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Tertiary Formations of Rim Rock Country, Presidio County, Trans-Pecos Texas

By
RONALD K. DeFORD

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ABSTRACT

The rim rock of the Vieja Rim, the quartz pantellerite of Lord, is named the Bracks Rhyolite. Beneath the Bracks, the "Vieja series" of Vaughn (1900), which is newly subdivided into five formations named, in descending order, the Chambers Tuff, Buckshot Ignimbrite, Colmena Tuff, Gill Breccia, and Jeff Conglomerate, rests unconformably on Upper Cretaceous formations. The Vieja Group is expanded to include also the Bracks and three overlying formations, named, in ascending order, the Capote Mountain Tuff, the Brite Ignimbrite, the Petan Basalt. An ancient post-volcanic gravel above the Petan antedates the bolson fill. The minimum hiatus at the base of the Vieja may include part of the Upper Cretaceous, all the Paleocene, and most of the Eocene epochs. The age of major faulting that created the bolsons is pre-Pleistocene, and probably most of the bolson fill was deposited before the end of the Tertiary Period.

INTRODUCTION

In 1922 Charles Laurence Baker (1927, p. 5, fn. 1) completed a manuscript on the geology of the most inaccessible part of Texas, which he had mapped at the rate of 35 square miles per day. His mapping was an exploratory feat of the first order, and his account of the geology is fundamental. All geologic maps (Stose, 1932; Sellards, Adkins, and Plummer, 1933b; Baker, 1935; Sellards, 1936, 1939; Darton, Stephenson, and Gardner, 1937; Longwell, 1944; Sellards and Hendricks, 1946; Stose, 1946) of the Rim Rock country subsequently published are versions of Baker's (1927: Pl. 1), although Stovall's map (Stovall, 1948: 80) of part of it has additional information.

The Texas-Chihuahua border region, which is still a challenge to map makers, was long a veritable terra incognita. The first Europeans (Davenport and Wells, 1919: 248–259 and map) to visit the Rim Rock country were the fabulous Cabeza de Vaca and his companions, Castillo and Dorantes, who traversed it in 1535, traveling on foot up the east bank of the Rio Grande. In 1581, forty-six years later, Rodriquez (Bolton, 1915: 135–145), two other friars, nine soldiers, and sixteen Indian servants traveled the same route, and the Rodriquez party was followed in 1582 by another party led by Espejo (Bolton: 163–175), a wealthy citizen of the City of Mexico. Then almost exactly a hundred years elapsed before the next party, led by Captain Mendoza (Bolton: 316–326) and preceded 15 days by two friars, went down the west side of the river from El Paso to La Junta (Ojinaga) in the last half of December 1683, recording the precipitous topography

> well overgrown with lechuguilla so that it was not possible to travel by night.[1]

Three hundred years after Cabeza de Vaca's 17 *jornadas*, the first authentic map of any kind, geological or otherwise, was yet to be made. Two early summaries (Hitchcock and Blake, 1874: 8; Hitchcock, 1887) of geological maps of the United States record that Maclure's of 1809 and 1817, the first to be published, and James Hall's of 1843 showed only the geology of the eastern states and that the coloring on Sir Charles Lyell's of 1845 did not extend much west of the 95th meridian. The list contiues: Marcou, 1853; Edward Hitchcock, 1853; Keith Johnson, 1856; and a second by Marcou in July 1855, republished in March 1856 and in 1858. After the return of the Pacific Railway exploring expeditions in 1854–1855, a map of the region west of the 100th meridian was compiled by C. H. Hitchcock or W. P. Blake and exhibited at the meeting of the American Association in Albany, New York, 1856, but it was never published (Hitchcock and Blake, 1874: 8). Shortly afterward, the map of the country west of the Mississippi compiled by James Hall (1875b) of Albany was published.

The geology of the Rim Rock country as published for the first time on Hall's map was based on Emory's boundary survey. Fifteen years later Hitchcock and Blake prepared a geological map of the United States dated 1872 and another dated 1874. On these two most of Trans-Pecos Texas is shown as a wide outcrop of Cretaceous rock. Surprisingly, the 1872 version of Trans-Pecos geology is better than the 1874, and Hall's mapping in the Trans-Pecos region is better than either.

I have not seen Hitchcock's large wall map, scale 20 miles to the inch

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[1] " . . . es forzoso parar por ofrecerse el dia siquiente tierra fragosa y poblada de mesquite, y Uña de Gato aunque andable, y luego ofrecerse una Cuesta muy encumbrada y de la parte del Oriente ocinada y muy poblada de Lechuguilla, casi hasta llegar al Rio del Norte, y no poderse andar de noche."

(Hitchcock, 1887: 482) which was published in 1881. McGee's map (1885: 36–38) of 1884, scale 112.3 miles to the inch, served as the base for Hitchcock's handsomely colored map of 1886, on which the geology of Trans-Pecos Texas was revised once more; but Hall's version of the southwestern part was still the best to date. Hitchcock (1887: 488) justly concluded that

> In the earlier surveys no name stands more prominent than that of James Hall.

Hall's map provides interesting examples of geologic extrapolation. It was based on the work of early explorers, who, by submitting specimens to geologists, had correctly identified Carboniferous rocks, now called Permian, in the Guadalupe-Delaware Mountains on the north and in the Chinati Mountains on the south. Reasonably enough, albeit incorrectly, Hall joined the two outcrops through the Davis Mountains east of the Rim Rock country. He also showed an apocryphal Carboniferous core in the 120-mile range in Chihuahua immediately west of the Rim Rock country. A dozen years later Kimball (1869: 387) remarked that

> The number of Cretaceous fossils collected by myself west of Presidio del Norte, quite disproves the position of Dr. Parry, viz., that the "natural boundaries of this basin (near Presidio del Norte) consist of irregular mountain ranges composed principally of carboniferous limestone similar to that seen above" (near El Paso). But Dr. Parry (1857: 50) in this matter seems to follow Prof. Hall (1857a: 110) who referred the limestone of this section to the carboniferous exclusively on the ground of the lithological analogy with the Carboniferous limestone in numerous western localities of a simple specimen from the rapids of the Rio Grande, in which no fossils could be recognized.

When Streeruwitz (1891b: 685; Geiser, 1957) crossed Vieja Pass in 1886, he made no map but observed with foresight

> that the basaltic and other volcanic rocks predominate in that portion of Trans-Pecos Texas, and that in all probability they are second in value to the Chinatti prospects and the Quitman and the Carrizo Mountains, as far as ore bearing is concerned.

The topography was surveyed in 1892 (Chispa Sheet) and in 1895 (San Carlos Sheet; Vaughn, 1900: Pl. 6). In 1904, B. F. Hill and Udden published a geologic map of the region. Their rough reconnaissance was transferred to the first geologic map of North America (Willis and Stose, 1911) and the first detailed geologic map of Texas (Udden, Baker, and Böse, 1916b). Earlier versions of the geology of

Texas are shown in maps by McGee (1885: 40–41), the Merchants' Association of New York (1901: Chart 8), Simonds (1905: Fig. 2), and Dumble (Merrill, 1920: 492–493). The geology of the adjoining part of Chihuahua is not well known; it is shown on Hall's map, the maps of North America, the tectonic map of the United States, and the recent maps of Mexico (Flores, 1942; King, 1942: Pl. 1; King, 1947: Láminas 1 and 2; Eardley, 1951: Fig. 249, 422; Guzman et al., 1952; Carta Geológica, 1956; Diaz and de Cserna, 1956: Fig. 2). I have not seen "Sènor Antonio Castillo's excellent Geological Map of Mexico, Mexico, 1889," which was utilized by R. T. Hill (1893: Fig. 2), or Fleury's map, which was criticized by Kimball (1869: 382 and 383).

In July 1895 (Parker, 1895b: 193; Vaughn, 1900: 75; Bilbrey, 1957), when all Texas west of the hundredth meridian was wild, the Rim Rock country already had a railroad. The Rio Grande Northern, a spur line that extended from Chispa siding on the Galveston, Harrisburg, and San Antonio Railroad (Southern Pacific) over Chispa summit in the pass between the Van Horn Mountains and the Sierra Vieja, was laying track toward the coal deposits at San Carlos, where shafts were being sunk. The railroad reached San Carlos in November, but the shafts did not penetrate commercial coal. Mining by means of adits was begun in January, 1896, but the production was so small that the Galveston, Harrisburg, and San Antonio refused to furnish transportation because it would not be economical. The coal company hired an engine and may have hauled a little coal between January and June 1896, although there is no record of sale. Prior to 1896 the *Mineral Resources* volumes (Ashburner, 1886: 68; Parker, 1895a, 1895b: 193) gave highly optimistic reports of anticipated production, finally in summary (Parker, 1896: 522) of the year 1895, stating that

> The San Carlos mines in Presidio County did not get out any coal, commercially, before the close of the year, the first run over the tipple being made on January 3, 1896.

The authors of subsequent volumes not only failed to report production but simply ignored the subject. (*Cf.*, however, Ries, 1905: 105; Hornaday, 1911; Phillips and Worrell, 1913: 29–31; Phillips, 1915: 201–202; Dumble, 1916: 193; Darton, 1933: 120.) In 1900 the Rio Grande Northern was abandoned. To this day the chief sources of ranch lumber under the rim are the old ties and bridge timbers, and several miles of the old roadbed still serves as the main ranch road, which goes through the railroad tunnel (Vaughn, 1900: Pl. 10) at San Carlos.

The preceding paragraph might be taken as a paraphrase of the futile history, so far, of each mining prospect in the Rim Rock country—

nitrate, silver, manganese, uranium—although none other has entailed quite so elaborate a development as the San Carlos coal district. Exploration for petroleum has also been unsuccessful and unavoidably expensive in this remote country, but at least the wildcatters have drilled their dry holes without erecting tank farms or laying pipe lines to handle the oil they hoped to produce. The outlook for eventual discovery is still favorable.

In 1911, W. B. Phillips (1910, 1911a, 1911b, 1911c; Gale, 1912: 28) inspected a nitrate prospect in the Rim Rock country near Candelaria, where

> nitrate of soda exists as thin crusts on and thin seams in a hard dense trachyte, or lava.

Writing in the third person, Phillips summed up his investigation of nitrate in northern Mexico and western Texas (1911b) in words of disillusionment:

> He has ridden many miles to see white encrustations on the walls of canyons, along arroyos, etc., in the hope that they would prove to be what some enthusiastic prospector had reported they were. Except for the pleasure of the ride and the views of impressive scenery he might have been better employed.

H. M. Robinson (Mansfield and Boardman, 1932: 69–75, Fig. 8) examined the nitrate deposits at a mining camp on Capote Creek 8 miles NE by E of Candelaria in August 1918 and reconnoitred the geology (Robinson, 1918) within 5 or 6 miles of the camp. Mansfield and Vanderwilt examined other nitrate deposits (Mansfield and Boardman, 1932: 77, Figs. 9 and 10, Pls. 9B and 10; Wooton, 1927) in the Candelaria vicinity in June, 1928.

Darton's (1933: Sheet 15) guidebook has a sketch of the geology of the eastern slope of the Sierra Vieja. There is no published record of Sellards' (1933) trip through the Rim Rock country after the Valentine earthquake of 16 August 1931 or of the surveys made by a number of oil company parties in the three decades between 1927 and 1957. Among the early petroleum explorers were V. C. Maley and M. B. Arick; among the later, H. M. Neilson and associates.

In 1932 (Stovall, 1948: 84) Baker discovered bone fragments in the Rim Rock country. Stovall (1948: 85), Savage, McAnulty, and Langston collected fossil mammals in 1938 and 1940; Brown (1941: 103) and Bird collected a few bones and teeth in November 1940. Bryan Patterson (Goldich and Elms, 1949: 1144–1145) and Quinn collected vertebrate fossils in 1946, and Goldich and Patterson made a brief reconnaissance in November 1946; Carlisle, Mankin, and Quinn collected bones in 1954; and J. A. Wilson and Clabaugh, in 1956 and

1957. A field examination has indicated that the X marked "Fossil Locality" on Stovall's map and the corresponding description in the first paragraph of his text must both be wrong; it is probable that his fossils came from Big Cliff two miles farther west, where Patterson and Wilson subsequently collected.

In 1954, 1956, and 1957 graduate students from The University of Texas (DeFord, 1957) mapped the geology of the Rim Rock country in greater detail than has yet been published. The mapping in the summer of 1954 extended from Lat. 30° 06′ to 30° 22′ N. J. E. Peterson mapped part of the eastern slope of the Sierra Vieja east of the high rim. Four parties mapped between the Rio Grande and the high rim, as follows: 06′–10′ N, C. J. Mankin and B. J. McGrew; 10′–14′ N, J. C. Carlisle and C. R. Sewell; 14′–18′ N, B. Buongiorno and J. T. Smith; 18′–22′ N, R. C. Duchin and S. S. Moran.

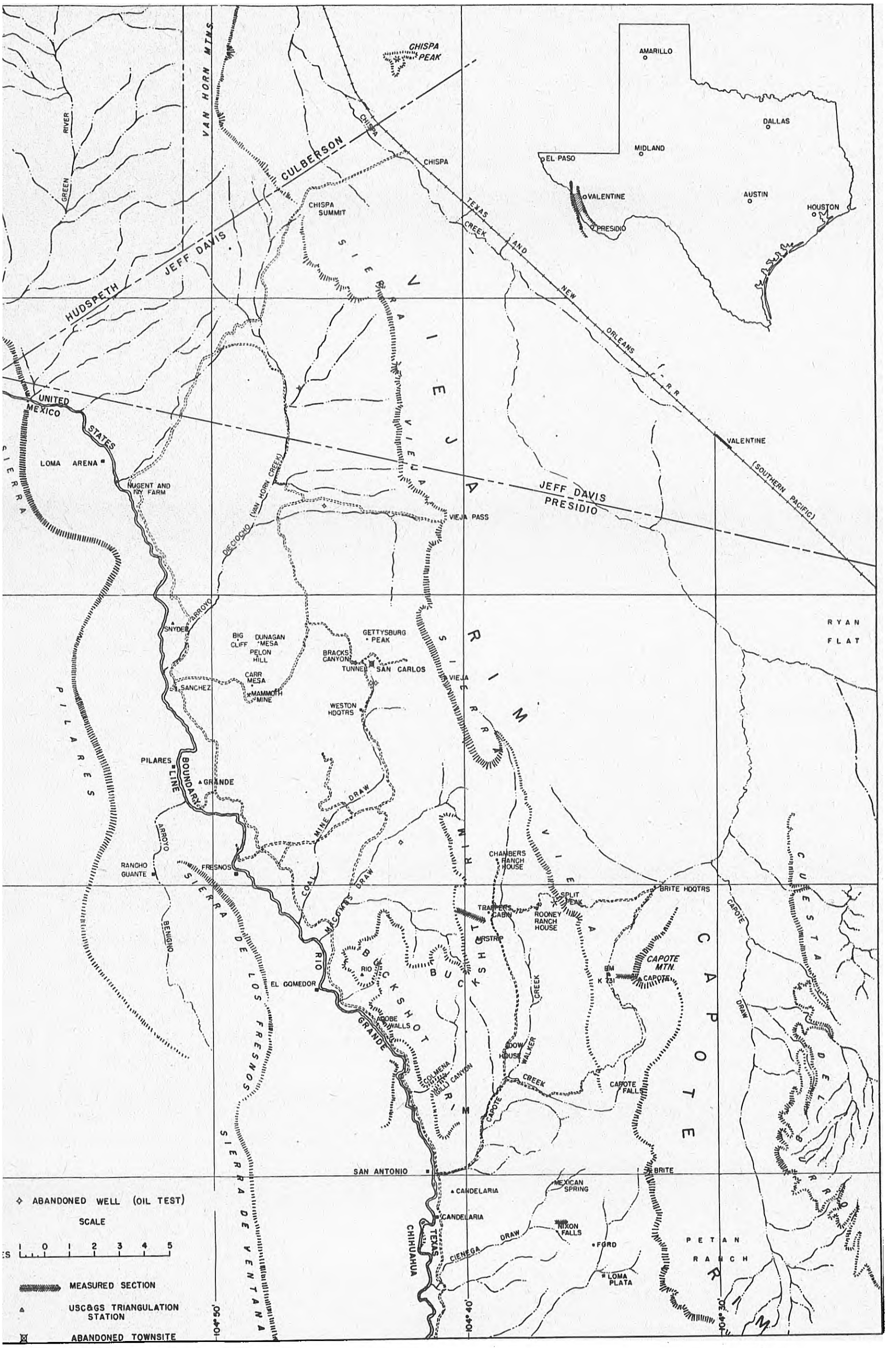
The mapping in the summers of 1956 and 1957 extended from south of Lat. 30° 22′ to 30° 42′ N. Five parties mapped between the Rio Grande and Vieja Rim, as follows: from south of 22′ to 26′ N, D. G. Bilbrey and J. T. Schulenberg; 26′–30′ N, J. D. Ferguson and W. D. Miller; 30′–34′ N, C. R. Colton and R. G. McKinney; 34′–38′ N, L. W. Bridges and E. J. Dasch; 38′–42′ N, P. Braithwaite and D. R. Frantzen. Robert Allen and J. C. Nichols mapped the Sierra de los Fresnos across the Rio Grande in Chihuahua from 15′ to 23′ N, and D. B. Clutterbuck and A. D. Ferrell, the north end of the Sierra Pilares from 34′ N to the Rio Grande. The mapping in 1957, north of 34′ N, is not shown in the figures in this paper.

As a result of the mapping, the Tertiary sequence may be divided into formations. The purpose of this paper is to present a local classification of the Cenozoic volcanic rocks to serve as a basis for further investigation and publication. It may prove useful to those who undertake to organize the biostratigraphic classification or unravel the tectonic history or find oil.

GEOGRAPHY AND STRUCTURE

The Rim Rock country occupies a deep valley between parallel mountain ranges. The talweg, the south-southeasterly course of the Rio Grande, called Rio Bravo del Norte by the Mexicans, descends about 7 feet per mile through this drouth-stricken country, which has long been dry. In 1535 Cabeza de Vaca (Davenport and Wells, 1919: 253) asked the Indians along the river

> why they did not raise maize, and they replied that they were afraid of losing the crops, since for two successive years it had not rained, and the seasons were so dry that the moles had eaten the corn, so



g. 1. Map of Rim Rock Country, Trans-Pecos Texas.

> that they did not dare to plant until it rained very hard. And they also begged us to ask Heaven for rain.[2]

All the explorers found the same xerophytes that still grow on the rims above the river.

Emory (1857, Part 1: 50)

> was informed, on good authority, that in the summer of 1851 a man drove a gang of mules along the bed of the river from Presidio del Norte to El Paso. The bed was dry for nearly the whole distance, occasional pools of water standing in places. . . .

Nearly 50 years later Dumble (1898: 491) described the river bed below El Paso as

> a sandy plain which is often entirely dry or with water standing in pools. At other times great floods pour down its channel and spread out in the valley. . . .

The drouth then recurrent has since become chronic: from McNary, about 50 miles southeast of El Paso, through the Rim Rock country to Ojinaga (Presidio del Norte), 140 miles southeast of McNary, the Great River now flows only when flooded by summer cloudbursts. Any upstream water spared by the drouth is claimed for irrigation.

The eastern border of the Rim Rock country, the Sierra Vieja, is about half of a 100-mile mountain range along the Texas border. From the north end of the range seven miles south of Van Horn, Texas, the Van Horn Mountains extend southward 17 miles to Chispa Summit. Thence the Sierra Vieja continues 35 miles southward to Capote Peak (Gannett, 1899: 684, 1906: 947; 1928 Texas Almanac: 45), and thence on southward another 15 miles to the head of Pinto Canyon. The high Chinati Mountains, about 20 miles long, extend from Pinto Canyon to Shafter, Texas. Beyond Shafter the range continues another 10 miles to its southern end in Çienega Mountain.

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[2] "Preguntámosles cómo no sembraban maíz; respondiéronnos que lo hacían por no perder lo que sembrasen, porque dos años arreo les habían faltado las aguas, y había sido el tiempo tan seco que a todos les habían perdido los maíces los topos, y que no osarían tornar a sembrar sin que primero hobiese llovido mucho; y rogábannos que dijésemos al cielo que lloviese y se lo rogásemos, y nosotros se lo prometimos de hacerlo ansí . . . dijérronos que el camino era por quel río arriba hacia el Norte, y que en diez y siete jornadas no hallaríamos otra cosa niguna que comer, sino una fruta que llaman chacan, y que la machucan entre unas piedras si aun después de hecha esta diligencia no se puede comer, de áspera y seca . . . y ansí, sequimos nuestro camino, y atravesamos toda la tierra hasta salir a la mar del Sur; y no bastó a estorbarnos esto el temor que nos ponían de la mucha hambre que habáiamos de pasar, como a la verdad la pasamos, por todas las diez y siete jornadas que nos habían dicho . . . y ansí pasamos todas las diez y siete jornadas, y al cabo de ellas atravesamos el río. . . ."

The Sierra Vieja (San Carlos Sheet, 1896; Hill, 1899; Gannett, 1902: 139; Phillips, 1904: 5; Simonds, 1905: Fig. 133; Bailey, 1905: Pls. 1, 3, 12, and 14; Deussen, 1910: 62, and 1911: 141; Ransome, 1915: 335; Dumble, 1916: 174; Mansfield and Boardman, 1932: Pl. 10; Texas almanacs, maps of Texas, 1936 and 1943; Darton, 1937; Sellards and Hendricks, 1946; Blair and Miller, 1947: 67, 68, 88; Handbook of Texas, 1952, Vol. 2: 609, 780; Texas almanacs, maps of Texas and Presidio County maps, 1941, 1945, 1947, 1949, 1951, 1953, 1955; Hammond and Encyclopedia Britannica atlases) has also been called the Vieja Mountains (Livermore, 1883; Havard, 1886: 482, 492; Vaughn, 1900: 73; Clarke, 1900: 60; Gannett, 1902: 153; Simonds, 1905: 28; Hammond atlas), the Vieja Range (Shipman, 1926: 19), the Tierra Vieja Mountains (Gannett, 1902: 42, 148; Udden, Baker, and Böse, 1916, 1st ed.: 12, 15, 78, 101; Baker and Bowman, 1917: 119, 124, 141; Baker, 1921: 25; Smith and Walker, 1923, Political Map; Texas almanacs, maps of Texas, 1925, 1926, 1927, 1928; Shipman, 1926: 116; Baker, 1927: 37, 49; Texas almanacs, 1927: 57, 1928: 338; Baker, 1928: 343, 348, 354, 355, 371; Adkins, 1931: 35 and Fig. 7; Carter, 1931: 159; Carter and Cory, 1932: 30; Sellards, 1933: 115; Plummer, 1933: 801, 803; Darton, 1933: 99, 101, 102, and Sheet 15; Baker, 1935: 156, 187, 188, Fig. 15 and Pl. 4; Sellards, 1936; Baker, 1941: 82, 88, 89, 90; Goldich and Elms, 1949: 1144–1145, Fig. 2; Eifler, 1951: 342; Handbook of Texas, 1952, Vol. 2: 780; McAnulty, 1955: 558; Rand McNally and Glydendals atlases) the Tierra Vieja Range (Texas almanac, 1929: 347), the Sierra Tierra Vieja (King, 1935: 241, 243, 254, and Fig. 5; Hinckley, 1947: 162, 164, 165, 171, 172, 177), the Sierra de Tierra Vieja (Baker, 1928: 373, Pls. 20, 21, 22; Baker, 1941: Pls. 10 and 11), the Rim Rock Mountains (Dumble, 1895: 385; Dumble, 1898: 485; Baker, 1935: Fig. 15 and Pl. 4), and, redundantly, the Sierra Vieja Mountains (Hill and Udden, 1904; Chispa Sheet as reprinted in 1938; Jameson and Flury, 1949: 54; York, 1949: 59 and Fig. 2; Phillips and Thornton, 1949: 102; Texas almanac, 1939: 447; Cram's and Stieler's atlases), the Sierra Vieja Range (Blair and Miller, 1949: 67; Jameson and Flury; York; Phillips and Thornton; Texas almanac, 1926: 178; Handbook of Texas, Vol. 2: 609, 841), the Sierra Viejas (Dumble, 1916: 176; Blair and Miller; Jameson and Flury; Phillips and Thornton), and the Sierra Tierra Viejas (York), and, mistakenly, the Sierra de Pilares (Humboldt, 1812b; Solm-Braunfels, 1846a and 1936), and the Chanatte Mountains (Roessler, 1874).

The forms *Viega* (Gannett, 1899, p. 706; 1906, p. 972) and *Viego* (Gillett, 1921: 278–280) are due to inaccurate transcription. The form *Viejo* (Streeruwitz, 1891b: 685; 1892: 386, and 1893: 175; Osann, 1893: 134; Dumble, 1895: 385, and 1898: 485; Shipman, 1926: 95, 156) probably came from Paso Viejo (Gillett, 1925, 200–202, account of 1881; Shipman, 1926: 95 and 199), now called Vieja Pass; indeed, the name of the mountains themselves may have been derived from the name of this old pass. The Sierra Vieja is bounded by two passes and subdivided by two more. From north to south these are Chispa Summit, Vieja Pass, the divide between Capote Creek and Capote Draw near Capote Peak, and the head of Pinto Canyon. Two early maps (Chispa Sheet, 1892; Vaughn, 1900: Pl. 6; cf. Presidio County maps in Texas almanacs, 1941, 1945, 1947. 1949, 1951, 1953, 1955) imply that the name *Tierra Vieja* denoted only that part of the range between Chispa Summit and Vieja Pass. Chispa Summit is mislabeled "Vieja Pass" on Presidio County maps in Texas almanacs, 1945, 1947, 1949, 1951.

The eastern face of the Van Horn Mountains is a scarp related to normal faulting downthrown to the east. The northern and southern parts of the scarp join in a sharp angle. The northern part extends about 9 miles S 10° W to the angle; from it the southern part continues about 5 miles S 45° E to Chispa Summit, beyond which the northern part of the Sierra Vieja shows the same trend for another 3 miles.

Reversing the features of the Van Horns, the western face of the Sierra Vieja, the great rim, is related to normal faulting downthrown to the west. A system of large persistent faults with less persistent smaller faults parallels the rim for 50 miles. The whole Rim Rock country is an intermontane depression due to block faulting. The mean trend of the crest of the sierra is close to SSE, and the local variations from this trend are neither marked nor persistent.

On the eastern slope of the Sierra Vieja the strata dip (Sellards: 1939; Sellards and Hendricks, 1946) eastward under Ryan Flat (Hill, 1900: 9, col. 1), a broad valley of interior drainages, Capote Draw and Chispa Creek, that are not connected with the sea. The altitude of the flat ranges between 4,000 and 4,500 feet above sea level. From it the surface of the ground rises (Vaughn, 1900: Pl. 7) approximately 2,000 feet in 4–8 miles to the crest of the range, terminating in a westward-facing precipice several hundred feet high. Between Chispa Summit and Capote Mountain this precipice (Vaughn: Pl. 8; Baker, 1928: Pls. 21 and 22; Baker, 1941: Pl. 11; Hinckley, 1947: Fig. 1; Keith, 1950: xix) is the Vieja Rim. On the north where its crest is about 12 miles from and 3,000 feet above the Rio Grande, there is a 2,000-foot difference in elevation within a mile and a half of the rim in places; at San Carlos, where the river is 11 miles away, the difference is 2,700 feet (Vaughn: 75, Pl. 6) in 3 miles; the topography of the rest of the country from rim to river is up and down. Farther south the rim is but 10 miles from the river and 3,500 feet above it; this has been described (Shipman, 1926: 117) as

> the highest, wildest looking bluff in the lonesome stretches of the Big Bend. The border bandit could stand on this bluff and look down two thousand feet, then out over miles of broken, uninhabited country to the Rio Grande. In the opposite direction, twenty miles distant he

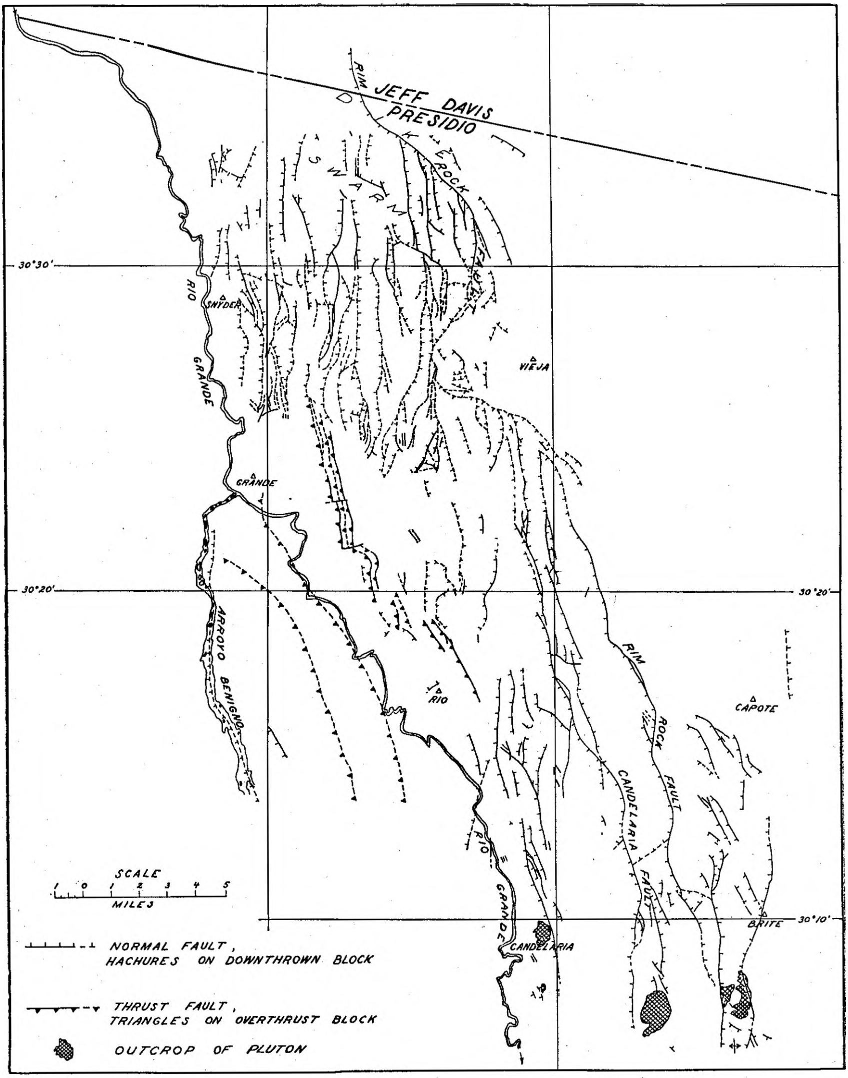

Fig. 2. Fault pattern in Rim Rock country.

might see the link with the outside world—the Southern Pacific passenger train. . . .

At first look the Vieja Rim appears to extend all the way to Pinto Canyon, but closer inspection shows that the still higher Capote Rim, which caps Capote Mountain, is the chief rim of the southern third of the Sierra Vieja. On Robinson's 1918 map the Capote Rim is mislabelled "pantellerite." It was correctly shown above the Vieja Rim by Baker (1928: Pl. 10), by Carter (1931: Fig. 82, mislabelled "Chinati Mts."), and by Baker (1941: Pl. 20; see also Keith, 1950: xix, xxix, and end papers).

The great valley under the Vieja Rim has many local rims that cap tilted blocks bounded by faults. One of the most prominent is the Buckshot Rim (Hinckley, 1947: Fig. 3), which rises many hundred feet directly above the Rio Grande in the southern part of the Rim Rock country (Fig. 1).

The western border of the Rim Rock country formed by the Sierra Pilares and Sierra de Ventana comprises about half of a 120-mile mountain range, most of which is in Chihuahua, Mexico. At the north end of the range, in Texas, is the imposing mass of the Eagle Mountains (Sierra Cola de Aguila of Humboldt, 1812b; Solms-Braunfels, 1846a, 1936; Streeruwitz, 1891a: xci), about 12 miles west of the north end of the Van Horns. The Indio Mountains extend from the Eagle Mountains 15 miles S by E to the Rio Grande, which transects the range in a deep canyon. The dry wash, tributary to the Rio Grande, between the parallel Van Horns and Indios is called Green River. On the Chispa Sheet and most subsequent maps it is named Glenn Creek, but that name is no longer in local use. Streeruwitz's usage (1891a: xci and xcii) seems to indicate that Green River Canyon and Glenn Creek once were names of different places, whereas Baker (1927: 40; see also 1935: 139 and 201) 30 years later wrote about the "head of Green River (Glenn Creek)" as a single locality.

From the Rio Grande the Sierra Pilares extends 30 miles S by E and the Sierra de Ventana continues another 30 miles, whence it swings due S 10 miles to a junction, near Cuchillo Parado, with the Sierra Grande, which continues 25 miles S by E to the southern end of the range at La Mula. The mountains are composed dominantly of Lower Cretaceous limestone, which, in contrast with the rim rocks, is sharply folded and thrust-faulted. The front of the Ventanas rises steeply from the Rim Rock country within three or four miles of the Rio Grande. The steep front of the Pilares is in similar position expect that on the north it joins the river, and on the south the Sierra de los Fresnos stands as a partly distinct frontal element within a mile of the river. The *ventana* from which the Sierra de Ventana probably got its name is actually in the crest of the Fresnos; it was mentioned in Mendoza's narrative[3] of the expedition of December 1683.

LITHOSTRATIGRAPHY

The chief rim rock, the Bracks Rhyolite that caps the Vieja Rim, is the key to the Tertiary stratigraphy of the Rim Rock country. This is the quartz pantellerite of Lord (Vaughn, 1896; Vaughn, 1900: 77, 81, 82, 83, Pls. 8 and 10; Lord, 1900: 88–95). The "Vieja series" as originally defined by Vaughn (1900: 77; p. 81, Resumé of San Carlos section) included all the Tertiary formations below the base of the Bracks, but excluded the Bracks, although Adkins (1933: 513) stated inaccurately that Vaughn's Vieja included the pantellerite. Adkins instinct was right. Vaughn was not aware of the presence of volcanic rocks younger than the pantellerite. Mapping in the northern part of the Rim Rock country where the Bracks key bed is missing has emphasized the practical need for a group of all the volcanic formations. It is therefore proposed to expand the Vieja Group to include also the Bracks, the Capote Mountain, the Brite, and the Petan formations.

The Vieja rests unconformably on Upper Cretaceous rocks; in many places the contact is concordant, but in others the Cretaceous rocks were folded or thrust-faulted prior to Vieja deposition. The minimum unconformity at the base of the Vieja Group under the Vieja Rim near San Carlos probably entails the absence of some of the Upper Cretaceous, all the Paleocene, and most of the Eocene. In some other outcrops in the Rim Rock country most of Upper Cretaceous is also missing.

In descending order the formations of the Vieja Group are:

> Petan Basalt, Brite Ignimbrite, Capote Mountain Tuff, Bracks Rhyolite, Chambers Tuff, Buckshot Ignimbrite, Colmena Tuff, Gill Breccia, Jeff Conglomerate.

All except *Jeff* and *Vieja* are new names proposed in this paper; their descriptions are extracted chiefly from two unpublished theses by Sewell and McGrew. To understand the derivation of the new names let us refer to Figure 1, beginning at Candelaria (8.5–41).[4] The mouth of Capote Creek is two miles upstream from Candelaria. Colmena Canyon, the next considerable tributary to the Rio Grande on

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[3] "En veinte y quatro dias del dho. mes y año salimos de este pasage que por nombre se le puso N. S. de Belen por un Portillo que hace en los alto de una sierra que está de dicho pasage como media legua poco mas ó menos y el dicho Portillo hace como á modo de ventanas." Bolton (1916: 323).

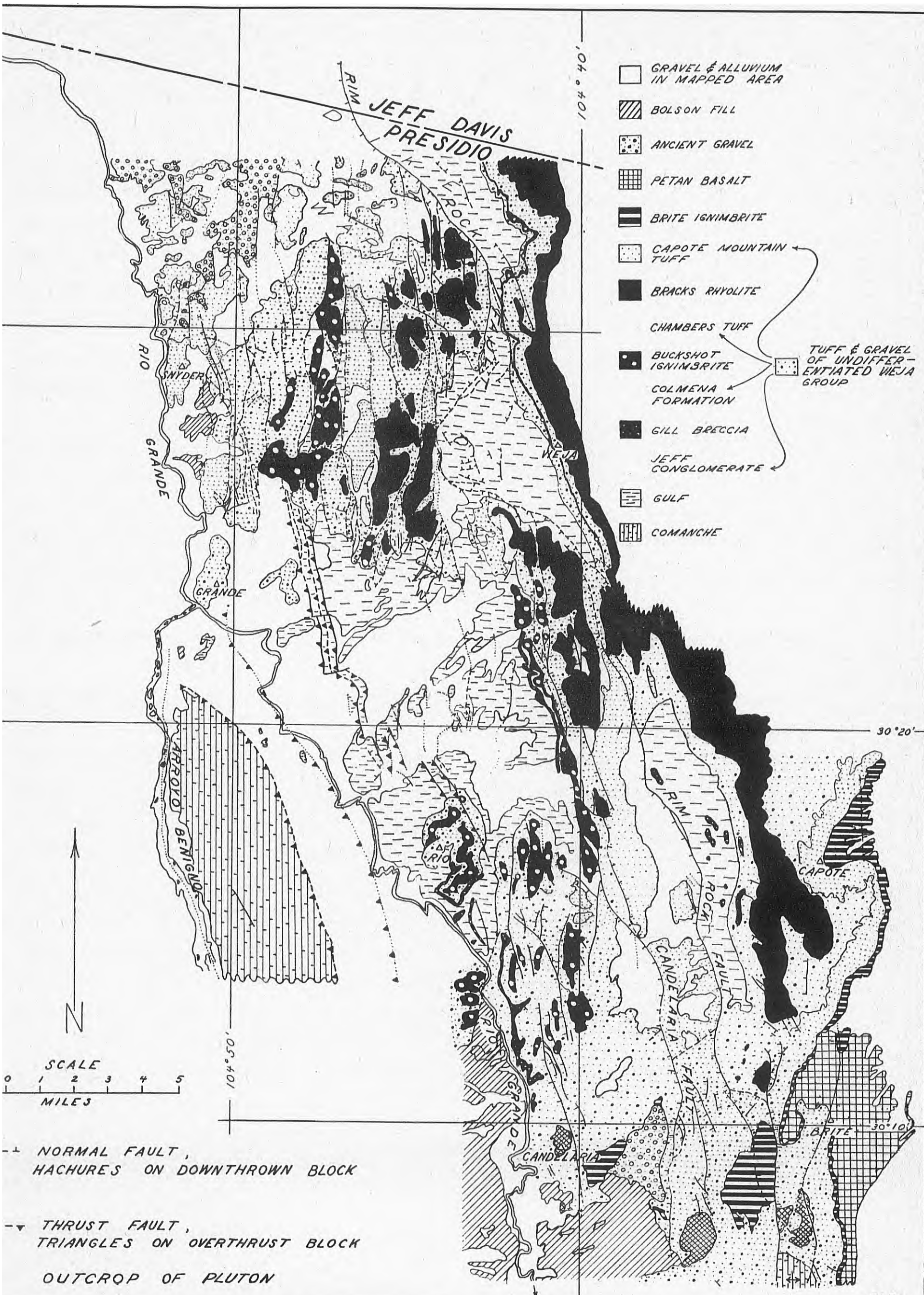
[4] 30°8.5'N, 104°N41'W; the geographic coordinates used hereinafter are ~~well~~ all in minutes north of Lat. 30°N and west of Long. 104°W.

the Anglo-American side, three miles farther upstream (13–42), called Gill Canyon on the San Carlos Sheet, is a gap in the Buckshot Rim. The Chambers (20.8–38.8) and the Rooney (19–37.2) ranches are N of Candelaria between the river and the Vieja Rim, the Chambers headquarters 15 miles N by E from Candelaria and the Rooney 2½ miles SE of the Chambers. The Rooney ranch is directly beneath Split Peak (Keith, 1950: xxxvii), where a trail over the high rim marks the site of an abandoned road; this is 8 miles N of another trail over the rim that marks the site of the abandoned grade of the old county road from Valentine to Candelaria via the Brite headquarters N of Capote Mountain. The Petan ranch is on the Capote Rim near Pinto Canyon. The name *Jeff* does not belong to the Rim Rock country.

Jeff Conglomerate.—Eifler (1951: 343–344) named the Jeff Conglomerate, the type locality of which is in the Barrilla Mountains about 70 miles from the Rim Rock country, NE of Pinto Canyon (2–28) and E of Chispa Summit (43–47). By mapping outcrops, the Jeff has been traced as a practically continuous body from its type locality to the northern end of the Davis Mountains about 30 miles NE of Chispa Summit. There are no outcrops of Jeff in these intervening 30 miles.

The basal conglomerate (Baker in King, 1935: 243; Goldich and Elms, 1949: 1145) of the Vieja Group is notably similar to the Jeff Conglomerate (Eifler: Pl. 2; McGrew, 1955: 34–36, Figs. 9–11: Sewell, 1955: 17–19, Pl. 9; Peterson, 1955: 20–22). In much of the southern part of the Rim Rock country the Gill Breccia intervenes between the basal conglomerate and the Colmena Tuff. Northward the breccia pinches out and the conglomerate thickens, presumably as the lower part of the Colmena Tuff grades into conglomerate, so that on the north a major part of the interval between the Buckshot Ignimbrite and the base of the Vieja Group is occupied by conglomerate. It is arguable that a new name should be given to the basal conglomerate of the Rim Rock country or that the conglomerate and the tuff should be described as interfingering facies of the Colmena Formation, but it is proposed, nevertheless, to use the name *Jeff Conglomerate*, at least until the detailed mapping on the north is more nearly complete.

Gill Breccia.—In much of the southern part of the Rim Rock country where the outcrops of Jeff Conglomerate are difficult to detect, the obvious basal unit of the Vieja Group is a flow breccia, named herein the Gill Breccia, which attains a maximum thickness of 300 feet in the type section in Colmena Canyon. The Gill may be composed of a series of flow breccias. Sewell (1955: 22–31, Pls. 11–16) recognized three rock types, to-wit: (1) medium gray fragments in a grayish red



Areal geology of Rim Rock country.

matrix; (2) mottled fragments (pink, green, yellow, gray, and brown) in a dark greenish gray to orange pink matrix; and (3) brecciated to massive light olive green to dark greenish gray fine-grained rock. The majority of the fragments are composed of trachybasalt porphyry. although the composition of the rock may be said to range from trachyandesite to basalt. McGrew (1955: 36–43, Figs. 12–16) described and illustrated the petrography in detail.

The Gill Breccia contains blocks (Sewell, 1955: 14, 23–26, Pl. 8; Moran, 1955: 55–60, Figs. 12 and 13; Duchin, 1955: 26) of massive Lower Cretaceous limestone, some of them as large as a three-story building. The locations of nine of these blocks were described by Sewell (1955: 23–24) as follows: (block 1) the most accessible limestone block is on the east bank of the Rio Grande, where it causes a steep hill (10.5–41.4) on the river road about 2½ miles N of Candelaria and a quarter of a mile N of the Capote Creek crossing; (blocks 2 and 3) there are two blocks in Colmena Canyon (13–41.5) about 0.8 mile from the mouth, and (blocks 4 and 5) two more in Colmena Canyon (13.5–41.1) about a mile and a half from the mouth and about 0.1 mile up the eastern fork of the mainstream; (blocks 6 and 7) there are two blocks about a mile (16–34) up a draw from its mouth at Adobe

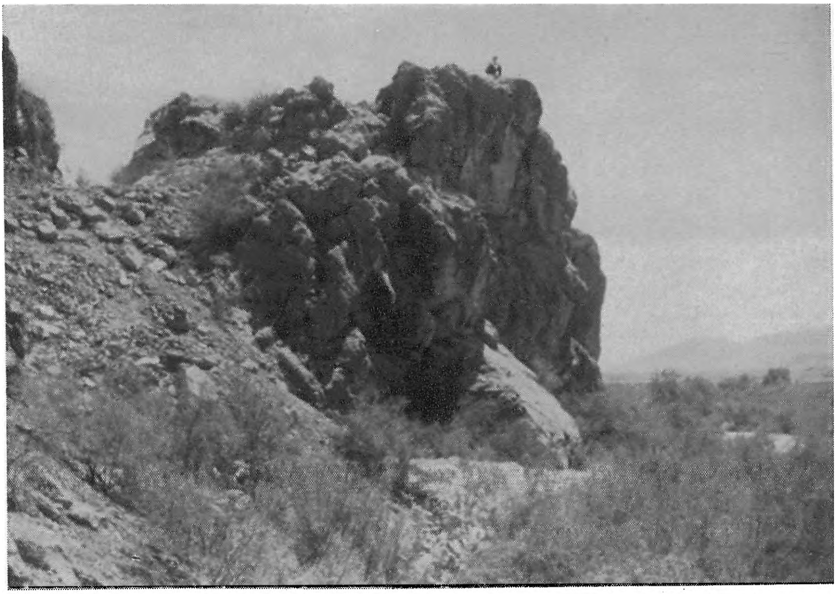


Fig. 4. South-southwestward view of block of Lower Cretaceous limestone (block 1) in Gill Breccia 2½ miles N of Candelaria. The Rio Grande skirts the base of the block. In the distance beyond the Rio Grande valley is the Sierra de Ventana. Man on top gives scale. River road passes through notch at upper left. Photograph by C. R. Sewell (1955).

Walls on the river road about six miles upstream from block 1; (block 8) there is a block under the Vieja Rim about a mile N (13.7–35.4) of the old Candelaria-Brite ranch county road; (block 9) and another along the Rim Rock fault about a mile NW (14–36.3) of block 8. After reviewing the several possibilities that the blocks are klippen, landslide blocks, peaks of buried mountains or eroded crests of anticlines, or the result of sedimentary intrusion, Sewell, Moran, Clabaugh, and DeFord favored the hypothesis that the blocks were brought up by the magma that formed the Gill Breccia. Lonsdale did not concur.

In most of the few good exposures on the south, the base of the Gill Breccia is concordant with the underlying Jeff Conglomerate or Upper Cretaceous formation. Its upper surface appears to form buried hills under the Colmena Tuff.

Measured Section 1.—The type locality (8.3–37.2) of the Colmena and Buckshot formations, which overlie the Gill, is Measured Section 1 (MS 1), four miles due E of Candelaria (8.5–41). It is hard to get to. The trail to Mexican Spring (9.7–36.6) joins Cienega Draw about three miles east of Candelaria and continues thence up the draw the rest of the way, passing the mouth of the tributary from Nixon Falls about half a mile upstream. MS-1 (8.3–37.2) is in a northeastern side canyon about a mile up this tributary from its mouth and about a mile down it from Nixon Falls (8–36.4), which are a mile and a half WNW of Ford ranch (7.5–35). It may prove desirable after further work to propose a more accessible reference locality, although no part of the Rim Rock country is readily accessible.

From bottom to top, MS-1 extends from SW to NE. The beds dip about 8° E. The section was measured and sampled in August, 1954, by C. J. Mankin and B. J. McGrew (McGrew, 1955, MS 4: 100–102; Sewell, 1955, MS 4: 96–98; Peterson, 1955, MS-4: 65–68). Their description follows:

Unit	*Description*	*Thickness in feet*
BUCKSHOT IGNIMBRITE:		
18	*Rhyolite porphyry*	50
COLMENA TUFF:		
17	*Tuff conglomerate:* dusky yellow, weathers dark brown; massive; extremely hard; boulders round to subround	32
16	*Tuff conglomerate:* white on fresh exposure, weathers light brown; weathered surface is rough and hackly; contains well-rounded pebbles, cobbles, and boulders of igneous and tuffaceous material; jointing strikes N66°E, dips 75°SE	21

Unit	Description	Thickness in feet
15	*White tuff:* hard; slightly nodular on surface; random jointing probably due in part to weathering	18
14	*Tuff and conglomerate:* pale red purple tuff grading upward into red conglomerate with boulders up to 2 feet in diameter; conglomerate grades upward into pale purple tuff	106
13	*Tuff:* light brown; containing numerous holes due to weathering; locally changes to tuff conglomerate and grades upward into conglomerate	81
12	*Tuff conglomerate:* yellow; massive; boulders and pebbles subangular to subround, diameter 1 inch to 1 foot, average 3 inches; resistant to weathering	48
11	*Tuff:* pale purple; nodular; no evident bedding; locally numerous holes due to weathering; faintly cross-bedded in a few places	49
10	*Tuff:* white; thin-bedded; grading upward into light brown tuff, then upward into pale green tuff; upper 4 feet resistant and thick-bedded; green tuff contains pebbles of purple, white, and dark green tuff	11
9	*Tuff:* dark red; hard; beds 1 foot or more thick; nodular	11
8	*Tuff:* variegated, predominantly pale green with stringers of pale purple	5
7	*Tuff:* pale red purple with white splotches; hard; nodular; some beds are honeycombed	22
6	*Tuff:* very light gray (N8), containing small, greenish yellow, rounded inclusions and random splotches of pale purple; massive	11
5	*Tuff:* variegated, grayish red purple on fresh exposure, weathering to pale purple; nodular; very loose; contains several 6-inch bands of greenish yellow tuff	11
4	*Tuff breccia:* matrix pale red purple on fresh exposure, weathering to light brownish gray; angular fragments pale green, red, brown, and black; massive	22
	Measured thickness of Colmena Tuff	448

UNCONFORMITY.
JEFF CONGLOMERATE:

Unit	Description	Thickness in feet
3	*Conglomerate:* cemented by calcareous reworked material; boulders and pebbles subround to round, chiefly well-polished sedimentary-quartzite pebbles and dark-gray limestone pebbles, diameter ranging from 1 inch to more than 1 foot, with a few boulders of 3 feet, average 4 inches; local sandstone lenses 1–2 feet long, sand is the same as in Unit 2	20

Unit	Description	Thickness in feet
2	*Sandstone:* dusky yellowish gray on fresh surface weathering to dark yellowish gray; medium-grained; calcareous; faint cross-bedding in places; grades upward into conglomerate	2
	Measured thickness of Jeff Conglomerate	22
	Total thickness measured	520

BASE OF VIEJA GROUP.
UPPER CRETACEOUS MARL:

1	*Marl:* dark yellowish orange on weathered surface, medium yellowish orange on fresh exposure; massive; locally contains gypsum and irregular concretions; in places bears shells of *Gryphaea aucella;* shows polygonal jointing on exposed surface	?

Colmena Tuff.—The rough topography created by the emplacement of the Gill Breccia was smoothed by the deposition of the Colmena Tuff. Consequently the Colmena is missing in some places, even though its thickness exceeds 450 feet in others.

The Colmena is composed of beds of rhyolitic tuff and beds of conglomerate with pebbles, cobbles, and boulders of Gill Breccia and some pebbles and cobbles of Lower Cretaceous limestone; near the mouth of Capote Creek it contains beds of tuffaceous non-marine limestone 4 to 10 feet thick; near Loma Plata (6.3–34.5), beds of silty claystone and a layer of a glassy flow-rock. It can be described as a light-brown tuff-conglomerate interbedded with variegated tuff. The principal colors are brown, pink, and red. The lower part of the formation is calcareous. Four random thin sections described by McGrew (1955: 44 and 114) show a fine-grained rhyolitic tuff containing 7–10% quartz with some chert; the remainder is composed of sanidine, orthoclase, plagioclase, and igneous-rock fragments; magnetite or ilmenite is common; biotite, sphene, apatite, and augite are present. The grains are subangular, poorly to well sorted. The usual cement is opal and chalcedony; locally the rock contains as much as 30% calcite. Bone fragments are common in the lower part of the formation.

The available information about the vertebrate fossils collected from the Colmena Tuff in the southern part of the Rim Rock country has been summarized by Mankin (1955: 86–91). The age of the fossils is Duchesnean or Chadronian; that is, latest Eocene or early Oligocene. In most places, but unfortunately not in all, the Colmena is overlain by the Buckshot Ignimbrite; the caprock of the Buckshot Rim is a typical outcrop of the Buckshot.

Buckshot Ignimbrite.—Although the rhyolite prophyry that caps the Buckshot Rim looks like lava rock, its matrix in thin section shows glass shards and other pyroclastic material, and it is proposed to call it the Buckshot Ignimbrite (McGrew, 1955: 25–30, 44–53, Figs. 18–21). It is resistant to erosion and forms a caprock 40 to 75 feet thick in many places. The rock exhibits well-developed vertical jointing and breaks with an even to slightly conchoidal fracture. The color of the fresh rock is grayish red to moderate yellowish brown; the weathered surface, pale to dark reddish brown. A dusky green layer of brittle glassy rock is present locally at the base of the Buckshot. The ignimbrite ranges from non-porous at base to vesicular at the top, the length of the amygdules averaging about 1 cm., most of them containing a ferriferous carbonate or chalcedony or both. In many places the rock is characterized by abundant round dark-reddish-brown spots of buckshot size, many of which have small centers, grayish red like the matrix, and thick, very dark red to blackish red rims. Most of the phenocrysts, which compose about 20% of the rock are sanidine; some are orthoclase, and some, quartz.

The upper surface of the Buckshot Ignimbrite (Sewell, 1955: 34–38, Pls. 17–20; Peterson, 1955: 27–29) is dotted by circular blister cones (Sewell, Pl. 17) from 1 foot to 5 feet high and 2 to 50 feet in diameter and marked by folds (Sewell, Pl. 18) about 100 feet long, 6 feet high, and 5 feet across. Next above the Buckshot is a thick tuff, which rests directly on the Colmena Tuff where the Buckshot is absent.

Chambers Tuff.—The name *Chambers Tuff* is proposed for a formation that comprises the strata between the top of the Buckshot Ignimbrite and the base of the Bracks Rhyolite. Where the Buckshot is absent the Chambers and Colmena may be differentiated by identifying the horizon of the Buckshot; if its identity proves somewhere to be too problematic for practical use, the lithostratigraphic name *Vieja* will still be applicable to the combined sequence. Similarly where the Bracks Rhyolite is absent as in the southern end of the Rim Rock country and in its northern third west of the Vieja Rim, the undifferentiated Vieja may serve as a map unit. Probably the horizon of the Bracks, that is, the Chambers-Capote Mountain contact, can be practically established in some places, but not everywhere.

The moderately to well bedded Chambers Tuff presents a drab array of colors, mostly pale yellowish brown, and grayish green in the upper 250 feet, and dull somber, pale red to dark reddish brown in the lower 150 feet (Sewell, 1955: 39–40, 100–101, 105–106, Pl. 17). In the southern part of the Rim Rock country it contains a persistent layer of coarse sandstone with lenses of cobble conglomerate about 130 feet above the base.

In two thin sections from the Chambers, McGrew (1955: 53–55, 104–105, 108–109, 113) described a fine- to medium-grained rhyolitic tuff containing 5 to 10% quartz with some chert, sanidine, orthoclase, plagioclase, and fragments of rhyolitic glass and volcanic rock. Magnetite or ilmenite, biotite, and a pyroxene are also present. The grains are subangular. Most of the cement is calcite; some of it is silica.

The vertebrate fossils collected in the northern part of the Rim Rock country by Stovall, Patterson, Wilson, and their associates all came from the Chambers Tuff. Although superposition demonstrates that the Chambers is younger than the Colmena, the first look at the fossils from each seems to indicate the same geologic age. Careful paleontological work may yet show a difference or may fail to show it; the resemblance is close.

Measured Section 2.—The type locality (20–40) of the Chambers Tuff is at Measured Section 2 (MS-2), about 12 miles N of Candelaria (8.5–41). The river road extends about 2 miles N of Candelaria to the mouth of Capote Creek. Thence the road to Chambers, formerly Dan (Robinson, 1918), Ranch (20.8–38.8) extends northeastward up Capote Creek about 5½ miles to the mouth of Walker Creek, up which it extends about 1½ miles N to the Dow house and continues N up Walker Creek 5 miles to an airplane landing strip and thence N another mile to a house on the W side of the road, known as the trapper's cabin. The end of the road is at Chambers Ranch another 2 miles N. The top (18.75–39.1) of MS-2 is 0.3 mile W of the road, half a mile NNW of the airstrip, and 0.4 mile S of the trapper's cabin. The base (19.2–40.4) of MS-2 is about 1.4 miles almost due W of the cabin and 2.5 miles SW of the Chambers headquarters. From bottom to top, MS-2 extends about 1½ miles ESE. The section was measured and sampled by R. C. Duchin and S. S. Moran in the summer of 1954. Their description follows:

Unit	*Description*	*Thickness in feet*
CAPOTE MOUNTAIN TUFF:		
4	*Tuff:* very thin-bedded; above is about 100 feet of tuff that was not measured; section ends on Triangle Hill between the Bracks Rhyolite and the Brite Ignimbrite	9
3	*Tuff:* alternating red and pink beds that weather to rounded ledges; fine-grained	76
2	*Tuff:* pinkish gray; hard; fine-grained; thick-bedded; bottom part is very pitted by weathering	13

Unit	Description	Thickness in feet
51	*Sandy tuff:* pale reddish brown with mottled patches locally; fine- to coarse-grained; weathers to rounded ledges	77
50	*Tuff:* pale reddish brown; coarse-grained; beds 1–3 feet thick, weather to rounded ledges; surfaces pitted	51
49	*Calcareous tuff:* white at base, grading upward to alternating soft and hard, pale purple layers; weathers into the hill	5.8
48	*Purple tuff*	12
47	*Tuff:* very light gray (N8) at base, beds above are grayish pink (5R8/2) and pale red (5R6/2); beds 1–8 feet thick, weather to rounded ledges	70
46	*Tuffaceous-sandstone key-bed:* brown, weathering to pale red and dark reddish brown, hard, tuffaceous quartz-sandstone, just below which is 3-foot bed of pink, highly calcareous tuff; beds 1–4 feet thick weather to rounded, prominent ledges	16
45	*Tuffaceous quartz-sandstone:* pale red; hard; medium- to coarse-grained; beds 1 foot to several feet thick; weathers to well-rounded ledges	45
44	*Tuffaceous quartz-sandstone and sand:* brown; subrounded fine-to-medium quartz grains; weathers to form ledges	47
43	*Sand and sandstone:* interbedded, fine- to coarse-grained sandstone and calcareous sand; sand is light yellow green, soft, friable, with subrounded quartz grains; sandstone is brown to pale red purple, hard; together they form a slope with protruding ledges; harder layers are near the top	68
42	*Quartz-sandstone:* light brown to reddish brown; hard; coarse-grained; thick-bedded at base and thin-bedded at top; quartz grains subrounded; weathers to form large rounded masses and ledges	29
41	*Quartz-sandstone:* light gray; fine-grained; calcareous; alternating soft and hard layers; thin-bedded	3.8
40	*Sandstone and tuffaceous sandstone:* medium- to very coarse-grained; some beds well consolidated, light yellow gray, form ledges; interbeds of soft, loose, grayish red sandstone	45
39	*Argillaceous limestone:* soft; thin beds; weathers back into the hill	12
38	*Sandstone and tuff:* pale reddish brown; coarse-grained; a few soft tuff beds and one thin calcareous layer are present	16
37	*Sandy tuff:* red brown; indurated; top 3–5 feet is pale pink, soft	24
36	*Quartz-sandstone:* grayish brown, weathering to dark red brown; coarse-grained; forms rounded ledges	11
35	*Quartz-sandstone key-bed:* moderate brown, weathered surface reddish brown; irregularly bedded to cross bedded; medium-to-coarse subangular quartz grains; weathers to form prominent ledge above the light-colored beds	27

Unit	Description	Thickness in feet
34	*Sandstone:* light pink to grayish pink, (light color distinguishes this bed); very fine-grained; indurated to hard; calcareous at base, tuffaceous at top; thin-bedded, weathers to thin ledges and rounded blocks	6.4
33	*Tuffaceous sandstone:* pale red purple; weathered surface grayish red; coarse-grained with a few pebbles; subrounded quartz grains; weathers to prominent ledges several feet thick	30
32	*Tuff:* pale purple; soft; weathers back into hill	11
31	*Tuff:* pale purple; very fine-grained; hard; thick-bedded; pitted surfaces; weathers to prominent, rounded ledges	8.8
30	*Sandstone and tuff:* purple; soft; medium-grained; thin-bedded; hard, pale purple sandstone forms a prominent ledge in middle of Unit 30	7.6
29	*Sandstone and tuff:* dusky red; coarse, subrounded quartz grains; beds 1–3 feet thick	34
28	*Sandstone:* pale grayish purple to light gray, weathers to give a pink and white streaked appearance, upper part is brown and contains pebbles locally; coarse, subrounded quartz grains; forms a rounded ledge	27
27	*Tuff:* dull red with white spots; hard; fine-grained; slightly sandy; weathers to form block-shaped ledges	1.8
26	*Sandy tuff:* mottled and purple and white; indurated; fine-grained; contains large amount of biotite; weathers to gentle slope	4.3
25	*Tuff:* brownish gray, weathering to rusty gray brown with white patches; very fine-grained; hard; contains key bed 1–4 feet thick that stands out as a massive ledge	22
24	*Tuff:* mottled, light grayish purple; indurated; very fine-grained; thin-bedded	6
	Measured thickness of Capote Mountain Tuff	817

BRACKS RHYOLITE:

Unit	Description	Thickness in feet
23	*Rhyolite:* thickness not measured.	

[redacted]

CHAMBERS TUFF:

Unit	Description	Thickness in feet
22	*Quartz-sandstone:* light gray, weathers to light green; indurated; grains coarse to very coarse, subangular; beds 1–4 feet thick	25
21	*Tuff:* light grayish purple; hard; thin-bedded; weathers to broken, block-shaped ledges	17

Unit	*Description*	*Thickness in feet*
20	*Tuff:* light gray with white specks; slightly sandy; hard; massive; weathers to steep, rounded ledges which form prominent breaks in the slope	18
19	*Tuffaceous quartz-sandstone:* light gray; grains coarse to very coarse, subangular to round; beds 1–2 feet thick	22
18	*Tuffaceous sandstone:* very dull reddish brown; hard; grains subrounded, medium to coarse; thin-bedded; weathers to a ledge with some thin tuff breaks	15
17	*Tuffaceous quartz-sandstone:* light gray; medium-grained; indurated; thin-bedded; weathers to ledges with some soft breaks	15
16	*Tuff:* light gray with green splotches; slightly sandy; alternating soft and hard layers	9.8
15	*Quartz-sandstone:* reddish brown; indurated; coarse-grained; beds 1–2 feet thick form subrounded ledges	23
14	*Quartz-sandstone:* light gray to dull reddish brown; medium- to coarse-grained; most layers are indurated, some are friable; slightly calcareous; beds 1–2 feet thick weather to rounded ledges	30
13	*Tuff key-bed:* grayish red (10R4/2); very hard; very fine-grained; weathers to sharp, angular blocks that form a ledge	1.8
12	*Tuff:* pale red purple; fine-grained; beds 1 foot to several feet thick; weathers to rounded blocks	139
11	*Tuff:* pale red purple with white specks; beds 1 foot to several feet thick weather to rounded blocks	32
10	*Tuff:* grayish purple; fine-grained; indurated; poorly bedded	37
9	*Tuff:* pale green; fine-grained; indurated; some dark minerals present, but sparse; irregular, nodular bedding with more consistent bedding toward the top	7.2
8	*Tuff:* grayish purple (5P4/2) to dark gray (N4); fine-grained; soft at bottom grading to hard at top; weathers to resistant, block-shaped masses	6.0
7	*Tuff:* light greenish gray to greenish white; fine-grained; thin-bedded; weathers to rounded blocks	13
6	*Tuff:* dark reddish brown with small dark specks; hard; thin-bedded; contains some small pebbles; weathers to small blocks	57
5	*Tuff:* grayish purple; homogeneous, very fine-grained; beds 1–2 feet thick; some beds form ledges	64
4	*Tuff:* pale red purple; fine-grained; massive	11
3	*Sandy tuff:* grayish purple with dark specks; massive; weathers back into hill	6.1
2	*Tuff:* pale red (5R6/2) speckled by muscovite; fine-grained; beds form ledges	4.7

Unit	Description	Thickness in feet
1	*Tuff:* pale red purple; soft; friable; thin-bedded, forms gentle slope	4.8
	Measured thickness of Chambers Tuff	558
	Total thickness of MS–2 (excluding Bracks)	1,375
	TOP OF BUCKSHOT IGNIMBRITE.	

Bracks Rhyolite.—The preceding section (MS–2) shows more than 800 feet of tuff overlying the Chambers and separated from it by the Bracks Rhyolite, which Lord called pantellerite. This important stratigraphic marker is the chief rim rock of the Rim Rock country. Its place in the stratigraphy was first recognized during the development of the coal deposits at San Carlos. The end of the abandoned railroad grade still marks the site of the coal mining town, but not a building remains. San Carlos was located in a topographic basin (Vaughn, 1900: 75) that is almost completely surrounded by rims of Bracks Rhyolite, and Coal Mine Draw (Fig. 1), Vaughn's San Carlos Arroyo, drains the basin southward. The newly proposed stratigraphic name *Bracks* is taken from the narrow gorge (38–44) called Bracks Canyon (San Carlos Sheet; Vaughn: 82, Pls. 6 and 10), which cuts through the outcrop of Bracks Rhyolite just west of San Carlos. In view of the original description, the proper place for a type locality appears to be in the vicinity of San Carlos, probably the high Vieja Rim (Vaughn: Pl. 8) east of the basin, which is the thickest outcrop of Bracks, although the rim is not readily accessible, and the high cliff face would be difficult to sample foot by foot. The maximum thickness of 300 feet or more decreases northward, southward, and westward, as the Bracks completely peters out on the northwest, north, and south; but its fate due west of San Carlos is not recorded in the outcrops, and eastward it dips underground.

The characteristic color of the Bracks is greenish, ranging from light olive gray to greenish black. In places it is dark reddish brown. The original description by Lord (1900: 90–95), which includes a chemical analysis (also in Clarke, 1900: 60–61), has recently been supplemented by McGrew (1955: 55–60, 113, Figs. 24–26). Sewell (1955: 40–46, Pls. 7 and 10), in restudying its origin, concluded that it was probably emplaced by lava flows. In the few places where the Bracks-Capote Mountain contact (Sewell: 43) is exposed, it appears to be fairly regular with a suggestion of breccia on the surface of the Bracks. The Bracks-Chambers contact also appears to be regular. The following section (MS–3) begins not far above the top of the Bracks.

Measured Section 3.—The type locality (17–34) of the Capote Mountain Tuff is Measured Section 3 (MS–3) on the high west face of Capote Mountain. The base of MS–3 is appoximately 4 miles from the Brite Ranch headquarters along the abandoned county-road to Candelaria; it is 0.28 mile E of U.S. Coast and Geodetic Survey's bench mark *K731,* 1943, and 30 feet NE of a wooden hitching post at the base of the mountain. The top of MS–3 is 0.1 mile NW of triangulation station *Capote* (16.75–33.0), which is on the summit of Capote Peak, the highest point of Capote Mountain. (The 1928 Texas Almanac: 45, has a striking picture of "Summit of Capote Peak, Presidio County.") Thus, MS–3 extends eastward up the face of the mountain, ascending 1,000 feet in a horizontal distance of about 3,000 feet. Near the top, the beds dip about 9° E. The section was measured and sampled in the summer of 1954 by J. E. Peterson (1955: 97–105; Sewell, 1955: 110–111; McGrew, 1955: 110–111).

Unit	*Description*	*Thickness in feet*
	BRITE IGNIMBRITE:	
7	*Rhyolite porphyry:* with aphanitic grayish orange pink (5YR7/2) to light brownish gray (5YR6/1) groundmass; phenocrysts are small angular clear quartz and opalescent tabular sanidine crystals; forms a cliff……Estimated	100
	CAPOTE MOUNTAIN TUFF:	
6	*Tuff:* moderate orange pink; indurated……	24
5	*Tuff:* very light gray (N8) to white (N9), contains black and orange specks; fine- to coarse-grained; indurated; bottom 15 feet is massive, but most beds are 2 inches or less thick; cross-bedded; forms a slope under the Capote Rim……	288
4	*Tuff:* white to pinkish gray, overall appearance is whitish gray with many black specks that give a salt-and-pepper effect; fine- to coarse-grained; indurated; weathered surface is rough and irregular……	51
3	*Tuff:* variegated, predominant colors are white, pinkish gray, moderate orange pink, and moderate reddish orange; indurated bottom 20 feet forms cap of ledge with white tuff beneath; upper 75 feet is not so well indurated and forms stair-step ledges; fine- to coarse-grained; weathered surface is rough, uneven, and nodular……	123
2	*Tuff:* white to grayish pink, overall appearance is dull pinkish white, salt-and-pepper; indurated; beds are 6 inches to 2 feet thick; most beds are fine- to medium-grained and nodular on the surface, a few beds are very fine-grained and weather into smooth vertical faces; strike N4°W, dip 9°NE; bottom contact is obscured by pebbles, cobbles, and boulders littering the slope……	42

Unit	*Description*	*Thickness in feet*
1	*Tuff:* pale red to grayish red, overall appearance is pale red alternating with grayish red; fine- to coarse-grained; indurated; beds 2 inches to 6 feet thick; the beds 2 feet thick to 6 feet thick form most of the ledges, beds less than 2 feet thick form most of the slopes; material from 230 to 280 feet above base of MS–3 exhibits castellated weathering, with alternating light and dark red beds, the lighter beds 1 foot to 3 feet thick, the darker beds 2 to 6 inches thick appearing as plates between the thicker, lighter beds; weathered surface is rough and uneven, and the slopes are littered with pebbles, cobbles, and boulders	1,350
	Measured thickness of Capote Mountain Tuff	1,878
	Total thickness of MS–3	1,978

At this place the basal part of the Capote Mountain Tuff is covered by alluvial and colluvial material, but the top of the Bracks Rhyolite is not far below the base of MS–3.

Capote Mountain Tuff.—At places in the southern part of the Rim Rock country, according to Sewell (1955: 48, Pl. 21), the Capote Mountain Tuff has a characteristically three-fold outcrop that exhibits an upper white-to-pinkish-gray member nearly 1,300 feet thick, a middle red siltstone layer 10–40 feet thick, and a lower variegated tuff member, predominantly dusky brown to grayish red purple, more than 200 feet thick. According to Peterson (1955: 34, Fig. 6) the lower 1,350 feet of the type section shows alternating pale red and grayish red beds above which are white beds and gray beds. Be that as it may, a thick sequence of white tuff characterizes the Capote Mountain, but more work needs to be done assuredly to differentiate the Capote Mountain from the underlying Chambers on the north and south where the Bracks is absent.

The Capote Mountain (Peterson, 1955: 33–36, 90–94, 97–105, Figs. 4 and 6; Sewell, 1955: 47–50, 99–104, 110–111, 115–116, Pls. 6, 7, 21, 22; McGrew, 1955: 60–62, 103–107, 110–111, 113, Figs. 21, 27, 40) has the general composition (McGrew: 61) of a fine- to coarse-grained non-calcareous rhyolitic tuff consisting of 70–80% volcanic glass (n c. 1.50) with 2–5% quartz and 1% biotite and heavy minerals; the remainder is alkalic feldspar with a little plagioclase. The rock is loosely cemented with silica. In places it contains beds of pebble-to-boulder conglomerate. The middle, resistant layer of red siltstone is well-sorted and cemented with calcite and some opal; it has an even to subrounded fracture and is minutely cross-laminated; it is an arkose composed of subangular grains of which 70% are alkalic feldspar and

10% quartz and chert; the rest are volcanic rock, magnetite altering to hematite, pyroxene, and rare plagioclase. Only a few turtle bones have yet been collected from the Capote Mountain. The top of the Capote Mountain Tuff is at the base of the overlying rhyolite, which is called the Brite Ignimbrite.

Brite Ignimbrite.—Capote Mountain, which towers above the headquarters of the historic Brite Ranch (Keith, 1950; Shipman, 1926: 115–119; Darton, 1933: 100), is composed of typical Capote Mountain Tuff, capped by typical Brite Ignimbrite about 100 feet thick (Peterson: Fig. 6; Baker, 1928: Pl. 10; Baker, 1941: Pl. 20; 1928 Texas Almanac: 45; Keith, 1950: xix, xxix, and end papers). In other words, the top of Capote Mountain is the type locality of the Brite. The rock (McGrew: 62–71, 103, 110, 112–113, Figs. 21, 28–32, 36; Sewell: 50–52, 99, 102, 110, 114, 115, Pl. 23; Peterson: 36, 69, 73, 97, Fig. 6) resembles a sanidine rhyolite porphyry, but the matrix (McGrew: 62) shows glass shards and other pyroclasitic material in thin section. The sanidine crystals are opalescent. The fresh rock is light-colored ranging from grayish orange pink to light brownish gray. The Brite is overlain by the Petan Basalt.

Petan Basalt.—The first part of the new name *Petan Basalt* is taken from the Petan Ranch, which occupies the Capote Rim and Capote Draw from the south fence of the Brite Ranch to the head of Pinto Canyon. The second part is a field term for a dark-colored fine-grained igneous rock not necessarily used in a strictly petrographic sense. The Petan is exposed in the general vicinity of the U.S. Coast and Geodetic Survey's triangulation station *Brite* (19.1–32.4), where it attains a maximum thickness (Peterson, 1955: 37) of approximately 300 feet. The rock appears to have poor resistance to erosion, for only remnants rest on the Brite Ignimbrite in the form of small hills up to 300 feet high. Both the Brite and the Petan crop out in the Cuesta del Burro, a westward-facing bluff along the east side of Capote Draw about 5 miles east of the Capote Rim. Amsbury plans to describe the Petan in more detail in a forthcoming paper.

The Petan is composed of trachyandesite porphyry (McGrew, 1955: 71–74, 112, Figs. 33, 34; Sewell, 1955: 56, 114–115, Pls. 21, 26). The color of the fresh rock is dark greenish gray to brownish gray. It contains numerous vesicles partly filled with calcite. The texture is merocrystalline, porphyritic with an aphanitic matrix. Andesine (An_{85}) and orthoclase phenocrysts compose 25–50% of the rock. Accessory minerals are magnetite or ilmenite, augite, olivine almost completely altered to iddingsite, and apatite. The groundmass consists of laths of plagioclase and orthoclase, the interstices filled with orthoclase and cryptocrystalline material. The formation next above the Petan is an ıncient gravel, which, for the time being, will be informally called :he post-volcanic gravel.

Post-volcanic gravel.—The post-volcanic gravel lies discordantly on he Petan Basalt, and, in places, on the Brite Ignimbrite. It antedates :he mighty faulting that created the rim-rock topography, for it too is 'aulted down into the southern part of the Rim Rock country. Its depoition was subsequent to most of, and perhaps all, the volcanic out›ursts, for no igneous rock has yet been found in or on it. Its subroundo-round pebbles and cobbles are composed chiefly of extrusive igıeous rock and Lower Cretaceous limestone. The gravel is cemented vith caliche.

Bolson fill.—During the Tertiary Period, subsequent to the widepread volcanism, extensive faulting created deep intermontane ›asins, which were thereafter partly filled with bolson deposits. The ill tends to be conglomeratic near the mountains and to grade outvard into calcareous sandstone and silt. Recent work by W. S. Strain oral communication, Aug. 1956) near McNary, Texas, indicates that he age of the top of similar bolson fill in the Rio Grand Valley 70 niles upstream from the Rim Rock country is latest Pliocene or arliest Pleistocene.

CONCLUSION AND ACKNOWLEDGMENT

Inasmuch as this preliminary paper aims chiefly to lay a nomenlatural foundation for stratigraphic geology of the Tertiary volcanic eposits of the Rim Rock country, the intrusive igneous rocks in the ɔrm of dikes and thick sills are not described. The lithostratigraphic ata are taken largely from the work of students, particularly Messrs. 'uongiorno, Carlisle, Duchin, Mankin, McGrew, Moran, Peterson, ewell, and Smith and the petrographic data from Messrs, McGrew nd Sewell, whose theses were supervised by Dr. Clabaugh. Drs. . A. Wilson, S. E. Clabaugh, and J. T. Lonsdale kindly contributed dditional information and editorial criticism.

BIBLIOGRAPHY

DKINS, W. S., 1931—Some Upper Cretaceous ammonites in western Texas. *Univ. Texas Bull. No. 3101* (1 Jan 1931), *Bur. Econ. Geol.*, Contributions to Geology, 1931, issued Oct.: 35–72, 2 figs., 4 pls.

DKINS, W. S., 1933—The Mesozoic systems in Texas. Pt. 2. Sellards, Adkins, and Plummer, 1933: 239–518.

SHBURNER, C. A., 1886—Coal. *Mineral Resources, 1885, U. S. Geol. Survey:* 10–73.

AILEY, VERNON, 1905—Biological survey of Texas. *U. S. Dept. Agriculture Biological Survey, North American Fauna, No. 25,* 222 p.

AKER, C. L., 1921—The Cretaceous of West Texas and its oil possibilities. *Bull. Amer. Assoc. Petrol. Geol.*, 5, 1 (Jan.–Feb.): 5–28.

———, 1927—Exploratory geology of a part of southwestern Trans-Pecos Texas. *Univ. Texas Bull. No. 2745, Bur. Econ. Geol.:* 70 p., map c. 1 in.: 4 mi., ms. submitted Sept., 1922; published Oct., 1927.

———, 1928—Desert range tectonics of Trans-Pecos Texas. *Pan-Amer. Geol.,* 50, 5 (Dec.): 341–373, Pls. 20–27.

———, 1935—Major structural features of Trans-Pecos Texas. Pt. 2, of Sellards and Baker, 1935: 137–214; Pl. 4, structural map of Trans-Pecos Texas, c. 1 in.: 16 mi.

———, 1941—Rim Rock country of Texas. *Pan-Amer. Geol.,* 75, 2 (March): 81–90, Pls. 10 and 11.

———, and W. F. Bowman, 1917—Geologic exploration of the southeastern Front Range of Trans-Pecos Texas. *Univ. Texas Bull. No. 1753* (20 Sept.), *Bur. Econ. Geol. and Technology:* 61–177.

Bilbrey, D. G., 1957—Economic geology of Rim Rock country, Presidio County, Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vii + 114 p., 13 figs., 3 pls.

Blair, W. F., and C. E. Miller, Jr., 1949—The mammals of the Sierra Vieja region, southwestern Texas, with remarks on the biogeographic position of the region. *Texas Jour. Sci.,* 1: 67–92.

Blake, W. P., 1874—General view of the geology of the western portion of the United States. P. 6–8 of Hitchcock and Blake, 1874.

Bolton, H. E., 1915—Explorations on the northern frontier of New Spain 1535–1706. Map frontispiece of Bolton, 1916, 1 in.: 178 mi.

———, 1916—Spanish exploration in the Southwest, 1542–1706. Charles Scribner's Sons, N. Y.: 487 p., 3 maps; reprinted without maps, 1952, Barnes & Noble, Inc., N. Y.

Brown, Barnum, 1941—The methods of Walt Disney productions. *Trans. N. Y. Acad. Sci.,* Ser. 2, 3, 4 (Feb.): 100–105, abstract of address given 11 Dec. 1940.

Carta Geologico de la Republica Mexicana. 1956—*Congreso Geologico Internacional, XX Sesion, México,* 1:2,000,000 (c. 1 in.: 30 mi.).

Carter, W. T., 1931—The soils of Texas. *Texas Agricultural Experimental Station Bull. No. 431* (July) A. & M. College, College Station: 192 p., 90 figs., and "General Soil Map of Texas" 1 in.: 24 mi.

———, and V. L. Cory, 1932—Soils of Trans-Pecos Texas and some of their vegetative relations. *Trans. Texas Acad. Sci. 1930 to 1931,* 15: 19–32.

Chispa Sheet, Texas, 1892—*U. S. Geol. Survey,* 1:125,000 (c. 1 in.: 2 mi.), contour interval 50 ft., 30′ quad. (30°30′–31°00′N, 104°30′–105°00′W).

Clarke, F. W., 1900—Analyses of rocks from the laboratory of the United States Geological Survey, 1880–1899. *U. S. Geol. Surv. Bull. No. 168:* 308 p.

Conference on Latin-American Geology, March 29–30, 1954—Proceedings. Dept. Geology, Univ. Texas, Austin: 103 p., 1 map.

Darton, N. H., 1933—Guidebook of the western United States, Part F. The Southern Pacific Lines New Orleans to Los Angeles. *U. S. Geol. Survey Bull. 845:* 304 p., Sheet 15 c. 1 in.: 8 mi.

———, L. W. Stephenson, and J. Gardner, 1937—Geologic map of Texas. *U. S. Geol. Surv.,* compiled between years 1924 and 1935, edited by G. W. Stose, 1:500,000 (c. 1 in.: 8 mi.), Lambert conformal conic projection, North American datum.

DAVENPORT, H., and J. K. WELLS, 1919—The first Europeans in Texas, 1528–1536. *Southwestern Historical Quarterly*, 22, No. 2 (Oct. 1918): 111–142; No. 3 (Jan. 1919): 205–259 with "Map Showing Route of Cabeza de Vaca's Party, 1528–1536" prepared under supervision of Prof. Herbert E. Bolton, c. 1 in.: 33 mi.

DEFORD, R. K., 1957—Graduate degrees in geology conferred by The University of Texas from 1897 to 1956. *Dept. of Geology*, Univ. Texas, Austin: 23 p. The following unpublished theses, which concern the geology of the Rim Rock country, are on file in the library of The University of Texas, Austin. Some of the stratigraphic names used in those marked with an asterisk (*) are field names that were subsequently found to be preoccupied or otherwise unsuitable: 1949, Ellsworth, Havard, Kennedy, Throop; 1950, McIntire, Murrah; 1953, Adams, Allday, Bostwick, Wightman; 1954, J. E. Woodward; 1955, *Buongiorno, *Carlisle, *Duchin, *Mankin, *McGrew, *Moran, *Peterson, *Sewell; 1956, *J. T. Smith; 1957, Allen, Amsbury, Bilbrey, C. R. Colton, McKinney, W. D. Miller; 1958, Schulenberg.

DEUSSEN, A., 1910—Physiography and geology of Texas. *Texas Almanac and State Industrial Guide for 1910*, Galveston-Dallas News, A. H. Belo & Co.: 59–64.

————, 1911—Natural and geographic conditions. *Texas Almanac and State Industrial Guide for 1911*, Galveston-Dallas News, A. H. Belo & Co.: 139–161.

DIAZ, T., and Z. DE CSERNA, 1956—Estratigrafía Mesozoica y tectónica de la Sierra de Chihuahua; Pérmico de Placer de Guadalupe, Chih.; geohidrología de la Región Lagunera; estratigrafía Mesozoica y tectónica de la Sierra Madre Oriental entre Mapimí, Dgo. y Monterrey, N. L. Excursion A-13, *Congreso Geológico Internacional, Vigesima Sesion*, México: 120 p., 27 figs., 4 tablas; Fig. 2, Mapa geológico de Chihuahua, c. 1 in.: 16 mi.

DUCHIN, R. C., 1955—Pre-Cenozoic stratigraphy of Candelaria area, Presidio County, Trans-Pecos Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vii + 85 p., 6 figs., 2 pls., 1 table, 3 measured sections.

DUMBLE, E. T., 1891—Second annual report of the Geological Survey of Texas, 1890. Austin, Texas: cix + 756 p.

————, 1892—Third annual report of the Geological Survey of Texas, 1891. Austin, Texas: 410 p.

————, 1893—Fourth annual report of the Geological Survey of Texas, 1892. Austin, Texas: Pt. 1, 481 p., Pt. 2, 474 p.

————, 1895—Cretaceous of western Texas and Coahuila, Mexico. *Bull. Geol. Soc. Amer.*, 6, 13 April: 375–388.

————, 1898—Physical geography, geology, and resources of Texas. With 10 pls. of scenic photos; Chap. 4: 471–516, of Wooten, 1898, Vol. II.

————, 1898—The geology of Texas. Rice Institute Pamphlet, 3, 2 (Apr. 1916): 125–204.

EARDLEY, A. J., 1951—Structural geology of North America. Harper & Bros., N.Y.: Fig. 249, p. 422, is reduction of King (1947) Lámina 2 c. 1 in.: 209 mi.

EIFLER, G. K., JR., 1951—Geology of the Barrilla Mountains, Texas, *Bull. Geol. Soc. Amer.*, 62, 4 (April): 339–353; also published as *Univ. Texas Bur. Econ. Geol. Rept. Inv. No. 8*, dated Dec., 1950.

EMORY, W. H., 1857—United States and Mexican boundary survey. Report of William H. Emory, Major First Cavalry and U. S. Commissioner, Vol. I. 34th Congress, 1st Session, House of Representatives, Ex. Doc. No. 135, Transmitted

29 July 1856; Part 1: 258 p., 1 general map—scale 1:6,000,000, 4 maps—scale 1:600,000 (not bound with report); Part 2, 174 p., 1 colored geol. map—1:6,000,000 (c. 1 in.: 100 mi.).

FLORES, TEODORO, 1942—Carta Geológica de la Republica Mexicana. *Instituto de Geología,* 1:5,000,000 (c. 1 in.: 80 mi.), dibujo P. Letechipia, talleres de fotozincografía de la Dir. de Geografía, Meteorología e Hidrología, Edición 1942.

GALE, H. S., 1912—Nitrate deposits. *U. S. Geol. Survey Bull. 523:* 36 p.

GANNETT, H., 1899—A dictionary of altitudes in the United States. 3d ed., *U. S. Geol. Survey Bull. No. 160:* 775 p.

————, 1902—A gazetteer of Texas. *U. S. Geol. Survey Bull. No. 190, Series F., Geography, 28,* 162 p.; 2d ed. (1904), *Bull. No. 224:* 177 p.

————, 1906—A dictionary of altitudes in the United States. 4th ed., *U. S. Geol. Survey Bull. No. 274, Series F, Geography, 47:* 1972 p.

GEISER, S. W., 1957—William H. von Streeruwitz (1833–1916), geologist on the Dumble Survey of Texas. *Field & Laboratory:* 25, 1 (Jan.): 21–31.

GILLETT, J. B., 1921—Six years with the Texas Rangers, 1875 to 1881. Von Boeckmann-Jones Co., Austin, Texas: 332 p.

————, 1925—Six years with the Texas Rangers, 1875 to 1881. Yale Univ. Press. New Haven: 259 p., edited with introduction by M. M. Quaife; republished by Lakeside Press, Chicago, 1943: 364 p., map of Texas by Quaife, 1 in.: 117 mi.

GOLDICH, S. S., and M. A. ELMS, 1949—Stratigraphy and petrology of the Buck Hill Quadrangle, Texas. *Bull. Geol. Soc. Amer.:* 60, 7 (July): 1133–1182.

GUZMAN, E. J., E. LOPEZ RAMOS, and R. SUAREZ C., 1952—Geological map of eastern Mexico. Pl. 1 of Guzman et al. 1953 and map in Conference on Latin-American Geology (1955), c. 1:3,500,000 (c. 1 in.: 55 mi.).

————, 1953—Petroleum geology of Mexico. *Congrès Géologique International, Comptes Rendus de la Dix-Neuvième Session, Alger, 1952,* Sec. 14 "Les Champs de Petrole des Regions Mésogéennes," Fascicule 16: 33–63.

HALL, J., 1857a—Geology and paleontology of the boundary: 101–140 of Emory, 1857, Pt. 2.

————, 1857b—Map illustrating the general geologic features of the country west of the Mississippi River. Compiled from surveys of Emory and from Pacific R.R. surveys and other sources by Prof. James Hall assisted by J. P. Lesley, Esq., 1:6,000,000 (c. 1 in.: 100 mi.); this is colored map in Emory, 1857, Pt. 2.

Handbook of Texas, 1952—W. P. Webb ed., *Texas State Historical Assoc.,* Austin: 1: 977 p.; 2: 953 p.

HAVARD, V., 1886—Report on the flora of western and southern Texas. *Proceedings U. S. National Museum,* 8, 29–34 (23–30 Sept. 1885): 449–533.

HILL, B. F., and J. A. UDDEN, 1904—Geological map of a portion of West Texas showing parts of Brewster, Presidio, Jeff Davis, and El Paso counties, and south of the Southern Pacific R.R. *Univ. Texas Mineral Surv.,* field work by W. B. Phillips, B. F. Hill, and J. A. Udden, c. 1:300,000 (c. 1 in.: 5 mi.).

HILL, R. T., 1893—The Cretaceous formations of Mexico and their relations to North American geographic development. *Amer. Jour. Sci., 3d Series,* 45, 268 (April), Art. 37: 307–324, 4 figs.

————, 1899—Map of Texas and parts of adjoining territories. Compiled by Hill, drawn by Henry S. Selden and Willard D. Johnson, 1 in.: 25 mi (c. 1: 1,584,000); topographic contours, interval 250 ft.; this is Sheet 11 in Hill, 1900, and Pl. 1 in Gannett, 1902.

————, 1900—Physical geography of the Texas region. *U. S. Geol. Surv. Topographic Atlas of U. S.*, Folio 3 (April, 1900): 12 p., 66 figs., 11 sheets.

————, 1932—Interpretation of the routes of the earliest Spanish American explorations of the Mexican border region of the United States by identification of the geographic and physiographic data mentioned in the narrations. Abstract, *Bull. Geol. Soc. America*, 43, 1 (31 Mar.): 183–184.

Hinckley, L. C., 1947—Contrasts in the vegetation of Sierra Tierra Vieja in Trans-Pecos Texas. *Amer. Midland Naturalist*, 37, 1 (Jan.): 162–178, 9 figs.

Hitchcock, C. H., 1886—Geological map of the United States and part of Canada. c. 1:7,000,000 (c. 1 in.: 111 mi.), in Hitchcock, 1887.

————, 1887—The geological map of the United States. *Trans. Amer. Inst. Mining Engineers*, 15: 465–488, 1 colored map, St. Louis meeting October 1886.

————, and W. P. Blake, 1872—Geological map of the United States. Compiled for 9th Census, "Base is the Military Map of the United States by permission of the Chief of Engineers," J. Bien, Lith., c. 1:5,700,000 (c. 1 in.: 90 mi.).

————, 1874—Geological map of the United States and Territories. With colored map—scale 1:7,115,000 (c. 1 in.: 114 mi.), and p. 8–9 reference list of geological maps and publications 1806 to 1874; this is Pt. 1: 6–9 and Pl. 14 of Walker, 1874.

Hornaday, W. D., 1911—Texas coals and lignites and their composition. *Mining and Engineering World*, Chicago, 35, 20 (11 Nov.): 970–971.

Humboldt, A. de, 1812a—Atlas géographique et physique du Royaume de la Nouvelle-Espagne. Chez Dufour et Cie., Rue des Mathurins, No. 7: 4 p., 20 cartes, 4 profils, 6 diagrammes, 2 vues.

————, 1812b—Carte générale du Royaume de la Nouvelle Espagne depuis le parallele de 16° jusqu'au parallele de 38° (latitude nord). Dressée sur des observations astronomiques et sur l'ensemble des materiaux qui existoient à Mexico, au commencement de l'annee 1804, 1:3,000,000 c. (c. 1 in.: 48 mi.), Carte 1 dans Humboldt, 1812a.

Jameson, D. L., and A. G. Flury, 1949—The reptiles and amphibians of the Sierra Vieja range of southwestern Texas. *Texas Jour. Sci.*, 1: 54–79.

Keith, N. L., 1950—The Brites of Capote. *Texas Christian Univ. Press*, Fort Worth: xlvi + 272 p.

Kimball, J. P., 1869—Notes on the geology of western Texas and of Chihuahua, Mexico. *Amer. Jour. Sci., 2d Series*, 48, 144 (Nov.): 378–388, New York, 10 Aug. 1869.

King, P. B., 1935—Outline of structural development of Trans-Pecos Texas. *Bull. Amer. Assoc. Petrol. Geol.*, 19, 2 (Feb.): 221–261.

————, 1942—Tectonics of northern Mexico. *Proceedings 8th Amer. Scientific Congress*, Washington, 10–18 May 1940, 4 Geological Sciences: 395–398, Plate 1 Geologic map of northern Mexico, c. 1 in.: 147.8 mi., reduction King (1947) Lámina 2.

————, 1947—Carta geologica de la parte septentrional de la Republica Mexicana. *Universidad Nacional Autonoma de Mexico, Instituto de Geologia, Geofisica y Geodesia, Cartas Geologicas y Mineras de la Republica Mexicana,* No. 3 (Octubre), traducción del inglés hecha por Carl Fries, Jr., U. S. Geol. Survey: iv + 24 p., 5 figuras; 2 maps of northern Mexico, Lámina 1 geologic map c. 1 in.: 38.5 mi., Lámina 2 tectonic map c. 1 in.: 69 mi.

LIVERMORE, W. R., 1883—Military map of the Rio Grande frontier. Prepared from original surveys, county maps, reports of officers, etc., property of General B. H. Griers, c. 1 in.: 19 mi., in Shipman, 1926.

LONGWELL, C. R., 1944—Tectonic map of the United States. Amer. Assoc. Petrol. Geol., compiled by members of Committee on Tectonics, Div. Geol. and Geog., National Research Council, arranged for printing by P. B. King, 1:2,500,000 (c. 1 in.: 40 mi.), 2d printing 1947, 3d 1949, 4th 1951.

LORD, E. C. E., 1900—Report on igneous rocks from the vicinity of San Carlos and Chispa, Texas. p. 88–95 of Vaughn, 1900.

MANKIN, C. J., 1955—Biostratigraphy of Tierra Vieja, Trans-Pecos Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vii + 104 p., 14 figs., 7 pls., 9 stratigraphic sections.

MANSFIELD, G. R., and L. BOARDMAN, 1932—Nitrate deposits of the United States. *U. S. Geol. Survey Bull. 838:* 107 p.; "Presidio County, Texas": 69–84, Figs. 8–13, Pls. 4, 9B, and 10.

MCANULTY, W. N., 1955—Geology of Cathedral Mountain Quadrangle, Brewster County, Texas. *Bull. Geol. Soc. Amer.*, 66, 5 (May): 531–578.

MCGEE, W J, 1885—Report of Mr. W J McGee. *U. S. Geol. Survey 5th Ann. Rept., H. R. Ex. Doc. 1, Pt. 5,* 48th Cong. 2d Sess. 1884–85, 13, 1 (Pt. 5, Vol. 3): 34–41, Washington, D. C., 22 July 1884.

MCGREW, B. J., 1955—Petrography of Candelaria area, Presidio County, Trans-Pecos Texas. Unpublished M.A. thesis, Univ. Texas, Austin: viii + 122 p., 41 figs., 2 pls., 8 measured sections.

Merchants' Association of New York, 1901—The natural resources and economic conditions of the State of Texas. Dec.: 146 p.

MERRILL, G. P., 1920—Contributions to a history of American state geological and natural history surveys. Smithsonian Institute, U. S. National Museum Bull. 109: 549 p.

MORAN, S. S., 1955—Structure of Candelaria area, Presidio County, Trans-Pecos Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vii + 84 p., 14 figs., 5 pls., 4 tables.

OSANN, A., 1893—Report on the rocks of Trans-Pecos Texas. P. 121–138 of Dumble, 1893, Pt. 1.

PARKER, E. W., 1895a—The San Carlos coal fields. *Mineral Resources, 1893, U. S. Geol. Survey, H. R. Misc. Doc.*, 28, 53d Cong. 2d Sess.: 384–385.

————, 1895b—The production of coal in 1894. *U. S. Geol. Survey 16th Ann. Rept.*, Pt. 4—Mineral Resources, 1894, Nonmetallic Products: 1–217.

————, 1896—Coal. *U. S. Geol. Survey 17th Ann. Rept.*, Pt. 3—Mineral Resources, 1895: 285–542.

PARRY, C. C., 1857—Geological features of the Rio Grande valley from El Paso to the mouth of the Pecos River. Chap. 3: 49–61, of Emory, 1857, Pt. 2.

PETERSON, J. E., 1955—Cenozoic stratigraphy of Candelaria area, Presidio County, Trans-Pecos Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vi + 113 p., 9 figs., 1 pl., 4 tables, 12 measured sections.

PHILLIPS, H. W., and W. A. THORNTON, 1949—The summer resident birds of the Sierra Vieja range in southwestern Texas. *Texas Jour. Sci.*, 1: 101–131.

PHILLIPS, W. B., 1904—Report of progress for the year ending December 31, 1903. *Univ. Texas Bull. No. 22, Mineral Survey Bull. No. 7:* 14 p., 1 map.

————, 1910—Nitrate of soda in a Texas county. *Manufacturers Record,* Baltimore, 58, 5 (11 Aug.): 53.

————, 1911a—Texas phosphate. *Manufacturers Record,* Baltimore, 59, 2 (19 Jan.): 60.

————, 1911b—Nitrate of soda in northern Mexico and West Texas. *Mexican Mining Jour., Mexico City,* 13, 3 (Sept.): 21–22.

————, 1911c—Sodium and sodium salts, Texas. *The Mineral Industry, Its Statistics, Technology and Trade During 1910,* 19, McGraw-Hill Book Co., N. Y.: 616.

————, 1915—The mineral resources of Texas. *Univ. Texas Bull. No. 365, Scientific Series No. 29,* (15 Oct. 1914): 320 p.

————, 1916—Investigations of sources of potash in Texas. *Trans. Amer. Inst. Mining Engineers,* 51 (papers of N. Y. meeting, Feb. 1915): 438–450, 3 figs.

————, and S. H. WORRELL, 1911—The composition of Texas coals and lignites. *Univ. Texas Bull. No. 189, Scientific Series No. 19* (1 July 1911): 1–57.

————, 1913—The fuels used in Texas. *Univ. Texas Bull. No. 307, Scientific Series No. 35* (22 Dec. 1913), Bur. Econ. Geol. and Technology: 287 p.

PLUMMER, F. B., 1933—Cenozoic systems in Texas. Pt. 3: 519–818 of Sellards, Adkins, and Plummer, 1933; "Volcanic rocks of Cenozoic age": 798–808.

RANSOME, F. L., 1915—The Tertiary orogeny of the North American cordillera and its problems. *Problems of American Geology,* Yale Univ. Press, New Haven, Chap. 6: 287–376, 1 map, lecture delivered at Yale Univ. on Silliman Foundation in Dec. 1913.

RIES, H., 1905—The coal fields of Texas. *Mines and Minerals,* Scranton, Pa., 26, 3 (Oct.): 104–105, 3 figs.

ROBINSON, H. M., 1918—Map of part of San Carlos Quadrangle, Presidio County, Texas. Pl. 10 of Mansfield and Boardman, 1932, c. 1 in.: 2 mi.

ROESSLER, A. R., 1874—Latest map of the State of Texas, exhibiting mineral and agricultural districts, post offices & mailroutes, railroads projected and finished, timber, prairie, swamp lands, etc. etc. etc. Compiled and drawn by M. Y. Mittendorfer, C. E., printed by Ferd. Mayer, 96 & 98 Fulton St., New York, c. 1 in.: 20 mi.

San Carlos Sheet, Presidio County, Texas,1895—*U. S. Geol. Survey,* 1:125,000 (c. 1 in.: 2 mi.), contour interval 100 ft., 30′ quad. (30°00′–30°30′N, 104°30′–105°00′W).

SELLARDS, E. H., 1933—The Valentine, Texas, earthquake. *Univ. Texas Bull. No. 3201* (1 Jan. 1932), *Bur. Econ. Geology,* Part I. Contributions to Geology, 1932, (h): 112–128, issued Feb. 1933.

————, 1936—Structural map of Texas. *Univ. Texas Bur. Econ. Geol.,* issued July, 1936, showing structural contours (interval 500 ft.), oil and gas fields, salt domes, and major faults; scale 1:1,000,000 (1 in.: 15.78 mi.); drawn by C. E. McCarter; base adapted from U. S. Soil Conservation Service.

————, 1939—Structural map of Texas. 2d ed. rev. of Sellards, 1936, issued Jan. 1939, drawn by Atlee Manthos, based adapted from U. S. Geol. Survey base map of Texas (1:5,000,000) polyconic projection, shows 500-foot contours on "top of Georgetown" on E slope of Sierra Vieja.

———, W. S. Adkins, and F. B. Plummer, 1933a—The geology of Texas, Volume I, stratigraphy. *Univ. Texas Bull. No. 3232, Bur. Econ. Geol:* 1007 p., issued July, 1933.

———, ———, ———, 1933b—Geologic map of Texas. Scale 1: 2,000,000 (1 in.: 31.56 mi.), Pt. 5, Pl. 11 of Sellards, Adkins, and Plummer, 1933a; base and geologic mapping adapted from 1932 preliminary edition of Darton, Stephenson, and Gardner, 1937.

———, and C. L. Baker, 1935—The geology of Texas, Volume II, structural and economic geology. *Univ. Texas Bull. No. 3401, Bur. Econ. Geol.:* 884 p., issued Dec., 1935.

———, and Leo Hendricks, 1946—Structural map of Texas. 3d ed. rev., issued July, 1946, 2d printing 1951, 1:500,000 (c. 1 in.: 8 mi.).

Sewell, C. R., 1955—Igneous petrology of Candelaria area, Presidio County, Texas. Unpublished M.A. thesis, Univ. Texas, Austin: vii + 127 p., 4 figs., 27 pls., 9 measured sections.

Shipman, O. L., 1926—Taming the Big Bend. A history of the extreme western portion of Texas from Fort Clark to El Paso: 215 p., 4 illus., 1 map.

Shuler, E. W., 1926—Geology of Texas. *Texas Almanac and State Industrial Guide 1926*, A. H. Belo & Co., Dallas: 170–179, 3 figs.

Simonds, F. W., 1905—The geography of Texas, physical and political. Ginn & Co.: 237 p.

Smith, H., and D. Walker, 1923—The geography of Texas. Ginn & Co.: 327 p., 40 maps including "Political map of Texas showing natural regions."

Solms-Braunfels, Carl, Prinz zu, 1846a—Texas. Geschildert in Beziehung auf seine geographischen, socialen und übrigen Verhältnisse mit besonderer Rücksicht auf die deutsche Colonisation. Ein Handbuch für Auswanderer nach Texas. Johann David Sauerlander's Verlag, Frankfurt am Main: x + 134 Seiten, 2 Karten.

———, 1846b—Karte von Texas entworfen nach der General-Land-Office der Republic. In Solms-Braunfels 1846a; also as end papers in Solms-Braunfels 1936.

———, 1936—Texas 1844–1845. Anson Jones Press, Houston, translated from the German: 141 p., 4 illus., 4 maps including end papers.

Stose, G. W., 1932—Geologic map of the United States. *U. S. Geol. Surv.*, compiled by George W. Stose assisted by O. A. Ljungstedt, 1:2,500,000 (c. 1 in.: 40 mi.), Albers equal-area projection, North American datum, source of data on Texas: pre-publication of Darton, Stephenson, and Gardner, 1937.

———, 1946—Geologic map of North America. *Geol. Soc. Amer.*, 1:5,000,000 (c. 1 in.: 80 mi.).

Stovall, J. W., 1948—Chadron vertebrate fossils from below the Rim Rock of Presidio County, Texas. *Amer. Jour. Sci.*, 246, 2 (Feb.): 78–95, 3 figs., 2 pls., map, Fig. 2, p. 80, 1:250,000 (c. 1 in.: 4 mi.); cross section, Fig. 3, p. 88.

Streeruwitz, W. H., von, 1891a—Report of Mr. von Streeruwitz. Austin, Texas, Dec. 30, 1890: xci–civ of Dumble, 1891.

———, 1891b—Report on the geology and mineral resources of Trans-Pecos Texas: 665–738 of Dumble, 1891.

———, 1892—Trans-Pecos Texas: 383–389 of Dumble, 1892.

———, 1893—Trans-Pecos Texas: 139–175 of Dumble, 1893, Pt. 1.

Texas Almanac, 1925, 1926, 1927, 1928, 1929, 1936, 1939, 1941, 1943, 1945, 1947, 1949, 1951, 1953, 1955—Texas almanac and state industrial guide. A. H. Belo Corp., Dallas; all those cited have folded map of Texas except 1929.

UDDEN, J. A., C. L. BAKER, and E. BÖSE, 1916a—Review of the geology of Texas. *Univ. Texas Bull. No. 44, Bur. Econ. Geology and Technology* (5 Aug. 1916): 164 p., 1 map; 2d ed., 1916, 169 p., 1 map; 3d ed., rev. 1919: 178 p., 1 map.

———, 1916b—Geological map of Texas. Drawn by E. L. Porch, Jr., 1:1,500,000 (1 in.: 23.67 mi.) in Udden et al. 1916a, 1st and 2d eds.; rev. ed., in 3d ed., 1919.

VAUGHN, T. W., 1896—Notes on the geology of the San Carlos coal field, Trans-Pecos Texas. *Science*, New Series, 3, 62 (6 Mar.): 375.

———, 1900—Reconnaissance in the Rio Grande coal fields of Texas. *U. S. Geol. Surv. Bull. No. 164*, 100 p., Fig. 1 showing general position of Rio Grande coal fields; Pt. II, The San Carlos coal field of Trans-Pecos Texas and adjacent portions of the Vieja Mountains, p. 73–95, 6 pls.; Pl. 6, topography of San Carlos region showing positions of measured sections, c. 1 in.: 2 mi.

WALKER, F. A., 1874—Statistical atlas of the United States based on the results of the ninth census 1870 with contributions from many eminent men of science and several departments of the government. Julius Bien, lith.: 46 p.

WILLIS, BAILEY, 1912—Index to the stratigraphy of North America. *U. S. Geol. Surv. Prof. Paper 71:* 894 p., Pl. 1 in box.

———, and G. W. STOSE, 1911—Geologic map of North America. Compiled by U. S. Geol. Surv. in cooperation with Geol. Surv. Canada and Instituto Geologico de Mexico, 1:5,000,000 (c. 1 in.: 80 mi.); this is Pl. 1 of Willis, 1912.

WOOTEN, D. G., 1898—Comprehensive history of Texas 1685 to 1897. Edited by Dudley G. Wooten, published by William G. Scarff, Dallas; Vol. I: 890 p.; Vol. II: 851 p.

WOOTEN, PAUL, 1927—Sodium nitrate deposit found near Candelaria, Texas. P. 817, in "Washington Letter," *Engineering and Mining Jour.*, 123, 20 (14 May): 816–817.

YORK, C. L., 1949—The physical and vegetational basis for animal distribution in the Sierra Vieja range of southwestern Texas. *Texas Jour. Sci.*, 1: 46–62, 2 figs.