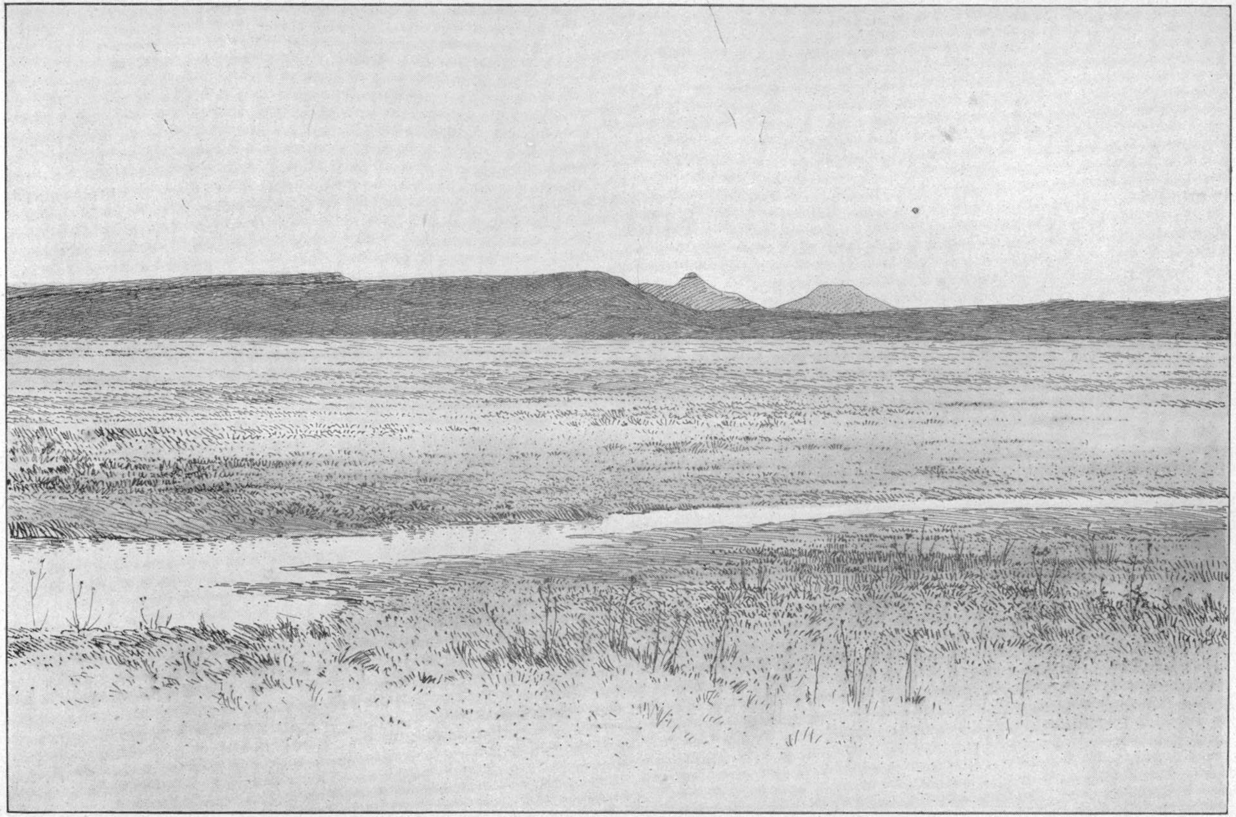
		Feet.
[1] 23.	Massive reddish porphyritic rhyolite, with some fragmental material	40
22.	Clay	30
21.	Red sandstone	60
20.	Grayish rock (probably pyroclastic rhyolite) overlain by clays	40
19.	Conglomerate and clays	80
[1] 18.	Rhyolite breccia, white, gray, green, or pinkish in color	100
[1] 17.	Thick ledges of hard whitish or gray rock, greenish in upper portion (rhyolite breccia)	30
16.	Conglomeratic sandstone and clays	50
15.	Whitish rock, probably rhyolitic	34
14.	Clay ?	3
[1] 13.	Rhyolite breccia, groundmass altered to calcite	3
[1] 12.	Rhyolite breccia, gray in color, containing considerable basaltic material	2
[1] 11′.	Amygdaloidal facies of 11, contains many cavities infiltrated with chlorite, calcite, zeolites, etc	10
	From 11′ small stringers run into 12, and there are both necks and small masses of the amygdaloid in 12. The rhyolite breccia at the contact is very much indurated, while at a short distance above the contact it has a much looser texture.	
[1] 11.	Dense, almost black, basalt with feldspar phenocrysts	65
[1] 10.	Fine-grained pink rhyolite breccia, containing considerable basaltic material	6
9.	Fine-grained material (pyroclastic ?)	60
8.	Conglomerate, underlain by clay	20
7.	Sandstone pebbles at base, grading into dark vermilion-colored clays, conglomerate again above the clay	60
6.	Very coarse conglomerate, containing pebbles of slate, red quartzite, greenish quartzite, cherty limestone, and red eruptive rock	50
	(Just below 6 a much-decomposed greenish eruptive rock was seen, but it may not have been in place.)	
[1] 5.	Massive reddish rhyolite, containing in a portion of the bed vesicles that have been filled with chalcedony	20
4.	Sands and clays	40
3.	Sands and clays, with occasional lenticular masses of conglomerate	60
2.	Lenses of conglomerate	1–5
1.	Laminated sandstone and clays, clays very sandy. The color of the rock is greenish, due to the presence of considerable quantities of chlorite	40

A small dike, striking east and west and cutting the lower part of the above series, was observed. This dike is probably of basaltic material.

The dip where the above section was made is 4°+, S. 50° E.

This section can be simplified and described as consisting of alternating beds of sedimentary rocks and lava flows, or beds of rhyolitic

[1] Determined from a study of thin sections by Dr. Lord.



VIEW OF VIEJA MOUNTAINS, LOOKING SOUTH FROM CHISPA.

The sharp-pointed peak is the one of which the section described on page 76 was made.

pyroclastic material. The basalt occurs at about the center of the section, and apparently is intrusive into the bed immediately overlying it. The reasons for this conclusion are given in the discussion of No. 11′ of the preceding section.

In the sediments interbedded with the lavas and pyroclastics no fossils were found, and we could not determine the precise age of the series. For these interbedded lavas, pyroclastics, and sediments the name *Vieja series* is proposed, from the Vieja Mountains, where they are well exposed and where they were studied.

SECTIONS IN THE VICINITY OF SAN CARLOS.

Section of the Vieja Mountains from the San Carlos arroyo, 1 mile below San Carlos, to the top of the mountain east of the town.

(Pl. VIII; Pl. XI, fig. 2.)

	Feet.
22. Rim rock, a greenish-yellow rock, containing large phenocrysts of anorthoclase feldspar, determined by Dr. Lord to be quartz-pantellerite	400–600
21. Variegated sandstones and clays, and probably rhyolite breccias (It was not possible to examine this part of the section carefully, so the notes are very meager.)	500
20. Grayish and purplish clays, etc., approximately	500
19. Yellow clays, or soft yellow sandstone, with occasional carbonaceous seams	150
18. Carbonaceous seam	20
17. Yellow or purplish clays, with ledges of soft yellow sandstone and occasional carbonaceous seams	250
16. Coarse, soft, yellow, cross-bedded sandstone	25
15. Yellow clay, with two or three carbonaceous seams	20
14. Coarse, soft, yellow, laminated sandstone in ledges	30
13. Yellow clay, carbonaceous at base	6
12. Coal	1⅚
11. Impure coal	3
10. Carbonaceous shale	1
9. Purple clays	4
8. Coal	1⅙
7. Purplish clays	4
6. Soft yellow sandstone and argillaceous sandstone	110
5. Yellow or brown sandstone; 40 feet above base limestone concretions; a few poor fossils, mostly Exogyra fragments	90
4. Ledge of brown sandstone, containing well-preserved specimens of a large Inoceramus (*I. oblongus* Meek) in great abundance	4 or 5
3. Laminated brown or yellowish fossiliferous sandstone; about 20 feet below the top there is an indurated ledge containing many oysters	250
2. Clay, with calcareous concretions which contain many well-preserved fossils	40
1. Thinly laminated clays weathering yellowish, capped by soft, yellow, laminated sandstone	20
The total thickness examined, a little less than	2,700

The following is Dumble's section published in the Bulletin of the Geological Society of America, and previously alluded to:

General section of Vieja Mountains near San Carlos.

	Feet.
1. Lava flow, rim rock of mountain	200–300
2. Sandstones of various colors, interbedded with calcareous clays and volcanic ash	550
3. Conglomerate, resting unconformably on No. 4	1–16
4. Lava flow, apparently conformable on No. 5	50
5. Interbedded brown and red sands, purple shales, and yellow quartzitic sandstone	500
6. Gray and purple shales, with thin strata of sandstone	200
7. Coal shales, with beds of laminated sands and two seams of coal, highly fossiliferous between and below the coal seams	800
8. Interbedded sands and sandstones, some highly calcareous; fossiliferous	250
9. Shales with concretions of clayey limestone containing fossils	175
This gives a total thickness of over	2,800

The general character of the writer's section from San Carlos arroyo to the top of the mountain is almost the same as Dumble's. No. 22 of the writer's section equals No. 1 of Dumble's; No. 21 of the writer's section equals No. 2 of Dumble's.

The conglomerate bed and lava flow, 3 and 4 of Dumble's section, were not seen in going up the mountain at San Carlos. A conglomerate occupying the same stratigraphic position as Dumble's No. 3 was found near the base of Gettysburg Peak, a section of which will be described later. Huge bowlders, evidently derived from the disintegration of a conglomerate, are very abundant on the low hills in the valley of the San Carlos arroyo.

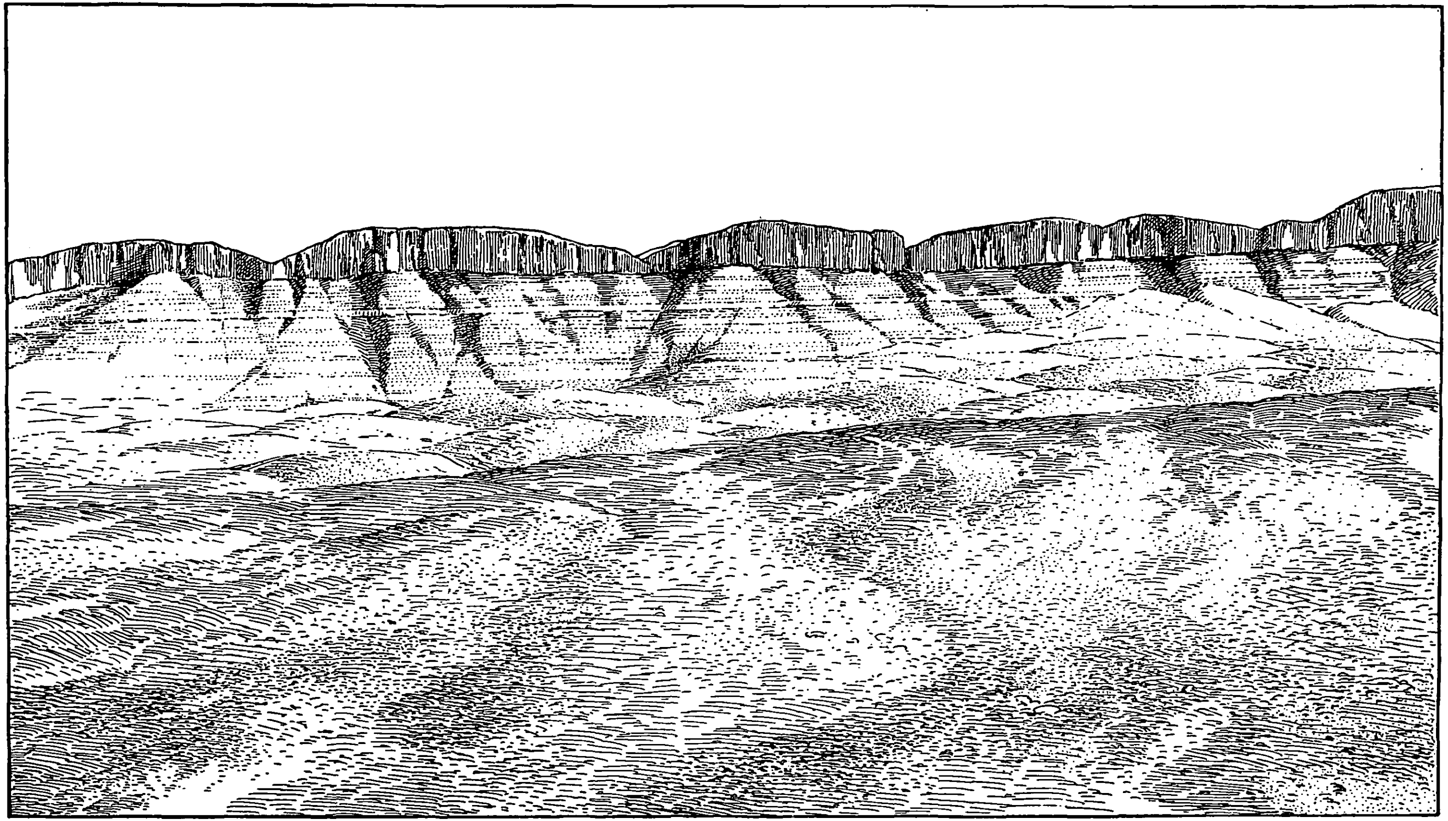
No. 20 of the writer's section equals for the greater part Nos. 5 and 6 of Dumble's; Nos. 19 to 15 equals No. 7 of Dumble's; Nos. 4 and 3 equals No. 8 of Dumble's; Nos. 2 and 1 equals the upper part of No. 9 of Dumble's. The aggregate thickness of the two sections is practically the same. As definite lines of demarcation between the sedimentary beds could not be found, of course the exact details could not be expected to agree. No fossils were found between the coal seams. The minimum thickness given for the rim rock was determined, instrumentally, by Mr. C. C. Bassett, who made the San Carlos topographic map.

Fossils from section of Vieja Mountains from San Carlos arroyo, 1 mile below San Carlos, to top of mountain east of town.

Fossil from No. 4 (field No. 301).[1]

Inoceramus oblongus Meek, possibly identical with I. cumminsi Cragin, but these specimens do not have the characteristic posterior plication on which that species was founded.

[1] The field numbers are those used by Mr. Stanton.



VIEW OF VIEJA MOUNTAINS, LOOKING EAST FROM SAN CARLOS.

The quartz-pantellerite forms the top of the mountain.

Fossils from No. 3 (field No. 298).

Pecten sp.
Veniella sp.
Cardium carolinese Conrad?
Cardium sp. Cf. tenuistriatum Whitfield.
Cyprimeria sp., same as that in No. 2.
Mactra sp., related to M. warreneana M. & H.
Mactra sp.
Corbula sp.
Dentalium sp.
Gyrodes petrosa (Morton).
Anchura sp., large species related to A. abrupta Conrad.
Pugnellus sp.
Volutomorpha sp.
Rostellites sp.
Pyropsis trochiformis Tuomey?, apparently identical with the New Jersey form doubtfully referred to this species by Whitfield.
Placenticeras guadalupæ (Roemer). Rare.

Fossils from No. 2 (field No. 297).

Exogyra costata Say, a variety intermediate between this species and E. ponderosa Roemer.
Pecten sp.
Avicula linguiformis E. & S.
Inoceramus cripsi var. barabini Morton.
Inoceramus proximus Tuomey.
Inoceramus vanuxemi M. & H.
Pinna sp. Cf. P. laqueata Conrad.
Cucullæa sp.
Veniella sp.
Cyprimeria sp., related to C. alta Conrad.
Pholadomya sp.
Turritella trilira Conrad var.
Anchura sp.
Gyrodes sp.
Strepsidura ? sp.
Nautilus dekayi Morton.
Placenticeras guadalupæ (Roemer). Abundant.
Schloenbachia delawarensis (Morton).
Baculites asper Morton.
Baculites ovatus Say ?
Hamites ?, fragments of two species.
Scaphites sp., related to S. nodosus, but a distinct species.

Detailed section through coal seams at tunnel of mine No. 4 of San Carlos Coal Company, on west slope of the Vieja Mountains, about 2 miles east of San Carlos.

(Pl. XI, fig. 2*a*.)

	In. Ft.
9. Clay, thickness variable	13 to 3
8. Upper coal seam (coal noncoking)	10 to 3
7. Clay, thickness variable	6 to 2
6. Sandstone, thickness variable	2 to 7
5. Clay, sometimes present.	
4. Lower coal seam, thickness variable	2 to 3

The lower limit in thickness occurs over a very small area; the average thickness is about 2 feet. In this seam a binder occurs. The binder consists of two thin seams of sand, and varies in thickness from half an inch to 2 inches. Between the seams of sand is a thin coal seam about half an inch thick. Of this coal seam where examined:

a. Upper 9-inch does not coke.
b. Nine inches just above binder coking.
c. Binder.
d. Below binder, 9 inches, coal all coking.[1]

3. Carbonaceous shale	1 to 3 in.
2. Fire clay	2 ft.[2]
1. Sandstone.	

This section of the coal corresponds to Nos. 13 to 6, inclusive, of the general section of the mountain.

Along the side of the mountain the usual dip is 5° to 7° (though it may sometimes be more or less), and the strike is N. 35° to 50° E.

Section in arroyo northeast of shaft of San Carlos Coal Company, 2 miles east of south of San Carlos.

(Pl. XI, fig. 2*b*.)

	Feet.
11. Soft yellow sandstone	10
10. Yellow clays	10
9. Ledge of soft yellow sandstone	15
8. Clay.	
7. Coal, upper seam.	
6. Clay.	
5. Coal, lower seam.	
4. Soft yellow sandstone	6
3. Bluish clay, with fossils, Cyprimeria, Inoceramus, Exogyra, etc	35
2. Layer of clay containing many limestone nodules and fossils	1
1. Clay.	

Above the soft sandstone (No. 11) are two other prominent sandstone ledges, about 30 feet apart, the upper of which is conglomeritic.

The strike of the rocks at the foregoing exposure is southwest and northeast, dip 20° to 30° SE.

Fossils from No. 3 (field No. 299).

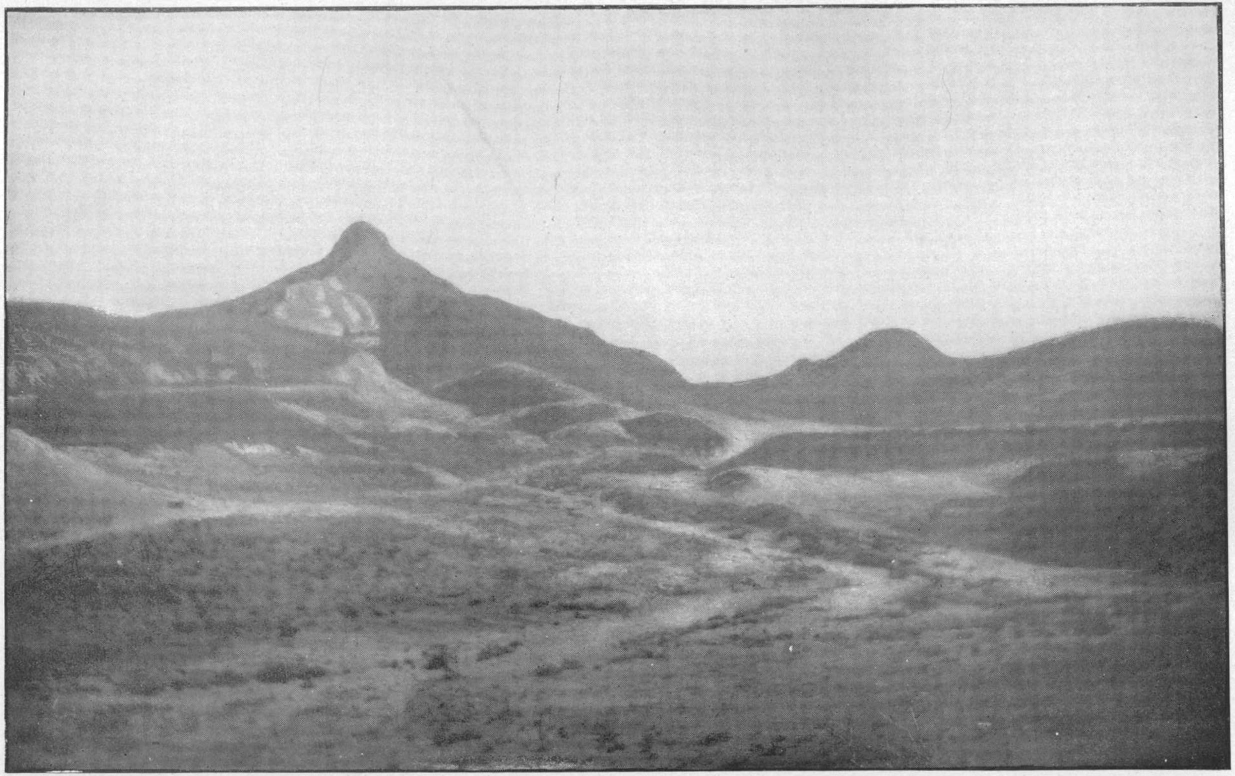
Ostrea sp.
Exogyra costata Say var.
Inoceramus sp., fragments of a large form.
Trigonia sp.
Cyprimeria sp., the same as for field Nos. 297 and 298.

OVERTURNED FOLD NORTH OF SHAFT OF SAN CARLOS COAL COMPANY.

A short distance north of the shaft of the San Carlos Coal Company there is a small overturned fold accompanied by an overthrust fault. On the overthrust side of the fault a fossiliferous horizon is exposed, but it

[1] The information concerning what part of the coal seam would coke was furnished by Mr. Maloney, mine superintendent. Samples of the coke were furnished by the mine officials.

[2] Or more.



VIEW OF GETTYSBURG PEAK FROM SAN CARLOS.

was not determined which of the horizons it represents, i. e., whether the one just below the coal or the one at the base of the section of the mountain.

Fossils from fault north of shaft of San Carlos Coal Company (field No. 300).

Ostrea elegantula Newberry.
Exogyra costata Say var.
Inoceramus proximus Tuomey.
Cyprimeria sp.
Cardium alabamense Gabb.
Rostellites sp.
Gyrodes sp.
Gyrodes crenata Conrad?
Schloenbachia delawarensis (Morton).
Placenticeras guadalupæ (Roemer).

SANDS AND CLAYS.

From observations in the entries at the shaft of the San Carlos Coal Company and in mine No. 4, it was ascertained that the clays and sandstones, which are yellowish on the surface, are of bluish color before exposure to the influence of weathering.

SAN CARLOS AND ARROYO ABOVE.

Near the store at San Carlos (field No. 296) were collected *Placenticeras guadalupæ* (Roemer) and *Schoenbachia delawarensis* (Morton).

Along the San Carlos arroyo, above San Carlos, in the sandstone and clays above the coal, a few fragmentary vertebrate remains were collected, which have been examined by Mr. F. A. Lucas. He states that they include a fresh-water turtle and several dinosaurian bones of Cretaceous type.

Section of Gettysburg Peak, 1 mile north of San Carlos.

(Pl. IX; Pl. XI, fig. 2c.)

	Feet.
3. Quartz-pantellerite	180
2. Ledges of variegated rock resembling sandstone, but probably composed largely of pyroclastic rhyolite	300
1. Conglomerate bed.	

Résumé of San Carlos section.

Quartz-pantellerite.
Vieja series:
 5. Ledges of variegated rock, probably largely pyroclastic.
 4. Conglomerate bed.
San Carlos formation:
 3. Sandstone and clays above coal, containing Cretaceous vertebrates.
 2. Coal horizon.
 1. Sandstone and clays below the coal, containing three or four horizons of invertebrate fossils.

For the sandstones and clays containing the coal, below the Vieja series to the base of the San Carlos section, the name *San Carlos formation* is proposed.

AGE OF FOSSILS BELOW THE COAL.

Stanton makes the following notes regarding the fossils from the San Carlos region:

The invertebrate fossils from the neighborhood of San Carlos (Nos. 296–307) come from several different horizons ranging through a considerable thickness of strata, but they all clearly belong to one fauna. Essentially the same list of species was identified in 1894 for Mr. E. T. Dumble, who had visited the region with Mr. Cummins. The list, with a note on the relationship of the fauna, was published by the former.[1] There seems to be no reason for changing the opinion there expressed, that the horizon is beneath the Ripley and above the Austin chalk—that is, it is equivalent to a part of the Taylor (*Exogyra ponderosa*) marls of central Texas and of the Pierre of the western interior region. It is not now possible to fix the horizon more definitely.

The same fauna occurs near Presidio, Texas, on the Mexican side of the river, where its relations to the underlying beds are more clearly shown. There it is underlain by a series of Upper Cretaceous shales with an estimated thickness of 3,000 or 4,000 feet, in the lower part of which *Inoceramus labiatus*, the characteristic fossil of the Benton, was found.

The age of the coal is thus definitely determined to be Upper Cretaceous, because Upper Cretaceous fossils were found both above and below the seams. The Pierre fauna occurs almost in contact with the lower seam, from which it would seem that the coal should be referred to the Pierre beds.

A point of special interest is that by means of the fossils here collected a part at least of the Taylor (*Exogyra ponderosa*) marls are referable to the lower member of the Montana division of the northwestern interior Cretaceous region.[2]

BRACKS CANYON.

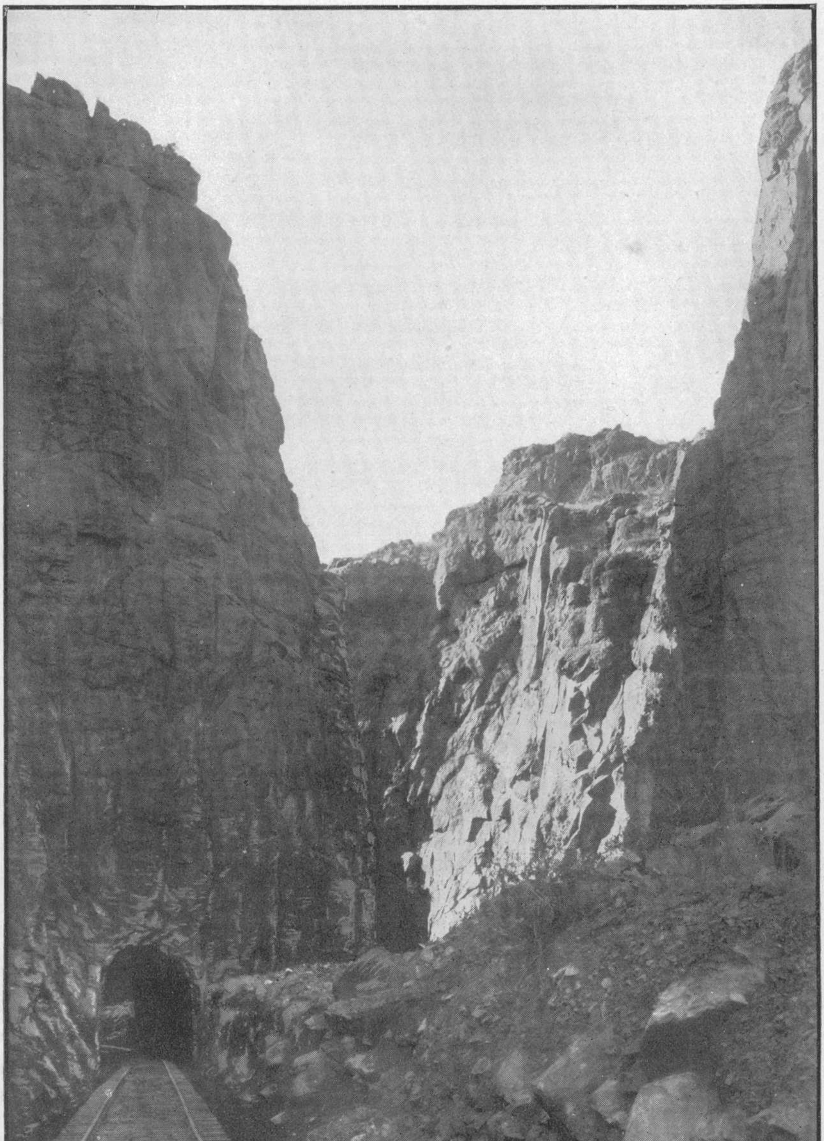
(Pl. X.)

About a half mile west of San Carlos is the eastern end of a narrow gorge, known locally as Bracks Canyon, which cuts across a mass of the quartz-pantellerite. This gorge is about one-fourth of a mile long, from 15 to 20 feet wide at the bottom, 250 feet deep, with nearly perpendicular walls, and extends in an east-west direction. It is one of the drainage channels from the San Carlos Basin, the divide between it and San Carlos arroyo being within the San Carlos Basin. It is a question whether this canyon has been cut by erosion or is simply a cleft in the rock, but it is apparently the bed of a stream whose head waters have been captured by San Carlos arroyo.

In the middle portion of this canyon a large mass of rhyolite breccia was found included in the pantellerite. Just beyond the western end of the canyon a mass of baked clay was found, but owing to the limited time at our disposal it was impossible to decide whether the clay was or was not included in the pantellerite. It did not appear to be an inclusion.

[1] Bull. Geol. Soc. America, Vol. VI, April, 1895, pp. 386–387.

[2] Dr. C. A. White, in Bull. 82 of the U. S. Geological Survey, p. 160, although he does not state it explicitly, evidently intends to include the Taylor (*Exogyra ponderosa*) marls in the Montana. Mr. E. T. Dumble, in his paper already frequently quoted, refers these beds to the Montana.



ENTRANCE TO BRACKS CANYON, EASTERN END, SAN CARLOS.

GEOGRAPHIC DISTRIBUTION OF QUARTZ-PANTELLERITE.

From the peak 6 miles west of south from Chispa one can, upon looking east, see a very thick sheet of rock above the rocks which form the peak. Going south along Van Horn arroyo, this sheet can be traced with the eye, and is seen to form the top of the mountain the entire distance to San Carlos. Messrs. Bassett and Chapman, who during the field season of 1895 made the San Carlos topographic sheet, noticed this peculiar rock, and have furnished additional observations in regard to its distribution. It extends south and east of San Carlos for many miles. (Pl. VIII.) As the area covered by the pantellerite has not been mapped geologically, it is not possible to state what extent of territory was originally covered by that enormous sheet, but from present knowledge it was certainly many hundred, possibly several thousand, square miles.

CORRELATION OF THE CHISPA AND SAN CARLOS SECTIONS.

So great a variety of volcanic products as was observed south of Chispa was not seen at San Carlos, but taking the pantellerite and the rocks immediately underlying it as starting points for a comparison, there can be no doubt that all of the section studied in the peak south of Chispa is above the coal horizon. The beds at Gettysburg Peak, near San Carlos, from and including the conglomerate bed to the base of the pantellerite, certainly represent, in part at least, the Vieja series. The stratigraphic relations existing between the Vieja series and the underlying San Carlos beds were not discovered. Whether two series of beds are comformable or are separated by an unconformity was not ascertained.

TIME OF THE VOLCANIC OUTBURSTS.

Dumble,[1] in his paper on the Cretaceous of Western Texas and Coahuila, Mexico, states: "Since no erosion was observed in the bed immediately underlying the first lava flow, this lava of the Vieja Mountain is * * * seemingly of Ponderosa age." It may be true that the outbursts occurred during the time in which the Taylor (*Exogyra ponderosa*) marls were deposited, but neither Dumble's nor our own observations were sufficiently extensive to solve the problem. It should be stated that the interbedded fragmental rhyolites and sediments have been subjected to orogenic movements, showing that the faulting and folding have taken place since volcanic activity ceased.

DIKES.

Two systems of dikes were noted, as pointed out by Dumble. As no collection of the dike rocks was made, this subject is passed without further remarks.

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[1] Bull. Geol. Soc. America, Vol. VI, p. 387.

STRATA BELOW THE SAN CARLOS FORMATION.

About 6½ miles from Chispa, along the Rio Grande Northern Railroad, there is an exposure of thinly laminated bluish calcareous shale, containing *Inoceramus labiatus*, Placenticeras sp., and Ptychodus sp. These shales represent the Eagle Ford shales and the Valverde flags of eastern and central Texas, and the Benton shales of the western interior region.

Running subparallel to the railroad, on its west side, is a ridge 300 or 400 feet above the roadbed. Along the eastern foot of this ridge the Benton shales are exposed; they have a dip of 7° or 8° S. Three hundred feet above the railroad, near the summit of the ridge, a limestone with a rather steep westerly dip, and containing a fauna apparently of Washita age, is exposed. The Benton shales have been faulted several hundred feet below the Washita.

A section up the side of this ridge was as follows:

Section of ridge about 6 1-2 miles from Chispa, on Rio Grande Northern Railroad.

(Pl. XI, fig. 3.)

	Feet.
4. Alternating ledges of hard nodular or soft nodular limestone, the nodules containing numerous fossils.	
3. Flaggy brown sandstone.	
2. Ledges of massive limestone, hard, bluish, weathering brown, much jointed, weathered surface very rough, fossiliferous. Contains silicious or cherty nodules in which were found Radiolites, Requienia, Monopleura, and Pholadomya	25
1. Nodular, argillaceous limestone, fossiliferous, resembling in lithologic aspect the Comanche Peak limestone of central Texas.	

The following fossils were collected from the foregoing section:

Fossils from No. 4 (field No. 303).

Enallaster texanus Roemer.
Holectypus planatus Roemer?
Kingena wacoensis (Roemer).
Neithea texana Roemer.
Cypricardia texana Roemer?
Cinulia sp.
Chemnitzia ? sp.
Ammonites sp.

Apparently this fauna is of Washita age. *Kingena wacoensis* is usually a Washita species, though it also occurs in the Edwards limestone.

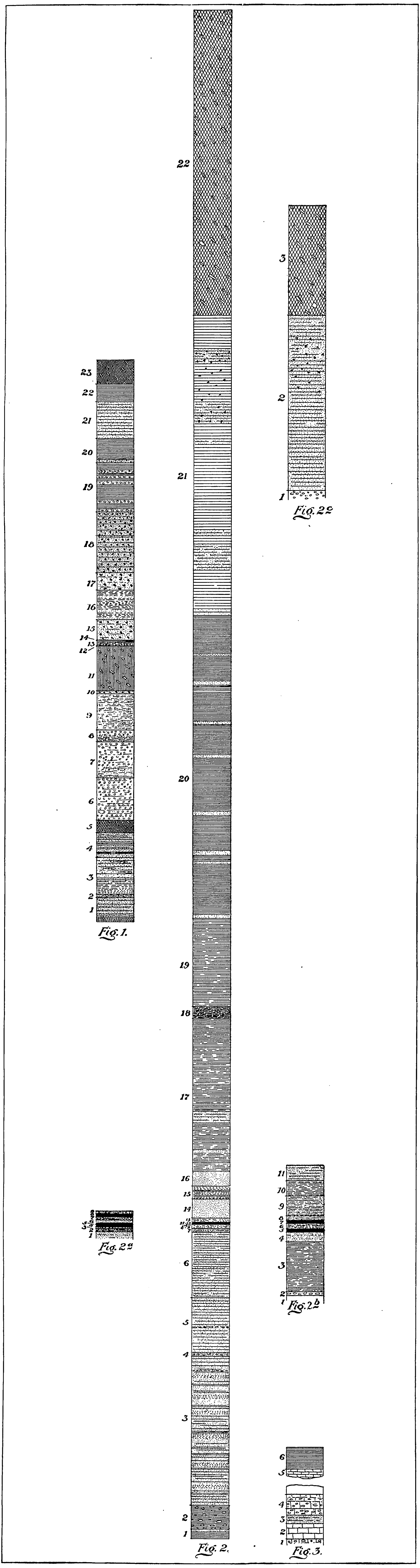
Fossil from No. 2 (field No. 303a).

Ichthyosarcolithes anguis Roemer?

This bed is referred to the Edwards limestone.

Fossils from No. 1 (field No. 303b).

Gryphæa sp.
Neithea texana Roemer.
Pleuromya knowltoni Hill?
Turritella seriatim-granulata Roemer?
Tylostoma pedernalis Roemer.



COLUMNAR SECTIONS IN THE VICINITY OF CHISPA AND SAN CARLOS.

Fig. 1. Section of peak 6 miles west of south from Chispa. Scale, 32 feet to 1 inch. (See p. 76.)
Fig. 2. Section of Vieja Mountains in vicinity of San Carlos. Scale, 32 feet to 1 inch. (See p. 77.)
Fig. 2*a*. Section through coal seam at Tunnel Mine No. 4. Scale, 53 feet to 1 inch. (See p. 79.)
Fig. 2*b*. Section through coal seam 2 miles east of south from San Carlos. Scale, 53 feet to 1 inch. (See p. 80.)
Fig. 2*c*. Section of Gettysburg Peak. Scale, 32 feet to 1 inch. (See p. 81.)
Fig. 3. Section of beds below the San Carlos formation, as exposed on the south side of Chispa Summit. (See p. 84.)

From the presence of such a form as *Tylostoma pedernalis*, this bed is referred to the Fredericksburg division of the Comanche series, but no attempt is made to correlate it with any definite horizon.

Along the railroad, where it begins to climb Chispa Summit, a hard blue limestone, in thick ledges, is frequently exposed beneath the Benton shales. This limestone contains fossils, but no identifiable specimens were secured, except in one place, on a weathered slope, a specimen of *Alectryonia carinata* Lam. was found. This limestone is apparently conformably overlain by the Benton shales, and occupies, with reference thereto, the same stratigraphic position as the Buda limestone of central Texas, but no distinctive Buda fossils were collected.[1] Neither was it discovered what underlies this limestone. Therefore, in spite of presumptive evidence in favor of it, any definite correlation with the Buda limestone would be premature. (Pl. XI, fig. 3, Nos. 5 and 6.)

The following summary of the general characters of the section below the San Carlos formation is given:

1. No exposures from the lowest outcrop of the San Carlos beds to near the base of the Benton shales were seen, but according to Stanton's observations in the vicinity of Presidio, Mexico, the intervening beds consist of shales.

2. The Benton shales overlie, apparently conformably, a hard blue limestone, probably the equivalent of the Buda limestone of central Texas.

3. What immediately underlies No. 2 was not seen. A limestone containing species of fossils characteristic of the Washita division, and representing a lower horizon than No. 2, was found. Below this limestone there is a stratum of brown sandstone probably 30 to 50 feet thick.

4. Below the sandstone mentioned were found ledges of limestone containing cherty nodules and a fauna characteristic of the Fredericksburg division.

EXTENT OF SAN CARLOS AND OTHER TRANS-PECOS TEXAS COAL FIELDS, AND CONDITION OF MINING.

The San Carlos coal basin is situated in the basin valley of the San Carlos arroyo, described in preceding pages. At the time of the visit to San Carlos, work was being prosecuted at two places. The first working was in a shaft 2 miles, in a straight line, south of southeast from San Carlos. This shaft was unfortunately sunk near a fault, and at that time the coal seam had not been found in the drift to catch it. Mr. Bassett, who was engaged during the summer of 1895 in making

[1] *Alectryonia carinata* occurs in the Buda limestone and in the lower horizons of the Washita division.

the San Carlos topographic sheet for the United States Geological Survey, states that work in this shaft has been abandoned. The second working was along a slope on the side of the mountain, a little less than a mile and a half slightly south of east from San Carlos. It has been reported that the mine here has been abandoned. There are other outcrops of coal on the side of the mountain and along the courses of some of the arroyos in the basin.

Mr. G. N. Marshall, chief engineer of the Rio Grande Northern Railroad, informed the writer that coal also outcrops on the western slope of the Vieja Mountains, in the valley of Van Horn Creek, but that it had not been found in commercial quantities. The inference is that coal will be found here, as lower geologic horizons are exposed along that creek and between it and the mountain.

Coal has been reported from several other localities in Trans-Pecos Texas, but so far as ascertained they have been neither prospected nor investigated. These localities are: El Paso County,[1] Eagle Springs,[2] between Sierra Barda and the Rio Grande,[3] and between Alpine and Paisano Pass.[4] Mr. R. T. Hill, who has recently made an expedition into the Great Bend country of the Rio Grande, furnishes the following note: "On the east and south side of the Chisos Mountains there are extensive areas of the Montana formation in which there are coal beds of unknown value."

Although the coal fields of western Texas have been little explored, there are indications that there are several occurrences of poor coal in the region.

The Cretaceous coals of Colorado are, according to Hills,[5] practically all of Laramie age, i. e., they belong to a horizon above the Pierre or Fox Hills. The Texas Cretaceous coals are geologically older than the Colorado coals.

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[1] C. A. Ashburner, Mineral Resources U. S. 1885, p. 68.
[2] W. M. Chandler, Mineral Resources U. S. 1886, p. 350.
[3] W. H. von Streeruwitz; Fourth Ann. Rept. of Geol. Survey of Texas, Austin, Texas, July, 1893, p. 175.
[4] W. H. von Streeruwitz; loc. cit.
[5] Mineral Resources U. S. 1892, pp. 319–324.

CHARACTER OF SAN CARLOS COAL.

The San Carlos coal is lustrous black in color, compact, and has a dark-brown streak and a subcubical cleavage. The following analyses were made by Dr. Peter Fireman:

Analysis of San Carlos coal from mine No. 4, lower seam.

	Upper part of seam above binder.	Just above binder (coking).	Below binder (coking).	In clay above lower seam.
Moisture	1.09	1.17	1.19	1.68
Vol. hydrocarbon	39.61	39.93	39.73	60.37
Fixed carbon	35.29	35.39	40.30	24.89
Ratio $\frac{F.\ C.}{V.\ H.\ C.}$	.89	.886	1.01	.41
Ash	24.01	23.51	18.78	13.06
Color of ash	Brownish gray.	Gray.	Grayish brown.	Reddish brown.
Coke	Coherent, hard, lustrous.	Coherent, hard, lustrous.	Coherent, hard, lustrous.	Coherent, lustrous.

Analysis of San Carlos coal from mine No. 4, lower seam.

	Coal (shaft).	Coke.
Moisture	.97	1.24
Vol. hydrocarbon	40.95	4.96
Fixed carbon	43.77	66.93
Ratio $\frac{F.\ C.}{V.\ H.\ C.}$	1.06	
Ash	14.31	26.87
Color of ash	Yellowish gray.	
Coke		Coherent, hard, lustrous.

The following data were furnished by Mr. R. E. Russell, former general manager of the San Carlos Coal Company:[1]

Analysis of coal from Presidio County, Texas.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Moisture	1.	0.94
Volatile matter	39.05	34.48
Fixed carbon	49.05	58.96
Ash	10.	5.62
Sulphur	Trace.	.64

This analysis was undoubtedly made from picked samples.

A test of the coal for steaming purposes was made on the Southern Pacific Railroad. The coal tested had been subjected to exposure for five or six months on the various dumps, and was practically crop coal, yet the average mileage for a ton of coal was 52.21 on passenger trains of five or six coaches.

Tests of the coking qualities of the coal were made at Connellsville, Pennsylvania, with good results. Forty-eight hour coke, burned in the oven at the mine, quite recently gave the following results:

Analysis of coke from Presidio County, Texas, coal.

	Per cent.
Combustible matter	93.7
Ash	6.2

REPORT ON IGNEOUS ROCKS FROM THE VICINITY OF SAN CARLOS AND CHISPA, TEXAS.

By E. C. E. Lord.

The material submitted to me by Mr. T. Wayland Vaughan for petrographic examination was taken from a series of late Cretaceous or early Tertiary lava flows, constituting a large part of the Vieja Mountains, Texas.

The geologic relationship and distribution of these igneous rocks is explained by Mr. Vaughan in the foregoing text.

The only literature bearing directly upon the petrography of the region is a short report by A. Osann[2] on a specimen of nepheline-tephrite and a series of syenite-porphyries or quartzless porphyries from the Vieja Mountains. The description of the latter rock corresponds somewhat with that of the quartz-pantellerite given below, but no reference is made by the author to triclinic feldspar, ægirine-augite, or porphyritic quartz.

[1] Mineral resources U. S. 1893, p. 385.

[2] A. Osann, Report on the rocks of Trans-Pecos Texas: Fourth Ann. Rept. Geol. Survey of Texas, 1892, p. 34.

The specimens submitted represent three distinct rock types, which may be classified as follows:

(1) Rhyolite breccia, composed chiefly of fragmental rhyolitic material.

(2) Quartz-pantellerite, containing quartz, anorthoclase, and monoclinic pyroxene, as principal mineral constituents.

(3) Basalt, having olivine, augite, and plagioclase as essential minerals.

RHYOLITE BRECCIA.

Under this heading are considered a series of yellowish, or purplish-grey, very fine-grained, vesicular breccias, and a series of brownish-red more massive rhyolites (5, 23),[1] containing little fragmental material. The specimens are considerably weathered. They adhere to the tongue, and have a strong clayey odor when breathed upon.

With the aid of the microscope considerable variation in the mineralogical composition of these pyroclastics is discernible. Angular particles of quartz, orthoclase, plagioclase, biotite, muscovite, hornblende, magnetite, and occasionally titanite, augite, and zircon, together with fragments of rhyolite, sandstone, limestone, and basalt, are seen cemented together by rhyolite glass decomposing into argillaceous material. This groundmass, although greatly altered to quartz and chalcedony and impregnated with calcite, chlorite, and limonite, showed, with two exceptions (Nos. 12 and 13),[2] fluidal phenomena.

Microscopic cavities are very abundant in these rocks. They are in many cases elongated, approximately in the direction of flow, and are more or less completely filled with silica, either in the form of radiating quartz (17), chalcedony (5), or opal (18). This secondary silica is stained reddish or yellowish brown by infiltrated iron ore.

In one instance (No. 13) the siliceous cement of the rock was almost completely replaced by calcite.

On comparing the relative amount of fragmental material occurring in the different members of the series, it was found that Nos. 10, 12, 13, 17, and 18 contain all the clastic constituents enumerated above, whereas Nos. 5 and 23, representing the more massive flows, were characterized by the scarcity of foreign material and by the abundance of corroded quartz, orthoclase, and biotite phenocrysts. These latter specimens are much decomposed, and owe their peculiar brownish-red color to the presence of limonite and iron oxide in the groundmass of the rock. The feldspar phenocrysts are, in many cases, found completely altered to an aggregate of cryptocrystalline quartz. In some instances the rock from flow No. 5 is much fractured, and near

[1] The numbers used in referring to the rock specimens are the same as those used by Mr. Vaughan in describing the section 6 miles west of south of Chispa, p. 76.

[2] These specimens were not vesicular, and may perhaps be more properly designated tuffs.

the surface very vesicular. The fissures and amygdaloidal cavities are filled with quartz and chalcedony.

Nos. 10 and 12 differ from the other specimens described in the predominance of augite, plagioclase, magnetite, and fragments of basalt over the débris of more acid rocks.

QUARTZ-PANTELLERITE.

This rock type is characterized macroscopically by the presence of large feldspar phenocrysts embedded in a dense, aphanitic groundmass. The prevailing color of the rock is grayish green, with a slight yellowish tint.

The altered specimens are either spotted brown or have a brownish-red color similar to much-altered varieties of the fragmental rhyolites Nos. 5 and 23. On exposed surfaces the pantellerite weathers yellowish brown and the feldspars are completely decomposed and leached out. Under the microscope the porphyritic character of the lava is more pronounced by the identification, besides feldspar, of porphyritic quartz, augite, magnetite, and apatite. These minerals are strewn in a fine-grained, holocrystalline groundmass composed of ægirine-augite, brown hornblende, feldspar, quartz, and magnetite.

The feldspar phenocrysts are thick tabular, formed after M (010). The planes M (010), P (001), $y(\bar{2}01)$, $T(1\bar{1}0)$, and l (110) were identified. The crystals are large, measuring about one-third cm. in thickness, one-half cm. in width, and two-thirds cm. in length, and cleave readily ‖ M and P.

On cleavage plates parallel to the latter face a small extinction angle of not over 3° was observed, whereas on the plates parallel to the brachypinacoid the angle from $\mathfrak{a}$ to $\breve{\mathfrak{a}}$ was circa 10°. These triclinic feldspar crystals are apparently single individuals, but occasionally show a wavy extinction, owing, presumably, to polysynthetic twinning. The specific gravity of the feldspar was determined with great care from selected material, by means of the Thoulet solution, and found to be 2.59, or that characteristic of anorthoclase.

These crystals contain inclusions of magnetite, augite, and apatite, and are frequently considerably altered, either to calcite or natrolite and kaolin.

The augite of intratelluric origin is of a light-green color, and slightly pleochroic: ‖ $\mathfrak{c}$ pale olive green, ‖ $\mathfrak{a}$ and ‖ $\mathfrak{b}$ yellowish green. It has an extinction angle of about 42°, and occurs in long prismatic form, with imperfect terminal faces. On basal sections the crystals are seen bounded by ∞P (110), $\infty P\bar{\infty}$ (010), and $\infty P\bar{\infty}$ (100) in about equal development.

Considerable variation in the relative amount of augite was noticed in the different specimens of pantellerite. In the slides containing least quartz the pyroxene was found to be most abundant.

The quartz phenocrysts are small and much rounded by magmatic corrosion. They are quite free from inclusions and reasonably abundant in rocks poor in augite.

Magnetite and apatite occur in the form usually met with in rhyolitic rocks. Phenocrysts of the former mineral are frequently covered with a coating of limonite, which discolors the surrounding rock for some distance and produces the brown spots referred to above.

In the groundmass of the pantellerite the presence of ægirine-augite and hornblende is of special interest. The former mineral occurs in the form of minute, irregularly bounded crystals of a rude prismatic habit.

The microlites are of a grass-green color, and in polarized light show characteristic pleochroism: ‖ 𝔞 grass green, ‖ 𝔟 sap green, and ‖ 𝔠 pale yellowish green. The absorption is 𝔞>𝔟>𝔠. On prismatic sections the axis of greatest elasticity (𝔞) was found to lie nearest c, the extinction angle not exceeding 25°. Twins after $\infty P\bar{\infty}$ (100) are occasionally observed.

The hornblende is not so abundant in the groundmass of this rock type as is the pyroxene. It occurs in thin sections, in irregular wedge-shaped patches, showing distinct prismatic cleavage, and is often intimately associated, although never intergrown, with the ægirine-augite. It is dark brown and exceedingly pleochroic: ‖ 𝔠 dark brown, ‖ 𝔟 purplish brown, and ‖ 𝔞 brownish yellow. Absorption is strong: 𝔠>𝔟>𝔞.

The extinction is considerable, 𝔠 forming on sections in the prism zone a maximum angle of 15° with the trace of the prismatic cleavage.

From the optical properties mentioned it is probable that this amphibole is closely related to barkevicite.[1]

Both the brown hornblende and the ægirine-augite are in many cases altered to chlorite and limonite. The fibrous mineral is regularly distributed through the rock; it occasionally occurs associated with serpentine as the probable alteration product of preexisting olivine crystals.

Feldspar and quartz of the effusive period are of microgranitic development and constitute the greater part of the pantellerite groundmass. The former mineral is of prismatic form, and occasionally quite idiomorphic. The microlites are elongated parallel $\breve{a}$, but in no instance could twinning be identified. As prismatic sections they show extinction angles not exceeding 10°, and may properly be regarded as a second generation of anorthoclase. The interstices of the rock are filled with allotriomorphous quartz.

The following analysis of the quartz-pantellerite from Presidio County, Texas, was made by Mr. Geo. Steiger, of the United States Geological Survey. Before making the analysis the calcium carbo-

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[1] H. Rosenbusch: Mikros. Physiographie, Vol. I, 3d edition, Stuttgart, 1892, p. 561.

nate present was removed by treating the rock powder on the water bath for ten minutes with diluted hydrochloric acid (1–10). The result of the analysis is found under Table I.

For comparison, the average of five analyses of pantellerite from Pantelleria[1] is placed under Table II, and under Table III is placed the average of paisanite from Mosquez Canyon.[2]

I. *Analysis of quartz-pantellerite from Presidio County, Texas.*

Constituent.	Per cent.
SiO_2	68.71
TiO_2	.21
Al_2O_3	13.45
Fe_2O_3	5.31
FeO	.75
MnO	.14
CaO	.96
BaO	None.
SrO	None.
MgO	.19
K_2O	5.51
Na_2O	4.63
Li_2O	None.
Water 100°—	.13
Water 100°+	.36
SO_3	.05
P_2O_3	.04
CO_2	None.
Total	100.44

[1] H. Foerstner: Zeitsch. für Krystallog., Vol. VIII, 1884, p. 125.

[2] A. Osann, Beiträge zur Geologie und Petrographie der Apache (Davis) Mountains, Westtexas: Min. und Petrogr. Mitth., Vol. XV, 1895, p. 439.

II. *Average of five analyses of pantellerite from Pantelleria.*

Constituent.	Per cent.
SiO_2	68.78
Al_2O_3	8.59
Fe_2O_3	5.12
FeO	3.78
CaO	1.44
MgO	.53
K_2O	3.50
Na_2O	7.16
CuO	.15
H_2O	.36

III. *Analysis of paisanite from Mosquez Canyon, Texas.*

Constituent.	Per cent.
SiO_2	73.35
Al_2O_3	14.38
Fe_2O_3	1.96
FeO	.34
MgO	.09
CaO	.26
Na_2O	4.33
K_2O	5.66
Total	100.37

It will be seen that while the silica, iron oxide, and some of the alkalies are essentially the same in the first two tables, the amount of FeO and Na_2O is smaller, and of Al_2O_3 and K_2O is larger, in Analysis I than in Analysis II.

This discrepancy in the chemical constitution of the two rock types is caused by the chemical dissimilarity of their amphibole constituents, all other silicates being alike in both rocks. The barkevicitic hornblende (rich in Al_2O_3 and comparatively poor in FeO and Na_2O) of the pantellerite from Presidio County is represented in the lava from Pantelleria by cossyrite, poor in Al_2O_3 and very rich in FeO and Na_2O.[1]

The relatively large amount of potash in Analysis I would indicate also a predominance of the potash feldspar molecule in the composition of the anorthoclase in the Texas pantellerite.

Comparing the analysis of this lava (Table I) with that of the paisa-

[1] F. Foerstner, Ueber Cossyrite: Zeitsch. für Krystallog., Vol. V, 1881, p. 354.

nite (Table III) it will be noticed that the latter rock differs essentially, containing a larger amount of silica and a smaller amount of iron. This chemical variation is manifested mineralogically by a greater development of free silica and by a total absence of ferromagnesian constituents in the groundmass of the rock.[1]

The geological occurrence of the paisanite[2] in the characteristic dike form is in marked contrast to the typical effusive character of the pantellerite.

The distribution of pantellerite outside of Texas is limited to the island of Pantelleria, although similar lava types are found on some of the volcanic islands off the coast of Africa, as well as on the mainland itself.

Pantelleria is situated about 70 miles southwest of Sicily, nearly midway between that island and Africa. It was visited in 1829 by Gemmellaro, who described from there a peculiar, greenish-gray rock type as "lave trachitichi moderne."[3]

In 1881 Foerstner named this lava pantellerite, and characterized it as a young, effusive rock, rich in iron, and containing a hornblendic mineral, called by him *cossyrite.*[4] In a later paper[5] he says that the rock shows sometimes a trachytic, often a vitreous obsidian, habit, and that it covers an area of 40 to 60 square kilometers, or the major part of the island. Forty-five volcanic centers and fifty flows surround an andesite core. Besides the latter rock, the pantellerite was associated with phonolite, feldspar, basalt, and rhyolite.

It has already been shown that in the Vieja Mountains the two latter rock types accompany the pantellerite. Phonolite and andesite from the Davis Mountains, 30 to 70 miles east of the Vieja Range, have been described by Osann.[6] This similarity in the mineral composition, as well as the geological associations of these younger rocks with the lavas from Pantelleria, renders the discovery in Texas of a similar circumscribed area of eruption a matter of great interest.

The following are some of the more important occurrences of younger-rock types resembling pantellerite in their mineral composition:

(1) Acmite-trachyte from the islands of San Miguel and Fayal, of the Azores, and from the island of Terceira;[7] also from the neighborhood of Naiwaseha Lake and from the Kaiwangaine Valley, northeast of Kilimandscharo Massif, East Africa.[8]

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[1] Osann, op. cit., p. 438.

[2] Ibid., pp. 404, 405.

[3] C. Gemmellaro, Sopra l' isola vulcanica di Pantelleria: Atti dell' Accad. Gioenia, Vol. V, 1829.

[4] H. Foerstner, Nota preliminare sulla geologia dell' isola di Pantelleria: Roma, Tipogr. Barbea, 1881, p. 15.

[5] Ueber Cossyrite: Zeitsch. für Krystallog., Vol. V, 1881, pp. 348-349.

[6] Osann, op. cit., p. 126.

[7] O. Mügge, Petrog. Untersuchung. an Gesteinen von den Azoren: Neues Jahrb. für Min., Vol. II, 1883, pp. 212-218.

[8] O. Mügge, Ueber einige Gesteine des Massai-Landes: Neues Jahrb. für Min., Vol. IV, 1886, p. 591.

(2) Dacitic rhyolite from Iceland, in Oexnadalr.[1]

(3) Trachyte from Sierra Madre, on southwest flank, near the town of Tulancingo, Mexico.[2]

(5) Volcanite from the island of Volcano, of the Liparian group.[3]

BASALT.

This rock varies in color from grayish black to dark brown, and on macroscopical examination presents a decided porphyritic character, owing to the development of large olivine and plagioclase phenocrysts.

It appears in the form of an intruded sheet between rhyolite breccias Nos. 10 and 12. Near its upper surface the rock is a typical amygdaloid.

With the aid of the microscope the basalt was found to pass from a dense holocrystalline porphyritic rock to a vesicular, hypocrystalline porphyritic variety.

The first-mentioned type (11) is composed of large, tabular-formed labradorites, irregularly bounded olivine and magnetite crystals of intratelluric origin, and light-brown augite, plagioclase, and magnetite of the effusive period. The augite is rarely of idiomorphic form, and contains abundant plagioclase inclusions. In many cases this pyroxene was the last mineral constituent of the groundmass to crystallize, and in taking the part of a mesostasis produced a characteristic ophitic structure common to many types of diabase. In some cases the olivine is replaced by the questionable mineral iddingsite.

The vitreous and porous variety of basalt (11′) differs from the holocrystalline rock in the development of a dark-brown granulated glass base in the groundmass. This rock type is, however, very much decomposed, olivine and augite being often completely altered to limonite, chlorite, and serpentine. These secondary minerals, together with either calcite, natrolite, or opal, are concentrated in the amygdaloidal cavities of the rock.

[1] P. Schirlitz, Islandische Gesteine: Min. u. Petrographische Mitth., Vol. IV, 1882, p. 423.

[2] C. A. Tenne, Ueber Gesteine des Cerro de las Vajos (Messerberg) in Mexico; Zeitschr. Deutsch. geol. Gesell., Vol. XXXII, 1885, pp. 612–613.

[3] W. H. Hobbs, Ueber den Volcanit, ein Anorthoklas-Augit-Gestein von der chemischen Zusammensetzung der Dacite: Zeitschr. Deutsch. geol. Gesell., 1893, p. 578.

INDEX.

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