

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 45



WASHINGTON
GOVERNMENT PRINTING OFFICE
1887



UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

T H E

PRESENT CONDITION OF KNOWLEDGE

OF THE

GEOLOGY OF TEXAS

BY

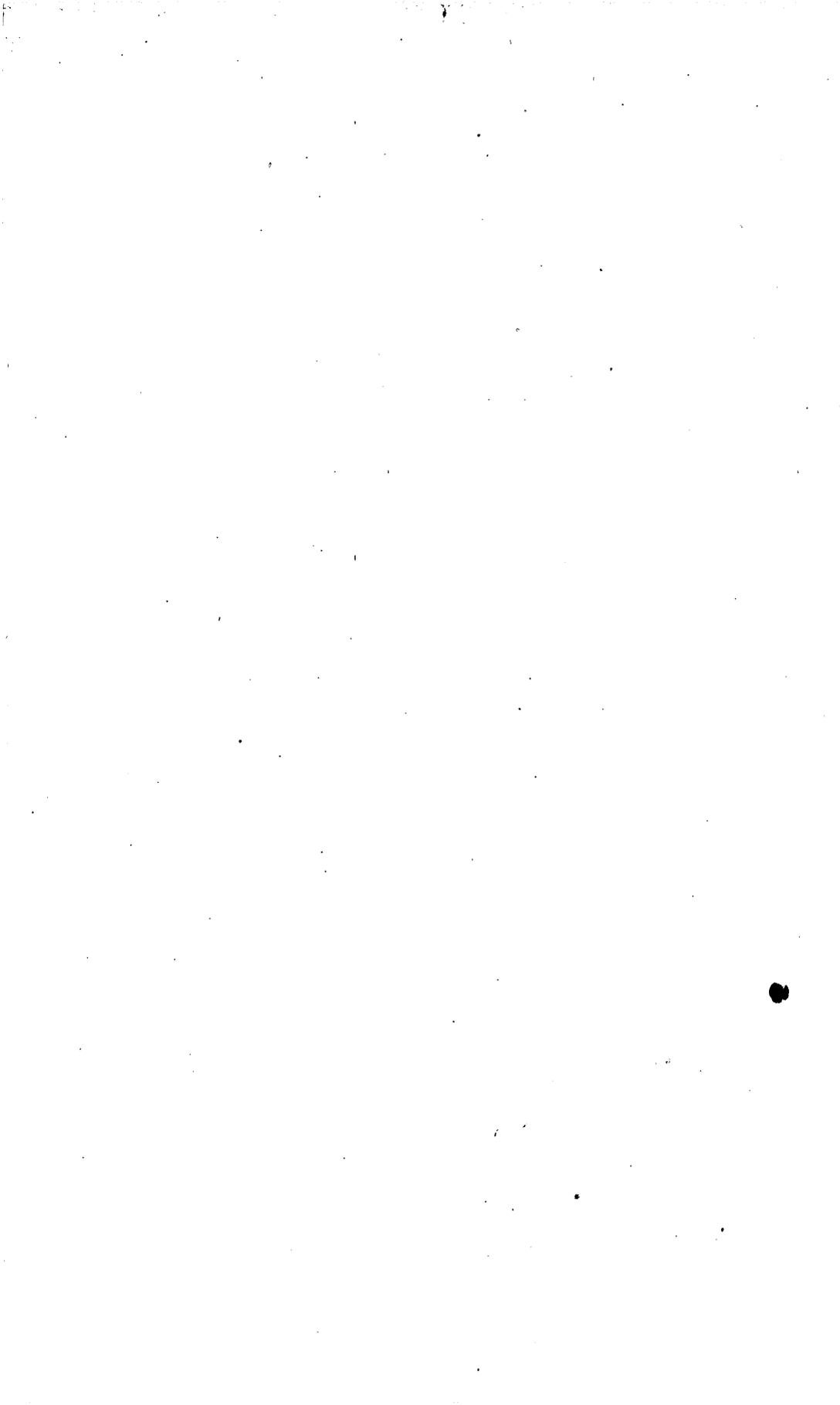
ROBERT T. HILL



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PREFATORY NOTE.

Geologic investigation in Texas has been fragmentary and unsatisfactory for many reasons: hostile Indians till recently ravaged the western half of the State; the civil war suspended the work of a comprehensive geological survey inaugurated under the State legislation of 1858, and that survey resuscitated and a later organization both came to naught. The U. S. Geological Survey has extended its operations into the State too recently to increase greatly the published knowledge of the geology of Texas.

To study intelligently the geology of this State it is important that a digest of such material as has been already published should be made. The present bulletin comprises an historical statement of such scientific work as has added to available knowledge of the topography and the paleontology as well as the geology of the State, but it is not intended to include unpublished knowledge gained by my residence and study in the State, except as that knowledge modifies comments on conclusions already in print. Other publications will embody such matter in due time. The present work does not extend the record beyond January 1, 1886.



PRESENT KNOWLEDGE OF THE GEOLOGY OF TEXAS.

BY ROBERT T. HILL.

I. HISTORICAL STATEMENT RESPECTING GEOLOGIC INVESTIGATION.

KNOWLEDGE AT THE BEGINNING OF THIS CENTURY.

Geology as a distinct science is so recent that we should not expect to find specific information upon that subject in early records; but geologic facts worthy of our attention are sometimes discernible in the descriptions of local geography and natural history given by intelligent travelers. The most complete and trustworthy compilation of the early Spanish, French, and Mexican authorities, with other historical data, is to be found in a work prepared by William Kennedy,¹ which is preferable to many later histories because of the scholarly and unprejudiced manner in which it was written.

The knowledge derived from previous authorities was embodied in the works of Baron Friedrich Heinrich Alexander von Humboldt, who visited Spanish America in the employ of Spain in the years 1799-1804, collecting all available information.

Although his studies extended into this century, his writings may justly be considered a correct statement of the geologic and geographic knowledge at the opening of the century. He first attempted to represent the principal features of the region on a map which accompanies the *Voyage au régions équinoxiales du Nouveau Continent, par A. de Humboldt et A. Bonpland*. His physical observations upon the mountains and plains, his numerous measurements of the region of the Upper Rio Grande, and his formulation of meteorologic laws concerning that region were all valuable, though indirect, contributions to our knowledge of Texas, which it seems he did not visit personally. A glance at his map is sufficient to show that the conception he possessed of this region, although the best of his time, was vague and indefinite. The sources and the courses of the rivers are incorrectly delineated. Streams having their sources in the eastern portion of the plains are represented as originating in lakes, an error probably arising from the fact that in the vicinity of San Antonio de Bexar, which at that time was the nucleus of Spanish settlement, the water courses arise from outbursting springs which usually expand into extensive pools of water. These phenomena

¹Texas: The Rise, Progress, and Prospects of the Republic of Texas. By William Kennedy, esq. In two volumes. London, 1841. 8°.

are purely local, however, and the streams of Texas as a general rule are but the seaward continuation of long arroyos usually dry in the beginning of their courses.¹ The latitude and the longitude of all interior places are incorrectly given by many degrees.

The delineation of the old Spanish roads across Texas is also a feature of Baron von Humboldt's map indirectly bearing upon the geographic and geologic knowledge of the last century, for they indicate the extent of the country that came under the observation of the travelers of that time. They also indicate that the Spanish inhabitants were familiar with some of the results of one of the characteristic geologic features of Texas, for a road leads to the Paleozoic region of the San Saba, where it is certain that extensive explorations for minerals and some mining operations were conducted by them.²

ANGLO-AMERICAN ADVENTURERS AND COLONISTS.

The general exclusion of foreigners from the region while it was a province of the viceroyalty of New Spain, at the close of the last and in the beginning of the present century, tended to prevent exploration similar to that then going on in the United States, where the war of the Revolution had hardly closed before an epoch of scientific experiment and exploration was inaugurated. Before two decades of the present century had passed, governmental and private expeditions had explored a great portion of the territory of the United States as then defined. According to William Kennedy, who occupied a diplomatic position at a later period in Mexico,³ "it will readily be inferred that the success of the United States in achieving their independence and the rapid growth of the federation were not regarded with indifference by the intolerant and suspicious government of Spain, whose step-dame treatment of its transatlantic dependencies supplied abundant cause of disaffection. Lest the dreaded principles of the North American Republic should contaminate the populous districts of Mexico, it became more than ever necessary to guard against the intrusion of foreigners through Texas. The feelings entertained by the Spanish authorities were manifested in a favorite saying of a captain general of the eastern internal provinces * * * that, had he the power, he would prevent the birds from flying across the boundary between Texas and the United

¹Attention is here called to the misapplication of the old Spanish names by American travelers of this century, to be seen on comparison of any recent map with Humboldt's. It may have been the natural result of the confusing manner in which the Spaniards applied the terms "muddy" and "red" to all streams within this region that we have a great multiplication of "Red," "Colorado," "Pecos," and "Puercos" rivers throughout the Southwest.

²Traditions of these old Spanish mines still cause the people of Central Texas to spend much time in endeavoring to find precious minerals in the various formations of that region.

³Texas: The Rise, Progress, and Prospects of the Republic of Texas. By William Kennedy, esq. In two volumes. Vol. I, p. 236. London, 1841.

States. Perpetual imprisonment, at least, awaited the unlucky wanderer who was caught on the forbidden soil without the protection of a special license." It is not to be understood, however, that the Spanish government was not in its way a most liberal patron of natural science; its encouragement of Humboldt affords sufficient evidence of this. It must be remembered, however, that the time of which we write (1790-1810) was one of peculiar relations to scientific work in New Spain. Not only did the Spanish government, after its manner, encourage science, but, according to the laws of the Indies, which governed the supreme courts of Spanish America, permission to travel was procurable only upon condition that its object was research in natural history. The fact must not be forgotten, on the other hand, that the diluvian theory of that day had not yet met disastrous defeat from the stratigraphists and that the church that governed New Spain still directed and defined the scope of scientific exploration within its territory, and infidel observations were considered no more desirable by the clergy than were Anglo-American explorations by the state. These, also, were the last days of Spain's tottering rule in Mexico, and soon the revolution that ultimately freed the latter country from her power formed another serious obstacle to investigations of Spanish America by citizens of the United States.

PHILIP NOLAN.

Notwithstanding the numerous difficulties, an irrepressible spirit of adventure led many citizens of the United States into Spanish territory. To one of these we are indebted for the first Anglo-American contribution to the knowledge of the geography of Texas. Philip Nolan, a frontier trader, an Irishman by birth, in 1797 made a trading expedition into the Province of Texas from Natchez, Miss., at that time the out-fitting town of the southwestern border. He was a shrewd observer and recorded his impressions of the country, which, on his return to Natchez, he published in a small work accompanied by a topographic map, his being the first description of Texas by an actual observer printed in the United States. The results were trifling, the map was incorrect and restricted, and, moreover, the book is practically out of existence. Upon returning to Texas, Nolan paid the penalty of death for his offense against Spanish jealousy, being shot while resisting capture March 21, 1801.

Others soon followed Nolan, notwithstanding the watchfulness of the Spaniards. None of these, however, except one or two military explorers, referred to hereafter, left written reports of their labors.

AMERICAN COLONIZATION PERIOD.

The Anglo-American adventurers who had so assiduously penetrated the Spanish possessions brought back to the United States many reports of the fertility of the region. The Spaniards cared little for the land

and were desirous of securing actual settlers. The combination of these two facts resulted in that unique epoch of the history of Texas now generally spoken of as the period of colonization under the empresario grants,¹ 1820-1834, during which time Anglo-American settlers gained a firm foothold in what had hitherto been the jealously guarded territory of Spain. During this period Mexico threw off the Spanish yoke, which gave increased impetus to Anglo-American settlement of Texas.

The Spanish system of empresario or contract grants of land was as follows: The authorities gave large tracts to parties or companies upon condition that they would locate upon them a certain number of colonists. The metes and bounds of these grants were not defined by actual surveys, but by certain vaguely understood natural boundaries, such as the streams and mountains. This system of land grants obviated the immediate necessity for governmental topographic surveys and permitted the location of lines to be intrusted to individuals, which much confused the topographic knowledge of the state.

Stephen F. Austin, who on the death of his father, Moses Austin, inherited the latter's concessions, also succeeded him as leader of a body of immigrants from Missouri, and conducted the first colony from the United States to Texas, at the time (1821) a portion of Mexico. He was a man of more than ordinary intelligence, and, pursuing a different course from that adopted by most of the men who accepted the empresario grants, before locating his colony he personally explored the region granted him. He made a practical contribution to the knowledge of the country by means of many articles in the newspapers of the Northern United States and he compiled a map of Texas that was far superior to any that had previously been published.

Mary Austin Holley, in 1833, wrote a small work upon Texas, which gave popular descriptions of its natural history and topography, but was not of marked value to science.

The Texan war of independence (1834-1836), the Texan Republic (1836-1845), and the war of the United States with Mexico (1846) marked years unproductive of important Anglo-American contributions to scientific knowledge of Texas, although a map was issued by Messrs. Hunt and Randall, of the Texas land office, in 1835. They also published a small guide to Texas. The Santa Fé expedition took place during this time, but its annals contain nothing of definite scientific value.²

EUROPEAN INVESTIGATORS.

We owe to foreign investigators the greater portion of the knowledge we now possess of the geologic features of Texas. The writings of Baron von Humboldt have already been mentioned. During the political

¹ See various histories of Texas: Thrall, Kennedy, Foote, and others.

² See Narrative of the Texan Santa Fé Expedition. By George Wilkins Kendall. Harper Brothers, New York, 1850.

troubles incident to the war of Texan independence and its accompanying excitement several distinguished foreigners visited the region, and to them we owe not only the first purely scientific information but also by far the most satisfactory geologic treatise yet published regarding Texas.

WILLIAM KENNEDY.

The British government in the year 1838 sent William Kennedy upon a diplomatic mission to the young Republic of Texas. This gentleman, in addition to a most liberal education, possessed very keen powers of observation, which had been greatly sharpened by years of cosmopolitan travel. While in Texas he closely studied the topography, natural history, and geology of the country, and upon his return to England he published, in 1841, the first intelligent statement of the natural and political history of Texas and the first scientific description of the country based upon personal observation.

Considering the time and the conditions under which this work was written, too much praise cannot be bestowed upon it. Its title page¹ makes no allusion to the valuable scientific matter it contains, and to this alone can I attribute the fact that the book is so little known to scientific men. Book I of Volume I, consisting of 200 octavo pages, is entirely devoted to the "Geography, natural history, and topography of Texas," and contains much of the knowledge set forth by later writers, most of whom, strange to say, have not mentioned this fountain head of their information.²

Although the contribution was small in volume and general in character, it justly deserves the following credit:

(1) It gives the first carefully compiled topographic map of the region. This map represents authentically the state of geographic knowledge of Texas in the year 1839 and is far superior in points of detail, accuracy, and completeness to any of the maps that had been compiled previously or that appeared at about the same period.³

(2) It presents the first geologic description of the country. This description, although short and untechnical, outlines much of what later workers have more carefully described and published, excepting that of a purely paleontologic nature.

(3) It has the first intelligent description of the natural history of the country.

Mr. Kennedy gives first an account of the geographic extent and boundaries of the country and its natural divisions. Stating the "remarkable contrast between the border sections and the lands of the interior," he next deals with the seacoast peculiar to this region, and

¹ Texas: The Rise, Progress, and Prospects of the Republic of Texas. By William Kennedy, esq. In two volumes. London, 1841.

² Dr. Roemer is a notable exception.

³ Hunt and Randall's and Scherpf's maps appeared about the same time as this.

he notes the "alluvial accumulations and encroachments of the land on the gulf." He also gives a general hydrographic view of the State and a comparison of the rivers on the eastern side with those on the western side of the Rocky Mountains, describing many physical features that have now become the common basis of all descriptions.

He devotes an entire chapter to the peculiar climatology of Texas, a subject of great importance in the superficial geology of the State, and one the peculiarities of which Mr. Kennedy described most ably, considering the state of knowledge at the time he wrote. The zoölogic and botanic resources are given, and he was the first to describe the "cross timbers," a unique feature of the country which still remains an unsolved geologic problem.

Mr. Kennedy in describing the general features of the country notices the great extent of the Cretaceous formation in Texas and mentions for the first time in print the older Paleozoic strata. He speaks of fossils, of the various minerals, of "peculiar species of stone," &c. The appearance of asphaltum is mentioned, as well as the superabundant petrified woods of Texas. Mr. Kennedy also gives us the most complete and trustworthy enumeration of the early Spanish, French, and Mexican explorations in Texas.

G. A. SCHERPF.

An emigration movement in Germany gave an impulse at this period to another series of investigations. We probably owe the first German description of Texas to G. A. Scherpf, who in 1841 published a work¹ accompanied by two maps, one being a map of the country to the Pacific Ocean and the other a map of Texas, compiled from the material of the General Land Office of the Republic, in 1839, by Richard S. Hunt and Jesse F. Randall.

The work, as indicated by Dr. Ferd. Roemer, is valuable from the fact that it is based upon the personal observations of the author during a long residence in the country, though Dr. Roemer generally found through observations of the region here and there that Scherpf had painted his picture in too glowing colors.

PRINCE CARL SOLMS-BRAUNFELS.

In connection with the Mainz-Verein, a company organized to facilitate German emigration to Texas, much was published concerning the country. The patrons of the movement were German noblemen, who organized the union at Mayence in the spring of 1844.

In 1846 Prince Carl Solms-Braunfels, the chief promoter of the union and at that time its resident agent in Texas, published and distributed

¹Entstehungsgeschichte und gegenwärtiger Zustand des neuen, unabhängigen, amerikanischen Staates Texas. Ein Beitrag zur Geschichte, Statistik und Geographie dieses Jahrhunderts. Im Lande selbst gesammelt von G. A. Scherpf. Augsburg, 1841. 8°, pp. vi, 154, 2 maps.

throughout Germany a handbook for emigrants to Texas, accompanied by two maps.¹

VICTOR BRACHT.

Victor Bracht added to the German works of this period one² describing Texas in the year 1848. It contained a few references to the topography and the natural history of the State, but it was mainly an enthusiastic appeal for German emigration.

FERDINAND ROEMER.

In 1845 Dr. Ferdinand Roemer, the distinguished geologist and paleontologist, visited Texas to make a scientific study of its adaptation to German settlement. Dr. Roemer was in the State from December, 1845, the month of annexation, until April, 1847. His labors resulted in the most valuable contributions to the knowledge of the geology of Texas that have yet been made. These were published as follows:³ Two preliminary papers in the *American Journal of Science and Arts* and two volumes in German, whose titles, given below, may be respectively translated as "Texas, with especial reference to German emigration and the physical condition of the country, based upon personal observations," Bonn, 1849, and "The Cretaceous formation of Texas and its organic remains, with a description of the Tertiary and Paleozoic strata appended," Bonn, 1852.

These works contain the first purely scientific discussions of Texas. The volume first named, as its title indicates, was chiefly written for

¹ Texas: *Geschildert in Beziehung auf geographischen, socialen und übrigen Verhältnisse, mit besonderer Rücksicht auf die deutsche Colonisation. Ein Handbuch für Auswanderer nach Texas. Seinen deutschen Landsleuten gewidmet von Carl Prinzen zu Solms-Braunfels; nebst zwei Karten von Texas. Frankfurt-am-Main, 1846. 8°.*

² Texas im Jahre 1848, nach mehrjährigen Beobachtungen dargestellt von Victor Bracht (seit 1845 Bürger jenes freien Staates). Elberfel und Iserlohn, 1849, bei Budeker. 8°.

³ Following is a list of the writings of Dr. Ferdinand Roemer on the geology of Texas:

(1) "A Sketch of the Geology of Texas; by Dr. Ferdinand Roemer. (In a letter to the editors dated New Braunfels, German settlement on the Guadalupe, in Western Texas, Comal County, June 12, 1846)." *Am. Jour. Sci.*, 2d ser., Vol. II, pp. 358-365 1846.

(2) "Contributions to the Geology of Texas; by Dr. Ferdinand Roemer." *Am. Jour. Sci.*, 2d ser., Vol. VI, pp. 21-28, 1848.

(3) Texas: *Mit besonderer Rücksicht auf deutsche Auswanderung, und die physischen Verhältnisse des Landes nach eigener Beobachtung geschildert von Dr. Ferdinand Roemer. Mit einem naturwissenschaftlichen Anhang und einer topographisch-geognostischen Karte von Texas. Bonn, bei Adolph Marcus, 1849. 8°, pp. xiv, 2, 464, with map.*

(4) *Die Kreidebildungen von Texas und ihre organischen Einschlüsse, von Dr. Ferdinand Roemer. Mit einer Beschreibung von Versteinerungen aus paläozoischen und tertiären Schichten enthaltenden Anhang und mit 11 von C. Hohe nach der Natur auf Stein gezeichneten Tafeln. Bonn, bei Adolph Marcus, 1852. 4°, 100 pp., with plates.*

German emigrants, but its contents include much valuable scientific matter in addition to the first geologic map of Texas. This was printed in colors, indicating the superficial distribution of the formations. Although crude and imperfect, it contains all the definite information of the region then accessible and most of what has been delineated on more recent maps.

The scientific contents of this work, in addition to the above described map, are as follows:

- (1) The geographic position and bounds of the State.
- (2) A description of the topographic features of the country.
- (3) Its general botanic and zoölogic features.
- (4) Its mineral products.
- (5) Bibliography of writings on Texas.
- (6) Stratigraphic features of the State, including descriptions of the following formations: The diluvial and alluvial (Quaternary), the Tertiary strata, the Cretaceous strata, the older or Paleozoic strata, the Azoic¹ strata.
- (7) The first contribution to the paleontology of Texas, consisting of descriptions (not figured) of the following faunas that he studied, many species of which were entirely new to science: The fossils of the Cretaceous and the fossils of the Carboniferous and Silurian strata on the San Saba River.
- (8) A description by Rev. Adolph Scheele of the plants of Texas collected by Dr. Roemer.
- (9) A zoölogic description of the region, giving many descriptions and localities of the radiata, articulata, mollusca, and vertebrata.

Although Mr. Kennedy had previously alluded to many of the facts here set forth, Dr. Roemer deserves the credit of developing and presenting them to the world; for, as he said at the time this publication was made, he had been unable to find a single European or American publication on the peculiar features or distribution of the geologic formations of Texas.² The explorations of Dr. Roemer in the western portion of the State were limited by the fact that those formations whose exploration would yield the most interesting geologic results begin where the settlements left off and where were located the hunting grounds of murderous Indian tribes.³ So important were the geologic observations of Dr. Roemer, as announced in this volume (and a few scattering magazine articles the year before), and so minutely do they bear upon the subsequent pages of this account that it is thought desirable to give a brief résumé of the work.

(1) He outlined and discussed the age and stratigraphic conditions of the alluvial and Quaternary deposits as now generally accepted and noted the finding of fossil vertebrates⁴ in many localities. He also noted the fossil exogenous woods which they contained, lamenting that their proper horizon was not known. Their occurrence with flint nodules in the detritus of the Tertiary strata he thought an indication of their Cre-

¹ Not so considered now.

² Texas, p. 365.

³ Ibid., p. 366.

⁴ Previously noted by Wm. M. Carpenter. See Am. Jour. Sci., 2d ser., Vol. I, p. 244.

taceous origin. He expresses the opinion that this "diluvial and alluvial" formation is composed by the sedimentation from the erosion going on in the western portion of the State.

(2) He first described the occurrence of the Eocene in Texas, at Wheelock, Caldwell County, where he found *Pleurotoma*, *Fusus*, *Turritella*, *Cerithium*, *Natica*, *Bulla*, *Dentalium*, *Cardita*, *Corbula*, *Nucula*, &c., and justly concluded that they were identical with those of the formation at Fort Claiborne, Alabama. "It is hardly to be believed," he correctly says,¹ "that this Tertiary formation is limited only to this point on the Brazos in Texas, but most probably it is part of a continuous band, as is the case in Mississippi and Alabama, extending along the foot of the Cretaceous, and only the detritus of the later alluvial formations prevents its exposure in most places."

(3) He outlined and described the Cretaceous formation of Texas.² "Of all the formations," said he,³ "either eruptive or stratified, the Cretaceous formation plays by far the most important part in the geologic features of Texas."

(4) He first noted the absence of the Jurassic and the probable absence of the Triassic⁴ formation from the geologic series in Texas.

(5) He first described the stratigraphic relations and the organic inclosures of the Paleozoic rocks between the Pedernales and San Saba Rivers, upon the right bank of the Colorado. This peculiar, isolated outcrop of Paleozoic strata (Potsdam of Walcott), upon the position and relations of which Mr. C. D. Walcott has lately thrown so much light, was well described by Dr. Roemer, considering the state of geologic knowledge at that time. He also noted its resemblance to a certain isolated patch of what he considered similar rocks in Missouri.

Of these rocks:

(a) He first recognized the Carboniferous formation, not by any lithologic peculiarity, but by its undoubted, characteristic fauna, including *Orthis umbiculatum* von Buch and *Spirifera crenistriata* Sowerby. This outcrop was the most southern exposure of the Carboniferous in Texas and Dr. Roemer was unable to explore it farther north.⁵

(b) He first noted the absence of the Devonian in Texas, but erroneously concluded that this formation does not extend west of the Mississippi.⁶

(c) He described an impure, fragmentary, semicrystalline limestone north of the Llano River, in horizontal or hardly disturbed strata, full

¹ Texas, p. 372.

² For details, see p. 71.

³ Texas, p. 373.

⁴ Dr. Roemer's observations did not extend westward to that portion of Texas now said by some disputants to be Jura-Trias.

⁵ Innumerable allusions to "coal" are found in popular works, but most of these undoubtedly refer to the widely disseminated *true lignite* of the Cretaceous and Tertiary, which is very abundant in this portion of Texas.

⁶ Texas, p. 339.

of organic remains, mostly trilobites, only one *Orthis* in addition to these having been observed.

Dr. Roemer observed the same strata some forty miles distant and described several additional organic forms, including the new species *Pterocephalia Sancti Sabæ* Roemer. This he concluded¹ was Lower Silurian. He found at another place a stratum which he also considered Lower Silurian, and which he described as consisting of a firm, white, silicious limestone containing *Euomphalus Sancti Sabæ* Roemer.

(d) He described the character of the older crystalline rocks that underlie the Silurian (Cambrian) strata.

Dr. Roemer's celebrated monograph (*Die Kreidebildungen von Texas und ihre organischen Einschlüsse*) was an elucidation of the facts he had already given in his Texas. Its chief additional points are the figures of Texas fossils and the careful, accurate descriptions of the same, as well as the more detailed account of the Texas Cretaceous. The author alluded to his descriptions in the work entitled Texas as being merely diagnoses, although they far excel in accuracy and fullness many of the descriptions since published by early American paleontologists. This work is one of the most complete and satisfactory of the early contributions to the geology of the United States, and, although printed in 1852,² it still remains the only monograph devoted entirely to the geology of Texas.

U. S. MILITARY RECONNAISSANCES AND EXPLORATIONS.

Principal military reconnaissances and explorations in Texas conducted by the United States Government.

	1806.	1807.	1819.	1820.	1840.	1841.	1845.	1849.	1850.	1851.	1852.	1853.	1854.	1857.	1858.
Maj. Z. M. Pike	—														
Freeman's exploration of Red River.		—													
Maj. S. H. Long			—	—											
Texas-Louisiana boundary					—	—									
Lieut. J. W. Abert							—								
Lieuts. Bryan, Michler, Smith, and Whiting and Capt. French.....								—							
Capt. R. B. Marcy								—	—	—					
Exploration of Red River (Capt. R. B. Marcy).....									—		—				
Pacific Railroad surveys, thirty- fifth parallel (Lieutenant Whip- ple).....												—			
Thirty-second parallel (Capt. J. Pope)													—		
United States and Mexican bound- ary survey (Maj. W. H. Emory) ..														—	—
Artesian well experiment on Staked Plains (Capt. J. Pope)....															—

¹ Texas, p. 388.

² Written in 1848-'49 on material collected from 1845 to 1847.

Our Government has always exhibited commendable enterprise in the exploration of its own territory. President Jefferson inaugurated this wise policy during his first administration by sending Lewis and Clarke upon their memorable expedition to the Northwest. Had the State of Texas shared the benefits of the first half of the century that were enjoyed by the States already in the American Union, its geologic and topographic features would now be much better understood. Notwithstanding that Texas was then part of another country, early United States explorations several times traversed its territory, as recorded in the works mentioned below.¹

In 1806 Major Pike was ordered to ascend the Arkansas River to its source, thence to strike across the country to the head of Red River, and then descend that stream to Natchitoches. By mistake he descended the Rio Grande. He was captured by the Spanish authorities, who sent him home under escort, by way of Chihuahua, El Paso, San Antonio, and the Sabine. His work was of much geographic value concerning the Upper Arkansas region, but added little of value to scientific information concerning Texas. It failed in its original object, to discover the sources of the Red River.

The next year (1807) Lieutenant Freeman and party were sent out by President Jefferson to explore the Red River to its sources, but they were arrested near the eastern border of the present Panhandle of Texas and returned to the United States. The Spanish government, alarmed by these explorations, strengthened its fortifications on the eastern border of Texas to keep out all intruders.

The next Government expedition to penetrate Texan territory was the one conducted by Major Long, in 1819-'20. On his return from the Upper Arkansas he traveled several hundred miles down the Canadian, under the supposition that it was the Red River. A report of his journey was published.² This contained an interesting geographic description of the country, with some geologic facts. Although the Canadian region naturally belongs with the Indian Territory, political boundaries have included a portion of it in Texan territory, and hence to Major Long's description of it belongs the credit of being the first practical

¹ Thrall's History of Texas, p. 24.

Exploration of the Red River of Louisiana, by R. B. Marcy, &c., p. 3.

An account of expeditions to the sources of the Mississippi, and through the western parts of Louisiana, to the sources of the Arkansas, Kans, La Platte, and Pierre Jaun Rivers; performed by order of the Government of the United States during the years 1805, 1806, and 1807. And a tour through the interior parts of New Spain, when conducted through these provinces, by order of the captain-general, in the year 1807. By Maj. Z. M. Pike. Illustrated by maps and charts. Philadelphia, 1810-8°, pp. 7, 277; 4, 67, 55, 87, 1 portrait, 6 maps.

² Account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819 and '20, by order of the Hon. J. C. Calhoun, Secretary of War: under the command of Major Stephen H. Long. From the notes of Major Long, Mr. T. Say, and other gentlemen of the exploring party. Compiled by Edwin James, botanist and geologist for the expedition. 2 vols. Philadelphia, 1823. 8°.

contribution to geologic knowledge of Texas by the Government explorations.

Lieut. J. W. Abert, while returning from New Mexico in 1845, also descended the Canadian River through the northern portion of the Panhandle of Texas. His itinerary and the accompanying illustrations throw some light upon the physical features of the region, but convey little accurate geologic information.¹

In 1840-'41 a joint commission, representing the United States and the Republic of Texas, ran the Louisiana-Texas boundary. The Journal of the Joint Commission affords no geologic information, although a few facts may be inferred from the meager topographic data. This exploration was exceptional in a period of reconnaissances.²

Government explorations were inaugurated in Texas soon after the annexation of that Republic and the subsidence of excitement incident to the war with Mexico which followed.

By the articles of annexation (1845) it was stipulated that the United States Government should protect the people of Texas from the Indians upon their western and northern borders. The settlements at that time did not extend beyond the eastern third of Northern Texas and the city of San Antonio in the south. One of the first acts of the United States Government was to establish a chain of forts from Fort Washita, Arkansas (now Indian Territory), on the Red River, to near the present site of Fort Duncan, near Eagle Pass, on the Rio Grande,³ including Fort Worth (now the prosperous city of the same name); Fort Graham, on the Brazos, in Hill County; Fort Martin Scott, near the present town of Fredericksburg; Fort Croghan,⁴ on the Colorado; and Fort Lincoln, on the Rio Seco, in the southwest corner of Medina County. This chain of fortifications became the base of a series of military explorations in Western Texas that added greatly to the fund of knowledge concerning that region.

The work accomplished was of two kinds, each of which was of some definite value to geologic knowledge. The first was work of reconnaissance for the purpose of obtaining an idea of the general topography of the country in order to facilitate military operations. The second comprised detailed surveys for purposes other than military, embracing the great surveys for the exploration of the railway routes to the Pacific, the exploration of the Red River of Louisiana, the United States and Mexican boundary survey, and an experiment in digging artesian wells on the

¹ Report of an expedition, by Lieut. J. W. Abert, on the Upper Arkansas and through the country of the Comanche Indians, in 1845. Twenty-ninth Congress, first session, Senate Document 438. Washington, 1846.

² Twenty-seventh Congress, second session, Senate Document 199, pp. 54-57, with maps.

³ The northeast and southwest line of this chain of forts almost coincides with the eastern boundary of the true Texas Cretaceous area.

⁴ Abandoned.

plains. All these expeditions were conducted by officers of the regular Army, frequently accompanied by scientific specialists.

The greater part of the reports of these expeditions were published; the first in 1850,¹ though some of them can only be found in manuscript in the archives of the War Department at Washington,² including all preceding 1849.

The character of the published reports was of every degree of value, varying in length from brief communications of only a page or two to large sets of octavo volumes replete with original matter.³

RECONNAISSANCES.

At the close of the Mexican war very little was known of Texas west of the line of fortifications erected in 1846-'47. Not the source of a single river heading in the great plains was definitely known and nothing whatever of the geology of that territory had been revealed.

The first military reconnaissance was that undertaken by Lieut. William F. Smith,⁴ February, 1849, for the purpose of reconnoitering a wagon road from San Antonio to El Paso, a distance of 632 miles. His brief report is very general in its character, but gives many hints concerning the topographic features of the country. It contains no direct contribution to geologic knowledge.

The next expedition was conducted by Lieut. N. Michler, jr.,⁵ and had for its object the reconnaissance of a military road from Corpus Christi to the military post on the Leona. His report contains numerous descriptions of the topographic features of the region traversed. Although its character is purely that of preliminary reconnaissance and its scientific allusions are vague and incidental, the report still remains one of the best descriptions of that portion of the country.

The next exploration of 1849 was that reported upon by Lieut. William H. C. Whiting.⁶ The object of the undertaking can be best understood by the following extract from the original orders under which he acted:⁷

It being very important that a military reconnaissance should be made of the western frontier of Texas, indicated by the chain of posts now established, commencing at the Rio Seco and terminating on the Red River at the mouth of the False Washita, you have been selected for that duty. You will be pleased to embrace in your report the general character of the country, the roads to be constructed between the posts, timber and stone for quarters, fuel and water, and the healthfulness of the country.

¹ Senate Ex. Doc. No. 64, Thirty-first Congress, first session, 1850. Reports of the Secretary of War. This contains reconnaissances in Texas and adjacent regions by sundry officers in 1849.

² For a complete map of Government explorations, see Progress Map of the United States Geographical Surveys West of the One Hundredth Meridian, 1882.

³ Reports of the United States and Mexican Boundary Survey, 4^o, 3 vols.; Pacific Railway Reports, 4^o, 12 vols., &c.

⁴ Senate Ex. Doc. No. 64, Thirty-first Congress, first session, 1850. Report of the Secretary of War, p. 6.

⁵ *Ibid.*, p. 7.

⁶ *Ibid.*, pp. 235-250.

⁷ *Ibid.*, p. 236.

Lieutenant Whiting's report, made in accordance with the foregoing instructions, is by far the most intelligent and comprehensive of the military reports of that year. While keeping the main object of the journey in view, he does not lose an opportunity to interpolate observations upon the geology of the region. His report, of only thirteen pages, is the best yet made of the country traversed, although its contribution to scientific knowledge is small.

A most important contribution to the topography of the region between El Paso and Fort Washita was made by Capt. Randolph B. Marcy upon his journey eastward from Santa Fé to Fort Smith. His route intercepted the headwaters of the rivers that rise along the eastern borders of the Staked Plains and was subsequently visited by the Pacific Railroad surveys. His report includes the first printed description of the region, which will be treated somewhat at length in subsequent pages.

This journey, the first of a series made by Captain Marcy in that region, furnishes the greater portion of our knowledge concerning it. The publications of his observations consist of a large map, showing the routes traversed by him during the years 1849, 1850, and 1851, and his report upon the exploration of the Red River of Louisiana, the latter belonging to the work of exploration, more fully noted hereafter.

Meanwhile Lieut. W. F. Smith, who had completed his reconnaissance of the country between San Antonio and El Paso, was detailed to explore the Sacramento Mountains west of the Pecos River. His report of the work is only two printed pages, but, comparatively, is a valuable contribution to the topography of the region, about which so little is yet known.

Lieut. Francis N. Bryan conducted another expedition in this year. His object was to survey a road from San Antonio to El Paso. His published itinerary of the forty-six days occupied in performing the journey contains much general information concerning the country traversed.

Another contribution to the geography and topography of Texas was made by Lieutenant Michler in the year 1849. He followed Captain Marcy's trail from Fort Washita to the Pecos River. Upon arriving at the Pecos he turned eastward to San Antonio. His printed report was of a general character.

Other reconnaissances were made during the succeeding years, but little has been published concerning them except what is embodied in the reports of the more detailed explorations.

EXPLORATIONS.

The work of the Government expeditions hitherto made, although often securing valuable data, was purely that of hasty military reconnaissances; but we shall see that the national authorities commenced

a series of more deliberate expeditions, usually accompanied by scientific specialists, beginning with Captain Marcy's exploration of the Red River of Louisiana in the year 1852 and continuing until the completion of the United States and Mexican boundary survey in 1855, and including some minor work extending to the year 1858. Thirty-five years ago little was known of Texas west of the one hundredth meridian; even the headwaters of Red River had not been explored; to-day little is known of this region, and no map exists containing more than an approximation to its topography.

EXPLORATION OF THE RED RIVER OF LOUISIANA.

In 1852 Captain Marcy was ordered to explore Red River to its source. Upon his return he published a report¹ of the expedition, which contains the first geologic contribution of value for that part of the State. From this report is compiled the following résumé of the work accomplished by the exploration and its scientific corps:

(1) Barometric and astronomic observations were made by Lieut. George B. McClellan. Although these were oftentimes incorrect,² they constituted a definite contribution to the altitude of that region.

(2) A practical geologist, Dr. G. G. Shumard, accompanied the expedition and made many notes of value, communicating to the world through his own report and the reports of others upon his collections many facts concerning the local geology. His work will be further noticed in this paper.

(3) The source and the confluent of Red River were delineated upon the map.

(4) Collections of botanic and zoölogic specimens of great value were made, upon which many publications were afterwards based.

The strictly geologic work accomplished by this expedition was as follows:

(1) Dr. George G. Shumard, the accompanying geologist, gives a brief description of the country from Fort Smith, Arkansas, westward, by the way of Fort Washita (ten miles north of the present city of Denison, Tex.) and Fort Belknap, Texas, to the headwaters of Red River. His paper contains the first descriptions of the Coal Measures (Carboniferous) of the Indian Territory and Central Texas; many sections of the gypsum bearing region, commonly called the Jura-Trias or Red beds, and the best we now possess of them; descriptions of the Wichita Mountains, composed of granitic rock, which are still but little understood; and interesting data concerning the Cretaceous strata of that region.

¹ Exploration of the Red River of Louisiana, in the year 1852, by Randolph B. Marcy, captain Fifth Infantry, U. S. Army, assisted by George B. McClellan, brevet captain U. S. Engineers; with reports on the natural history of the country and numerous illustrations. Washington, 1854.

² Lieutenant McClellan located the one hundredth meridian nearly 70 miles east of its true position, an error which has caused considerable misunderstanding concerning the boundary of Texas.

It is to him that we owe the first presentation of these strata as they occur at Fort Washita and southward from that place in Texas.

(2) A valuable contribution to the mineralogy of the region, by Dr. Edward Hitchcock, of Amherst. His paper treats of the vast gypsum deposits and the economic and scientific value of that mineral as it occurs in Texas.

(3) Descriptions of the Carboniferous and Cretaceous fossils collected, with figures. This, the paleontologic portion of the work, was the first contribution by Dr. Benjamin F. Shumard to the geology of Texas. The figures are very poorly executed and it is doubtful whether their publication has been of value.

(4) A valuable map of the region, by Captain Marcy, accompanies the report. It contains the results of observations during many years of that officer's travels in this region.

UNITED STATES AND MEXICAN BOUNDARY SURVEY.

While Captain Marcy was exploring the northern portion of the State, another expedition was in progress upon a much larger scale along the southern boundary. This was the United States and Mexican boundary survey of 1848-1855. It is well to bear in mind the immense size of the State of Texas and to remember that Marcy's investigations were in the northwestern portion and Roemer's in the southeastern central, the United States and Mexican boundary survey being confined to the southern region.

The work of this survey in Texas commenced in the year 1853, under Major W. H. Emory, and the field work continued through the year 1854. In 1857 the report¹ of the survey was published. This is of inestimable value to science. It contains the first geologic descriptions of the great region drained by the Rio Grande. In fact, the three large quarto volumes of this report, except a few magazine articles, still form almost the sum total of the literature of that section.

The report embraces papers upon the geology of the route by Messrs. Arthur Schott, James Hall, and T. A. Conrad. Messrs. Hall and Conrad had not seen the region, but made vague and general deductions from reports and from specimens collected by members of the party. Mr. Schott's descriptions are clear and accurate so far as I have observed. Mr. Conrad's paleontologic descriptions were too often based upon material that modern paleontologists would not consider trustworthy evidence of new species. In several instances the localities he gives in the publication disagree with the ones marked by the collector, Mr. Schott, upon the specimens now in the collections of the National Museum.

¹ Report on the United States and Mexican boundary survey, made under the direction of the Secretary of the Interior, by William H. Emory, major First Cavalry and United States commissioner. Vol. I. Washington, 1857.

Dr. C. C. Parry, who wrote the paper in Major Emory's report upon the geology of the upper portion of the Rio Grande, states that the portion of the river from seventy miles below El Paso to Presidio del Norte did not come under his personal observation.¹

These facts are given not to disparage the work, which, as already said, is by far the best contribution to the geology of the Rio Grande from El Paso to its mouth, but to show how infinitesimal is our knowledge of the region of which these small geologic reports are as yet our only authority, a section of country, following the general course of the stream, over twelve hundred miles in length.

The astronomic and topographic determinations of this survey were also very valuable and in general it is the most important and accurate addition to the cartography of Texas that has yet been made.

PACIFIC RAILROAD SURVEYS.

Another Government undertaking that followed closely upon Captain Marcy's exploration of Red River, and that was inaugurated while Major Emory's work upon the Rio Grande was still in progress, was the series of surveys across the region lying between the Mississippi River and the Pacific Ocean, commenced in the year 1853. Two of the lines crossed portions of the State of Texas.

The first of these surveys was conducted by Lieut. A. W. Whipple in 1852 and 1853 and is generally known as the thirty-fifth parallel survey.

The thirty-fifth parallel survey.—This survey traversed that extreme northwestern portion of the State locally designated as the Panhandle (all of Texas north of Red River and west of the one hundredth meridian), a region differing much in its physical aspects from the remainder of the State. The line traveled was approximately that of the Canadian River, and the results were a fair geographic section of the region and a contribution to the scientific knowledge of the Indian Territory, whereby some light was thrown upon the northern extension of the Texas formations.

Lieutenant Whipple, besides having a well equipped corps of topographic engineers, was accompanied by Mr. Jules Marcou, who as geologist took careful notes and collected many specimens. His observations were valuable, but his deductions involved American geologists of the time in a discussion that has not been settled to this day; for, while Mr. Marcou was said to be wrong in certain of his conclusions concerning the so-called Jurassic age of what is now generally accepted Cretaceous, he still possessed the advantage over his antagonists of being the only one who had visited the field. It is often a question in my mind whether Mr. Marcou's terms Jurassic and Neocomian, which he applied to the Cretaceous of Western Texas, are not much nearer the truth than those of the writers who make that portion of the Texas

¹ Report on the United States and Mexican Boundary Survey, Vol. I, Part II, p. 49.

Cretaceous the equivalent of the upper members of the European series. He was one of the first practical geologists to visit this northwestern section of Texas. His observations were limited to that small portion of the State traversed by the Canadian River, but they constitute the chief data concerning the region to which they pertain. It is much to be regretted that their usefulness was impaired by the misunderstanding that ensued between him and the Secretary of War. Before Mr. Marcou could write a final and complete report his notes were peremptorily demanded as he was departing for Europe, and later they were intrusted to Mr. W. P. Blake to write out. He published Mr. Marcou's field notes in full, although he failed in that interpretation which could have been made only by Mr. Marcou, and gave the world an opportunity to make its own deductions.

The results¹ of the thirty-fifth parallel survey, although presenting many imperfections and marred by this unfortunate occurrence, were upon the whole a great addition to our knowledge of the Indian Territory and Northwest Texas regions.

The thirty-second parallel survey.—Another survey across the State of Texas for the purpose of finding a suitable railway route to the Pacific was that conducted by Capt. John Pope along the thirty-second parallel in 1853. Practically the route was the same as the one traveled by Captain Marcy upon his return from New Mexico, in 1848, a description of which has already been given (p. 24). The work of this exploring expedition, so far as it pertained to Texas, commenced at El Paso, in the western portion of the State, and progressed eastward. It approximately followed the thirty-second parallel to near the mouth of Delaware Creek, and thence passed slightly north of eastward to Preston, on Red River, a few miles northwest of the site of the city of Denison. It crossed, en route, the Paleozoic strata of the trans-Pecos region, the Jura-Trias or gypsum bearing series, the typical Texas Cretaceous, the Central Texas Coal Measures, the two belts of the cross timbers, and the Cretaceous to the east of the central Carboniferous exposures. The astronomic, topographic, and barometric measurements were important, but the geologic results were impaired by the fact that no trained geologist accompanied the expedition. The notes of the officers and the specimens gathered under Mr. Marcou's direction, however, were turned over to him by Captain Pope, and he wrote a brief general preliminary report upon them.²

¹ Reports of explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War in 1853-'54,-'55, according to the acts of Congress of March 3, 1853, May 31, 1854, and August 5, 1854. Volume III. Washington, 1856.

² Report of Secretary of War. House Document 129, Vol. 4, Chap. XIII, pp. 125-128. Geological notes of a survey of the country comprised between Preston, Red River, and El Paso, Rio Grande del Norte, in Report of Exploration of a Route for the Pacific Railroad near the Thirty-second Parallel of Latitude, from the Red River to the Rio Grande: By Bvt. Capt. John Pope, Corps of Topographical Engineers, 1855.

The notes and specimens of this expedition were taken from Mr. Marcou, together with those of the thirty-fifth parallel survey, and hence he was debarred from the privilege of writing the final report for the large quarto volumes that subsequently appeared.¹ These contained a written report by Mr. W. P. Blake, which gave little additional knowledge.

ARTESIAN WELL EXPERIMENT.

The last exploration in Texas conducted by military officers under specific Government appropriations was that for the purpose of boring artesian wells upon the plains, conducted by Capt. John Pope, in 1857 and 1858.² This experiment yielded important geologic information, for accompanying the expedition as geologist was Dr. George G. Shumard, who collected much material and wrote an article on the local geology,³ adding much to our knowledge of the trans-Pecos region, showing the existence of the Carboniferous, the Cretaceous, and the gypsum bearing Mesozoics in that part of the State.

During this expedition Dr. G. G. Shumard collected the material that formed the ground work of Dr. B. F. Shumard's article upon "New fossils from the Permian strata of New Mexico and Texas." This paper first announced the existence of Permian strata in Texas.⁴

This work practically ended United States explorations in Texas for the time. The State then exhibited a keen desire to explore its own geologic resources. In a few years the civil war drew the energies of our military forces to a more serious field and the posts along the Texas frontier were evacuated, and until the inauguration of work by the United States Geological Survey in the State no further contributions were made by United States explorers.

GEOLOGIC SURVEYS CONDUCTED BY THE STATE.

For the information contained in the following pages I am indebted to various persons. Much of it has been compiled from the official reports

¹ Reports of explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. Made under the direction of the Secretary of War, in 1853-'54, according to acts of Congress of March 3, 1853, May 31, 1854, and August 5, 1854. Vol. II. Washington, 1855.

² Artesian well experiment. Reports of Capt. John Pope, Top. Eng., to Capt. A. A. Humphreys, Top. Eng., in charge of office of Exploration and Survey, War Department. To be found in Senate Ex. Doc., Thirty-fifth Congress, second session, 1858-'59, Vol. 2 (which is Report of the Secretary of War, J. B. Floyd, first part), pp. 582, 590-608.

³ Trans. Acad. Sci. St. Louis, Vol. I.

⁴ Still little understood, but now considered either Permian or uppermost Carboniferous, being the latest of the latter age.

of the several State geologists. A greater portion, however, has been kindly furnished by those familiar with the facts presented.¹

The burning of the archives by the capitol fire in 1881 has deprived me of what under ordinary circumstances would be the most useful source of information.

To some it is a matter of surprise that the State of Texas has not made a thorough geologic survey of its territory, especially since the State has always been comparatively free from financial embarrassment and owns the public lands within its borders, the value of which could not but have been enhanced by a scientific knowledge of their characteristics. A thorough study of the political history of the State will show, however, that a combination of untoward circumstances has invariably thwarted the effect of enactments looking toward such a survey.

Up to the time when the Anglo-American population extricated Texas from the Spanish-Mexican régime (1835) it had been under the non-progressive rule of the Middle Ages. The other States of the Union had previously attained a permanent form of government, allowing the public mind to follow intellectual and scientific pursuits with the greatest impetus during the first third of the nineteenth century. Amidst the throes of political organization scientific interests always flag. Time is required for the establishment of a stable government. While undergoing its political evolution, Texas had two wars with Mexico and a continual fight with hostile savages. Twenty years from the date of its separation from Mexican domination seems but a short period for the establishment of a geologic survey.

But a still greater obstacle to an early thorough survey of its domains was the fact that the population, even until the last decade, was confined to the eastern third of the State, and that until a dozen years ago the hostility of the Indians made observation in the vast unsettled region exceedingly dangerous. In 1849 Dr. Roemer said that Texas became interesting geologically at the points where civilization left off and where exploration was almost impossible. His remarks would have been equally applicable thirty years later.

Notwithstanding these obstacles, the State of Texas did establish by legislative enactment and appropriation what was intended to be a thorough topographic and geologic survey of its domains. This honorable design was defeated by the civil war and the petty jealousies of the scientific men to whom the State had intrusted the labor. The State made two earnest endeavors to secure a geologic survey of its domain and that such a survey has not been made is not due to its indifference.

Before describing these surveys and their results, it will be well to mention briefly the Texas land office, an institution whose functions have a distant connection with scientific results.

¹I am especially indebted to Prof. G. C. Broadhead, of Pleasant Hill, Mo.; Mr. Frieuch Simpson, of Columbus, Tex.; Hon. A. D. Norton, of Dallas, Tex.; Mr. C. K. Lee, of Colorado, Tex.; Hon. J. G. Tracey, of Houston, Tex., and Mr. N. A. Taylor, of Abilene, Tex.

THE TEXAS LAND OFFICE.

The Republic of Texas, having in its possession a large unsettled domain, found it necessary, as one of the first acts of its existence, to establish some method of administering the duties incident to the survey and the disposition of the land. By act of December 22, 1836, a land office was opened at the capital in February, 1838, under the control of a salaried commissioner.

The functions of this office were to preserve a record of surveys, to issue warrants for land, and to prevent error or fraud in their location. The Republic of Texas followed the Spanish method of granting lands,¹ by which the State incurred no expense of survey in their location. Instead of making topographic surveys of the public lands and dividing them according to the township system of the United States land surveys, the State issued scrip for a designated number of acres to be located upon any portion of the territory found vacant. The person locating the land employed a surveyor (oftentimes of inadequate skill), who ran the lines of the location and sent in field notes of his survey to Austin. By this method the State obtained very unsatisfactory information of these surveys. By the township system, on the other hand, at least a correct map of the main topographic features would have been secured. The land office of the State published several maps of Texas, but they were chargeable with incorrectness. Dr. B. F. Shumard said: "The maps in the land office at Austin are more or less imperfect and the surveys in some instances exceedingly erroneous;"² yet these maps were the only contributions of the State land office to a scientific knowledge of Texas. Their value is of a doubtful if not of a negative character. The commissioners have made regular reports to each legislative body. A few of these have been printed, but they contain nothing of scientific value. The whole series of reports can be found only in the land office at Austin.

FIRST GEOLOGICAL SURVEY (SHUMARD).

By act of the 10th of February, 1858, the legislature of the State of Texas authorized a geological and agricultural survey of the State. It was made the duty of the State geologist to make as speedily as possible "a thorough and complete geological survey of the State, so as to determine accurately the quality and characteristics of the soil and its adaptation to agricultural purposes; the species of produce to which the soil in different sections is adapted; its mineral resources, their location and the best means for their development; its water powers, their location and capacities; and generally everything relating to the geological and agricultural character of the State."³

¹ See p. 12.

² First Report of Progress of the Geological and Agricultural Survey of Texas, by B. F. Shumard, State Geologist, pp. 8, 9.

³ *Ibid.*, p. 5.

To fill the office of State geologist, which was created by the same act, Governor H. R. Runnels, on the 28th day of August, 1858, appointed Dr. Benjamin F. Shumard.¹ This gentleman's life of scientific training and his experience in geologic surveys gave him every qualification for the position.²

Organization and equipment.—His first act³ was to select from the works of the best instrument makers a set of chemical and physical apparatus for the equipment of analytical laboratories at Austin and of meteorologic stations at one or two other points. Since the climatic and meteorologic conditions existing in the State of Texas are important factors in the geologic effects, the wisdom of Dr. Shumard's endeavors to study these phenomena will be apparent.

He organized his staff of assistants as follows: Assistant geologist, Dr. George G. Shumard; chemist and assistant geologist, Prof. W. P. Riddell; topographer, Mr. A. R. Roessler; meteorologists, Prof. Caleb G. Forshey, at Rutersville, and Swante Palm, esq., at Austin.

The qualifications of all these gentlemen were considered the best for their day and time. Dr. George G. Shumard possessed the largest store of scientific information, especially concerning the western portion of the State, having accompanied Captains Marcy and Pope as a geologist in their numerous explorations.

Professor Riddell, besides being an able chemist, was especially well informed respecting the structure of the settled portion of the country.

Mr. Roessler, although a young man, possessed a good scientific education, was a hard worker, and to him is due much of the accurate topographic knowledge of the State we possess at the present day.

The meteorologic stations were established in accordance with the plan adopted by the Smithsonian Institution.

Field labors.—The geologic corps proper was divided into field parties, and in January, 1859, these entered upon their duties. The first of them, under Dr. George G. Shumard, constructed an accurate section of the country between Austin and the Red River in Grayson County. Dr. Shumard also made "thorough and final surveys" of the counties of Grayson, Fannin, and Cass, and partial surveys of Bowie, Red River, and Lamar Counties. In addition to this work, he made a

¹ There is a tradition, with some ground for belief, that Governor Runnels intended to appoint Dr. G. G. Shumard to the office of State geologist, but, by a clerical error, the name of his brother, Dr. B. F. Shumard, was inserted in the original commission. This being before the days of rapid communication it was impossible to remedy the error, and Dr. G. G. Shumard gracefully accepted the position of assistant State geologist.

² For a sketch of Dr. Shumard's qualifications, see Texas Almanac for 1859.

³ The following account of the operations of the survey is principally based upon the First Report of Progress of the Geological and Agricultural Survey of Texas, by B. F. Shumard, Austin, 1859.

careful exploration of Red River from Cooke County to the Louisiana boundary.¹

Professor Riddell made final surveys of the counties of Caldwell and Guadalupe, south of Austin, the State capital, and of McLennan and Coryell, near the geographic center of the State; also of the greater part of Bosque County.

Dr. Benjamin F. Shumard, the head of the survey, made detailed surveys of Burnet and Rush and partial surveys of Travis, Bastrop, Washington, Fayette, and Young Counties. He also made a series of reconnaissances. Dr. Shumard in his report² said:

It will be seen that besides a general survey extending over a large portion of the eastern and middle portions of the State, we have made minute and final surveys of eleven counties. Two are nearly finished and a number partially surveyed.

Methods of survey.—From the report cited we extract the following:

In making these preliminary surveys careful sections of the strata have been made at all points of outcrop within reasonable distances of the route traveled, and the thickness, stratigraphical order, dip, and mineral and fossil characters of the various beds have been determined with as much precision as possible. * * * In some counties sections of the strata have been measured at more than one hundred and fifty localities. * * * We made frequent barometrical observations to ascertain the elevation of the country above tide-water, and much attention has been directed to obtaining a correct knowledge of the topographical features.

We have also determined, with as much accuracy as possible, the amount and quality of timber in each county, proportion of timber and prairie, elevation of hills, depth and width of valleys, and the amount of available water power furnished by the streams.

A large share of attention has also been devoted to the agricultural capabilities of these counties. The different varieties of soils and subsoils have been carefully examined, numerous specimens have been collected for future study and analysis, and we have spared no pains to ascertain the most advantageous methods of cultivating and improving them.

Particular search has been made for minerals of economical importance, and all mines, whether of prospective or known value, have been examined with special care and the probable amount, richness, and quality of the ores determined. Samples of ores and their accompanying minerals, coals, limestones, marbles, clays, mineral waters, &c., have been collected, and are now deposited in the laboratory at Austin, for chemical analysis and final preservation in the State cabinet.³

¹ Since this work was prepared for the press the notes of Dr. G. G. Shumard have been collected and published by the State of Texas in a volume entitled "A Partial Report of the Geology of Western Texas, consisting of a General Geological Report and a Journal of Geological Observations along the Routes traveled by the Expedition between Indianola, Tex., and the Valley of the Mimbres, New Mexico, during the years 1855 and 1856; with an Appendix giving a detailed Report of the Geology of Grayson County. By Prof. George G. Shumard, assistant State geologist of Texas. Austin, State Printing Office, 1886." 8°, pp. vii, 145, with illustrations.

² First Report of Progress of the Geological and Agricultural Survey of Texas, by B. F. Shumard, State geologist, p. 8.

³ *Ibid.*, p. 8.

Of the fossils, Dr. Shumard remarked that the collection was "especially large and valuable, and, it is believed, when carefully studied will throw considerable light on some disputed points of the geology of the West and Southwest."

Maps.—On the subject of maps Dr. Shumard said:

Our county maps will embrace the areas occupied by the different geological formations, localities of workable mines, ore deposits, coals, lignites, marble and stone quarries, medicinal and other springs, furnaces, towns, post offices, churches, saw and grist mills, and boundaries of timber and prairie. This portion of our labor has often been attended with considerable difficulty, arising from the fact that the maps in the land office at Austin are more or less imperfect and the surveys in some instances exceedingly erroneous. It has been sometimes almost impossible to locate our observations with that degree of minuteness and precision which was thought desirable, but we have spared no exertions to remedy defects, supply omissions, and to make our maps as complete as possible in their geographical as well as in their geological details.

Such is a brief account of the first year's operation of the geological and agricultural survey of Texas, as stated by its director in his first annual report of progress. It is obvious that Dr. Shumard had accomplished much during this brief time and that the plans of organization and operation were such as to result in the accomplishment of one of the most valuable State surveys, could they have been carried out.

Operations of 1860.—After a brief winter's work in quarters at Austin, the Survey resumed the field in 1860. The records of the year's work are meager, for a series of misfortunes occurred by which the results of the survey, excepting a few fragments to be hereafter noted, were lost to science, and a blow was inflicted upon State encouragement of scientific investigations from which the State has not yet recovered.

The personnel of the scientific corps remained unchanged, except that at the beginning of the year Dr. Shumard employed as a collector of plants a young man, S. B. Buckley, who became a prominent figure in the subsequent history of the surveys.

From Mr. Buckley we have the only published account of the survey's operations during the year,¹ of which he speaks as follows:

In January, 1860, I was also employed as an assistant by Dr. Shumard, I having charge of the botanical department, also making geological observations.

In May, 1860, Drs. Shumard, Riddell, and myself went, via San Antonio, to Corpus Christi, returning by the way of Goliad and Lockhart to Austin. About the 1st of June we started for the survey of Navarro County, which was finished about the 1st of July; then we removed, spending the month of July in the survey of Washington County. The month of August was employed in the examination of Bastrop County. Thence returning to Austin, we went into San Saba, remaining there until November.

Dr. George G. Shumard spent the summer in Northern Texas, in Grayson, Lamar, Fannin, and other counties on the Red River. He returned to Austin in September.

During the summer Dr. B. F. Shumard had been a large portion of the time at Austin, leaving Dr. Riddell and myself in the field. At Austin he was closely watched by Governor Houston, who, being convinced that Dr. Shumard was not a suitable person for a State geologist, removed him about the 1st of November, 1860.

¹ First Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, A. M., Ph. D., State geologist, Houston, 1874, p. 8.

On the same page from which the above is quoted and on the following one Dr. Buckley shows very plainly the spirit in which he served his chief. He says :

Returning in January, we found Dr. Shumard still at Austin, occupying his former room at the geological department. Dr. Moore thought it rather strange that Shumard had not vacated the office. In excuse, Dr. Shumard assured Dr. Moore that he would do nothing which would injure the interests of Dr. Moore, and that he only wished to arrange his business and start for the North. Thus assured, we started for Llano County, but on our route Dr. Moore, thinking that all might not go right at Austin, where the [secession] convention of 1861 was then in session, requested me to return and arrange specimens, and watch Dr. Shumard, with whom I was then on friendly terms. Soon after my arrival at Austin a friend informed me that Dr. Shumard was busily engaged in persuading the members of the convention to displace Dr. Moore and reinstate him in office again, and that, too, with every prospect of success. To thwart this, I drew up some charges against Dr. Shumard and placed them in the hands of Governor Houston, who showed them to some of the leading members of the convention, and nothing further was done in favor of Dr. Shumard, who soon after left for St. Louis, vowing vengeance, saying that he would break down my scientific reputation.

Mr. Roessler says :

Aside, however, from Mr. Buckley's own acknowledgment of his motive in drawing up these charges, he shows his maliciousness and willful intention, if possible, to suppress the truth by neglecting to state that when these charges were presented the legislature of Texas, in its session of 1860-'61, appointed a committee for their investigation, of which Mr. Waelder was chairman. He also neglects to state that Dr. Shumard courted an investigation and voluntarily and promptly appeared before the committee appointed, and that the utter falseness of the charges was proved by such well known gentlemen as Professor Forshey, Senator Russell, and Colonel Timmons.¹

A State election had occurred in the fall of 1859, and after much bitterness on both sides Governor Runnells, the democratic incumbent and the patron of the survey, was succeeded by Gen. Sam. Houston, independent, who, under the influence of political and personal effort brought to bear for that end, removed Dr. Shumard, after an administration of twenty-six months.² Dr. Shumard left the State at the outbreak of the war, during which most of his notes, collections, and maps were lost or destroyed, and made his home at St. Louis, where he died in 1869,³ having had no opportunity to publish an official report, but having contributed to our knowledge of the geology of Texas by his fragmentary pub-

¹ Reply to the charges made by S. B. Buckley, State geologist of Texas, in his official report of 1874, against Dr. B. F. Shumard and A. R. Roessler, p. 7.

² Dr. Shumard was reinstated by the legislature, in April, 1861, to prepare his final report, which was never published.

³ For the biographical data concerning Dr. Shumard in this paper we are indebted to the sketch in the *Am. Jour. Sci.*, 2d ser., Vol. XLVIII, pp. 294-296; to A. R. Roessler's reply to S. B. Buckley; and to Prof. G. C. Broadhead and others.

Dr. B. F. Shumard was born at Lancaster, Pa., November 24, 1820. His father afterwards removed to Cincinnati, and while he was living there Dr. Shumard graduated at Oxford, Ohio; returning to Philadelphia, he went through one course in the medical college of that city. His father then removed to Louisville, Ky., where young Shumard completed his medical studies, in 1846. He then practiced medicine in one of the interior towns of Kentucky. Here he developed his taste for paleontologic investigation, and after a few months' country practice he removed to Louisville. In this

lications, of which we shall speak more definitely hereafter. The survey as carried on under his immediate successors may, for convenience, still be called the Shumard survey, as it was an attempt to continue his work rather than to inaugurate any new system of work or of organization.

Immediately upon the removal of Dr. Shumard, November, 1860, the governor appointed Dr. Francis M. Moore State geologist. He was an honorable and cultured gentleman, of much executive ability. For many years he had been the editor of *The Houston Daily Telegram*, then the leading newspaper of the State. It was owing to his public spirited and intelligent advocacy of its necessity that the survey was originally established.

According to Dr. Buckley¹ he himself was appointed first assistant State geologist; Dr. Riddell, who had been assistant State geologist and chemist, was retained as chemist; and Mr. Roessler was

city he became associated in scientific and professional pursuits with Dr. L. P. Yandell, and together they devoted much of their leisure to the study of geology and paleontology. Several valuable paleontologic contributions were published under their joint authorship. Dr. Shumard was an earnest and careful collector, and his cabinet at Louisville was visited by many distinguished foreigners.

Dr. Shumard's geologic talent was not long in receiving recognition. He was appointed by Dr. David Dale Owen as assistant geologist in the geological survey of Iowa, Wisconsin, and Minnesota, which was inaugurated in 1846 by authority of Congress.

Dr. Shumard was busily engaged in the field during 1848 and 1849 as the head of one of the divisions of the survey. Many of the most valuable reports upon the geology and paleontology of this survey, from his pen, "remain monuments to the industry, acquirements, and ability of their author."

Besides his share in the publication of these reports, Dr. Shumard, about the same time, published a valuable monograph, entitled *Contributions to the Geology of Kentucky*. In the work of the Iowa, Wisconsin, and Minnesota survey he was associated with many men who have since become eminent in the annals of North American geology; including F. B. Meek, Dr. J. Evans, Prof. A. Litton, and others.

In 1853 Dr. Shumard removed to St. Louis and was appointed assistant geologist and paleontologist of the Missouri geological survey under Professor Swallow. He labored here until the summer of 1858, when he was appointed State geologist of Texas. He arrived at Austin on October 30 of the same year and initiated the work of a survey upon a broad and comprehensive plan.

At the beginning of the war the doctor returned to St. Louis. He was obliged to leave a large part of his collections and library at Austin through the war. He again took up the practice of medicine, which he continued to the year of his death.

He had been in a declining state of health for about a year, having suffered from hemorrhage of the lungs, when his death occurred, April 14, 1869.

In St. Louis Dr. Shumard had the intellectual and social companionship of that small coterie of western scientists who made that place a scientific center for many years.

As a paleontologist he held a high rank. He was president and one of the organizers of the Academy of Science of St. Louis and a member of many other similar societies at home and abroad.

He was a man of science in the highest sense of the word and devoted himself entirely to its pursuits; in the prosecution of it he contributed more, perhaps, than any other man to the revelation of the immense resources of the Mississippi Valley.

¹First Annual Report of the Geological and Agricultural Survey of Texas, p. 8.

retained as draftsman. In December, 1860, Drs. Moore and Buckley¹ made a short reconnaissance through the southern counties of the State, and in March they made a tour through Western Texas, during which trip the survey was suspended. The resolution suspending the survey is as follows:

Be it resolved: (1) That the geological survey be suspended, with the exception of the State geologist and chemist, who shall continue in the survey only so long as it may be necessary to make out the report hereinafter provided for.

(2) That B. F. Shumard, the State geologist, be requested to make a report of his survey so far as the survey has been completed, and for that purpose shall have control over the cabinet and rooms and his notes and the services of the chemist, and he shall receive a like salary heretofore paid the State geologist until the work be completed: *Provided*, Said report shall be made by the 1st of July next; which compensation shall be paid out of the appropriations heretofore made for the support of the geological bureau.

(3) That Dr. Francis Moore, present State geologist, be requested to make out a report of the work executed up to the present time.

Approved, April 8, 1861.

What was done towards complying with this act cannot be ascertained. It is certain that no reports were published and apparently the agitation of the civil war prevented further work. The act seems to imply an official justification of Dr. Shumard, which is not mentioned in any of Dr. Buckley's sketches of the history of the surveys.

The civil war had now broken out and Dr. Moore left for the North in July, 1861, and in 1864 died in Northern Michigan, while in the employ of a mining company.

During the war the State capitol was occupied by troops and the laboratories and the museum of the survey were converted into a manufactory of percussion caps. The magnificent specimens were taken away as curiosities or wantonly destroyed and many of the precious notes and maps were scattered to the winds.

At the opening of the war Dr. Buckley also left the South, taking with him, as has been charged by Mr. Roessler,² the notes of the survey. At the close of the conflict he returned to Austin, assumed charge of the collections and effects of the survey, and secured the passage of a joint resolution repealing the act of April 8, 1861, by which the survey had been suspended. He was appointed by Governor Throckmorton, in November, 1866, to take charge of the survey, notwithstanding the protests of Dr. B. F. Shumard,³ Mr. Roessler, and others, previously of

¹ First Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, p. 8.

² Reply to the charges made by S. B. Buckley, State geologist of Texas, in his official report of 1874, against B. F. Shumard and A. R. Roessler, p. 10.

³ In a letter to Swante Palm, esq., under date of August 11, 1866, Dr. Shumard thus characterizes Mr. Buckley's standing in his service: "In the same article he claims that he was connected with me in the geological survey. Now, he came to me ragged and penniless, and I employed him to collect plants at one dollar per day, giving him precisely the same wages I was giving my teamsters and cooks. All the geology he knows I taught him, and that was precious little."

the survey. The unfinished report of Dr. Shumard, which the legislature in 1861 had given to Dr. Moore to complete, now fell to his charge so far as materials remained. Dr. Buckley put forth in 1866 a work entitled *A Preliminary Report of the Geological and Agricultural Survey of Texas*. In a prefatory note he speaks of the book as the report of work done under the supervision of Dr. Moore, adding that his connection with the survey had been longer than Dr. Moore's and that all the knowledge obtained by service under Dr. Shumard which promises to have any public value is embodied in its pages. The book contains 92 octavo pages, including title and index, and a large proportion of these pages is occupied with general statements as to agricultural operations and the whole is of little scientific value. In the words of Mr. A. R. Roessler:¹

It does not contain the analysis of either soils or minerals or the delineation of a single fossil, geological section, or anything else in that direction. In fact there is nothing new in it, the whole report being a poor rehash of articles published in the *Texas Almanac* and other periodicals.

In 1867 the political winds blew out the administration that upheld Dr. Buckley before he printed any further report. Under military rule and changes that ensued was swept away the last remnant of the original geological survey of Texas as inaugurated by Dr. Shumard nine years before, except a few disordered specimens, which were completely destroyed by the capitol fire in 1881.

Official results.—The destruction of records by the capitol fire leaves no opportunity to gather official information as to what was accomplished by the survey, but from unofficial sources I have endeavored to make up as accurate and complete a statement as possible.

There were two direct publications of the survey. The first was the *First Report of Progress of the Geological and Agricultural Survey of Texas*, by B. F. Shumard, State geologist. It was a pamphlet of 17 pages, of which 1,700 copies were printed for distribution. It may be found in the libraries of the National Museum and the U. S. Geological Survey at Washington. The second official publication was *A Preliminary Report of the Geological and Agricultural Survey of Texas*, by S. B. Buckley, 1866, already described.

Indirect results.—Although the State published so little concerning the geological investigations of the Shumard survey, the scientific men who were attached to it made known useful data concerning the geology, topography, and paleontology of the State. Dr. Shumard described many new species and contributed much to the stratigraphic knowledge of the State. His publications, based upon material gathered and observations made while connected with the State survey, are as follows:

¹ Reply to the charges made by S. B. Buckley, p. 11.

"Observations upon the Cretaceous strata of Texas," Acad. Sci. Saint Louis, Vol. I, pp. 582-590, 1860.

"Descriptions of new Cretaceous fossils from Texas," Trans. Acad. Sci. Saint Louis, Vol. I, pp. 590-610, with figures, 1860, published by Dr. C. A. White in his Contributions to Paleontology, No. 1, Eleventh Annual Rep. U. S. Geological (Hayden) Survey.

"Descriptions of five new species of Gasteropoda from the Coal Measures, and a Brachiopod from the Potsdam Sandstone of Texas," Trans. Acad. Sci. Saint Louis, Vol. I, pp. 624-627, 1851.

"State House artesian well at Austin," Texas Almanac, pp. 161, 162, 1860; gives valuable geological section.

"Geological survey of Texas," Texas Almanac, pp. 199, 200, 1860, Galveston, 1859.

"The Primordial zone of Texas, with descriptions of new fossils," Am. Jour. Sci., 2d ser., Vol. XXXII, pp. 213-321, 1861.

"Descriptions of new Cretaceous fossils from Texas," Proc. Boston Soc. Nat. Hist., Vol. VIII, pp. 188-205, 1861-1862.

"Observations on the Cretaceous strata of Texas," Texas Almanac, pp. 203-205, 1861.

Extract from a letter to the corresponding secretary of the Academy of Science of Saint Louis, read November 5, 1860; mentions the discovery of dicotyledonous leaves in the Cretaceous strata of Red River, Trans. Acad. Sci. Saint Louis, Vol. II, pp. 140, 141.

"Descriptions of new Paleozoic fossils," Trans. Acad. Sci. Saint Louis, Vol. II, pp. 108-113, 1862; describes *Goniatites Texanus*, a new Carboniferous fossil from the bluffs of Wallace Creek, San Saba County, Texas.

Communication to the Academy of Science of Saint Louis, March, 1861, announcing the apparent discovery of the Ripley group of the Cretaceous in Texas, Trans. Acad. Sci. Saint Louis, Vol. II, p. 152.

At the time of his death Dr. Shumard had in his possession many valuable notes and unpublished manuscripts concerning the geology and paleontology of Texas that would, no doubt, throw much light upon some of the important points concerning that region. Dr. C. A. White has published illustrations of some of the species¹ he described without figures, and this will probably be done in the case of others of his unfigured specimens as soon as duplicates can be collected and identified. The notes and manuscripts, however, should not be lost to science, and it is hoped that some friend of the deceased will produce them ultimately for publication.

Mr. Roessler, the topographer of the survey, has published several valuable maps, among them a large topographic map of the State, printed in 1874, embodying the plans set forth by Dr. Shumard in his report of progress.

The final remnant of the collections remained for many years in the capitol building at Austin, until the burning of that structure in 1881 completely destroyed the last trace of them.

Expense.—It is impossible to ascertain the exact cost of the Shumard survey to the State of Texas from the date of its inception, November, 1848, until the publication of Dr. Buckley's report in 1866. Dr. Buckley states that Dr. Shumard expended \$28,000 during the twenty-six months of his administration, which was \$8,000 in excess of the appropriation.

¹ Contributions to Invertebrate Paleontology No. 2. Twelfth Annual Report U. S. Geological and Geographical Survey of the Territories. F. V. Hayden, U. S. Geologist. Part I, Geology, Paleontology, and Zoölogy. See pp. 22, 38, 39.

The following items of expenditure are mainly compiled from Dr. Shumard's First Report of Progress, pp. 16, 17. They represent the disbursements of the first fourteen months of his administration :

Salaries: Chief geologist, at \$3,000 ; two assistant geologists, at \$1,500 each ; topographer, at \$600 ; various subordinates: aggregating.....	\$7,195 71
Equipment (including fitting up of office, apparatus, laboratories, stables, purchase of teams, camp equipment, &c.).....	4,947 62
Traveling and transportation expenses.....	2,845 96
Office expenses.....	83 71
	<hr/>
Total expenditure.....	15,073 00
Deduct cost of equipment	4,947 62
	<hr/>
Actual running expense for fourteen months.....	10,125 38

The expense of the continuation of the survey under the four months of Dr. Moore's administration cannot be obtained. Based upon the cost of Dr. Shumard's for a similar time they could not have exceeded \$4,000, for it must be remembered that retrenchment was the watch word under which he was appointed to the directorship.

The cost of Dr. Buckley's administration for one year could not have exceeded \$4,000, as he had no assistants and the State was only at the expense of his salary and the cost of publishing his pamphlet. It may be fairly estimated that the total expense of this survey to the State was less than \$25,000.

THE SECOND GEOLOGICAL SURVEY (GLENN-BUCKLEY).

Since the disastrous end of the Shumard survey in 1867 little work of positive scientific value has been done by the State of Texas. When the immediate effects of the civil war had passed away and the political excitement of the reconstruction period had subsided, the expediency of reorganizing the State survey was again broached.

To distinguish it from the Shumard survey, described in the previous pages, this new organization may be called the second geological survey or the Glenn-Buckley survey. It accomplished even less than the first one.

By legislative enactment, approved August 13, 1870, the governor was authorized to appoint a State geologist, with the consent of the senate, the incumbent to give security in the sum of \$5,000. The State geologist was to appoint two assistants, one of whom was to be an expert chemist and mineralogist. The duties of the survey were to make a descriptive survey of the State, and an agricultural, geologic, and mineralogic examination and classification of rocks, soils, minerals, mineral waters, fossils, &c. Rooms were to be provided by the governor for the deposit and arrangement of specimens by the geologist. A report of progress was to be made to the governor at each regular session of the legislature. The salary of the principal geologist was to be \$3,000; of the principal assistants, each, \$1,800, traveling and incidental expenses to

be paid by the State. Appointees were required to take an oath of office, agreeing not to purchase, with the view of speculation, any landed or mining interest in the State during their term of office and not to conceal any information relative to any discovery &c. The governor was authorized to offer for sale the reports, when published, to citizens of the State, at a cost not to exceed that of publication, proceeds to be placed to the credit of the common school fund. The State geologist was allowed fifty copies for distribution to scientific men and the assistants twenty copies each. The governor was empowered to remove for neglect or malfeasance in office. All former laws were repealed.

Early in 1873 Governor Edmund J. Davis appointed John W. Glenn State geologist. In November he took the field, with Charles E. Hall as first assistant, and went into Burnet, Llano, and San Saba Counties,¹ returning to Austin in January, 1874, and soon afterwards he resigned. In view of the destruction of the archives it is satisfactory to have Mr. Glenn's direct statement regarding his connection with the survey, kindly furnished in reply to a request for it, and not without value in its bearing upon the work of others in the same field.

LETTER OF MR. J. W. GLENN.

NEW ORLEANS, LA., *August 7, 1886.*

DEAR SIR: Reply to your letter has been delayed until now from necessity of referring to the comptroller of Texas for some details of expenditures which I had forgotten.

I reply to your interrogatories in their order, viz :

1. I was State geologist for Texas from March 31, 1873, to March 6, 1874, when I resigned.

2. The expenses of my administration for that time were \$3,637.34.

3. I had no predecessor; my successor was S. B. Buckley.

4. Mr. Rossiter was never State geologist. One A. B. (or A. R.) Roessler was a draftsman in the geological department in 1861 under Dr. Shumard. He was also employed in printing and distributing circulars &c. in 1875 and 10,000 copies of Texas maps in 1875.

A geological survey of Texas was authorized by law and prosecuted to some extent under Dr. Shumard, but was brought to an abrupt ending in 1861 by the war. Nothing further was done until 1873, when I was appointed under a law just then passed, which law contemplated a complete work.

The disorders of the time and want of proper appreciation of the importance of geological work on the part of the public caused me to resign, and S. B. Buckley, who in 1861 was an employé of Dr. Shumard in the division of botany, was appointed my successor. His official existence was brief and barren of scientific results. I have always regarded Roemer's report on the Cretaceous in Texas with favor, and have found that Dr. Shumard's reports, so far as they were published, agree in the main with my examinations; and Roemer and Shumard may be considered as the sole authorities on the geology of Texas up to 1873, unless we add to them part of the United States boundary report.

No publication was made of any of my reports. Before I assumed the duties of State geologist I was familiar with the area and outlines of the coast formations,

¹First Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, p. 13.

Tertiary, Cretaceous, and the Carboniferous, in the northern part of Texas. My first work was to establish a base line which would include outcroppings of the known formations. As established, this line began in Blanco County, in the Cretaceous, thence northward until it encountered the Cretaceous again overlying the Carboniferous in the north part of the State.

Between these two ends of the base line, beginning at the south end, it passed through the following formations in the order as stated, viz: Cretaceous, Carboniferous, Upper Silurian, Lower Silurian, Azoic, Lower Silurian, Upper Silurian, Carboniferous, Cretaceous.

The result was one of the most interesting I ever accomplished. Every square mile of the territory surveyed was carefully platted on the map and defined in the field, and each one numbered and worked over with great care, and the collections taken from each bore its number and from what part each came. Probably the most valuable part of my work, from an economic stand, if the report of it had only been promulgated in print, was my report on the wild sumach of Texas (*R. copallina*), from detailed analyses extending through the entire growth and determining the period of greatest economic value in tannic acid.

These analyses were made by Mr. George H. Katteyer, in the most elaborate and painstaking way, and included an amount of exact information which, owing to the vast growth of wild sumach in Texas, would have proved of immense value to her people in that new industry.

The paleontology of Texas is to me more interesting than that of any other part of the country, especially in the Carboniferous and Lower Silurian formations.

I believe I have replied substantially to all of your inquiries. If not, and you will indicate where, I will gladly supply the omission.

Respectfully,

ROBERT T. HILL,

Assistant Paleontologist, U. S. G. S., Washington, D. C.

JOHN W. GLENN.

OPERATIONS OF 1874.

In March, 1874, Governor Richard Coke appointed Dr. S. B. Buckley State geologist. Dr. Buckley appointed Prof. Richard Burleson assistant geologist, Charles E. Hall su bassistant, James E. Horn book-keeper and commissary, having Friench Simpson and Jack Coke as volunteer assistants without wages. Field work was begun May 11, and William D. Carrington, Ed. Shands, and a cook were of the party. Dr. Buckley says of his summer's work:

Our trip during the summer has only been a general reconnaissance or partial survey of the following counties. [Here follow the names of forty-five counties.]

No detailed surveys have been made, the object being merely to ascertain the leading geological, mineralogical, and agricultural features of the counties visited as a guide to future examinations and aid to the capitalist and immigrant.¹

Although during a part of the time Professor Burleson traveled with a subparty over a separate route, it is clear that in covering such a scope of country the field work consisted of little more than a jaunt in an ambulance, rarely deviating from the main road.²

The parties traveled rapidly from day to day, gathering fossil and mineral curiosities and noting extravagant stories of agricultural possi-

¹ First Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, p. 16.

² See *The Coming Empire, or Two Thousand Miles in Texas on Horseback*, by H. F. McDaniels and N. A. Taylor, New York, A. S. Barnes & Co., 1878, p. 315.

bilities by farmers along their routes. No stratigraphic or topographic work was done, nor were any barometric or other measurements made. From the first annual report of the survey, already cited, some localities can be identified, but its 142 octavo pages are essentially devoid of scientific interest. No office or laboratory work was reported.

The expenses of the half year from May 1 to November 1 are given as follows :

Camp outfit.....	\$1,508 50
Field expenses	871 15
Help	750 00
Total	3,129 65

From Mr. French Simpson, of Columbus, Tex., one of the gentlemen who accompanied Dr. Buckley as a volunteer assistant, I have received the following detailed account of the appropriations and expenditures of the survey for the first year of its existence :

Total amount of appropriation	\$7,250 00
Salary of geologist	\$3,000 00
Office and chemical supplies	300 00
Wood	50 00
Books and instruments.....	200 00
Traveling expenses	2,700 00
Total expenditures	6,250 00
Returned to treasury.....	1,000 00

OPERATIONS OF 1875.

The work of 1875² was in continuance of the plan adopted the preceding year of ascertaining, by a general reconnaissance of the State, its main geologic and agricultural features.

The observations for this year were mostly made in the region west of the Colorado River and north of latitude 29°. These observations were of the same general character as those of the preceding year, except that a barometer was introduced into the survey and a few altitudes were recorded.

For an account of the expenses of this year we are again indebted to Mr. Simpson. They were as follows :

Salary of the geologist.....	\$3,000 00
Office and chemicals	500 00
Traveling expenses	2,000 00
Postage	200 00
Fuel.....	50 00
Total expenses	5,750 00

¹First Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, p. 119.

²Second Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, A. M., Ph. D., State geologist, Houston, 1876, p. 5.

At the end of the fiscal year Governor Richard Coke, who had himself appointed Dr. Buckley, being convinced that the geological survey as conducted was of no value to the State, vetoed the annual appropriation, thus terminating the survey. The two reports cited contain all the contributions made, to my knowledge, by the reorganized survey, and the State has done no work of the kind since.

RECENT MISCELLANEOUS INVESTIGATIONS.

Some additions to the geologic knowledge of Texas have been made by individual contributors.

Most of the papers contributed were only semi-scientific, written with a view to furnishing popular descriptions of the region. Many of them are now lost, owing to the destruction of the obscure mediums in which they were published.

INDIVIDUAL CONTRIBUTORS.

Previous to the civil war several gentlemen, residents of the State, contributed articles to the southern press upon these questions.

Professor Caleb G. Forshey and *George Wilkins Kendall* were among them. To secure a complete list of their writings would now be impossible, but many of them are still extant in the almost inaccessible files of New Orleans and Texas papers and in *De Bow's Commercial Review*.

Since the civil war not many residents of the State have contributed to its geologic literature. There have been one or two gentlemen, however, who have been interested in the geology of their State.

N. A. Taylor has contributed many articles to the press of the State, as well as written a book that contains valuable data concerning the geologic features of Texas. While his works are lacking in the exactness of detail that is necessary in scientific matter, his deductions are original and oftentimes so plausible as to seem worthy of extended development and treatment. Unfortunately most of Mr. Taylor's contributions are now inaccessible, he himself being unable to furnish a complete list of them or of their dates and places of publication. His little book¹ contains much general information of value to one who contemplates studying this region.

*Ex-Governor Oran M. Roberts*² gives much information concerning the physical geography of the State. Perhaps no other man is so thoroughly acquainted with the general topography of Texas as he. His observations are acute, but he makes no claim to modern scientific knowledge and the valuable data he gives are unaccompanied by geologic deductions.

¹The Coming Empire, or Two Thousand Miles in Texas on Horseback, by H. F. McDaniels and N. A. Taylor. A. S. Barnes & Co., New York, 1878. 12°, 390 pp.

²A Description of Future Texas; Its Advantages and Resources, with Some Account of their Development, Past, Present, and Future, by O. M. Roberts, Present Governor of Texas, St. Louis, Mo., Gilbert Book Company, 1881.

W. F. Cummins has also written many valuable papers for the State press. His observations are wide, but his writings are valuable for the localities they give rather than as direct contributions to stratigraphy. Mr. Cummins has been of great service as a collector, having made Prof. E. D. Cope's vertebrate collections in Texas. A list of his sketches in periodicals is given below.¹ He has an important mass of unpublished material.

Dr. Charles A. Ashburner made an economic study of the coal fields of Northwestern Texas in 1881 on behalf of certain railroad companies. He contributed a valuable paper to the American Institute of Mining Engineers upon the geology of the region.²

Professor E. D. Cope has spent much time in Texas studying its zoölogy. He also studied the fossil vertebrata collected for him. Unfortunately for science, this gentleman made the stratigraphic and geographic information of secondary value, and, in addition to giving few localities, has accepted as present in Texas a geologic formation the existence of which has not been scientifically demonstrated. His brief exposition of the areal distribution of the formations³ is one of the most valuable extant upon that subject, but it contains an interpretation from which I dissent. He says:

To the eastward of this line [the eastern border of the Cretaceous] a belt of the Laramie extends from the northeast and terminates at the south, without continuing immediately to the west.

It does not seem to me that this is the Laramie in any sense of the word, for, although it may have been synchronously deposited it has no paleontologic or lithologic resemblance to what the great authorities on that formation have described and located as the brackish water Laramie of the West. This view is based upon my personal observation of both the true Laramie of the West and what Professor Cope terms the Laramie in Texas. It is true that both formations belong to the uppermost Cretaceous or the lowest Eocene, but I think that conclusive stratigraphic and paleontologic evidence exists to show that Professor Cope's Texas Laramie is but the southern continuation of the lignitic formation of Mississippi and Arkansas or the Eolignitic group of Heilprin.

Professor Cope has also described numerous vertebrate remains from what he terms "the Permian formation of Texas." These beds should not be confounded with the trans-Pecos Permian beds of the Messrs.

¹ "Texas geology," Galveston (Texas), Daily News, December 1, 1884. "Geology of North Texas," "Permian formation in Texas," "Tertiary coals in Texas," "Carboniferous formation in Texas," and "Artesian water on the Staked Plains;" these articles were published in the Dallas (Texas) Herald and the Galveston (Texas) News at various times. The exact dates Mr. Cummins cannot give.

² "Brazos coal-field, Texas," Trans. Am. Inst. Min. Eng., Vol. IX, pp. 495-506, 1880-'81.

³ On the Zoölogical Position of Texas, by Edward D. Cope, Bulletin No. 17, U. S. Nat. Mus., pp. 5-8.

Shumard, which are now known to be late Carboniferous. Professor Cope's use of the word is not verified by stratigraphic or invertebrate paleontologic data so far published.

Professor Jacob Boll, an able Swiss zoölogist and geologist, in 1875-1880 conducted a series of explorations in Texas and published a few papers upon its geology.¹ He, with Mr. Cummins, also collected vertebrate fossils for Professor Cope. His writings were only the introduction to what promised to be valuable original contributions to the geology of Texas; but the strange fatality that has so often interposed a barrier to the completion of all thorough work in this State intervened, and he died in the field in the summer of 1880.

Walter P. Jenney contributed a short but valuable article upon the geology of the trans-Pecos region.²

W. H. Adams published an important paper in which he makes some generalizations concerning the coal bearing strata of the Rio Grande region.³ His deductions concerning the age of the strata at Eagle Pass, Tex., are erroneous and misleading in that he makes it Triassic—from the lithologic appearances and from the occurrence of an ammonite resembling the genus *Ceratites*, when in reality it is the very latest of the Cretaceous, as may be seen by material in the National Museum.

Dr. R. H. Loughridge prepared for the Tenth Census a brief but valuable paper⁴ on the geologic features of the State. This may be classed as one of the most important contributions to the general topography and the geology of Texas. It is accompanied by maps showing the distribution of soils &c. and by a brief geologic discussion of the whole region. It contains a comprehensive statement of the areal distribution of the geologic formations and is by far the best general paper upon the subject thus far written. Much detail is given concerning the hitherto indefinite boundary between the Tertiary and the Cretaceous, which Dr. Loughridge deflects too much to the westward south of San Antonio. He notes the occurrence of the Ripley group of the Cretaceous near Terrell, Kaufman County, and gives a list of its fossils. He also describes the character of the rotten limestone as it occurs near Clarksville, but erroneously includes in this formation the several distinct prairie regions of Central Texas. He uses Dr. B. F. Shumard's section, but his own observations are not altogether in harmony therewith. The work is chiefly valuable for the topographic information concerning the State.

¹ "Texas in its geognostic and agricultural aspect," *American Naturalist*, pp. 375-384, June, 1879; "Geological examinations in Texas," *American Naturalist*, Vol. XIV, pp. 684-686, September, 1880.

² "Notes on the geology of Western Texas, near the thirty-second parallel," by Walter P. Jenney, *Am. Jour. Sci.*, 3d ser., Vol. II, pp. 25-28, 1874.

³ "Coals in Mexico, Santa Rosa district," *Trans. Am. Inst. Min. Eng.*, Vol. X, pp. 270, 271, 1881-'82.

⁴ "Report on the cotton production of the State of Texas, with a discussion of the general agricultural features of the State," Tenth Census of the United States, Vol. V, pp. 653-831, 1884.

A. R. Roessler was the original topographer of the Shumard survey, and thus acquired a fund of geographic knowledge with which he has favored the public through the medium of several maps. One of these, printed in 1874, is by far the best contribution to a knowledge of the general surface features of the State. Mr. Roessler has published a series of county maps, giving colored areas to represent the geologic formations, but these maps are not entirely trustworthy. Mr. Roessler has also contributed several articles on the local geology.

Dr. V. Havard, U. S. A., made a most valuable contribution to the knowledge of the general topographic features of the State during 1835. Although the work¹ is primarily botanic, these topographic descriptions of a region about which so little has heretofore been known are important and far more extensive than those in some of the works giving geologic titles.

James P. Kimball, Ph. D., in an article on the geology of Western Texas,² discusses the orologic and paleontologic relations of the trans-Pecos country and corrects several errors in the writings of earlier travelers. He describes the peculiar metamorphic formation capping the Cretaceous strata of the region, termed *cantera*, and shows its local variations. The extension of the Texas Cretaceous formation into Mexico is also described. It is one of the most valuable of the very few articles on the region of which it treats.

Charles D. Walcott is the only representative of the scientific corps of the U. S. Geological Survey who has as yet published any results upon the Texas region founded upon personal observation. He visited the Paleozoic rocks of Central Texas in 1834 and published a short paper on them the same year, entitled "Notes on Paleozoic rocks of Central Texas."³ This article, although brief, ranks in the same category of original investigation as the works of Shumard and Roemer. It contains the following results: Additional data on the Potsdam section and fauna; the Silurian section and fauna; the geologic relations of what has long been known as the Archaic region and its first reference to the Cambrian; and the determination of the age of the granite of Burnet County.

There are several writings upon Texas geology by gentlemen who have not visited the State that deserve mention. Of this number, few have dealt with other than isolated paleontologic descriptions of fossils, and it is of the latter class that it is proper to insert here a few remarks. Paleontology as a science is inseparable from stratigraphy. When they are divorced, paleontology becomes a misnomer for what more

¹ "Report on the flora of Western and Southern Texas," Proc. U. S. Nat. Mus., Vol. VIII (1885), Nos. 29-30, pp. 449-533, Washington, 1885.

² "Notes on the geology of Western Texas and of Chihuahua, Mexico," by James P. Kimball, Ph. D., Am. Jour. Sci., 2d ser., Vol. XLVIII, p. 379, 1869.

³ Am. Jour. Sci., 3d ser., Vol. XXXVIII, pp. 431-433, 1884.

properly deserves the title of systematic or descriptive zoölogy. It is to be regretted that only three invertebrate paleontologists—Drs. Ferdinand Roemer, Benjamin F. Shumard, and C. D. Walcott—have visited the State.¹ The innumerable descriptions of new species of “Cretaceous” and “Tertiary” fossils from Texas that have adorned the annals of the scientific literature of our country for many years will have little value to science until the fossils are studied upon the ground and their proper stratigraphic position is ascertained.²

*Dr. Samuel George Morton*³ was the first to make allusion to the Cretaceous strata of Texas. He describes, from the “Calcareous platform of Red River,” the fossil *Gryphaea Pitcheri*, now accepted as the most characteristic fossil of the typical Texas Cretaceous. This locality, we can only surmise, was the same as that now called the Staked Plains region of Texas. The specimens were collected by Army officers.

F. B. Meek has contributed very little to the number of new species from Texas, but he has made an earnest endeavor to correlate the Cretaceous strata of Texas with those of the other kindred areas of this country.⁴

Dr. C. A. White has not at this date (December 31, 1885) visited the State, but he has published several papers on the paleontology of Texas, as well as figured many of the species described, but not illustrated, by Dr. Shumard. He has also figured and described several new and distinct species and printed lists of fauna from characteristic localities.⁵

¹ Since writing the above, Mr. T. A. Aldrich, Dr. C. A. White, and others have done some valuable work in Texas.

² “Descriptions of new Lower Silurian (Primordial), Jurassic, Cretaceous, and Tertiary fossils collected in Nebraska by the exploring expedition under the command of Capt. Wm. F. Reynolds, U. S. Topographical Engineers, with some remarks on the rocks from which they were obtained,” Proc. Acad. Nat. Sci. Phila., Vol. XIII, pp. 415-447, 1861.

³ Synopsis of the Organic Remains of the Cretaceous Group of the United States, by Samuel George Morton, M. D., Philadelphia, 1834.

⁴ A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country, by F. B. Meek. Report of the U. S. Geological Survey of the Territories. F. V. Hayden, U. S. Geologist in Charge, Vol. IX, Washington, 1876.

⁵ Dr. White's writings on Texas geology are here given for the convenience of those who may be interested, because they are not noted in the existing paleontologic check lists, which were printed before his articles were written :

“Report on the paleontological field work for the season of 1877,” Eleventh Annual Report of the U. S. Geol. and Geog. Surv. Terr., for 1877, pp. 159-320, 1879. Describes several new species of fossils from the Cretaceous strata of Texas.

“Descriptions of new Cretaceous fossils from Kansas and Texas,” Proceedings of the U. S. National Museum for 1879, Vol. II, pp. 292-298.

“Report upon the Invertebrate Fossils collected in Portions of Nevada, Utah, Colorado, New Mexico, and Arizona, by Parties of the Expeditions of 1871, 1872, 1873, and 1874,” in Report upon the Geographical and Geological Explorations and Surveys West of the One Hundredth Meridian, in charge of First Lieut. Geo. M. Wheeler,

Prof. Angelo Heilprin has published a valuable compilation of the observations that have been made upon the Tertiary geology of the State in his work entitled *Contributions to the Tertiary Geology and Paleontology of the United States*, printed at Philadelphia in 1884. Besides being a compilation of previous research, the observations and the deductions of Professor Heilprin therein expressed are of great value. He has, besides, described several species from the Tertiary of the State.

The writings of Messrs. James Hall, Conrad, and Gabb have been referred to in the preceding pages in connection with the expeditions upon which the fossils and other specimens were collected. They also made a few individual contributions. The true horizon of the species cannot be known until further stratigraphic observations are made.

WORK OF THE U. S. GEOLOGICAL SURVEY.

This narration of the geologic work accomplished in Texas practically closes at the date when the U. S. Geological Survey was authorized to carry its work into the States (1884), although I have included some work done by C. D. Walcott, thus extending the narrative to December 31, 1885. The date at which the U. S. Geological Survey was enabled to extend its operations into the States is one of the most important in our scientific history, and to the State of Texas it will prove of especial consequence. The era of hasty reconnaissance and poorly published results may be considered ended and the work

Corps of Engineers, U. S. Army, Vol. IV, Part I, Paleontology, pp. 1-219. 4^o. Washington, 1875. Gives lists of fossils from Cretaceous localities in Texas.

"Conditions of preservation of invertebrate fossils," in Bull. U. S. Geological and Geographical Survey of the Territories, Vol. V, article VII. Describes characteristic condition of preservation of fossils from the Cretaceous rocks of Texas. Washington, 1879.

"Descriptions of new Cretaceous invertebrate fossils from Kansas and Texas." Proc. U. S. National Museum, Vol. II, pp. 292-298, Plates I-IV.

"Contributions to invertebrate paleontology No. 1: Cretaceous fossils of the Western States and Territories," in Eleventh Annual Report U. S. Geological and Geographical Survey of the Territories [for the year 1877], pp. 273-319, Plates I-IX. Washington, 1879. Describes a few fossils from the Cretaceous of Texas.

"Contributions to invertebrate paleontology No. 2: Cretaceous fossils from the Western States and Territories," in Twelfth Annual Report of the United States Geological and Geographical Survey of the Territories [for the year 1878], pp. 1-38; Appendix, pp. 38, 39, Plates XI-XVII. Washington, 1883.

Notes on the Mesozoic and Cenozoic Paleontology of California. U. S. Geological Survey Bulletin 15, Washington, 1885. Describes the westward extension of fossils common to Texas.

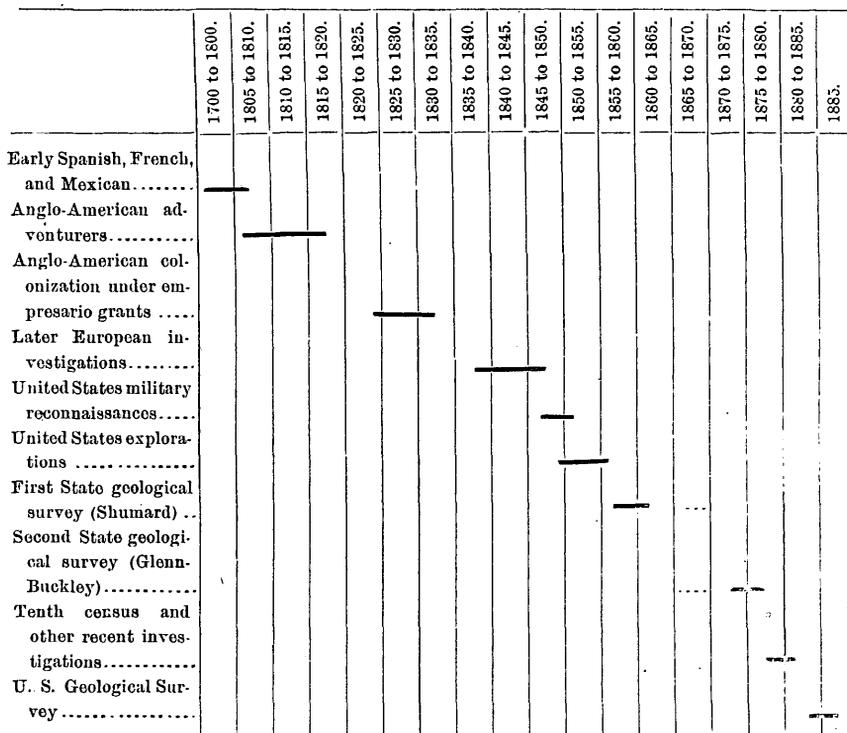
"On Mesozoic Fossils. Description of certain aberrant forms of the Chamidæ from the Cretaceous rocks of Texas." U. S. Geological Survey Bulletin No. 4, Washington, 1884.

"A review of the fossil Ostreidæ of North America; and a comparison of the fossil with the living forms," in Fourth Annual Report of the U. S. Geological Survey, pp. 273-333, Plates XXXIV-LXXXII, Washington, 1864.

of thorough scientific exploration will be continued under more adequate methods. Already several sheets of the topographic map have been issued.¹

SUCCESSION OF SCIENTIFIC EXPLORATIONS.

Diagram of succession of eras of scientific explorations in Texas.



¹Respecting the methods of the U. S. Geological Survey in making maps, see *Annuaire géologique universel, tome II, 2^e partie, appendice, Paris, 1886: Méthodes de cartographie géologique employées par l'United States Geological Survey, presented at Berlin by W J McGee.*

II. SUMMARY OF RESULTS.

TOPOGRAPHY.

It is plain that the scientific investigations heretofore made in the State of Texas have been elementary and fragmentary in character. Especially does this become apparent when we contrast the small amount of work done with the size of the State. For instance, strata of the Cretaceous period are found near both Texarkana and El Paso, although these cities are nearly eight hundred miles apart; but not a line is published noting a single dissemblance between the stratigraphic and the zoölogic features of this formation between these two places, except the confessedly limited observations of Roemer, Marcou, Shumard, Schott, Parry, and Marcy. The contributions of others, especially those of a paleontologic nature, will remain unavailable until further verification. Many of the paleontologic descriptions of species are even without any locality, much less any detailed assignment to a stratigraphic horizon, and nothing has been done in the direction of tracing faunal or specific range and variation. For the stratigraphy even less can be said than for the paleontology, although a few sections of great value have been presented. It must be said, however, that stratigraphic work has been peculiarly neglected in this State. Even Roemer's great work, the best ever printed on the geology of Texas, does not give a single stratigraphic section, and we find extending through its otherwise almost incomparable pages a fundamental stratigraphic error whereby the value of the whole is impaired.¹

The topography of the State, excepting the limited portion covered by the recent operations of the U. S. Geological Survey, is poorly delineated. The slope of the surface, the directions of the streams, and the principal forest regions were known in a general way to the Spaniards long before the present century and were crudely delineated by Humboldt in 1804. The development of detail and the delineation of these features upon successive maps until the present time have been successively expanded and recorded by Kennedy, Roemer, and other individuals, the various land locating parties, railroad surveys, and military expeditions. The finer points of inland topography,²

¹ Roemer thought that the Cretaceous formations at the foot of the highlands between New Braunfels extended beneath instead of resting unconformably upon them.

² The U. S. Coast and Geodetic Survey has carried its work along the immediate coast line of the State.

such as triangulation, determination of altitudes, meandering of streams, &c., have never been attempted until the recent operations by the U. S. Geological Survey, and even the coarser topographic features have not been correctly presented. For instance, it is utterly impossible at this writing to obtain an idea of the trans-Pecos mountain systems, and no map makes a distinction between the hills or buttes east of that region and true disturbed mountain ranges. The chief defect in our topographic knowledge of the State is incident to the fragmentary manner in which the same has been collected, no attempt having ever been made by the State of Texas to make a systematic map of its territory.¹

The most accurate description of the topographic features is that of Loughridge, 1884, but even this fails to classify the natural divisions in a comprehensive manner. He says:²

In the State of Texas we find combined a great diversity in both soil and topography; * * * in topography, from the extreme of low and flat prairie lands and a very little marsh along the coast, by gradual transitions and elevations, to the chains and peaks of mountains on the far west [southwest], whose summits are 5,000 feet or more above the sea.

Several of the great agricultural regions that form so prominent a feature in the other Southern States have their termini in Texas, and are cut off on the southwest either by the prairies of the coast or by the great mesquite and cactus chaparral prairies of the Rio Grande region, or they abut against the eastern bluffs of the plains.

The coast of Texas * * * is here bordered by an almost continuous chain of islands and peninsulas (the latter having the same trend as the islands). * * * The large estuaries that have been formed at the mouths of the streams, except the Sabine, the Rio Grande, and those of the Brazos section, form another feature peculiar to the Texas coast. The border lands of these estuaries are usually high, their almost vertical clay bluffs being washed by the waters of the bay, and the open prairies of the uplands often extend to their very edge.

Mr. Gannett estimates the water area of the coast, bays, gulfs, &c., to be 2,510 square miles and that of the rivers and lesser streams at about 800 square miles.

A general view of the State, as presented in two cross-sections, presents the following features:

1. *Along the Louisiana line.*—From the mouth of Sabine River northward we find at first a small area of marsh lands, terminating the marsh region of Louisiana, and not occurring to any extent westward. Passing these, we come to the long-leaf pine flats, extending westward only to the Trinity River, and being also the western ter-

¹The map representing the physical geography of Texas more minutely than any other is entitled "A. R. Roessler's latest map of the State of Texas, exhibiting mineral and agricultural districts, post-offices and mail routes, railroads projected and finished, timber, prairie swamp lands, &c. Authorities: Official maps of the United States and Texas State General Land Offices, surveys and reconnoissances of the U. S. Coast Survey, the various railroad surveys, U. S. Mexican Boundary Commission Surveys, U. S. Engineer Dept., and other authentic materials, compiled and drawn by M. Y. Mittendorfer, C. E., 1874." Much of the excellent detail of this map was evidently made from data collected by the Shumard survey, of which Mr. Roessler was topographer.

²Tenth Census: Report on Cotton Production in the United States. Report on the Cotton Production of the State of Texas, Part I, pp. 653-831.

minus of the belt that extends across all of the Gulf States, the lower part of Florida, and along the Atlantic coast through North Carolina. Its surface in Texas is quite level northward for about 50 miles, when the more undulating or rolling pine hills are reached, which also form a border to the pine flats just mentioned across the southern Gulf States. Thence northward to Red River the country is rolling and hilly, and is covered with oak, hickory, and short-leaf pine—a region that extends eastward through Louisiana, Arkansas, and the northern part of Mississippi into Tennessee. This region passes southwestward, becoming more and more narrow, until it tapers off to a point 100 miles from the Rio Grande, and also includes the belt of the red Tertiary hills of the other States that probably terminates on the southwest in Guadalupe County.

2. *From the coast in a northwest and west direction.*—The mainland coast of Texas presents a very irregular outline, with its many bays, peninsulas, and islands, and but a small proportion of the mainland reaches the waters of the Gulf. As before stated, there is scarcely any marsh land on the coast west of the Sabine marshes.

For a distance of from 50 to 100 miles inland from the coast the country is very level, with open prairies, whose continuity is broken only by the timbered streams, with occasional strips or "motts" or clumps of timber, and by the broad and heavily timbered alluvial or "sugar bowl" region of the Brazos.

The rise, slight and very gradual inland from the coast, is almost imperceptible for many miles, when the country becomes undulating and then rolling, and the prairies give way to the more or less broken and hilly oak and pine uplands, which cover all of the northeastern part of the State, as already mentioned. The country rises rapidly to the north and northwest, reaching an elevation of several hundred feet along the western edge of the timbered region, and is interspersed throughout with small "brown loam prairies." Leaving the timber lands and continuing northwest we find a region of "black waxy prairies," underlaid by the Cretaceous "rotten limestone," extending southwest to San Antonio and thence west to the foot of the plains. Northward this region passes through the southern part of the Indian Territory into Arkansas. These prairies are at first, on the east, rather level, or at most undulating, with an altitude of 500 or 600 feet, but westward become more rolling, hilly, and broken, until finally, on their western limits, high and bald hills and peaks stand out in bold relief at an elevation of nearly 1,000 feet above the sea. The monotony of these interior prairies is broken by the timbered streams and on the north by the wide belt of "lower cross timbers," which reaches from the Red River to the Brazos in an almost due south course. Otherwise there is very little timber to be seen.

At the western edge of the northern half of the black prairie region there is another belt of cross timbers,¹ interspersed with small, black, Cretaceous prairies, very irregular in outline and in width, and beyond it is the broad red-loam and partly timbered region, comprising high ridges, mesquite prairie valleys, and broad tablelands, the country gradually rising to the foot of the high plateau of the Llano Estacado, several thousand feet above the level of the sea. This region terminates on the southwest against the bluffs of the plains south of the Llano Estacado, and a large area penetrates southeastwardly almost across the black prairie region.

On the northwest there is a large, extensive region, lying wedge shaped, with its point south, between the red loam lands and the Llano Estacado, and comprising the great gypsum lands of the State, with high and rolling prairies, whose uplands are largely destitute of timber.

To the westward the broad, level, and bare plains of the Llano Estacado occupy a terrace with abrupt bluffs on the north, some 200 feet above these regions, and with a gentle rise pass out of the State into New Mexico on the west and to the mountains on the southwest. Deep cañons have been cut into the eastern part of this plateau

¹Mr. Loughridge places this edge of the black prairie too far west. It ends at the eastern edge of the lower cross timbers.

by the headwaters of the large rivers of the State, but to the west there is only a vast, treeless plain, more or less undulating, with a few low but prominent sand hills and ridges.

On the extreme west, between the Pecos and the Rio Grande, the country reaches its maximum height, with several chains of almost treeless mountains rising several thousand feet above the general level, and separated from each other by broad and level plains 20 or 30 miles in width and almost destitute of vegetation. These mountain ranges enter the State from New Mexico. Southward the plains extend along the Rio Grande to a point a little south of its junction with the Pecos. Thence to the Gulf are broad and high prairies, broken by deep arroyos or ravines, and with little growth other than occasional live oak trees and great chaparrals or thickets of thorny shrubs.

CLASSIFICATION OF TOPOGRAPHY OF TEXAS.

For convenience of discussion I broadly classify the general topography of Texas as follows:

First. The coastal plain, representing the continuation of the topographic features of the other Gulf States, so far as they represent the sedimentation of the former waters of the Upper Cretaceous outlines of the Gulf of Mexico, the topographic and geologic boundaries coinciding. In Texas this approximately coincides with a line drawn concentric with the Gulf coast about 200 miles inland.

Second. The black prairie region, a triangular area immediately succeeding the foregoing to the west. It is also a southern continuation of similar topographic and geologic features of Arkansas, Mississippi, and Alabama. Its western boundary extends from Eagle Pass via Austin to Denison, on Red River. It is a level or gently undulating prairie, with a general slope to the southeast and an altitude of from 500 to 750 feet. The underlying strata are uniformly Cretaceous and of a horizon that will be described elsewhere.

Third. The central or denuded region, embracing all the country between the escarpment of the plains and the black prairie region and north of the hydrographic basin of the Colorado. This region comprises a number of geologic formations and is between 600 and 2,000 feet in altitude.

Fourth. The plateau region, comprising the Llano Estacado. It is a continuation from the northward of the topographic and geologic features of the great plains along the eastern slope of the Rocky Mountains.

Fifth. The mountainous or trans-Pecos region. This consists of the country in Texas and Northern Mexico adjacent to the disturbed area of the southern or southeasterly prolongation of the Rocky Mountains. It is chiefly west of the Pecos, in Texas, but crosses into Mexico west of that river, again recrosses the Rio Grande east of it near Eagle Pass, and continues until a few miles south of Laredo.

Each of the areas has a well marked individuality, although the boundaries between them cannot always be closely defined.

Chart illustrating the progressive classification of the topographic features of Texas.

Kennedy, 1841.	Ferd. von Roemer, 1848.	R. H. Loughridge, 1884.	Classification used in this work.	
The level region.	The level region (niedriges, flaches Land).	Southern and coast prairies. Gray silt and pine lands. Sea marsh. Oak, hickory, and pine region. Brazos delta and other alluvial lands.	(1) The coastal plain. Pine lands. Pine, oak, and hickory lands. Prairies of East Texas. Coast alluvium. Southwestern prairies.	Continuation of salient topographic features of coast plain of Louisiana, Arkansas, Mississippi, Alabama, &c.
Rolling or undulating region.	Hill land, or rolling or undulating region (sanftwelliges Hügelland).		(2) Black prairie region.	Continuation of black prairie regions of same States, except Louisiana.
Mountainous region.	Highlands (das zum Theil felsige Hochland).	Central black prairie region. Cross timbers. Sand hills and metamorphic lands of Central Texas. Northwestern red loam prairies and timber lands. Gypsum prairie region.	(3) Central or denuded region. Cross timbers. Coal Measures. Grand prairie. Butte districts. Hamilton County prairie. Granite region. Gypsum lands. Red prairies.	Peculiar to Central Texas and southern part of Indian Territory. Terminates west of San Antonio before reaching Rio Grande.
	Steppen-Lande.	Llano Estacado (table lands and sand hills).	(4) Plateau or Staked Plains region.	Southern continuation of Great Plains at eastern foot of Rocky Mountains, British America to Southern Texas.
			Plains with granitic mountains and probably "sand" desert of Rio Grande.	(5) Mountainous or trans-Pecos region. West of Pecos River and Lower Rio Grande, between Eagle Pass and Laredo.

HISTORIC GEOLOGY AND STRATIGRAPHY.

In the following table are given, from the writings already mentioned, the members of the geologic series that have been reported from Texas. The authority for some of these groups is slight and untrustworthy, but

nevertheless they have been thus published. Many of the subdivisions are synonyms of different authors, which will require extensive field work for positive identification and correlation.

Geologic formations reputed to occur in the State of Texas, with authorities.

Era.	Period.	Subperiod.	Local formations.	Reported occurrence in topographic area—	
Cenozoic.	Quaternary	Recent ¹	Alluvium ¹	1	
			Diluvium ¹	1	
	Tertiary.		Grand Gulf ⁵	1	
			Mauvaises Terres ⁴	1	
		Vicksburg ⁷	1		
		Claiborne ¹			
Mesozoic.	Cretaceous.	Senonian ¹	<i>Laramie</i> , ⁶ <i>Eolignitic</i> ⁷	1 and 2	
			Kreide des Hochlandes ¹	2	
			Comanche Peak group ⁴	3	
			Senonian ²	Washita Limestone ^{2, 3}	3
			Turonian ¹	Kreide am Fusse des Hochlandes ¹	2
				Ripley group ^{4, 5} , Austin Limestone	2
			Greensand ³	Rotten Limestone ⁵	2
			Neocomian ³	Dakota Sandstone ⁴	2 or 3
	Triassic and Jurassic.			Washita Limestone ³	3
				Comanche Peak group ³	3
				Staked Plains ³	
			Triassic ³	Gypsum region ⁸	3 and 4
			Jura-Trias ²	Red beds ⁶	3
			Permian ^{2, 6}	Upper Carboniferous ²	
	Paleozoic.	Carboniferous.	Permo-Carboniferous	Upper Carboniferous ⁸	3
			Permian ^{2, 6}	Trans-Pecos region	5
Upper Carboniferous.			{ Central region ⁹	3 and 5	
			{ Trans-Pecos region ⁸ }		
Sub-Carboniferous ⁹		Brazos Coal Field ⁹	3		
Devonian.		Devonian ⁹	Central region	3	
Lower Silurian.		Cincinnati ³		3 and 5	
		Chazy ³		5	
		Calceiferous ¹⁰		3 and 5	
Cam-brian.		Potsdam ¹⁰		3 and 5	
Pre-Cambrian.	Llano ¹⁰		3		
	Archean ¹				
	Azoic ¹				

NOTE.—Authorities: ¹Ferdinand Roemer; ²G. G. Shumard; ³Jules Marcou; ⁴E. F. Shumard; ⁵R. H. Loughridge; ⁶E. D. Cope; ⁷Angelo Heilprin; ⁸James Hall; ⁹C. A. Ashburner; ¹⁰C. D. Walcott. Names of local formations, in italic, as applied by the writers referred to are no longer accepted.

SO-CALLED ARCHEAN AND EARLIER PALEOZOIC STRATA.

The older rocks of the geologic series are found in both the central and the trans-Pecos area, but they have been studied chiefly in the former and little or nothing is known of their exact occurrence in the latter.

A few miles south of the present geographic center of the State, in the counties of Mason, Llano, Burnet, and San Saba, is an outcrop of so-called Archean and earlier Paleozoic rock. This region was known to the Spaniards and was evidently considered by them of much mineral importance. Kennedy¹ first intimated its geologic age and Roemer was the first to give an intelligent description of it. Dr. B. F. Shumard confirmed Roemer's work, but its true stratigraphic relations were not understood until lately studied by C. D. Walcott, of the U. S. Geological Survey. Of these Paleozoic strata Mr. Walcott says:²

At all localities where the base of the Potsdam was observed it rests *unconformably* on a great formation that is stratigraphically the equivalent of Powell's Grand Cañon series (Grand Cañon and Chuar groups).³ In the Grand Cañon of the Colorado the latter are overlaid by the Tonto group, a series of rocks in both lithologic and paleontologic characters singularly like the Texas Potsdam group.

For this series of pre-Potsdam strata the local name of Llano group is proposed, from the best exposures of the group occurring in the county of Llano. Outcrops also occur in Burnet, Mason, San Saba, Blanco, and Gillespie Counties.

Mr. Walcott speaks of "extrusions of granite at or near the close of the erosion of the Llano group and before the deposition of the Potsdam," and says further: "It is to this age that the great masses of granite observed in Western Burnet and all through Llano County belong." The early students of these strata supposed that the outcrops of eruptive and granitic rocks were Azoic or Archean, and that they were the base of the entire series. Mr. Walcott showed that there are no rocks there exposed of the undoubted Archean and that the granites before referred to that era were not fundamental, but extrusive, and since his deductions are based upon more careful stratigraphic study

¹ Texas: The Rise, Progress, and Prospects of the Republic of Texas, Vol. I, pp. 114 et seq.

² "Note on Paleozoic rocks of Central Texas," Am. Jour. Sci., 3d ser., Vol. XXVIII, pp. 431-433, 1884.

³ In a later paper Mr. Walcott refers these groups to the Keweenaw, and says: "The Keweenaw system is here used to include the Keweenaw series of the Lake Superior region, the Llano series of Texas, and the Chuar and Grand Cañon series of the Grand Cañon of the Colorado, Arizona, and is considered of equal value with the Cambrian, Lower Silurian (Ordovician), Upper Silurian, and other systems of the Paleozoic rather than the Archean. It may be that the Keweenaw and Grand Cañon series belong to distinct systems of strata, but until this is proven I prefer to provisionally refer them to the pre-Cambrian, post-Huronian system. I think the Grand Cañon and Llano strata belong to one system."—"Classification of the Cambrian System of North America," Am. Jour. Sci., 3d ser., Vol. XXXII, pp. 138-157, 1886. The extract forms a note on p. 153.

than those of his predecessors they are more trustworthy. According to him these earlier Paleozoic rocks consist of the following :

(1) *The Llano group*.—Alternating beds of shale, sandy shale, sandstone, limestone, and schists; thickness not determined, but probably over 2,000 feet; continuity broken by extrusive sheets of granite of pre-Potsdam origin; stratification disturbed by movement at the close of the Paleozoic, whereby the dip increases from 10° at the north end of the ridge to 40° at the south end; strike, eastward; unfossiliferous.

(2) *The Potsdam group*.¹—Consists of massive sandstone, limestone, and Potsdam sandstone, marked by abundant Upper Cambrian (Potsdam) fauna.

(3) *The Calciferous group*.—Lower Silurian, with its characteristic fauna.

(4) *The Carboniferous group*, which was not here studied in detail.

From the observations of Mr. Walcott it is evident (*a*) that there are no Archean exposures yet known in Central Texas (this being the only Paleozoic region yet studied); (*b*) that the pre-Potsdam, the Silurian, and the Carboniferous groups are represented; (*c*) that the Devonian is absent; (*d*) that the age of the so-called Archean granites is Paleozoic; (*e*) that there were two well marked epochs of disturbance, one after the close of the sedimentation of the Llano group and the other near the close of the Paleozoic; (*f*) that the Llano group is the equivalent of the Grand Cañon and Chuar groups of Powell, and hence at the time of their deposition the sedimentation was continuous to the westward of the Grand Cañon.

The Paleozoic strata, excepting the Carboniferous, have only a limited outcrop in Texas, so far as has been discovered. The disturbed areas of the Wichita Mountains, in the southwestern corner of Indian Territory, theoretically present every favorable condition for the presence of similar exposures, but no evidence of their existence has been reported, except the similarity of their granitic structure.²

The large trans-Pecos disturbed mountain area also presents exposures of early Paleozoic strata, as has been reported by G. G. Shumard, Jenney, Kimball, and members of various government expeditions. Concerning the occurrence of the Lower Silurian in that region, Dr. G. G. Shumard said of the valley of the Rio Grande above El Paso: ³

The limestone of the Lower Silurian system is seen strongly upheaved against the western base until we reach a point ten or eleven miles north of the place where it was first discovered, when it disappears and is succeeded by strata of the Carboniferous system, which are exposed in places to the thickness of about three hundred feet. Against the western declivity, El Paso Mountains, the limestone strata are strongly upheaved, and where it is in immediate contact with the eruptive strata it

¹ Well described by B. F. Shumard, *Am. Jour. Sci.*, 2d ser., Vol. XXXII, pp. 213-221, 1861.

² See numerous references in *Exploration of the Red River of Louisiana in the year 1852*, by Randolph B. Marcy, 1854.

³ *Trans. Acad. Sci. St. Louis*, Vol. I, p. 288.

is highly metamorphosed. I was much interested by finding here, near the base of the exposure, well marked strata of the inferior Silurian system, corresponding in age to the blue limestone of Cincinnati and the Hudson River group of the New York series. The following fossils were procured from these beds: *Orthis testudinaria* Dalman, *O. occidentalis* Hall, *Rhynchonella capax* Conrad, *Rhynchonella* (a species of the blue limestone of Cincinnati), *Streptelasma cornicula*? Hall, and columns of crinoids.

Every reason exists for the supposition that the Cambrian strata are exposed there, but no surveys of the region have been made.¹ Walter P. Jenney² gives a section of the rocks north of El Paso, two miles, in the Organ Mountains, and recognizes there the following formations in descending series: Carboniferous, or Niagara, deposited unconformably upon a coarse conglomerate, which he thinks probably equivalent to the Oneida conglomerate of New York; gray limestone of the Hudson period; black limestone representing the Trenton, the Chazy, the Calciferous sand rock, and the Potsdam. He finds similar rocks in the Hueco Mountains, twenty miles north of the Organ Mountains, and concludes that "the greater part of the Upper Silurian and the whole of the Devonian periods are unrepresented in the rocks of Western Texas." He notes an immense development of the Carboniferous strata in the Sacramento and the Guadalupe Mountains, and of syenite at Los Cornudos. He also gives a section of the Llano Estacado as exposed at Castle Cañon and affirms their Cretaceous age; the highest he makes the Caprina Limestone of Shumard. He erroneously concludes that the denuded Cretaceous buttes east of the plains almost as far as Austin "were islands in the sea which produced the denudation, their tops showing no evidence of having ever been submerged, and in some cases wave worn cavities extend at the same height along their sides."³

CARBONIFEROUS SYSTEM.

The absence of the Devonian from the stratigraphic series in Texas has been noted, first by Roemer and later by Walcott and others. Dr. S. B. Buckley asserts in one of his reports that Dr. B. F. Shumard had previously announced the occurrence of the Devonian strata in Texas, but I have failed to find such a statement in any of Shumard's publications. If the Devonian is not represented, then it is evident that the Carboniferous strata are next in order after the Silurian. This fact was demonstrated by Roemer, who first noted the positive occurrence of the Carboniferous strata in Texas resting upon the older rocks along the San Saba River. He formed no idea of the extent of these rocks, however, and was not aware of their great development northward.

It is now evident that there are two widely separated areas of the Carboniferous strata in Texas, each of which has well marked individ-

¹ C. H. Hitchcock's geological map of the United States gives a large Cambrian area in the trans-Pecos region of Texas.

² "Notes on the geology of Western Texas near the thirty-second parallel, by Walter P. Jenney," *Am. Jour. Sci.*, 3d ser., Vol. VII, pp. 25-28, 1874.

³ These buttes are the remnants of subaerial erosion entirely.

uality. These I will describe separately under the names of the Central Carboniferous area and the trans-Pecos Carboniferous area.

The central Carboniferous area.—This is a comparatively narrow but elongated area of exposures, continuing from Indian Territory, between the ninety-eighth and the one hundredth meridian. Its eastern border is limited by the upper cross timbers. The extent of this area in Texas is some two hundred miles north and south between the Colorado River and the Red River. Geologically it may be said to extend along the axis of greatest denudation from the point of greatest disturbance, in Llano County, to the connection with the great Missouri coal field in Indian Territory. The latitudinal development of exposures is of varying width, owing to the irregularity of the denudation of the superincumbent Cretaceous strata, and other causes. The exposure widens, however, towards its southern base. At no place does it exceed one hundred miles in width. Exposures have been noticed in Young, Jack, Montague, Stephens, Shackelford, Palo Pinto, Baylor, Wise, Coleman, Brown, Comanche, Runnels, McCulloch, Tom Green, and San Saba Counties. Its exact boundaries are unknown. The exposures of these strata are the result of denudation of the Cretaceous, which once covered them entirely, and I have noted on the preceding pages the history of the discovery of this area. Dr. Roemer's determinations were based upon stratigraphic and paleontologic data and he did not discover the existence of bituminous coal. Various Army officers have noted the occurrence of coal to the northward, but it was first clearly described by Dr. G. G. Shumard in his remarks accompanying Marcy's report on the exploration of the Red River of Louisiana (1854). Mr. Jules Marcou the next year contributed much toward a knowledge of the geologic and stratigraphic relations and in subsequent maps intimated the continuity of the Young and San Saba County areas. Dr. B. F. Shumard, as State geologist (1858), was the first to demonstrate in the field the actual continuity of the two regions, concerning which he contributed nearly all we know. The local occurrence and the general extent having been proved by these earlier reconnaissances, there still remains much to find out concerning nearly all the geologic data of the region. Prof. C. A. Ashburner, of Pennsylvania, in a study of the northern portion of these coal fields in 1879, made the following section of the strata in the vicinity of Fort Belknap, Young County:¹

	Feet.
Sandstone and conglomerate	40
Coal	1
Sandstone and shale	12
Coal	1
Sandstone and shale with occasional beds of limestone.....	15
Belknap coal bed	2½ to 4
Sandstone and shale	12

¹ "Brazos coal-field, Texas," *Trans. Am. Inst. Mining Eng.*, Vol. IX, p. 497, 1880-'81.

	Feet.
Coal	1
Gray slate	10
Sandstone	25
Brazos coal bed,	4 to 6
Gray limestone	150

From the above section he made the following deductions:

This succession of the strata is not unlike that to be found in many localities where the Carboniferous rocks are found in the Middle States. It seems to point clearly to the conclusion that the top sandstone and conglomerate is the representative of the Carboniferous conglomerate or Millstone Grit; that the limestone is the sub-Carboniferous or Mountain limestone, known generally throughout the Mississippi Valley as the Saint Louis or Chester limestone, and that the included Coal Measures are really subconglomerate.

His final conclusions are summed up at the close of the paper just quoted as follows:

The Brazos coal field is the southwestern limit of the Missourian or fourth bituminous coal basin of the United States. The Coal Measures of Stephens and Young Counties belong to the Carboniferous age. The coal strata proper are 85 feet thick, and are included between an upper sandstone and a conglomerate, representative of the Millstone Grit or Pottsville conglomerate No. 12 of the Pennsylvania series, and a lower gray limestone, representative of the Mountain limestone or Chester and Saint Louis limestone of the Mississippi Valley. The coal strata contain two coal beds of workable thickness. The upper bed, named Belknap, ranges from 2½ to 4 feet; and the lower, named Brazos, from 4 to 6 feet. The coals are high in ash and sulphur, but have never been thoroughly tested. The Brazos bed underlies a great area and will no doubt prove to be a valuable commercial coal in some localities.

The southern portion of these central exposures has not been so well studied, and we have nothing but analogy from which to infer¹ that there they are practically the same, except that the carbonaceous layers in that region become almost if not quite extinct.

Dr. Buckley reports coal from this southern region, but he was not an authority on the subject of coals, not having had a clear idea of the distinction between the true coals of the Carboniferous and later Western formations and the lignite of the Mississippi area, which is known to occur in near proximity.²

The trans-Pecos Carboniferous area.—Along the disturbed axes of the trans-Pecos mountainous region extensive beds of limestone have been frequently noted by reconnoitering parties. The knowledge of the topography of this area is very limited, and, this being true, it is evident that little can be known of the distribution of the geologic formations. That Carboniferous rocks occur in this region has been recorded by many observers, but very little is yet known of their true nature, except that they usually consist of massive limestone, are barren of coal seams, and that they occur along the disturbed and denuded mountain re-

¹ "Brazos coal-field, Texas," Trans. Am. Inst. Mining Eng., Vol. IX, p. 506, 1880-'81.

² See discussion of coals, First Report of Progress, Geological and Agricultural Survey of Texas, B. F. Shumard, State geologist, Austin, 1865.

gions. These rocks are probably a continuation of the New Mexican Carboniferous, as has been noted by Marcou and others.¹

Two expeditions have supplied some details concerning this region, but our knowledge of it is still very general. One expedition recorded the Carboniferous as it occurs near the Rio Grande, the other as it occurs approximately along the thirty-second parallel. The observers were Dr. C. C. Parry,² of the Mexican boundary survey, and Dr. G. G. Shumard,³ of Capt. John Pope's expedition for boring artesian wells in the Great Plains. The collections of both of these gentlemen fell into the hands of good geologists, and reports were written upon them by Prof. James Hall⁴ and Dr. B. F. Shumard,⁵ respectively.

Dr. Parry, in his remarks,⁶ gives the following general facts concerning the occurrence of this formation along his line of observation: The first disturbance, traveling westward from San Antonio to El Paso, is Sierra Diablo, or Limpia Range, near Fort Davids. The elevation at Leon Springs, the last point upon the horizontal, undisturbed Cretaceous strata before reaching this range, is some 2,200 feet above San Antonio,⁶ giving an average rise of seven feet to the mile and a total elevation above the sea of 2,788 feet.

This range is characterized at nearly all the separate points noticed by Dr. Parry by the presence of igneous rocks accompanied by metamorphic rocks and strata of sedimentary character, which Professor Hall considered to be of the Carboniferous period. The dip varies, but is generally to the southwest. From this range westward to El Paso there are several other mountainous elevations and intervening plains, the former being of the character of the Limpia Range just mentioned and the latter consisting of alluvial deposits, the detritus from the surrounding mountains. At El Paso the character of the region again changes, a greater disturbance being noted. On the Mexican side the various formations, stratified and igneous, are blended and intermixed in great confusion, while on the American side the strata consist of stratified limestone dipping W.S.W., in the face of which rest igneous outbursts associated with the disturbed Cretaceous beds.⁷ This limestone was determined by Professor Hall to belong to the Carboniferous series, being a continuation of that above noted.

¹ Described in Report U. S. Geog. Surv. West of One Hundredth Meridian, under charge of Capt. G. M. Wheeler, Vol. III, Supplement, Geology.

² See Report U. S. and Mexican Boundary Survey, Vol. I, Part II.

³ See Trans. Acad. Sci. St. Louis, Vols. I and II. Numerous papers by both Dr. G. G. and Dr. B. F. Shumard.

⁴ Observations on the Carboniferous limestone of the Boundary Survey collections, and its relations with the Carboniferous limestones of the Mississippi Valley. By James Hall, in Report U. S. and Mex. Bound. Surv., Vol. I, Part II, p. 122.

⁵ Trans. Acad. Sci. St. Louis.

⁶ Report U. S. and Mexican Boundary Survey, Vol. I, Part II, p. 4.

⁷ Ibid., p. 8.

Concerning its age, he said:¹

The Carboniferous limestone so often mentioned in the preceding pages, and which has been usually referred to in published reports as "Carboniferous limestone" and as Lower Carboniferous limestone, is actually of the same age as the Coal Measures.

* * * In all the collections which I have examined from Texas and New Mexico, and from points farther north in the same line, and particularly in the collections made by Captain Stansbury on his route from the Missouri to the Great Salt Lake and in that region, I have never observed fossils which are characteristic of the Lower Carboniferous limestone.²

Dr. G. G. Shumard's observations of these strata along the thirty-second parallel agree with those of Parry in general respects. Along this route he repeatedly found exposures of the Carboniferous strata, where he crossed the disturbed mountain chains of the Guadalupe, the Cornudos, the Sierra Alta, the Sierra Hueca, and the El Paso Mountains, respectively. In addition to the features noticed by Parry he observed the Lower Silurian (Cambrian?) underlying the Carboniferous to the north of El Paso and elsewhere.

He noted the following stratigraphic features of the region:

(1) It is underlaid by a granite bearing series (the Llano Group of Walcott?).

(2) The Carboniferous in some places rests conformably upon the Lower Silurian strata.

(3) The Cretaceous rests unconformably upon the Carboniferous.

(4) The Paleozoic strata of the region are greatly disturbed.

(5) The occurrence of characteristic fossils of the Coal Measures proves the age of these strata. Here, however, they were purely marine, the rocks being almost entirely of limestone and the fossils characteristic invertebrates similar to those of the Carboniferous of Missouri and Illinois.

Above these rested a later series, which he and his brother, Dr. Benj. F. Shumard, called the Permian,³ containing fossils having many characteristics of Permian fossils and similar to the rocks of the same nature reported by Swallow and Horn and by Meek and Hayden in Kansas. Other species were said to be identical with characteristic Permian fossils of England and Russia and many were new to science.

Upon comparison with the Llano County strata, as noted by Roemer, Shumard, Walcott, and others, it will be seen that they have some common features. The distance between these two areas of disturbance, from Llano County to the intersection of the Guadalupe Mountains and the thirty-second parallel of latitude, is 300 miles, and the intervening surface is occupied by nearly horizontal undisturbed series of Mesozoic rocks, which at each place are unconformable with the

¹ Report U. S. and Mex. Bound. Survey, Vol. I, Part II, pp. 122, 123.

² This opinion of Professor Hall has been confirmed by observations of the extension of these strata farther north. See U. S. Geog. Surv. West of the One Hundredth Meridian, in charge of Capt. G. M. Wheeler, Vol. III, Supplement, Geology.

³ Concerning these Permian strata I shall say more in the following pages.

Carboniferous, indicating beyond doubt that there was a period of great disturbance at the close of the Paleozoic.

It is very doubtful whether the Carboniferous strata of this region of the State are of economic value. Coal deposits have been discovered within the past few months very near the region visited by Dr. Shumard,¹ but their horizon is not announced.² Coals have also been reported north of El Paso, but their place in the geologic scale is Cretaceous, coal not now being considered as representing the Carboniferous age unless accompanied by stratigraphic or paleontologic proof.

General conclusions.—From the foregoing résumé of investigations of the Texas Carboniferous the following general facts are evident:

1. It occupies two widely separated areas the relation of which is unknown.

2. The first or central area consists of coal bearing strata and is allied by geographical continuity to the coals of Indian Territory, Arkansas, Missouri, Iowa, &c.

3. The second or trans-Pecos area belongs to the great western deposit of non coal bearing, marine Carboniferous of the West.

4. Both of these areas are greatly disturbed and the Cretaceous is deposited unconformably upon them.

5. Although one distinguished authority has announced the presence of sub-Carboniferous strata in Texas, their existence has not been demonstrated,³ and both areas probably belong to the later Carboniferous, the trans-Pecos graduating into almost Permian facies.

THE SO-CALLED PERMIAN⁴ OR PERMO-CARBONIFEROUS.

The term Permian has for many years been applied, with much indefiniteness, to certain Texas strata, and it is difficult to form from

¹ Sierra Blanca.

² It is now known that these coals are later Cretaceous.

³ Prof. C. A. Ashburner announced that the limestone at the base of his section (see p. 59) was sub-Carboniferous. Prof. W. F. Cummins, of Dallas, Tex., first called my attention to the fact that Mr. Ashburner was probably mistaken. From personal observation I have also good reason for doubting its existence. Not a single sub-Carboniferous fossil has been found in Texas, and the limestone of the Central Coal Measures bears great lithologic and faunal resemblances to that of the non coal bearing western strata.

⁴ The word Permian has been applied for many years to various strata in the great area between the western boundary of the exposures of the Missourian or fourth coal basin of the United States and the Sierras, especially in the States of Texas and Kansas, the Territories of New Mexico and Arizona, and in Indian Territory. Prof. J. S. Newberry, at the meeting of the International Geological Congress at Berlin (1885), asserted that he believed no Permian strata to exist in the United States. Whether the existence of Permian strata here can be proved or not I cannot say, but it has been clearly demonstrated that sedimentation was going on in this country synchronously with the deposition of the Permian of Europe. That this sedimentation was different from the European in lithologic and organic characters is true.

published writings even a general idea of what was intended by those who have most frequently used it.

It has been applied, by different authors¹ to at least two entirely distinct geologic horizons occupying widely separated areas. Although one of these has been described with comparatively much more distinctness than the other, there is still much danger of confounding the two. No paleontologic or stratigraphic data have ever been produced showing any relation between them.

The trans-Pecos region of Shumard.—The first locality to which the term Permian was applied was the region west of the Pecos River, near the Rio Grande, occupied by the disturbed outliers of the Rocky Mountains, known as the Guadalupe Range or Ranges.

At a meeting of the St. Louis Academy of Science, held March 8, 1858, the following report was made:²

Dr. Benjamin F. Shumard stated that since he had examined Major Hawn's collection from the Permian rocks of Kansas he had studied a series of fossils from the White Limestone of the Guadalupe Mountains, New Mexico, which were obtained by his brother, Dr. G. G. Shumard, while acting in the capacity of geologist of the Government expedition, under Capt. John Pope, for obtaining water by means of artesian wells along the line of the thirty-second parallel, and that he had arrived at the conclusion that these also were of Permian age. This White Limestone, he remarked, contains a number of fossils that are identical with Permian species of England and Russia, while others are near analogues of characteristic Permian forms of those countries; several are also identical with Permian species, described by Professor Swallow,³ from Kansas. The collection contains well marked examples of *Aulosteges*, a genus that has not been recognized in formations below the Permian. The species, however, were distinct from the English and Russian forms. There are specimens which agree perfectly with the descriptions and figures of *Camarophoria Schlotheimi*, *C. Geinitziana*, and *Productus Leplayi*, as given by Verneuil and King; also a *Productus* very analogous, if not identical, with *Productus Cancrini*, and a *Terebratula*, that agrees with *T. superstes* of Verneuil in every respect except that the dorsal valve of the American fossil is not quite so gibbous. There is also in the collection *Terebratula elongata*, *Terebratula (Spirifera) pectinifera*, *Spirifer cristata*, *Acanthocladia anceps*, *Synocladia*, and fragments of a *Monotis* which approaches nearest to *M. speluncaria*. Besides these, the collection embraces new species of *Productus*, *Spirifer*, *Chonetes*, *Corals*, *Trilobites*, and a slender *Fusulina* nearly two inches in length. Scarcely any of these fossils are positively identical with forms of our western [Missouri] Coal Measures.

In subsequent papers⁴ Dr. B. F. Shumard described these forms more at length, and his brother, Dr. G. G. Shumard, contributed an article⁵ giving a very succinct stratigraphic description of the region.

¹ B. F. and G. G. Shumard, 1860, and E. D. Cope, 1874.

² Trans. Acad. Sci. St. Louis, Vol. I, pp. 112-114, 1856-1860.

³ Ibid., p. 111.

⁴ "Notice of new fossils from the Permian strata of New Mexico and Texas, collected by Dr. George G. Shumard," &c., Trans. Acad. Sci. St. Louis, Vol. I, pp. 290-297; "Notice of fossils from the Permian strata of Texas and New Mexico," &c., *ibid.*, pp. 387-415.

⁵ Observations on the geological formations of the country between the Rio Pecos and the Rio Grande, in New Mexico, near the line of the thirty-second parallel, &c., *ibid.*, pp. 273-289.

According to the latter the white, gray, and other colored limestones forming this series have a thickness of over a thousand feet, are greatly disturbed, and have a varying dip.

The extent of these exposures is probably identical with that of the trans-Pecos Carboniferous area already described, from which the rocks are stratigraphically inseparable. These occur entirely west of the Pecos River, so far as is now known, and between the Rio Grande and the thirty-second parallel. The only points where they have been positively noted are in the section of country from 30 miles west of the mouth of Delaware Creek to the mountains in the vicinity of El Paso, Tex., approximately following the thirty-second parallel. The United States and Mexican boundary survey party noted the occurrence of similar rocks along a section parallel to the foregoing, but from one to two hundred miles to the southward. In the report of the survey, however, which was printed a year or two before Dr. B. F. Shumard's application of the term Permian, these strata were termed Carboniferous. That they are identical there is little room to doubt.

Dr. Shumard pointed out many supposed resemblances to the so-called Permian of Kansas, and, if these are real, the two areas may be in some degree related.

Concerning the western extension of this region little is definitely known, but good authorities think there is reason to believe that it is more closely related to the Permo-Carboniferous, as described in Southern Utah and along the Grand Cañon of the Colorado in Arizona, than to the Coal Measures of the Mississippi Valley and the Appalachian region.

It would of course be impossible to make any definite statements about the equivalents of trans-Pecos Permian, but it is highly probable that future investigation may demonstrate more clearly the above mentioned resemblance.

There is no reason to doubt that these rocks are a continuation of the Carboniferous sedimentation, and the remarks of James D. Dana¹ concerning the Permian rocks of Kansas are equally applicable to them, to wit: They "are continuous with the Carboniferous without interruption or unconformability, and yet are referred to the Permian because they probably belong to the Permian in geologic time or at least its earlier portion." Whether these strata are of the Carboniferous or of the Permian, they present paleontologic and stratigraphic features of a purely transitional group. If it is granted, however, that these Texas and Kansas strata are the highest Paleozoic beds in this country and if it is shown that they contain a commingling of typical Carboniferous and Permian species, the term Permo-Carboniferous would be the most appropriate one that can be applied to them.

From all the literature we have upon the subject, it is evident that at the close of the time of the deposition of these trans-Pecos, Permo-

¹ Manual of Geology, p. 369.

Carboniferous strata a great elevation had been attained and that they must have remained a portion of a continental area for some time, when subsidence ensued and the Mesozoic sediments were next deposited unconformably upon them.

The Permian of Cope and his assistants.—The second area in Texas to which the term Permian has been applied (which it should be remembered may belong to an apparently different horizon from the trans-Pecos region just described) is situated along the western boundary of the northern portion of the central area of Carboniferous exposures continuing into Texas from Indian Territory approximately along the line of the one hundredth meridian and extending southward to the thirtieth parallel.

Although this formation has frequently been alluded to in the writings of Prof. E. D. Cope, Jacob Boll, and others, nothing has been printed concerning its stratigraphy or that of the surrounding country, except the fragmentary data which I have compiled and which I present in the following pages.

From Prof. W. F. Cummins,¹ of Dallas, Tex., I have learned that the term Permian was first applied to the region by Prof. William DeRyee, who occupied the office of State chemist during the war of the rebellion. Upon what geologic evidence Professor DeRyee called the region Permian I have been unable to ascertain. The printed statement from his pen is as follows:²

To the Directors of the Texas Copper Mining and Manufacturing Company :

GENTLEMEN: In accordance with instructions received at Weatherford on the 12th day of June [no year is given], I hereby transmit to you the following sketch of my researches in the Wichita copper region. The limited time which I was able to devote to it and the difficulties incident to an exploration of a comparatively uninhabited district will palliate its deficiency. After traversing the *Lias* and *Carboniferous* series northward of Weatherford, I was agreeably surprised by a grand panorama of the outcropping Permian formation. This system is extensively developed in Russia between the Ural Mountains and the river Volga, in the north of England, and in Germany, where it is mined for its treasures of copper, silver, nickel, and cobalt ores. It has not heretofore been known to exist in this State, or has been mistaken for the Triassic system, which is overlying the former to the southeast. Its hills, which have been traced through Archer and Wichita Counties, resemble in shape the copper bearing and gossan crested upheavals in Ducktown, Tenn., but they are of different age and composition. They are nearly barren and, towering above the most beautiful mesquite prairies fringed by the finely timbered tributaries of Red River, are exceedingly picturesque. The members of the Wichita system, as far as open to ocular inspection by outcrop or cross-cut, making allowances for climatic differences, correspond closely with the lower strata discovered at Perm and Mansfield, but its mineral resources are evidently more promising.

¹ This gentleman is the most thoroughly informed concerning the origin and history of the application of the term Permian, having been intimately connected with Messrs. Cope, DeRyee, and Boll, who applied it so frequently.

² Charter and by-laws of the Texas Copper Mining and Manufacturing Company. A history of the company. Letter from the Department of the Interior, by Joseph S. Wilson, Commissioner. Prof. Wm. DeRyee's and W. F. Cummins's Geological Reports. Dallas, Texas, 1883, p. 6.

Then follows a description of the mineral products of the formation, throwing no light on its age or stratigraphy.

The foregoing is the first and only description I have been able to find in print of the Permian of the Wichita region of Texas from the pen of the man who first applied that name to its geologic formation.

In the same pamphlet are geological reports from Prof. Jacob Boll and Prof. W. F. Cummins. The former says (p. 11) of the geologic age:

The company's land lies wholly within the transition period, especially within the lower Permian formation.

The latter says, however (pp. 8, 9):

I had visited frequently before this trip the immediate country in which these lands are situated and had already determined the geological period to which Archer County belongs. Under an engagement with Prof. E. D. Cope, of Philadelphia, Pa., I have been for the last two years collecting fossil vertebrates of the Permian period in Archer and adjoining counties. Archer County is almost entirely within the lower Permian period. The rocks and clays of the Permian thin out to the south, where there is a fine presentation of the rocks of the upper Coal Measures. The Permian strata in Texas lie conformably above the Carboniferous measures; in fact, the Permian and Carboniferous rocks constitute a continued series, so that it is impossible to determine just where one ends and the other begins; but I am certain the lands of the company are wholly within the Permian, for I have collected fossils on these lands that are undoubtedly of that period.

Prof. Jacob Boll made the first intelligible announcement of the Permian in Northwest Texas in a brief sketch in the *American Naturalist* for 1880.¹ He mentioned his explorations of the previous field season, which extended over the entire length of Little Wichita River and its confluents. As the result of this six months of exploration he announced that he had discovered many new "plants and animals, consisting of petrified ferns, fishes, and reptiles." These, he asserted, all belonged to the transitional period, and especially to the lower and upper Permian.

Such is the meager testimony upon which the existence of the Permian in Texas was originally announced. I have been able to gather from a few scattering newspaper articles a better understanding of the region thus termed Permian. These articles were written by Prof. W. F. Cummins, an intimate friend and companion of Professor Boll, who accompanied him upon his journeys of investigation. The substance of the observations given in these newspaper articles is here reproduced somewhat at length, as the original publications are now inaccessible to the public.

In an article published in *The Galveston Daily News*, of December 1, 1884, Professor Cummins describes a geologic expedition into the country which Professor Boll was exploring at the time of his death, in 1880, in the vicinity of the Double Mountain Fork of the Brazos River. The principal object of Professor Cummins's journey was to discover the

¹ Vol. XIV, p. 684, 1880.

extent of the Permian formation in that part of the State. He had previously traced the formation from the Wichita Mountains, near Fort Sill, Indian Territory, southward to the South Fork of the Brazos River. From the fact that Professor Cummins was such an intimate friend of Professor Boll, it is inferred that they had the same ideas concerning the use of the term Permian. According to Professor Cummins it would appear that—

(1) On the west side of the Carboniferous exposure, from Fort Griffin to the Clear Fork of the Brazos, there is a series of limestone hills similar to those in Baylor and Throckmorton Counties, which he considered Permian from their stratigraphic position above the Coal Measures, although unable to determine from the poorly preserved fossils and “the character of the rocks.”

(2) At the base of these hills, on the east side of California Creek, are the “red marls of the Permian.”

(3) Four miles farther west, still *at the base of the limestone hills*, is the vertebrate stratum,¹ which apparently has a wide extent and seldom exceeds two feet in thickness. Fossils are abundant in this stratum, “over fifty species heretofore unknown to science having been described from these beds” by Professor Cope.

(4) Twenty miles west of the above mentioned locality is Flat Top Mountain, presenting a vertical exposure of 250 feet. These rocks belong to the Permian, but are geographically too high for the vertebrate strata, only a few poorly preserved shells having been collected.²

(5) Twenty-five miles north of the above mountain is Kiowa Peak, situated at the junction of Croton Creek and the Brazos River. “A trip to the mountain disclosed the fact that it is of the Permian age. The whole mountain from top to bottom was a mass of saccharoidal gypsum.” Fossil vertebrates were collected in the vicinity.

(6) At Double Mountain, to the south of the above mentioned locality, “the base of the mountain is gypsum, while at least two hundred feet above are Cretaceous, the Cretaceous shells being abundant and well preserved.” Between the Permian and the Cretaceous beds is an unfossiliferous bed, 60 feet thick, similar to that “which immediately overlies the Carboniferous in Young and other counties, and which has hitherto been supposed to belong to that series of beds.”

From the above data, together with my own observations in the region, the Permian of Messrs. Cope, Boll, and Cummins may be described as follows:

(1) A stratum of limestone, probably a part of that surmounting the true Carboniferous hills of Shackelford County, the Permian age of which is based upon its position, the fossils being pronounced indistinct by those who have seen them. This stratum of limestone is most prob-

¹I have been informed that the vertebrate stratum is above the gypsum beds.

²No study has ever been made of the invertebrate fossils of the region.

ably that described by Ashburner¹ as outcropping a few miles from Cummins's locality and belonging under the Brazos coal bed, the superincumbent strata probably being washed away by erosion. It may possibly be the White Limestone of Shumard's trans-Pecos region.

(2) The red marls so characteristic of that region of Texas and described by many travelers as occupying the gypsum beds. According to Professor Cummins, these are at the base of the Carboniferous hills above mentioned, indicating non-conformability and later deposition.

(3) A vertebrate bearing stratum, the relation to the foregoing not being known, the fossils of which have been the basis of Professor Cope's term Permian.

(4) The well known gypsum strata of Texas, which have been so often mentioned in the literature of the State. These immediately underlie the typical Texas Cretaceous, a barren stratum of only a few feet intervening.

From the foregoing it will be seen that Professor Cope's Permian, as interpreted by Professor Cummins's observations, includes all the strata in Texas west of the central Carboniferous area from the late Carboniferous to the base of the Cretaceous, inclusive. It is doubtful whether this evidence, based upon a vertebrate bearing stratum and unaccompanied by any stratigraphic detail, is sufficient to justify the application of the term Permian to such an important and unexplored series of Mesozoic rocks.

The age of this series is still in the same condition of uncertainty as before Professor DeRyee applied a name to it. The rocks may be Carboniferous, Permian, Triassic, Jurassic, or Cretaceous, or all. It is certain that they are the representatives of the sedimentation of the entire Mesozoic age previous to the well authenticated Cretaceous. A little investigation would throw much light upon the subject.

Detailed comparison will now be considered unnecessary to show that there is no similarity between the two regions in Texas to which this term Permian has been applied. The Permian of Shumard, beyond the Pecos River, whether Permian or Carboniferous, occupies a clear stratigraphic position; it is well marked by a characteristic fauna; there is no doubt as to where it belongs in the geologic succession. On the other hand, the Permian of Cope has as yet no well defined stratigraphic relations; it is involved in ambiguous uncertainty and its fossils are of a vague and indefinite character. There are no stratigraphic, lithologic, or paleontologic points common to the two, and hence they have no established relationship whatever, the latter author having applied the name apparently without knowledge of its use by the other.

¹"Brazos coal-field, Texas," Trans. Am. Inst. Mining Eng., Vol. IX, pp. 495-506, 1880-'81.

THE JURA-TRIAS OR GYPSUM STRATA.

The few geologic observers who have traveled in Texas west of the ninety-ninth meridian, south of the North Fork of the Canadian, have all commented upon the occurrence of immense gypsum deposits in that region, but so far as I am aware no one has endeavored to offer any hypothesis as to their formation or to interpret their accompanying phenomena. Captain Marcy was the first observer to give this formation extensive notice, but he throws little light on its stratigraphic relations. He records numerous localities of occurrence, however, which are of value. He describes the strata as snow white gypsum, from fifteen to twenty feet thick; resting horizontally upon substrata of red clay and sometimes accompanied by red sandstone. Mr. Jules Marcou, who observed the same formation a few miles north of Captain Marcy's localities, in his notes conveyed the idea that these beds were white and rose colored gypsums; the beds were from one to twenty feet thick, a thin, argillaceous dolomite being found below them. Captain Pope also noted the occurrence of the same beds several hundred miles to the southwest, on Delaware Creek, where Dr. G. G. Shumard, who accompanied both him and Captain Marcy as geologist, affirmed his identification. At various other points west of the central Carboniferous exposure, between Red River and the mountains west of the Pecos, these gypsum strata have been noted and many sections given. I have observed them at several of the localities mentioned, and in Jones, Haskell, Mitchell, and other counties. At every point these gypsum strata are of the same character, consisting of white or pink deposits of saccharoidal, hydrous calcium sulphate. Sometimes they are accompanied by deposits of magnesium and other sulphates.

That these gypsum beds do exist; that they extend over a large area of country; that they do not consist of fragmentary crystals or impregnations, but are extensive, massive bedded strata, presenting a similarity of structure indicative of identical deposition, is now evident.

What bearing or relation they have to the geologic structure and history of Texas, is a most pertinent question. So far as I am aware no study has been made in this direction. Previous to 1860, when these beds were attracting the greatest attention, the formation of gypsum was little understood, and there has been no interpretation of the bearings of this region upon our American geology. The simple laws of chemical and physical precipitation of limestones, gypsums, and dolomites have but recently become aids to the stratigraphist in his studies.

The fact that the typical strata of the peculiar Cretaceous rocks of Texas have been observed by Professor Cummins and others resting immediately upon these gypsum beds is evidence that their age is pre-Cretaceous, and not the age of the Dakota group, as has recently been averred by students of the gypsum strata of Kansas. I also have reason to believe that some of the numerous "red beds" of the gypsum

region are Carboniferous, but that the age of the gypsum beds themselves is still unknown, except that they are intermediate between the Carboniferous and the Cretaceous, including what has been termed the Permian and the Jura-Trias. The intimate stratigraphy of these beds is not known, but it is probable that they are the eastern exposure of the immense deposits of the "red beds" observed throughout the Southwest, especially in New Mexico, Utah, and Arizona.

THE SO-CALLED JURASSIC ROCKS OF TEXAS.

I have already shown (page 54) that Mr. Jules Marcou referred certain of the Mesozoic rocks of Texas to the Jurassic. These rocks were along the breaks of the Llano Estacado and along the Canadian River near the boundary of New Mexico. I have also alluded to the fact that Mr. Marcou's opinions were attacked by nearly all of the leading geologists of the day,¹ none of whom visited the region, except perhaps Dr. Newberry. It was a warfare of theoretical discussion, for very little was known of the region. Mr. Marcou held to his point,² and has not yet conceded that these strata are Cretaceous, as his opponents unanimously maintained. It is highly probable that the fossils *Gryphæa dilatata* and *Ostrea Marshii*, upon the occurrence of which Marcou held his position, are the same species that Dr. Shumard afterwards described as *Gryphæa Pitcheri* and *Ostrea belliplicata*, and now known to occur in the well defined Cretaceous of Central Texas; but it is certain that Marcou's allegations that these fossils are Jurassic were founded upon as logical grounds as those of his opponents, who, at a distance, made them equal to the Upper Chalk. It is probable that they are the continuation of Jurassic forms into the Lower Cretaceous, which Marcou called elsewhere "Neocomian;" and from later and more definite information it is very probable that Marcou's Jurassic is basal (not Upper) Cretaceous.

Another writer, Mr. N. A. Taylor, has been outspoken in referring the Cretaceous strata of Texas to the Jurassic. He thus expresses himself:³

The conformation of this great region seems to show unmistakably that it was once an inland sea, whose southern shore was probably at first along the Azoiic hills below the San Saba, contracting gradually to the great backbone between [Fort] McKavett and Kickapoo Springs, whose western shore extended at least thus far, and whose northern shore may have reached the Red River. Its eastern shore probably crossed the Colorado above the mouth of the Concho, extending northward to the limit of Texas and perhaps beyond. This immense basin slopes inward from

¹ See "Criticisms on Marcou's work by American geologists," Am. Jour. Sci., 2d ser., XXVI, p. 323; 2d ser., Vol. XXVII, pp. 34, 134; 2d ser., Vol. XXVIII, pp. 153, 256, and 298; Report of U. S. Geological Survey, Vol. IX; Report of U. S. and Mexican Boundary Survey, Vol. I, Part II; Pacific Railway Reports, Vols. II and III, quarto editions.

² See Geology of North America, by Jules Marcou, Zurich, 1858, for gist of Mr. Marcou's defense.

³ See The Coming Empire, or Two Thousand Miles in Texas on Horseback, by H. F. McDaniels and N. A. Taylor, pp. 314, 315, 1878.

every direction, but its deepest parts are probably along the valleys of the Concho, not far from its southern border. The altitude of Fort Concho is only one thousand nine hundred feet above the level of the sea, while that of the great ridge below Kickapoo Springs and this on which I stand must be quite a thousand feet higher. This sea in drying up left enormous deposits of gypsum, great beds and areas of salt and other alkalies, with which all the streams that flow through its ancient bed are more or less impregnated. This sea, as I believe, existed during the Jurassic age. The geologists who have written of this region, from observations at telescopic distance or no observations at all, have all assigned it to the Cretaceous; but my judgment is that there is little or no Cretaceous in it. I have seen no fossils to confirm this judgment; but this basin in general outline is totally unlike the Cretaceous as developed in other portions of Texas or elsewhere. Nor has that formation in any part of the globe, if this be Cretaceous, developed such enormous deposits of gypsum and salt. If, then, it is Cretaceous, it is anomalous and without precedent.

The region he alludes to is the central or denuded area. He says:

This portion of Texas has never been geologically examined, except in a most cursory way, and it is not always easy to distinguish Jurassic from Cretaceous fossils. The late State geologist, Professor Buckley, rode over it in an ambulance, not deviating from the El Paso stage road.

Mr. Taylor has simply taken the work of subaërial erosion to be that of a lacustrine shore line, and his Jurassic sea is the denuded area of all the formations from the Carboniferous into the Cretaceous.

Although no one could say positively that there are no strata of the Jurassic age in Texas (for the problematic gypsum bearing red beds may be of that age), it is perfectly safe to say that none have as yet been demonstrated to exist.

THE CRETACEOUS.

The Cretaceous strata of Texas form by far the most extensive and important geologic deposit of that State. Fortunately for science the earliest writings on this particular formation were very explicit. Dr. Ferdinand Roemer's *Kreidebildungen von Texas* and his other writings on the subject, however erroneous they may be in their deductions, are exceedingly complete and clear, so that in their perusal there can be but little doubt as to the exact opinions he entertained. He studied the Cretaceous rocks of the State from the marine Tertiary on the east to the Paleozoic rocks in the Llano County region, embracing a cross section of the entire thickness of the series. This was from Seguin to the old Spanish fort on the San Saba. He also collected all possible legendary evidence and platted upon a map his ideas of the distribution of the Cretaceous strata in Texas. His descriptions and figures of the fossils of this formation remain to this day the most accurate and perfect of any paleontologic literature of the country. The principal points he developed concerning this formation were as follows:

(1) He delineated its eastern border as extending from Presidio del Rio Grande northeastward 440 miles to the Red River, enumerating many intermediate points. This line is generally accepted to-day.

(2) He explained the peculiar lithologic characteristics—a white chalky rock, with the appearance and consistency of the German Plä-

nerkalk, containing calcite crystals and flint nodules, a chalk marl, and a harder yellow limestone.

(3) He gave the first exposition of its organic remains and asserted their great similarity to the fauna of the Upper Cretaceous of Southern Europe.

(4) He gave the fauna of the various strata and of different localities, describing 118 species, 58 of which were new to science.

(5) He noted the escarpment line, running from the neighborhood of San Antonio northward, via New Braunfels and Austin, to an indeterminate point north of the latter city. He found the Cretaceous formation to extend in a comparatively narrow strip along the base of this escarpment, as well as far to the west along the surface of the tableland, of which it was the boundary.

He found well differentiated faunas in each of these topographic areas, and accordingly divided the formation in two great subdivisions,¹ to wit: Die Kreidebildungen am Fusse des Hochlandes (the Cretaceous formation at the foot of the highlands) and Die Kreidebildungen des Hochlandes (the Cretaceous of the highlands). He discussed the last named formation as the Cretaceous as he found it near Fredericksburg² and the Cretaceous eight miles west of New Braunfels.³ Of these divisions and subdivisions he considered the Fredericksburg, or most western outcrop, the newest, and the Cretaceous at the foot of the highlands the oldest, and expressed the opinion that there could be no doubt that the latter extended under the highlands, instead of resting unconformably upon it, which recent investigations have shown to be the case.

¹ Dr. Roemer made no tabulated section of the Cretaceous of Texas, but from many statements in the text of his works it is evident that he had the following opinions of the subdivisions:

There are three general divisions of the Cretaceous in Texas, to-wit: The Cretaceous at the foot of the highlands; the Cretaceous of the highlands; the Cretaceous of the hills near Fredericksburg.

On page 17 of *Kreidebildungen* he says: "It is known that the hills in the country to the north of Fredericksburg, on the Pedernales River, are the latest of all the Cretaceous of the highlands of Texas." On page 18 of the same work, he says: "After these observations it cannot be longer doubted that the Fredericksburg strata belong to the youngest of the three accepted divisions of the Cretaceous period."

Concerning the relation of the Cretaceous of the highlands to that at their foot, he says (Texas, p. 379): "Before we can enter upon a discussion of the general significance of the Cretaceous strata in Texas we must endeavor to investigate how the Cretaceous, which caps the high table-lands of Texas, consisting of a series of silicious, chalky strata, are related to the earlier observed formation at the ford of the Guadalupe, near New Braunfels, and at other points along the foot of the highlands, consisting of less firm white limestone and marls. The undoubted succession of these strata cannot be seen plainly at New Braunfels.

"But, since the firmer strata of the highlands plainly occupy a much higher bluff, it is not to be doubted that here at New Braunfels the loose white chalk and chalk marls are the lowest and the firmer limestones of the highlands the highest."

² Comanche Peak group of Shumard.

³ Washita Limestone of Shumard.

He intimated the westward extension to the Rocky Mountains of the Cretaceous formation, and showed that it differed materially in its organic and lithologic characters from what is now known as Meek and Hayden's section in the Northwestern Territories and that it bore slight resemblance to the Alabama section, based upon the occurrence of Hippurites.¹ He also asserted, upon the occurrence of identical organic remains, that this formation was equivalent to the Upper Chalk and displayed by both its paleontologic and its lithologic characters a resemblance to the Upper Cretaceous of Southern Europe in the countries bordering on the Mediterranean.

From the above facts, together with similar observations upon the relation of the Cretaceous of New Jersey with that of Northern Europe, he derived the following important conclusions concerning the Cretaceous of Texas :²

(1) The rocks of the Cretaceous period in Texas, which are generally of a chalky character, have an extensive distribution, reaching from the Red River to the Rio Grande, comprising the greatest part of the highlands (central region) and the southern border, even extending into the undulating region (black prairie).

(2) The rocks vary greatly in character, those of the undulating region (black prairie region) consisting of white, chalky limestones of little firmness, and those of the highlands (central region) of a great system of strata consisting in part of very firm limestone layers, with inclosures of flint nodules and intervening layers of marls.

(3) The Cretaceous formations of Texas collectively belong to the Upper Chalk (i. e., the chalk above the Gault), and so much so that they may be referred to the horizons of the white chalk (Étage Sénonien d'Orbigny) and the upper part of the chloritic chalk (Étage Turonien d'Orbigny) of Europe.

(4) The rocks of the Cretaceous formation in Texas, particularly those of the highlands (central region), upon comparison show a decided analogy with the Upper Cretaceous formations of Southern Europe, especially along the Mediterranean, which analogy is especially seen in the strong representation of the fossil family of Rudistes.

(5) The same physical differences in the natural conditions of the oceanic regions of the north of England and Northern Germany, on the one hand, and those of the Mediterranean on the other, that existed at the close of the Cretaceous age and that caused the variance in faunas and lithologic characters of the synchronous deposits in these two regions, existed at the same time and do still exist in the seas of North America. From these facts it is evident that the Cretaceous of New Jersey then bore the same relations to that of Texas³ as did that of the north of Europe to that of the Mediterranean, and that the same northerly deflection of the isothermal lines from the eastern coast of North America to the western coast of Europe, was evident at so early a time in the earth's history as the Cretaceous.

The next observation of the Cretaceous strata of Texas was made by Dr. G. G. Shumard along the northern border of the State. He included the strata which his brother, Dr. B. F. Shumard, afterwards incorporated in his section under the name of Washita Limestone. These he traced from Fort Washita (a few miles north of the present

¹ Radiolites, as corrected in Kreidebildungen.

² Kreidebildungen, pp. 25, 26.

³ The next to the latest of the European Cretaceous.

city of Denison) to east of Fort Belknap, in Young County. A comparison of his descriptions with those of Roemer shows that the Cretaceous of this northern region of Texas has many paleontologic similarities with that described by Roemer from an Indian camp on the Guadalupe, eight miles west of New Braunfels, but that their lithologic features vary greatly.

Dr. G. G. Shumard said of these strata:¹

From this point [Fort Washita], the Cretaceous rocks were found to extend uninterruptedly until we reached the southwestern boundary of the cross timbers in Texas. From the best information I was able to procure it constitutes the prevailing formation from Fort Washita in the direction of Fort Towson for upwards of a hundred miles with an average breadth of fifty miles. It forms part of that extensive belt of Cretaceous strata that extends from Georgia to Texas, and which, from the character of its fossil fauna, is now regarded as the equivalent of the Upper Chalk of England, and with that division of the Cretaceous group to which d'Orbigny gives the name of l'Étage Sénonien. Wherever sections of the strata were to be seen, they presented the following characters: Grayish yellow sandstones, with intercalations of blue, yellow, and ash colored clays and beds of white and bluish white limestone. The limestone reposes on the clays and sandstones. At some points it attains the thickness of a hundred feet, while at others it is quite thin and sometimes even entirely wanting. It is usually soft and friable and liable to disintegrate rapidly when exposed to the action of the weather. These Cretaceous rocks are often full of fossils. At Fort Washita the layers are crowded with *Ananchytes*, *Hemiaster*, *Nucleolites*, *Ammonites*, *Ostrea*, *Pecten*, &c., descriptions and figures of which will be found in Dr. B. F. Shumard's reports on the paleontology of the expedition. We saw here some specimens of *Ammonites* several feet in diameter and weighing between four and five hundred pounds.

Mr. Jules Marcou published a more accurate description of the Fort Washita strata and fauna a year after Dr. G. G. Shumard. He showed that in that region they were greatly denuded and covered to the east by higher strata like those of Arkansas and Mississippi. He asserted that the true age of the Fort Washita strata was Neocomian.²

The first results of the expedition were published by Mr. Marcou, prefaced with the statement that he had as yet neither the specimens which he had collected nor a good map of the country passed through, and since the time was very short in which he could make the required report he begged that its brevity and incompleteness be excused. In this paper he announced the existence of various formations which he more or less correlated with European strata. He described the red beds of the western portion of the Indian Territory as the Trias and discussed its divisions. The most important announcement, so far as concerns the geology of the Texas region, was as follows:³

I have mentioned two points between Topofki Creek and Anton Chico, where the Triassic rocks are covered by more modern formations. The first of these points is

¹ Expl. Red River of La., 1852, by R. B. Marcy and Geo. B. McClellan, p. 158.

² This is the only recorded reference of Texas Cretaceous strata to a position below the Gault.

³ Geology of North America, by Jules Marcou, p. 17, 1858. The wording varies from that used in the résumé printed as a part of House Doc. 129, 1854, Lieutenant Whipple's report, p. 40, and makes locations more explicit.

upon one of the tributaries of the False Washita River, Comet Creek (latitude $35^{\circ} 32' 21''$, longitude $99^{\circ} 14' 40''$), near our camp, No. 31, where, upon the heights, are found the remains of beds of a limestone filled with shells which I connect with the Neocomian of Europe, or, in other words, with the Lower Division of the Cretaceous rocks. This limestone is only 5 feet thick; it is of a whitish gray color, containing an immense quantity of *Ostracea*, which I consider as identical with the *Exogyra* (*Gryphæa*) *Pitcheri* Mort. * * * having the closest analogy with the *Exogyra Couloni* of the Neocomian of the environs of Neuchâtel (Switzerland). As it is the first time the Neocomian has been recognized in America, where, until now, only the Greensand and Chalk Marl or Lower Chalk have been found, I will add that these strata are much more developed at Fort Washita, where Dr. G. G. Shumard has made a collection of fossils such as *Pecten quadricostatus*, *Gryphæa Pitcheri*, *Cardium multistriatum*, *Ammonites acuto-carinatus*, *Holaster simplex*, all fossils or genera characteristic of the Neocomian of Europe. Further, at Fort Washita, the Neocomian is covered by the Greensand, containing very fine *Hemiaster*, large *Ammonites flacidicosta*, *Gryphæa sinuata* var. *Americana*, *Exogyra Texana*, &c.

This Neocomian has nearly been destroyed and carried away by denudations, for it is only found on the summits of the hills, where it appears like the ruins of ancient buildings; it occupies actually only a width of three or four miles. Probably at the time of the deposit it covered more space, but as at Fort Washita, where it has been very little denuded, it is only twenty-five or thirty miles wide. This shows it to have been but a narrow band in the immense basin of the prairies.¹

The other reference of Mr. Marcou relating particularly to the geology of the State of Texas, although made, like the foregoing remark, upon strata continued beyond its border, was to the effect that certain other rocks on the Llano Estacado were Jurassic, as follows:

These rocks belong to the Jurassic or Oölitic epoch. Fossils are very rare in the sandstone and limestone; but the beds of blue clay which are found in the middle of this formation contain in abundance a *Gryphæa* which has the greatest analogy with the *Gryphæa dilatata* of the Oxford Clay of England and France, and which I call provisionally *Gryphæa dilatata* var. *Tucumcarii* * * * and a very large *Ostrea*, having a resemblance to the *Ostrea Marshii* * * * of the Inferior Oölite of Europe. * * * This American Jurassic presents, at least thus far, one point of considerable difference from the Jurassic of Europe and Asia, where such large quantities of *Cephalopoda* are found, such as *Ammonites* and *Belemnites*, while here the *Ammonites* are only found in the Greensand and the *Belemnites* in the Marly Chalk; and even there these fossils are never so abundant as in the corresponding strata of Europe.

In another preliminary paper, based upon specimens collected by Captain Pope's expedition, which he did not accompany, Mr. Marcou speaks as follows of the Cretaceous rocks in the vicinity of Preston, Tex., near the present site of Denison:²

Preston and its environs are formed of the Cretaceous rocks that extend along the Red River and the False Washita as far as the Canadian River. These rocks form also

¹ Field observations by the writer, made and published since the manuscript of this bulletin was sent to press, show that this small and hitherto unappreciated description of Mr. Marcou, is really the most accurate that has ever been written on the Cretaceous formations of the Indian Territory, and that it is equally applicable to those of Texas, of which they are the continuation.

² In House Doc. 129, 1854. Rep. of Exploration of a Route for the Pacific Railroad near the Thirty-second Parallel of Latitude from the Red River to the Rio Grande. By Bvt. Capt. John Pope, Chap. XIII, Geol. Notes of a Survey of the country comprised between Preston, Red River, and El Paso, Rio Grande del Norte, p. 25.

the beds of the several tributaries of the Trinity River, especially of the Elm Fork of the Trinity, where your survey has found this formation very well developed, with numerous fossils. The Cretaceous consists at the base of yellowish gray limestones, filled with broken oysters, of which the most common species is the *Gryphaea Pitcheri*; then pale grayish blue clays are superposed, containing numerous fossils, such as *Exogyra Texana*, *Ostrea carinata*, *Pecten quinquecostatus*, *Toxaster Texanus*, &c. Upon these clays are sandy limestones, grayish white, containing large *Ammonites* and *Baculites*; the most common are *Baculites asper* and several other new species that you have collected and which I will describe in the final report. The lower part, formed of limestone with *Gryphaea Pitcheri* and blue clay with *Toxaster Texanus*, corresponds with what is called by geologists the Neocomian formation, while the upper portion, containing *Ammonites* and *Baculites*, corresponds to the formation designated as Greensand and Marly Chalk.

The next cross section of the Cretaceous strata was made along the Rio Grande, by Arthur Schott,¹ of the United States and Mexican boundary commission. This he describes as "a Cretaceous basin, which consists chiefly of strata of greensand, which extends from Las Moras to the vicinity of Reynosa, and forms a belt of 380 to 400 miles in width" (p. 34) in Texas and Mexico. In this basin he notes various lithologic characters and some slight local disturbances. In this region, "from Las Moras to the vicinity of Arroyo Sombretillo, which is about ten miles above Laredo, lignite coal occurs frequently" (p. 35). "Prints and even remains of plants preserved in these coals indicate vegetable forms of the higher orders, as Gramineæ, and even dicotyledonous trees, such as willow and ash" (p. 35). He also notes the extension of these coals into the Santa Rosa mountainous regions of Mexico, where the strata are nearly vertical. The fossils, plants, and mollusks from these localities bear a close affinity to the coal bearing beds of the late Cretaceous of the Northwestern Territories, but their relation to that region as well as to the Cretaceous of the west of Texas is still problematic.

Dr. Benjamin F. Shumard was the next geologist to study the Cretaceous strata in the field. He had the advantage of previous observations as well as of residence in the State for a few years as State geologist (1858-1861). His writings give evidence of much labor, but, like Dr. Roemer's, they are deficient in stratigraphy and are mostly of a paleontologic character. His section of the Cretaceous strata of Texas has been accepted to the present time by most writers. I quote the section with his immediate comments upon it:²

The order of succession and thickness of the different members of the Cretaceous system, so far as observed in Texas, are expressed by the following section, which is believed to be in the main correct, although it is not improbable that further researches may render some slight modifications necessary.

¹ Substance of the Sketch of the Geology of the Lower Rio Bravo del Norte, by Arthur Schott, asst. surveyor U. S. B. C., &c. Report of U. S. and Mex. Boundary Surv. Vol. I, Part II, pp. 28-48, 1851.

² Trans. Acad. Sci. Saint Louis, Vol. I, pp. 582-589, 1856-1860.

	Subdivisions.	Feet.	Characteristic fossils.	Eq. Nebraska section.	Eq. Alabama section.	Eq. Pyramid Mt. sec.
Upper Cretaceous or Calcareous division.	Caprina Limestone.....	60				
	Comanche Peak group..	300 to 400	<i>Exogyra Texana</i> , <i>Gryphæa Pitcheri</i> , <i>Janira occidentalis</i> , <i>Cardium multistriatum</i> , <i>Lima Wacoensis</i> , <i>Ammonites Pedernalis</i> , <i>Natica Pedernalis</i> , <i>Heteraster Texanus</i> , <i>Holcotypus planatus</i> , <i>Cyphosoma Texana</i> , and <i>Diadema Texana</i> .	Wanting.	Wanting.	Wanting.
	Austin Limestone	100 to	<i>Gryphæa vesicularis</i> , <i>Exogyra costata</i> , <i>Radiolites Austinensis</i> , <i>Nautilus Dokayi</i> , <i>Baculites anceps</i> .	No. 4 & 5 (?)	A B C	
	Fish bed.....	120	Fish remains — <i>Mosasaurus</i> ,			
	Indurated Blue Marl.....	60	<i>Exogyra arietina</i> , <i>Dentalina</i> .			
	Washita Limestone.....	100 to 120	<i>Gryphæa Pitcheri</i> var. <i>Tucumcarii</i> , <i>Ostrea subovata</i> (O. <i>Marshii</i> , Marc.), <i>O. carinata</i> , <i>Inoceramus problematicus</i> , <i>Hamites Freumonti</i> .	No. 3.	Wanting.	E F G
	Blue Marl.....	50	<i>Inoceramus problematicus</i> , <i>Ostrea</i> , &c.	No. 2.		
Lower Cretaceous.	Caprotina Limestone...	55	<i>Orbitolina Texana</i> . <i>Caprotina Texana</i> . <i>Natica acutispira</i> .			
	Arenaceous group.....	80	<i>Ostrea bollarugosa</i> . <i>Cyprina</i> (?). Fish remains.	No. 1.	E	B C D
	Fish bed.....					
	Marly Clay or Red River group.	150	<i>Ammonites Swallowii</i> , <i>A. Meekianus</i> , <i>Ancylloceras annulatus</i> , <i>Scaphites vermiculus</i> , <i>Baculites gracilis</i> , <i>Gervilla gregaria</i> , <i>Inoceramus capulus</i> , fossil wood.			A

I. UPPER CRETACEOUS OR CALCAREOUS DIVISION.

This division, in the eastern or settled portion of the State, attains a thickness of from 800 to 1,000 feet, but in its western extension reaches a much greater development. It presents the following subdivisions from above downwards: *Caprina Limestone*, *Comanche Peak group*, *Austin Limestone*, *Exogyra arietina marls*, *Washita Limestone*, *Inoceramus problematicus beds*, and *Caprotina Limestone*.

Caprina limestone.—This is the uppermost recognized member of the series, and, although of no great thickness, has a somewhat extended geographical range. It is a yellowish white limestone, sometimes of a finely granular texture and sometimes made up of rather coarse, subcrystalline grains, cemented with a chalky paste. It

generally occurs in thick, massive beds, and is capable of withstanding the action of the weather to a greater extent than most of the members of the Cretaceous system. This formation is usually found capping the highest elevations, and its presence may be nearly always recognized, even at a distance, by the peculiar flat-topped and castellated appearance it imparts to the hills [buttes]. According to Dr. Riddell, it is finely displayed along the bluffs of Brazos River, in Bosque, McLennan, and Hill Counties; also along the Leon and Bosque Rivers. The summits of the remarkable elevation known as Comanche Peak, in Johnson County, and that of Shovel Mountain, in Burnet County, consist of this rock.

The fossils are chiefly *Caprina*, *Cytherea*, and *Ammonites* of undetermined species.

Comanche Peak group.—The Comanche Peak group, which next succeeds in descending order, is an important member of the series, and presents a greater development, both horizontally and vertically, than either of the others. It is made up of soft yellowish and whitish chalky limestone and buff and cream colored limestones of greater or less compactness. * * *

The best exhibitions of this formation that we have seen are at Comanche Peak, Shovel Mountain, and at Mount Bonnell, near Austin.

Fossils: This group is remarkably rich in organic remains, a large portion of them, however, occurring usually as casts. The species most frequently observed are *Exogyra Texana*, *Gryphaea Pitcheri*, *Janira occidentalis*, *Cardium multistriatum*, *C. Texanum*, *C. Coloradoense*, *Pholadomya Sancti-Sabae*, *Lima Wacoensis*, *Arcopagia Texana*, *Trigonia crenulata*, *Astarte lineolata*, *Cardita erminula*, *Corbula occidentalis*, *Modiola contricecostellata*, *Leda*, *Thracia*, *Ammonites acuticarinatus*, *A. Pedernalis*, *Scolaria Texana*, *Phasianella tumida*, *Rostellaria (Eulima Sh.) subfusiformis*, *Natica Pedernalis*, *Nerinea acus*, *Avellana Texana*, *Turritella serialim-granulata*, *Cyrrhium Bosquense*, *Pleurotomaria* (undet. sp.), *Solarium* (undet. sp.), *Heteraster (Toxaster Roe.) Texanus*, *Holotypus planatus*, *Cyphosoma Texanum*, and *Diadema Texanum*.

It is quite probable that this and the preceding subdivision of our Cretaceous system are not represented in Nebraska. We have collected more than fifty species of fossils from these beds and not a single one has been found identical with any of the numerous Nebraska forms that have been described by Messrs. Meek, Hayden, Hall, the writer, and others. Neither have we seen any paleontological evidence that the beds under notice are parallel with any of the members of the New Jersey and Alabama series, though it is not improbable that a closer study of the Cretaceous rocks in Alabama will show them to exist there.

Austin Limestone.—This subdivision consists of cream colored and bluish earthy limestone, and resembles in lithological features portions of the preceding group, but contains quite a different assemblage of organic remains. Some of the beds are soft and crumble readily upon exposure, while others are moderately hard and furnish a handsome building rock, which may be cut into almost any required shape with a common handsaw. The State house and several of the public buildings at Austin are constructed of this stone. This formation occurs at Austin and near San Antonio and New Braunfels. Dr. Riddell also recognized it in McLennan and Bosque Counties and Dr. G. G. Shumard in Grayson County. The greatest thickness observed is in the vicinity of Austin, where the beds are exposed to the height of about one hundred feet.

Organic remains: The most characteristic [fossils] are *Inoceramus biformis*, *Gryphaea vesicularis*, *Exogyra costata*, *Ostrea anoniaformis*, *Arca vulgaris*, *Radiolites Austinensis*, *Nautilus DeKayi* (?), *Baculites anceps*, *Helicoceras*, *Ammonites*, *Cassidulus equoreus*, *Hemiaster parastatus*, and scales and teeth of fishes.

At the base we have shaly layers of dark bluish gray calcareous sandstone, containing numerous fish scales, teeth of *Corax heterodon*, *Lamna Texana*, and remains of *Mosasaurus*.

This assemblage of fossils establishes pretty clearly that the Austin Limestone represents divisions A, B, and C of the Alabama section, as determined by Professor Win-

chell, which are regarded by Messrs. Meek and Hayden and Professor Hall as on a parallel with Nos. IV and V of the Nebraska section.

Exogyra arietina marl.—This is an indurated blue and yellow marl, with occasional bands of gray limestone and thin seams of selenite interstratified. It contains iron pyrites in the form of small spherical masses and the fossils are also frequently studded with brilliant crystals of this substance. It is well exposed towards the base of Mount Bonnell, near Austin, where it presents a thickness of about sixty feet. It may also be seen to advantage near New Braunfels, in Comal County, at various points in Bell County, and Dr. G. G. Shumard found it resting upon the limestone of Fort Washita, in Arkansas.

Fossils: *Exogyra arietina*, *Gryphaea Pitcheri*, *Janira Texana*, and a small undescribed species of *Dentalina*. On Shoal Creek, near Austin, *Exogyra arietina* occur in the greatest profusion, the surface of the ground being sometimes literally covered with them.

Washita Limestone.—This important member of our Cretaceous system is made up of a nearly white, yellow, gray, and blue limestone, some of the layers being moderately hard, while others disintegrate rapidly from exposure. This formation is exhibited at many localities in the State. Good exposures occur near Austin and in Grayson, Fannin, and Red River Counties. According to Dr. G. G. Shumard, it is finely developed at Fort Washita. * * *

Blue marl.—This member was examined in Grayson County by Dr. G. G. Shumard, who describes it as an indurated, arenaceous marl of a schistose structure, with small nodules of iron pyrites and irregular masses of lignite disseminated through it. It has not been recognized south of Grayson County.

The fossils are *Inoceramus problematicus*, *Ostrea*, and *Plicatula*, of undetermined species. It also abounds in fish remains, the scales and teeth of which are sometimes elegantly preserved.

This subdivision should, perhaps, be grouped with the preceding. It corresponds with No. 2 of the Nebraska section.

Caprotina Limestone.—The Caprotina Limestone, which follows in descending order, forms the base of the Upper Cretaceous and is composed of light gray and yellowish gray earthy limestone, with intercalated bands of yellow marl and sometimes flint. It is exposed at the base of the hills near Comanche Peak and is seen underlying the Washita Limestone near the Colorado, at the foot of Mount Bonnell.

Fossils: The lower portion abounds in *Caprotina Texana* and the upper portion contains *Orbitolina Texana*, *Panopæa Newberryi*, *Cardium Brazoense*, *Arca Proutana*, *Cytherea*, *Cyprina*, *Natica acutispira*, *Phasianella perovata*, and *Cerithium*, and *Nerinea*, of undetermined species.

II. LOWER CRETACEOUS.

For a knowledge of this division of our Cretaceous system I am indebted to Dr. G. G. Shumard, who has had excellent opportunities for examining it. He describes it as being composed of sandstones and gypseous and marly clays, the latter containing numerous septaria, filled with fossils. It is separable into two groups, namely, Arenaceous and Marly Clay or Red River group.

*Arenaceous group.*¹—This member consists of light yellow and blue sandstone and beds of sandy clay, with crystals of selenite and some lignite. Its characters may be understood from the following section, taken by Dr. G. G. Shumard on Post Oak Creek, in Grayson County:

No. 1. Soft, fine grained, yellow sandstone.....	10 feet.
2. Hard, fine grained, blue sandstone, becoming yellow upon exposure, and sometimes passing into gritstone and fine conglomerate.....	5 feet.
3. Yellow sandstone, same as No. 1.....	10 feet.
4. Indurated, blue, slaty clay, with crystals of selenite.....	20 feet.
5. Thinly laminated layers, same as No. 2.....	3 feet.

¹Dakota Sandstone. See Trans. Acad. Sci. St. Louis, Vol. II, p. 140, quoted, p. 176.

Fossils: The upper part is characterized by *Ostrea bellarugosa* [*O. belliplicata*?], *Ostrea congesta*, *Lucina*, *Plicatula*, a small species of *Cyprina* (?); fossil wood, and occasionally obscure impressions of plants. The *Ostrea* occurs in distinct bands and is extremely abundant. The lower beds have yielded an undescribed species of *Lingula* and abound in fish remains which Dr. Leidy refers to the following species: *Ptychodus mammillaris*, *Lamna compressa*, *L. Texana*, *Galeocerdo pristodontus*, and *Carcharodon*. * * *

With regard to the Nebraska equivalent of our Arenaceous group, I think there can scarcely be a doubt that it represents No. 1 (perhaps the upper part) of the section of Messrs. Hall, Meek, and Hayden. * * *

Marly Clay or Red River group.—This member immediately underlies the fish bed of the Arenaceous group and is described by Dr. G. G. Shumard as "a blue, marly clay occasionally variegated with red and brown, and with thin bands of sandstone interstratified. The clay contains crystals of selenite, flattened nodules of compact brown and blue limestone, and septaria of compact, blue limestone, reticulated with brown, yellow, and purple spar. The nodules occur in the upper, and the septaria towards the base of the formation. The best exposures of the group are in Grayson, on Post Oak, Choctaw, and Big Mineral Creeks, where sections of from fifty to sixty feet have been measured. It occurs also on Red River, Fannin and Lamar Counties. The estimated thickness of the group in this part of the State is about one hundred and fifty feet, but we have not seen the base of the formation."

Fossils are exceedingly abundant in the septaria and nodules, and so far as I have been able to learn they belong to hitherto undescribed species. From the collections of Dr. G. G. Shumard I have been able to characterize the following: *Ammonites Swallowii*, *A. inaequiplacatus*, *A. Meekianus*, *A. Graysonensis*, *Ancylloceras annulatus*, *Scaiphites vermiculus*, *Baculites gracilis*, *Cythera Lamarensis*, *Tapes Hilgardi*, *Gervilia gregaria*, *Nucula Haydeni*, *Panopæa subparallela*, *Corbula Graysonensis*, *C. Tuomeyi*, *Inoceramus capulus*, and *Inoceramus*, n. sp. Fossil wood is also quite common at several of the localities visited.

The section contains what have been called grave discrepancies by another writer,¹ and from my residence in the State I think the criticism well founded. Why these errors appear in Shumard's section is easily explained. It is a composite one, made up at the city of Austin from the observations of three geologists working in widely separated portions of the State, and influenced by his predilection towards Roemer's opinions. His Comanche Peak series is evidently the same as Roemer's Fredericksburg subdivision, his Austin Limestone is Roemer's Kreidbildungen am Fusse des Hochlandes, and his Washita Limestone is the same as described by his brother and Mr. Jules Marcou. The lower part of his section is based upon the observations of his brother along Red River, where the lithologic and paleontologic variations are different from those of synchronous formations of other parts of the State. Dr. Riddell, assistant geologist, studied the formations in Bosque County, while Dr. B. F. Shumard himself studied them at Austin. He arranged, as he thought the data warranted, these observations of his brother on Red River, those of Dr. Riddell's in Central Texas, and his own and Dr. Roemer's near Austin to make up

¹ See "Notes on the Cretaceous and Carboniferous rocks of Texas, by Jules Marcou," Proc. Bost. Soc. Nat. Hist., Vol. VIII, pp. 86-97, 1861-1862.

the published section. From this section, by careful comparison of Roemer's work, it will be seen that he had the same fundamental opinion, to wit, that the Cretaceous of the lower land east of Austin extended under that of the table lands to the west, and that the tops of the hills (buttes) farther inland was the newest Cretaceous of the State.

Upon the publication of this section, Mr. Jules Marcou wrote a criticism of the same,¹ in which he pointed out many discrepancies in sequence of the groups and rearranged Dr. Shumard's section upon his own data, as follows :

Upper Cretaceous or Senonian.	Austin Limestone. Fish bed in sandstone (<i>Lamna Texana</i>). Blue Marl, with <i>Inoceramus problematicus</i> .	Arenaceous group with <i>Ostrea congesta</i> . Fish bed, <i>Lamna Texana</i> &c.
Middle Cretaceous or Green-sand and Turonian.	Marly Clay or Red River group. Caprina Limestone. Comanche Peak group (superior part with <i>Exogyra Texana</i>). <i>Exogyra arietina</i> marl.	
Lower Cretaceous or Aptian and Neocomian.	Washita Limestone (comprising the inferior part of the Comanche Peak group, with <i>Gryphaea Pitcheri</i>). Caprotina Limestone.	
	Trias or Carboniferous.	

From my own observations in the State I am inclined to believe, notwithstanding the disagreement with older geologists, that Mr. Marcou's deduction is more in accordance with the actual relations of the strata than any other published and especially than those of Roemer and Shumard.

In the following years (1861, 1862) Dr. B. F. Shumard announced the occurrence of two more groups of the Cretaceous in Texas. The first of these was the Ripley group of Mississippi, which he announced before the Academy of Science of Saint Louis to have been found in Navarro County, Tex. The other was the Dakota sandstone, which he reported from Grayson County. He studied the first, named group and identified over twenty species common to the Tippah County (Mississippi) beds and the Navarro County (Texas) beds. Concerning the alleged occurrence of the Dakota sandstone in Grayson County, he said that he based his opinion upon the occurrence of dicotyledonous leaves in the ferruginous sandy strata there,² of which he would speak further

¹ Proc. Bost. Soc. Nat. Hist., Vol. VIII, pp. 86-97, 1861.

² You will, perhaps, remember the statement in my paper on the Cretaceous strata of Texas (p. 589 of Transactions) that, although we had not succeeded in finding dicotyledonous leaves in the lower Cretaceous marls and sandstones of Texas, as has

at a future day, an expectation not fulfilled. These leaves, however, are now thought to be from the lower cross timbers strata, which are on a direct line of geographic continuity with the alleged Dakota of Kansas.

Dr. Shumard died without incorporating these later additions into his geologic sections. If he had done this it would have been necessary to revise the relative position of the strata entirely. He deserves credit, however, for some points which are not dwelt upon in his writings; one of these is the correlation of the groups of other States with those of Texas. He was the first to prove conclusively that the Cretaceous of the other Gulf States¹ was represented in Texas and also to intimate the occurrence there of the Dakota sandstone.²

Dr. R. H. Loughridge, in his sketch of the geology of the State,³ shows clearly the occurrence of the Gulf States formation along the eastern portion of the Cretaceous areas of Texas, and traces it to the line of the Red River, north of which it had been identified and studied by D. D. Owen, in Arkansas, many years before.

From the observations of all these geologists the following is at present known concerning the Texas Cretaceous:

(1) It has been studied hastily and independently along three widely separated, parallel cross sections, to wit, by Dr. G. G. Shumard and by Jules Marcou along the northern borders, by Dr. Ferdinand Roemer and by Dr. Benjamin F. Shumard in the central (Austin and New Braunfels) region, and by Arthur Schott along the Rio Grande. The section as studied by the last mentioned, being the continuation of Mexican geologic features into Texas, has but slight resemblance to the Cretaceous of the rest of the State, so far as it has been studied.

Concerning the rest of the State two diverse opinions have been presented, especially concerning the order of sequence and the correlation of the Cretaceous strata of most of the State of Texas, one of which is based upon observations of a cross section south of Austin across the

been done by Meek and Hayden in Nebraska and Kansas and Newberry in New Mexico, they would probably be found in this position. I have now the pleasure of informing you that further explorations in Lamar County, near the Red River, have resulted in the discovery, by Dr. G. G. Shumard, of numerous impressions of leaves in alternations of yellowish sandstones and bluish shales which are believed to occupy a position below the Marly Clay or Red River group of my section, and which we regard as being on a parallel with the lower beds of No. 1 of the Nebraska section. The collection made by Dr. G. G. Shumard contains several species of monocotyledonous leaves which appear to belong to the genera *Salix*, *Ilex*, *Laurus*, &c. I am unable to determine positively the generic affinities of these leaves, for want of proper works of reference, but shall submit the collection to a competent fossil botanist, and think they will be found analogous to those discovered by Meek and Hayden at the base of their Nebraska section. (Trans. Acad. Sci. St. Louis, Vol. II, p. 140. Read Nov. 5, 1860.)

¹ Trans. Acad. Sci. Saint Louis, Vol. II, p. 152, 1861, and Proc. Bost. Soc. Nat. Hist., Vol. VIII, pp. 188-205, 1861.

² Trans. Acad. Sci. St. Louis, Vol. II, pp. 140, 141.

³ Tenth Census: Report on Cotton Production in the United States, Vol. V, Part I, pp. 653-829. Report on the Cotton Production in the State of Texas, 1884.

eastern escarpment of the central region while the other is based upon a cross section along the northern border of the State. The first of these opinions, formulated by Roemer and reiterated by Dr. B. F. Shumard, makes the eastern division of the Cretaceous (the Gulf series) the oldest and the northwestern the newest, and correlates the whole with European strata later than the Gault.

The other opinion, and the one hitherto least accepted, partially on account of its manner of presentation, is that the Cretaceous strata are exposed in descending series in going from east to west, and that the limestone group is of the Neocomian age instead of Senonian, or White Chalk, as asserted of these strata farther south by Roemer and the Shumards. This is the opinion of Jules Marcon, as briefly expressed in 1858, and I think it the most plausible.

Concerning the extent of this formation in Texas much has been given. Roemer platted the eastern boundary from Clarksville, Red River, to near Laredo, on the Rio Grande. This boundary has not been changed by more recent observations, but rather confirmed.¹ The Cretaceous has been reported west of this line far beyond the western boundary of the State, being interrupted only where it has been denuded from above the Paleozoic and early Mesozoic areas.

It is also very well demonstrated that the eastern portion of this Cretaceous is a continuation of the Rotten Limestone and probably other subdivisions of the Cretaceous from the other Gulf States; that in the central portion of the State there is a lower division from which the overlying strata have been eroded, which is unique and probably older than the marine Cretaceous of the United States and different from them; and that along the lower Rio Grande there is an elongated area of coal bearing strata, which Mr. Schott denominates late Cretaceous and which has marked paleontologic affinities with the Upper Cretaceous of the Northwestern States and Territories.²

¹ Dr. R. H. Loughridge gives the eastern boundary of the Cretaceous a great western deflection from San Antonio to Eagle Pass. This is a mistake, founded primarily on an error of Conrad's, whereby he gave the wrong localities to certain Tertiary fossils, now known to be from the vicinity of Laredo. See p. 85; also, Tenth Census, Vol. V, Part I, Report on Cotton Production in Texas.

² There is reason to believe that these late Cretaceous coals underlie much of the Rio Grande, trans-Pecos, and Upper Canadian regions of the State. They have been recently reported all along the Rio Grande between Laredo and El Paso, at White Oaks, New Mexico, and at other places. They are probably the same coals of which Dr. Edward Hitchcock speaks in his Report accompanying Exploration of the Red River of Louisiana in the year 1852, by Randolph B. Marcy, captain Fifth Infantry. 1854, 33d Congress, 1st session, House of Reps. Ex. Doc., Appendix D, p. 144. He says: "I ought to have mentioned that among the specimens in my hands is one of lignite, collected July 3 near the sources of Red River, not far from the Llano Estacado and within the limits of the gypsum deposit to be described. It is an exceedingly compact coal and burns without flame, emitting a pungent but not bituminous odor. It is doubtless Tertiary or Cretaceous, but I think, if in large masses, it might easily be mistaken for anthracite."

THE SO-CALLED LARAMIE.

No observations of the true brackish water Laramie formation, which marks the transition from Cretaceous to Tertiary in the West, have been recorded from Texas. The term has been misapplied¹ to the lignitic strata at the base of the Gulf Tertiary in Eastern Texas, but this is not the true Laramie of the West. That the same species of vegetation grew along the coast of the marine waters of the old Gulf of Mexico as well as of the great Laramie basin in the interior of the continent is more than probable, but the term Laramie is a local group name and is not applicable to the synchronous subdivisions of the marine Cretaceous-Tertiaries.²

That the true Laramie may occur in the trans-Pecos region is not improbable, but it has not as yet been so recorded.

THE TERTIARY.

But one area of Tertiary formations has been positively identified in Texas, and that is the continuation of the Gulf States (marine) Tertiaries from Louisiana and Arkansas into its northeastern borders. Prof. Angelo Heilprin³ has said nearly all that can be said of them. He remarks:

The Tertiary formations of this State are yet too imperfectly known to admit either of an absolute localization of the various boundary lines or of an accurate subdivision into the minor geological groups. It may be safely assumed, however, from the geological conformation of the neighboring States, that all, or nearly all, of the divisions ranging from the Eolignitic to the Grand Gulf, inclusive, are represented, and that the positions occupied by these follow each other in regular succession, beginning with the oldest, from the interior coastward, with a general dip to the southeast or east. The geological notes on this region by Schott, Hall, and Conrad, and of Shumard and Buckley are exceedingly meager and unsatisfactory, and give us barely more than a general idea as to where the Tertiary formation exists.

According to Dr. Loughridge, who, more than any other geologist, has closely investigated the outcrops of the different formations occurring throughout the State, the Cretaceous-Tertiary boundary line starts on the northeast from the Red River at a point a few miles above Texarkana, on the Arkansas frontier, and, taking a general southwestern direction, passing at or near Clarksville, Red River County; Corsicana, Navarro County; Marlin, Falls County; Cameron, Milam County; Elgin, Bastrop County; Seguin, Guadalupe County; and the northwest corner of Atascosa, crosses the Rio Grande at about the mouth of Las Moras Creek.

Professor Heilprin also says (p. 38) that the "westerly deflection, indicated as beginning a few miles south of San Antonio and extending to the Rio Grande, can scarcely be said to be definitely proved as yet, although Loughridge affirms that 'the glauconitic sandstones mentioned

¹ On the Zoölogical Position of Texas, by Edward D. Cope. Bull. U. S. Nat. Mus., No. 17, p. 5, Washington, 1880.

² In justice to Professor Cope it is but fair to state that this is more of a difference of opinion as to nomenclature than as to geologic time.

³ Contributions to the Tertiary Geology and Paleontology of the United States, by Angelo Heilprin, pp. 37 et seq., 1884.

by Mr. Schott as occurring along the river [Rio Grande] from the Cretaceous rocks at the mouth of Las Moras Creek, north of Eagle Pass, southward to Roma, near Rio Grande City, are doubtless of Tertiary age.¹ Further evidence is needed on this point, however, although some confirmation of the supposition is lent by the discovery of Tertiary fossils (*Cardita planicosta* among others) in a locality (Arroyo las Minas), situated between El Paso and Leon."¹

I have carefully studied the literature and the facts concerning this supposed western deflection of the Tertiary strata as reported by Loughridge in Texas and accepted by McGee in his map of the United States accompanying the Fifth Annual Report of the U. S. Geological Survey. The first recorded boundary between the Cretaceous and the marine Tertiary was that made by Roemer in his writings before mentioned. It was practically the same as that of Loughridge, without this western deflection, and made the Cretaceous end on the Rio Grande near Presidio del Rio Grande, a short distance above Laredo. The work of the United States and Mexican boundary survey is misinterpreted through a small error of Conrad, who in his published description states that the *Cardita planicosta* comes from Arroyo las Minas, a small creek in what is now Zavalla County. The label pasted upon the original type specimen of this fossil,² in Mr. Arthur Schott's handwriting, as identified by his son, Albert L. Schott, reads as follows: "Cretaceous ridges next to the Arroyo Sufre, in the vicinity of Mier, Mexico. Schott, October, 1853." Hence it is presumable that this fossil is valueless for determining the alleged western deflection. Dr. Loughridge's other data for making this change in the accepted map is his belief that certain strata described by Schott as Cretaceous are Tertiary. I have described these strata on page 76, and from personal observation, as well as from much paleontologic material in the U. S. National Museum, I know them to be Cretaceous. Among the fossils described from them by Conrad, and with locality labels pasted upon them by Schott, are the following from Jacun, three miles east of Laredo:³ *Ammonites pleurisepta*, *Exogyra costata*, *Inoceramus cripsii* Mantell, *I. Texanus* Conrad, *Ostrea crenulimargo* Roemer, *Dosina*, *Turritella*, *Natica*, and *Ammonites pleurisepta* Con.⁴ These fossils are positively known to belong to the Cretaceous, and the locality where they occur is one hundred and fifty miles east of the boundary of that formation as deflected by Dr. Loughridge.

The *Exogyra costata* and *Inoceramus cripsii* are characteristic fossils of the Upper Cretaceous of all the Gulf States, and the *Ammonites pleu-*

¹ Report U. S. and Mex. Boundary Survey, Vol. I, Part II, pp. 141 and 161.

² Now in collection of the U. S. National Museum.

³ Report on U. S. and Mex. Boundary Survey, Vol. I, Part II, p. 143.

⁴ *Ibid.*, p. 159. This species is described under the name of *Ammonites pleurisepta*, but figured (Plate XV) as *A. pedernalis*.

risepta of Conrad is a typical fossil of the peculiar formation which Mr. Schott described and is now known to be very late Cretaceous. Even were it not for the original label pasted on the *Cardita planicosta*, alleged to be from Arroyo las Minas, a glance at the fauna among which it is placed by Mr. Conrad¹ would be sufficient to show that it is a stray specimen, for the rest are all typical Cretaceous forms. Instead of this western deflection of the Tertiary in Texas I am of the opinion, from the evidence we have, that it is many miles to the east of Laredo.

This eastern or Gulf Tertiary has been recognized as such by several authors under many names. Roemer noted the presence of beds similar to those at Fort Claiborne, Ala., and after a revision of all the printed evidence it is to be doubted whether much more is known about the Tertiary in Texas than is implied in his remark and noted on his map, to wit:

It is hardly to be believed that this Tertiary formation of Texas is to be found exclusively in the country of the Brazos [where he observed it]. It occupies a very similar zone to the Tertiary of Alabama, Mississippi, and other States, and like it, at most places is at the foot of the Cretaceous to the west and covered to the east by diluvial strata. (Texas, p. 372.)

Several other areas of the Tertiary have been reported besides this continuation of the Gulf group. The principal of these are the two anomalous forest regions known as the cross timbers. Dr. S. B. Buckley calls these Tertiary, Miocene, Eocene, &c. in his reports, but his evidence, as stated, is not such as to warrant his deductions.

The stratigraphy of the Tertiary in Texas has been neglected entirely, and we have nothing concerning its exact relation to the Cretaceous below or to the later formations. Neither is there any information concerning the stratigraphy of the group itself. In fact, the development of these strata is still to be made. All that can possibly be said of it at present is that it possesses certain broad resemblances to the Tertiary of the other Gulf States and that it consists of unstudied strata, lignitic at the base and ferruginous higher up. It rests upon the Cretaceous strata, but no evidence has been taken to ascertain whether it is simply a continuation of the sedimentation of that period or whether there is a non-conformity between them. Neither is there any evidence concerning its relation to the post-Tertiary strata.

QUATERNARY AND OTHER POST-TERTIARY STRATA.

Very little is known concerning the surface geology of Texas or of the later formations, but it is apparent that the great deposits of the coastal region result from the erosion of the interior surface. Dr. Ferdinand Roemer wrote the most of what we now know of these formations. He divides the coastal region of Texas into the alluvial and the diluvial region and describes the character of the drift and depositions of each.

¹*Ostrea carinata* Lam., *O. anomiaformis* Roemer, *Neithia occidentalis* Con. Report U. S. and Mex. Bound. Survey, Vol. I, Part II, p. 143.

He showed that there was considerable very recently made land extending for a varying distance inland from the coast, and that it was so recent in deposition that it contained at Houston, 50 miles inland, the fossil shells whose living representatives are found in the bay of Galveston. He also describes with much clearness certain of the older drifts, but his descriptions are purely local. Dr. R. H. Loughridge notes the occurrence of Quaternary stratified drift as composing the arenaceous, cross timber region of Central Texas, and other writers have noted the drift of the lower Brazos, Red, and Colorado Rivers. The various papers of the United States and Mexican boundary survey reports describe several peculiar drift formations of the Rio Grande along its course from its mouth to El Paso. The presence of a fine, decomposing mass of pebbles over the gypsum beds has also been mentioned by writers on that region. In fact, the literature is full of fragmentary reference to local superficial formations, which we are left to presume to be of any age we please, but absolutely nothing has been done towards classifying these phenomena. It is well known that the "red rises" of the great rivers of the Texas region have been carrying down their loads of sediment, taken from the receding escarpment of the plains among which they rise, and depositing them in the lagoons along the coast. The richest sugar lands of Louisiana and Texas have been built up in this manner, in almost recent times, and the vastness of the process is grand and impressive beyond expression. No other theme is so promising to the future geologist in the region under discussion as the subject of the laws of distribution and the age of the post-Cretaceous formations of Texas

GEOLOGICAL DEDUCTIONS.

From these fragmentary writings we can only make the following general deductions concerning the geology:

The Cambrian and Pre-Cambrian strata probably underlie the State and extend as far west as the Grand Cañon of the Colorado. Upon these are deposited Lower Silurian rocks, with occasional outcroppings in the limited central and trans-Pecos areas. The Devonian strata are absent. The Carboniferous strata present two phases and are in two widely separated areas, the first being a continuation of the Missouri coal fields through Indian Territory into Northern Texas and the other being a continuation of the non coal bearing strata from the great West. Little is known of the intimate relations of the strata between the well defined Carboniferous and the Cretaceous, but there are many ideas concerning them: (1) The older Mesozoic, consisting of an extensive deposit west of the ninety-ninth meridian, extending all the way, perhaps, from the typical Coal Measures of the Carboniferous to the well defined fossiliferous lower Cretaceous. This group comprises the gypsum bearing strata, and has been called in our literature Permian, Permo-Carboniferous, Triassic, Jura-Trias, and the Dakota group of

the Cretaceous. The minute stratigraphy of these strata has never been studied and their exact age is still an unsolved problem. (2) The fossiliferous Lower Cretaceous, being easily distinguished everywhere by its unique lithologic and paleontologic characters. It overlies nearly all of the older formations, the latter being exposed usually by the erosion of its strata. Concerning the character and extent of this formation very little is known, and it is only determinable by the peculiar individuality of its fauna and the interpretation of Mr. Jules Marcou's description of a small local outcrop. It can only be said that this formation does exist, that it is older than all writers except Mr. Marcou have made it, and that its extent seems to be confined to the portion of Texas west of the black prairie region and indeterminately southward into Mexico. The higher divisions of the Cretaceous immediately overlie this. These have been traced directly from the older Gulf States, and, like the succeeding Tertiaries, seem to represent the earlier stages of the contracting shores of the present Gulf of Mexico. The Tertiaries are generally conceded to be merely a continuation of the Tertiaries of the older Gulf States, with local variations. The coast of the Gulf of Mexico of to-day is a continuation of the results of the same forces in operation since Middle or early Cretaceous time, so far as can be ascertained by interpretation of all the evidence.

GENERAL CONCLUSIONS.

Only a word is necessary to express the net results of all the observations described in the previous pages. The following facts are obvious :

(1) There is no accurate knowledge of the essential topographic features of Texas upon which geologic work can be based.

(2) The geologic work has been fragmentary, unconnected, uncorrelated, and unsystematic throughout. It has been mostly descriptive paleontology instead of stratigraphic work.

(3) There has been very little accurate stratigraphic work recorded.

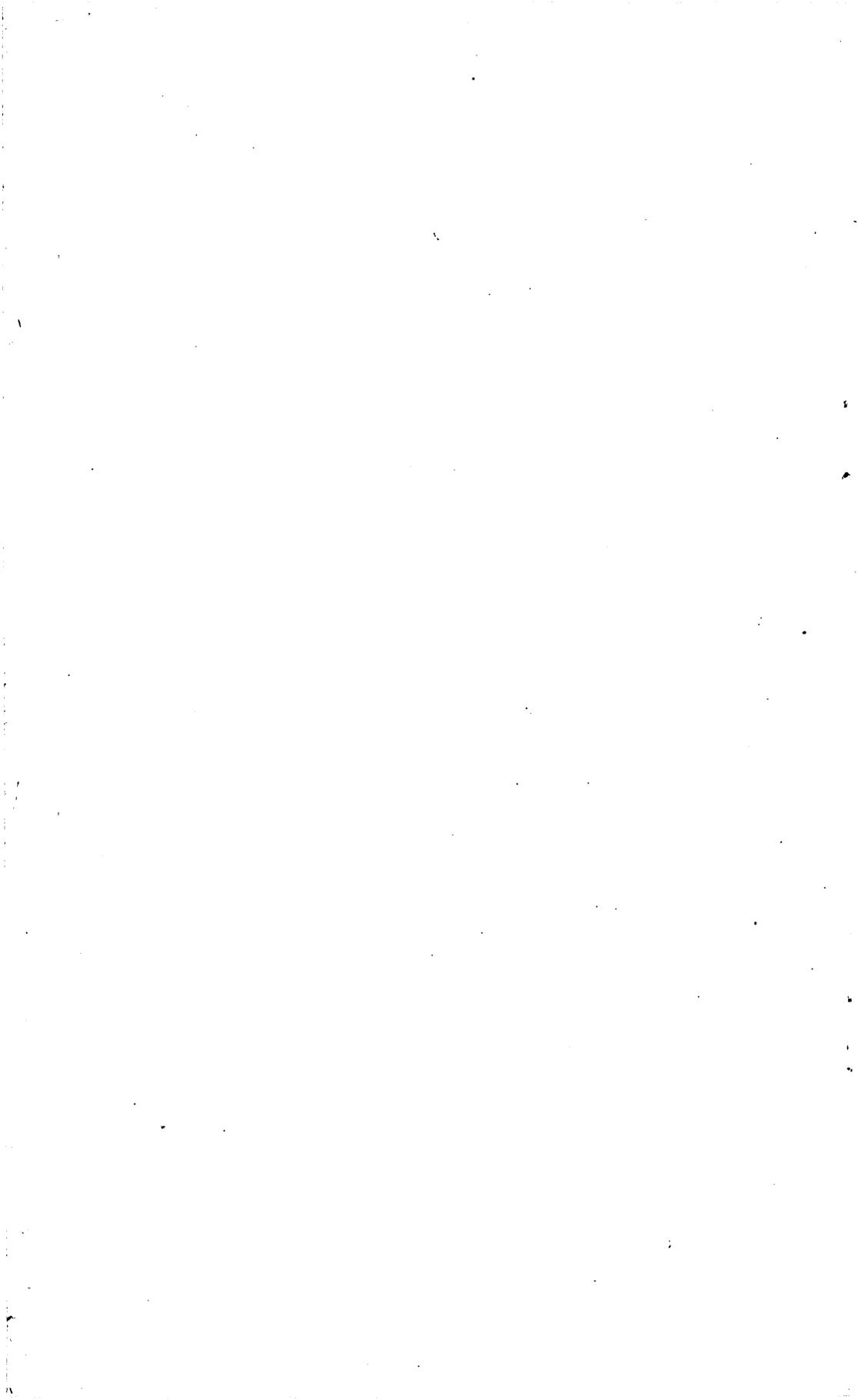
(4) Most of the literature deals with broad generalities rather than with specific description.

It is evident that very little of the work deserves to be classified above preliminary reconnaissance and that the need of the future is apparent: the careful study of typical sections by combined stratigraphic and paleontologic data, the tracing of the extent and variation of these features, and, first of all, a correct and reliable topographic survey of the entire State. There is not on record a clear and intelligible section of a single local area.

In the preceding pages I have tried to prepare the way for honest students to take up the work without long years of weary research in endeavoring to find out what has been done in this great region. No portion of our country is more pregnant with unstudied features of

geologic interest. Important relations in the history of the continent have been traced to its borders on every side and stopped there by a want of minute knowledge of its formations. To the student who will undertake the solution of a single one of the questions involved the reward will be results of incalculable value. Among these problems are the history of the river systems, the elevation of the land features from the sea, the effects and the results of subaërial erosion, the intimate features of the stratigraphy, the tracing of ancient interior continental shore lines, the history of the recession of the escarpment lines (especially that of the Llano Estacado), the building up of the coast by the sedimentation resulting from this erosion, the accurate enumeration and distribution of typical faunas, and the stratigraphic position of its fossils, and, chief of all, the deduction from these scientific determinations of those economic results appertaining to agriculture, industry, and commerce without which the true possibilities and impossibilities of the great region will forever remain unknown and its development depend upon blind and costly experiment.

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