GEOLOGIC AND HISTORIC GUIDE TO THE STATE PARKS OF TEXAS

BY ROSS A. MAXWELL

WITH CONTRIBUTIONS BY
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L. EDWIN GARNER

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

COVER: The Lighthouse in Palo Duro Canyon State Scenic Park. Caprock of resistant Trujillo Sandstone protects the less resistant shale and sandstone.

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The University of Texas at Austin
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Guidebook 10

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PREFACE

Texas is no longer a frontier. The expansion of cities, industries, super highways, and reservoirs, and changing land uses are fast absorbing the open spaces that once were so abundant in Texas. Unlike many states that contain vast areas of National forests and parks, there is little federally owned land in Texas, so the State must rely on its own State parks system for outdoor recreational activities. Until recently, however, the State parks program was operated with limited finances, and as a result Texas is far behind the established national acreage average in its State parks. The present State parks cover about 64,000 acres, but of this total, only 18,888 acres is land area available to meet the public's demand for recreation, and only slightly more than 8,000 acres is currently developed to an adequate standard. For our own well-being and for those who follow after us, we must treat the land with respect, conserve it, and wisely develop it.

In addition to the 61 recreation, scenic, and historic parks listed in this report, there are many other places in Texas that are of historic interest—old missions, old houses and buildings, burial sites, etc. Some of these have been included as points of interest if they are near a specified State park; many have granite or metal markers at or near their sites. Inscriptions on these markers are listed by W. M. Jones (1958); official Texas historical markers are listed in the Humble Oil & Refining Company guide (undated).

Personnel of the Texas Parks and Wildlife Department have assisted in furnishing compiled data for this report. Mr. William M. Gosdin, Director of Park Services, has been most helpful. Members of Mr. Gosdin's staff who have furnished data for the report include Mr. E. B. Camiade, Director of Special Park Services; Mr. Fred A. McNiel, landscape architect; Mr. Bob Carlyle and Mr. Wayne Tiller, who made the Parks Department's photograph file available; Mr. Jay Vessels (now retired), information specialist; and Mrs. Elaine Bostic, a former employee in the information office. Several park managers have made available information from their files. Mr. Eugene A. Walker, Director of Wildlife Services, and members of his office have been helpful in furnishing data on wildlife.

Special thanks are due Mr. Frank D. Quinn, former Executive Secretary of the Texas State Parks Board and later a Board member, who permitted the use of his personal files and furnished much early history.

Thanks are due the late Mr. Raymond Brooks, who permitted the use of his article; Mr. D. Hoye Eargle and Mrs. Edward Mott Davis, U. S. Geological Survey, who furnished geological data; and Mr. and Mrs. Eargle, Mrs. Davis, and Mr. Quinn, who read parts or all of the manuscript and gave constructive criticism.

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INTRODUCTION

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In February 1966, the Austin *American-Statesman* carried an article from the memoirs of the late Raymond Brooks, "dean" of the Capitol staff of that newspaper, entitled "The Birth of Texas' Great State Parks." This article follows, in part:

In the first year of Pat Neff's governorship, 1921, interest spread in parks more spacious than city squares and having some of the varied regional scenic values. Some unimproved tracts had been deeded or promised to the State.

Two factors—Neff's leadership in envisioning the future system of State parks and D. E. Colp's unique, unpaid career of effort to make it a reality—gave the ever-spreading parks system the start that has made it notable in the nation.

At Neff's suggestion, a joint legislative committee was created in his first year in office to inspect several proposed park sites in West Texas. The group journeyed to Pecos, then up into the Davis Mountains, and members, on horseback, scaled the mile-high ridges. The group went on to view storied Phantom Lake at Balmorhea, then on to the Marfa-Alpine "gateway" to the future Big Bend National Park.

Next, the committee journeyed to Amarillo and was escorted by Amarillo and Canyon citizens to the impressive Palo Duro Canyon. There, the legislators saw a local wonder—a gas well spouting many thousands of feet of gas into the air—gas that wouldn't burn. To show its nature, they tossed torches into the gas. This well, after wasting millions of feet of its pressure, was one of those harnessed by the federal government to become the nation's main source of helium, the nonburning gas in great demand in the period of the big dirigibles, and in demand and use otherwise ever since.

The legislators journeyed across New Mexico to El Paso, and had a great banquet as guests of Mexican officials in Juarez. Some of its speakers were so gay they fought the Alamo, Goliad, and San Jacinto all over again.

Out of that tour came the impressive Davis Mountains State Park, with its Indian pueblo architecture, beautiful little Balmorhea State Park, and the Grand Canyon type Palo Duro State Park in the canyon where the headwaters of the Red River originate.

Governor Neff did more. In a step typical of his way of doing things, he recommended systematic development of big parks outside the cities, and to start the program, he donated to the State Mother Neff State Park near Waco.

The Legislature created a State Parks Board, and authorized it to accept gifts. But no money was provided for development, no staff was authorized or funds voted to hire people to develop the parks.

But the right man was on the scene, and D. E. Colp took on the job, unpaid, of getting the parks developed and built up. There was limited permission for concessions, and private interests were encouraged to build lodges and camping facilities in some of the parks, such as Caddo Lake, Bastrop, the park at Uvalde which was to become Garner State Park, others at Huntsville and many other spots. Lakeside parks grew later with new lakes, such as Roy Inks Lake Park, Texarkana Lake State Park, Possum Kingdom, and so on. Some federal facilities were provided on Texoma. D. E. Colp saw impressive development at Palo Duro, where a magnificent "gateway" was built at prairie level, and a road opened down the canyon wall to a headquarters lodge and shelter within the canyon itself. Colp drove his 10-year-old car over the gravel and dirt roads from Austin to Amarillo, without salary or expense account, to take part in dedication of these buildings.

The federal program of NYA and CCC camps started in 1933 gave a big push to make the parks accessible and usable for the public.

Then later, as major lakes came into being, park facilities and water recreational areas, such as those for Falcon and Amistad reservoirs on the Rio Grande, were planned as the lakes themselves were being created.

In later years, the State has been offered even more attractive park sites than it could hope to develop, and in some cases, it has had to decline them because the donors imposed the condition that so much money had to be spent to develop and open up the proposed parks. . . .

During the period 1923 to 1933, several park sites were acquired by the Texas State Parks Board as donations from individuals, cities, counties, and other organizations. There were no public funds for the operation, development, or improvement of the parks and some areas were kept open by the original donors. Two areas, Palo Duro Canyon and Longhorn Cavern, were purchased under authority granted the Texas State Parks Board by the 43rd Legislature; the vendors' liens were secured by the gross receipts of the park admissions. Since 1942 several park sites have been acquired under lease agreements with the Federal government in connection with reservoir construction.

The growing demand for public recreational facilities in State parks and the lack of sufficient general revenue appropriations that would enable the Texas State Parks Board to maintain the park structures that were built during the CCC program caused Governor John Connally, in his address to the Joint Session of the Texas Legislature on January 16, 1963, to state that "our present State Parks System is sick to the point of dying. Our parks are many, scattered, and without tourist-attracting features needed for effective use. I propose the consolidation of the State Parks Board and the Game and Fish Commission under a three member commission. These agencies perform different aspects of the same function and the administrative structure and field organizations of each can be meshed to provide stronger programs in each area with greater efficiency . . . . We must decide what we want in the way of parks and what it will cost, then provide this service to our people, or not attempt to engage in the activity at all."

The Texas Legislature then passed House Bill 21, signed by Governor Connally on April 17, 1963, which became effective August 23, 1963. This bill provided that the term of office of the members of the Game and Fish Commission be terminated, that the Texas State Parks Board be abolished, and that all the powers, duties, and authority previously vested in both State departments be transferred to a reorganized agency known as the Parks and Wildlife Department, administered under a commission consisting of three members.

This was the beginning of a new era for the State parks. The Legislature appropriated funds for the construction of visitor facilities in undeveloped parks and the rehabilitation and improvement of facilities in inadequately developed areas. The Federal Land and Conservation Act of 1965 provided as matching funds $5.5 million for State park projects and $4.6 million for city, county, and river authority parks. The State Legislature appropriated $2.7 million and local political subdivisions provided $2.3 million through bond issues, local funds, or gifts. Some of the State parks included in the new construction and rehabilitation projects were Meridian, Davis Mountains, Kerrville, Eisenhower, Tyler, Bastrop, Palo Duro Canyon, Stephen F. Austin, Copano Bay, Lyndon B. Johnson, Caddo Lake, Goliad, Lockhart, and Huntsville.

Governor Connally also proposed a State parks program which called for acquisition and development of 26 additional parks. This investment would be made by means of a 10-year, $75 million, self-sustaining bond program to be financed by a $1-per-car entrance fee. The proposal was submitted as a constitutional amendment to the voters on November 11, 1967. The amendment passed and plans are being formulated to acquire and develop the new areas.

We are but a few generations removed from the wilderness area that our grandfathers found as they moved westward to claim and settle the State. The prairie schooner, the ax, the sodbuster, the long rifle, the hunter and trapper are all part of the State's tradition. As the pioneer settlers moved into the State, they fought Indians, other nations, outlaws, and sometimes each other. They made the early trails and in so doing gained information about the terrain, the rocks, the soil, the streams, the waterholes, and the climate. It is our belief that Texas is our State and that it is our responsibility to know something about its natural features that caused Texas to differ from other states and to preserve and protect the wilderness, recreational, and historic areas, and State parks as part of our heritage.

FIG. 1. Colorado River delta with offshore bar (barrier island) in foreground; scale 1" = 6,000'. Deltas form and grow seaward at the mouths of rivers at places where the strength of wave and ocean currents exceeds that of the stream currents. Waves and ocean currents continually rework the deposits and reshape the delta margins. (Photograph by Edgar Tobin Aerial Surveys, San Antonio, Texas.)

PHYSIOGRAPHY AND GEOLOGY

Ross A. Maxwell

Texas comprises about 263,500 square miles; it occupies the area from the Red River on the north to the Rio Grande on the south, an area ranging from near the Rocky Mountains foothills to the Gulf of Mexico. Elevations range from 8,751 feet at the top of Guadalupe Peak in Culberson County to sea level at the Gulf of Mexico. A wide variety of physical features is distinctly divisible into strongly contrasting types of terrain that cover extensive parts of the State (Pl. I). The most conspicuous of these subdivisions are:

Gulf Coastal Plain
Black and Grand Prairies
Edwards Plateau
Llano Estacado
North-central Plains
Trans-Pecos Texas

PHYSIOGRAPHIC SUBDIVISIONS

Gulf Coastal Plain.—Texas, the most westerly of the Gulf coastal states, has a shoreline approximately 375 miles long, extending from the Sabine River on the east, southwestward to the Rio Grande (Pl. I). This shoreline is irregular and is broken by numerous bays and various smaller re-entrants which are fringed seaward by long, narrow barrier islands, peninsulas, and similar coastal features. The Coastal Plain forms an arc about 200 miles wide inward from the shoreline and its surface slopes generally southeastward from an average elevation of about 500 feet at the inner boundary to sea level. All of the largest rivers head outside the Coastal Plain belt, and they and their larger tributaries flow generally southeastward with the slope of the surface.

The Texas rivers that flow directly into the Gulf of Mexico carry an enormous load of sand and silt. The rock waste carried by the rivers now, as in the past, tends to fill the bays and extend the coastline seaward. The Rio Grande has produced a marked outward encroachment —a delta—into the water of the Gulf of Mexico, and deposits made by the Colorado and Brazos Rivers have given rise to similar, although not as conspicuous, results (fig. 1). Probably the Trinity River has built the most typically shaped of the Texas river deltas (fig. 2).

The prevailing wind from the Gulf produces waves, and these, assisted by the ocean currents and in some places the tides, are continually working against the river's efforts to extend the shoreline seaward. Along lines where the ocean currents become stronger than the river currents, the forward motion of the river water ceases and the stream's load of mud and sand is deposited. The ocean currents force back the rock debris deposited by the rivers and mold the sand and silt in barrier islands, peninsulas, and other offshore features (fig. 3), so the Texas shoreline is continually being modified by conflicting forces between the sea and the rivers.

In some areas man has attempted to modify or to control nature's depositional forces by building jetties that encourage the water currents to deposit their loads outside shipping channels or away from industrial areas (fig. 4). In some places it is necessary to open channels by dredging (fig. 5). At other places intracoastal

FIG. 2. The Trinity River delta. River deltas have variable shapes, depending upon the local environment. Some of the controlling factors are: volume and velocity of water and the number of stream tributaries, the character of the water basin, strength of ocean currents, prevailing wind direction, and presence of offshore bars or other shoreline features. (Photograph by U. S. Department of Agriculture, Salt Lake City, Utah.)

waterways have been constructed to inland ports.

If one travels across the Coastal Plain from the shoreline toward the interior, as the elevation of the land increases he crosses successive belts of country, each distinguished by its peculiar soil, rocks, and vegetation. Some areas are flat and grass covered, others are mildly dissected, and there are ridges with gently southeastern back-slope and steeper northwest-facing escarpments. Some areas are heavily forested, others are brush covered, and there are extensive prairies. The physical and chemical composition of the underlying bedrock and the degree of weathering and erosion are mainly responsible for these diverse characteristics. If the underlying rock is a sandstone, the soil is sandy and has a yellowish to light reddish-brown color; the surface is normally covered with trees; shallow wells are

FIG. 3. Wave and current action along a regular shoreline has built a uniformly sandy beach in the Gulf of Mexico.

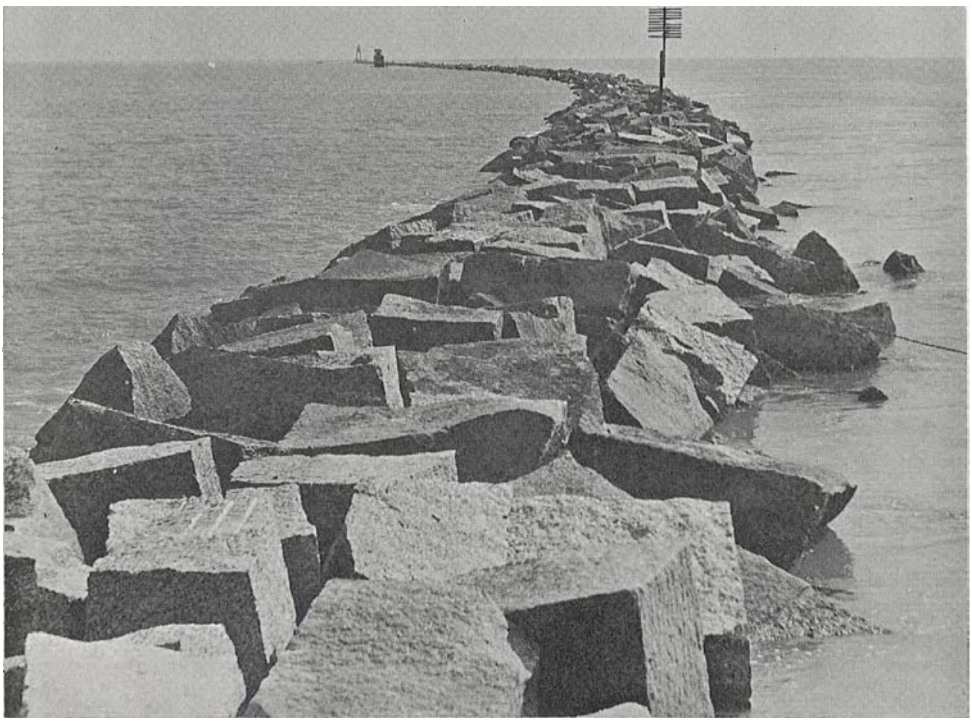

FIG. 4. Jetty at Galveston, Texas. Built with Precambrian granite blocks quarried and shipped from the Central Mineral Region (Pl. I). (Photograph by Corps of Engineers, U. S. Army, Galveston District, Galveston, Texas.)

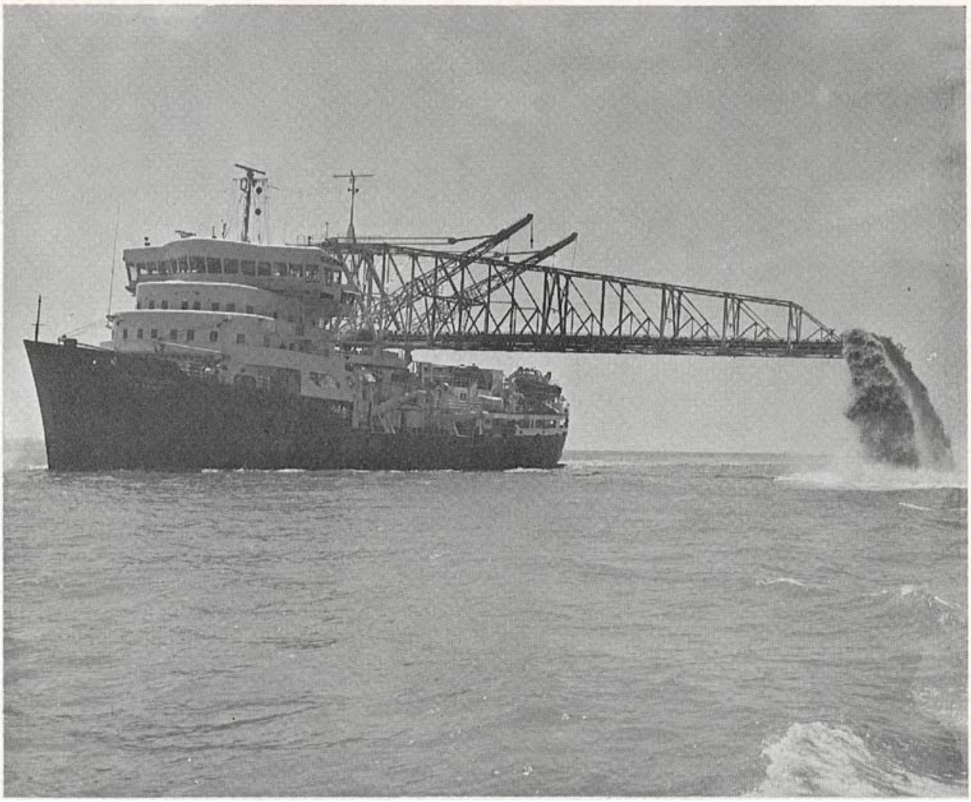

Fig. 5. U. S. Army Corps of Engineers hopper dredge "McFarland" during a dredging operation. Sand, gravel, mud, oyster shell, and other debris are sucked from the channel through an intake pipe and spilled to a side of the channel through the spoil pipe supported along the boom. (Photograph by Corps of Engineers, U. S. Army, Galveston District, Galveston, Texas.)

abundant, and water is of good quality. In areas underlain by clay, the soil is dark to black and sticky, the surface is normally treeless except for low brush, and the water is of poor quality and scarce.

The rocks that underlie the Coastal Plain are layers of sandstone and clay superimposed one upon the other in a definite order. They all dip southeasterly toward the Gulf of Mexico at a very low angle. The arrangement of the formations may be illustrated by placing a pack of cards one by one upon the table and sloping them toward the southeast (fig. 6). Each card represents a rock layer and the bottom card is the oldest because it was laid down first. The oldest rock layers are at the inner border of the Coastal Plain; in Central Texas they overlap older rocks between Austin and Bastrop. The youngest rock layers are at the coastline where the muds and sands being deposited today will eventually become the rock layers of tomorrow. The Coastal Plain formations are geologically very young and belong to the Cenozoic Era (fig. 21, p. 26). They were deposited during the time that streams were extending the land surface into the area then occupied by the sea. Some were deposited in shallow offshore water and contain fossil shells. Others were deposited as bars and deltas at the mouths of rivers and some in swampy mud-flats along streams and in lagoons. Lignite, a low-grade coal, is included in some formations, which indicates that there were many land plants growing in the swamp areas.

The Coastal Plain has been subdivided into belts with distinguishing characteristics. Skirting the shoreline is a belt up to about 100 miles wide called the Coastal Prairie. The area immediately adjacent to the shore is low and flat, and in some places there are extensive marshes containing a tangle of cane, reeds, salt grass, and similar vegetation. Inward from the coastal margin is an area of grasslands that is nearly void of trees except in some of the old drainage channels; its surface seldom exceeds 100 feet in elevation, and this is where the rice fields of Texas occur (fig. 7). All of the Coastal Prairie is exceedingly level, its surface is scarred by the largest rivers that are confined in low terraced banks, and between the rivers are smaller drainage channels that become fewer and less plainly developed

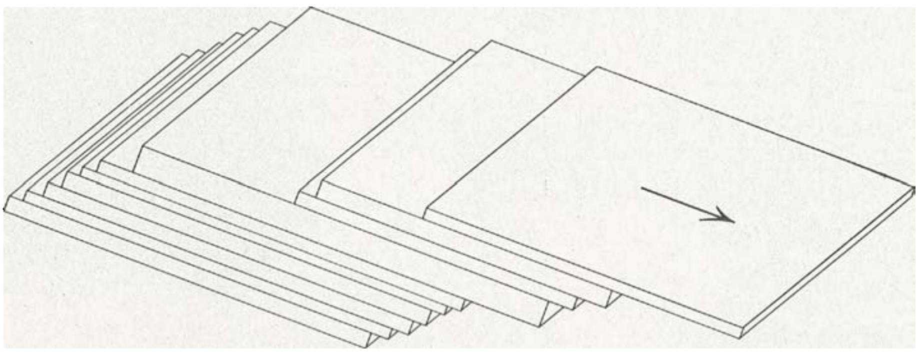

FIG. 6. Diagram illustrating sequence of strata, Gulf Coast. The bottom rock layer is the oldest, was deposited first, and is found near the inner margins of the Gulf Coastal Plain. The youngest rock layer is on top and is at or near the shoreline.

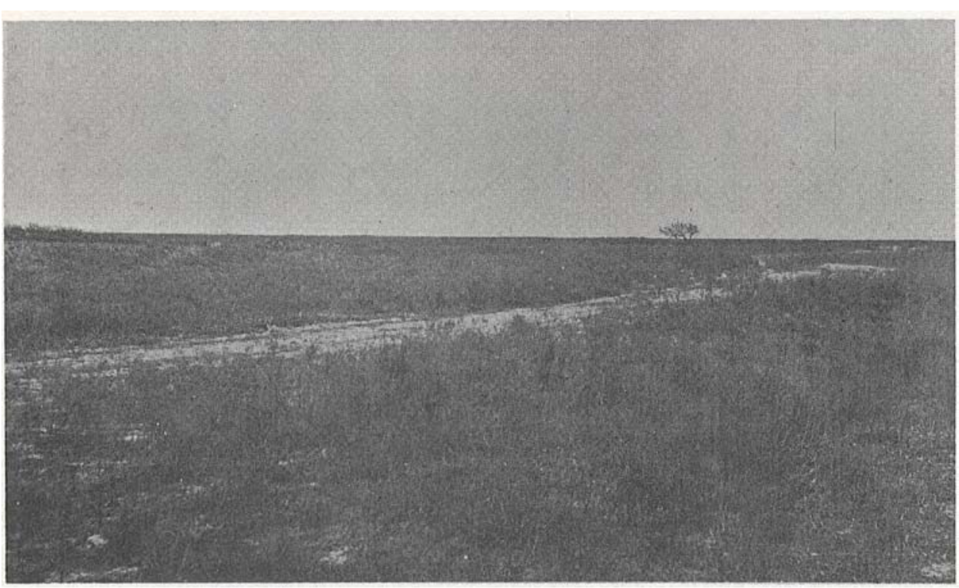

FIG. 7. The low, level, featureless surface of the Coastal Prairie. This is an area of grasslands that is nearly void of trees. Cattle and rice are the dominant products.

FIG. 8. The East Texas forest and bayou terrain. Mixed stands of dense forests flourish, and poor drainage in an area of heavy rainfall gives rise to swamps. (Photograph by Texas Parks and Wildlife Department.)

from east to west toward the Rio Grande.

The Coastal Prairie grades northward without abrupt change into the area of the main Coastal Plain whose inner margin is marked by a low northwest-facing escarpment southeast of Dallas, and in Central Texas by the Balcones Escarpment. At the eastern end of this area, in the vicinity of the Sabine River, there are many sluggish-flowing streams and bayous fed by an annual precipitation of about 50 inches. Here there are forests with thick stands of gum, oak, magnolia, pecan, and thickets of palmetto (fig. 8). Farther west is a mildly dissected surface that is better drained and the trees include loblolly and longleaf pine and such hardwood species as oak, ash, and hickory. These forests have been used for a variety of building and paper industry purposes and are still an important part of the East Texas economy.

The Coastal Plain increases in altitude toward the west, in the Austin—San Antonio area the average surface elevation is about 500 feet. The precipitation decreases to about 30 inches per year and the effects of the ever-increasing aridity become more and more apparent in the kinds and amount of vegetation. The forests that began to thin east of the Brazos River are mostly hardwood varieties that are limited to the sandy soils along streams. Farther west, the oak population thins even in the sandy soils, and along the Nueces River south of Uvalde is the Brush Country, made famous by the writings of the late J. Frank Dobie. Here the mesquite, huisache, black brush, yucca, cac-

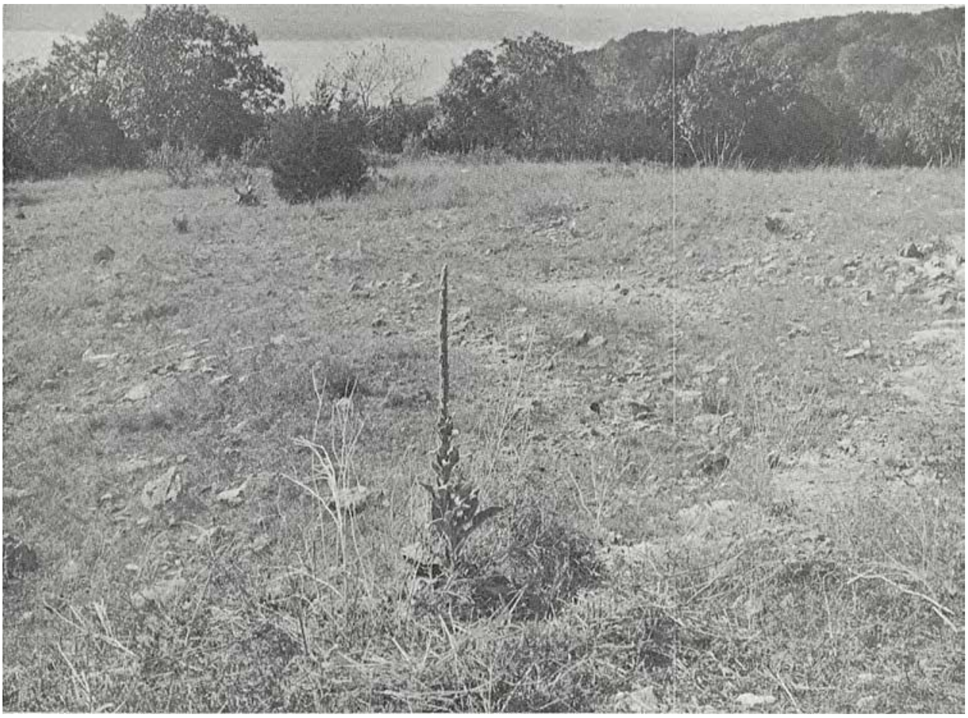

FIG. 9. Oaks, juniper (cedar), and other hardwood trees grow in the well-drained, rolling terrain along the Nueces River valley. Loose rock is exposed on many ridge tops; the thin, coarse, well-drained soil supports bunchgrass, weeds, prickly pear, and thornbrush. (Photograph by Texas Parks and Wildlife Department.)

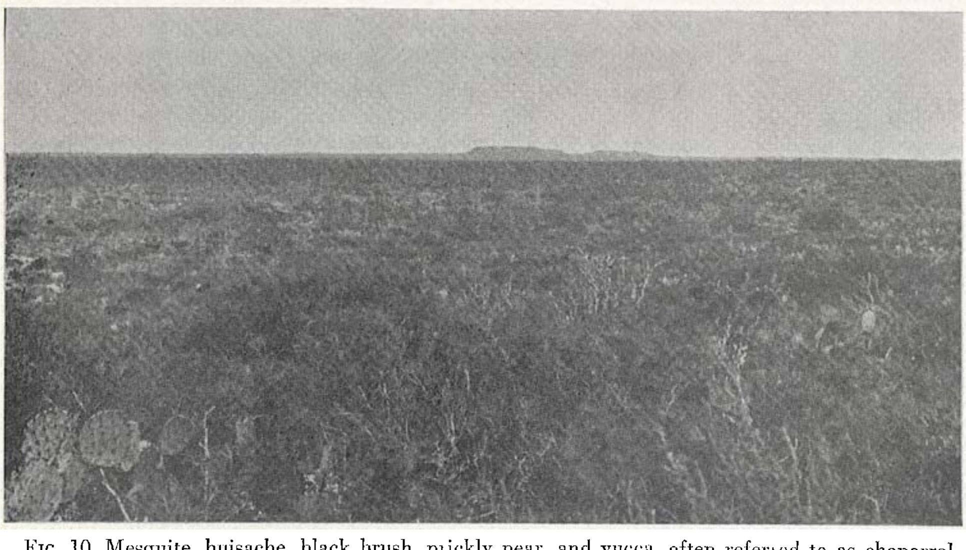

FIG. 10. Mesquite, huisache, black brush, prickly pear, and yucca, often referred to as chaparral, and scattered bunchgrass in Duval County, Texas. (Photograph from Deussen, 1930).

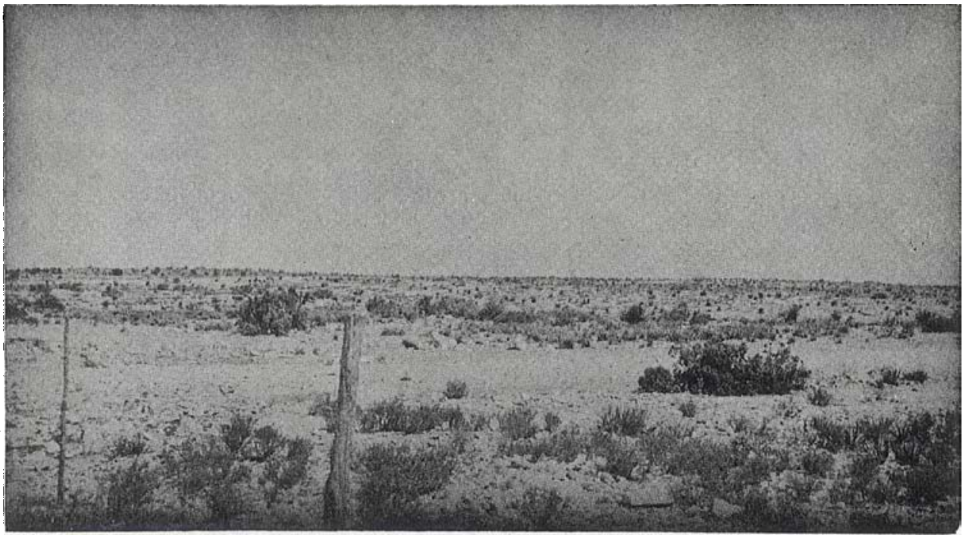

FIG. 11. Rocky upland surface, west of Del Rio, with a sparse covering of low shrubs and bunchgrass. Compare the vegetation in this area with that of East Texas where the normal rainfall is much greater (fig. 8) and with the Coastal Prairie (fig. 7).

tus, and many dry-soil grasses are prevalent (figs. 9 and 10).

The western end of the Gulf Coastal Plain grades without marked contrast into the southern end of the Trans-Pecos Plain; in the Del Rio area, the elevation is up to 1,000 feet and the rainfall is about 20 inches annually (Pl. I). The surface includes wide rocky plains and rolling ridges, many of which are covered with gravel that sustains chaparral growths and bunchgrass much more widely spaced than in the area along the Nueces River (fig. 11).

Black and Grand Prairies.—In Northeast Texas, generally north and west of the East Texas timbered areas, are the Black and Grand Prairies, a southwest-trending belt averaging about 65 miles wide and 275 miles long (Pl. I). Although the area is termed a prairie, the region is not void of trees as the streams are often fringed with timber and occasional clumps of live oaks or other hardwood varieties occur. The Black Prairie has a gentle undulating surface characterized by deep, black, waxy fertile soil like that exposed in the vicinity of Waco and Dallas. The soil is derived from the decomposition of Cretaceous marl (fig. 21) that dips beneath the Tertiary rocks of the East Texas Coastal Plain. Although there is no marked topographic change at the border (contact) between the Cretaceous and Tertiary strata, the vegetation and soils are distinctly different. The East Texas timbered belt ends quite abruptly with the beginning of the thick Black Prairie soils which are lime-rich, as contrasted with the thin, lime-deficient red clay and sandy soils of the East Texas Coastal Plain.

The Cretaceous rocks under the Grand Prairie are more resistant to erosion and cause the area to be more plateau-like than the Black Prairie (Pl. I). The effects of weathering and erosion upon the harder limestone leaves rocky ledges and as a result, the cultivated fields are smaller and have more irregular shape; the soils, although mostly black and lime-rich, are thinner. North and west of Fort Worth, where the plateau-like surface is best exposed, there is much flat or gently sloping land but numerous streams have cut into the surface. The western margin of the Grand Prairie is underlain by the Antlers Formation (table 1, pocket). Here the soil is sandy, uncultivated areas are heavily forested with oaks, and the crops are mainly peanuts, maize, and peaches. On some maps this is designated the Cross Timbers belt. Farther southwest, erosion has left many flat-topped hills and ridges as remnants of the original plateau-like surface. Beginning near Lampasas, the upper surface of the Grand Prairie begins to merge with the upper surface of the Edwards Plateau, and in some places the once continuous limestone formations are so severely eroded that it is difficult to trace them visually from one province to the other.

Edwards Plateau.—Southwest of the Grand Prairie, beginning northeast of Austin and extending somewhat south of west toward the Rio Grande, is a conspicuous escarpment forming the southern boundary of the Edwards Plateau (Pl. I). The escarpment is the result of displacement (faulting) in the rocks of the earth's crust and this line of fracturing is called the Balcones fault zone; the ridge is called the Balcones Escarpment. The displacement is not along a single fault but a belt of many subparallel fractures that separate the Lower Cretaceous rock in the plateau from the younger Cretaceous and Tertiary rock that underlies the Coastal Plain (fig. 21).

The Edwards Plateau is capped by hard Cretaceous limestone formations that dip gently southeastward with a general slope that is almost parallel with the slope of the plateau's surface. The out-facing escarpment is deeply notched by erosion, and in some places isolated hills whose tops represent the old plateau surface are left standing in front of the retreating ridge.

The plateau's summit is scarred by deep, wide-bottomed box canyons. Streams including the Blanco, San Marcos, Guadalupe, Medina, Frio, and Nueces Rivers head on the plateau. Their upper drainages are generally waterless draws that suddenly deepen into box canyons that are fed by large springs, and the permanently flowing water in some of the canyons is of great beauty. Southeast of the Balcones Escarpment, however, the same river valleys are entirely changed, for on the Coastal Plain the river canyons are only slightly indented, there are no steep-walled canyons, and some of the rivers flow only following heavy rainfall.

The rocks, rainfall, and elevation of the Edwards Plateau affect the soils and vegetation. Along the large streams, the vegetation varies from heavy deciduous forests in the lower valley bottoms to sparse and stunted scrub oak, cedar, and chaparral on the higher slopes (fig. 12). In places the upper surface is heavily forested by oak, cedar, and mesquite. In others it is more like a prairie and where the forage is overgrazed, which is very common, the humbler forms of trees such as cedar (juniper) seize the area. When this occurs, the effect is an economic loss, for grazing is the leading industry.

As a physiographic subdivision the Edwards Plateau includes the Stockton Plateau, the mesa-land west of the Pecos River. Like the Edwards Plateau, this area is also underlain by Cretaceous limestone including some of the same formations that crop out west of Austin. The Stockton Plateau is separated from the Edwards Plateau by the 1,000-foot-deep Pecos River canyon and is terminated on the south by the Rio Grande, which cuts across the highland separating it from a similar terrain in Mexico.

Llano Estacado.—The Llano Estacado, sometimes called the Staked Plains, is the largest non-mountainous relief feature in Texas (Pl. I). The surface is as flat as any land surface found in nature and much of its surface is almost untouched by erosion (fig. 13). The flatness is the result of a building-up process by stream deposition. The streams that built the Llano Estacado headed on the east slope of the southern Rocky Mountains and flowed southeasterly toward the Gulf of Mexico. As the water currents reached the flatter land east of the mountains, the velocity of the moving water was checked, and the water began depositing its load. Each large stream built its own alluvial fan near the foot of the mountains, but farther out the fans merged into an alluvial slope, and still farther into an extensive plain. As this deposit spread and thickened, the streams and streamlets built so many bars and shoals that the currents divided; the streams shifted position and as each channel was filled, the current shifted again. Thus the stream currents not only shifted once but many times, reunited, and became entwined like the threads in a giant net that stretched from east to west across the area.

The depositional blanket that underlies the surface of the Llano Estacado varies in thickness from a few feet in some places to several tens of feet in others. The character of the gravel mantle has influenced recent drainage patterns, and present erosion is slowly reducing the size of the area and destroying its flat surface. The Canadian River, heading in the Rocky Mountains, has developed its course across the debris mantle and separates the Llano Estacado from the Great Plains

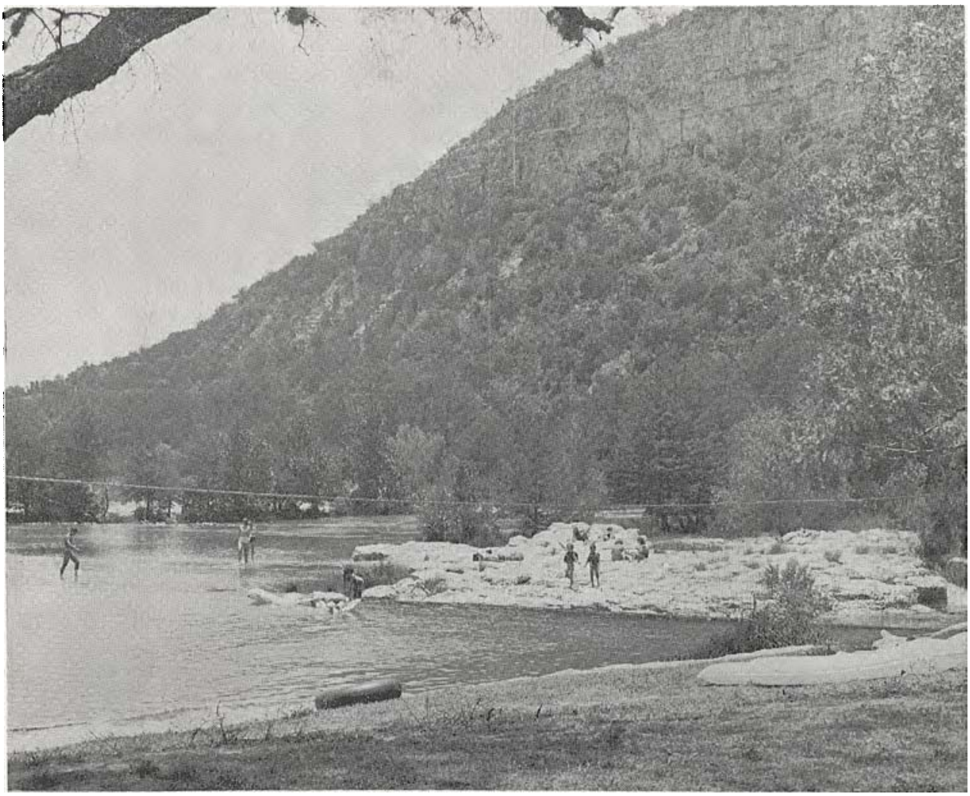

Fig. 12. The Frio River has cut a beautiful canyon into the resistant Cretaceous limestone of the Edwards Plateau. The river is fringed with trees; stunted trees and brush are found on the slopes and many of the ridge tops (not shown). (Photograph by Texas Parks and Wildlife Department.)

proper to the north. At one time, the gravel mantle extended westward to the foothills of the southern Rockies, but now the Pecos River valley separates the Llano Estacado from the western mountains. Erosion has restricted the eastern boundary, and rivers like the Red, Brazos, and Colorado have deeply notched the retreating eastern escarpment that is often referred to as the Breaks of the Plains, or sometimes locally as the Rim Rock Country (fig. 14). Only on the south side is the Llano Estacado not marked by a prominent escarpment. Here it grades without conspicuous change into the Edwards Plateau. The chief differences in the Llano Estacado—Edwards Plateau boundary area is that the gravel mantle disappears and the flattish bedrock surfaces in the Edwards Plateau are the result of erosion.

North-central Plains.—In North-central Texas, irregularly outlined by the west-facing Grand Prairie escarpment on the east and the east-facing Llano Estacado escarpment on the west, are the North-central Plains (Pl. I). The summit is that of an irregular erosion surface, cut across Paleozoic formations that were uncovered when Cretaceous rocks like those now exposed in the Grand Prairie and the Edwards Plateau were stripped from the area (fig. 15). The North-central Plains surface has variable relief that is intimately related to the resistance of the underlying rocks. Where shale prevails,

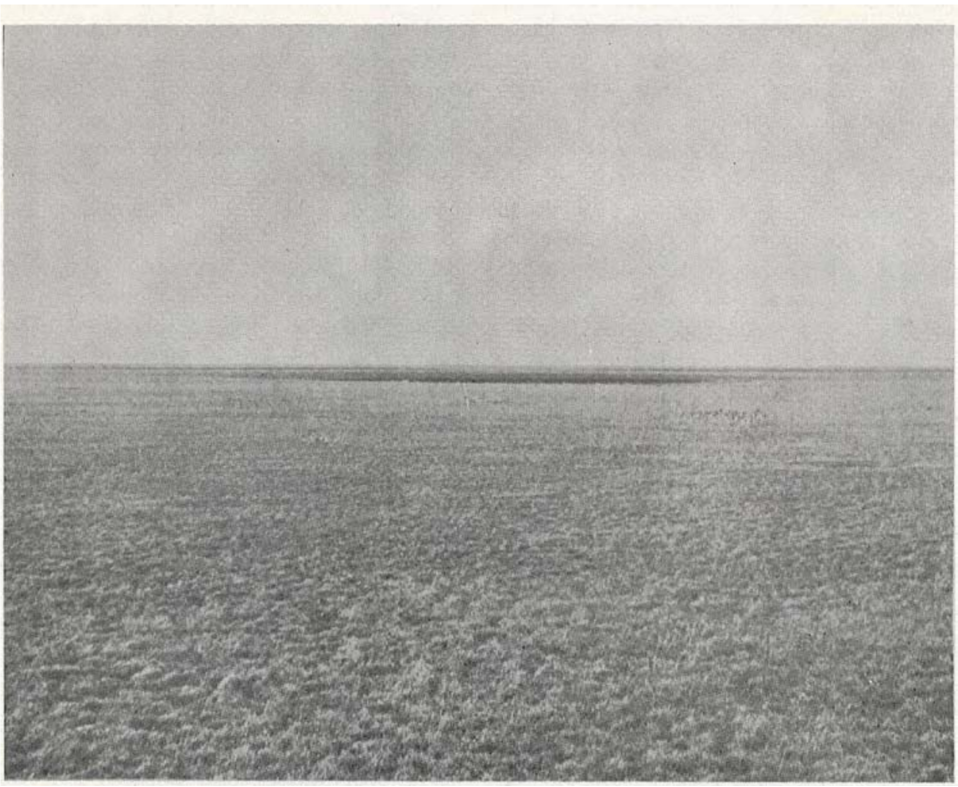

FIG. 13. Surface of the Llano Estacado, with a sinkhole lake in the background. This surface was built by streams that flowed eastward from the southern Rocky Mountains depositing their loads on a lower flattish surface that extends eastward from the mountains. In many places the Llano Estacado is untouched by erosion. (Photograph by R. T. Hill.)

there are stretches of level prairie and the rivers have low banks and make broad sweeping curves. In areas of harder rock, there are hills and rolling plains, and in some places, the surface is severely dissected and has strong relief. The Callahan Divide is a hilly belt of Cretaceous rocks that separates the watersheds of the Colorado and Brazos Rivers (Pl. I). Because of the wide variety of physical features and the difference in drainage history, the province is divisible into several sections, but only the Central Mineral Region is specifically described herein.

The Central Mineral Region (Llano area) at the southern end of the North-central Plains is strikingly different in general appearance to the other parts of the province. Its most characteristic feature is a central basin about 25 miles wide and 50 miles long. The basin has a rolling floor, studded with "mountains" that rise to heights of about 400 to 600 feet. Both the basin floor and "mountains" are among the oldest rocks in Texas (*see* pp. 22–24). Some of the granite has won fame as a building stone and was used for the construction of the State Capitol and in other State office buildings. The oldest rocks are partly surrounded by a rim, about 5 to 25 miles wide, formed by the overlying erosion-resistant Paleozoic formations that in some places rise to heights equal to the granite peaks in the basin (fig. 21). Behind the discontinuous Paleozoic rock rim is a second rim formed by Cretaceous limestone like the rock that crops out in the Edwards Plateau. The Cretaceous rock rim is more irregular than that formed by the Paleozoic formations, and in some places the Cretaceous rock extends through topographic saddles and overlaps the Precambrian formations. The overlap is most conspicuous along the southern border of the area where some of the Cretaceous rock hills rise to heights of 200 to 400 feet.

Trans-Pecos Texas.—The Trans-Pecos province, lying west of the Pecos River, is a region of mountains, plateaus, and plains that is about equally divided between the mountain-plateau areas and the plains (Pl. I). The mountains resulted from forces that elevated and deformed certain belts of rocks or by necks and plugs of molten igneous rocks that rose from below. Some mountain ranges are flanked by plateaus in which the rocks are more or less horizontal and were not severely deformed. There are also some flat-topped mesa-like elevations, great rounded domes, and deep, steep-walled canyons, some of which are popular for their scenery.

The mountains normally rise abruptly from barren rocky plains with surface elevations that average 2,000 to 4,000 feet (fig. 16). They occur as single eminences and in groups of peaks but the largest highlands are normally a series of peaks forming a mountain range. The highest of the Texas mountains, the Guadalupe Range, enters the State from New Mexico, ending about 20 miles south of the border. Guadalupe Peak, the highest point, has an elevation of 8,751 feet, and its twin peak, El Capitan, has an elevation of 8,078 feet. El Capitan's almost perpendicular face is much photographed; because of the perspective, as observed from plains below, it looks higher than Guadalupe Peak and for many years was believed to be the highest peak in Texas. Mount Livermore, in the Davis Mountains, has an elevation of 8.382 feet, Mount Emory, in the Chisos Mountains, is 7,835 feet, and there are scores of peaks having elevations above 7,000 feet.

The Trans-Pecos has diverse drainage basins and the character of its valley differs greatly with respect to length, breadth, gradient, structure, amount of rainfall received, volume of water carried, evaporation, and porosity of the surface rocks. The Rio Grande and the Pecos are the principal rivers, but there are scores of broad drainage channels that

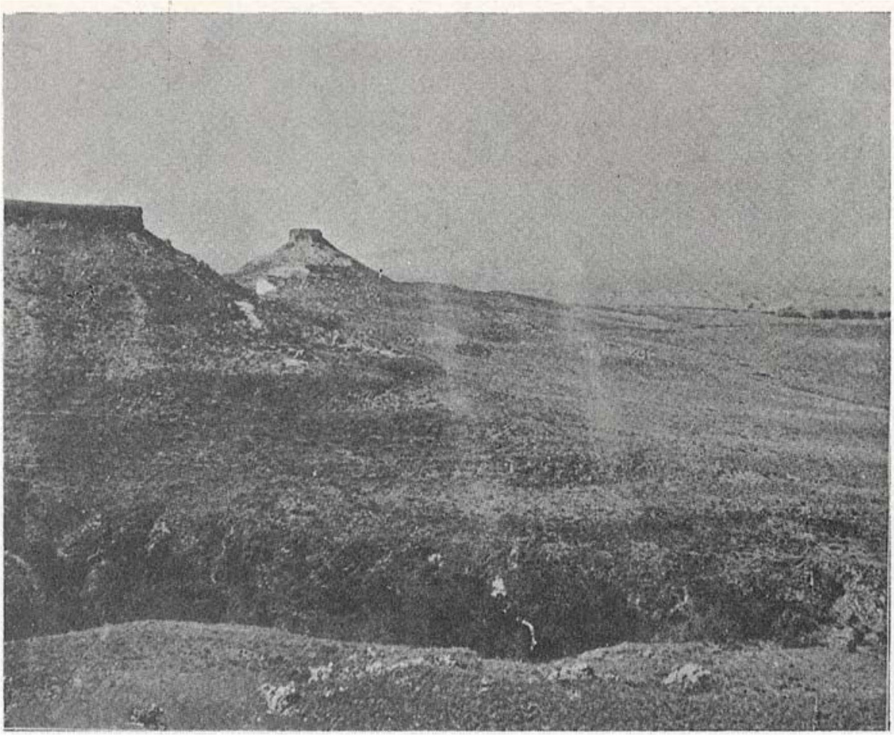

FIG. 14. Breaks of the Plains, or Rim Rock Country, where erosion has notched the retreating eastern margin of the Llano Estacado. The two flat hilltops are remnants of a once flat surface that is capped by the Ogallala Formation. (Photograph by R. T. Hill.)

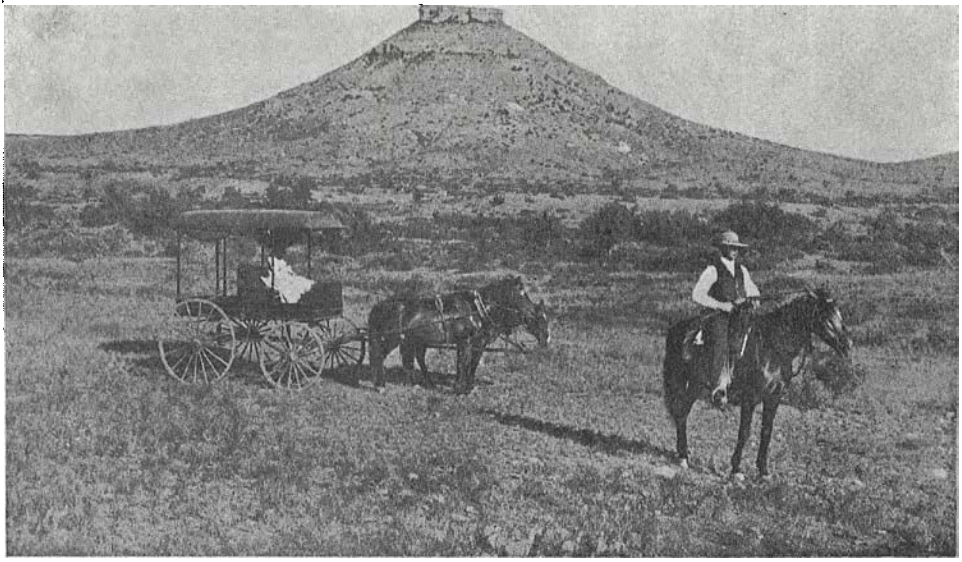

FIG. 15. Signal Peak, a hill formed of Cretaceous rocks in the Callahan Divide in Mitchell County, Texas (Pl. I). The flattish surface in the foreground is underlain by the late Paleozoic formations that underlie much of the western North-central Plains. (Photograph by R. T. Hill.)

contain running water for only a short time each year. Some of the intermittent streams drain into closed basins where the water is evaporated to form salt. Salt from the deposits in northern Hudspeth County was used by the Indians and its economic importance led to the Salt Wars. The water from other intermittent streams sinks into the loose valley-fill gravel where it is later tapped by wells and used for

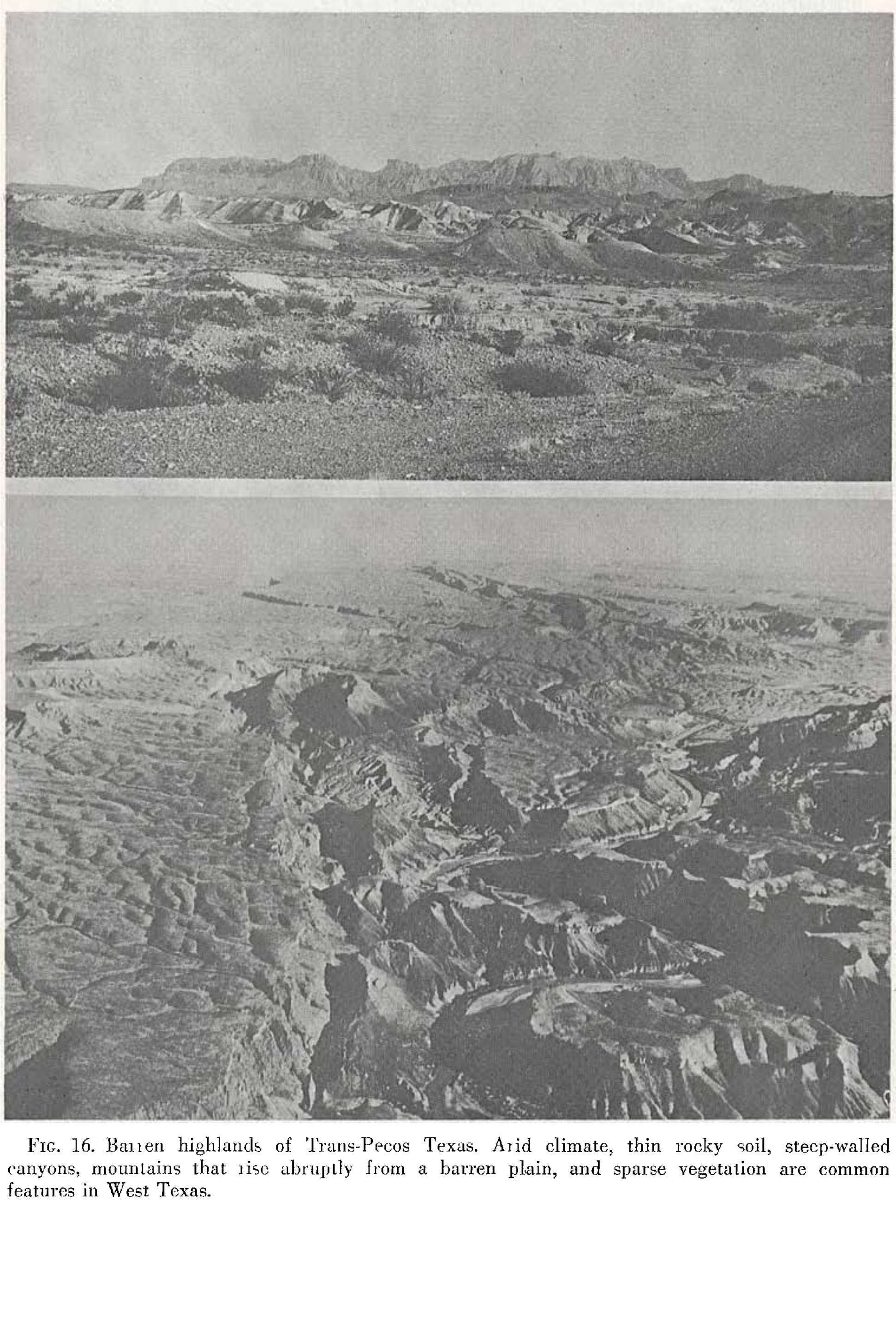

FIG. 16. Barren highlands of Trans-Pecos Texas. Arid climate, thin rocky soil, steep-walled canyons, mountains that rise abruptly from a barren plain, and sparse vegetation are common features in West Texas.

irrigation. Most areas are without vegetal or structural obstructions to the run-off and the surface is drained rapidly after each rainfall. In some places the annual precipitation is less than 10 inches and here the cacti, lechuguilla, sotol, ocotillo, century plants, and a variety of desert bunchgrasses have their greatest development. Extensive areas of barren rock slopes and ledges, steep-walled waterless canyons, rugged treeless mountain peaks, and broad gravel-filled valleys comprise most of the Trans-Pecos landscape.

GEOLOGY

Texas has two broad types of terrain: (1) mountains and (2) the plain-plateau areas. In the former, the rock layers are commonly highly deformed and in the latter, they are comparatively flat. In most places, the rock layers are extensive sheets of more or less similar rock materials that have been deposited under similar conditions and are grouped in units called formations (fig. 17).

The rocks in each formation have characteristic textures, structures, composition, solubility, and porosity. When the formation is attacked by the agencies of weathering and erosion, certain kinds of topographic features are formed. In most mountains, high plateaus, ridges, and hills, the hard rocks resist erosion and stand up above softer rocks. The flat surface of many plains and plateaus is due to an underlying caprock that is also resistant to erosion. Soluble rocks, such as limestone, gypsum, and rock salt, dissolve and form sinkholes and caverns. Soft clay weathers into rounded hills and flat plains; loose sand is heaped into dunes by the wind. Each formation not only produces a characteristic topographic relief but also its own distinctive soil type. The soil may have a high or low lime content, it may be soft and sandy or stiff and sticky, and the colors may be gray, black, red, brown or yellow. Each soil type supports a characteristic vegetation; specific plants are dominant in certain areas because of the soil's texture and composition and the amount of precipitation. In Texas there is an intimate relationship between the surface terrain, the soil, the kind of vegetation, and the underlying rock formation.

KINDS OF ROCKS

Rocks are formed when a quantity of mineral matter is brought together and deposited by some natural process or when molten rock or magma from the earth's interior crystallizes. There are three general kinds of rocks in Texas: (1) sedimentary or stratified rocks, (2) igneous rocks formed by solidification of magma, and (3) metamorphic or altered rocks (fig. 18).

Sedimentary rocks.—When small rock and mineral particles, resulting from the wasting away and decay of pre-existing rocks, are picked up and transported by running water or wind, the deposit that settles out of suspension is called sediment and the rocks formed in this manner are sedimentary rocks. Sedimentary rocks are the most common rocks in Texas and most of them were deposited in layers (stratified), one upon the other, in more or less orderly succession. Sedimentary rocks are normally grouped according to their sites of deposition, i.e., (1) marine, those formations deposited upon the marginal bottom of the sea, and (2) continental or surficial accumulations that were deposited upon land slopes or in lakes and on overflow areas along streams.

The marine rocks include the common types of sandstone, shale, and limestone and any or all of them may contain the fossil shells or shell fragments of marine life, such as oysters, clams, snails, and corals. Continental deposits also include sandstone and shale, and fresh-water limestone has been deposited in some lakes, but the fossils, if present, are land flora

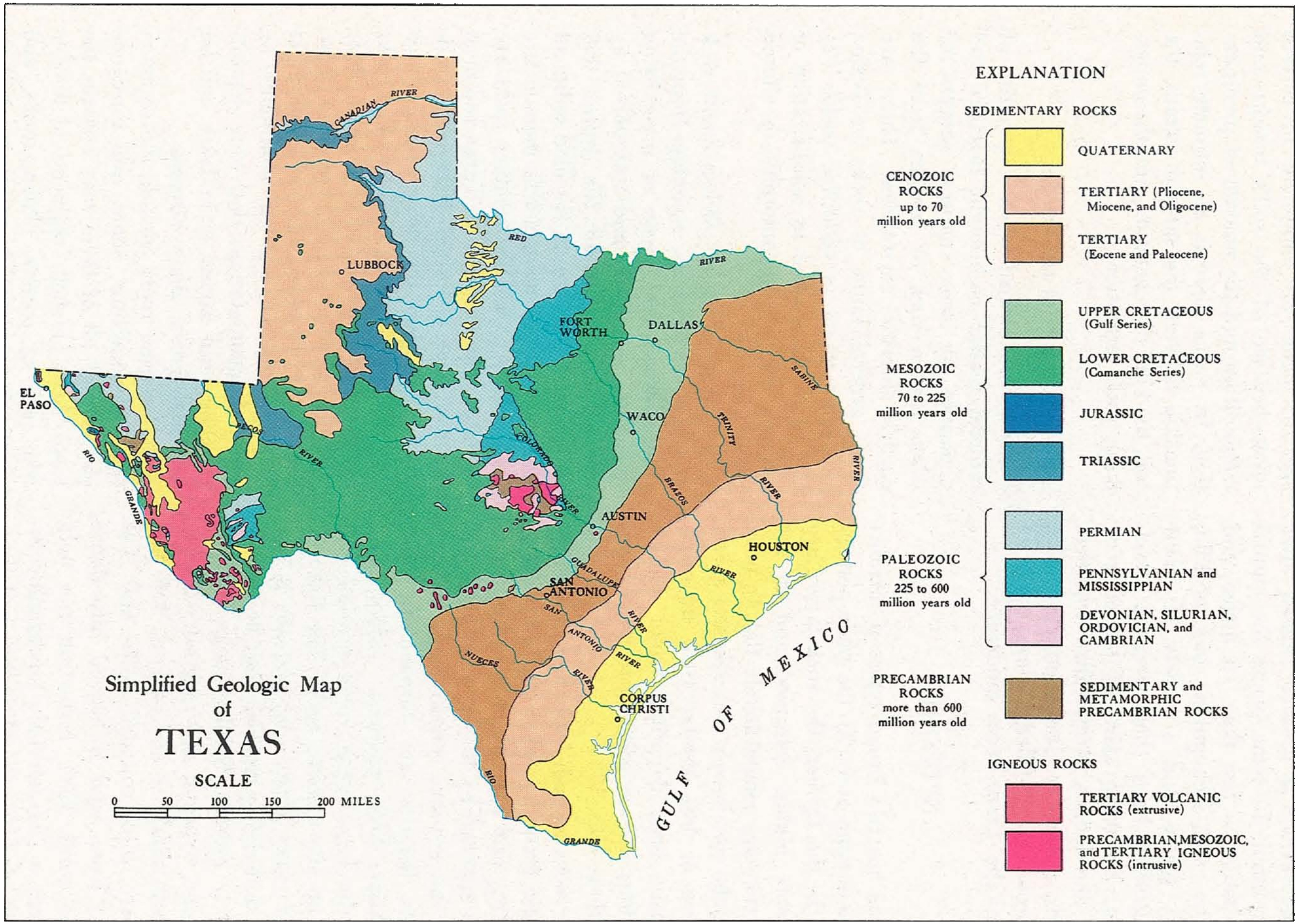

Fig. 17. Generalized geologic map of Texas.

and fauna, such as dinosaur bones, fresh-water fish and clams, tree trunks, stems and leaves, and perhaps coal.

Running water, as in streams, or turbulent water along the shore carry the finer sediment away leaving the coarse-grained materials as sand or gravel deposits. When consolidated, these deposits form sandstone, and the gravel-size pebbles conglomerate. In Texas conglomerates occur over extensive areas. Sand and gravel sheets cap the Llano Estacado; there are gravel-filled river channels in East and North-central Texas, and large gravel-filled basins occur in the Trans-Pecos. Sandstone consists largely of quartz grains that have been worn to their present size and shape, but some sandstones also contain fragments of feldspar, mica, and other minerals. The grains are held together by mineral cement and the degree of cementation determines the hardness of the rock. The most common cementing materials are calcium carbonate, iron oxide, silica, and in rare cases, pyrite. Most sandstones are porous and are important reservoir rocks for water, oil, and gas.

The finer mineral grains eventually settle to the bottom of the water forming clay or mud. Compaction converts the clay or mud to a soft plastic mass, and eventually the weight of the overlying sediments hardens the mud or clay, converting it to mudstone or shale. Some clays and shales

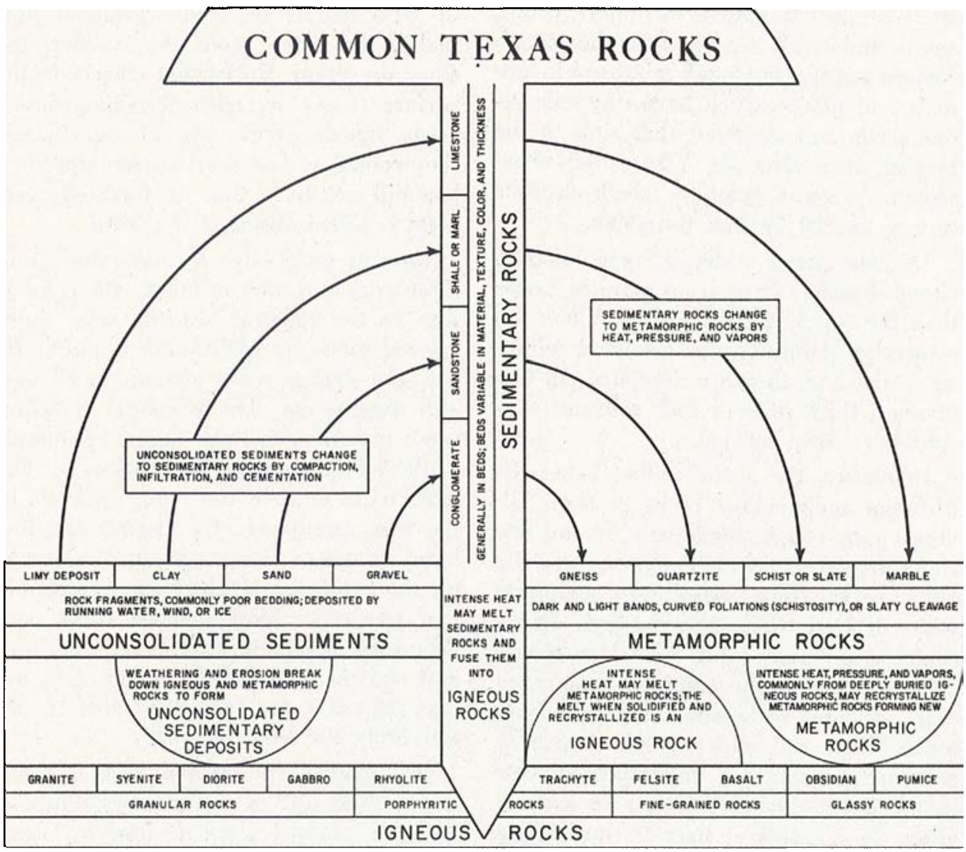

FIG. 18. Sketch showing the relationships of the three general kinds of Texas rocks.

contain fine quartz grains but most of the clay minerals are soft aluminum silicates derived from feldspar, hornblende, mica, and the insoluble residue of limestone. Some clays contain a high percentage of calcium carbonate and effervesce when hydrochloric acid is applied; such deposits are called marl, and marl is a common rock in some parts of Texas.

Limestone is a rock composed chiefly of the carbonate of lime. Most limestones contain impurities including clay, fine sand grains, and various forms of iron oxide. The impurities normally give the rock a gray, yellow, orange, red, or black color. Some limestones are chemical precipitates; others are made of the accumulated tests of lime-secreting animals. Some limestones (coquina) consist almost entirely of shell fragments of oysters, clams, snails, and corals. On and near the ocean's surface are myriad small microscopic animals and plants which have tiny calcareous shells and skeletons that sink to the bottom when they die. Where they accumulate in great numbers, chalk deposits form a special kind of limestone.

In some places water is impounded in closed basins where it evaporates faster than the supply is replenished. When the saturation point for the dissolved minerals is reached, they are deposited. In this manner, thick beds of rock salt and gypsum have been formed.

In nature, the agencies that cause the different sedimentary rocks to form seldom operate as a simple process and few rocks are pure. This is partly because the older rocks from which the sediments were derived were also impure. Many shales are sandy and most sandstones contain some of the common shale minerals, calcium carbonate, and shell fragments. Rock salt and gypsum frequently contain layers of clay indicating currents in the basin during the time of evaporation. In practice, it may be misleading to regard some rocks as belonging strictly to one group for there may be two or more mineral ingredients mingled in nearly equal parts; some of the qualifying terms often used are sandy shale, calcareous sandstone, or argillaceous (clayey) limestone.

Igneous rocks.—Igneous rocks are those formed by the cooling of melted mineral matter. They may cool on the earth's surface (lavas or extrusions) or at great depths (intrusions). Extrusive rocks are common near volcanoes and include the lava flows and fragmental material ejected at the surface. Intrusive igneous rocks commonly fill cracks and fissures at shallow depths, but some of the largest masses cooled far below the earth's surface.

The grain size in igneous rocks is variable. The masses that cooled slowly at great depths are coarse grained. Normally, the more rapid the cooling, the finer the grain. Rocks that cooled on the surface (lava) are normally fine grained. Some igneous rocks are glassy because they cooled so fast that the mineral crystals did not have time to form. Natural glass is called obsidian or perlite.

Igneous rocks have a color range from light gray and pink to black; the color is due to the mineral content. The light-colored rocks are high in silica and alumina, the darker rocks contain more iron and magnesium. The principal light-colored minerals include quartz, minerals of the feldspar group, and muscovite. The dark rocks contain the basic minerals in the mica group, chiefly biotite, and two large groups of iron-magnesium minerals, the most common of which are hornblende and pyroxene. Most igneous rocks contain a few opaque ore minerals. The mineral content of the rock and to some extent the color are important aids in determining the kind of rock.

One example of igneous rock is granite, a rock with a coarse crystalline or granular texture (cooled slowly). Granite crops out in the Llano area and was used to construct the State Capitol and other State buildings. Granite contains the minerals quartz, feldspar, hornblende, mica, and small amounts of several other minerals. The quartz normally looks like transparent glass granules in the aggregate with other minerals. The feldspar is commonly pink or gray and gives the predominant color tint to the rock. The feldspar cleaves (breaks) along smooth surfaces that are not rough and hackly as is the quartz. The hornblende is greenish black and quite hard. Mica may be either white or black and is easily recognized by its thin scaly layers.

Rhyolite is a common rock in West Texas, occurring in both extrusions and intrusions. It is often gray, pink, or brown, is fine grained (cooled rapidly), and has a chemical composition similar to granite, but because of the small grain size it is difficult to recognize the individual minerals with the unaided eye. Some rhyolites have large crystals, called phenocrysts, scattered through a fine-grained or glassy groundmass. There are many dark, fine-grained igneous rocks in

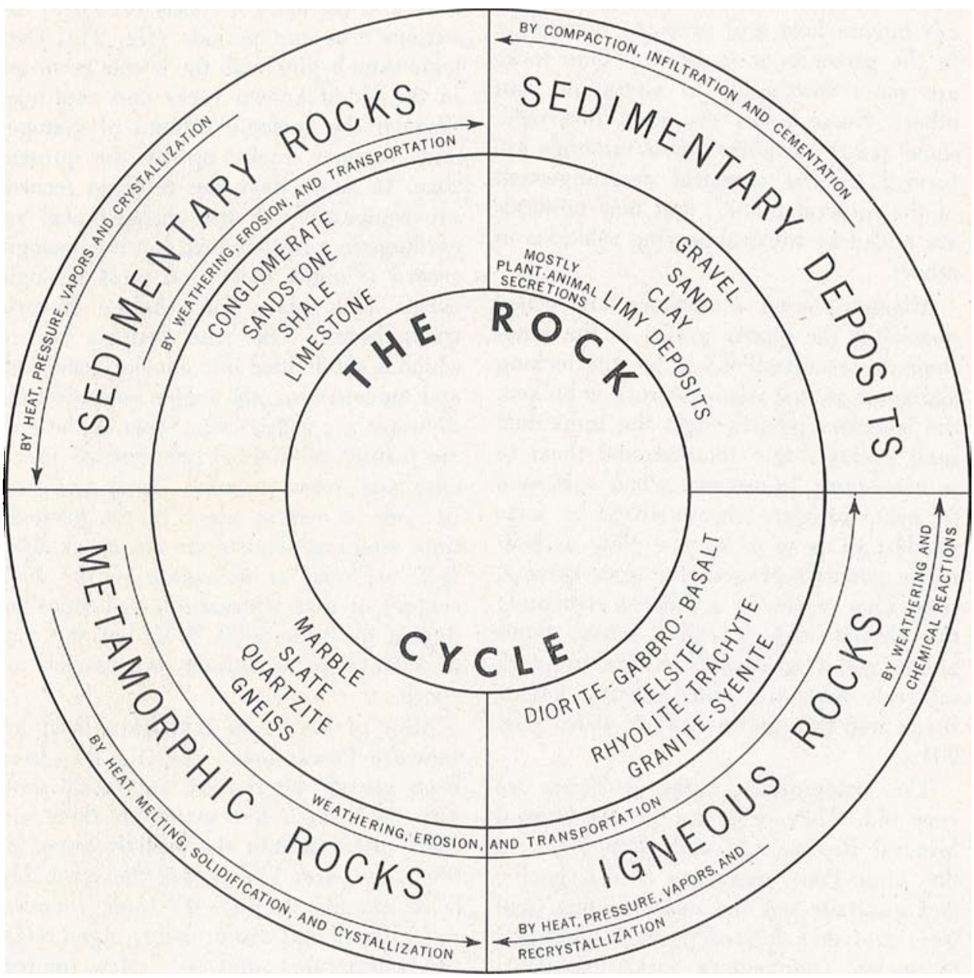

FIG. 19.The Rock Cycle, illustrating how chemical and physical processes may change the rocks.

West Texas that are commonly classified under the general term basalt; there are also some natural glasses, mostly perlite and obsidian. Most of the igneous rock bodies in West Texas are lava or small intrusions. They cooled relatively fast and the individual mineral grains are normally small. Although some of them are similar in composition to granite, they do not look like granite, mainly because they cooled too rapidly for large crystals to form.

Metamorphic rocks. — Metamorphic rocks are derived by alteration in the solid state of either sedimentary or igneous rocks (fig. 19). The principal agents are intense heat and pressure, commonly in the presence of moisture. Some rocks are more susceptible to alteration than others. Some rocks are only hardened. some are recrystallized, new minerals are formed by the chemical rearrangement of the mineral matter, and new minerals are added by mineral-bearing solutions in others.

Metamorphosed sandstones are called quartzite; the quartz grains in the sandstone are recrystallized in an interlocking aggregate so that when the rock is broken, the fractures pass through the individual sand grains rather than around them as in sandstone. Limestone, when subjected to heat, pressure recrystallizes to form marble. In some rocks new platy or prismatic minerals grow in the same orientation. This results in a foliated structure; the altered rock is called schist. Some altered rocks have bands of light and dark minerals and are called gneiss. Others break into thin plates and are slates (fig. 20).

The metamorphic rocks in Texas are very old. They crop out in the Central Mineral Region and near Van Horn in the Trans-Pecos province. Schist, gneiss, and quartzite are the most common and were probably derived through alteration of ancient sedimentary rocks. Metamorphic rocks, with variable degrees of alteration, have been encountered at depths in some oil wells. There is some degree of metamorphism beneath the lava flows and in rocks adjacent to the intrusive masses in West Texas. These alterations are relatively young as compared with the age of the metamorphic rocks in the Llano and Van Horn areas. Most of these changes are increases in hardness due to the baking effect of the hot molten rock.

GEOLOGIC TIME SCALE

The geologic time scale is a graphic chart showing subdivisions of geologic time and the ages of rocks formed in the various eras and periods (fig. 21). Geologic time begins with the events recorded in the oldest known rocks and continues through the geologic column of younger and younger rocks up to the present time. In some ways the geologic records are comparable to the chronological recordings in a history text, but the geologic record is much older and most geologic events took place long before historic times began. Like the historic record which is subdivided into ancient, medieval, and modern eras, the major geologic time divisions are called eras. Some of the eras are further subdivided into systems (periods) and series (epochs). Each rock unit fits into a certain place in the geologic time scale; geologists do not speak of a rock or fossil as belonging to the 17th century or that a formation was deposited during the year 5000 B. C. but say that it belongs in a certain era, series, or epoch.

Most of the rocks that have been assigned a Precambrian age (fig. 21) have been greatly altered by heat and pressure. Only in a few places do these ancient rocks contain the earliest traces of life. These are: (1) carbon that probably is of organic origin, (2) some rounded rock masses that are probably algae reefs, (3) worm tubes, and (4) a few impressions of jellyfish-like animals. Recent stud-

SEDIMENTARY ROCKS		METAMORPHIC ROCKS	
Loose	Compacted	Moderately	Intensely
Gravel	Conglomerate	Gneiss	Schist
Sand	Sandstone	Quartzite	Schist
Silt and clay	Shale	Slate	Schist
Lime deposits	Limestone	Fine-grained marble	Coarse-crystalline marble

IGNEOUS ROCKS	METAMORPHIC ROCKS	
Normal rocks	Moderately	Intensely
Fine-grained rock	Fine-grained gneiss	Schist
Coarse-grained rock (granite, etc.)	Coarse-grained gneiss	Schist

FIG. 20. Summary of metamorphic rocks.

ies have shown that the duration of eras for these ancient rocks can be obtained with reasonable accuracy by studying the amount of decay of certain radioactive elements found in them. This helps geologists to determine the age relationships and place the rock units in chronological order. In some places, however, it is like reading one of the ancient scrolls—we do not clearly understand all that we see. Rocks belonging to the Precambrian in Texas crop out in the Llano and Van Horn areas. The ancient rocks are also found in the bottom of Grand Canyon, the Black Hills, Lake Superior—Hudson Bay region, and other parts of North America.

Fossils are the common tool used to place rock units in their proper chronological position for the three younger eras of geologic time. With the beginning of the Paleozoic Era (fig. 21), some of the animals developed shells or other hard parts, resulting in better preservation, and it was at this time that a continuous fossil record began. The animals included floating and crawling creatures in the sea, flying creatures in the air, and dinosaurs and mammals on land. Plants included trees, shrubs, cereals, and flowering plants on land. Most of the many forms of life lived only during a part of geologic time before becoming extinct. These were replaced by a new and different life form. A few creatures were able to change, became adapted to a changing environment, and extended their fossil records through many periods. By recognizing the fossil types, geologists are able to place most fossiliferous rocks in their proper chronological sequence.

In most places there are many breaks in the record of geologic time. The breaks occur where all the rock units are not present in a certain area. This may be because the surface was above the sea and all the rocks were not deposited, or if all were deposited some of them were removed by later erosion. These breaks are comparable to a missing chapter, or the absence of a few pages from a history text. In order to read the complete story one has to get another book. The geologist may have to study the rock records in another State or perhaps a different continent before he can complete the

ERA	SYSTEM or PERIOD	EPOCH	AGE (Millions of Years Ago)
CENOZOIC	QUATERNARY	RECENT	
		PLEISTOCENE	1
	TERTIARY	PLIOCENE	12
		MIOCENE	25
		OLIGOCENE	36
		EOCENE	60
		PALEOCENE	63
MESOZOIC	CRETACEOUS	GULFIAN	135
		COMANCHEAN	
	JURASSIC		181
	TRIASSIC		230
PALEOZOIC	PERMIAN		280
	PENNSYLVANIAN		310
	MISSISSIPPIAN		345
	DEVONIAN		405
	SILURIAN		425
	ORDOVICIAN		500
	CAMBRIAN		600
PRE-CAMBRIAN			3,000

Fig. 21. Simplified chart of geologic time.

geologic story and place all the events in proper chronological sequence. There are many breaks in the geologic records as shown by the rocks exposed in Texas, but geologists have been able to compile a reasonably complete sequence of geologic events by studying the rock outcrops in the adjacent States. An incomplete stratigraphic column of rocks exposed in Texas, oldest at the bottom, is presented as table 1 (in pocket), which also shows the position of Texas State Parks in geologic time.

THE STATE PARKS

Recreational, Scenic, and Historic Parks and Historic Sites

For convenience, the 61 parks and historic sites are discussed alphabetically. Plate I shows the location of the parks, the trunk highways, key towns, major drainage, and the physiographic provinces. A list of the parks, the nearest town, and the area's facilities are summarized in table 2. The areas that are being considered for parks under Constitutional Amendment (Section 49e) authorization are not included in this discussion.

TABLE 2. *Texas State Parks showing location and facilities.*

RECREATION PARKS	Located Near the Town of	Camping	Screened shelters	Group camp	Trailer sewer facilities	Trailer water and electricity	Rest rooms	Showers	Cabins	Picnicking	Groceries	Prepared food	Fishing	Swimming	Boats for rent	Water skiing	Boat ramp	Golf	Museum and or exhibit	Saddle horses	Historic structure	Playground
Abilene	Buffalo Gap	●	●				●	●		●		●		●								●
Atlanta	Queen City	★					●			●			★	★		★						
Balmorhea	Toyahvale	●			●	●	●	●	●	●		●		●								●
Big Spring	Big Spring						●			●												●
Blanco	Blanco	●	●				●	●		●		●	★	★								●
Bonham	Bonham	●		●			●	●		●		●	★	●			●					●
Buescher	Smithville	●	●	●			●			●			★									●
Cleburne	Cleburne	●		●	●	●	●	●		●	●		★	●	●		●					●
Copano Bay	Rockport						●			★			★	★		★	●					
Daingerfield	Daingerfield	●		●		●	●		●	●		●	★	●			●					●
Eisenhower	Denison	●	●		●	●	●	●		●		●	★	★	●	★	●					
Falcon	Falcon	●	●		●	●	●	●		●	●	●	★	★	●	★	●					
Fort Parker	Mexia	●	●	●			●	●		●		●	★	●	●	★	●					●
Garner	Concan	●	●	●			●	●	●	●	●	●	★	★								
Goose Island	Rockport	●					●	●		●			★	★			●					●
Huntsville	Huntsville	●	●		●	●	●	●		●	●	●	★	●	●		●			●		●
Inks Lake	Burnet	●	●			●	●	●		●	●	●	★	●	●	★	●	●				
Kerrville	Kerrville	●	●	●	●	●	●	●		●	●	●	★	★			●					●
Lake Brownwood	Brownwood	●	●	●			●	●	●	●	●	●	★	●		★	●					●
Lake Corpus Christi	Mathis	●	●			●	●	●		●	●		★	★	●	★	●					
Lake Whitney	Whitney	●	●	●	●	●	●	●		●	●	●	★	●	●	★	●					
Lockhart	Lockhart						●			●				●				●				●
*Mackenzie	Lubbock	★				●	●			●		●		●				●				
Martin Dies, Jr.	Woodville	●	●		●	●	●	●		●	●	●	★	★	●	★	●					●
Meridian	Meridian	●	●		●	●	●	●		●			★	●	●							●
Mother Neff	Moody	★					●	●		●			★									●
Port Lavaca Causeway	Port Lavaca						●					●	★									
Possum Kingdom	Caddo	●				●	●	●	●	●	●		★	★	●	★	●					●
Tyler	Tyler	●	●				●	●		●		●	★	●			●					
SCENIC PARKS																						
Bastrop	Bastrop	●		●	●	●	●	●	●	●			★	●				●				●
Bentsen-Rio Grande Valley	Mission	●								●			★									
Brazos Island	Brownsville	★	Undeveloped Gulf beach							●			★	★								
Caddo Lake	Karnack	●		●	●	●	●	●		●			★	★		★	●					●
Davis Mountains	Fort Davis	●			●	●	●	●	●	●		●		●					●			
Longhorn Cavern	Burnet	Daily cavern tours					●			●		●							●			
Monahans Sandhills	Monahans	★					●			●		●							●			
Palmetto	Luling	★					●			●			★									●
Palo Duro Canyon	Canyon	●					●	●		●	●	●				Summer drama				●		
HISTORIC PARKS																						
Fort Griffin	Albany	●					●			●			★	Texas Longhorn herd							●	
Goliad	Goliad						●			●			★						●		●	
Gov. Hogg Shrine	Quitman						●			●									●		●	
Indianola	Port Lavaca	★	Open bay beach							●			★	★								
Jim Hogg	Rusk						●			●												
Lyndon B. Johnson	Stonewall		Texas wildlife exhibit							●			★									
Mission Tejas	Weches	★					●			●											●	
San Jacinto Battleground	Deer Park						●			●		●							●			
Stephen F. Austin	San Felipe						●	●		●	●	●	★	●				●			●	●
Varner-Hogg Plantation	West Columbia		Guided tours				●			●									●		●	
Washington-on-the-Brazos	Washington						●			●			★						●		●	●
HISTORIC SITES																						
Acton	Granbury		Burial site of Davy Crockett's wife																			
*Alamo	San Antonio						●												●		●	
*Battleship Texas	Deer Park						●												●			
Eisenhower Birthplace	Denison						●					●							●		●	
Fannin Battleground	Fannin						●			●									●			●
Gen. Zaragoza Birthplace	Goliad			Monument only																		
Monument Hill	La Grange						●			●												●
Old Fort Parker	Groesbeck						●												●		●	
Port Isabel Lighthouse	Port Isabel																				●	
San Jose Mission	San Antonio						●												●		●	

* Facilities not operated by Texas Parks and Wildlife Department
★ Permitted but no facilities provided
● Facilities or services provided for activity

ABILENE STATE RECREATION PARK

Gus K. Eifler, Jr.

Abilene State Recreation Park (507 acres) in central Taylor County is 18 miles south-southwest of Abilene near the small community of Buffalo Gap. At Buffalo Gap on State Highway 613, a road sign indicates the way to the park on Farm Road 89.

Buffalo Gap was named for the natural pass or gap between two high flat-topped hills northeast of the park. It served as a north-south passageway for great herds of buffalo and later for the cattle drives of such pioneer cattlemen as Loving and Goodnight. The gap was probably useful in connecting trails from the north with the old Butterfield Overland Route crossing southern Taylor County. It was inevitable that an outpost should get a foothold nearby; this was Buffalo Gap, later selected as the county seat. This position was maintained until 1880, but when the Texas and Pacific Railroad was built, Abilene became the leading settlement of Taylor County.

Prior to the advent of the white man, the Tonkawa Indians inhabited the area, camping principally in the grove of tall trees along Elm Creek. Some of the older pecan trees bear Tonkawa markings. Later the Comanche Indians made camp intermittently along Elm Creek until finally pushed westward by early settlers, cattlemen, and land surveyors, all of whom feared the savage Comanche. Arrowheads and other artifacts of these Indians can still be found in the park.

In 1917, the City of Abilene acquired a large tract of land along Elm Creek to be used as the site of a storage lake needed for an additional municipal water supply. In 1933, the City deeded 507 acres of this land to the State of Texas for use as a park. Later it gave 40 acres to the Boy Scouts of America who named their tract Camp Tonkawa. In the middle 1930's, the Civilian Conservation Corps built a swimming pool, a concessions and administration building, of native red Permian sandstone, and minor structures. The Corps also cleared passages for park roads, trails, and nature paths.

From the earliest pioneer days this wooded area was used for reunions and later for camping and picnicking. Facilities for extensive outings have been modernized by the installation of concrete tables and fireplaces, together with water, electricity, and plumbing. Although no cabins are available in which to spend the night, there are screened shelters which facilitate overnight camping and trailers are also permitted. For entertainment, one can enjoy the playground equipment, the 100,000-gallon swimming pool, or the large dance terrace. Adjoining the park on the west is Lake Abilene, the municipal reservoir covering 675 acres. Here are opportunities for boating and fishing on a day basis.

Except for scattered hills, the country is a prairie grassland; a grove of large trees provides a shady place for rest and entertainment. At one time there were about 4,000 pecan trees, but they are not so abundant today. These, together with the live-oaks, dominate this small forest. In addition, there are cedar, post-oak, mesquite, and hackberry trees. Underbrush is thick but has been cleared in some places. Among the native animals the squirrel and armadillo are the most abundant, but there are also coon, coyote, bobcat, skunk, and deer.

The region is part of the Callahan Divide (Pl. I). This physiographic province is composed of rolling lowlands from which numerous buttes and mesas rise to a height of 400 feet. One of the most conspicuous of them is Big Chief Mountain overlooking the park; in the early days it was a landmark for the Indian scout, trail driver, and land surveyor.

Beds of Comanchean (Lower Cretaceous) limestone cap the hills of the Callahan Divide (table 1). This limestone was once a continuous body extending eastward across North-central Texas and westward into the Llano Estacado. Under semi-arid climate, limestone is resistant to erosion and here it has protected the underlying soft sand and shale to form steep-sided remnants of erosion.

The lowlands are underlain by marine Permian red beds, outcrops of which can be seen in the park. These beds are composed of thick shale, silt, and sandstone interbedded with thin limestone, dolomite, and gypsum. These rocks, up to 1,200 feet thick, make up the Clear Fork Group, which in parts of the High Plains is divided into the Arroyo (oldest), Vale, and Choza Formations (table 1).

These formations dip westward into the Permian Basin of West Texas where they are represented by thick dolomite, thin limestone, and sandstone at depths of 6,000 to 7,000 feet. In this area many of the great oil fields, such as Fullerton and Goldsmith, produce from Clear Fork formations.

After the Permian sea withdrew, this region remained as land until the Cretaceous sea encroached upon it from the southeast. Thus the Permian and Cretaceous strata are separated by a great unconformity (break).

Cretaceous rocks of the Callahan Divide belong to the Trinity and Fredericksburg Groups. They are well exposed and have a thickness of about 250 to 300 feet. The Antlers Sand (Trinity) is a white quartz sand with a few beds of red clay in the middle part of the formation. At the base is a conglomerate of black and red chert and quartz pebbles. The Antlers is 100 to 125 feet thick.

The Fredericksburg Group is made up of the Walnut Formation (oldest), Comanche Peak Limestone, and Edwards Limestone. The Walnut Formation is composed of alternating beds of marl and nodular limestone grading upward in the massive limestone of the Comanche Peak. Oyster shells are relatively abundant in the Walnut Formation. The Comanche Peak is massive, nodular, chalky limestone weathering gray. In places it is very fossiliferous with well-preserved shells of oysters and other mollusks. The Walnut and Comanche Peak Formations have a total thickness of 80 to 100 feet. The Edwards is a massive, gray to cream, hard limestone capping the hills of the Callahan Divide. Like the formation in Central Texas, the limestone contains flint and an abundance of rudistid clam fossils. It ranges in thickness from 20 to 50 feet.

ACTON STATE HISTORIC SITE

Ross A. Maxwell

Acton State Historic Site, smallest unit in the State Parks system (0.006 acre), is on Farm Road 208 about 6 miles east of Granbury in Hood County. The site consists of a cemetery plot in the Acton Cemetery in which is located the grave of Elizabeth Crockett, second wife of Davy Crockett (fig. 22). The Texas Almanac (1964-1965) indicates that Davy Crockett and Mrs. Elizabeth Patton were married in Tennessee during 1815, and that Mrs. Crockett died March 2, 1860. She and her son Robert were among the earliest settlers in Hood County. The State of Texas erected a monument to the memory of Elizabeth Crockett in 1911.

The Paluxy Formation is a lenticular sandy unit in the upper Antlers Formation of Northeast Texas. It is mostly sand or a weakly indurated sandstone about 100 feet thick that crops out in the vicinity of the historic site. The formation is mostly a relatively pure quartz sand that in some places (Santa Anna, North-central Texas) is used for the manufacture of glass. Near Acton there are several beds of impure sand, some shale, and a few poorly preserved fossils.

Fig. 22. Acton. The gently sloping surface in the old cemetery illustrates the ridgetop terrain developed on the Paluxy Formation in the Grand Prairie. The oak trees are characteristic of the sandy soil along the Brazos River (Pl. I). (Photograph by Texas Parks and Wildlife Department.)

ALAMO HISTORIC SITE

Ross A. Maxwell

The Alamo is the shrine of Texas Independence and the best known historic site in the State. The battle of the Alamo was a sad and disastrous defeat for the Texas defenders, but in later conflicts when the cry "Remember the Alamo" rang out over the fields of battle, it spurred the citizen-soldiers on to a victory that eventually won for them their independence from Mexico.

The Alamo is on the San Antonio River in downtown San Antonio. The downtown section of the river bank has been landscaped. There are sidewalks, restaurants, electric fountains, outdoor theater, and other municipal improvements along the river, and the stream has been made navigable for small craft. These changes, together with the construction of large buildings and paved streets, have obliterated the surface that was present when the mission was built.

The mission San Antonio de Valero (the Alamo) was established by Father Antonio de Olivares, who by the authority of the Marquis de Valero, Viceroy of New Spain, moved the mission from the Rio Grande to the site of the present-day San Antonio in 1718. The village and presidio (fort) were located near San Pedro Spring and the mission, later called the Alamo, was established on the bank of the San Antonio River about 2 miles farther south. Father Olivares was undoubtedly impressed by the running water, fertile soil in the river terraces, abundance of timber, and the large village of friendly Indians. He brought with him soldiers, their families, horses, cattle, sheep, goats, chickens, and seed; the work of establishing a permanent settlement was begun.

The natural advantages that induced settlement at this place were the existence of a large spring (San Pedro), the fertile soil found in the river terraces, the timber that could be used for building purposes and fuel, and a mild climate. The spring formed a permanent stream in a region otherwise lacking in surface water, and the gently sloping surfaces of the river terraces were ideal for constructing an irrigation system. The mission, presidio, and village were built around the early irrigation system, and some of the present streets follow closely the ancient irrigation ditches and aqueducts.

The missionary priests' chief activities were to convert the Indians to Christianity and to bring them into the mission. The priests also taught the Indians to dig ditches through which water from the river was taken to their fields and used to irrigate their crops of grain and vegetables. They also built a stone-adobe church and small huts where the Indian converts lived. In time there was a two-story convent for the missionaries, workshops where the Indians made pottery, clothing, and tools for the mission, and a 4-acre tract with irrigated patio, all enclosed by a stone-adobe wall. This development required about 25 years as it was necessary not only to teach the Indians the ways of the Church and to farm but also to make mortar and to cut stone; the cornerstone of Mission San Antonio de Valero (Alamo) was not laid until 1744 (fig. 23).

The Mission era ended during the last decade of the 18th century and the Alamo was abandoned in 1794. The houses, farm animals, and plows that had been used at the mission were divided among the Indians living there. Only the church building and convent remained as Church property. The Alamo played its part in Mexico's war for independence from Spain and was occupied by Mexican forces until December 1835 when General Cos was defeated by Texans who captured the Alamo.

Open conflict between Texas and Mexico had raged for several months but it

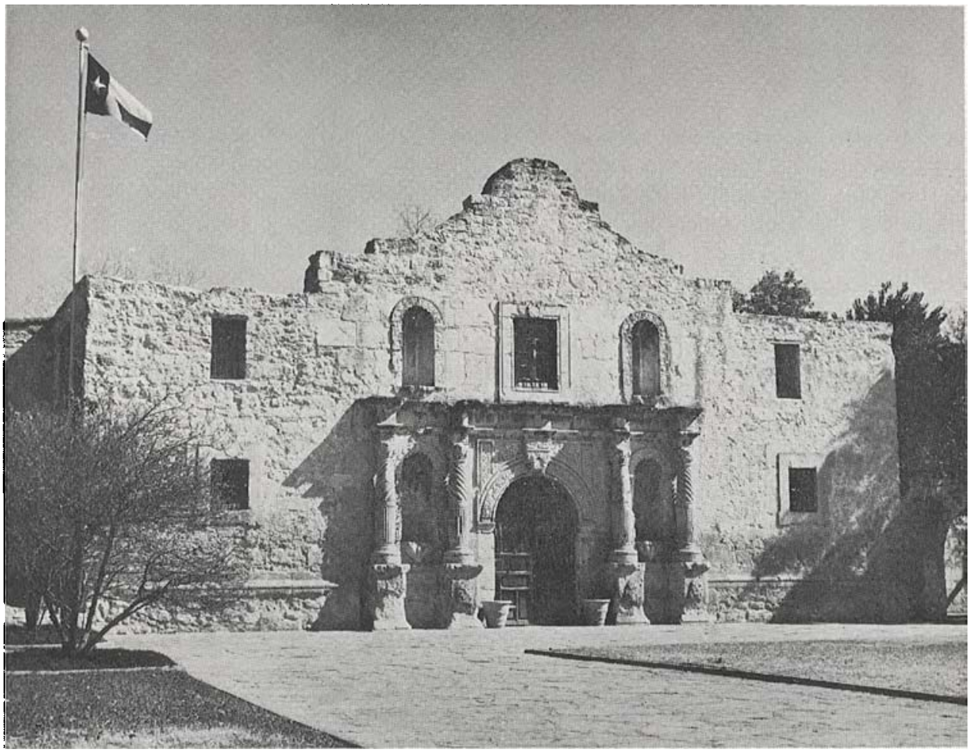

FIG. 23. The Alamo. The walls of the Alamo are now plastered and most of the rock masonry is covered. The rocks used in constructing the walls are mostly roughly hewn blocks probably from the Austin Group (table 1). Location of the original quarry is not known, but the rock looks like that now exposed in the old quarries within Brackenridge Park. (Photograph by Texas Parks and Wildlife Department.)

was not until February 23, 1836, that Santa Anna and the first of his troops entered San Antonio. The defending Texans under the command of William B. Travis and James Bowie numbered 187 men as compared with Santa Anna's army of about 5,000 men. When Santa Anna demanded surrender, the defenders answered with a cannon shot. The battle lasted for 13 days, when on March 6 the Mexican soldiers stormed the walls of the Alamo, overwhelming the defenders, who with ammunition exhausted, resorted to hand-to-hand fighting with crude weapons until all were dead.

The Alamo was neglected for many years but from 1849 to 1861 the United States used it as a supply depot; the buildings were similarly used by the Confederacy. Following the War Between the States, hay and grain were again stored at the Alamo. In 1883 the church of the Alamo was purchased by the State of Texas. In 1892, the Daughters of the Republic of Texas began a campaign to raise money to purchase the convent and the long barracks-like building northwest of the church. The project was only partially successful and the Texas Legislature appropriated the remainder of the sum, bought the property in the name of the State, and gave custody of the Alamo to the Daughters of the Republic of Texas in 1905.

The Alamo and related historic structures, as well as the downtown section of the modern city of San Antonio, were built near the upper edge of the Gulf Coastal Plain (Pl. I). A few miles north of the downtown business district is the edge of the Edwards Plateau, an area having pronounced relief, characterized by broken topography with deep, steep-walled, flat-bottomed, narrow canyons. The plateau is separated from the Coastal Plain by the Balcones Escarpment formed by a series of subparallel faults that permitted the Coastal Plain area to sink. Thus any individual formation or stratum exposed in the Edwards Plateau is about 500 to 1,000 feet beneath the surface of the Coastal Plain in downtown San Antonio.

The northern edge of the Coastal Plain has a moderate, hilly, gently rolling surface with broad, low-banked stream valleys, a conspicuous contrast to the topography of the Edwards Plateau whose erosion-frayed southern edge appears sharp as seen from the lower and more open surface of the Coastal Plain. The formations in the Coastal Plain dip, with some variation, toward the southeast, which is also the slope of the surface. This permits successively younger and younger formations to crop out in areas toward the Gulf of Mexico. The hard rock layers resist erosion, forming hills and ridges. The soft formations, being less resistant to erosion, form valleys. In addition to the principal erosion features, the ancient streams that flowed from the higher Edwards Plateau deposited a blanket of gravel on the northern edge of the Coastal Plain. As the San Antonio River developed a valley on the Coastal Plain it formed a succession of step-like terraces along its channel. The terraces are at different levels and of different ages. Some of the higher terraces, which are also the older, are strongly dissected. The lower terraces are commonly more flat and become younger near the present valley. The youngest terrace is represented by the flood-plain, commonly called bottom land, and is adjacent to the stream channel.

The Alamo was built on one of the younger terraces above flood stage and its gently sloping surface was an aid to the construction of the early irrigation system. Although the rocks beneath the surface are not now exposed, the terraces were probably cut in the Taylor Clay (table 1).

The rocks that underlie the surface are largely responsible for the soil and vegetation types. The clayey formations normally form dark to black fertile soils that in the San Antonio area were originally covered with mesquite, huisache, and other thorny brush. The sandy formations common in the hills and ridges formed a yellowish to reddish-brown sandy soil that is covered with post-oak and black-jack. The high terrace gravels were washed from the Edwards Plateau and consist largely of chert and limestone pebbles. The soil is thin, the gravel loosely consolidated, water seeps away rapidly, and crops fail during times of drought. The intermediate terraces are flat, although they also contain gravel; there is enough silt to produce good soil, and these areas are often called "second bottom." Oak, elm, pecan, ash, hackberry, and other hardwood trees are common. The flood-plain terraces are narrow bands adjacent to the river, they have fertile soil, and it was in these areas that the cottonwood (Alamo) trees once grew that gave a name to the Spanish mission.

Part of the precipitation that falls in the Edwards Plateau sinks into the ground and some of the subsurface strata are water saturated. In places where the stream channels are eroded to the saturated stratum, the water seeps from the rocks, forming springs. This condition exists in many places and has formed clear flowing springs in several of the deeper canyons. In other places the ground water from the saturated subsurface strata ascends along fractures in the Balcones fault zone forming fissure springs. Several of the fissure springs are within the limits of the modern City of San Antonio, and in other places the subsurface water stratum has been tapped by wells, several of which are artesian.

ATLANTA STATE RECREATION PARK

Ross A. Maxwell

Atlanta State Recreation Park includes 1,475 acres of land acquired by the Texas Parks and Wildlife Department from a Department of Army lease in 1954; the present lease expires in 2004 A.D. The park is on the south side of Lake Texarkana, a reservoir on the Sulphur River at the end of Farm Road 1154, which is reached via Farm Road 96 and U. S. Highway 59. It is about 12 miles northwest of Atlanta, Texas, the principal town in Cass County. The town was named for Atlanta, Georgia, former home of many of the early settlers. In the early settlement days, lumbering and farming were the chief industries; oil discoveries beginning in 1935 gave new impetus to the growth and development of the nearby towns.

The park is inadequately developed but has heavy use, especially for water sports and recreation. Water skiing, swimming, and fishing are the most popular activities. There is a boat ramp; camping, picnicking, and hiking are permitted. A grant to improve facilities at Atlanta has been approved. These include trailer campsites, tent campsites, rest rooms, sanitary dump, roads, landscaping, and utilities.

The rocks exposed in and in the immediate vicinity of Atlanta State Park belong to the Queen City and Weches Formations (table 1). Most of the rocks in the Weches Formation are ferruginous (iron-bearing) sandstone. Generally south and southeast of the park, some of the iron deposits have been included in the iron ore reserve deposits of East Texas. The Queen City Formation within the park is mostly shale.

The topography of the iron-bearing rocks forms a series of ridges, or a chain of ridges, that extend west-southwest from Bowie Hill, near Springdale, into Marion and Morris counties. They resist erosion and some of them rise 50 to 150 feet above the intervening stream valleys, which in most places are flat or gently rolling surfaces but on the Queen City Formation.

The park is along the northeast axis of the East Texas Embayment, a structural feature commonly called the East Texas Basin. In most places, the rocks are flat, but the Rodessa fault system toward the southeast has caused some variation in the normal sequence of rocks in nearby areas and variation of rock dips within the park.

Most of the iron exposed in the park is limonite (iron oxide) but some deposits are siderite (iron carbonate). There are a few fossils in the Queen City Formation. These are mostly imprints or molds of clams, oysters, and snails. Petrified wood or imprints of plant leaves and stems are also present. Fossil imprints or molds are occasionally found in the ferruginous sandstone of the Weches, but most of the fossil material has been leached from that formation.

BALMORHEA STATE RECREATION PARK

Ross A. Maxwell

Balmorhea State Recreation Park in the Trans-Pecos province (Pl. I) is at Toyahvale in southwestern Reeves County about 4 miles southwest of Balmorhea. The park is noted for its large swimming pool which incorporates the total flow of San Solomon Spring, one of the largest artesian springs in West Texas.

The park is adjacent to U. S. Highway 290, about 56 miles west of Fort Stockton. It includes 47.68 acres and is operated by the Parks and Wildlife Department through a long-time lease to the local water conservation district. The original improvements were built by the Texas State Parks Board in the 1930's during the Civilian Conservation Corps program. The National Park Service was the sponsoring Federal agency. The facilities are currently undergoing modernization and the grounds are being landscaped with trees and shrubs in preparation for year-round utilization. In addition to the swimming pool, other accommodations include cabins, small picnic area, restaurant facilities, cold drinks, and a souvenir store. The area is not only a famed watering spot but has long been popular with residents and tourists as an overnight stop for those who visit the Davis Mountains State Park, McDonald Observatory, Fort Davis National Historic Site, and nearby scenic attractions (fig. 24).

Use by the Indians of the several springs in the Balmorhea area is attested to by the many artifacts found in their camp sites. The springs were also along what was later known as the great Indian trail that led to the buffalo hunting grounds and to the salt lakes east of the Pecos River; San Solomon Spring was on the old trail used by the Comanche Indians en route to their raids into Mexico. Probably the first European to pass this way was Cabeza de Vaca, who, in about 1535, is believed to have crossed the Pecos River at either the Horsehead or Sheffield Crossings, thence traveled westward to Comanche Spring at Fort Stockton, San Solomon Spring, up Limpia Canyon, and across the Davis Mountains to Kokernot Spring near Alpine. He continued on a trail through Paisano Pass, down Alamito Creek, and up the Rio Grande to near what is now Presidio, Texas. After completing his journey into New Mexico in 1582, Antonio de Espejo traveled east to the Pecos River, thence south to the great Indian trail, and back to Presidio by a route similar to that traveled by De Vaca. Captain Juan Dominguez Mendoza in 1683 took this trail in reverse, traveling from the Rio Grandevia (Rio Grande) to the great Indian trail crossing the Pecos River to a site near the San Saba Mission. San Solomon Spring was also a watering place for the freight, stage, and mail services on the San Antonio—San Diego trail and a camping site for the Army, early law enforcement groups, immigrants, and outlaws.

The earliest farmers were of Mexican descent, who built irrigation ditches to provide water for their fields. Daniel Murphy was probably the first Anglo-American settler who started farming the Toyah Creek valley in 1871. The thriving farming community of Balmorhea dates back to 1906 when three land developers named Balcolm, Morrow, and Rhea acquired a 14,000-acre land tract which they irrigated with the water from San Solomon Spring. Parts of each of the developers' surnames were combined (Bal-Mo-Rhea) to give the town its name.

The surface in the immediate vicinity of the park is part of a gently sloping plain at the northeastern foot of the Davis and Barrilla Mountains (fig. 24). Streams flowing from the mountains de-

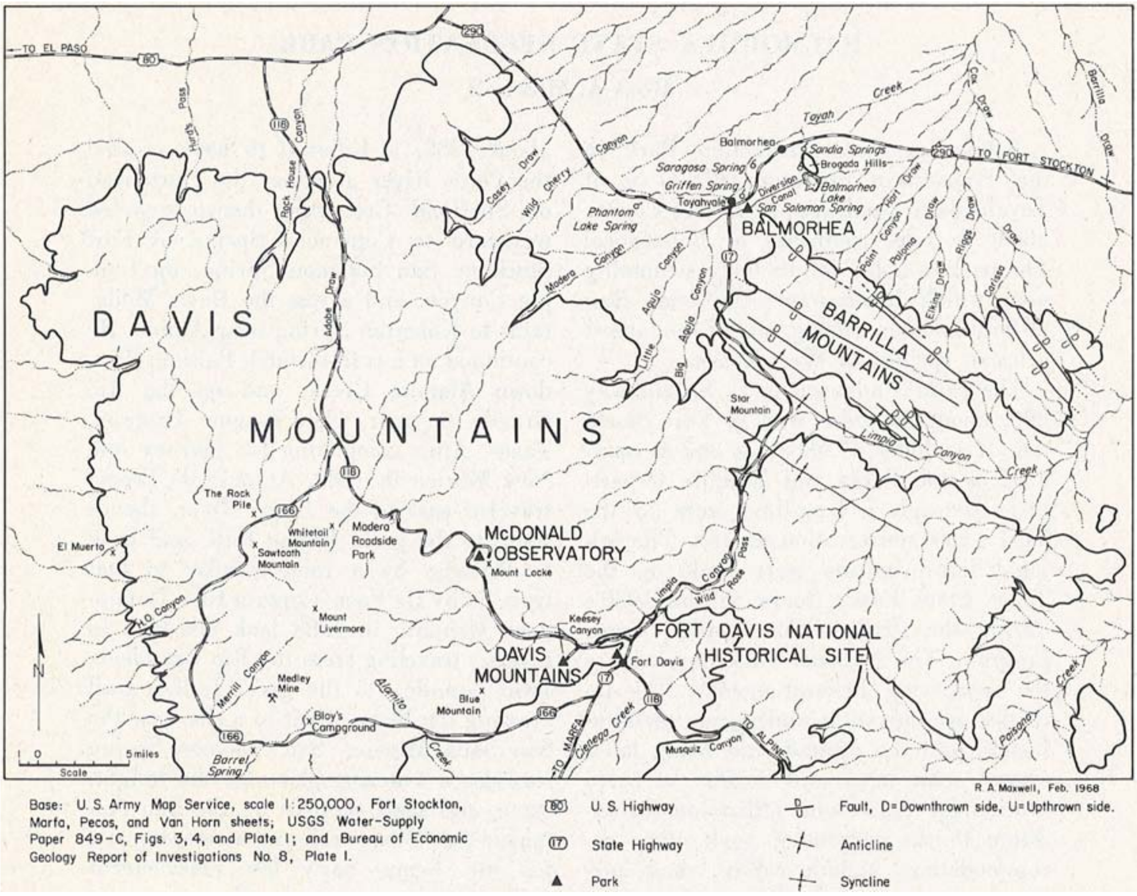

FIG. 24. Geography of the northern Davis Mountains region with sketch of some faults and folds in Barrilla Mountains area. (In lower left-hand corner of map, Barrel Spring should read Barrel Springs.)

posited a blanket of alluvium covering most of the bedrock and formed the flat plain surface which has an average elevation of about 3,200 feet. The northwest-trending Davis—Barrilla Mountains front, southwest of the park, owes its eminence to deformation of the rocks and their resistance to erosion. Some of the precipitous flattish-topped peaks rise to altitudes of about 2,000 feet above the plain, and in the mountains farther west some peaks have an elevation of more than 7,500 feet. The plain's surface between the mountain front and Balmorhea is broken by several fault ridge blocks, groups of hills, and isolated hills. These include a ridge extending northwestward from the Barrilla Mountains almost to the park, and the Brogada Hills, a northwest-trending ridge about 3 miles long, east of Balmorhea.

The mountains and plains in the vicinity of the park are drained by Toyah Creek, formed about 6 miles southwest of Balmorhea by the junction of streams flowing from Big Aguja, Little Aguja, and Madera Canyons in the Davis Mountains. Toyah Creek is generally dry, except in its lower course which is fed by perennial springs. The creek occasionally carries large quantities of storm water, most of which is diverted into the Reeves County Water Improvement District's reservoir near Balmorhea and used for irrigation. During the heaviest floods, part of the water by-passes the reservoir and this fraction either sinks into the gravel deposit that blankets the plain or empties into Toyah Lake about 30 miles toward the northeast. The adjacent area north of Toyah Creek is drained by a stream flowing from Cherry Canyon and the area south is drained by Limpia Creek. Both streams occasionally carry large volumes of flood water and both have perennial flow in the Davis Mountains, but most of the water is lost into the gravel deposits after reaching the foothills and the adjacent plain.

Only alluvium is exposed at Balmorhea State Park. In order to determine the formation that probably underlies the alluvium, it is necessary to make observations in the surrounding area. Lower Cretaceous formations crop out locally along some of the canyons on the northeast slope of the Davis Mountains, but more complete sections are exposed near Hovey along the flank of the Glass Mountains about 35 miles toward the southeast and near Kent, about 30 miles to the northwest. In both of the latter areas, most of the formations exposed belong to the Fredericksburg and Washita Groups of the Comanchean (table 1). The basal unit is sandstone that in some places contains gravel. This is overlain by thick-bedded, jointed, cavernous, fossiliferous limestone that in the outcrop area weathers craggy, or to solution-rounded ledges forming low, rolling hilly topography. The thickness of the Lower Cretaceous rocks in the vicinity of the park is believed to be about 500 feet. They overlie older formations, and drill cuttings collected from oil wells indicate the rock units belong to the Triassic and Permian; Jurassic-age rocks are absent (table 1).

The Upper Cretaceous formations are mostly of clayey composition but they include some limestone beds near the base. The limestone layers belong to the Eagle Ford and Austin Groups; they rest on the Buda (table 1). The limestone is commonly thin, flaggy, and has hard layers that when freshly broken are white but weather to noticeably rusty red or yellow; most hillsides underlain by these rocks are densely covered by slabs of the flaggy debris. The limestone is suitable for masonry construction and was used in the swimming pool walls, walks, terraces, cabin floors, and other construction (fig. 25).

Above the lower Upper Cretaceous limestone is a considerable thickness of clay that when encountered in wells below the depth of weathering is described by the drillers as "blue mud." On the surface, however, most weathered exposures are yellow or ochre, and since the clay is weakly resistant to erosion, it forms featureless valleys and is commonly covered by overwash debris.

Following deposition of the Upper Cretaceous rock, the earth's surface was elevated, the sea withdrew, and the newly deposited formations were eroded. Early in the Tertiary, volcanic rocks having an aggregate thickness of 1,500 to 1,700 feet were deposited upon the irregular Upper Cretaceous surface. The volcanic formations were probably originally spread beyond their present outcrop area but later erosion removed them from some parts and now they are found only in the Davis—Barrilla Mountains, the foothill slopes, and the adjacent ridges and hills. They occur in a succession of five lava units alternating with five tuff (indurated volcanic ash) units that Eifler (1951) named the McCutcheon Volcanic Series. The lava units are predominantly of acid composition and are called rhyolite and trachyte. Presumably the lava erupted from fissures; being quite fluid, it spread over extensive flat surfaces, giving individual flows fairly uniform thickness and lithological characteristics. The tuff units are not all indurated volcanic ash as the name implies, for some of them also contain layers of sandstone, conglomerate, and breccia (a mass of angular volcanic rock fragments in a matrix of tuff or lava), and in some places there is fresh-water

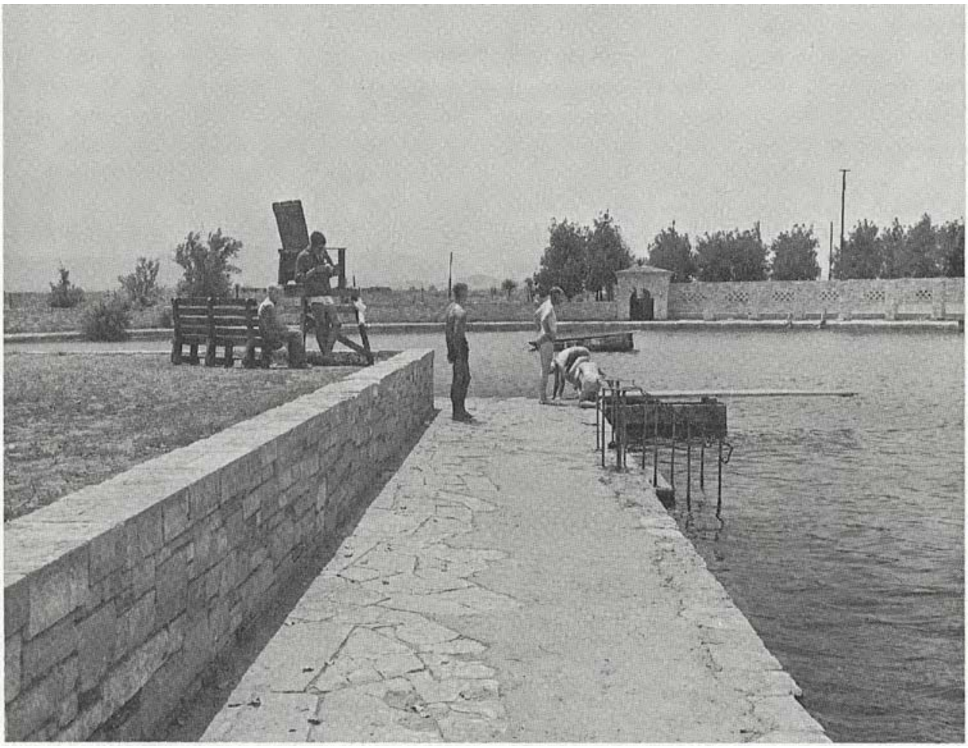

FIG. 25. The Balmorhea swimming pool which incorporates the total flow of San Solomon Spring. The spring was used by the Indians and frontiersmen and later for irrigation. Prior to the building of the masonry walls and walks of native Boquillas Flagstone, the water issued from a large swamp. (Photograph by Texas Parks and Wildlife Department.)

limestone. Some of the volcanic rocks are exceedingly porous because of the joints and fractures, and some layers are filled with natural cavities because of the slaggy character of the rocks.

The rock exposures southwest of the park show that the strata were deformed by broad northwest-trending folds and broken by generally paralleling faults. The most conspicuous fold is a syncline (downfold) that separates the Barrilla Mountains (which are actually a northeastward outlier of the larger Davis Mountains) from the Davis Mountains to the west (fig. 24). State Highway 17 (park to Fort Davis) after entering the mountains bears southeast along the upper Toyah Creek drainage for a few miles and is near the trough of the syncline. Northwest of the syncline is a prominent anticline (arch), the crest of which is exposed in the eastern edge of the Davis Mountains with its crest passing through Star Mountain, the highest peak in that area. A second anticline passes along the top of the Barrilla Mountains a short distance northeast of the syncline. The principal faults are along the top of the Barrilla Mountains. They have broken the rocks into linear blocks and most of the segments have been stepped down northeast toward the park. Thus each successive block is lowered toward the plain and most of the bedrock in the lowest segments is covered by an alluvial blanket similar to that exposed near the park. As the faults are traced northwestward, several of them pass beneath the alluvium and are not exposed.

The permeability of rocks and the geologic structure are the controlling factors that determine the movement of ground water and the existence and location of springs. The Lower Cretaceous limestone contains a network of fissures and solution cavities through which the ground water moves. As water moves to lower levels, the porosity becomes saturated and hydrostatic pressure is developed. The Upper Cretaceous rocks on the whole are relatively impermeable and serve as an effective confining layer for aiding the development of hydrostatic pressure in the Lower Cretaceous strata. In areas where the Upper Cretaceous formations have been down-dropped by faults and lie against the faulted ends of the Lower Cretaceous rocks, the former strata may act as a barrier causing the ground water to rise along the fault and emerge at the surface as an artesian spring. It appears that Phantom Lake Spring, west-southwest of Balmorhea, San Solomon Spring in the park, and nearby Griffin Spring were formed in this manner.

The extensive gravel deposits that blanket most of the plain surrounding Balmorhea and the tongues of stream and terrace gravels that extend for some distance into the mountains serve both as reservoir and conduit rocks. The water that falls on them may descend until it reaches an impermeable layer, which in the Balmorhea area may be one of the tuff layers in the volcanic rocks or the Upper Cretaceous clay. The ground water will then move along the top of the impermeable bed until it reaches a natural outlet, normally where streams have eroded to the level of the water table (saturated zone), forming a gravity spring. Some of the better known gravity springs near Balmorhea are Saragosa, West Sandia, East Sandia, and the springs along Toyah Creek.

The principal intake area for the artesian springs flow at Balmorhea is probably in the folded belt adjacent to the northeastern front of the Davis Mountains. Here the eroded edges of the permeable Lower Cretaceous rocks crop out or lie at shallow depths beneath a mantle of gravel. The honeycombed and cavernous members of the limestone absorb and store a large part of the local rainfall, and the streams that flow from Madera, Big Aguja, Little Aguja, and Cherry Canyons in the Davis Mountains, west or southwest of the park, lose heavily of their runoff volume between the canyon mouths and the downstream border of the anticline. Limpia Creek, about 20 miles southwest of Balmorhea, furnishes considerable recharge water during storms, and during low runoff stages most of the water disappears into the bedrock.

The best clue to the geologic structure controlling the location of San Solomon Spring is found along the southwest side of the lava-capped range of hills that extends from the Barrilla Mountains into the valley about 1 mile east of the springs. A probable fault, down-dropped to the northeast, is exposed in the ridge and a narrow band of the underlying Upper Cretaceous is exposed along the drainage southwest of the fault. The fault trace, if projected northwestward beneath the alluvium, will pass about one-third of a mile northeast of San Solomon Spring. It is believed that the down-faulted block of impermeable Upper Cretaceous strata forms a barrier to the lateral ground-water movements in the Lower Cretaceous rocks. The artesian pressure caused the ground water to rise along the fault, emerging through the thin alluvial blanket to form San Solomon Spring and Griffin Spring, across U. S. Highway 290 a short distance to the northwest.

Originally San Solomon Spring discharge formed a swamp of considerable size that drained into Toyah Creek. The water now issues from gravel in the bottom of the park's swimming pool. The average flow is about 26,000,000 gallons of water per day, which makes a sizeable stream, but there is considerable variation in the rate of discharge. Normally the rate of discharge increases after periods of heavy rainfall and decreases during periods of drought, but a steady flow is maintained during periods of annual drought and even during several successive dry years.

The water is normally perfectly clear but following abrupt increases in the discharge rate, it may become clouded due to the suspension of very fine, light-colored sediment derived from the alluvium. It has a high mineral content but this is also variable and is commonly associated with the volume of discharge. Probably the normal mineral content of the artesian basin water is diluted by the mixing with fresh water from the gravel deposit. The water temperature is relatively constant at about 75° to 78° F. The lower temperatures are normally noted during periods of peak discharge.

BASTROP STATE SCENIC PARK

Ross A. Maxwell

Bastrop State Park, about 1 mile east of Bastrop, can be reached from either State Highway 71 or 21; the area is about 30 miles east-southeast of Austin (Pl. I). The park was established (1933-1935) when the Texas State Parks Board acquired 2,100 acres of land by donation from the City of Bastrop and from private donors. A Civilian Conservation Corps camp was located just outside the park boundary (1934) and some of the old foundations are still visible. The park roads, concessions building, cabins, swimming pool, golf course, and other improvements were constructed by the CCC in cooperation with the Texas State Parks Board, by plans approved by the National Park Service. Until recently, when the State Parks Board and the Game and Fish Commission were combined (1963) into the new Parks and Wildlife Department, the Texas State Parks Board maintained the central warehouse and shops at Bastrop State Park. It was here that the rustic furniture and signs seen in other parks were made.

Bastrop State Park has about 150,000 visitors annually, and the park facilities include a wide range of accommodations. There are concrete tables, grills, rest rooms, and electric and water outlets for the outdoor camper and picnicker. There are also group campsites. Most of the cabins have cooking facilities and bath; towels and bed linens are furnished. Dining facilities range from confections or a light lunch at the concession counter to dining room service and dancing on the terrace. Recreation includes a large swimming pool (for both adults and children), playground equipment for the youngsters, and a nine-hole golf course. Fishing is possible at nearby Lake Bastrop and in the Colorado River. There are scenic drives through the park and also popular is a slow and leisurely drive along Park Road 1 to Buescher State Park near Smithville.

The City of Bastrop is one of the oldest settlements in the State. The town is astride the Camino Real (the Royal Road), which was the trace connecting San Antonio with Natchitoches in Louisiana. This trace was first an Indian trail, later a Spanish-French trade route, and still later the main entry route of the early Anglo-Saxon settlers. The town was originally called "Mina," but when the village was incorporated (December 18, 1837) the name was changed to Bastrop, in honor of the Baron de Bastrop, a German pioneer, soldier, and member of the Coahuilan-Texas Congress. The Baron used his influence to enable Moses Austin to secure a land grant from the Mexican government and later aided Stephen F. Austin in establishing the colony of Anglo-Americans in Texas that later proclaimed the Republic of Texas as a free and independent nation.

The first settlers in the Bastrop community arrived in 1829; they included William Barton, Josiah Wilbarger, and Reuben Hornsby (ancester of the famous ball player Rogers Hornsby) who came to Texas and located their headrights in the Stephen F. Austin colony. A village was laid out, schools and churches established, and a cultural center was formed. The first church was organized in 1835, Bastrop Academy was built in 1850, the first newspaper (*The Colorado Reveille*) was published on November 29, 1851 (its name was changed to the *Bastrop Advertiser* in 1852) and is probably the oldest newspaper in the State. The first drug store was organized and opened for business about the same time. In 1862, N. B. Turner built a factory to manufacture guns and bayonets for the Confederacy.

The initial pursuit of the early settlers was mostly agriculture, but small industries were soon developed. Among these were lignite mining; at one time reportedly there were 13 lignite mines within 6 miles of Bastrop. It was not long until the brickmaking industry started; the brick kilns were built close to the lignite mines which produced the fuel. Bastrop was also a lumbering center and much of the pine lumber used in Central and West Texas came from the area now included in Bastrop State Park. The pines (loblolly) are locally known as the "Lost Pine Forest" because they are separated from the chief pine regions of East Texas and Louisiana by several hundred miles. This isolated pine forest is presumably a relic of a much more extensive pine belt that grew in Central Texas during the ice ages (Pleistocene).

On the Gulf Coastal Plain the vegetation often reflects the type of bedrock from which the soil is derived, and it is sometimes possible to map the approximate contact of geologic formations by observing the changes in vegetation. Clay beds commonly characteristic of the Wilcox Group (table 1) weather to form a black waxy (chernozem) soil on which there may be dense growth of the "brush prairie" vegetation. There are normally many individual plants, but the most common are mesquite, huisache, and snake (broom) weed; the cultivated crops are mostly cotton or some variety of sorghum. The sandstone formations weather to form a podsol soil with a native vegetation of pine, post-oak, and blackjack; the cultivated crops are mostly berries, sweet potatoes, peanuts, and melons. The Sabinetown-Carrizo contact near the entrance to Bastrop State Park can be more easily recognized by noting the abrupt change of vegetation than by looking for the rock outcrops. The mesquite trees and brush are on the Sabinetown—the pine and oak trees are on the overlying Carrizo Sandstone (fig. 26).

Some of the sandstone formations in Central Texas contain the mineral glauconite; this is a greenish rock and chemically is essentially a hydrous iron-potassium silicate. In season (March) on a drive through the Bastrop area there are many bluebonnets (*Lupinus subcarnosus*). The bluebonnets are indicative of soils rich in glauconite.

Most of the major rivers in Texas have developed a terrace system; these are flattish surfaces or benches along the river channel that indicate the different levels in the stream valley development. Terraces may be seen along the Colorado River between Austin and Bastrop. The City of Bastrop is on one of them that the Colorado River cut (eroded) into the Sabinetown Formation of the Wilcox Group (table 1). Just east of Bastrop along the old highway toward the park, the Sabinetown Formation—Carrizo Sandstone contact (fig. 27) can be seen in the roadside drainage, but the approximate position of the contact is more easily recognized by noting the abrupt changes in the types of vegetation—pines on the sandstone, mesquite and related bushes on the clay.

The top bed of the Sabinetown Formation is a structureless clay that may be an old soil zone. Most of the Sabinetown is clay but there are also thinly laminated lenses of sandy clay and laminated sandstone flags. In some places there are large smooth-surfaced ferruginous (iron oxide) concretions. The formation was deposited in a transgressing sea; the deposition began as beach deposits and ended with deeper water deposition. The entire formation is mostly a near-shore deposit or shallow-water facies and contains some marine fossils. The fossils include a few species of clams, oysters, and snails; these are most easily seen in or adjacent to the concretions and are considerably more abundant in the Camp Swift area (abandoned) than near Bastrop.

Ascending the road grade east of Bastrop, the Carrizo Sandstone underlies the slope that causes a car to labor as it climbs the grade; the Carrizo also forms the west-facing escarpment exposed east

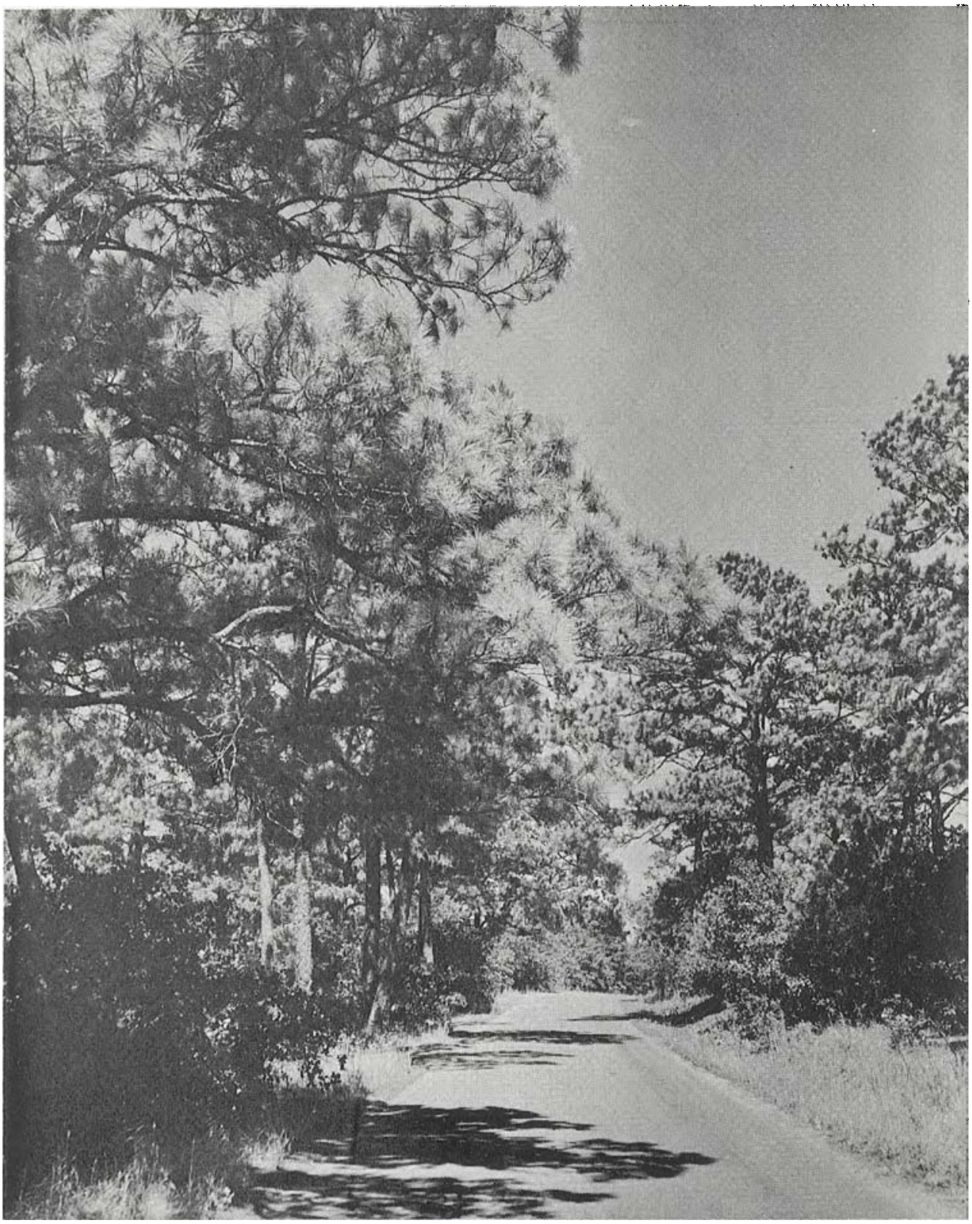

FIG. 26. Roads wind through the pine forest at Bastrop State Park. The pines grow in the sandy soil developed by weathering and erosion of the Carrizo Sandstone. (Photograph by Texas Parks and Wildlife Department.)

of Camp Swift. This formation is mostly of continental origin and the rocks were deposited by streams that laid down their loads on a flat coastal plain; the deposit formed a broad alluvial apron along much of the coastal area. The basal beds consist mostly of rounded quartz grains that in some places are cemented with ferruginous (iron oxide) materials that make the beds resistant to erosion. The iron

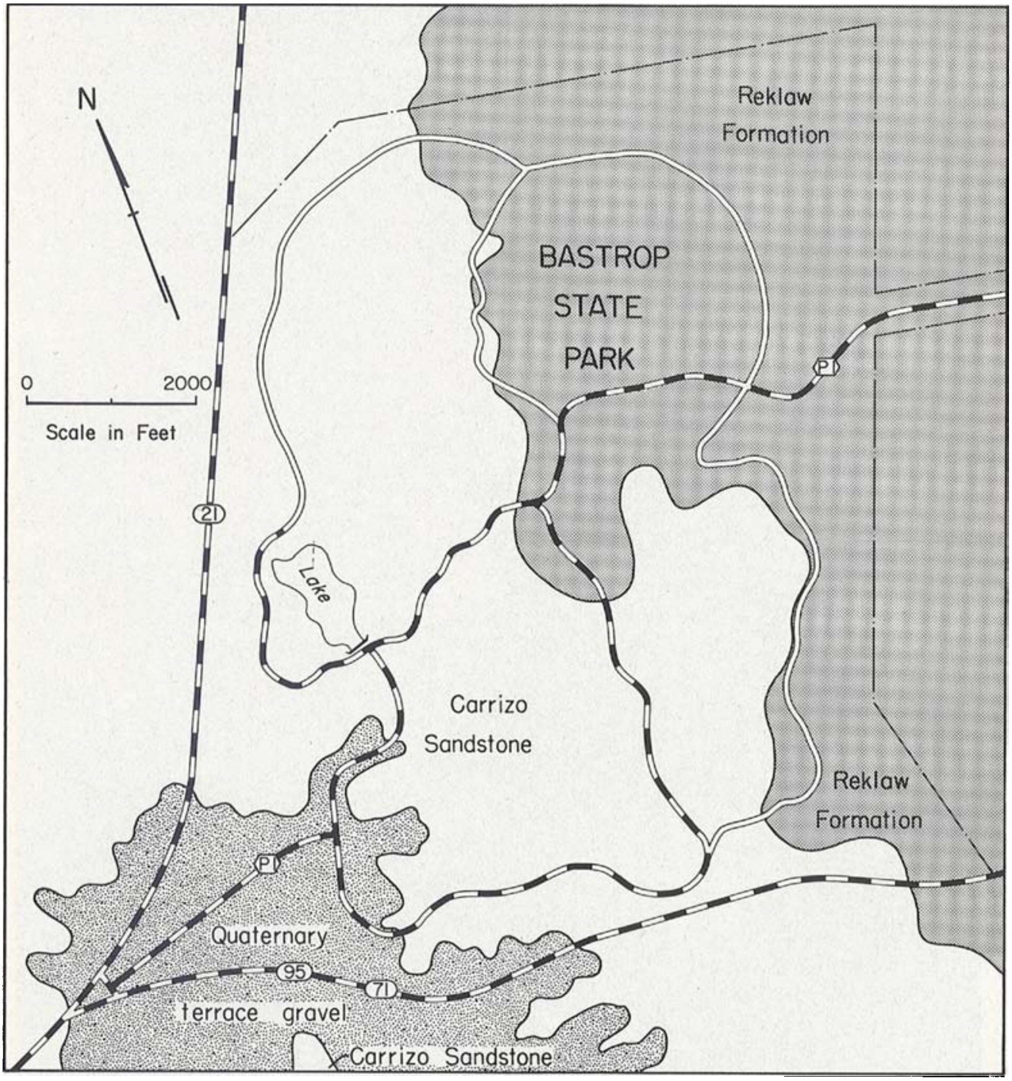

FIG. 27. Geologic map of Bastrop State Scenic Park.

oxide lends some reddish color to most outcrops and a yellowish color to the soil. The Carrizo Sandstone is also an important aquifer on the Coastal Plain and many of the farm and ranch wells in the Bastrop area obtain water from the Carrizo Sandstone. During the early days of the park's operations, the water supply was obtained from shallow wells in the Carrizo; more recently the park's water supply is piped from the Bastrop water system.

Near the top of the escarpment is the Carrizo-Reklaw contact (table 1), but because of weathering and development of the soil profile, the contact is not visible from the road. The basal beds in the Reklaw Formation are called the Newby Member. These are mostly orange or brown sandstone layers but most of the overlying part of the formation is clay;

part of the clay is glauconite and can be seen from the road toward Smithville. The Reklaw was deposited in shallow marine water along the flat-lying or gently inclined coastal plain. The rocks are not conspicuously fossiliferous and most of the fossils are poorly preserved. Molds or casts of snails are the most abundant; there are a few species of fossil clams.

Some of the park structures are built of rock from formations other than mentioned above. The character of these rocks is more easily seen in the structures themselves than in poorly exposed outcrops in the park area. For example, at the visitor center building the reddish conglomerate blocks came from a consolidated gravel deposit in terraces along the Colorado River. The greenish sandy flagstone is from the Sabinetown Formation, quarried east of Bastrop. The orange and brown sandstone blocks are from the Newby Member of the Reklaw Formation (table 1).

BENTSEN—RIO GRANDE VALLEY STATE SCENIC PARK

L. Edwin Garner

Bentsen—Rio Grande Valley State Park consists of 587.5 acres of native forest land that is 6 miles southwest of Mission, Texas. The park is on Park Road 43 and the Rio Grande off U. S. Highway 83 (Pl. I). It was acquired in 1944 by deed from private owners and set aside for recreational purposes. The unique forest grove includes chapote, guayacan, ebony, huisache, Brazilwood, and Spanish daggers (fig. 28). Bird watching is a popular activity because a large variety of migratory birds find refuge there during the autumn and winter seasons.

The facilities include camp and picnic areas, trailer sites, group shelters, rest rooms, showers, and concessions building. A general rehabilitation and facility expansion program was completed during the 1967-68 biennium, a part of which was necessitated because of flood damage caused by Hurricane Beulah. An additional Federal grant to be matched by State funds is for more rest rooms, service and storage building, trailer camping, picnic units, roads, parking areas, and utilities.

The area is steeped in lower Rio Grande Valley history. The City of Mission was named for a mission established in 1824 by priests of the Oblate Order on a site 3 miles south of the present town. The priests planted an orange grove that is said to be one of the first experiments with citrus fruit culture in the Rio Grande Valley. By 1930 Mission was the heart of the grapefruit district.

The park is along the route taken by the Spanish when they entered Texas. In August 1638 Jacinto Garcia de Sepulveda passed through the area in search of Dutch sailors reported to be on the Texas coast. In 1750 Jose de Escandon began colonizing the area; large land grants from the Spanish Crown were made north of the Rio Grande, and some of the Latin-American families are descendants from the oldest pioneers in Texas. During the Mexican War, Zachary Taylor established the old Military Road (Fort Ringgold to Brownsville) to furnish supplies for his men in northern Mexico. The road passes close to the park entrance and evidence of this thoroughfare is still visible.

The park is located on the extreme southern edge of the Texas Gulf Coastal Plain. The terrain is very gently rolling to flat; vegetation is profuse, consisting of a variety of trees, shrubs, and grasses; and soils are dark gray sandy and clay loams. The sediments in the park were deposited by the Rio Grande as alluvial terraces and are of Recent age (table 1). Surface material consists mostly of sand, silt, and clay, and subsurface material often contains much gravel derived from areas of northern Mexico and southwestern Texas.

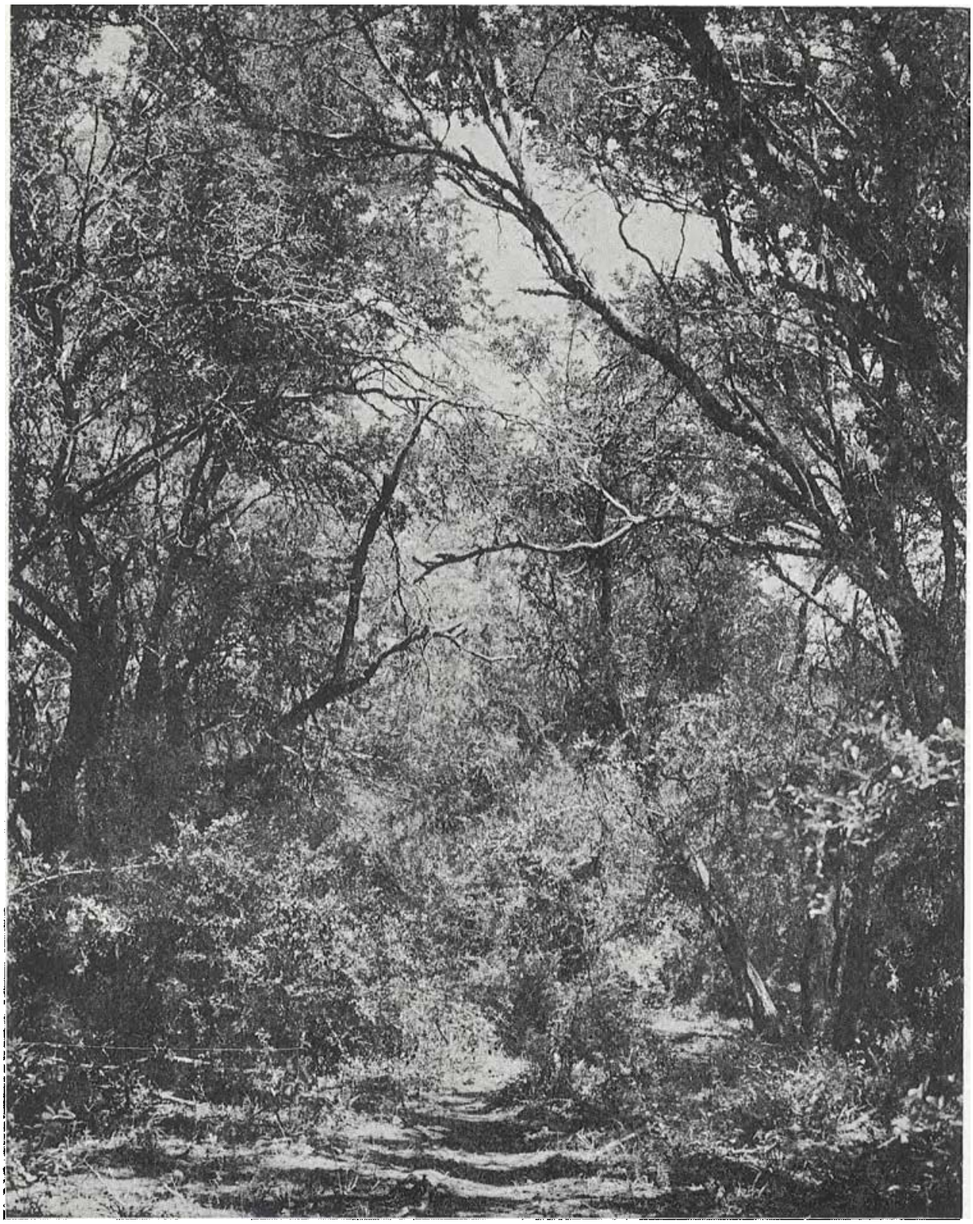

FIG. 28. A nature trail winds through a dense forest at Bentsen-Rio Grande Valley State Park. Water and minerals in the porous alluvium along the Rio Grande terrace nurture the vegetation. (Photograph by Texas Parks and Wildlife Department.)

BIG SPRING STATE RECREATION PARK

Gus K. Eifler, Jr.

Big Spring State Park, in the southwest edge of Big Spring, is readily accessible by paved streets from U. S. Highways 80 and 87 (Pl. I). It is a tract of 321 acres obtained in the 1880's by W. P. Edwards, who deeded it to the City in 1924. In 1934, the City gave the land to the State for use as a park; improvements were begun immediately by the WPA. These included road construction, a concessions building, and residence for the superintendent, which were built of native limestone.

Facilities for recreation and overnight visits are limited, for the park has largely preserved the rustic atmosphere of the pioneer days of Big Spring. Hiking, picnicking, and camping in the rough are the main activities of most visitors. Picnic tables of native stone with nearby barbecue grates are conveniently located near the park roads. Water and modern plumbing are available. For the children, there are slides, a swing, a pool, and a merry-go-round. Some 80,000 to 90,000 people visit the park each year. Additional facilities to be added from Federal and State funds include shaded picnic areas, roads and parking, and necessary utilities.

The spring after which Big Spring, Texas, is named is 2 miles south of the city post office. About 9 miles east-southeast is another large spring called Moss Spring. Together they were directly or indirectly related to much of the early history of the area because no other water was available within 60 miles.

These springs were the watering holes for buffalo, antelope, wild mustang, coyote, and wolf. Game as well as water was sought by the Indians, particularly the Comanche and Shawnee, who reportedly fought each other as well as the whites. The remains of Indian campsites can still be found near the springs. Only the native trees such as mesquite, cedar, wild chinaberry, and hackberry grow in the park, but there are also scattered growths of greasewood, catclaw, chaparral, small cactus, and prickly pear in the countryside.

In the 1820's, Big Spring was a settlement of buffalo hunters and frontiersmen who lived in tents and huts made of buffalo hides. A wagon yard, a hotel, and several saloons completed the local accommodations. Several important early trails crossed near Big Spring. The most notable was the Butterfield Overland Mail Route running from St. Louis through Memphis and Big Spring to San Francisco. On returning from Santa Fe in 1849, Captain R. B. Marcy established an official campsite on the Butterfield Trail at Big Spring. No doubt this permanent location led to the settlement and growth of the town. Two prominent hills served the early explorers, settlers, and cattlemen as landmarks. One was Scenic Mountain in the park and the other was Signal Mountain 11 miles southeast of Big Spring. At the latter, Indians sent up smoke signals. Three Indian skeletons, numerous arrowheads, bits of pottery, and other artifacts have been found.

Comanche and Apache markings, together with arrowheads and broken pottery, are still being found in the park. Spanish markings have been the basis of tales of buried treasures. One, particularly, relates to a treasure hidden in a large cave in the park. The extent of the cavern is unknown for it is still being explored.

Three physiographic divisions merge near Big Spring: the Edwards Plateau, the Llano Estacado, and the North-central Plains (Pl. I). The Edwards Plateau stretches southward as flat uplands capped by thick resistant limestone beds of Comanchean (Lower Cretaceous) age. In the vicinity of Big Spring, the Plateau is terminated abruptly by prominent scarps. Here dissection by streams heading along the edge of the Plateau has left a rugged topography of steep valleys and ridges. To the northeast lies the gently rolling North-central Plains underlain by red shale and red and gray sandstone of Triassic age. West and north of the Edwards Plateau lies the Llano Estacado or Staked Plains, a flat to scarcely undulating surface with numerous shallow playa basins. The Staked Plains are underlain by the Ogallala Formation (Pliocene). This formation is capped by 10 to 15 feet of caliche (variety of limestone), which in most places is covered by a veneer of windblown sands of Pleistocene age. The north edge of the Edwards Plateau at Big Spring abruptly joins the Staked Plains, but to the southwest these two physiographic features merge imperceptibly.

Rocks that crop out in the vicinity of Big Spring are sedimentary in origin and range in age from Triassic to Quaternary. The Triassic rocks cropping out east of the Llano Estacado and northeast of the Edwards Plateau (near Big Spring) are assigned to the Dockum Group (table 1). These form the eastern part of an extensive deposit of red beds in Arizona, New Mexico, and Texas. In Texas, they were deposited mainly by braided streams upon an uneven erosion surface developed on Permian beds. Most of the sediments are flood-plain and channel deposits, but locally these may be interbedded with eolian and possibly lacustrine sediments. Permian strata are exposed east of the Triassic outcrop and dip westward at very low angles beneath Triassic strata.

In the Big Spring area, Triassic strata range in thickness between 100 and 200 feet at the outcrop. These beds are chiefly consolidated massive clays and shales, which are maroon to reddish brown with greenish-gray streaks of sand. In places these sediments are sandy to micaceous with thin bands of gypsum. At some levels, there are thick lenses of sandstone which are grayish green to gray. The sandstone is coarse and gritty and is conspicuously cross-bedded. Northward from Big Spring the lower part of the Triassic contains conglomerates with pebbles of white quartz and bright varicolored chert.

Fossils are sparse and poorly preserved in the Triassic beds. A few species of the fresh-water mussel *Unio* have been collected. Locally, fossil wood is fairly abundant but poorly preserved. Dinosaur and crocodile bones have been identified but no complete skeletons have been found. Other fossil vertebrates include amphibians and fish.

The Cretaceous sea advancing from the southeast transgressed a subdued surface eroded during the Jurassic period, and the Cretaceous rocks unconformably overlie the Dockum beds. Sand and gravel deposited along the advancing shoreline were covered by marl and limestone as the sea continued to advance northwestward.

The sandstone and conglomerate at the base of the Cretaceous section (table 1) make up the Antlers Formation ("Trinity Sands"). The beds range between 60 and 80 feet in thickness and crop out along the base of the Edwards Plateau scarp. The basal conglomerate is composed chiefly of pebbles of black and red chert and other siliceous materials, which are well consolidated. Above the conglomerate is a fine to medium sandstone, which is distinctly cross-bedded at some levels. Some sandstone is friable and some is tightly cemented. Many of the beds contain small amounts of varicolored siliceous pebbles. The sandstones are buff, light gray, lavender, red and brown. Fossils are rare, except for some poorly preserved petrified wood specimens.

The Antlers Formation is overlain abruptly by a sequence of limestone beds with minor interbedded marl. These beds, which total 160 feet in thickness, are assigned to the Fredericksburg Group. The lower 35 feet is nodular limestone and thick, distinctly bedded limestone interbedded with thin layers of marl. Those beds are gray buff to brown. Fossil oysters, gastropods, and echinoids are abundant and moderately well preserved. The overlying 45 feet of gray, nodular limestone and thin marl beds are evenly bedded and weather light gray to buff. Although there is a great variety of pelecypods and gastropods, the specimens are scarcer than in the beds below.

The uppermost 80 feet of strata is massive, chalky limestone and interbedded thin marl. These rocks are buff, weathering light gray. Near the top are large chert concretions, a feature of the Edwards Limestone of Central Texas. Microscopic fossils are abundant, but large fossils, such as the oysters, are relatively scarce. Several kinds of rudistid clams occur in the purer limestone; these also abound in the Edwards Limestone of Central Texas.

Younger Cretaceous strata were deposited on the Fredericksburg rocks but were eroded after the Cretaceous sea retreated southeastward. This erosion largely removed Cretaceous rocks north, west, and east of the Edwards Plateau at Big Spring.

During the Pliocene epoch (Tertiary), heavily laden streams flowing eastward from the Rocky Mountains built floodplain deposits which merged with one another into one extensive fluvial mantle. These sediments constitute the Ogallala Formation. This formation is made up of gravel, sand, and silts. The gravel, which occurs in the lower part of the formation, is commonly sandy and contains pebbles of quartz, quartzite, limestone, chert, crystalline rock, and abraded oyster shells locally derived from Cretaceous rocks. Similar gravels appear higher in the formation as channel deposits. The sands are chiefly quartz and some are silty. They are typically massive but in places are thin bedded and cross-bedded. Most of the sand is pink and gray but some is maroon. Silt composes only a small part of the formation and is generally sandy. At the top of the formation a 10- to 15-foot resistant caliche bed forms the caprock which caps the Llano Estacado scarp on the east.

In the Pleistocene epoch (Quaternary) the Ogallala Formation was covered by windblown sands up to 15 or 30 feet thick. These are pink to orangish red and generally contain small nodules of caliche.

Subsequent to the deposition of the Ogallala, innumerable small playa basins developed on the Llano Estacado. These range up to a mile in diameter and from 10 to 50 feet in depth. After heavy rains they are almost completely filled with water, most of which evaporates within a few days.

BLANCO STATE RECREATION PARK

Ross A. Maxwell

Blanco State Park is situated on both sides of the Blanco River about 1 mile south of Blanco, Texas. It includes 110 acres that were deeded by private owners to the Texas State Parks Board in 1933 and 1934. Early developments and improvements were made by the CCC. The park may be reached via U. S. Highway 281 about 50 miles north of San Antonio or 14 miles south of Johnson City (Pl. I). The park has facilities for camping, screened shelters, picnic tables, and rest rooms. Fishing and swimming in the Blanco River are popular activities. No water skiing is allowed.

Blanco County was first settled in 1853 by James H. Callahan and John D. Pitts. Most of the settlers selected home sites along the Blanco River near the present site of Blanco and the park. Indian depredations were frequent and on July 5, 1855, State authorities commissioned Mr. Callahan to organize a company of soldiers to protect the Blanco settlement. He was aggressive and led his followers on several forays against the Indians. One of these was into Mexico where they fought to a "draw" with Mexican soldiers. Both sides retreated and for a short period, Callahan occupied the Mexican village of Piedras Negras. He and his forces withdrew to the north side of the Rio Grande after setting fire to the village.

During the War Between the States, there was a group of Union sympathizers in the Blanco area; they organized the Union Loyal League in June of 1861. The League formed a fighting contingent and on June 10, 1862, had a skirmish with anti-Union forces along the Nueces River. It was a decisive defeat for the pro-Union "army" and following this engagement the Union Loyal League was abandoned.

Following the Indian depredations that were ended with the battle at Packsaddle Mountain on August 5, 1873, Callahan's soldiers were disbanded, but horse thieves moved into the Blanco area. A vigilante committee to cope with the situation was organized in 1877. The committee acted, and when the horse thieves were caught, there was prompt execution. The lynchings decreased during the early 1880's when the courts began handling the various crimes.

Rocks exposed in Blanco State Park belong to the Glen Rose Limestone of the Trinity Group, and deposits of Recent alluvium form the Blanco River floodplain (table 1). The Glen Rose is easily recognized because of characteristic bench ("stairstep") topography produced by erosion of alternating resistant limestone beds and easily eroded marl beds (fig. 29).

A fossil zone near the middle of the Glen Rose is known as the *Salenia texana* zone because of the presence of a fossil sea urchin which has been given that name. This zone also contains several species of ancient oysters and clams, one of the most common of which is the clam *Corbula* occurring in a limestone ledge at the top of the *Salenia texana* zone. This ledge has been mapped from Travis County to Bandera County and crops out in the park in the banks of Koch Branch. The fossils in the *Salenia texana* zone as well as from other fossil zones in Central Texas have been described by Whitney (1952).

Although alternation of limestone and marl beds is characteristic for the Glen Rose as a whole, the limestone beds below the *Corbula* bed are commonly thicker, finer grained, and more resistant to erosion than those above the *Corbula* bed. George (1947) noted these differences and described the geology, structure, and ground-water resources in nearby areas.

About 1 mile up the river above the park is a good exhibit of dinosaur tracks in the Glen Rose along the banks of the river. These are on private property and the landowner's permission should be obtained before visiting the area.

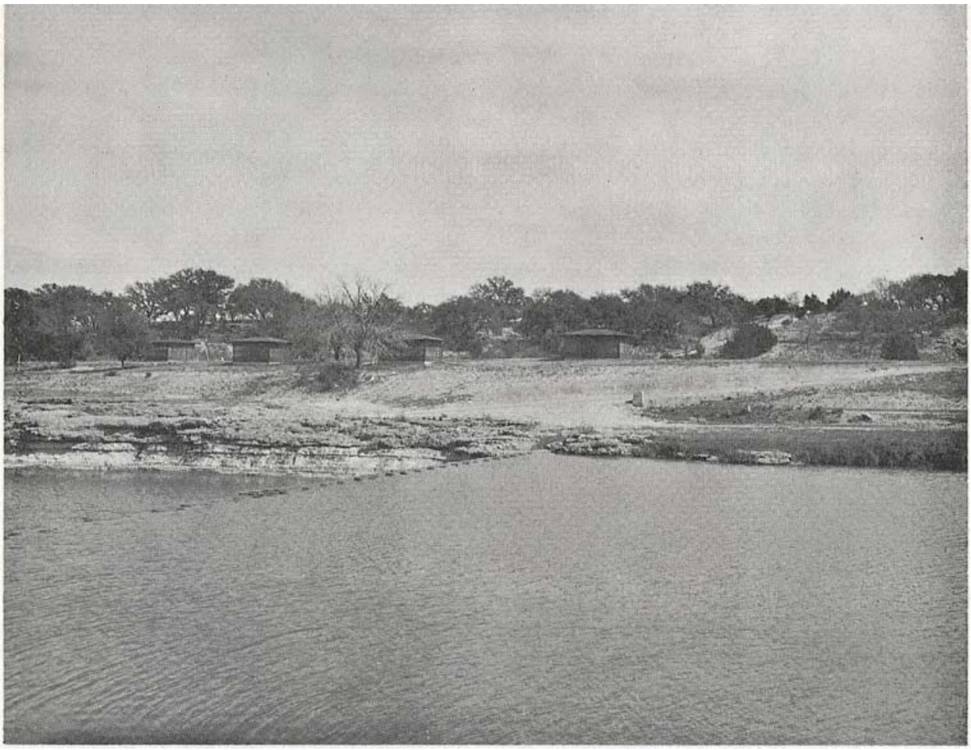

FIG. 29. Hard and soft rock layers in the Glen Rose Limestone at Blanco State Park. The limestone ledge near water level is sufficiently resistant to support the low-water dam. The screened shelters are on a thin resistant ledge that underlies a gently sloping surface. The top of the ridge is also capped by resistant limestone. The slopes in front and to rear of the shelters are underlain by less resistant marl. Stairstep topography similar to this profile is common in areas underlain by the Glen Rose. (Photograph by Texas Parks and Wildlife Department.)

BONHAM STATE RECREATION PARK

Ross A. Maxwell

Bonham State Park (299.8 acres) in Fannin County is on Farm Road 271 off State Highway 78, about 3.5 miles southeast of Bonham (Pl. I). The area is noted for its wide variety of wildflowers, shrubs, and trees.

The park was acquired in 1934-1935 by deeds from the City of Bonham. There are tables and grills and picnicking, camping, and rest-room facilities. Also available are group campsites, trailer sites, children's playground, swimming, fishing, boat rental, launching ramps, pedal boats, and a miniature golf course. Water skiing is not permitted.

In nearby Bonham is the Sam Rayburn Memorial Library; the Rayburn home is located 1 mile west of Bonham on U. S. Highway 82. Fort Inglish, built by Baily Inglish in 1836 for protection of his family and neighbors against Indians, was demolished in 1962. There is no trace of Fort Warren, established as a private fort in 1836 and abandoned in 1837.

The geologic formations at Bonham State Park and vicinity are shown on the Sherman Sheet of the Geologic Atlas of Texas. The rocks in the park are Gober Formation, named for the village of Gober in south-central Fannin County (table 1). In the park the rock is mostly a calcareous clay that forms a dark soil. Near Honey Grove, about 16 miles east of Bonham, and about the same airline distance east-northeast of the park, the Gober is mostly a chalky brittle marl which is bluish gray when fresh but weathers white. Near Honey Grove, the formation is about 300 feet thick, but it thins rapidly eastward, and the outcrop feathers out before reaching the eastern Lamar County line (about 35 miles). The eastward thinning may be due to gradation with the underlying Brownstown Marl Formation.

Southwest of the park, the Gober crops out in a broad southward band that is exposed in the southern end of the Preston anticline. Farther west and southwest, the Gober is covered by younger Upper Cretaceous formations in the Sherman syncline. The most western Gober exposure in that area is near Whiterock in Grayson County, about 16 miles west of Bonham.

BRAZOS ISLAND STATE SCENIC PARK

L. Edwin Garner

Brazos Island State Park consists of 217 acres and has approximately a mile of beach on the Gulf of Mexico (fig. 30). It is at the end of State Highway 4, off U. S. Highway 77, about 24 miles east of Brownsville, Texas (Pl. I). The park site was acquired in 1957 by Legislative Act which transferred title to the property from the General Land Office to the Texas State Parks Board. The favorable climate provides essential environment for year-round camping, picnicking, fishing, swimming, nature study, and hiking. The area is undeveloped and there is no supervisory personnel.

The history of the surrounding area includes two battle sites (Palo Alto and Resaca de la Palma) from the War with Mexico and the battle site of Palmito Ranch, the last land engagement of the Civil War. En route to the park can be seen the palmetto pilings of the Boca Chica crossing of the railroad from Boca Chica inlet to White's Ranch on the Rio Grande. This railroad was begun by General Francis H. Herron, U. S. Army, in 1864 and completed in 1865 by General Philip H. Sheridan for the transportation of military supplies. The cypress pilings 1,000 feet north are what remain of a floating bridge constructed across Boca Chica inlet by General Zachary Taylor in 1846. This is part of the road from Brazos Santiago to the White's Ranch landing and to Clarksville on the Rio Grande; it was used for the transportation of military supplies. Historical markers are placed near each of these sites.

The island is a part of the modern barrier island system which fringes the Texas coast. Sediments are of Recent age (table 1) and consist of sand and shell which were deposited by longshore currents and waves. Inland from the beach the dune ridge has been built by prevailing landward winds (fig. 31). In 1967 Hurricane Beulah altered the park's outline by cutting temporary channels in the beach, depositing piles of beach sand and shell in new places, and by scouring the tops of some sand dunes. Most of these recent scours will be healed by the natural shore processes, and within a few years the results of Beulah's destructive force on and near the beach will be gone.

Fig. 30. Open beach on Brazos Island. The waves continually move sand and shells along the beach. Note sand dunes at upper left. (Photograph by Texas Parks and Wildlife Department.)

Fig. 31. Sand dune area built by the prevailing landward winds from the Gulf of Mexico. Note vegetation that is partially retarding dune migration. The log and heavier driftwood were thrown onto the beach during storms.

BUESCHER STATE RECREATION PARK

Ross A. Maxwell

Buescher State Park, about 3 miles west of Smithville, can be reached on Farm Road 153 off State Highway 71. The park is also accessible by Park Road 1, a scenic drive from Bastrop State Park. It includes about 1,724 acres that were acquired by the Texas State Parks Board during 1933 and 1936 by deeds from the City of Smithville. Recreational facilities include fishing in a 13-acre lake within the park and from nearby Lake Bastrop and the Colorado River. The recreation hall was constructed by the CCC with ferruginous sandstone quarried from the Newby Member of the Reklaw Formation. There are picnic areas with tables, campgrounds, rest rooms, water and power outlets, equipped playgrounds for children, open group shelter, and screened shelters. Hiking and nature studies are also popular activities.

In April 1967, however, the 60th State Legislature authorized transfer of these lands to The University of Texas System and other institutions to be used as a science park. The land will continue to be used for recreational park purposes but the area will also be oriented toward the scientific aspects of park development, as these aspects relate to environmental health problems. The areas of mutual study will include planning for wise and economic development of future recreational centers, probing into the complex questions of ground compaction, erosion, air pollution, and determination of means to reduce this inadvertent destruction of our natural resources and scenic beauty through constant usage of our State Park facilities.

The park is steeped in early Texas history. The first known European in the area was Louis Juchereau de St. Denis, a French trader. In 1714, St. Denis started from Natchitoches, Louisiana and made his way across Texas to the Rio Grande where he was taken prisoner by the Spanish near the town of Eagle Pass. St. Denis was later employed as a guide to lead the Spanish across Texas and to aid them in the reestablishment of their East Texas missions.

During the next few decades, the trade and travel across this part of Texas localized along a route that became known as El Camino Real. This route passed through the park and Don Antonio Cordero, Spanish Governor of Texas, stationed troops to protect commerce at a nearby crossing of the Colorado River. The park is also within the original Stephen F. Austin land grants (1827 and 1831) (*see also* Bastrop State Park, pp. 43–47).

Most of the route between Bastrop and Buescher State Parks is over rocks belonging to the Reklaw and Queen City Formations (fig. 32). The Newby Sandstone Member, basal unit of the Reklaw Formation, briefly described on pages 46–47, was used in the stone masonry construction at both Bastrop and Buescher State Parks. The Marquez Shale Member overlies the Newby; it is rich in the mineral marcasite (FeS_2) and the outcrops are often weathered and iron stained. Some of the clay beds are highly fossiliferous; clams, oysters, snails, and corals are the most abundant. The Queen City Formation is mostly sandstone, but there is some sandy clay and a little lignite. The basal Queen City beds are distinctly glauconitic and the sandy soils derived from them are easily distinguished from the clay soils in the underlying Reklaw. Fossils are not common but some fossil wood occurs in the Queen City.

The Queen City—Weches contact is exposed near the park entrance and can be traced northward through the western side of the park. There is an abrupt change in the soil types along the con-

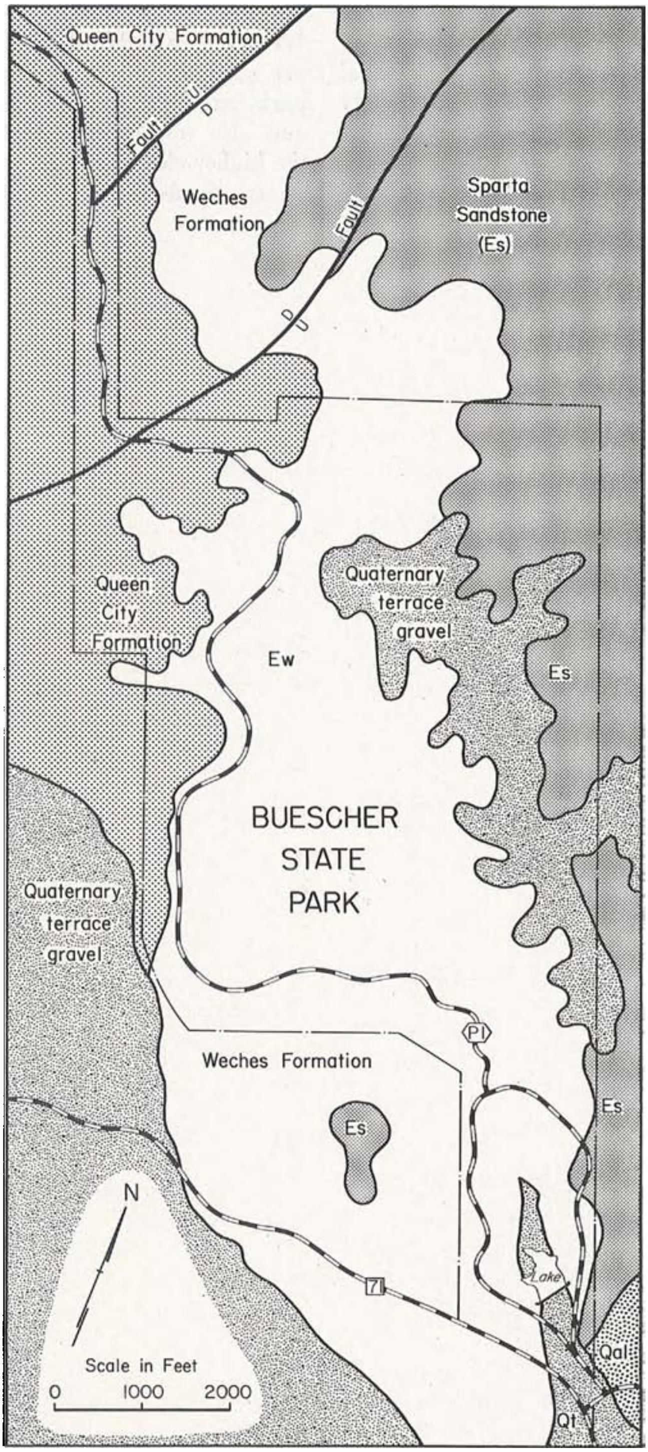

FIG. 32. Geologic map of Buescher State Recreation Park.

tact; the sandy soil is derived from the Queen City and the tight gummy soil from the Weches Formation. The normal vegetation types characterized by sandy and clay soils are prominent. This explains why pine trees are limited to the western margins of Buescher State Park and thick brush is more common on the Weches clay soils toward the east. There are some terrace gravel deposits in the park, and in the eastern side of the area and also toward the northeast, most of the higher elevations are underlain by the Sparta Sandstone (fig. 32).

CADDO LAKE STATE SCENIC PARK

Ross A. Maxwell

Caddo Lake, named for the Caddo Indians, is an expansion of the Big and Little Cypress Creeks in southwestern Marion and northeastern Harrison counties. The lake, which drains into the Red River through Soda Lake at Shreveport, Louisiana, extends into Texas for about 24 miles and has a total area of about 110 square miles. The park consists of about 478 acres in Harrison County on Farm Road 135 off State Highway 43 from U. S. Highway 59, about 15 miles northeast of Marshall. The land was acquired by deeds from private owners in 1933 and 1934.

Caddo Lake is famous for its giant cypress trees coated with Spanish moss (fig. 33) and for its fishing. Black and white bass, crappie, bream, and catfish are plentiful. A $108,850 Federal grant for the development of Caddo Lake was approved in January 1968. These funds were matched by a $217,700 appropriation by the State Legislature. The new construction will include an interpretation center, screened camping shelters, picnic units, tent camping units, trailer campsites, nature trails, road and parking facilities, rest rooms, a service and storage building, and utilities. Rehabilitation of existing facilities, landscaping, and boundary fence is also planned.

According to Caddo Indian legend, the lake was formed by an earthquake caused when a Caddo chief failed to obey the Great Spirit. A more likely explanation is that the lake was formed behind a log jam in the Red River. In about 1900, the United States government destroyed the log jam, known locally as the Red River Raft, and during the period before 1914, a silt and flood control dam was built near Mooringsport, Louisiana, to form the present Caddo Lake.

The Caddo Lake vicinity is noted for its early history and nearby ghost towns that date back to the days before the Texas Republic. Swanson's Landing on "Broad Lake" was near the place of the burning of the steamer *Mittie Stevens* in 1869 when some 60 persons perished, not realizing that the shore was so close or that the water was so shallow that they could have waded to safety. The first locomotive, "The Louisiana," was landed by steamer at Swanson's Landing. The "iron horse" was used on a local railroad that extended from the landing to Jonesville, a distance of about 14 miles. During the Civil War the locomotive was melted for scrap and mule power was used to move the freight. The mules pulled the railroad cars to the top of a hill, then the animals were loaded on board to coast to the bottom. This process was repeated for each successive hill. With the decline of steamboat traffic, this unique railroad was soon abandoned. Farther up the bayou was Port Caddo, the port of entry for those entering the Republic of Texas from the northeast. Nearby was Benton, from which most of the river freight was distributed to other parts of Texas before Jefferson became the head of water navigation. A short distance inland from Port Caddo is the site of Macon, once called "The Lost Colony" after its settlers moved to Port Caddo. Another point of historic interest is the government ditch which was dredged up the Big Cypress Creek in order that cotton could be shipped by water from Jefferson via the Red River to New Orleans. About the beginning of this century, pearls were discovered in some of the fresh-water mussels and for about 10 years, thousands of people came to the lake in search of pearls. Caddo Lake is also near the childhood home of Mrs. L. B. (Lady Bird) Johnson.

The general geology of the Caddo Lake area is shown on the Tyler Sheet of the

FIG. 33. Giant cypress trees with Spanish moss at Caddo Lake State Park. The cypress and other vegetation flourish in the poorly drained areas of the East Texas Coastal Plain. (Photograph by Texas Parks and Wildlife Department.)

Geologic Atlas of Texas. Except for small areas covered by alluvium or terrace gravel deposits, all of the rocks belong to the lower Wilcox Group (table 1). The area is on the northern side of the Sabine Uplift and all strata have a northern dip.

The formations included in the Wilcox Group are sedimentary units deposited in advancing and retreating seas. Most of the lower Seguin Formation (table 1) is a medium-grained, thin, evenly bedded, gray, fossiliferous, marine sand containing large, flat, rough-surfaced concretions. It can be distinguished from the underlying unevenly thick bedded, fine silty black beds in the upper Midway. Fossils in the Seguin are mostly thick-shelled clams, oysters, and snails that occur in bands and are water worn. This suggests wave and current action in shallow water along a beach. Fossils in the Wills Point Formation of the Midway are more numerous and include corals and fragile shells that probably lived in quiet or deeper water and could not have lived in a shallow shoreline environment.

The Rockdale Formation is a nonmarine unit deposited on a low, broad, gently inclined coastal plain. Most of the formation is sand or sandy clay and the present outcrop is often covered with heavy growths of post-oak and blackjack. The tree cover aspect leads to use of the term "Timber Belt" for the broad area underlain by rock in the Rockdale, and the formation's outcrop boundaries are clearly indicated by the vegetation; they can be seen from an airplane and are evident on aerial photographs.

The Rockdale deposits suggest an epoch of heavy rainfall with numerous streams that were laden with fine sand and mud. A humid climate induced thick vegetation; logs and large branches were deposited by currents in stream-channel and ripple-marked delta deposits; fossil wood is common. Mud and fine plant debris were buried with vegetation that grew in low-lying swamps and marshes. As the streams shifted and overflow areas changed, vegetation was buried in new areas and eventually some of it was changed to black carbonaceous clay and lignite. Some lignite beds are thin, others are several feet thick, all have lenticular shape, and are interbedded with variable thicknesses of clay.

The Rockdale Formation is noted for its lignite deposits. Prior to 1930 there were scores of mines at many places in the State, but only the deposits near Rockdale in Milam County and at Darco in Harrison County are now actively mined. Clay from the Rockdale is used extensively for the manufacture of brick and tile. Some of the clay is used locally for ceramics and drilling muds. Some industrial sand is produced locally.

The Sabinetown Formation is a marine unit deposited in an advancing sea. The basal beds were probably laid down in shallow water along the beach because the pebbles and fossils appear to have been worn and rounded by wave action. The upper deposits are evenly bedded sand, glauconitic sand, and clay that were deposited in deeper and more quiet water.

The conditions of deposition during the Sabinetown and Seguin epochs were similar but reversed. The Seguin strata were deposited in a retreating sea that ended with the broad coastal plain lignite deposits; the Sabinetown beds were laid down in an advancing sea, beginning with shallow beach debris accumulations and ending with deeper water deposition.

Analyses of clay samples from Harrison County are given by Fisher et al. (1965, pp. 107, 172); analyses of lignite samples and information on lignite reserves are also given (pp. 27, 282). Sample localities are shown on maps accompanying that report.

CLEBURNE STATE RECREATION PARK

Ross A. Maxwell

Cleburne State Park, consisting of about 498 acres, is on Park Road 21, off U. S. Highway 67, in Johnson County, about 14 miles southwest of Cleburne. The park includes a 116-acre lake; there are camping, group campsites, picnicking, trailer sites, rest room and shower facilities, rental boats, boat ramp, pedal boats, swimming, and fishing but no water skiing. A major construction program for new facilities and renovation of old structures begun in the 1967–1969 biennium is now complete. These include rest rooms, service and storage building, tent and trailer camping units, picnic unit roads, parking areas, and utilities. The park was acquired by deeds from the City of Cleburne in 1935-1936 and includes a 75-acre wildlife refuge tract and a nesting site for the almost extinct Golden-cheeked Warbler. Nearby is the famous dinosaur track area along the Paluxy River near Glen Rose (figs. 34 and 35).

The lake was formed by damming a branch of Camp Creek, a tributary of the Brazos River. The cliffs and hills along the drainage were formed by erosion of the Lower Cretaceous formations (fig. 36). At most places, the caprock is formed by the Edwards Limestone (fig. 37), a pure hard resistant limestone, and the lower slopes are underlain by the Comanche Peak and Walnut Formations (table 1), which are mostly calcareous, fossiliferous clay or marl, and nodular argillaceous limestone. The park is near the marginal area where these formations change from north to south. Toward the

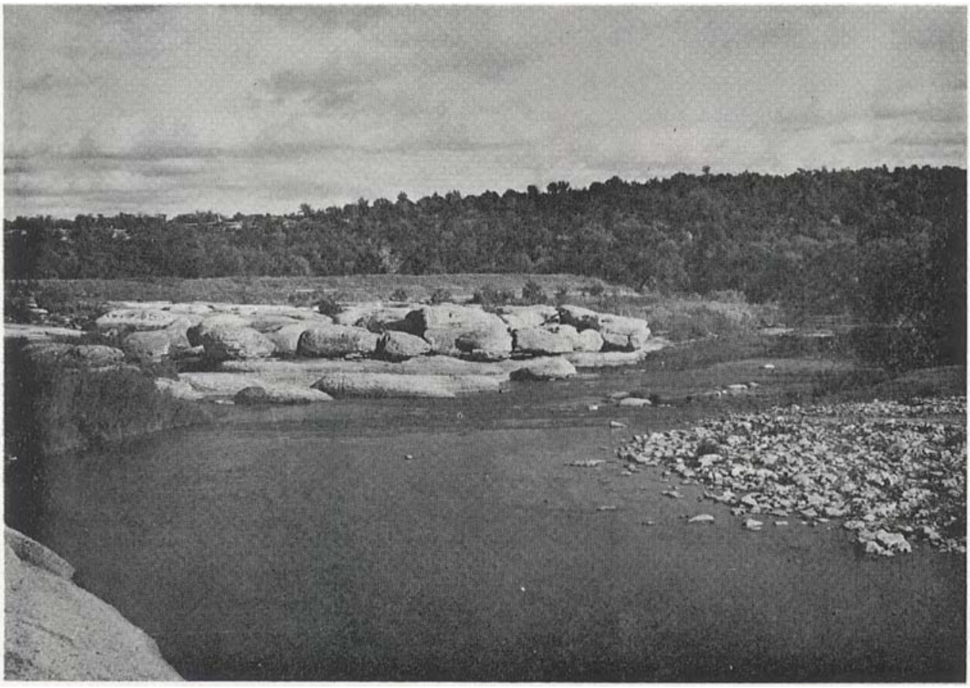

FIG. 34. The Glen Rose Formation along the Paluxy River valley near the famous dinosaur track locality, about 12 miles from Glen Rose, Texas. The ledge is limestone; the slopes are underlain by soft layers of shale and marl. (Photograph by P. U. Rodda.)

FIG. 35. Dinosaur tracks in the Glen Rose Formation along the Paluxy River near Glen Rose, Texas. At the right are tracks of a four-legged herbiverous dinosaur. Note the tracks made by the right and left hind and front feet; the stride was about 10 feet. At the left is the trail of a bipedal carniverous dinosaur with a stride of about 12 feet. (Photograph by Texas Memorial Museum.)

north, from Parker County into southern Oklahoma, the Edwards Formation pinches out, and a stratigraphic unit that is approximately equivalent to the Edwards and Comanche Peak Formations in Texas is called the Goodland Limestone (fig. 38). Southward from the general park area, the Edwards, Comanche Peak, and Walnut Formations thicken and the rock units of Central Texas begin to appear.

The Edwards becomes a hard, fine- to coarse-grained limestone with many mound-like reef deposits which are intergrowths of rudists (conical-shaped clam shells), corals, and lime-secreting algae (fig. 39). The Edwards Formation also

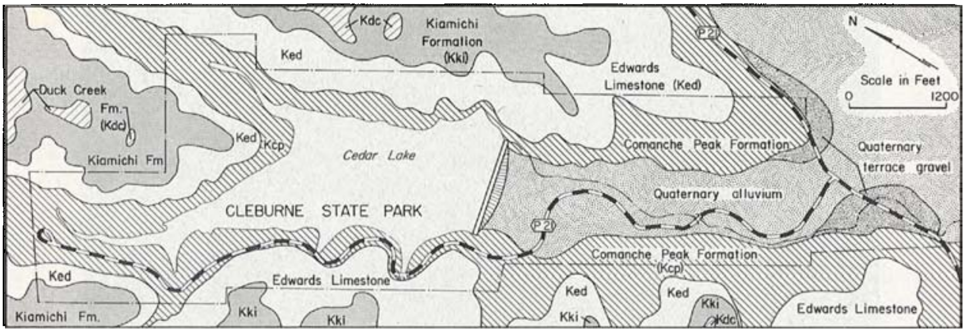

Fig. 36. Geologic map of Cleburne State Recreation Park.

contains foraminifera (microscopic shells of one-celled animals) and other clams, oysters, and snails. There are also bands and nodules of silica (chert) within the limestone. The thickness of the Comanche Peak Formation also increases toward the south, the marly layers become more limy, and at many places in Central Texas, it is difficult to distinguish between the Comanche Peak and the basal Edwards; at some places, both units have been mapped as Edwards Limestone.

The Edwards is the most important high-calcium limestone in the State. It is extensively processed for the manufacture of high-calcium lime, agricultural lime, fluxstone for smelting metals, and the manufacture of glass, paper pulp, caustics, and alkalies. At some plants, the Edwards is blended with clay to make

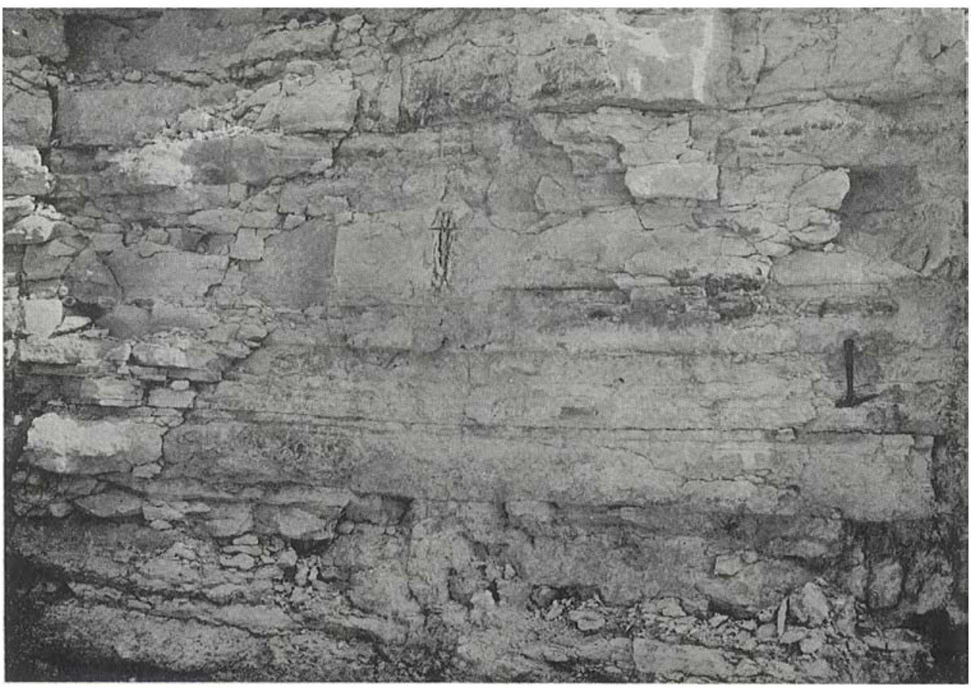

Fig. 37. The Edwards Limestone. Note the thick, hard, cherty limestone beds as they appear in an excavation about 5 miles northwest of Cleburne State Park. (Photograph by P. U. Rodda.)

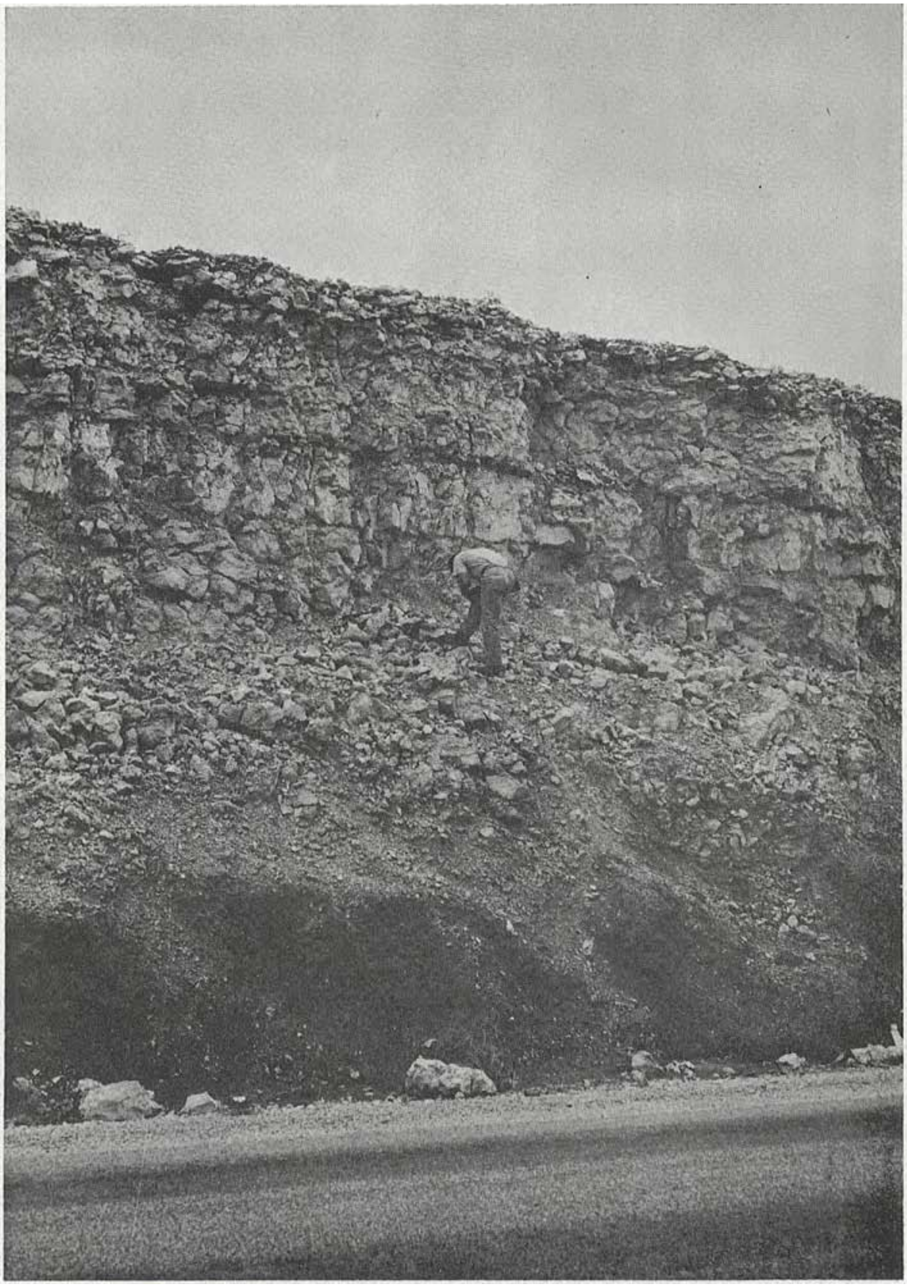

FIG. 38. Goodland Limestone near the Red River northwest of Cleburne. Note the similarity to the bedding in the Edwards (fig. 37). (Photograph by P. U. Rodda.)

Portland cement, but the most common use of the crude limestone is for crushed aggregate; some of it is used for dimension stone.

The Walnut Formation also changes facies southward. In the Cleburne area, it is mostly calcareous shale or marl that underlies the Edwards-Goodland (fig. 40),

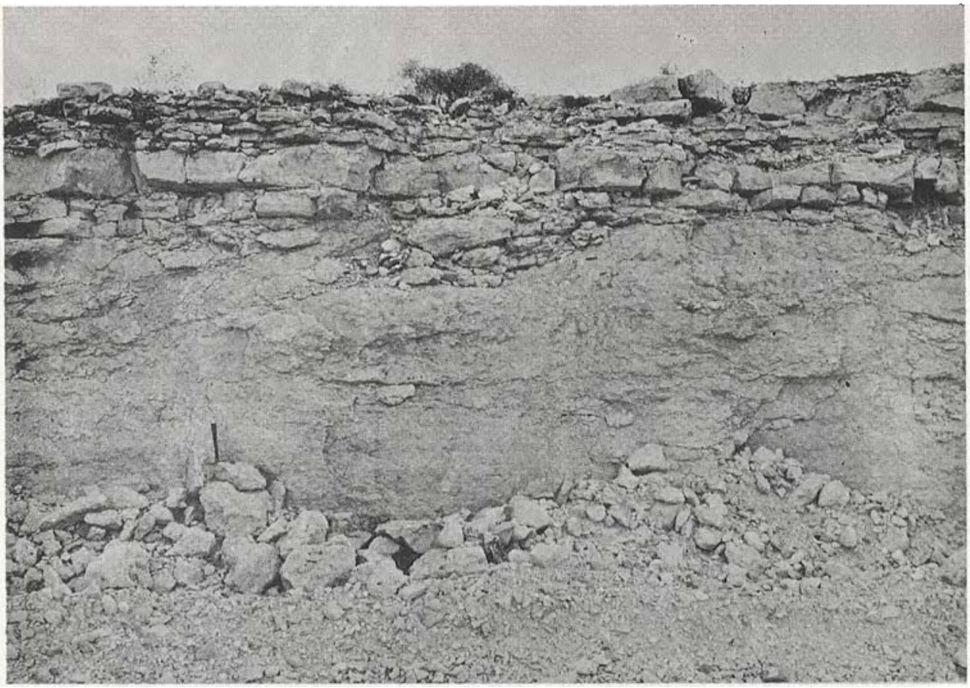

FIG. 39. A small mound or reef-like deposit in the Edwards Limestone. Note lack of bedding in reef (center) and overlap of well-developed horizontal beds along upper left side and over top of reef. Reefs are commonly high-calcium limestone. Oil may accumulate in reef deposits. Example, Horseshoe Atoll field in West Texas. (Photograph by P. U. Rodda.)

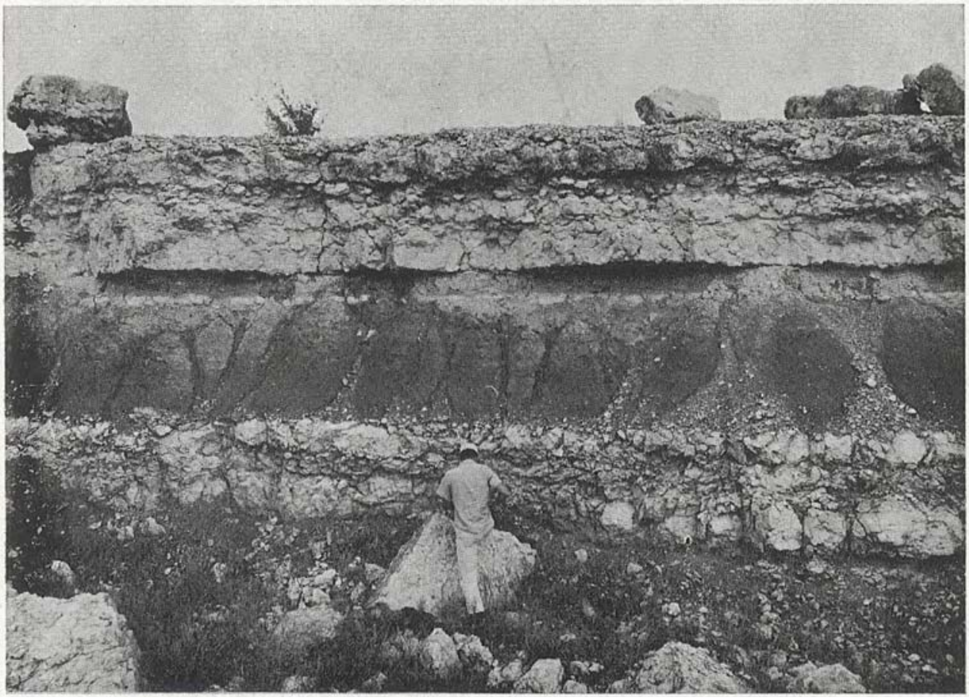

FIG. 40. Contact between the Edwards Limestone and Walnut Formation. The nodular limy beds (in Walnut) level with the man's head are abundantly fossiliferous. (Photograph by P. U. Rodda.)

but in the Cedar Park area, Williamson County (Central Texas), limestone ledges are quarried and used for dimension stone. One ledge, a buff-colored oolitic (small spherical bodies) limestone is marketed as Cordova Cream; underlying this is a distinctive limestone bed with well-preserved molds of clams and other shells which is marketed as Cordova Shell. Two companies operating in the Cedar Park area and one at Liberty Hill produce about 80 percent of the State's dimension limestone.

Near Cleburne, one company produces high-calcium lime from the Edwards that is used mostly in chemical industrial processing and road base stabilization, but they also produce some agricultural lime as a by-product. There are several small companies that process the Edwards for crushed stone aggregate, and some larger blocks are used locally for riprap and guard rails along highways. Much of the shale and marl from all of the formations is used as fill for highways and for surfacing secondary roads.

DAINGERFIELD STATE RECREATION PARK

Ross A. Maxwell

Daingerfield State Park (Morris County) is on Park Road 17, off State Highway 49 and U. S. Highway 259, about 5 miles southwest of Daingerfield. The park is unique in that it preserves a small area (580 acres) of natural beauty in the center of the East Texas iron industrial development. On the grounds of the nearby Lone Star Steel Company is the old blast furnace that helped in manufacturing guns and other metal objects during the Civil War. In addition to the blast furnace and other ore beneficiation plants at the steel company, there are several sawmills, woodworking plants, and coke ovens nearby.

The park was acquired in 1935 by deeds from private owners. It includes an 80-acre lake stocked with fish, and there are cabins, rest rooms, boat ramp, fishing, and camping facilities, but no water skiing. New facilities to be constructed with Federal and State funds include a fishing pier, increased trailer and tent camping units, rest rooms, sanitary dump station, roads, landscaping, and utilities.

In 1642 the Moscoso expedition, which was a remnant of the De Soto command, is believed to have passed near the park. The French were also in the area and by 1750 had established a trading post; this was later moved to the Caddo Indian village. The first Anglo-Saxon settlers arrived about 1814. Among them were Sam Pounds, W. B. Ellis, and Col. Tom Beavers. In 1820 Nicholas Trammel blazed a trail, later known as Trammel's Trace, from Jonesborough to Nacogdoches; it was used for smuggling slaves and other contraband and was the trail used by Davy Crockett and Sam Houston when they came to Texas.

The general geology at Daingerfield State Park is shown on the Texarkana Sheet of the Geologic Atlas of Texas. The area is along the axis of the East Texas Embayment and most of the exposed rocks are in the Queen City Formation; the Sparta Formation caps some of the highest hills and the Weches forms most of the slopes between the Sparta and the Queen City (fig. 41).

The Queen City Formation is mostly a sand formation with irregular beds of clay and sandy clay (fig. 42). It is of continental fluviatile origin laid down by meandering and shifting rivers on a flat coastal plain. The strata merge gulfward with shallow-water beds that were in part deposited in marshes or bays and some are shallow-water delta deposits. Well-preserved plant leaves are present in the lagoonal beds but rare in other parts of the formation. The Queen City is an important aquifer in East Texas and water is obtained from it at many farms and some of the small towns.

The Weches is essentially a unit of glauconitic sand and clay. In most of East Texas the formation has two divisions: (1) an upper unit consisting of concretionary ferruginous strata in which glauconite, sometimes called greensand, has weathered and altered to iron ore, and (2) a lower unit that is mostly clay but has some layers of quartz sand, granules of glauconite, and marl. The formation was deposited in shallow marine waters. Rolled and wave-worn shells at the base of the formation suggest a beach facies for the lower part of the unit and well-preserved shells in the upper beds suggest deposition in deeper water.

The Sparta is a sandstone formation that in the Daingerfield area crops out on hills and ridges above the Weches. The beds are mostly poorly consolidated sand that was deposited in conjunction with the withdrawal of the Weches sea. Cross-bedding and river-made ripple-marks occur in some beds; in others are beach

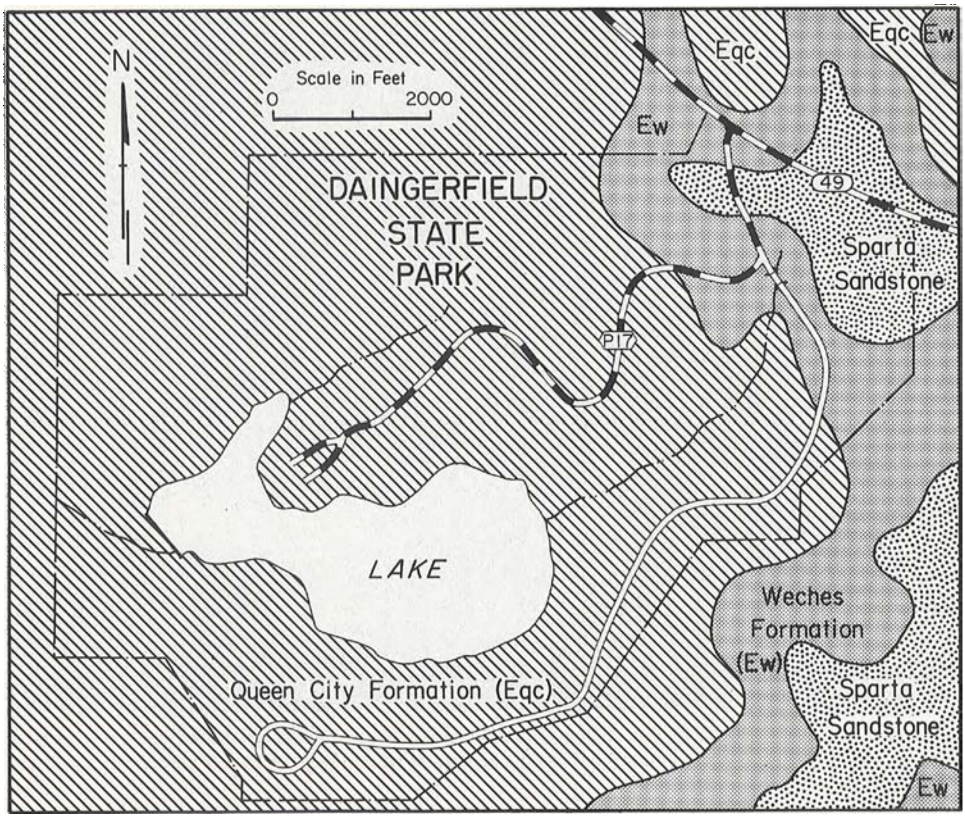

FIG. 41. Geologic map of Daingerfield State Recreation Park.

sands and sand dunes that interfinger with shallow delta deposits. Fossils are rare.

The rock and mineral resources of East Texas, including the Daingerfield area, have been discussed by Fisher et al. (1965) and Eckel (1938) has reported on the iron ore deposits. None of the mineral resources are endangering the park's existence, but a brief discussion of the iron ore deposits seems appropriate.

The ore is mostly limonite, a brown or yellow hydrous iron oxide ($Fe_2O_3+H_2O$), that weathering has concentrated into porous, or earthy, masses. Most deposits occur as nodules or thin lenticular bodies near the tops of flat, sand-covered hills in the glauconitic member of the Weches Formation. Glauconite is a complex hydrous silicate of iron, aluminum, magnesium, and potassium. Long periods of leaching have reduced the silicate content of the glauconite, concentrating the iron content to form the iron oxide limonite.

Glauconite is common in several of the Gulf Coastal formations and also occurs along the Atlantic Coast. In places where the potassium and phosphorous are present in sufficient quantities, the greensands are used as a soil conditioner or in the manufacture of fertilizers.

The brown iron ore deposits of eastern Texas are found in at least 22 counties, but deposits that could be worked under reasonable economic conditions are restricted to small areas in Cass, Cherokee, Marion, and Morris counties. If sufficient demand should arise, some additional ore might be produced from Anderson, Henderson, Upshur, Nacogdoches, and Smith counties. The existence of these deposits

FIG. 42. Sandy clay beds in the Queen City Formation. Note the disintegrated rock mixed with organic matter that forms the thin sandy soil covered by thick vegetation. (Photograph by Texas Parks and Wildlife Department.)

has been known almost from the time the first settlers reached East Texas and during the 1850's several small furnaces were erected. These have been abandoned and most of the ore reserves are now in the hands of a few large companies that expanded processing plants and increased production in 1966.

DAVIS MOUNTAINS STATE SCENIC PARK and FORT DAVIS NATIONAL HISTORIC SITE

Ross A. Maxwell

The Davis Mountains include an area of about 2,000 square miles in Jeff Davis, Brewster, and Presidio counties (Pl. I). They are not a single mountain range formed by complex folding and uplift of the earth's crust but are a broad, irregularly shaped upland capped by nearly flat-lying layers of volcanic rocks. These layers have been deeply dissected by stream erosion to produce a rugged terrain. Viewed from most any high elevation, there are dozens of large, irregularly shaped mountains that seem more or less to intersect at their bases and hundreds of smaller peaks that rise irregularly from the higher slopes. Between the peaks are alluvial-covered valleys, several basins, and deep canyons, a few of which give permanent water (fig. 43).

Mount Livermore (elevation 8,381 feet), named for an Army colonel who mapped the area, is the dominant topographic feature in the central Davis Mountains. Other prominent eminences are Sawtooth Mountain (7,748 feet), Blue Mountain (7,331 feet), Mount Locke (6,809 feet), and a score or more of peaks whose tops are above 1 mile elevation. The principal drainage radiates from the slopes of Mount Livermore (fig. 24, p. 38). The largest and best known stream is Limpia Canyon Creek that flows eastward through famed Wild Rose Pass. The upper drainage for Madera and Wild Cherry Canyons heads on the northeastern slope of Mount Livermore; its southern slopes are drained by Alamito Creek and its tributaries that flow southward to empty into the Rio Grande near Presidio.

There are many well known places of scenic, scientific, and historic interest in the Davis Mountains and surrounding area. Most of them are accessible from the Scenic Loop road, with a circumference of about 78 miles, formed by State Highways 118 and 166. State Highway 118 intersects U. S. Highway 80 toward the north and extends southward to U. S. Highway 90 at Alpine. Access to the Scenic Loop is provided from the northeast by State Highway 17 that intersects U. S. Highway 290 near Balmorhea, and from the southwest via U. S. Highways 90 and 67 at Marfa. Davis Mountains State Park, McDonald Observatory, and Fort Davis National Historic Site are near the east end of the Scenic Loop road (fig. 24, p. 38).

Davis Mountains State Park is administered by the Texas Parks and Wildlife Department. It is an 1,869-acre tract that includes the most scenic part of Keesey Canyon and a section of Limpia Canyon. The State of Texas owns 529 acres which were acquired by the Texas State Parks Board on September 11, 1933; the remaining acreage is held under a 99-year lease.

The Indian Lodge (park hotel) is an artistically planned, pueblo-type structure built on varying levels that stands in Keesey Canyon where it is enclosed on three sides by rocky ledged hills. The original 15 rooms were renovated and the lodge enlarged during a 1966-1967 one million dollar improvement program. In addition to the guest rooms with their tile baths, air conditioning, heating, and carpeting, there is a dining room that offers an excellent West Texas style menu; a swimming pool, recreation room, reading material, and souvenirs are also available.

A new and enlarged water supply enabled expansion of the trailer sites that have water, sewage, and electric connections. Cooking grills and picnic tables are also provided. The enlarged tent camp area has cooking grills, picnic tables, water, rest rooms, and showers. Most campers are especially pleased with the beautiful sunrise view down Keesey Canyon, the rare summer atmosphere, and the quiet vastness of the mile-high terrain.

Visitors have a choice of hiking trails: (1) a short self-guided nature trail, along which plants, rocks, and other natural features are identified and described, and (2) a 2-1/2-mile hiking trail that leads to the highest overlooks in the park and connects with the nature trail at Fort Davis National Historic Site, a partially restored military post. Those who do not care to hike will find a pleasant day-use picnic area, a visitor interpretative center, and a wildlife watering station where the visitor may watch native birds and small mammals as they come for a drink. Saddle horses are available at a nearby guest ranch, and a drive along the park's highest ridge offers pleasant views of the entire park and the nearby mountain peaks. The skyline drive has been widened and surfaced. These new facilities were dedicated by Governor Connally on March 28, 1968.

During the summer months the visitors may gather nightly at an outdoor campfire circle to hear a program presented by National Park and State Park personnel. The talks are illustrated with slides on topics of natural history, park history, and interesting phenomena and events in the nearby area. The campfire programs in the Davis Mountains park were the first in the Texas State Parks System; such programs are extremely popular in National parks for it is here that the visitor can obtain the real meaning for the park's preservation and ask questions at a relaxed friendly meeting.

FIG. 43. Davis Mountains from the air. Indian Lodge, the park's hotel, lower left; Blue Mountain, upper right. The rocks are all of volcanic origin. The spine-like features and ledges are lava that resists erosion. The slopes and valleys are underlain by volcanic ash and other soft materials. Blue Mountain is capped by resistant lava. (Photograph by Texas Parks and Wildlife Department.)

Most visitors to the State Park also stop at Fort Davis National Historic Site and the nearby town of the same name (fig. 44). Barry Scobee (1947) pleasantly recorded the historical events for the long-abandoned military post, the town, and the surrounding area. Mountain scenery is enjoyed by those who travel the Scenic Loop road. Some stop at Madera roadside park where wading water for children is available. At Rock Pile roadside park are the famous polished boulders believed by some to have been used by the Indians for defleshing animal skins. Near Barrel Springs are the ruins of an early stage station. Some may wish to visit El Muerto, or Dead Man's Hole, named for the remains found there of a man shot by an unknown assassin. El Muerto was also one of the early stage stations, a place where the Indians preyed on unwary emigrants and attacked the mail stage and small detachments of troops. Livestock raising is the main industry in the Davis Mountains; Highland Hereford cattle, sheep, and goats can be seen on the ranches. Game, including both blacktail and whitetail deer and antelope, is plentiful.

Scobee (1947, p. 4) reported that word-of-mouth history indicates that early pioneers who traveled through Limpia Canyon found a settlement near the present site of Fort Davis occupied by crop-planting Indians with traces of Spanish blood. During the middle 19th century, the Davis

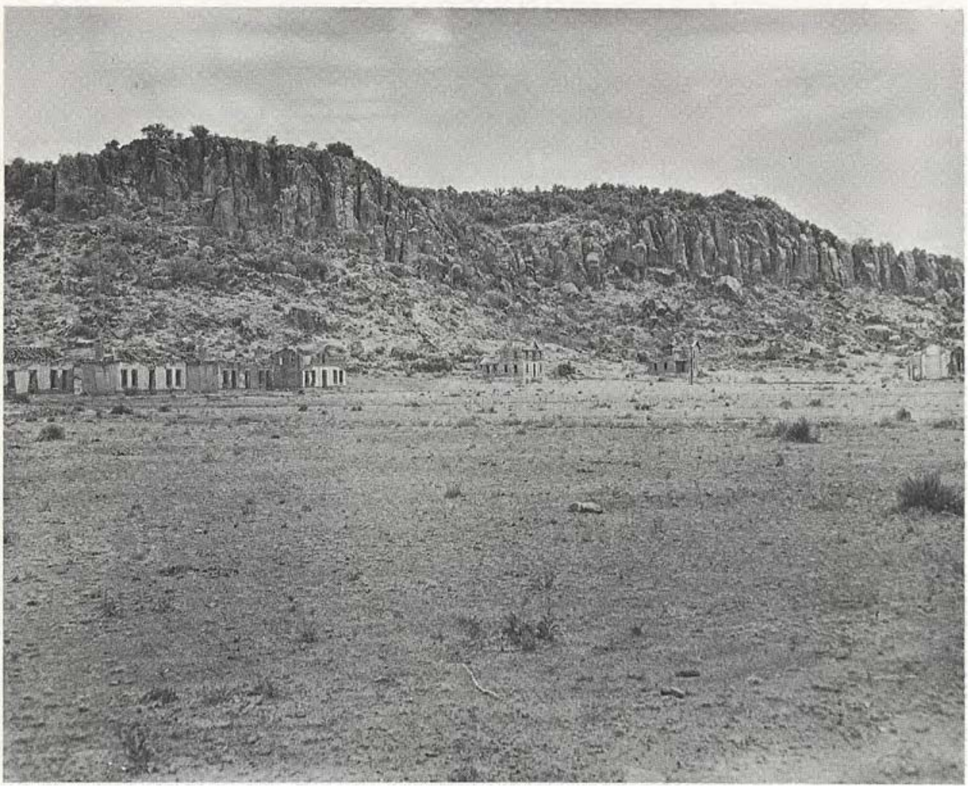

FIG. 44. Officers' Row at Old Fort Davis, 1854 to 1891. Following establishment of the National Historic Site (1963), these buildings along with others were reconstructed. During the 1860's and 1870's, Indian snipers shot arrows from crevices in the rhyolite cliff at rear. The palisades structure in the lava is due to weathering and erosion along joints in the Star Mountain rhyolite. (Photograph by Texas Parks and Wildlife Department.)

Mountains were inhabited by the Mescalero Apache Indians who lived in a village called La Limpia which was located along Limpia Creek north of Fort Davis. At this rancheria, the Indians used ditches for conveying water from Limpia Creek to their small cornfields. The Comanche Indians also used the area for pitching their tents as they trekked from Oklahoma and the Texas Panhandle southward to Mexico.

In the late 1840's, United States troops marched up Limpia Canyon en route to El Paso where they established a frontier military post then called Franklin. Gold was discovered in 1848, and by 1849, the vanguard of gold hunters and adventurers were traveling westward through the Davis Mountains. To aid the westward travelers, the U. S. Government ordered a military survey to find a route across West Texas where water for both man and livestock could be obtained from either springs or streams. The surveyors who left San Antonio on May 4, 1849, surveyed two alternate routes from the Pecos River to El Paso. One route followed up the Pecos River to the Horsehead Crossing, thence westward to El Paso passing north of the Davis Mountains; the other left Pecos River at the Sheffield Crossing, thence westward to Comanche Spring, up the Limpia Creek valley, and westward to El Paso. The southern branch of the San Antonio—San Diego trail intersected the Chihuahua Trail near the head of Limpia Creek and from there the trail led southward into Mexico. These routes were destined to become important as routes of commerce. military campaigns, and the settlement of the west.

In 1850, the Postal authorities contracted with Henry Skillman to haul the mail over that part of the Overland Route that lay between San Antonio and El Paso. In order to complete this obligation, it was necessary for Skillman to establish stage stations where teams could be changed and for the accommodation of the passengers. One of the stations was at La Limpia near the Fort Davis town site; others were at Barrel Springs and at El Muerto, or Dead Man's Hole. Skillman's initial run, a 693-mile trip, was made in a Concord coach, drawn by six mules and guarded by an escort of 18 mounted Indian fighters under the command of Big Foot Wallace. Two of the guards who rode the first trip were Diedrich Dutchover and E. P. Webster. Webster was left as station tender at La Limpia; Dutchover continued to ride guard for two more years, but in the meantime he established a small ranch in Limpia Creek valley below the stage station.

In an attempt to check the white man's encroachment into their hunting grounds, the Indians began attacking the mail stage and the wagon trains, some of which had sizeable herds of livestock. In order to protect these activities and the few settlers in the area, a U. S. military post was established by the 8th United States Infantry at La Limpia on October 3, 1854. It was named Fort Davis for Jefferson Davis, then Secretary of War for the United States (and later President of the Confederacy), who ordered the establishment of the fort; it was quietly surrendered to the Confederacy in 1861.

When the Confederate troops withdrew from Fort Davis after only a few months of occupancy, they left Diedrich Dutchover in charge of the fort. This was probably because Dutchover had taken no part in the conflict between the North and the South, nor had he joined in any of the Indian battles, and it was probably assumed that he and the fort would be unmolested. This was not the case, however, for the Apaches soon ransacked the fort; while the plundering and destruction of buildings was going on, Dutchover and perhaps half a dozen people were concealed on the roof of one of the buildings. After 48 hours, the Indians scattered, and Dutchover and his party crept from the rooftop and walked 92 miles to Presidio. During the next few years, the Indians, renegades of all nationalities, and riffraff travelers completely burned or destroyed the 60 pine-slab buildings that had been the first Fort Davis.

On July 1, 1867, troops of the 9th U. S. Cavalry reoccupied Fort Davis. Warfare with the Indians who were attacking the stage, wagon trains, and the settlers had been renewed. In addition to Indian fighting and riding patrol for the wagon trains, these troops also started constructing the fort's stone buildings, some of which are the ruins that can be seen now. By 1885, the Indians had been driven from the area and there was little need for a fort, which was abandoned during July 1891.

A few of the public-spirited people in Texas became disturbed to see the ruins of the old fort buildings, for they considered Fort Davis as a monument to the struggles of the pioneers against the Indians. Judge David A. Simmons of Houston was one of the leaders in the movement to protect the fort. He purchased the property on May 3, 1946, and started reconstruction of a few buildings. On September 8, 1961, the U. S. Congress authorized purchase of the fort property. The purchase was effected January 1, 1963, and Fort Davis National Historic Site was established.

Fort Davis National Historic Site contains 447 acres that are administered by the National Park Service, U. S. Department of the Interior. The National Park Service launched a comprehensive program to save all the buildings whose walls were mostly intact and to interpret the story of the fort. Of the more than 50 stone and adobe buildings that constituted Fort Davis when it was abandoned in 1891, visitors can inspect 18 residences on Officers' Row, 2 sets of troop barracks, warehouse, and hospital. Sites of some other buildings, marked in most instances by stone foundations, can also be viewed. The protection, reconstruction, and interpretation programs are under the direction of a superintendent, whose address is P. O. Box 523, Fort Davis, Texas 79734.

A few of the historic incidents related to the Fort Davis community are:

1. The story of Indian Emily, an Apache girl, who was mistaken for the enemy and shot by a sentry as she tried to warn the fort of an attack (Scobee, 1947, pp. 61-63).
2. The story of Dolores, a beautiful Mexican maiden, who nightly until her death kindled a signal fire on the mountain top as assurance of her love and fidelity for Jose, who was murdered by the Indians (Scobee, 1947, pp. 79-84).
3. The two camel caravans that stopped at Fort Davis while being tested as beasts of burden in the Southwest (Echols, 1860; Scobee, 1947, pp. 31-32) (*see also* Indianola State Park, p. 114; Kerrville State Park, pp. 119–120).
4. The establishment of Jeff Davis County (Scobee, 1947, pp. 76-78).

Fort Davis has two observatories. One is the W. J. McDonald Observatory owned by The University of Texas, and the other is the Harvard College—Air Force Radio Observatory. The latter is on Cook Flat about 8 miles from town and is used mainly for a study of the sun. The McDonald Observatory, on Mount Locke, is reached from the Scenic Loop 16 miles from Fort Davis. Visiting hours for the public begin at 1:30 p.m. on Saturday and 2:30 p.m. on Sunday. Those who wish to see the stars at night through the 82-inch mirror telescope should write for a reservation, enclosing a stamped addressed envelope for reply. Visiting night is on the last Wednesday of the month.

During Henry Skillman's lifetime, he obtained a tract of land on the southern slope of the Davis Mountains, known as Skillman's Grove. This is where the Bloys Camp Meeting Association has held its annual religious service since 1890. The Association is nonsectarian; any denomination having an organization in the community may have its minister in the pulpit. No expense is spared to bring the most able and best pulpit orators to the people, and pastors from the largest churches in the State, as well as pastors from churches in the small West Texas towns, attend the annual meetings.

The rocks seen from the Scenic Loop are mostly lava and tuffs[1] of Tertiary age (table 1) that generally dip in a southeasterly direction. Associated with the volcanic rocks are several small plug-like masses, some massive sills, and a few dikes that have intruded the lavas and tuffs. The most prominent of the intrusions are Mount Livermore and Sawtooth peaks on the western skyline, and toward the south, Mitre peak near Alpine. Tiny areas of metamorphosed limestone and sandstone occur south of Sawtooth peak. These are probably small patches of Cretaceous rocks that are belived to underlie the Tertiary volcanic rock that forms most of the mountains (table 1).

Comprehensive geological reports have not been made for most of the Davis Mountains, probably because the mountains lie outside the provinces that have been intensely studied during the quest for oil. Also, the volcanic rocks have not yielded important mineral deposits. Some peripheral areas have been studied; Eifler (1951) described the volcanic rock that occurs along the northeastern margin of the mountains where there is an aggregate thickness of 1,500 to 1,700 feet. Here he named the McCutcheon Volcanic Series, subdividing the sequence into three formations, some of which have several members (table 1). Anderson (1965, 1968) studied the geology in the western Scenic Loop area where there are about 2,500 feet of extrusive volcanic rocks that he divided into a dozen formational units and several intrusions.

The eastern Scenic Loop area, which includes the Davis Mountains State Park, has not been studied in detail and neither is a geologic map available. The rocks are mostly lava with some tuff flows and other tuffaceous materials (fig. 45). The lavas are massive, jointed, and reddish brown on weathered exposures. Freshly broken surfaces are mostly gray or have bluish-gray tints. They are more or less porphyritic[2] and the phenocrysts are predominantly one of the feldspar minerals. Some of the lava is porous and much of it is banded. The tuffs and tuffaceous rocks are normally light in color; being softer than the lavas, they form slopes and are often covered by talus from the rocky ledges above. The rocks exposed along Keesey Canyon and Limpia Canyon in the park are mostly rhyolite[3] and are similar to the Star Mountain Rhyolite described by Eifler (1951). At Star Mountain, however, the formation consists of six flows that form vertical cliffs with palisades structures; the number of individual flows has not been determined in the park and the palisades structures are not prominent. The lower and upper rhyolite members that Anderson (1965, 1968) described 4 to 10 miles northwest of Mount Locke are also similar to the park rhyolites, but it will be necessary for more geologic work to be completed before a correlation can be made and names given to the rhyolitic rocks in the park.

The rocks exposed in the upper slopes of Blue Mountain (fig. 24) southwest of the Indian Lodge (park hotel) are gently dipping flows and tuff beds. They include grayish-purple and reddish-brown porphyritic rhyolite, nonporphyritic rhyolite, trachyte (similar to rhyolite but without quartz), and tuff with degrees of induration from friable to vitric (glassy).[4] The

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[1] A rock formed of compacted volcanic fragments, mostly volcanic ash. Tuff fall—a rain of airborne volcanic ash falling from an eruption cloud. Tuff flow—an avalanche of volcanic ash traveling down the flank of a volcano.

[2] Porphyritic—a textural term which indicates two sizes of crystals. The large crystals (phenocrysts) float in a finer groundmass that may be either crystalline or glassy.

[3] Rhyolite—an extrusive equivalent of granite.

[4] Volcanic glass—a natural glass produced by the cooling of molten lava; the cooling is too rapid to permit crystallization, forming such materials as obsidian and vitrophyre.

Vitric tuff—an indurated tuff deposit composed dominantly of glassy fragments blown from a volcano during eruption.

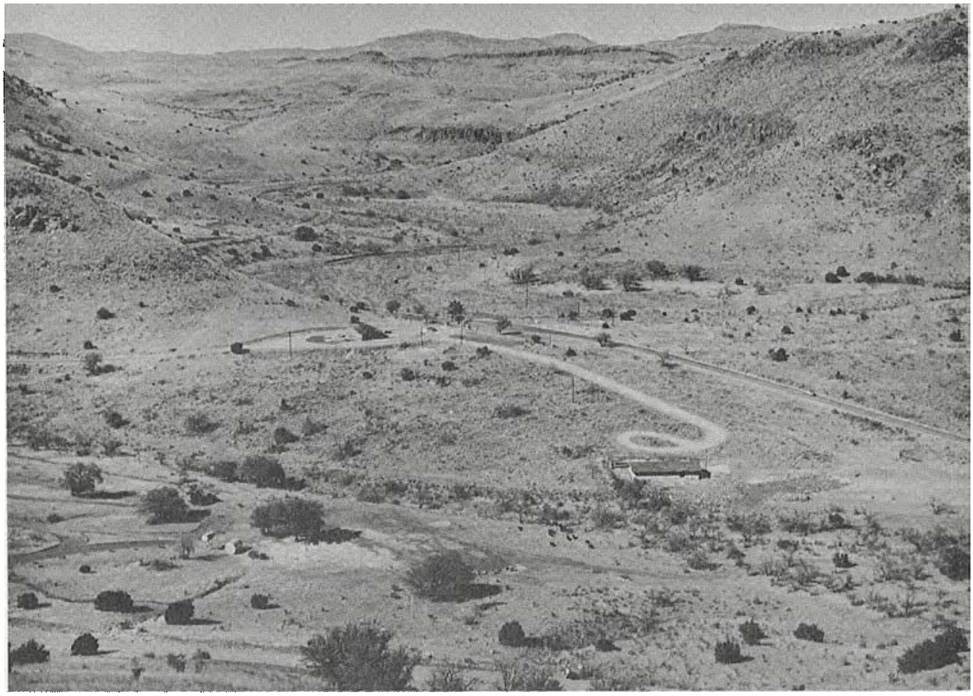

FIG. 45. Lava and tuff exposed in the Davis Mountains. The dark stony ledges are lava with columnar joints; the light slopes are underlain by tuff with variable induration. The valley was eroded in the soft rocks; the hilltops and ledges are capped by resistant lava beds. (Photograph by Texas Parks and Wildlife Department.)

rocks are similar to the Sheep Pasture and Barrel Springs[5] Formations described by Anderson (1965, 1968). The Scenic Loop road traverses these two formations in the lower southern slope of Mount Locke, and extensive outcrops of the Barrel Springs Formation are crossed by the road west of Bloys Campground.

As the Scenic Loop road ascends the western slope of Mount Locke, it traverses the Mount Locke Formation, named and described by Anderson (1965, 1968) from rocks forming the middle and upper slopes of the mountain. Here the formation is 580 feet thick and is mostly a gray porphyritic rhyolite with pinkish-gray phenocrysts that weather to reddish brown. Cliffs are formed near the base of the formation, but upward the slopes decrease and the surface becomes hummocky. The basal contact with the Barrel Springs Formation can be readily identified in a Scenic Loop road cut on the southwest side of Mount Locke. The rocks along this contact are altered; the green rock is the top of the Barrel Springs, the white (above) is the base of the Mount Locke Formation.

The summit of Mount Locke is capped by 110 feet of the Wild Cherry Formation (Anderson, 1965, 1968). The rocks include reddish-brown to black, banded vitrophyre (banded volcanic glass), a foliated purplish-gray porphyritic rhyolite that weathers brown, and indurated to friable vitric tuff. This formation is more extensively exposed in the upper drainage of Limpia Creek Canyon southwest of Mount Locke and is also seen on the hilltops at either side of the Scenic Loop road west and northwest of Bloys Campground.

Intrusive igneous rocks have not been found in the park, but persons who travel

[5] Shown incorrectly on table 1 (in pocket) as Barrel Spring Formation.

the Scenic Loop road will surely see Sawtooth Mountain (named for the peak's sawtooth-like notched summit), which is one of the larger intrusions in the central Davis Mountains. It is a sill or plug-like body at least 1,000 feet thick; its roof is eroded away and the floor is not exposed. The road crosses the southwest side of the mass and Bear Mountain west of the road is probably part of the same intrusion. Most of the rock is fine- to medium-grained, pinkish-gray syenite[6] that weathers reddish brown. The boulders at Rock Pile roadside park are also syenite and came from two small intrusions (hills) north of the road. Southwest of Bloys Campground is another intrusion, probably a thick sill. The rock is mostly yellow but it is also syenite. Anderson (1965, 1968) concluded that the color was produced by the iron oxide mineral limonite, which probably replaced the original mineral pyrite.

Mount Livermore, the dominant topographic feature in the central Davis Mountains, is also a plug-like intrusion. The rocks are mostly brick-red diorite and trachyandesite which are mineralogically different and also are more basic (mafic) than the syenites. On the northwestern slope near the summit are two prominent cliff areas formed by subcircular ring dikes. The dikes outline central depressions that are floored with landslide and talus debris. Another dike, about 1-1/2 miles long, is northwest of Whitetail Mountain and is visible from the Scenic Loop road about 3 miles southwest of the Rock Pile roadside park. There are some small dikes southwest of Whitetail Mountain. Some of the associated volcanic rocks are brecciated and are similar to a vent agglomerate. The brecciated rock areas are small, poorly exposed, and the presence of a volcanic vent area has not been established.

The northwesterly trending alignment of Sawtooth Mountain, Mount Livermore, and a smaller intrusion west of Blue Mountain suggests that the location of the larger intrusions is related to the regional structure of Trans-Pecos Texas. Faults in the underlying Mesozoic and older rocks (table 1) probably provided avenues for the ascent of the magma, which was formed from the refused, deeply buried sedimentary formations. From the studies now available, it is not possible to determine if the intrusions were the source of the extensive volcanic rock deposits, but it is commonly believed that the principal intrusions (Mount Livermore, Sawtooth Mountain, and similar intrusions) are younger than most of the volcanic rocks. The widespread occurrence of some lava units, the local distribution of others, and the scarcity of recognizable volcanic vents suggest that most of the volcanic rocks came from multiple fractures that are now concealed.

The volcanic rocks in the Davis Mountains normally dip 3 to 5 degrees in a southwesterly direction. There are a few small folds in some places but large-scale folding has not been recognized. Neither are there prominent erosion surfaces between the beds, which would certainly occur if there was extensive deformation during the time of deposition. There are, however, numerous nearly vertical gravity faults that have broken the volcanic rock layers. The majority of these have northwest trends paralleling the regional structure. In most places the vertical displacement is not more than 100 feet, but a few faults have a vertical displacement up to about 200 feet and can be traced for several miles. Some of the more prominent faults can be seen from the Scenic Loop road near the Barrel Springs Stage Route sign and from the road where it ascends the southern flank of Mount Locke. In the Mount Livermore—Sawtooth Mountain area, however, the faults have no apparent regular pattern and many of them do not have the northwestern trend. This suggests that the faults are related to the

[6] Syenite—normally a coarse-grained, pink or gray intrusive rock similar to granite except that syenites contain litt'e or no quartz. Most of the Davis Mountains syenites are fine grained and porphyritic.

emplacement of the intrusions and is supporting evidence to the suggestion that the large intrusions are younger than the volcanic rocks.

The rocks in some places in the central Davis Mountains have been silicified and otherwise altered by hydrothermal solutions. The altered material ranges from a hard, chert-like siliceous rock to a relatively soft granular rock rich in kaolin and other clay minerals. Probably the first area studied was at the "mine" on the Medley ranch where the altered rocks cover an area of a few square miles. They form a prominent pink and white escarpment north of the Scenic Loop road that is clearly visible from near Bloys Campgroup. Vogel (1942) studied the area, describing the silicification and the occurrence and distribution of the rutile and kaolin. Silicification is also present in the rocks on both sides of the road near the Barrel Springs Stage marker. Isolated patches of the altered rocks are found northwestward for 2 to 3 miles. The alteration at both the Barrel Springs and Medley Ranch areas is associated with faults which are believed to have provided the avenue for the movement of silica-rich solutions. Alteration along joints in the Barrel Springs Formation may be seen about three-quarters of a mile south of Bloys Campground.

Altered rocks are again present in an area near where the Scenic Loop road crosses Madera Canyon northwest of Mount Locke. Here a coarse-grained lava is faulted against a fine-grained lava with different mineral composition. Harvill (1961) concluded that the different mineral composition of the parent rocks was the controlling factor in the formation of the different minerals. He believed that acidic hydrothermal solutions, 100° to 300°C., ascended along the fault and joints adjacent to it, and that these solutions removed the sodium and potassium from both rocks. The coarse-grained lava contains more magnesium and iron than does the fine-grained rock, and part of these two minerals was left behind to form the green mineral nontronite, locally called "poison green rock." All of the magnesium and iron were removed from the fine-grained rock and the whitish kaolin deposit was formed.

Altered rocks are also found in some places where faults have not been recognized. One of these is at the stratigraphic contact between the Mount Locke and Barrel Springs Formation and is exposed in a cut along the Scenic Loop road on the northwest side of Mount Locke. Here the whitish alteration extends upward from the contact into the Mount Locke Formation for a distance of 4 to 5 feet, and the greenish alteration extends downward about 2 feet into the Barrel Springs Formation.

The hydrothermal solutions responsible for the alteration products are believed to have come from intrusions, most likely the syenite masses. The solutions ascended along faults or joints and in some places they moved laterally along stratigraphic contacts where sufficient permeability was encountered. The solutions reacted chemically with the different mineral content of the parent rocks producing the different alteration minerals.

EISENHOWER BIRTHPLACE STATE HISTORIC SITE

Ross A. Maxwell

Eisenhower Birthplace (about 3 acres) is a restored two-story, multigabled, frame house on the northeast corner of Lamar Avenue and Day Street in Denison (Grayson County), Texas (fig. 46). It was here that General Dwight David Eisenhower, supreme allied commander of World War II and 34th President of the United States, was born on October 14, 1890. The home, probably built about 1880, was rented by the future President's father, who worked in the Missouri, Kansas & Texas Railway shops. The house is clearly visible to passengers on the railroad and is only a short distance from U. S. Highway 75.

Much research regarding the original plan and appearance of the house and grounds was necessary before restoration could begin. Mr. Eisenhower was able to give but little help in planning the restoration, as his family had moved to Abilene, Kansas, in 1891. The President's mother, Mrs. Ida Eisenhower, verified the place of birth. Arthur Eisenhower, an older brother, remembered sitting on a flat-topped fence post waiting for the tamale man. Others who lived in the old house or were the Eisenhower's neighbors contributed some recollections.

Research on the Eisenhower birthplace home was accomplished by a committee from the City of Denison, the publisher of the local newspaper, and the Denison Chamber of Commerce. Representatives from these groups organized the Eisenhower Birthplace Foundation, Inc., that was chartered on the President's birthday in 1953. The National Park Service and the Texas State Parks Board were

FIG. 46. Eisenhower Birthplace. The house where Dwight D. Eisenhower, 34th President of the United States, was born. (Photograph by Texas Parks and Wildlife Department.)

asked to suggest plans for a park setting centered about the old home. When these plans were completed, the property needed for park purposes was acquired by the Foundation. These transactions were effected on February 8, 1955, and in 1958, the area was transferred to the Texas State Parks Board for a historic site.

The old house is a museum and is open to the public. The restoration is complete with furnishings of the period and a few personal effects of Mr. Eisenhower. One of the old furnishings is a crank-type telephone on the wall. When the receiver is lifted, the former President's voice is heard, saying: 'Hello, there! This is Dwight Eisenhower, born in this house, greeting you. While you are visiting here in Denison, I hope you will pause to contemplate for a moment the history of this great State of Texas and its importance to our great country."

The Main Street Limestone, named by Hill (1901) because of its presence beneath the main street of Denison, probably underlies all of the Eisenhower birthplace site but because of cultural improvements, the formation is now covered (table 1). Where the formation is exposed, it consists of massive, hard, buff, semicrystalline limestone, with thin layers of calcareous clay and marl (fig. 47). The Main Street is significant in the Denison area because it is the only hard limestone unit in a thick sequence of clay and is an important marker for stratigraphic and structural work. The rock is conspicuously fossiliferous and contains various species of clams, oysters, snails, and a few ammonites. The two distinctive species are *Exogyra arietina* (rams-horn-shaped oyster) and *Kingena wacoensis,* the only brachiopod commonly found in the Lower Cretaceous rocks in Texas.

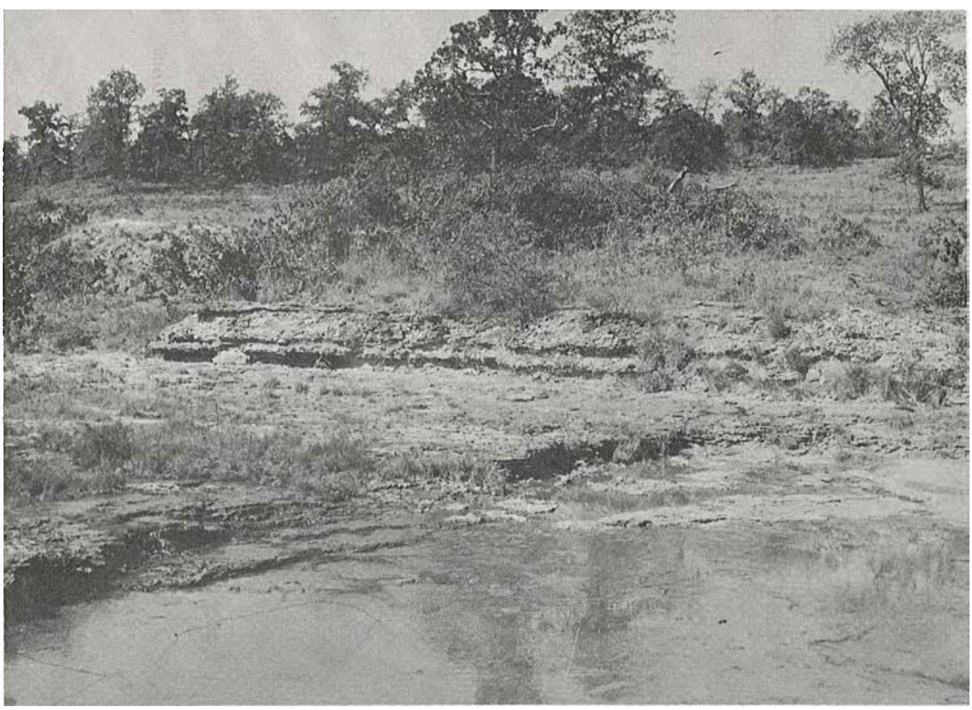

FIG. 47. Main Street Limestone (light-colored ledge) near Denison, Texas. Dark beds in lower left are Pawpaw Formation. The Main Street is a significant rock unit in the Denison area because it resists erosion, can be traced across the countryside, and is used for a stratigraphic marker during geologic mapping. (Photograph by P. U. Rodda.)

EISENHOWER STATE RECREATION PARK

Ross A. Maxwell

Eisenhower State Park is on the south side of Lake Texoma, formed by the Denison dam built across the Red and Washita rivers. The lake is among the largest man-made reservoirs in the United States and has a surface area of about 144,000 acres. In addition to protection from flood damage and the production of hydroelectric power, the reservoir provides water for municipal, industrial, and recreational uses in both Texas and Oklahoma. The park (450 acres) is off State Highway 75A about 7 miles northwest of Denison in Grayson County (Pl. I). The park was acquired in 1954 by Department of Army lease that expires in 2004 A.D. and was named for General Dwight D. Eisenhower, 34th President of the United States (*see also* pp. 82–83).

The Lake Texoma shoreline included within the park has rolling topography, many peninsulas and narrow points, coves, and beaches that make it an ideal area for water sports and recreation. Planning for development was started during the CCC program when it was called the Denison Dam Demonstration Area, but for several years there were few accommodations for visitors; a floating marina provided shelter for boats, boat repair services, fishing barge, and snack bar. A half-million dollar development program is now in progress. Planned improvements include paved boat ramp and fish-clean-

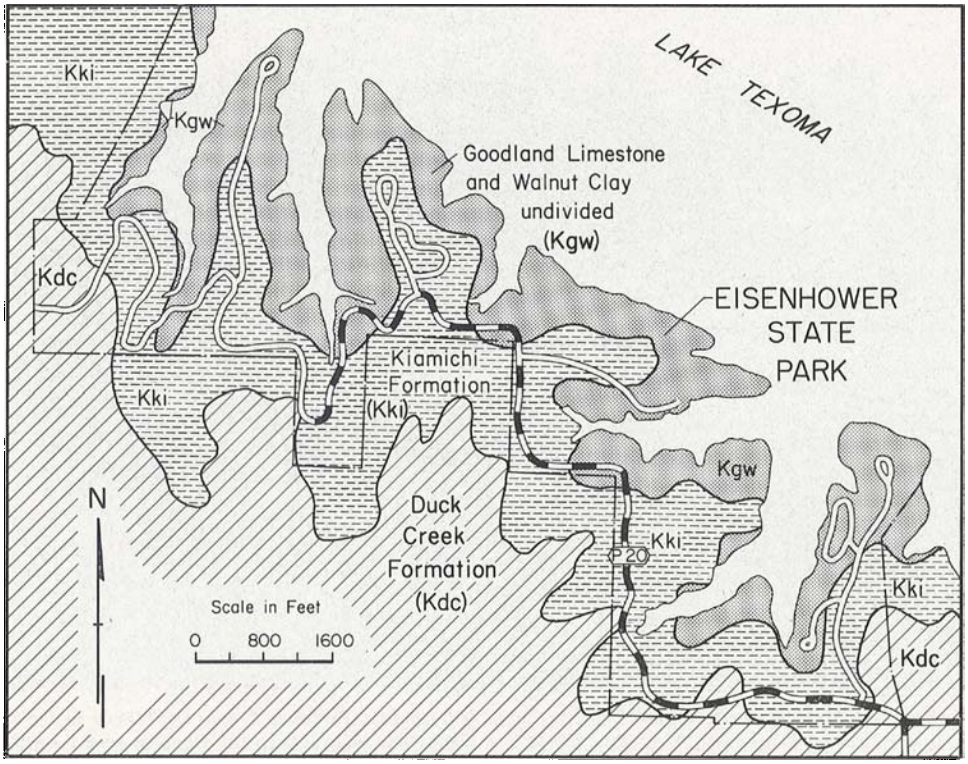

FIG. 48. Geologic map of Eisenhower State Recreation Park.

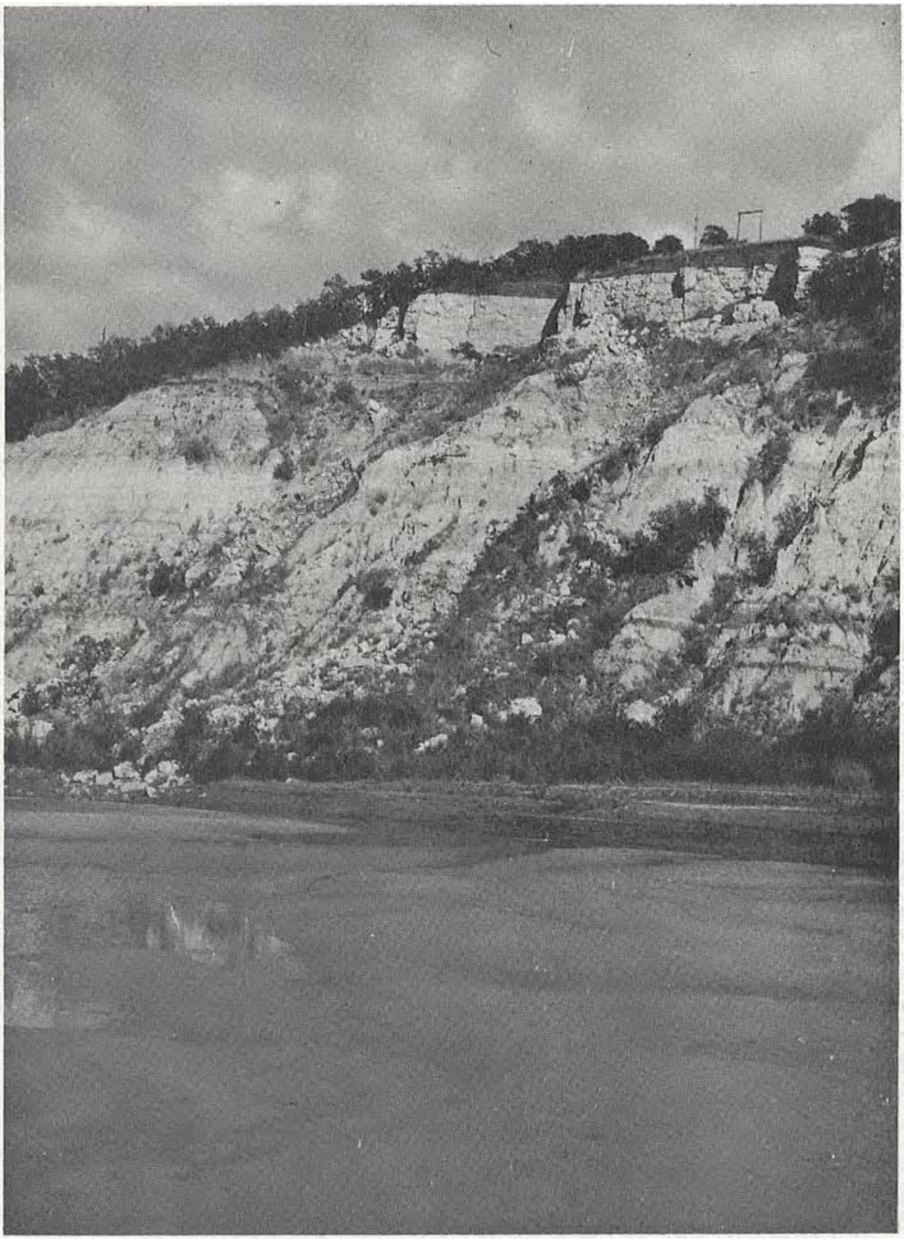

Fig. 49. Stratigraphic sequence like that exposed at Eisenhower State Park. Red River in foreground. Light sandstone and clay above the river are the Antlers Formation. The Walnut Formation underlies a dark slope above the Antlers. Goodland Limestone is light ledge near top. Kiamichi Formation (mostly soil) is the highest dark band. (Photograph by P. U. Rodda.)

ing shelter equipped with running water. There are new trailer sites, each with water, sewage, and electric connections. Screened shelters, picnic tables, cooking grills, and drinking water facilities are available. Modern rest rooms, showers, and extensive parking are planned.

A large section of the park's northwest

side is untouched by construction. The woodlands of cedar, elm, ash, and sumac, and the prairie grasses characterize the vegetation. This provides a natural home for white-tail deer, raccoon, squirrel, and numerous birds including mourning dove, bobwhite quail, and red-tailed hawk.

The geologic formations in Eisenhower State Park are shown on the Sherman Sheet of the Geologic Atlas of Texas. All of the rocks, except the river silt and alluvium, belong to the Trinity and Fredericksburg Groups of the Lower Cretaceous (table 1). Fluctuations in the lake level are responsible for periodic exposure of some of the lower units (fig. 48). When the water level is low, the upper part of the Antlers Formation is exposed locally in some of the coves. The Antlers is a sandstone and clay facies that toward the south, the middle part of the formation, grades into the Glen Rose Limestone (fig. 49). Where the Glen Rose is present, the underlying and overlying sand and clay units are, respectively, termed the Twin Mountains and Paluxy Formations. In the subsurface of Grayson County, the Antlers is up to 300 feet thick and is an important aquifer, but seldom is more than the upper 20 feet exposed along the lake shore within the park. It is mostly a fine- to coarse-grained quartz sand with subordinate amounts of clay; clay content increases northward, and in the park, the upper few feet of the formation are also clay.

At low water stages, about 7-1/2 feet of the Walnut Foundation may be exposed locally above the Antlers. This is a gray calcareous shale and clay with a few beds of limestone up to 1 foot thick. It becomes more calcareous southward toward Central Texas (*see* Cleburne State Park, pp. 64–69). The Walnut contains numerous fossil oysters, some clams, snails, and a few ammonites.

The Goodland Limestone overlies the Walnut Formation and at normal water level forms the beach line along the park. The rock is mostly fine-grained chalky limestone that weathers white or to various shades of gray. In the upper part of the formation, there may be a few thin beds of coarse-grained limestone, and this is quarried for aggregate in the Preston area. The Goodland in Grayson County seldom exceeds 30 feet in thickness and is about 12 feet thick in the park. The outcrop feathers out eastward and grades into the Edwards and Comanche Peak Formations toward the southwest.

The flattish areas above the lake shore are underlain by the Kiamichi Formation. This is mostly a dark bluish-gray calcareous clay with thin limestone beds. The thickness varies due to elevation but is only a few feet thick within the park. Fossils, mostly clams, snails, and sea urchins, are common.

Many fossils, some of them excellently preserved, were unearthed during construction of the dam. Some of these were collected, saved and later placed on display at the Corps of Engineers office. A brief trip to see the display is suggested for those who are interested in fossils. Other fossils were found during clearing and grading operations for the trailer camp. Some of them were saved and can now be seen in the stone gateway arch at the park entrance.

The Duck Creek Formation underlies a few of the highest slopes along the park's southern boundary and is more extensively exposed toward the south and southwest.

FALCON STATE RECREATION PARK

Ross A. Maxwell

Falcon Dam, on the Rio Grande Basin, is in Starr County; it is 3 miles west of Falcon Heights and about 80 miles downstream from Laredo (Pl. I). The international reservoir is in Starr and Zapata counties, Texas, and in Estado de Tamaulipas, Mexico. The project is owned jointly by the United States and Mexico and is operated by the International Boundary and Water Commission. The dam and reservoir were developed for flood control, water conservation, hydroelectric power, irrigation, and recreation. Construction began in 1950 and the completion date was April 18, 1954. The dam is a compacted, rolled-earth structure with a total length of 26,294 feet and a height of 150 feet. The reservoir's summer storage capacity is 2,371,220 acre-feet, with surface area of 78,340 acres. Above the summer storage elevation there are an additional 904,480 acre-feet for flood control storage, and 40,000 acre-feet for conservation storage is allowed during the winter months. Dowell (1964, pp. 137-140) has published additional data on the dam, reservoir, and power plants.

Several historical events have occurred in the area near Falcon State Park. Probably the first Europeans came in 1747 when Captain Miguel de la Garza Falcon and his men crossed the Rio Grande near Eagle Pass and followed the river's course to its mouth. Indians living in the area at that time were the Carrizo, Barrado, and Tepemaca tribes. Jose Vasquez Borrego brought the first Spanish settlers to the area in 1750. Later that year all settlements in the area were combined under the leadership of Jose de Escandon in a larger colony at Nuevo Santander. The town of Carrizo, later named Zapata, was settled in 1770. The original townsite was flooded by the Falcon Reservoir, and the town was moved to its present location.

Falcon State Park, a short distance above Falcon Dam, is mostly in Starr County, but a small flat promontory along the east side of Arroyo Medio juts into the Zapata County part of the lake. Land for the park, 572.6 acres, was leased by the Texas State Parks Board from the International Boundary and Water Commission in 1954; the present lease terminates in 2005. During 1964, the Parks and Wildlife Department began building the park's visitor facilities. The principal roads are paved, and the Administration-Concession building was completed in early summer 1965. The trailer park is heavily used and the new screened shelters are popular. There are also a conveniently located boat ramp, dock, and campground. The park is accessible via Farm Road 2098 from U. S. Highway 83, and there is a landing strip for those who choose air travel.

Fishing is the park's most popular recreational activity, and a fish-cleaning shelter is provided. Boating and water skiing activities are popular, and scuba divers, because of the clear water and rocky ledges along the river channel, are increasing in numbers. The bird watchers, who range up and down the Rio Grande Valley, frequent the park and a checklist of birds is being prepared by the Parks and Wildlife Department.

The Rio Grande and its tributary valleys have trenched the land surface from above Laredo to near the Starr-Hidalgo County line. The belt of maximum erosion is commonly called the Breaks of the Rio Grande and in this area is the Falcon Reservoir. The width of the erosion belt varies with the length of the tributary streams, which normally do not exceed 15 miles. Because most of the tributaries have shallow valleys in their upper course, the Breaks of the Rio Grande are confined to a belt more narrow than the tributary stream's length, and in some places the plain's unbroken surface extends almost to the Rio Grande gorge, now inundated by Falcon Lake.

The relief and roughness of the surface vary from place to place with the changes in the character of the rocks (fig. 50). Where the streams cut into hard rocks that resist erosion the valleys are normally deep, narrow, and have steep sides. Several hard rock ledges in the Cook Mountain Formation of Zapata County form a rough hilly surface with north-south-trending ridges that have steep western faces. In contrast, the clay in the Yegua offers less resistance to erosion, which, plus the eastward dip of the rocks, results in an attractively irregular shoreline.

Rocks in the vicinity of Falcon State Park are of Eocene age. They form north-south bands across the surface, the oldest formations crop out toward the west, and the rocks become younger eastward. When the reservoir is at the average operating level only the Yegua Formation crops out in the park; its average width of outcrop is about 4 miles (fig. 51). Along the Rio Grande gorge, now submerged, and also beyond the lake shore farther northwest in Zapata County is the Cook Mountain Formation. On the Gulf Coastal Plain toward the northeast, the rocks belonging to the Cook Mountain are subdivided into the Crockett Formation and the Sparta Sandstone (table 1). A short distance east of the park is a band of rock, average width about 12 miles, be-

FIG. 50. Flattish surface and landing strip near Falcon State Park. The underlying rocks are in the Yegua Formation that consists of sandstone and shale. The vegetation indicates the low sandy ridges that resist erosion and extend from left to right across the area. The more dense vegetation occupies the shale-covered valleys. (Photograph by Texas Parks and Wildlife Department.)

longing to the Jackson Group. At some places in the central Coastal Plain, the rocks of this unit have been subdivided into four formations (table 1). East of the Jackson are the younger Frio and Catahoula Formations. In northwestern Starr County and farther northwest in Zapata County are small sand dune areas of Recent age (table 1).

The Cook Mountain Formation is predominantly firmly cemented sandstone, but there are layers of clay, fossiliferous limestone, and limestone concretions (fig. 52). The formation is of marine origin and many of the beds are abundantly fossiliferous. The fossils are an aid when recognizing the Cook Mountain Formation and distinguishing it from the underlying rocks and the Yegua Formation above (table 1).

The Yegua occupies a stratigraphic position between the Cook Mountain and the overlying Jackson. It consists mostly of marine clay, but there is some weakly resistant lignitic sandstone. Fossils are found in most of the clay, but they are not so abundant as in the Cook Mountain nor is the number of species as great. Most of the area underlain by the Yegua Formation is open prairie with dark soil and is easily distinguished from the rolling sandstone hills and red sandy soil formed from the Cook Mountain.

The Jackson Group in Starr County

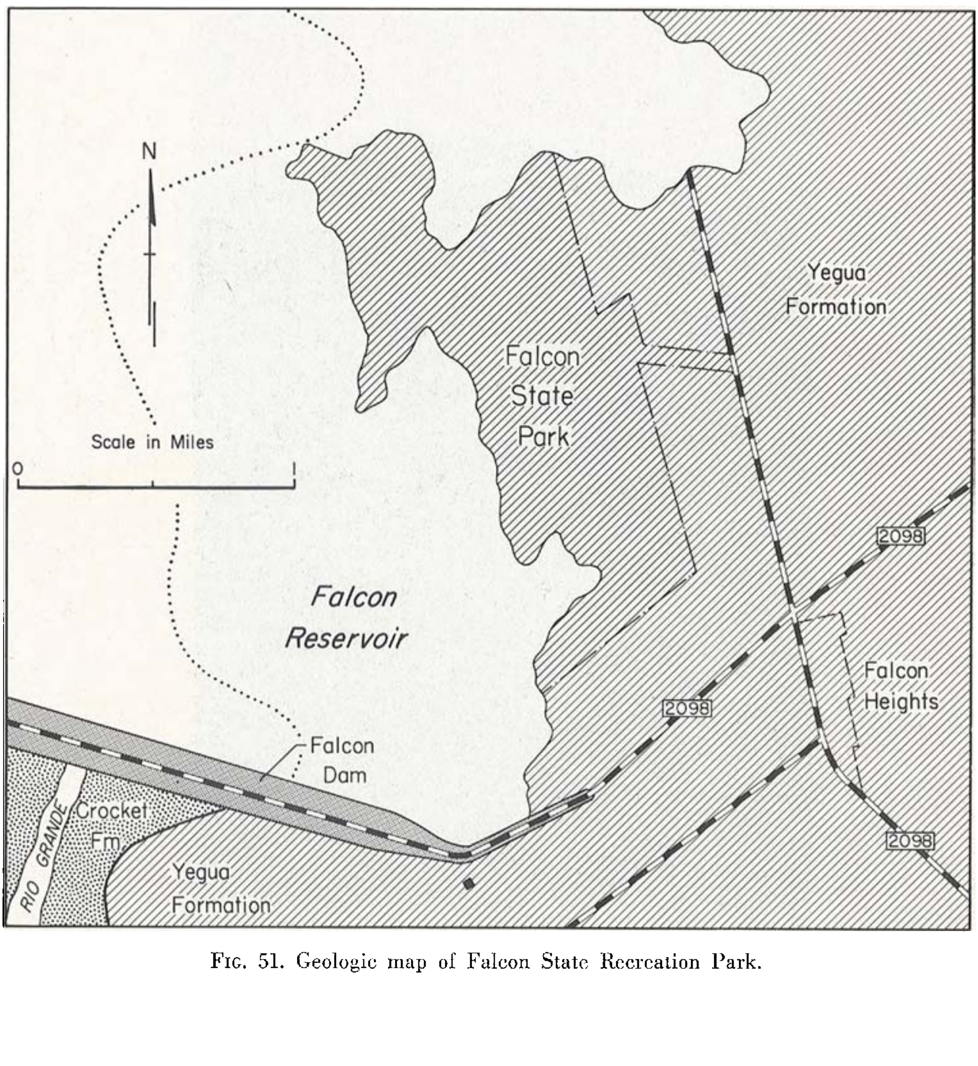

FIG. 51. Geologic map of Falcon State Recreation Park.

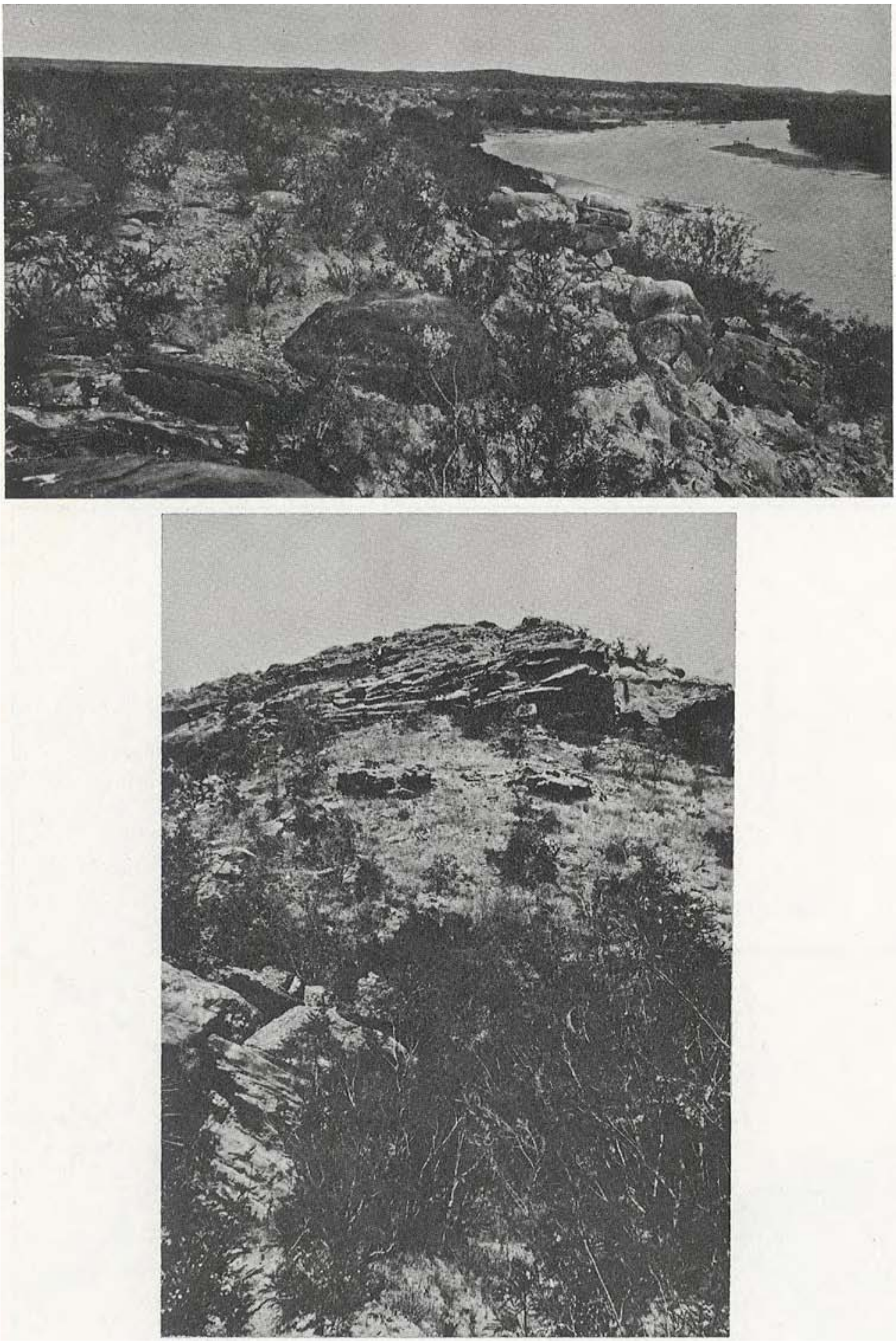

FIG. 52. Sandstone ledge and concretion beds cap shale slope in the Cook Mountain Formation along the Rio Grande northwest of Falcon State Park. (Photographs by John T. Lonsdale.)

contains more sandstone than clay, and the sandstone layers commonly have intricate cross-bedding. The sandstone is also exceedingly variable in color, texture, and consolidation. Interbedded with the sandstone, especially in the upper part, are varicolored clay layers and in some places thin beds of white volcanic ash; this indicates that volcanic eruptions were in progress during at least part of Jackson time, but the source of the volcanic dust is not known. The presence of land plants, leaves, and lignite streaks in some of the Jackson strata, numerous marine fossils, and current action, inferred by the cross-bedding in others, indicate a low-lying coastal plain or near-shore deposition with frequent oscillations in the level of the land surface; the formation is thus part continental and part marine.

FANNIN BATTLEFIELD STATE HISTORIC PARK

Ross A. Maxwell

Fannin Battlefield State Historic Park (13 acres) is in Goliad County on Park Road 27 off Farm Road 2506, which intersects with U. S. Highway 59 at Fannin, about 9 miles east of Goliad. It was on this site that Col. J. W. Fannin surrendered himself and 284 of his soldiers to the Mexican General Jose Urrea following the battle of Coleto Creek on March 20, 1836. Other soldiers under the commands of Amon B. King and William Ward who were captured near Refugio along with Fannin and his men were marched to Goliad and imprisoned. According to terms of the surrender, all soldiers were to be treated as prisoners of war, but General Santa Anna decreed that all were traitors and ordered their execution. On May 27, 1836, 342 of the men were shot, 28 escaped, some were eventually recaptured, and a few managed a second escape. Fannin, because he was wounded, was shot separately at the Mission in Goliad.

The historic site was acquired by Act of the Legislature on September 1, 1965, when jurisdiction was transferred from the State Board of Control to the Parks and Wildlife Department. The facilities and activities include a memorial monu-

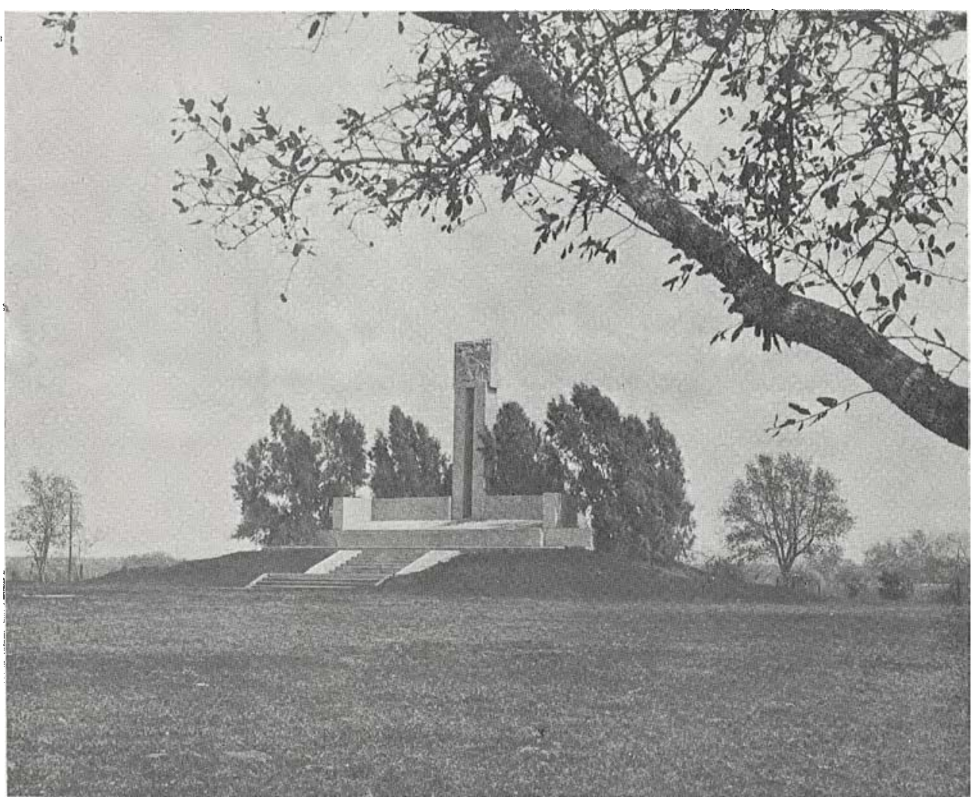

FIG. 53. Fannin Memorial Monument near Goliad State Park (pp. 106–108) rests on an artificial fill above a featureless plain eroded in sand and clay beds in the Lissie Formation. (Photograph by Texas Parks and Wildlife Department.)

ment honoring the heroes (*see also* Goliad State Park, pp. 106–108), picnicking, camping, and historic studies.

The battlefield site is underlain by strata of the Lissie Formation, named from the town of Lissie in Wharton County (table 1). The formation consists of sand containing lentils of gravel and clay that are cemented with caliche. The rocks weather to form a dark gray sandy loam soil on a featureless plain (fig. 53). Most of the formation was deposited along river flood-plains during the Ice Ages, but part of it is delta sand, silt, and mud deposited at the mouths of rivers as the streams enter coastal bays and lagoons. Fossils are rare but there are some fragmental plant stems and leaves and a few fresh-water snails.

FORT GRIFFIN STATE HISTORIC PARK

Ross A. Maxwell

Fort Griffin State Park, consisting of 503 acres, includes the old fort and village sites and a wooded section of the Brazos River bottom. Land for the park was donated to the Texas State Parks Board by Shackelford County in 1937. Ceremonies commemorating the 100th anniversary of the founding of Fort Griffin were held July 26, 1967, with then Lt. Governor Preston E. Smith as the keynote speaker.

The park is bisected by U. S. Highway 283 about 14 miles north of Albany (Pl. I). Ruins of the old military installation on Government Hill are west of the highway and are accessible by road (fig. 54). All that remains of the old village Griffin is on the edge of the flat below; campgrounds and picnic tables are in a wooded valley east of the highway.

The park's principal values are historical. The results of campaigns waged by soldiers, the Fort's responsibilities to outlying military camps, their geographic association to the old Clear Fork Comanche Indian reservation, the hardships of the early settlers who pushed the frontier into Indian country, the boom-town Griffin and its importance as a source of supply for the settlers, trail drivers, and

FIG. 54. Rolling plateau surface at Fort Griffin. Ledges of the Coleman Junction Limestone crop out in exposures at upper right and left and cap the plateau. The Santa Anna Branch Shale crops out in the valley along the highway. (Photograph by Texas Parks and Wildlife Department.)

buffalo hunters, and reasons for the town's decline have been ably described by Rister (1956) in his book "Fort Griffin on the Texas Frontier." The park's activities also include camping or picnicking in the shaded groves and fishing in the Clear Fork. Some visitors enjoy seeing the famous Longhorn herd from which Bevo IV, Bevo V, Bevo VI, Bevo VII, Bevo VIII, and Bevo IX, famous mascots for The University of Texas at Austin football teams, were selected.

The climate of the Fort Griffin area was not all that could be desired by the frontier families. There were dazzling snowstorms in mid-winter, choking dust storms in the spring, and frequently drought and heat that parched the soil and vegetation in summer. Normally, however, the April-May rains brought forth a luxuriant growth of green grass and flowers, and as the early cattlemen rode into the Clear Fork Valley, they recognized the value of the fertile river bottom soil and the desirable grazing lands in the hills. The area was inhabited by game, including buffalo, deer, turkey, and quail, and was a popular hunting ground for the Comanche and Tonkawa Indians. The advancing frontier was soon contested by the Indians, and in order to protect the settlers and to have a base for campaigning in other areas, the Army established Fort Griffin.

Fort Griffin's history began on July 31, 1867, when Lt. Col. S. D. Sturgin led a cavalry troop from old Fort Belknap to the Clear Fork of the Brazos, establishing a military post. It was temporarily called Camp Wilson, but later the name was changed to Fort Griffin in honor of Gen. Charles Griffin, who commanded the military department of Texas during 1866-67 (Rister, 1956, pp. 64-65). Col. Sturgin began work immediately, and in a few days the top of Government Hill was cleared of mesquite brush and cactus and the larger trees were either uprooted or trimmed. The Quartermaster depot at San Antonio sent ox-drawn wagon trains with building materials and tools. By winter a line of officers' quarters and 14 huts for the enlisted men were completed from locally sawed lumber and logs. The next summer the building program continued and included a log store building, two frame storehouses, one log hospital, log quarters for the commanding officer, the post surgeon, and two subordinate officers, 18 frame company quarters, and one frame stable. Other quarters for the assistant surgeon, hospital attendants, laundries, and the noncommissioned officers and their families were built before the fort was abandoned. Although the original building plan was to substitute stone buildings for the log, frame, and picket structures, only part of the program was completed. The commissary, bakery, hospital, powder magazine, and commanding officer's quarters were finally built wholly or in part of stone (fig. 55).

During the early 1870's, 300 or more officers and enlisted men (both cavalry and infantry units) were stationed at Fort Griffin. They campaigned against the Indians and bandits, protected the settlers, freight and mail routes, cattle drives and buffalo hunters from depredation, and served the community in many ways. These activities were documented by Rister (1956). As the need for military protection declined, the number of soldiers was decreased. Only one company remained during most of the late 1870's and the post was abandoned on May 31, 1881.

The village adjacent to Fort Griffin, commonly called Griffin or The Flat, was started in 1867 when Sam Newcomb established a mercantile business on the river valley flat at the foot of Government Hill. This was the only trading post for miles along the Clear Fork, and a number of families settled nearby because they had the fort's protection, could purchase supplies, sell produce, and send their children to a subscription school. Some of the men obtained contracts to furnish beef, hay, wood, and lumber to the fort, and others were employed as

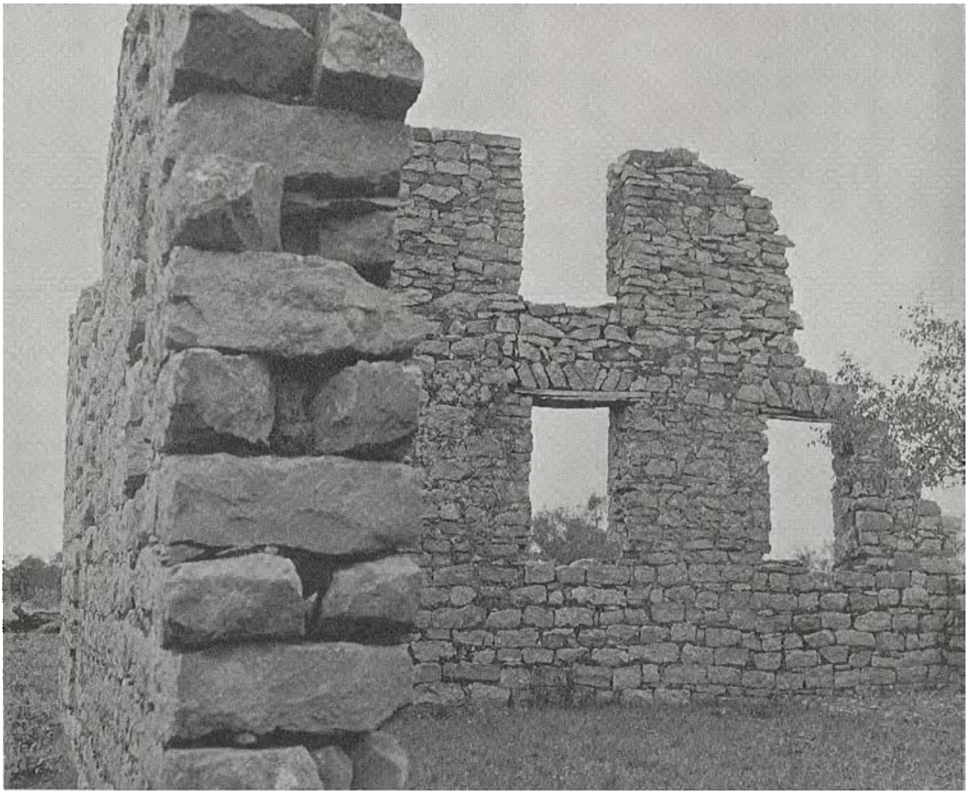

FIG. 55. Ruins of Fort Griffin. Structures built from the Coleman Junction Limestone. (Photograph by Texas Parks and Wildlife Department.)

freighters. Within about five years (1872) the settlement had grown from a few scattered houses to a boisterous bustling village whose main street stretched from the foot of Government Hill to the river. In front of every store, restaurant, saloon, dance hall, or other business was a long hitching rack that was often lined with saddle horses, and the street was congested with ox or mule-drawn freight wagons, hacks, and buggies.

The village population was a heterogenous mixture of soldiers, businessmen, settlers, Indians, bullwhackers, teamsters, buffalo hunters, cowboys, surveyors, gamblers, prostitutes, outlaws, murderers, horse thieves, and drifters. There were many brawls and personal privileges were often enforced with a six-shooter. There was but little legal restraint or law enforcement. For a time, The Flat was classed as one of the West's wildest towns, and for a few years Griffin was not outrivaled by Dodge City, Kansas.

By 1875 farmers had overrun parts of the established trails and many Texas cattlemen had shifted their drives westward, pointing their herds toward Griffin, thence northward to intersect the western trail from San Antonio to Dodge City. The Clear Fork Valley provided water, shade, forage, and a place to rest; the village was a place to purchase supplies for the trip ahead, relaxation, and entertainment. Drovers were scarce and the trail boss often employed cowboys without asking about their past. A few thus employed were desperadoes and ready for any kind of violence, but most of the drovers meant no real harm; they only sought release for pent-up spirits after spending days on the dusty trail. How many cattle went up the trail via Griffin is not known. Rister (1956, p. 151) reported that from 1875 to 1880, 450,000 head belonging to one man passed Fort Griffin, and there were at least six more large herd owners who used this trail. These heavy livestock movements brought the Griffin businessmen ever-increasing trade and wealth during the driving season.

Buffalo hunters and the hide industry comprised a large part of the business. Rister (1956, p. 195) reported that 1,600 hide hunters were on the southern buffalo range in 1877, that most of their supplies were purchased from Griffin merchants, and that during August of that year, 200,000 hides were sold in Griffin. Some of the merchants carried a stock of supplies valued up to $40,000 and made daily sales of as much as $4,000. Some of the merchants advanced cash to the hunters, received deposits from their hide sales, and performed some banking conveniences. The buffalo hide industry began a marked decline in 1878, and by the fall of 1879, the great southern herd was all but extinct; hunters left Griffin and the merchants lost a large percentage of their business.

Several factors contributed to Griffin's business recession that began in 1878 with a marked decline in the number of buffalo hides taken. In the late 1870's a few Albany merchants began to claim some of the trail drivers' trade and by 1880 had obtained most of it. Purchases made by the Fort and individual soldiers and their families declined as the men were moved out, but the fatal blow came when Griffin was by-passed by the railroads. After 1881, both the population and business declined rapidly, and in a few years, half the buildings were vacant. At the beginning of the 20th century, only a general store and post office re-

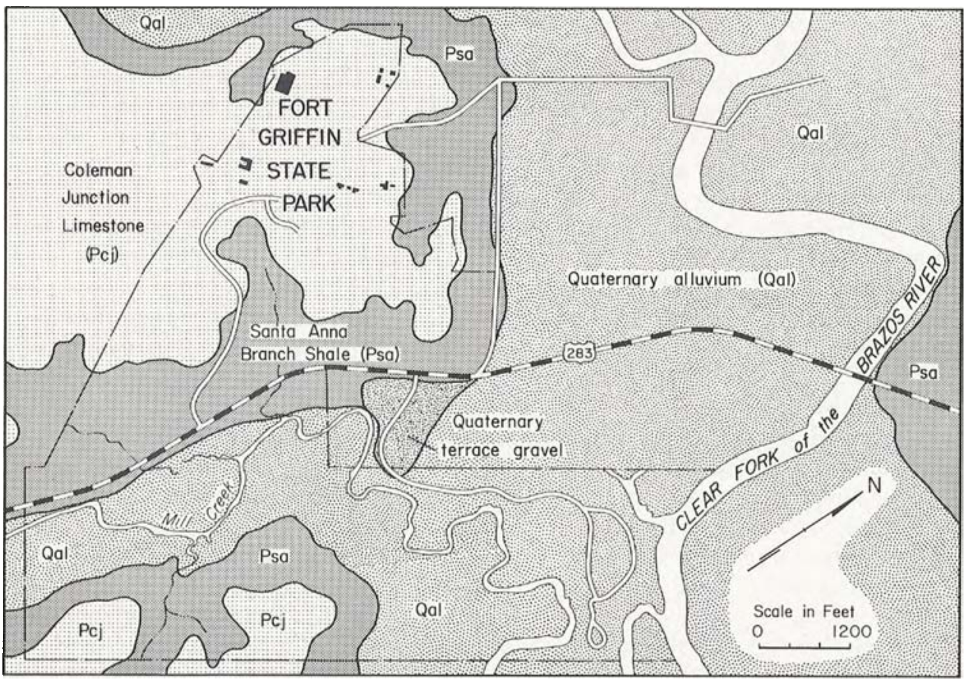

FIG. 56. Geologic map of Fort Griffin State Historic Park.

mained. They too were later abandoned and what was once the wildest town in the West passed into oblivion.

In the North-central Plains (Pl. I), streams have removed the Cretaceous rock from large areas, exposing the underlying Permian and Pennsylvanian formations (fig. 56). Following removal of the Cretaceous cover, streams like the Clear Fork of the Brazos began trenching the older Paleozoic formations, leaving valleys similar to those seen north of Fort Griffin. Here, except during flood stage, the river flows with sluggish current in a meandering channel, through a valley 1 to 2 miles wide. The channel is fringed with trees, mostly pecan, elm, and hackberry, and farms are common along the valley bottom. The river bottom is bordered on both sides by a rolling hilly plateau that rises 50 to 75 feet above the valley; it is clad with mesquite, oak, cactus, and grasses. It is along the plateau rim and in the tributary drainage channels that most of the bedrock is exposed (fig. 54).

The Lower Permian and Upper Pennsylvanian formations, like those exposed in Shackelford and adjacent counties, were deposited during epochs when there were frequent changes, both vertically and laterally, in the type of sediments deposited. Depositional and erosional features preserved in some of the rocks show that the shoreline shifted back and forth across the area many times. Most of the conspicuous limestone units exposed south of the Callahan Divide (Pl. I) thin northwestward and grade into clay or sandstone units. In the latitude of the park most limestone beds are thin and pinch in and out as the clay units thicken. Some thick clay units enclose long slender sandstone bodies; some of these are probably barrier sand bars and others are erosion channels that were filled by stream deposition when the surface was above sea level.

Geologists have been studying the rocks in the North-central Basin for many years. The rapid change in rock types, the pinch-out of lithologic units, the overlapping Cretaceous cover along the Callahan Divide and also in a large area east and north of Fort Griffin have caused confusion for those trying to trace key beds northward across the area. Certain formational names and lithologic divisions used in the southern part of the province do not always apply to the rocks farther north, and there has been disagreement as to formational boundaries and the correlation between units. Plummer and Moore (1922) laid the foundation presently used for dividing, naming, and correlating the rock units exposed in the Fort Griffin area. This work was subsequently modified by Stafford (1960b) who published a report and geologic map that includes Fort Griffin.

The rocks underlying the old Fort Griffin military installation belong to the Coleman Junction Limestone, upper member of the Putnam Formation of Permian age (table 1). The Coleman Junction Limestone also caps the prominent and persistent escarpment bordering the valley of the Clear Fork of the Brazos River. At most places in northern Shackelford County, this member consists of two units: (1) a lower hard, fine- to medium-grained, buff or light yellow to yellowish-brown limestone ledge, 3 to 12 feet thick, and (2) the upper ledge, a bright yellow, highly ferruginous layer, 1 to 2 feet thick. On weathering, the bright yellow higher ledge breaks into rounded yellow pieces that slump down the slopes forming a conspicuous colored trail around the hillsides. Some ledge surfaces have marine shell fragments and crinoid stems, a plant-like animal that lived in the Permian sea. The Coleman Junction Limestone was quarried locally and used for construction of the officers' quarters, bakery, powder house, and jail, all of which were built on Government Hill; the ruins of these are now standing. Lime produced by burning the limestone in local kilns was used in mortar during construction (fig. 57).

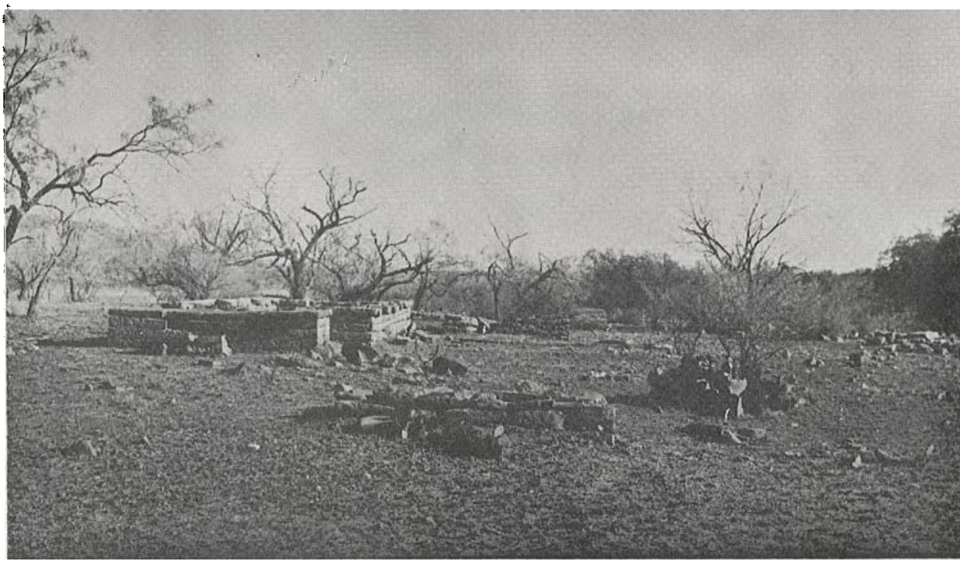

FIG. 57. Erosion surface cut on the Coleman Junction Limestone. Blocks of the limestone and lime made from burning the limestone were used to construct the fort. Some of the mesquite trees shown in this 1939 photograph were probably here when Col. Sturgin established the fort in 1867. The original grass cover, however, is now gone.

The Santa Anna Branch Shale, lower member of the Putnam Formation, crops out in slopes beneath the Coleman Junction Limestone and ranges from about 75 to 200 feet thick in northern Shackelford County (fig. 56). The best exposures of the shale are in upper slopes immediately beneath the limestone caprock and can be readily examined at several places near old Griffin village. The upper half of the member is commonly pale red, light green, or greenish-gray shale with thin layers of yellowish limestone and brown calcareous sandstone. In some places the upper shale contains an abundance of marine fossils. The lower half of the shale is commonly bluish gray, but it normally underlies soil-covered lowlands, like the Clear Fork Valley bottom, and is poorly exposed. It is commonly nonfossiliferous.

The Coleman Junction Limestone is overlain by the Admiral Formation (table 1), and the formational contact is near the western park boundary. In the Fort Griffin area, the Admiral Formation consists of poorly exposed light- to medium-gray and pink shales, some similarly colored thin limestone layers, and a few nonpersistent sandstone beds. It is not easily distinguished from the underlying Putnam Formation or the overlying Belle Plains Formation. Because of the difficulty in mapping all of the different rock units, Stafford (1960b, pl. 2) mapped as a single unit, the Coleman Junction Limestone (Putnam Formation), all of the Admiral Formation, and the basal member, Jim Ned Shale Member, of the Belle Plains Formation.

The valley bottom along the Clear Fork is a typical flood-plain sand and silt deposit. Thickness of the alluvium is not known but one well near the river bank did not reach the underlying Santa Anna Branch Shale at a depth of 48 feet. Near the old village, a thin alluvial deposit washed from the Coleman Junction escarpment above blankets part of the flood-plain surface; similar deposits can be seen at several places along the foot of the escarpment.

FORT PARKER STATE RECREATION PARK
and
OLD FORT PARKER HISTORIC SITE

Ross A. Maxwell

Fort Parker State Park (1,485 acres), on the Navasota River in Limestone County, is about 8 miles south of Mexia on State Highway 14 (Park Road 28) (Pl. I). The park includes Lake Springfield (750 acres) and offers pleasant scenery. Camping, screened shelters, group camps, trailer sites, picnicking, rest rooms, and shower facilities are available. Fishing from lighted fishing pier, swimming, boating, boat ramp, hiking, and nature study activities are popular; water skiing is permitted. The Old Springfield Cemetery, a 4-acre tract, has recently been cleared of brush and undergrowth and is to be fenced. There are between 150 and 175 graves, many of which are unmarked; most of the persons buried here are descendants of Negro slaves owned by the early settlers of that community. The park was acquired by deeds from private landowners during 1935 to 1937.

A few miles south on Park Road 35 is Old Fort Parker Historic Site (11.13 acres), also acquired by deed from private landowners. The principal interests here are historic studies and a replica of the Old Fort Parker stockade (fig. 58).

Fort Parker was north of the old San Antonio Road and not along routes taken by most of the Spanish explorers. However, the Marquis de Aguayo traversed the area in 1720 as he marched to reestablish and strengthen the missions in East Texas. The area was occupied by Indian tribes when the Anglo-American settlers

FIG. 58. Old Fort Parker on clay in the Kincaid Formation of the Midway Group (table 1). (Photograph courtesy of Texas Parks and Wildlife Department.)

arrived in 1833. Feuds between the Cherokee, Waco, and Tawakoni Indians and the colonists made settlement hazardous.

A colony led by James W., Silas M., and other members of the Elder John Parker family established a settlement in 1833. A private fort, near the headwaters of the Navasota River, was built in 1834 to protect eight or nine families who had settled in that area. On May 19, 1836, the fort was attacked by several hundred Comanche and Caddo Indians. Elder John Parker and his sons Silas M., Benjamin F., and Samuel M. Parker and Samuel's son Robert Forest were killed. Cynthia Ann Parker, age 9 years, her little brother John Parker, age 6, Mrs. Rachel Plummer and her son James Platt Plummer, and Mrs. Elizabeth Kellogg were taken captives.

Cynthia Ann Parker grew to womanhood with the Indians and married Comanche chieftain Peta Nocona. Their son, Quanah Parker, was the last great Comanche chieftain (1845-1911); he was instrumental in bringing a peaceful life to the Comanche Nation on a reservation in Oklahoma. Cynthia Ann lived with the Indians for 24 years and when recaptured, did not forget the Indian way of life; she died four years later.

Rocks in the Fort Parker area are mostly in the Kincaid Formation of the Midway Group (fig. 59). The lithology changes rapidly from place to place along the Midway outcrop, but in most of the park, the rocks are green or dark gray or sandy grayish-brown clay containing the mineral glauconite. There are also some fragmental fossil shell beds (coquina) and indurated marls that grade into compact limestone toward the northeast. Some of the lithologic units have been given member names. The basal sandy glauconites are commonly referred to as the Littig Glauconite Member, the overlying green, dark gray, and brown shales as the Pisgah Member, and the upper lenticular limestone beds as the Tehuacana Limestone Lentil (Member).

Fort Parker is on the southeast side of a major fault system. The Balcones fault zone beginning near Uvalde extends northeastward past San Antonio and Austin before it begins to die out near Waco. It is not a single fault but a belt of many generally parallel fractures. None of the faults can be traced the length of the zone, but as one fault dies out, another begins, first on one side then on the other, and they continue in the same subparallel direction. Most faults in the Balcones zone are downthrown toward the southeast and form the stepped-down Balcones Escarpment that separates the Edwards Plateau—Lampasas Cut Plain areas from the Gulf Coastal Plain. On the Coastal Plain, about 30 miles southeast of the Balcones Escarpment, is the Luling-Mexia fault zone. It begins south of San Antonio, passes west of Mexia, and extends northeastward past Dallas. Most of these faults are down-dropped toward the northwest.

Fort Parker lies to the southeast of the most prominent faults in that part of the Luling-Mexia zone. Some of the larger faults, immediately west of Mexia, have repeated the formations in the Midway Group several times and locally have brought these Tertiary units into contact with Cretaceous rocks (table 1). There are also several small fault slices within the park which do not have the general northeast trend. Some of them are difficult to recognize because they place clay beds against clay beds; another fault accounts for the presence of limestone beds probably belonging to the Tehuacana Member that are faulted against a lower shale.

Fossil molds and casts of a few clams and snails occur in the clay beds throughout the park. Locally where the Tehuacana Lentil (Member) is exposed, this bed is very fossiliferous. Commonly it is a coquina of clam and snail shells cemented with a very fine silty sand. Individual specimens are difficult to collect, but a block of the rock will include many individual fossils of various sizes and shapes.

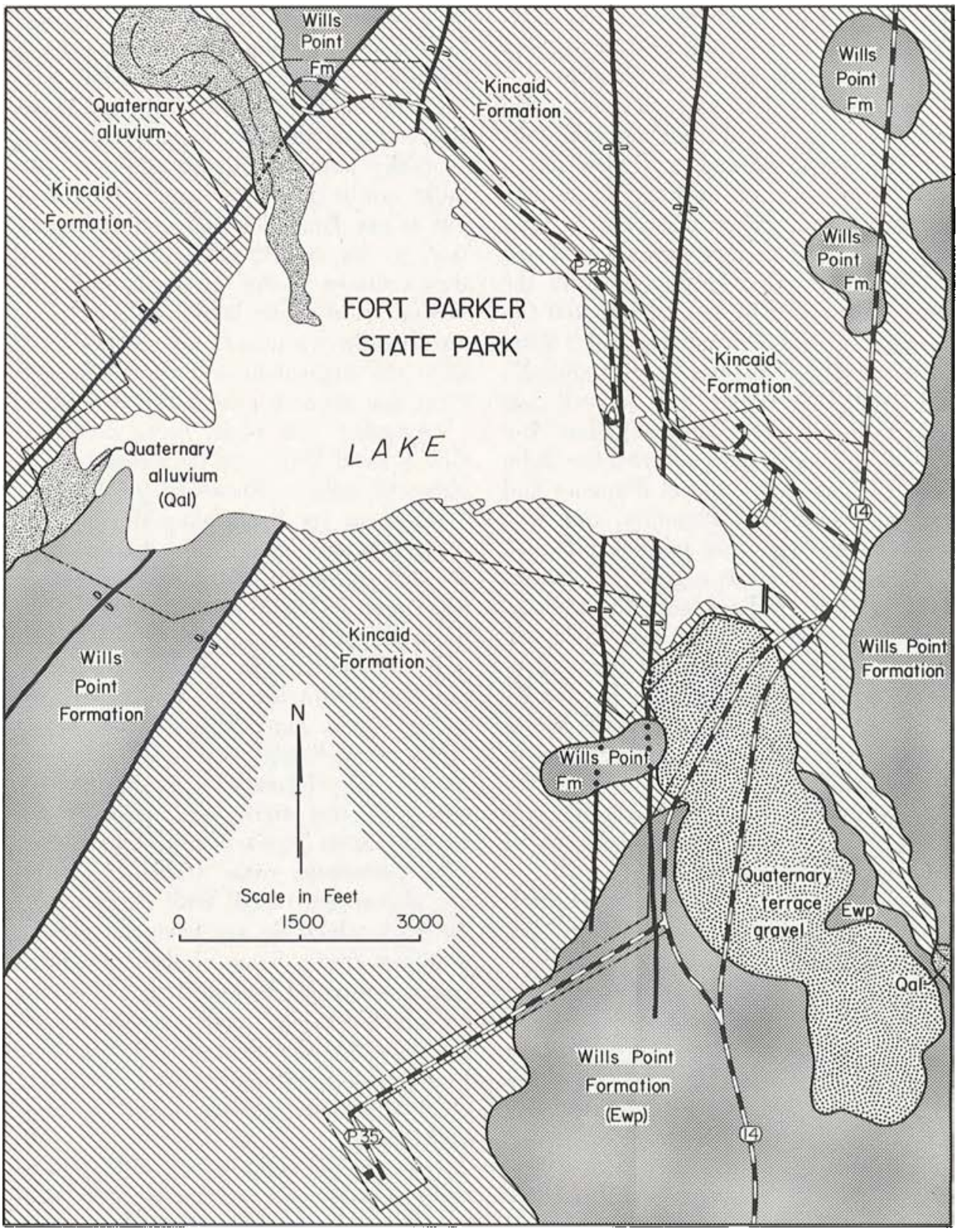

FIG. 59. Geologic map of Fort Parker State Recreation Park.

GARNER STATE RECREATION PARK

Ross A. Maxwell

Garner State Park (630 acres) is on the west bank of the Frio River in Uvalde County and is off U. S. Highway 83 (Park Road 29), about 31 miles north of Uvalde. The park was acquired in 1934 by deeds from private owners and named for John Nance ("Cactus Jack") Garner, Vice-President of the United States under the late President Franklin D. Roosevelt (1933-1941), who died at his home in Uvalde on November 7, 1967, two weeks before his 99th birthday. The facilities and accommodations include cabins, screened shelters, group shelters, concessions and recreation building, camping, picnicking, rest rooms, showers, groceries, dining room, miniature golf, fishing and swimming in the Frio River, horseback riding, and pleasing drives through the hill country. Other points of interest include the John Nance Garner museum in Uvalde; rock asphalt mines near Cline; historic ruins of Nuestra Señora de la Candelaria del Canyon, founded in 1749; Fort Inge, established in 1849; Camp Sabinal, a cavalry camp established in 1856 to protect travelers; guest ranches, livestock ranching, and hunting centers in Uvalde County.

The walls and slopes of the Frio River canyon at Garner State Park are underlain by strata belonging to the Glen Rose Formation (table 1). Most of the canyon's bottom is covered with alluvium or boulders that have fallen from the cliffs above. Here the Glen Rose includes clay and nodular marl beds that alternate with more resistant beds of impure limestone (fig. 60). The rapids are formed at places where the river has not cut through the more resistant limestone layers; the pools are where the soft rock has been eroded away (fig. 61). Most of the marl and limestone beds contain fossil oysters, clams, and snails but erosion has not yet reached the *Salenia* or *Corbula* beds described for Blanco State Park (p. 53). Several of the soft rock layers contain mud cracks, cross-bedding, and ripple-marks. These features indicate that the rocks were deposited in shallow water; it is only a few miles to where the dinosaur tracks near Bandera and also near Blanco are exposed.

Overlying the Glen Rose, in a general area from Garner State Park westward to beyond the Devils River (Pl. I), is a thick sequence of uniformly thick-bedded, hard, cherty, fine- to medium-grained limestone with numerous reef-like mounds that Udden (1907) named the Devils River Limestone (fig. 62). It was named from the rocks that crop out in the high canyon walls along the Devils River and is approximately equivalent to the Walnut, Comanche Peak, Edwards, Kiamichi, and Georgetown Formations exposed in Central and Northeast Texas. Udden used the term Devils River in this area because the rocks do not contain the marl and soft nodular limestone bands nor the fossil marker beds like the rock sequence in Central Texas. In fact, fossils are rare and it is often difficult to distinguish bedding. The rocks change, however, and northwestward in Big Bend National Park and in the Fort Stockton area (Pl. I) the rock sequence can be subdivided into units that are approximately equivalent to the formations exposed in Central Texas; some of them have different names (table 1).

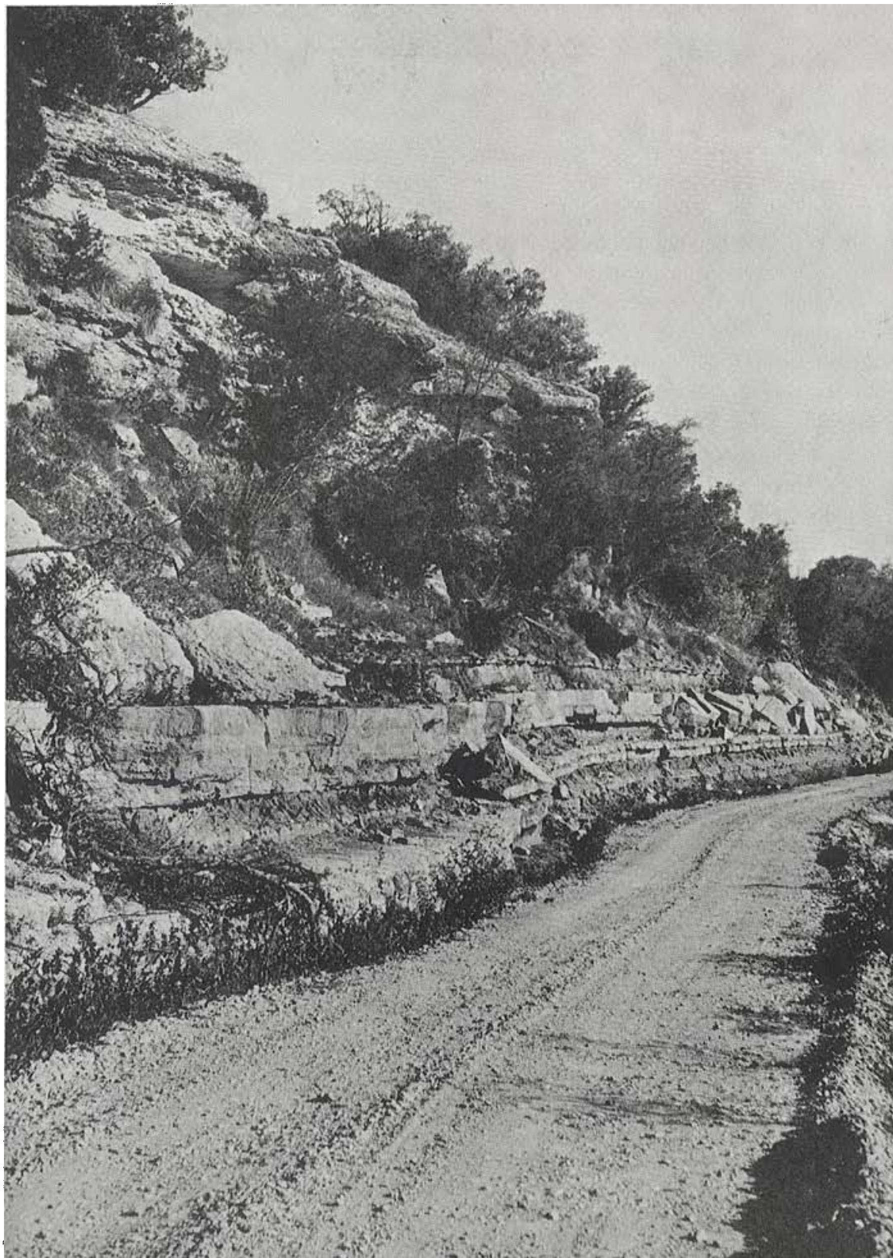

FIG. 60. The Glen Rose Formation. Beds of hard limestone alternate with bands of soft marl. On more gentle slopes the alternating hard and soft beds erode to form stairstep topography commonly seen in the Hill Country of Central Texas. Also see Blanco and Cleburne State Parks, figs. 29 and 34. (Photograph by P. U. Rodda.)

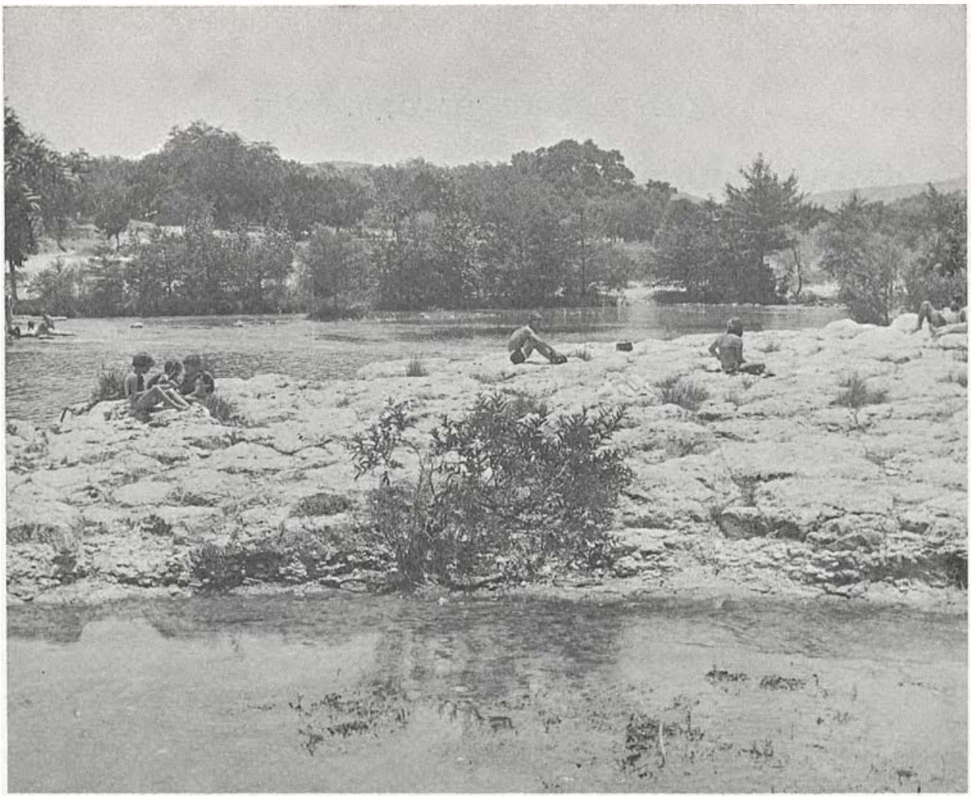

FIG. 61. Limestone ledge of the Glen Rose Formation in the Frio River at Garner State Park. (Photograph by Texas Parks and Wildlife Department.)

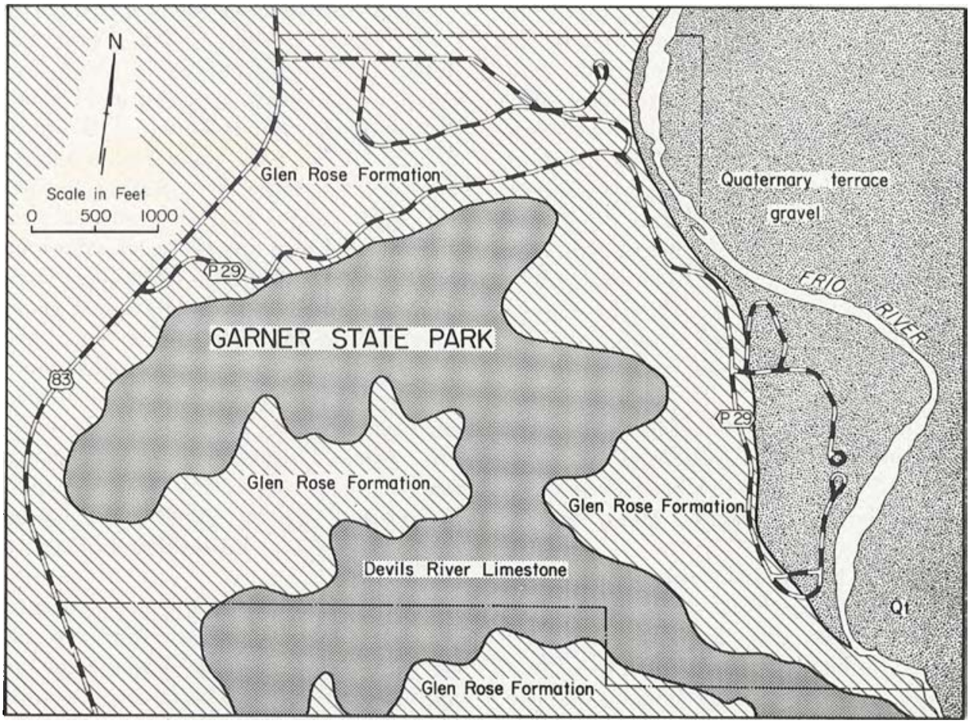

FIG. 62. Geologic map of Garner State Recreation Park.

GOLIAD STATE HISTORIC PARK
and
GENERAL ZARAGOZA BIRTHPLACE STATE HISTORIC SITE

Ross A. Maxwell

Goliad State Park, containing 208.6 acres, is on the north bank of the San Antonio River, about 1 mile south of Goliad off U. S. Highway 183. The park is best known for the historical events that occurred in that vicinity. The land was purchased jointly by the City and County of Goliad and formally dedicated as a State Park on March 24, 1931. Park facilities include screened shelters, camping units, rest rooms, picnicking, nature study, museum, and fishing in the San Antonio River.

During the Spanish Mission era, chapels and presidios were established at several places on the Texas Coastal Plain. Among these were the Mission Nuestra Señora del Espritu Santo de Zuñiga and the Presidio Nuestro de Loreto, which later became known as La Bahia; after several trial starts they were moved to Goliad in 1749. The settlement that gradually grew up around the presidio at Mission Zuñiga became the Goliad of modern times. The mission is within the park boundaries, has been restored, and is open to visitors. A program during 1967-1968 included renovation of present structures to prevent further decay. The auditorium, chief center of activity, is used for interpretation of historical events and the park's flora and fauna, and for group meetings.

The presidio of La Bahia has been restored by private owners. The outside walls of the compound have been completed, the chapel restored, and a museum is open to visitors.

Nearby is the birthplace of General Ignacio Zaragoza. The site is marked by the foundation of a three-room house adjacent to the presidio. A statue to General Zaragoza in San Luis Potosí, Mexico, gives a date and his birthplace—January 14, 1828, La Bahia, Texas. After Texas' independence. Gen. Zaragoza's family moved to Mexico. He entered the Army and rose to fame in 1855 when he was ordered to hold Pueblo Pass, which, if cleared of its military defenders, would have been the gate to and perhaps led to the fall of Mexico City. Gen. Zaragoza's 4,000 poorly equipped troops faced 8,000 of Maximilian's battle-tested veterans. Zaragoza knew the terrain and his brilliant encircling tactics lured Maximilian's forces into a trap where they were completely routed.

Immediately southeast of La Bahia is the monument to Col. James W. Fannin and his men who were executed at the Mission (*see* fig. 53, p. 92).

The rocks that crop out in Goliad State Park belong to the Goliad Formation (table 1). The formation is about 250 feet thick and crops out in a band about 15 miles wide, but it is one of the most difficult of the Gulf Coast formations to identify. It overlies the Fleming Formation, whose upper part is mostly calcareous clay and contains layers of sandstone that are often difficult to distinguish from the grayish-white, medium-grained sandstone beds in the Goliad. The top of the formation is less easily recognized because beds near the top are similar to and in some places grade into beds in the overlying Lissie Formation. In many places the surface is covered by a Recent windblown sand deposit which conceals the relationship of the underlying formations (table 1).

The Goliad Formation was deposited by streams that spread their sand and silt-laden floodwater over the lowlands of the Gulf Coastal Plain. This was at a time when there was more rainfall and corresponding floodwaters than at present. The formation consists of about 80 percent sand, 5 percent gravel, 10 percent clay, and 5 percent calcium carbonate. Most of the sandstone beds are sufficiently well cemented with calcium carbonate (indurated) that they form ledges which have been locally used for building stone. Perhaps the availability of building stone was one of the reasons for locating the early missions at Goliad (fig. 63). Sand

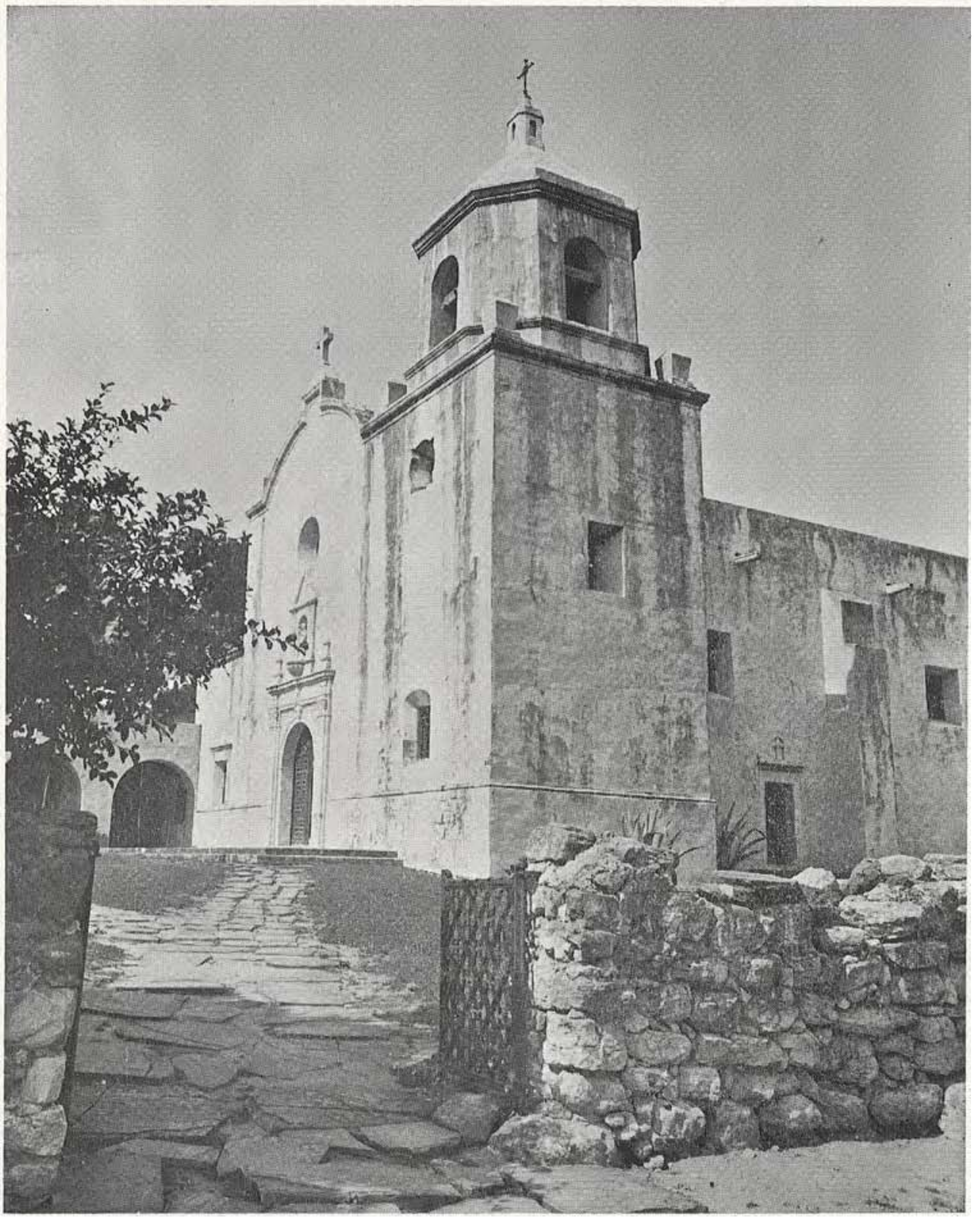

FIG. 63. Mission Señora del Espiritu Santo de Zuñiga at Goliad State Park. Stone in wall at gate to the mission is sandstone from the Goliad Formation. (Photograph by Texas Parks and Wildlife Department.)

produced by crushing and washing the ledgestone can be used for construction purposes. Prior to 1890, clay from the Goliad Formation was blended with river silt to make common brick. Some of the clay expands (bloats) when heated to a temperature of about 2000°F. and can be used for making lightweight aggregate.

The rocks in the Goliad Formation are not the same at all places along its outcrop belt. This is best shown by the gravels that crop out in the different river valleys. The chert pebbles found in the gravel along the San Antonio and Guadalupe Rivers came from the Lower Cretaceous limestones in the Edwards Plateau. In the Colorado River valley the gravel contains, in addition to chert, pebbles of quartz, feldspar, pegmatite, and associated minerals. This suggests that the ancestral Colorado River, during the Goliad epoch, had cut its valley through the Lower Cretaceous rocks that covered the Llano uplift and was eroding the Precambrian formations (table 1).

Invertebrate fossils are rare in the Goliad Formation and those that have been found are mostly extinct forms of clams and snails that lived in streams and lagoons of fresh water. Vertebrate remains are more plentiful. Those include bird bones and bones and teeth of the early horse, camel, and rhinoceros. Some of these are water worn which indicates that they were eroded from older formations, picked up by streams, and redeposited in the Goliad Formation. Thus the presence of fossil bones found in the Goliad does not necessarily signify the correct geologic age of the beds in which they are found.

GOOSE ISLAND STATE RECREATION PARK
and
COPANO BAY CAUSEWAY STATE PARK

L. Edwin Garner

Goose Island State Park is on Park Road 13, which intersects State Highway 35, 10 miles east of Rockport; it is the only developed State Park on the Gulf Coast. The park consists of 307 acres which were donated to the State by deeds from private owners. It is chiefly a recreation park and facilities include camping, open shelters, picnicking, rest rooms, showers, concessions building and recreation hall, boating, boat ramp, and fishing. There are also a 1,620-foot lighted fishing pier with fish-cleaning facilities and a 5,500-foot boat channel. The fishing pier connects three small islands, giving wade fishermen access to shallow water near the islands and deeper water along parts of the pier. The boat channel affords users of the park's ramp access to water in St. Charles and Aransas Bays.

Copano Bay Causeway is the old State Highway 35 causeway across the mouth of Copano Bay; it has been converted into a fishing pier. The facilities include snacks, cold drinks, fishing tackle, bait, and other fishing supplies. There are no overnight accommodations but future plans include limited development and improvement of the existing facilities.

There was a time when Live Oak (Rockport side of Copano Bay) and Lamar (Goose Island side of Copano Bay) peninsulas once swarmed with Indians, for over 200 campsites have been found around the shores of Copano, Mission, and Aransas Bays. These Indians had tools of shell, bones, and horns. They used tools for grinding grass seed and acorns and made hammers and adzes from the central portions of big conch shells. Shellfish was their chief food, but they also ate javelina, deer, buffalo, rabbits, various other rodents, drum and other fish, and even porpoises.

The old abandoned townsite of Lamar (originally called Point Lookout) stands close to the old park entrance. It was established in 1848 but faded after it was sacked by Union troops in 1864. Of note are the salt works which were set up in the 1840's. Old-timers say that the whole town of Lamar joined in to build the chapel of Our Lady Star of the Sea (Villa Stella Maris) of cement made entirely from oyster shell taken from the bay near where it stands. Villa Stella Maris is now a retreat.

Just east of the chapel of Villa Stella Maris is the chapel at the Mother House of the Schoenstatt Sisters of Mary. It is an exact replica of the chapel in Schoenstatt, Germany, where the religious order was founded. The Mother House is one of the only two in the United States and was built with money earned through labor by the sisters, who are a service organization. Of interest are the leaning live oaks to be found on the grounds of the Mother House, as well as along the Gulf Coast. They are bent by the trade winds that prevail during most of the year, blowing steadily from the southeast. A crumbling ruin made of shell cement, half hidden in the brush, is visible along Park Road 13. This was Mrs. Jane P. O'Connor's Seminary for Young Ladies where, for $35.00 a month, the young women attending were given room and board and taught the Three R's and the niceties of deportment.

Another point of interest in the park is the Big Tree of Lamar. This National Champion live oak is 32 feet in diameter at a point 4 feet above the ground, its top branch is 80 feet above the ground, it has a crown spread of 140 feet, and is believed to be about 2,000 years old. It is recognized as Texas' largest tree and is said to have been a council tree for the Karankawa Indians and for the white men who came after them. The tree was not damaged by Hurricane Beulah.

In 1785, Don Jose Galvez, Viceroy of Mexico, ordered a port to be opened at the site of Old Copano on the north bank of Copano Bay. The town soon degenerated into a smugglers' hangout, and smuggling and piracy grew to such proportions that a Mexican garrison was established at Copano. This was also an important Texas port until 1880, the landing place of many colonists famous in Texas history, and the winter quarters of the Texas Revolutionary Army in 1835. The site is marked by a granite marker on the shore of Copano Bay and can be reached only by boat.

St. Mary's, just northeast of the present town of Bayside, was also an important old town. A few houses from the earlier town are still standing, as well as the old post office. The town was raided by Union troops during the Civil War.

The community of Fulton was established in 1866. It was named for George W. Fulton, a fighter in the Texas Army and later a cattle baron. His home still stands; it is now a museum open to the public. One of the first beef packing plants in Texas was in operation here in the early 1870's.

The Aransas Wildlife Refuge is separated from the park by St. Charles Bay. This is the wintering grounds of America's last flock of whooping cranes; ducks, geese, and other water birds may also be found. Wildlife such as small animals, deer, wild turkey, javelinas, and occasionally coyotes ("red wolves") and bobcats may be seen.

The Marine Laboratory of the Texas Parks and Wildlife Department is located on the harbor at Rockport. It is open to the public.

Also of interest in the area is the Welder Wildlife Refuge located about 4 miles east of Sinton on U. S. Highway 77. It is open every Thursday at 3 p.m. for a tour of the museum and refuge. Many kinds of wildlife may be seen; nearly 500 species of birds have been reported and the area is internationally famous for the quantity and variety of its bird life.

The park is located on the coastward edge of the Gulf Coastal Plain and has many large and small oak trees covering the gently rolling terrain. The soil is tan sandy loam which is derived from sand deposited in the Beaumont Formation. Old sand dunes, now covered with vegetation, can be seen in some parts of the park. Sediments along the coastal margins are Recent deposits, but the major part of the park is underlain by an ancient barrier bar similar to Padre Island, which was deposited during late Pleistocene time. The covered sand dunes in the park were probably originally developed on this ancient bar (table 1). There was considerable alteration of the island's shape during Hurricane Beulah, but most of the scars will be healed by normal wave and current action.

GOVERNOR HOGG SHRINE STATE HISTORIC SITE

Ross A. Maxwell

Governor Hogg Shrine is at Quitman in Wood County. The area consists of 17 acres and may be reached via State Highway 37 from U. S. Highway 80 east of Dallas. The historic site was acquired in 1946 by deed from the Wood County Old Settlers Reunion Association. The facilities include the Old Settlers Reunion Tabernacle, rest rooms, picnic areas with tables, and a museum containing some of the personal belongings of Governor Hogg while he was Justice of the Peace and editor of the weekly Quitman newspaper. One of the special activities is the Old Settlers reunion meeting held annually in August. The Ima Hogg Museum, planned for immediate construction, will include an entrance foyer, lounge and display area, office and work room, work shop, collection and storage area, large display rooms, and rest rooms.

James Stephen Hogg, the State's first native governor, was born near Rusk on March 24, 1851. His father died in combat (1862) during the Civil War and his mother died during the following year. Hogg was reared by his two older sisters, and the family estate was sold to buy food, clothing, and books for the family. One of Hogg's early jobs was as a typesetter at a newspaper office in Rusk. He later ran his own newspapers in Longview and Quitman, always fighting against subsidies to railroads and local lawlessness. He served as Justice of the Peace at Quitman (1873-1875); during all his spare time he studied law and was licensed in 1875. During his governorship (1891-1895), Hogg did much to strengthen the public respect for law enforcement. He championed five major pieces of litigation and the legislative body probably most commonly referred to now as the Railroad Commission.

After his term as Governor of the State, Hogg sought no public office but maintained a home and law office in Quitman and also law offices in Austin and Houston. During this period, his address at Waco on April 19, 1900, did much to consolidate the thinking and to formulate new political principles for the State Constitution. He died at the home of his partner, Frank Jones, in Houston on March 3, 1906.

The general geology of the Quitman area is shown on the Tyler sheet of the Geologic Atlas of Texas. The rocks belong to the Queen City and Reklaw Formations. The contact between the formations passes through the western one-third of Quitman and the shrine is on the Queen City Formation. Here the Queen City at Tyler State Park (p. 179) taining a few plant leaf imprints, sticks, and stems. The description used for the Queen City at Tyler State Park (pp.) applies here. The formation is discussed in much more detail by Sellards et al. (1933, pp. 628-635).

Throughout most of Northeast Texas, the Reklaw is a glauconitic sandstone and in some places concretions have a high iron content (Eckel, 1938). In most places the dark red soils in the Reklaw are easily distinguished from the greenish sandy clay in the Queen City (table 1). Fossils are not common, but there are a few clams, oysters, and snails.

HUNTSVILLE STATE RECREATION PARK

Ross A. Maxwell

Huntsville is probably better known for the State Penitentary, created and established in 1847, for the annual Prison Rodeo, and for Sam Houston State College than for its State Park. Nevertheless, on U. S. Highway 75 about 10 miles south of Huntsville is a 2,123-acre State Park, including a 200-acre lake. The park is in the piney woods area of East Texas and the lake is called Lake Raven (Indian name for Sam Houston). The area was acquired by deeds from private owners in 1938 and is adjacent to the Sam Houston National Forest. The park can be reached by several scenic drives through the East Texas piney woods area; these roads are beautiful in the spring with dogwood and bluebonnets.

Overnight facilities at the park include campsites with tables and benches, cooking grills, drinking water, and garbage units. Screened shelters have tables and benches, cooking grill, electric outlet, and drinking water. Trailer park is provided with electrical connection, cooking grill, and drinking water. All overnight facilities are near modern rest rooms, showers, and laundry tubs.

The concessioner offers groceries, ice, soft drinks, gasoline, fishing tackle, bait, and boat rentals. There is a lighted fishing pier with fish-cleaning facilities and a boat ramp.

Daytime activities other than fishing, boating, bathing and picnicking include pedal boats, bicycling, hiking, and a 2-1/2-mile nature study trail, with informational signs, through the piney woods.

In nearby Huntsville are mementoes of the life of General Sam Houston. These include his old homestead, his last home (the Steamboat House, so named because it resembles a steamboat), his grave, and

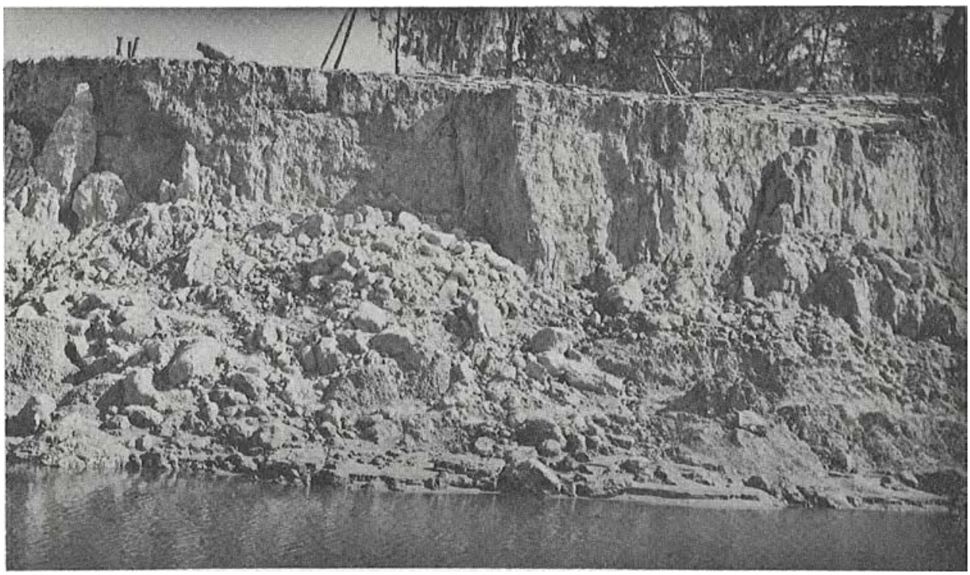

FIG. 64. The Fleming Formation. Note the massive, non-bedded clay that slumps when streams undercut their banks. It is mostly a sticky dark calcareous clay deposited in lagoons or shallow lakes. Locally there are bands of dark carbonaceous shale that grade into lignite. The lignite deposits contain leaf imprints and other fossil plant remains.

a museum containing many of his personal effects.

The general geology of Huntsville State Park is shown on the Beaumont Sheet of the Geologic Atlas of Texas. The geology and descriptions of the rocks at specific localities are given by Fisher et al. (1965). The rocks in the park belong to the Fleming Formation (Lagarto Formation on most of the older geologic maps). They are mostly dark, sticky calcareous clay that was deposited in brackish-water lagoons or shallow lakes (fig. 64). Locally there are lenses of dark carbonaceous clay that at some places grades into lignite. In these beds there are imprints of plant remains. Locally and especially north of Huntsville there are some poorly indurated sandstone units, and where the sandstone units are exposed the sand grains are commonly small and mixed with clay. There has been some commercial use of the sandstone for road metal from local areas, mostly north of Huntsville. Fossil wood occurs in some of the sandstone and there are a few molds and casts of oysters, fresh-water clams and snails.

INDIANOLA STATE HISTORIC PARK
and
PORT LAVACA CAUSEWAY STATE PARK

L. Edwin Garner

Indianola State Park consists of 300 acres in Calhoun County, located 13 miles southeast of Port Lavaca at the end of State Highway 316, off State Highway 35. It was acquired in 1958 by deed from Calhoun County. Activities include fishing, swimming, picnicking, camping, and history study. There is no development now, but developments are planned.

The original inhabitants of the area were the Karankawa Indians. The year 1519 marked the entry of the first white man into Matagorda Bay. Alvarez de Pineda mapped the coastline of the bay while completing the task of mapping the entire Gulf Coast from Florida to Vera Cruz. In 1685, however, Rene Robert Cavelier, Sieur de la Salle, and his two shiploads of French colonists sailed past the present site of Indianola and established their colony, Fort St. Louis, a few miles north on the west bank of Garcitas Creek. Somehow they managed to survive through four years of constant misfortune and in February of 1689, the Karankawas massacred the colonists and ended French settlement.

In 1722, the Spanish attempted a settlement on the site of the burned French fort. It, too, was a failure and in 1726 was moved to the site now occupied by the town of Victoria.

In 1840, Comanche Indians wiped out the little settlement of Linnville, an early port near the present site of Port Lavaca. Across the bay, on Cox's Point, the Indians also burned the town which had been established there.

In 1844, Prince Carl zu Solms-Braunfels and 1,000 German colonists landed at what was known as "Indian Point," later called "Old Town." When a storm wrecked the wharf, the settlement moved up the shore 3 miles where a pier was built and the town called "Powder Horn." This became the site of Indianola.

While the Prince was looking for a suitable place to take his colonists, they lived in tents and shacks made of mud and grass. This tent village was called "Karlshaven." Due to poor sanitary conditions, cholera and yellow fever broke out, and loss of life was great.

In 1853, Indianola began to become a town. The courthouse was built in 1857, and in 1859 the railroad was built to Victoria. Indianola became a thriving seaport by 1870, and the Morgan Steamship Lines made regular calls for imports and exports. Hides, tallow, cattle, and bones were the chief exports. Indianola had several slaughter houses and would kill cattle for their hides and tallow. There was also a turtle canning plant where huge sea turtles were caught in nets and canned to be shipped to all parts of the world.

In the 1850's, Indianola was the depot through which the U. S. Army sent men and supplies to frontier posts. Two shipments of camels, with which the Army was experimenting for western transport, arrived at Indianola in 1856. In the same year, a terrible hurricane leveled the town; it was rebuilt, but business declined. The Civil War and the Union blockade halted most shipping activities. After the war, the town was recovering when a fire destroyed 14 buildings. The final blow was dealt in 1886 when it was completely destroyed by a hurricane, tidal wave, and fire in rapid succession. No attempts were made to rebuild it.

The remains of Indianola are found in the crumbling foundations of the old courthouse, several of the huge cisterns built to provide a fresh-water supply, and the old cemetery where lie many of the victims of storm and pestilence that doomed the colony to failure. The present settlement of Indianola is a fishing camp.

The Port Lavaca Causeway State Park consists of 1.75 acres of land and a pier on Lavaca Bay; one strip is immediately east of Port Lavaca and one strip immediately west of Point Comfort on State Highway 35. The old State Highway 35 causeway was destroyed by Hurricane Carla in 1961 and was converted into a fishing pier 3,200 feet long. Limited concessions, mostly fishermen's needs, are available.

Indianola State Park is on the Beaumont Clay (400 to 900 feet thick), which consists of clay and marl interbedded with some more or less consistent layers of sand. It lies between the Lissie Formation and the younger surface silts, sand dunes, terrace, and alluvial deposits (table 1). The Beaumont forms a gently rolling surface along most of the Coastal Plain. It is normally grass covered, has few trees, and the soils are gray sandy or clay loams.

INKS LAKE STATE RECREATION PARK

Ross A. Maxwell

Inks Lake State Park (1,201.4 acres) borders the east side of Inks Lake, one of the Lower Colorado River Authority Highland Lakes, located about 10 miles west of Burnet on U. S. Highway 281. It can be reached from Burnet by traveling west on State Highway 29 and then south on Park Road 4. The park is near the eastern edge of the Llano region of Central Texas and includes some of the oldest rocks in the State (Pl. I).

Inks Lake was named for Roy Inks, member of a pioneer Llano family, who served on the Board of Directors for the LCRA until his death shortly before construction of the dam was started. The irregular shoreline provides many ideal fishing spots and good catches are frequently reported. Water skiing is a popular diversion and sand grains weathered from the Valley Spring Gneiss provide clean, sandy bottomed beaches where swimming is a pleasure. There is a 9-hole golf course and many prefer taking to the greens for a restful weekend.

Inks Lake is a popular recreation park and is probably best known for its pleasant camping facilities. The camping areas are near the lake shore and are provided with concrete tables, cooking grill, disposal unit, and drinking water faucets. Conveniently located are rest rooms with hot and cold showers, and laundry tubs. In addition to the regular camping units, there are screened shelters affording limited privacy, with electric service and table inside the shelter. Spaces for trailers with electric and water connections are also available.

For a convenience to the camper and/or park visitor, the concessioner offers a variety of services. These include groceries, cold drinks, ice, camping supplies, fishing tackle, and ski equipment.

In the spring, there is a profusion of wild flowers, and Inks Lake is included in the Highland Lakes Bluebonnet Trail. In addition, there are many birds, and deer are common along the roadways and in camping areas.

Probably the first European adventurer to be in the immediate vicinity of Inks Lake State Park was the Marquis de Aguayo, who is reported to have crossed the Colorado River near Austin on his journey to reoccupy the East Texas missions following the French invasion of that area in 1719. The Inks Lake area was also included within the Stephen F. Austin land grant from Mexico, and Samuel E. Holland was the first permanent settler (1848) to locate in Burnet County. There were several military and ranger forces in the area from 1849 to 1855. Henry E. McCullough and his rangers were at McCullough's Station on March 13, 1849, when that site was selected by Lt. C. H. Taylor, commanding officer of Company A of the Second Dragoons, as a location for Fort Croghan. The fort was first located on Hamilton Creek about 3 miles south of Burnet but was later moved to a site across the same creek about 3-1/2 miles above the first location. Here it was known as Camp Croghan, Camp Hamilton, and finally, Fort Croghan; it was abandoned in 1855. A Mormon settlement was established on Hamilton Creek in 1851, but because of Indian depredations in 1861, the settlers returned to Iowa.

In addition to the historic sites and events mentioned above, there is also Packsaddle Mountain, site of the last major Indian battle in the area (August 5, 1873); Longhorn Cavern State Park (pp. 133–134), reported to be the third largest cavern in the United States; Granite Mountain north of Marble Falls, where stone for the State Capitol was quarried;

and the Highland Lakes chain along the Colorado River, of which Lake Lyndon B. Johnson is one of the reservoirs.

The area was mapped geologically by Paige (1912), it has not been remapped since. Valley Spring Gneiss (table 1) is the chief rock within Inks Lake State Park. It received its name from Valley Spring in Llano County and is of Precambrian age (fig. 65). The Valley Spring Gneiss was formed from a thick sequence of rather uniform sedimentary rock through recrystallization caused by heat and pressure. The pinkish feldspar minerals developed during the recrystallization process account for the light color of the gneiss. Much of the rock is fine grained and some is difficult to distinguish from fine-grained pink granite to which it grades locally. Some of the gneiss is streaked by dark bands.

South of the park, the dark-colored Packsaddle Schist, also of Precambrian age, crops out. Both the schist and gneiss were intruded by a large mass of granite similar to the type used for construction of the State Capitol.

Paleozoic rocks crop out in Long Mountain visible toward the west and in Backbone Ridge visible to the southeast where Longhorn Cavern State Park is located.

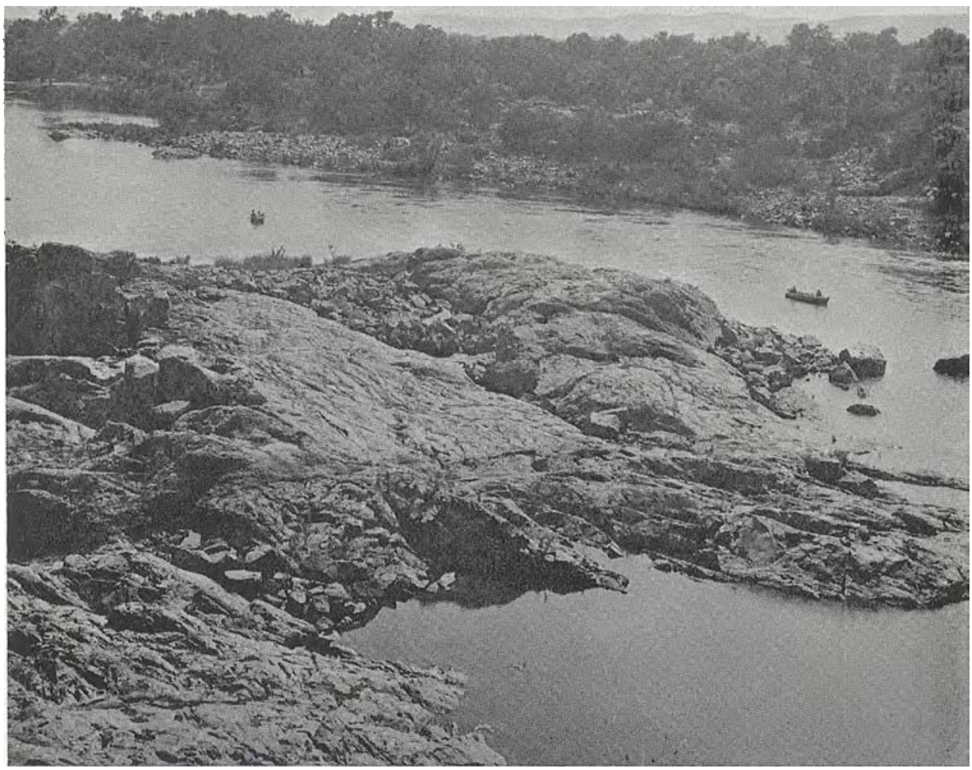

FIG. 65. Valley Spring Gneiss at Inks Lake. This is probably the oldest rock in Texas. Weathering along joints formed during metamorphism permit the rock to break into irregular blocks. (Photograph by Texas Parks and Wildlife Department.)

JIM HOGG STATE HISTORIC PARK

Ross A. Maxwell

Jim Hogg State Historic Park is the site of the home of Governor James Stephen Hogg (1851-1906). The 177-acre tract is a part of the plantation (called Mountain Home) where the first native Texas governor was born. The park is off U. S. Highway 84, about 2 miles north of Rusk, Cherokee County, and was acquired in 1941 by deed from the City of Rusk. Six acres of the park are included in a shaded picnic area with tables and grills for outdoor cooking and playgrounds for children. The remainder of the area is in the deep East Texas piney woods area, has flowing streams, and is particularly beautiful in the autumn.

Near Rusk is the marked site of Cook's Fort, established by James Cook as a protection against Indians. Also near Rusk is the site of old New Birmingham which was the scene of the great East Texas iron rush in 1891. It was once a prosperous community of about 3,500 inhabitants and had electric lights and electric street railway. After a brief boom, the town died, and the last remaining houses were demolished about 1938. Eight miles west of Rusk on U. S. Highway 84 is the site of a Confederate gun factory built in 1862, and 9 miles south of Rusk, the Cherokee Furnace Company was established in 1863.

Two miles southwest of Alto on State Highway 21 is a marker at the site of the home of exalted grand Xinesi Chief Priest and Custodian of Sacred Fire of Hasinai Confederacy of Indians. In the same locality, there are markers on the site of the Neches Indian Village and at the site of Lacy's Fort, built in 1835 as protection against the Indians.

The geology in Jim Hogg State Historic Park is much the same as in the several East Texas parks. The Queen City Formation underlies the flattish lowlands; the Weches Formation, containing some low-grade iron ore, forms slopes, and a few of the highest hills have a thin veneer of basal Sparta Sand. Descriptions of these formations are not repeated (*see* Tyler State Park, p. 179); references are included in the Bibliography. Some readers may be interested in Fairbanks and Berkey's (1952) memorial to R.A.F. Penrose, Jr., who was one of the first geologists to study the rocks in East Texas.

KERRVILLE STATE RECREATION PARK

Ross A. Maxwell

Kerrville State Park, about 487 acres, is on the Guadalupe River in Kerr County, about 3 miles southeast of Kerrville (Pl. I). The park is accessible from State Highway 16 and Farm Road 689 off U. S. Highway 290 and from State Highway 27 off U. S. Highway 87. The park was acquired in 1934 by deed from the City of Kerrville.

A recent renovation and expansion program at Kerrville enables the park visitors to enjoy better services. Information and interpretation service is available at the new headquarters building, which also doubles as a residence for the Park supervisor. A new storage tank and water system adequately supplies water for additional modern rest rooms, showers, and a new concessions building. New screened shelters designed for family reunions or group picnics and individual screened shelters have been added. The old campground was improved and new campsites added; a new trailer campsite with water, electricity, and sewage connections was constructed. The picnic area was enlarged and a stable and tack room for horseback riders are available. A 7-foot deer-proof fence is under construction.

The first settlement in the Kerrville area was started during the early 1840's by a group of shingle makers. They were harassed by the Indians and left for a few years, but in 1848, Joshua D. Brown, a veteran of San Jacinto, returned and established a settlement. Indian depredations continued and on July 8, 1855, Camp Verde was established. Indian raids grew worse during the Civil War years and a frontier battalion of soldiers and a Texas Ranger company occupied the fortress until 1877.

Brown's first settlement (eventually this became Kerrville) started with a few pole cabin homes and a shingle mill, and for several years the manufacture and sale of cypress shingles was the economic backbone of the community. The town was incorporated in 1856 and became the county seat. Captain Charles Schreiner opened the first general merchandise store in 1869. German settlers from San Antonio were attracted to the community, the cattle business thrived, and the Kerrville area became one of the first counties in Texas where sheep and goats were raised on a large scale.

Kerrville has become one of the health and recreation centers of the Southwest. Both boys' and girls' camps, hotels, motels, and dude ranches cater to guests from all parts of the United States. A U. S. Veterans Hospital, the Kerrville State Sanitorium, and three private sanitoriums indicate the healthful climate of the Kerrville country. Kerrville is also home of the Schreiner Institute; the Kerrville Bus Line furnishes transportation to many cities of Texas; and each year hundreds of hunters gather there to try their luck for a white-tail deer or wild turkey.

In 1836, Major George H. Crosman urged the U. S. War Department to use camels for the Indian campaigns in Florida because of the animals' ability to keep on the move with a minimum of food and water. The request came to the attention of Senator Jefferson Davis, whom President Franklin Pierce later appointed to be Secretary of War. On March 3, 1855, the Congress passed a bill making available $30,000 with which to purchase camels and dromedaries to be employed for military purposes.

On May 10, 1855, Major H. C. Wayne received a special presidential assignment to study the continental use of camels in the United States. Major Wayne went to the North African coast where he spent $12,000 and returned to the United States with 33 camels and three Arabs and two Turks for herdsmen and handlers of the camels. The camels arrived at Indianola on April 29, 1856, but because of bad weather, they were not unloaded until May 13, 1856. On June 4, Wayne started his camel caravan across country to Camp Verde, near Kerrville.

A second shipment of 41 camels arrived in Camp Verde in 1857. Several successful experiments were made to test their ability as beasts of burden and in pursuit of hostile Indians. At least two camel caravans were used to explore the Big Bend country. On June 16, 1857, 25 of the herd went westward to California, where some were turned loose, others were used in salt pack trains, and some were returned to Camp Verde. During the Civil War, part of the camel herd and two of the Egyptian drivers passed into Confederate hands; some of the camels were used to pack cotton bales to Brownsville, one became assigned to an infantry command, and others were turned loose on the open range near Camp Verde.

Kerrville State Park is in the Edwards Plateau and all of the rocks exposed in the park except the alluvium belong to the Glen Rose Formation. The Guadalupe River has cut a beautiful steep-sided gorge into the flat-lying strata. At places where the hardest Glen Rose beds are crossed by the flowing current, there may be rapids and where the marly beds are less resistant to erosion, the stream's channel widens, the current has less velocity, and there are occasional pools of "quiet" water. A few soft rock layers form slopes on either side away from the stream's channel.

The Glen Rose Formation (table 1) normally consists of a sequence of thin- to medium-bedded, hard limestone layers interbedded with less resistant beds of marl or marly limestone (fig. 60, p. 104). Erosion of rocks like these that have unequal hardness commonly forms stairstep topography on hillsides. This is the characteristic slope developed by erosion of the Glen Rose at most places in Central Texas.

From northeast to southwest across the Edwards Plateau, there is an increase in the amount of lime in the Glen Rose beds. The hard limestone layers become more numerous and the soft marly beds less conspicuous. Locally some of the Glen Rose beds look much like the overlying Edwards Limestone, and locally they have similar high lime content and the fossil reef development.

The soft marly layers in the Glen Rose are excavated for road fill and surfacing material on secondary roads throughout much of the Hill Country. The hard limestone beds are used locally for riprap and aggregate, but the Glen Rose is not an important source of construction materials.

Fossils are common at many levels in the formation, and in some beds, shells of foraminifers (one-celled animals) are abundant. Fossil oysters, clams, snails, and a spherical-shaped sponge are the types most commonly seen. Dinosaur tracks occur at several localities in the Glen Rose; one place is about 7 miles west of Kerrville; others are near Blanco, Bandera, and Glen Rose (fig. 35, p. 65).

LAKE BROWNWOOD STATE RECREATION PARK

Ross A. Maxwell

Lake Brownwood State Park takes its name from its chief attraction, Lake Brownwood, a reservoir impounded by a dam on Pecan Bayou, a tributary of the Colorado River. The 538-acre park is reached by Park Road 15, off State Highway 279 and U.S. Highway 67, near the center of Brown County, about 22 miles northwest of Brownwood (Pl. I). As one of the better developed State parks, Lake Brownwood offers a variety of water sports including boating, water skiing, swimming, fishing, and goose hunting on part of the lake. There are attractive cabins, campgrounds with screened shelters for individual or group camping, trailer parking space, shaded picnic areas, a dining room, and facilities for purchasing food and soft drinks. With funds from a Federal grant and State-matching appropriation, the above facilities are being improved and storage and service building, roads, parking areas, landscaping, and utilities are to be added.

Acreage for the Lake Brownwood State Park was acquired from the Brown County Water Improvement District No. 1 by the Texas State Parks Board on September 11, 1939. The park is on a point of land between Pecan Bayou and Jim Ned Creek. The dam is of earth-fill construction, 120 feet high and 1,580 feet long, and the reservoir has a capacity of 125,000 acre feet. Authorization for annual water diversion is for municipal, industrial, and domestic uses, and for irrigation not to exceed 50,590 acre feet. Construction was started in 1930 and completed in 1933.

The succession of changes in the name of the park is unusual. Originally named Lake Brownwood State Park, the name was changed to the Thirty-Sixth Division State Park in honor of that distinguished Division, which was trained for World War II duty at nearby Camp Bowie; later the original name was restored.

Although Brown County is steeped in lore concerning Indian attacks, frontier incidents, the development of the cattle industry, the barbed-wire fence war, and the search for oil, important historical events are not known to have occurred within what is now the park. Prehistoric Indian occupation is evidenced by burials and by the large quantities of flint and bone implements that have been found, and especially in connection with the burned-rock ring middens that are characteristic of the southern Great Plains.

Captain Henry S. Brown, a Texas Revolutionary soldier, was the first white man known to traverse the area. In 1828, Brown, with about 25 men and an Indian guide, trailed a Comanche raiding party into what is now Brown County where they recovered about 500 horses that had been stolen at Gonzales. The first land survey was made in 1838, followed by others in 1840, 1847, and 1852. Early settlement was slow because the area was in Comanche country and did not have military protection. Camp Colorado, the only outpost for protection of the region in the early years, was on the Colorado River 35 miles to the southwest until 1856 when it was relocated on Jim Ned Creek, 20 miles west of Brownwood.

The first home in Brown County was erected by W. W. Chandler in 1854 on his homestead on Pecan Bayou east of Brownwood, where it now stands. Other settlers followed and the county was organized in 1857 and named for Captain Brown. As settlers encroached upon the Comanches' hunting grounds, the Indians brought open conflict through raids on the new settlements; several settlers were killed, a few children were captured, and thousands of livestock were driven away. The last attack by the Comanches is reported to have been made on the Cox-

McGinnis ranch a mile south of the Lake Brownwood dam. Though the ranch was surrounded by an unmortared stone wall 4 feet high, the Comanches burned the barn and released the horses. The last organized battle was at Santa Anna in 1874, when Maltby's Rangers defeated the Indians under Chiefs Big Foot and Jape. At about that time the population began to grow rapidly. Small settlements grew into towns, churches were organized, public schools became numerous, and the desire for higher education was met in 1889 with the establishment of Howard Payne and Daniel Baker Colleges. In spite of Indian raids during the 1860's to 1874 and the distance to market, the cattle industry flourished in the 1870's but it began to boom in 1886 with the coming of the railroad. Merchandising expanded and small industries grew in the larger towns during the early 1900's, and in the 1920's oil became an important aspect of the county's economy.

Lake Brownwood State Park is in the southern part of the physiographic province known as the North-central Texas Plains and is near the crest of a broad subsurface fold known as the Bend Arch, whose axis extends northward from the Llano uplift to the Red River (Pl. I). Along the axis of the arch, rocks of Pennsylvanian age are exposed, and a short distance west, rocks of earliest Permian age overlie the Pennsylvanian. East of the Bend Arch the Paleozoic formations are covered by eastward-dipping Cretaceous rocks.

As the Pennsylvanian rock units are traced northward, some of them undergo gradual changes in facies, others change abruptly, and the continuity of some beds is interrupted by sandstone-filled erosion channels that cut through one or more of the limestone-shale units. The channels are believed to be the result of stream erosion rather than marine scour, although some of the channel-fill deposits lie between beds that contain undisputable marine fossils. These facts indicate that the sea level must have risen and fallen repeatedly in relation to the land during the period of deposition. Because the sea floor probably was extremely flat at that time, a rise or fall of only a few tens of feet in sea level would have caused the shoreline to shift several miles. After the channels were cut and filled by stream action during the periods when the region was above water the land area sank, and nearly flat layers of marine muds were spread by wave action over the new channel-fill deposits.

The Paleozoic rocks, in the Pennsylvanian System, consist mostly of alternating layers of limestone and shale that dip gently toward the west-northwest. Since the limestone beds resist erosion, they commonly occupy the tops of asymmetric ridges or cuestas whose back slopes are slightly truncated. The shale and weakly resistant sandstone or limestone beds occupy the frontal slopes and the valley bottoms, and the repetition of cuestas and valleys produced by the alternation of limestone and shale bedrock produces almost a corrugated effect on the landscape. The streams normally flow southeastward across the strike of the Paleozoic formations, and small gorges can be found where streams cross limestone-capped cuestas. It is in such a gorge, or water gap, that Lake Brownwood dam is located. The terrain is not spectacular, but the cuestas, rolling hills, and valleys produce a picturesque landscape.

Traced northward from the Lake Brownwood region, the Pennsylvanian and Permian rocks pass beneath the Cretaceous caprock of the Callahan Divide, emerging again to the north in the Brazos River basin (Pl. I). This interruption of continuity by the Cretaceous rock cover has made it difficult to correlate the Pennsylvanian and Permian rock units exposed in the Colorado River basin with similar units exposed in the Brazos River basin (fig. 66). Over the years two separate nomenclatures, rock descriptions, and age determinations have been applied to the rocks in the two drainage basins (*see* Fort Griffin State Park, pp. 94–99). The dual terminology has led to much confusion and, in some instances, disagreement among geologists working in the two areas. Because they are equivalent to some of the formations in West Texas that produce tremendous quantities of oil and gas, and some of the channel-fill deposits are related to lenticular sandstone bodies that yield oil and gas in fields nearby, the rocks are of economic interest. These economic possibilities have stimulated geologists to restudy the rocks in the area to try to resolve some of the very confusing problems of correlation. Eargle (1960, Pl. 27), in a report on Brown and Coleman counties, included a chart to show the differences in nomenclature and redefined some of the rock units. His terminology is used in this report. Cheney and Eargle (1951) mapped the rocks in Brown County, and Terriere (1960) mapped the geologic formations in the Grosvenor quadrangle; both maps include Lake Brownwood State Park (fig. 67).

The recent studies of the region by

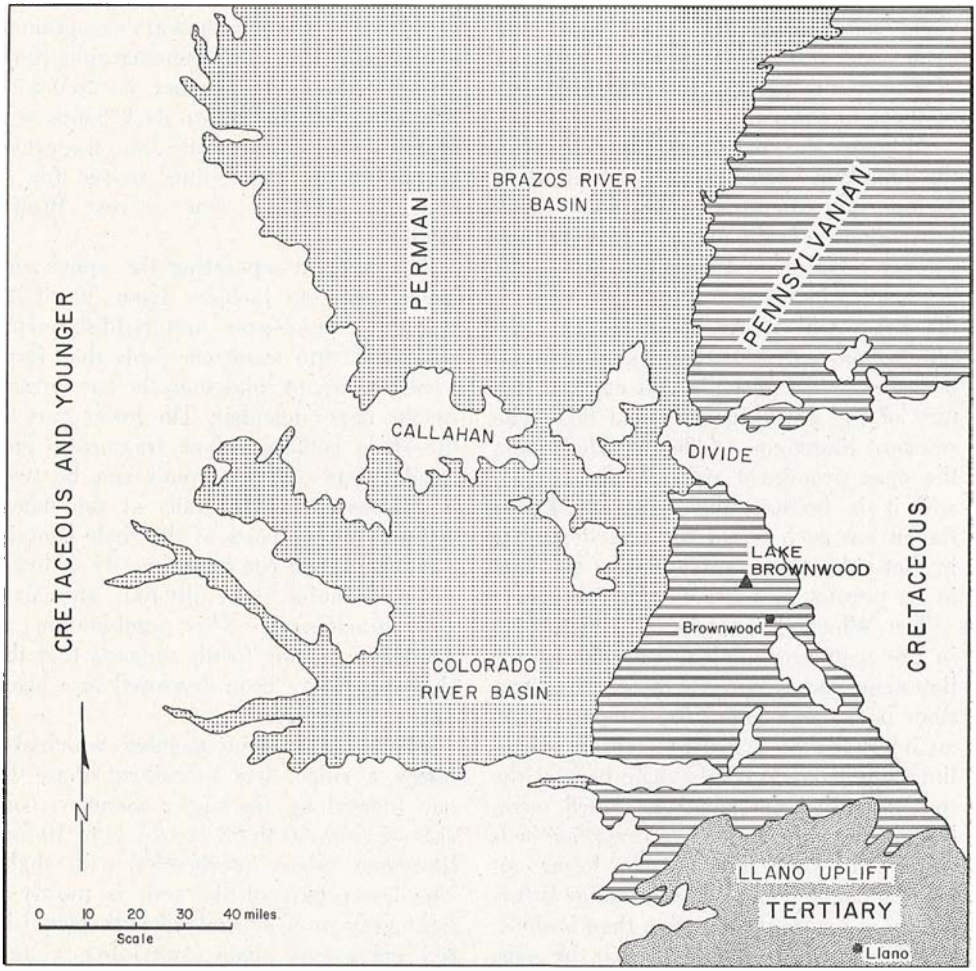

FIG. 66. Geologic map of an area in Central Texas showing how Pennsylvanian and Permian formations are covered by the Cretaceous rocks along the Callahan Divide (table 1). (Modified from Mendenhall et al., 1960.)

Cheney and Eargle (1951) and Terriere (1960) show that rocks in and near Lake Brownwood State Park belong to the Canyon and Cisco Groups of Pennsylvanian age (table 1). Rocks belonging to the Permian System crop out a few miles to the west, and it is only a few miles to the east that hills consisting of northwest-dipping Pennsylvanian rocks are capped by southeast-dipping Cretaceous formations. Looking northeastward from a point of vantage in the park, one can see this disconformity, which superficially resembles an arch or anticline in hills 3 or 4 miles away. Recent alluvium is found along most of the stream valleys, and older sand and gravel deposits (probably of Pleistocene age) cap several hills, one of them in the park.

Although the rocks cropping out within the bounds of Lake Brownwood State Park include only the Brad and Caddo Creek Formations of the upper part of the Canyon Group (Pennsylvanian), the Winchell Limestone, which lies beneath the Brad, will be discussed in some detail because of its prominence and importance to the geologic and cultural history of the area (figs. 67 and 68). The resistant limestones of the Winchell form the most prominent ridge in the region, and it is because the valley of Pecan Bayou cut such a narrow and deep gap in that ridge that construction of the dam in its present proportions was feasible.

The Winchell is about 100 feet thick in the dam area and averages one-third limestone and two-thirds shale. The limestone beds occur as two units separated by an interval that is mostly shale. A strong limestone ledge and thin shale beds at the top are called the upper unnamed member, and a concentration of limestone beds toward the base is called the lower unnamed member. Since the limestone ledges are more resistant to erosion than is shale, the Winchell forms two cuestas, the most prominent being the ridge formed by the upper member.

The upper limestone member includes two limestone ledges separated by a 4- to 10-foot layer of shale. The top ledge, where present, is about 20 feet thick, but commonly only a fraction of that thickness remains on the eroded top of the cuesta. The lower of the two ledges is a dark gray, fine crystalline limestone 4 feet thick. Fossils are not abundant in the member, but several distinctive species of brachiopods (marine mollusks having shells with two unequal valves) and bryozoans (colonial mass animals) can be broken from the limestone, and the shale between the limestones contains brachiopods, bryozoans, and other fossils. The limestones of the Winchell are exceptionally persistent. On aerial photographs limestones of the upper member, covered with live-oaks, show up as two dark bands separated by an almost white line, the grass-covered shale. These lines persist for at least 50 miles or more across Brown County.

The interval separating the upper and lower members includes from 30 to 40 feet of greenish-gray and reddish-purple shale and thin sandstone beds that form a less prominent ridge than the one formed by the upper member. The lower part of the shale contains plant fragments, and fossil prints of fern fronds can be seen in exposures in the walls at the dam's spillway. Other parts of the shale contain a marine fauna consisting mostly of bryozoans, crinoids (sea lily-like animals), and brachiopods. This combination of plant and marine fossils suggests that the shale may have been deposited in a near-shore environment.

The lower limestone member, which also forms a ridge, less prominent than the one formed by the upper member, consists of from 40 to 45 feet of 1- to 10-foot limestone ledges interbedded with shale. The lower part of the unit is mostly a light gray or gray mottled with purplish-red calcareous shale containing a few thin, lenticular layers of limestone. One of these, a nodular limestone layer, crops out at the spillway and is plastered with

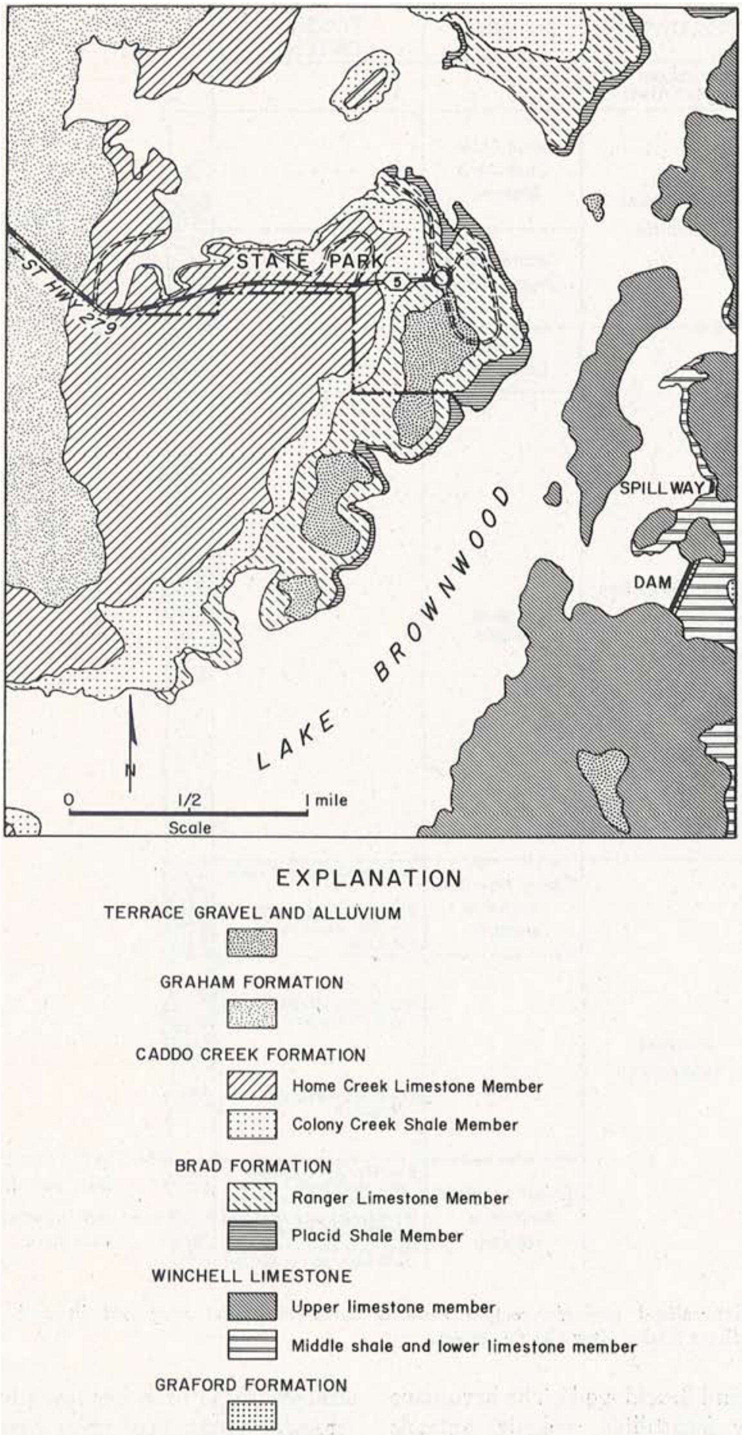

FIG. 67. Geologic map of Lake Brownwood State Recreation Park.

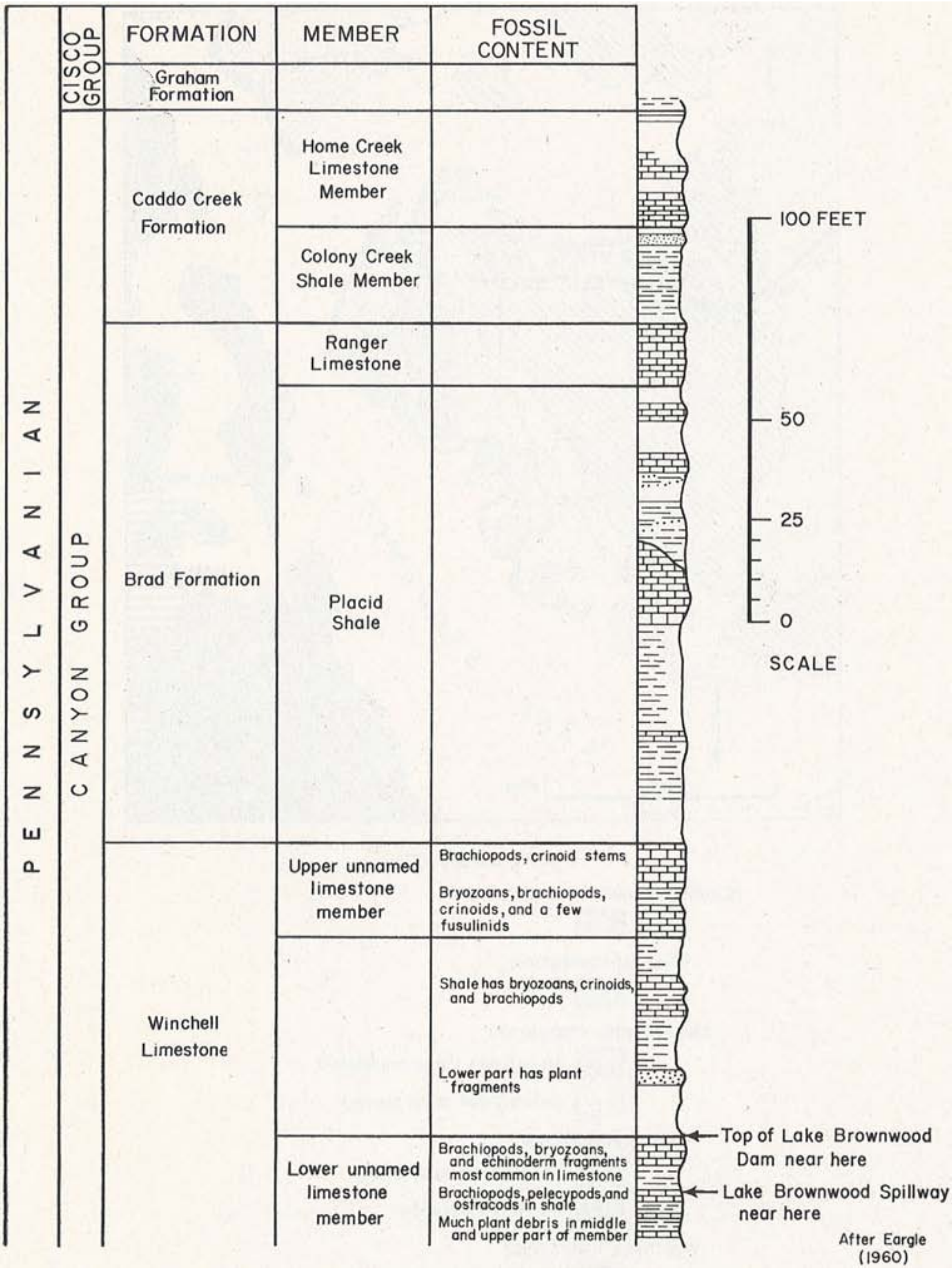

FIG. 68. Generalized geologic section showing formations that crop out in and near Lake Brownwood State Park (after Eargle, 1960).

bryozoans and brachiopods. The bryozoans are mainly fenestillids (colonial animals that secrete calcareous coverings and whose net-like frames are made up of straight radial branches laced together by irregular patterns of cross bars). Fossils collected from the spillway and from other outcrops of the Winchell Limestone have been described by Terriere (1960). Overlying the fossiliferous rocks exposed at the spillway is a massive, dense, dark gray limestone ledge whose under surface has a network of fucoidal or worm-like markings. Other beds contain structures that are apparently of algal origin. A channel-filling sandstone is present discontinuously above the fucoidal bed. It cuts through all underlying limestone beds of the lower member and in some places a considerable distance into the underlying Graford Formation.

Excellent exposures of the Winchell can be studied at the dam and in the walls and floor of the spillway (Eargle, 1960, Pl. 29).

Above the Winchell Limestone is the Brad Formation, which consists of two members, the Placid Shale Member, lying directly on the upper member of the Winchell Limestone, and the Ranger Limestone, which forms the crest of a cuesta above the Placid Shale. The Placid Shale, about 90 feet thick, is gray to red, in places silty and sandy, and crops out along the shoreline of the eastern part of Lake Brownwood. The Ranger Limestone, about 10 feet thick, is light olive gray and locally contains fusulinids (small wheat-grain-shaped fossils) and brachiopod shells. The Ranger occupies a broad band, partly covered by terrace gravel, becoming narrow at the northern point of the park, just west of the shoreline outcrop of the Placid Shale Member.

The highest formation found in the park, occupying all of the western part, is the Caddo Creek Formation, the topmost formation of the Canyon Group. The shaly Colony Creek member of the Caddo Creek lies beneath the strongly resistant Home Creek Limestone Member of that formation. The Colony Creek, which crops out west of the cuesta on the Brad Formation and along the shoreline in the western part of the park, consists of about 60 feet of silty shale and weak sandstone. The Home Creek, which occupies the remainder of the park, is a cherty limestone about 12 feet thick. Although sparsely fossiliferous in many places, elsewhere brachiopods, fusulinids, and shell fragments abound.

The rocks that crop out along Park Road 15 between State Highway 279 and the park are of the Graham Formation of the Cisco Group, which directly overlies the Home Creek Limestone Member of the Caddo Creek in the western part of the park. About 1 to 1-1/2 miles west of the park entrance the road crosses outcrops of limestones of the Gunsight Limestone Member of the Graham Formation. On well-exposed surfaces of these limestone ledges, and in the shales separating them, an unusually large and varied fossil fauna can be studied. Terriere (1960, table 1, locality No. 15098) recorded more than 50 species that were collected from a locality 900 feet north of the road and four-tenths of a mile east of a gravel road that joins the park road from the north.

West of the Gunsight outcrops the road traverses gently rolling land of the Wayland Shale Member of the Cisco Group. In a few excavations near the road excellent specimens of gastropods (snails) of the Wayland can be found, although not in great abundance. The rocks along Park Road 15, together with those in the park itself, abound in excellent specimens of fossil invertebrates and constitute some of the best locations for their study yet discovered.

Lake Brownwood State Park and its immediate vicinity is a convenient place to observe the geology of the region and to study many species of invertebrate fossils found there. It is situated in an area that is important in the effort to resolve problems of correlation between the Pennsylvanian strata of the Colorado and Brazos River basins, and it clearly illustrates an example of the importance of the relation of geology to dam construction. The use of impounded water for both irrigation and recreation constitutes a substantial contribution to the improvement of the local economy.

LAKE CORPUS CHRISTI STATE RECREATION PARK
and
LIPANTITLAN HISTORIC SITE

L. Edwin Garner

Lake Corpus Christi State Park is located 6 miles southwest of Mathis near State Highway 359 off U. S. Highway 181 (Pl. I). It consists of 14,187 acres, including the lake, which were acquired by lease from the City of Corpus Christi until the year 2032. The lake, also known as Lake Lovenskiold, was formed by damming the Nueces River. The park offers the water-sports fan, boating, boat ramp, fishing, swimming, water skiing, and skin diving. Campsites with screen shelters, tables, grills, and table spaces are also provided, along with rest rooms and showers, boat rentals, groceries, ice, etc. The lake is noted for its big blue, yellow, and channel catfish; perch, bass, and crappie also abound. It is a popular spring and winter park for nature enthusiasts.

The park is situated in the rolling hills of the Gulf Coastal Plain. Soils in the area are tan to gray sandy and clayey loams; these soils support wooded areas, mostly oak trees, and grassland areas (fig. 9, p. 11). The rock unit cropping out within the park is the Lissie Formation, which is composed of conglomerate and sands. This unit was deposited during Pleistocene time as alluvial terrace, flood-plain, and deltaic deposits.

Ten to 15 miles west, Lipantitlan Historic Site consists of 5 acres located in Nueces County, 9 miles east of Orange Grove off State Highway 359 and Farm Roads 624 and 70. The site was acquired in 1937 by deeds from private owners, and picnicking is the only recreational activity. A fort was constructed at this site in 1833 by the Mexican Government in anticipation of trouble with the Texas settlers. It fell to Texas forces in 1835 after a two-day battle.

LAKE WHITNEY STATE RECREATION PARK

Ross A. Maxwell

Lake Whitney State Park, consisting of 1,315 acres, is on the east shore of Lake Whitney, on Farm Road 1244, off State Highway 22 and U. S. Highway 81 about 4 miles west of Whitney in Hill County (Pl. I). Lake Whitney dam is on the Brazos River where that stream forms the boundary between Hill and Bosque counties. The reservoir impounds about 2,017,500 acre-feet of water; it is a part of the Brazos River Conservation and Reclamation Program and supplies water for municipal purposes, irrigation, and power production.

Lake Whitney State Park was acquired by U. S. Department of Army lease that extends to 2003 A.D. Camping, screened shelters, open shelters, group shelters, trailer sites, picnicking, rest rooms, showers, boat ramp facilities, and groceries are available. Fishing, swimming, water skiing, and other water sports are the most popular activities.

The town of Whitney was settled in 1879 when the railroad crossed the county. There was an earlier settlement, Tawasha Village (1835) named for a chieftain of the Hainai Indian tribe, but the old village is now inundated by the lake.

The rocks exposed in Lake Whitney State Park are of Lower Cretaceous age (table 1). In most places they include, from base to top, the Duck Creek, about 40 feet thick; Fort Worth, 40 feet; Denton, 13 feet; Weno, 35 feet; Pawpaw, 3 to 7 feet; Main Street, 30 to 50 feet; and the Del Rio (Grayson), about 100 feet thick. The entire area is underlain by the Edwards Limestone that is exposed at water level immediately above the dam (fig. 69). Several of the hill- and ridgetops outside the park are underlain by the Woodbine Sandstone that is commonly a soft sand with casehardened (indurated) ledge surfaces.

The rocks in the Lake Whitney area are difficult to divide into the above units because they crop out within a belt of facies change and many beds become more limy toward the south (*see also* Cleburne State Recreation Park, pp. 64–69). Because of this difficulty, two or more of the units are grouped and mapped as undivided formations (fig. 70). All formations, including Duck Creek to the Del Rio, are approximately equivalent to the Georgetown Formation of Central Texas (table 1).

The Duck Creek, Fort Worth, Denton Formations (undivided, fig. 70) are mapped as a unit. The Duck Creek beds are fairly massive to nodular limestone separated by clay seams. The formation is noted for its ammonites and several species can be collected along the outcrop that extends from Northeast to West Texas. There are also numerous oysters, clams, and snails in many places. The Fort Worth is mostly a nodular marl and soft limestone unit that represents a transition facies between the underlying more resistant limestone beds in the Duck Creek and the overlying Denton. The Denton consists of mudstone and limestone beds that become more limy toward the south. The basal beds are quite hard and form an inconspicuous ledge above the underlying Fort Worth. Fossil oysters are conspicuous at most outcrops in both the Fort Worth and Denton units; there are also species of clams and snails.

The Weno-Pawpaw, also undivided, underlie a slope that separates the overlying basal Main Street and the Denton (fig. 70). The Pawpaw is consistently covered and within the park is not identifiable as a formational unit. The Weno is mostly nodular to massive limestone, light gray when fresh, that weathers to yellowish-brown. The basal ledge, about

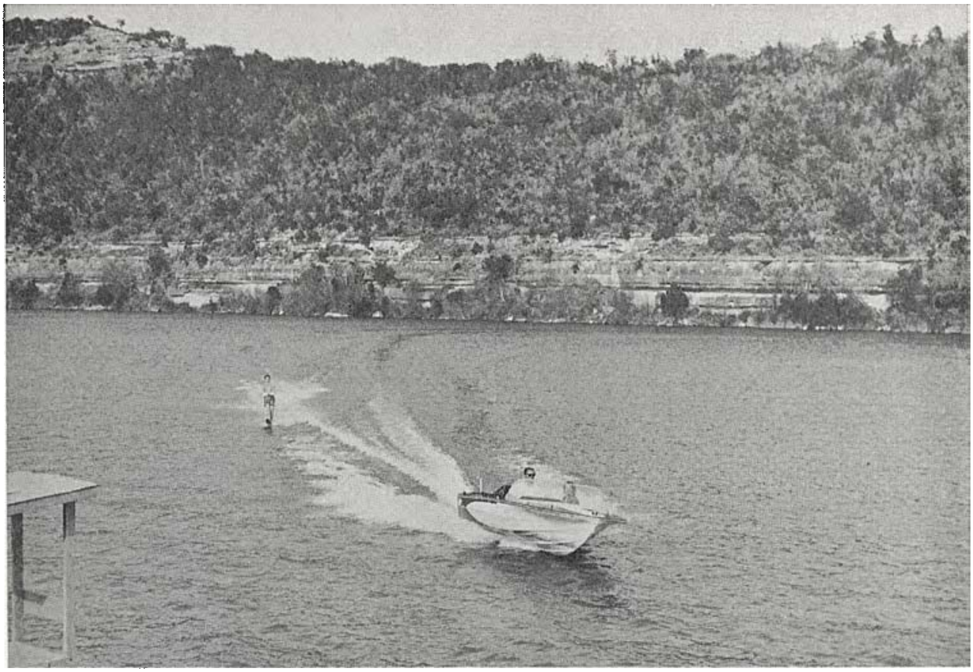

Fig. 69. Lake Whitney, a short distance above the dam. Edwards Limestone is exposed above the water level. The brush-covered slope is formed by the Kiamichi Formation and the very basal Duck Creek Limestone, not visible in the photograph. On the skyline at upper left is the Duck Creek (Lower Georgetown in Central Texas). (Photograph by Texas Parks and Wildlife Department.)

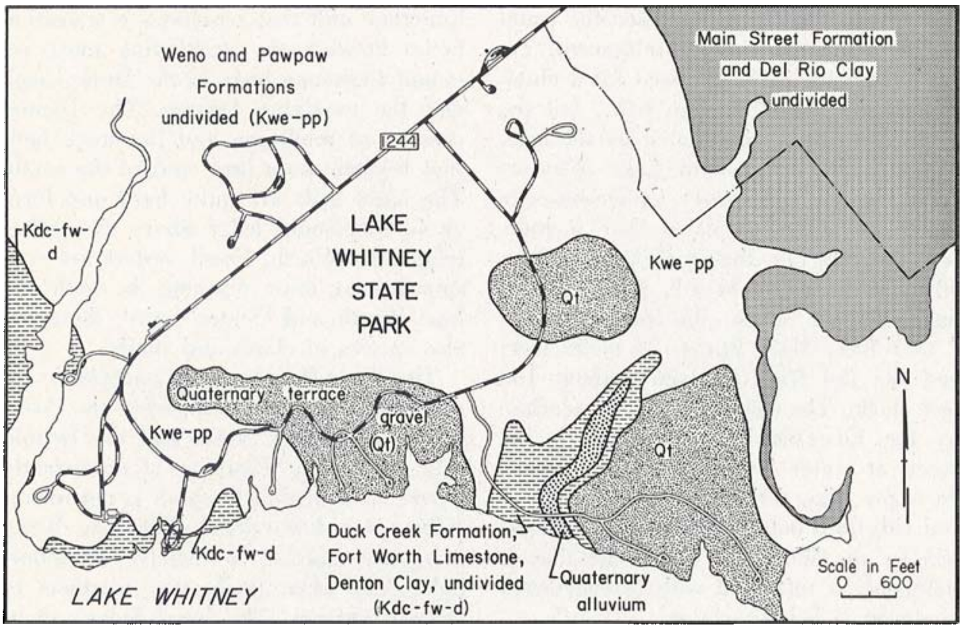

Fig. 70. Geologic map of Lake Whitney State Recreation Park.

5 to 10 feet thick, is the most massive and contains numerous worm burrows.

The Del Rio—Main Street form the upper slopes in the park. The Main Street is a nodular to massive limestone, similar in appearance to the Weno. The basal ledges are the most resistant limestone, about 20 to 25 feet thick; they also contain worm burrows. The Del Rio (Grayson) is mostly a blue-gray mudstone, when fresh, that weathers yellow; it contains a few thin limestone lenses. Fossils are common; the most abundant are oysters, clams, snails, and echinoids.

LOCKHART STATE RECREATION PARK

Ross A. Maxwell

Lockhart State Park, consisting of 257 acres of land, was acquired by deeds from private owners during 1934 to 1937. The park is about 4 miles southwest of Lockhart in Caldwell County. It may be reached via Farm Road 20 (Park Road 10), off U. S. Highway 183 about 28 miles from Austin (Pl. I). The park facilities include concessions building with facilities for group gatherings, picnicking for groups and individuals, trailer camping, grills for outdoor cooking, rest rooms and showers, well-equipped playground for children, swimming pool (open from May 1 through Labor Day), hiking trails, and a 9-hole golf course. There are no overnight accommodations.

Lockhart, originally called Plum Creek, had a post office as early as 1847. The following year, the name was changed to Lockhart in honor of Byrd Lockhart on whose land the town was established. Mr. Lockhart was a surveyor, made surveys from Lockhart to Gonzales, and was in command of the blockhouses at Gonzales built to ward off Indian attacks. He was also in command of a company of volunteer soldiers at the siege of Bexar in December 1835 but was sent from the Alamo to hurry reinforcements and supplies for that garrison. The Battle of Plum Creek, August 11, 1840, was led by General Felix Houston and was near the present town of Lockhart. It was a decisive defeat for the Comanches and an important victory for the Texans in their efforts to push the Comanches farther westward.

The Midway Group occupies the north-central part of Caldwell County, and the park is underlain by the Kincaid Formation of that Group (table 1). The Seguin Sheet of the Geologic Atlas of Texas (in progress) will show the distribution of the rocks and give a brief description of the geologic units. The Kincaid Formation is the basal Tertiary formation in this part of Central Texas, and the geology of Caldwell County has been discussed in considerable detail by Gardner (1933). Most of the rocks form a gray clay soil that overlies the older and darker Cretaceous clay soils.

Most of the basal Midway rocks in north-central Caldwell County are ledge-forming, highly calcareous, glauconitic greensands. The greensands were deposited as the invading Midway Sea advanced over the Cretaceous surface. Above the greensands are loosely compacted marl and soft clayey sandstones, with mottled yellowish-brown and bluish-gray colors that indicate a return to quiet water deposition following the deposition of the shoreline greensands. The marls and soft clayey sandstones grade upward into light yellow sandstone that is widespread throughout this part of the county.

At many places the Midway rocks are rich in microfauna, but most of the fossils that will be seen by park visitors will be molds or casts of clams, oysters, snails, and corals. There is fossil wood in some of the sandstone ledges.

The park is along the southeast border of the Luling-Mexia fault system, and there is at least one small fault adjacent to the western park boundary that may extend into the park area. Most of the faults in the Luling-Mexia fault system dip opposite to those in the Balcones fault system and the park is outside the complexly faulted area (*see also* Fort Parker State Park, pp. 100–102).

LONGHORN CAVERN STATE SCENIC PARK

Ross A. Maxwell

Longhorn Cavern is located about 10 miles southwest of Burnet in Burnet County, off U. S. Highway 281 on Park Road 4 (Pl. I). It was earlier known as Sherrad's Cave because the cave was in the Sherrad pasture. Following the purchase of about 708 acres of land, including the cave, by the Texas State Parks Board in 1931, the name was changed to Longhorn Cavern. The cave entrance is near the center of Backbone Ridge and was named for Sam Bass, a Texas outlaw, who reportedly sought refuge in the cave. The better known cave rooms are about 75 feet below the surface and extend northward from the Sam Bass entrance; they include the Big Room (Indian council room), the Crystal Room, the Lake Room, the Hall of Marble, the Cathedral Room, the Chandelier Room, and the Powder Room (not open to the public).

Improvement and development of the cave, which included the removal of thousands of tons of debris, were started by convict labor during 1931, but this project was short lived because local residents objected to the presence of the convicts in the community. Longhorn Caverns, Inc., a concessioner who obtained a lease to operate the cavern, made some improvements, but the principal developments and construction at Longhorn Cavern State Park were made by the CCC under the direction of the National Park Service in cooperation with the Texas State Parks Board. These developments included further clearing the cave of the accumulated debris, installation of the lighting system, construction of the concessions buildings and the entrance road from U. S. Highway 281; that road was later extended to Inks Lake State Park and became Park Road 4. Recent construction and improvements include a new headquarters and concessions building and landscaping. Lunches are available and complete meal service is in future planning. The old headquarters building is to be renovated and used as a museum.

Longhorn Cavern was officially opened to the public on Thanksgiving Day, 1932. Since that time, the Cavern has become a popular visitor attraction, and the surface area is used for picnics and other outings. There are daily guided tours of the Cavern; tickets may be purchased at the Administration Building, and the walking time of the tour is about two hours. A guidebook relating to the story of Longhorn Cavern (Matthews, 1963) may be purchased at the concession stand or from the Bureau of Economic Geology, The University of Texas at Austin, 78712.

It is not known who first discovered Longhorn Cavern, but the Big Room was used by the Confederate Army during the Civil War for making gunpowder. The gunpowder was later stored for safekeeping in the Powder Room. Indians used the cave before white men discovered it. Two skeletons have been found; one was identified as a Confederate soldier by buttons presumably from his uniform, and the other may have been an Indian burial.

Various incidents and some legends are associated with the history of the cave. One of these relates how a girl, captured by Indians, and her captors sought refuge in the Big Room. Texas Rangers followed the trail and by a surprise attack, followed by a hand-to-hand battle, the Rangers were able to free the captive girl. There is also a story of the Texas outlaw Sam Bass who reputedly used the cave as a hideout. It is legend that he left a tremendous treasure hidden in the cave, but the treasure has not been found.

There were earlier users and occupants of Longhorn Cavern. Bones of the grizzly bear, bobcat, elephant, bison (buffalo), pocket gopher, ground squirrel, jackrabbit, and terrapins have been found. Some of these are now on display in the Administration Building. Some of the larger deer and bison bones have been cracked, presumably by Indians to get the marrow. There are also spear and projectile points, crude stone tools, and flint chips that suggest, at least, temporary occupancy. In the Big Room, in addition to the skeletons mentioned above, bullet molds, old guns, a 19-3/4-inch bayonet (believed to be of Spanish origin), arrow points, bones of fossil camel and elephant have been found. A Colt .36 caliber cap and ball Navy revolver was found in the Cathedral Room.

Modern animals and insects include the Mexican cave bat, rats and mice, rock squirrels, crickets, spiders, daddy-long-legs, beetles, and worms.

The park is centrally located in a fault block of Ellenburger Group (table 1) near the eastern edge of the Central Mineral Region (fig. 71). The geology is complex; a description of the topography, rocks, structure, geologic history, mineral resources, and geologic map of the area have been published (Paige, 1912). Since that date, Barnes, Dawson, and Parkinson (1947), Bridge, Barnes, and Cloud (1947), Cloud and Barnes 1948), and Barnes et al. (1959) have described the building stones in the vicinity of Longhorn Cavern and made detailed geologic studies of the area.

The cavern is in the Gorman Limestone of the Ellenburger Group (table 1). This rock accumulated as a limy mud on the bottom of a shallow sea about 400 million years ago; compaction changed the mud into limestone. Uplift elevated the area above sea level and the rocks were exposed to the processes of weathering and erosion. Solution along joints and other passages in the rock layers formed the cave. Ground water that seeped downward through openings in the limestone slowly evaporated as it hung in droplets on the cave's ceiling or flowed down the walls, depositing a limy sediment forming the dripstone and other cave formations.

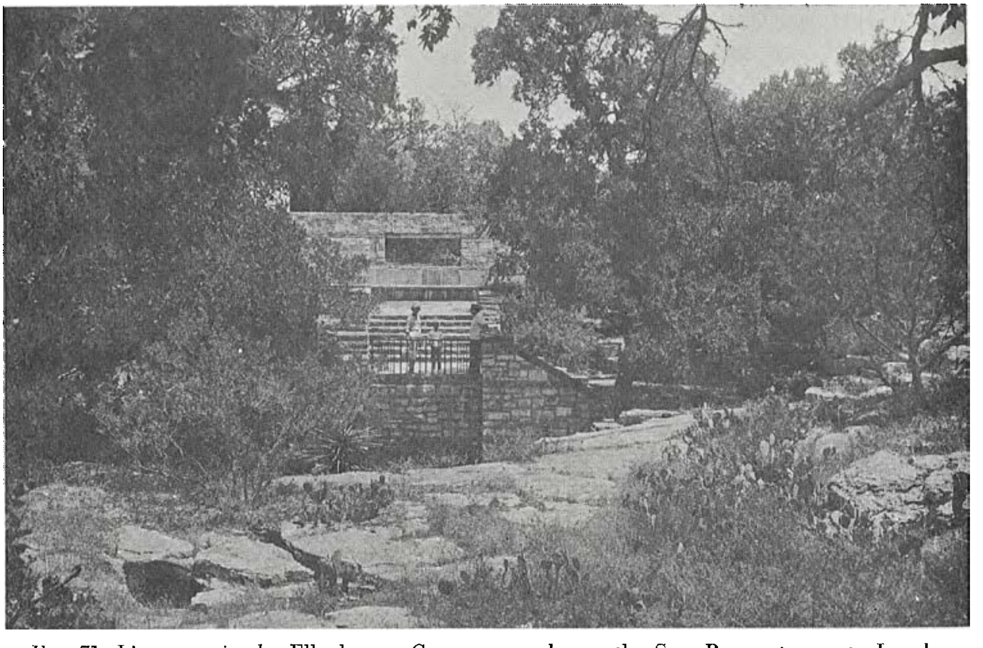

FIG. 71. Limestone in the Ellenburger Group exposed near the Sam Bass entrance to Longhorn Cavern. (Photograph by Texas Parks and Wildlife Department.)

LYNDON B. JOHNSON STATE HISTORIC PARK

Ross A. Maxwell

The original proposal (November 17, 1964) to establish the Lyndon Baines Johnson State Park included an area of about 245 acres of land that lies along the south bank of the Pedernales River opposite President Johnson's LBJ ranch home. This area is between Texas Ranch Road 1 and U. S. Highway 290 west of Austin (Pl. I). From Ranch Road 1 there are views of President and Mrs. Johnson's home. At a meeting January 6, 1966, the Parks and Wildlife Commission voted to increase the size of the original plot by adding 399 acres; the second tract extends eastward from the original tract.

The park and surrounding country were locally famous for its several celebrations, specialized crops, and historic structures long before the area's leading citizen was elected 36th President of these United States. It was not until after Mr. Johnson attained high office, however, that most of the citizens outside of Texas heard of the Pedernales River, Johnson City, Stonewall, Fredericksburg, and other points of general interest.

The post-Indian history actually began when Baron Ottfried, Hans von Meusebach, purchased 10,000 acres of good, well-watered, timber land in the heart of the Indian-infested Hill Country. The tract was subdivided into 10-acre plots and settled in 1845-1846; this was the beginning of Fredericksburg. Many of the people who live near the Lyndon B. Johnson State Park can trace their ancestry back to these German settlers. Nearby Stonewall is the peach center of Texas, Johnson City is President Johnson's birthplace, and the Hye community is where Mr. Johnson as a youth mailed his letters.

To those who plan a trip to the Lyndon B. Johnson Historic Park, it is suggested that they obtain the book "A President's Country" (Maguire, 1964). This publication summarizes the history, wildlife, and geology of the area; it also includes numerous photographs of historic structures and has an easily followed road log from Austin to Fredericksburg.

The area included within the park is shown on the geologic maps of the Hye and Stonewall quadrangles (Barnes, 1965a, 1966a). When traveling westward on U. S. Highway 290 from Austin, or in the reverse direction from West Texas, the road passes over rocks of Lower Cretaceous age (table 1). The junction of Texas Ranch Road 1 with U. S. Highway 290 is about 2.7 miles west of the Hye community and about 13 miles west of Johnson City. At this point, the road is on the Hensell sandstone of the Trinity Group (table 1). The Hensell underlies cultivated fields, and peaches are the main crop. The Johnson ranchhouse, the airstrip, the St. Francis Xavier Church, and the Stonewall community are also on the Hensell. Other formations within the park and adjacent to the Pedernales River are the San Saba and Morgan Creek Limestone Members of the Wilberns Formation of Paleozoic age, and alluvium.

Most of the distant hills are erosional remnants of the Edwards Plateau and are capped by Edwards Limestone (table 1). A few of the valleys are underlain by the Glen Rose Limestone. Most of these features can be seen from the park area and are included in the Hye, Rocky Creek, Stonewall, and Cave Creek School geologic quadrangle maps (Barnes, 1965a, 1965b, 1966a, 1966b).

The Lyndon B. Johnson Historic Park is in the planning stages of development. Some picnic tables and shelters and a comfort station have been built and additional accommodations now nearing completion are a visitor center, rest rooms, and electrical and water distribution systems. An animal-proof fenced enclosure, stocked with wildlife that is indigenous to the Edwards Plateau, and a perimeter road from which to view the wildlife are completed. The animals include white-tail deer, buffalo, longhorn steers, and other mammals.

MACKENZIE STATE RECREATION PARK

Gus K. Eifler, Jr.

Mackenzie State Park is in the eastern part of the City of Lubbock, Lubbock County, and is readily accessible from U. S. Highways 82 and 87, which pass close to it (Pl. I). From the time of establishment, it has been considered the playground and gathering place of the Texas High Plains.

The park is named after the Civil War veteran General R. S. Mackenzie, who in the 1870's was stationed near the present City of Lubbock. Here he protected the first trading post of the Southern High Plains and the early settlers and cattlemen against the Kiowa and Comanche Indians. In 1871 he defeated the Comanches in Blanco Canyon about 40 miles east of the park and again in 1874 in Tule Canyon about 75 miles to the north. The last encounter between the Indians and whites occurred within the park at a site now marked by a granite monument.

Mackenzie State Park comprises 549 acres and, except for the roads, is maintained by the City of Lubbock. In 1935, the land was purchased by the City and then deeded to the State for use as a park to meet the need for recreational facilities to serve the rapidly growing city and surrounding region. Since 1939, Lubbock has operated the park on a lease-back basis.

In the late 1930's the park was rapidly developed. Stone and stucco buildings were constructed by the CCC, and trees were planted in abundance, including the first Chinese elm in West Texas, honey locust, jujube, incense and red cedar, Chinese poplar, and willow. This wooded area in a treeless region, together with ample and varied facilities for entertainment, recreation, and camping, attracts great numbers. In 1964, about 1,750,000 persons visited the park.

There are no cabins for overnight guests, but ample camping accommodations are abundant. In addition, a 100-unit trailer camp is available with free electricity, water, and rest rooms. Facilities for recreation and exercise include a 27-hole golf course, a driving range, volley ball, tennis, and croquet courts, and a baseball diamond for hard ball; two softball State tournaments are often held here. There are swimming pools for adults, for young people, and for small children. Classes in arts and crafts are conducted throughout the year.

Three large houses are available through reservations for parties, reunions, and dances. For the picnicker, fireplaces, picnic tables, and benches are distributed throughout the park. A privately operated amusement park provides an assortment of rides for those wanting the carnival atmosphere.

Fishing is permitted only on the Fourth of July and Labor Day. The park fosters no wildlife, except for an extensive prairie-dog town, which has proved of great interest to most visitors.

Mackenzie State Park is in the eastern part of the Southern High Plains, known also as the Staked Plains or Llano Estacado. This nearly flat upland more than 3,000 feet above sea level stretches southward from the Canadian River to merge imperceptibly with the Edwards Plateau on an east-west line running through Big Spring. On the west in New Mexico and on the east in Texas, the Llano Estacado is abruptly terminated by prominent erosional scarps. The general flatness is broken by innumerable small, shallow playa basins, remnants of larger lake basins, sand dunes, and shallow intermittent streams, all of low relief.

The Llano Estacado is a constructional feature made largely during the Pliocene epoch by the deposition of the Ogallala Formation, which crops out in Mackenzie

Park (table 1). In the Lubbock region, this formation is 150 to 250 feet thick. It was built by streams flowing eastward from the rejuvenated Rocky Mountains and carrying great loads of silt, sand, and gravel. The streams meandered widely and deposited extensive flood-plains which ultimately merged to form one vast thick body of sediments. At first these streams flowed across an erosional surface developed on continental Triassic sandstone and marine Cretaceous limestone and shale; later they flowed across their aggraded flood-plain deposits. Remnants of the Cretaceous limestone are exposed along the lower valley walls of the Double Mountain Fork of the Brazos River below Buffalo Lakes. At Silver Falls on White (Blanco) River east of Crosbyton, the Triassic sandstones crop out below the basal beds of the Ogallala Formation.

The Ogallala Formation is made up of gray and pink quartz sand and maroon shale. In places the sand is cross-bedded and loose to friable. At some levels in the formation, the rock is massive and well consolidated. At the base of the formation is a conglomerate composed of well-rounded pebbles of quartzite, chert, crystalline rocks, Triassic sandstone, Cretaceous limestone, and abraded Cretaceous marine shells. Lenticular gravels of essentially the same materials occur higher in the formation. A prominent white "caprock" was formed at the top of the formation by the deposition of a calcareous material ($CaCO_3$) known as caliche, a variety of limestone. This resistant layer forms the flat upper surfaces of the park.

During the Pleistocene epoch, a vast sheet of windblown sand about 12 to 15 feet thick was spread upon the caprock. These are the "cover sands," which today mantle practically the entire surface of the Southern High Plains. Subsequently, in the late Pleistocene, the playas were formed and shallow drainages began to develop upon the "cover sands."

The Ogallala Formation is the water reservoir for the Llano Estacado. Rainwater seeps downward into the formation saturating the sandstone, which by virtue of its porosity, permits the water to migrate to well bores. It is used for human consumption and for extensive irrigation.

The Ogallala Formation contains fossil remains of ancestors of the horse, camel, and other mammals as well as fossil snails and plants.

At present the Llano Estacado is being eroded. The scarps are receding, the declivity being maintained by differential erosion between the caprock and the less resistant underlying shale and sand. Some streams are eroding headward toward the interior of the Llano Estacado. Inside Mackenzie Park, the Yellowhouse Fork joins the Double Mountain Fork of the Brazos River. These streams have eroded through the caprock and have exposed the uppermost layers of the Ogallala Formation.

MARTIN DIES, JR., STATE RECREATION PARK

Ross A. Maxwell

Martin Dies, Jr., State Park is on the Neches River near Town Bluff. The reservoir is crossed by U. S. Highway 190 about 14 miles east of Woodville (Tyler County) and is about 7 to 9 miles west of Jasper (Pl. I). The park, including 705 acres, is on the Dam B Reservoir and was acquired by license from the U. S. Army Corps of Engineers in 1964. The dam's primary function is flood control on the Neches River. It is a compacted earth structure with a concrete section in the river channel. It has a total length of 6,698 feet and a maximum height of 45 feet above the stream bed. The normal fluctuation in the lake level will be about 2 feet, but during extreme flood the lake level could rise to permit water to flow over the uncontrolled spillway. These conditions should not seriously affect the park's recreational facilities, which include screened shelters, trailer sites, tent campgrounds, camping, picnicking, and rest room facilities. There are also a concessions building, boat ramp, fishing, and nature study. The park is at the southern edge of the Big Thicket where a dogwood flower festival is held each spring at Woodville. It is also only about 35 miles from the Alabama-Coushatta settlement, the only Indian reservation in Texas.

The rocks at Martin Dies State Park are a part of the Fleming Formation, Lagarto Formation on most of the older geologic maps (table 1). Geologic mapping is shown on the Beaumont Sheet of the Geologic Atlas of Texas. The rocks are mostly black calcareous clay, containing rough nodular concretions that were deposited in brackish water lagoons or shallow lake waters (fig. 64, p. 112). In this environment most of the invertebrate fossils are the kinds of clams, snails, and oysters that could live in partially salt water. In some places, vertebrate animals presumably walked into the swampy areas either for food or water and perished. The fossil remains include beaver and camel skulls, horse jaws, and rhinoceros bones; these have been found along with fresh-water mussels, river snails, and foraminifers. Stenzel, Turner, and Hesse (1944) discussed in detail the relationships between the brackish and nonmarine deposits and described the fossils found at localities near Burkeville (Newton County) on U. S. Highway 190 about 20 miles east of Jasper.

MERIDIAN STATE RECREATION PARK

Ross A. Maxwell

Meridian State Park (about 462 acres) is on State Highway 6 (Park Road 7) between U. S. Highways 81 and 281 in Bosque County, about 4 miles southwest of Meridian (Pl. I). The park was acquired in 1933-1935 by deeds from private owners. A dam on Bee Creek forms Lake Meridian (73 acres), all within the park. The facilities include a concessions building, recreation hall, rest rooms, showers, screened shelters, camping, picnicking sites, nature trail, children's playground, fishing, swimming, boating, boat ramp, but no water skiing.

The town of Meridian was laid out and established by George B. Erath; the name was selected because the townsite is close to the 98th meridian. Prior to settlement, the area was occupied by the Tawakonis Indians. The Texas—Santa Fe Expedition of 1841 is believed to have passed through Bosque County near the present park area. Meridian became the county seat on July 4, 1854, when Bosque County was organized. The courthouse, a small log cabin, was the first public building, and the town was incorporated in 1874. Diversified agriculture is the principal occupation in the county; in the town are several small industries, a modern hospital, library, and Meridian Junior College.

Most of Bosque County is in a cut plain

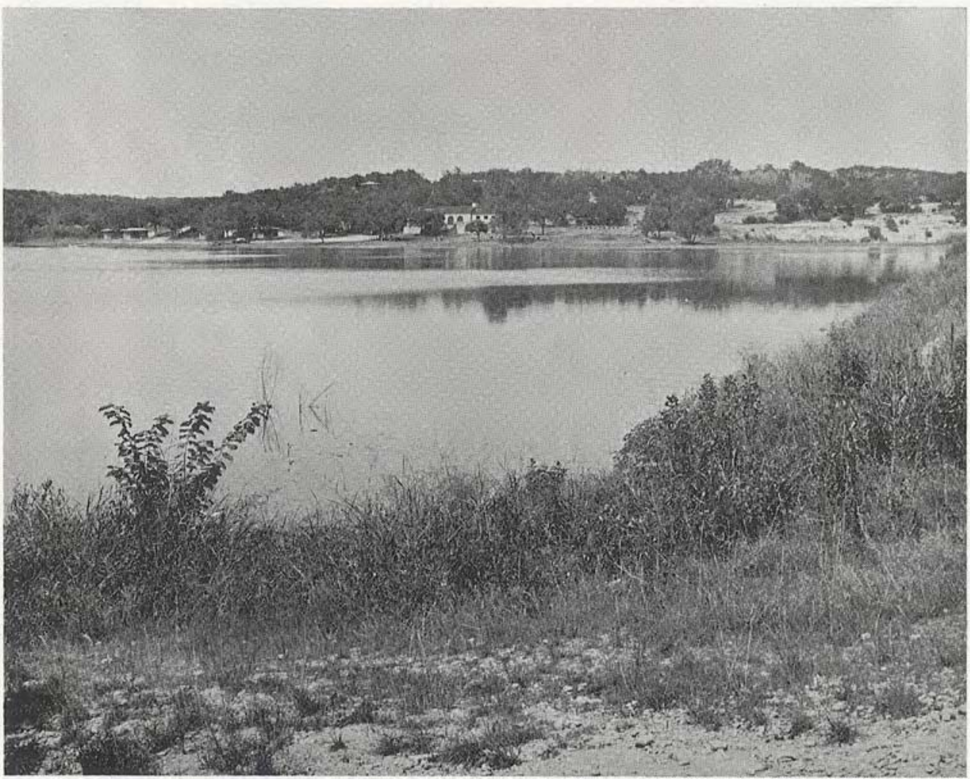

FIG. 72. Edwards Limestone exposed along the shoreline at Lake Meridian. This hard massive rock is ideal foundation material for the park's facilities. (Photograph by Texas Parks and Wildlife Department.)

area of the Grand Prairie province. Previously the area was relatively flat with a gentle southeastern slope on the hard, resistant Edwards Limestone (fig. 72). Erosion cut gullies in the Edwards and in time they developed valleys. Because of the resistant nature of the Edwards Limestone, steep slopes and incised canyons are common. Where erosion cut through the Edwards Limestone, the valleys are widened by undercutting; as erosion continued downward into the underlying less resistant Comanche Peak and Walnut Formations, it caused the Edwards to break into large blocks that fell into the valley below. Thus, the summit of the hills and ridges now exposed represents the old erosion surface previously developed on the Edwards Limestone (fig. 73).

The rocks along the margins of Lake Meridian and the adjacent ridge- and hilltops are mostly formed by the Comanche Peak — Edwards. The softer strata exposed along most of the canyon walls, and sometimes at low-water level in the lake, are Comanche Peak Formation. In some of the flat valley bottoms the Walnut Formation is exposed (table 1). The Edwards Limestone is about 30 to 35 feet thick. It contains a few mound-like reef-like bodies and some chert bands (fig. 74). Horn-coral-shaped clams (rudistids), foraminifers (one-celled animal shells), and fragmental fossil debris are especially

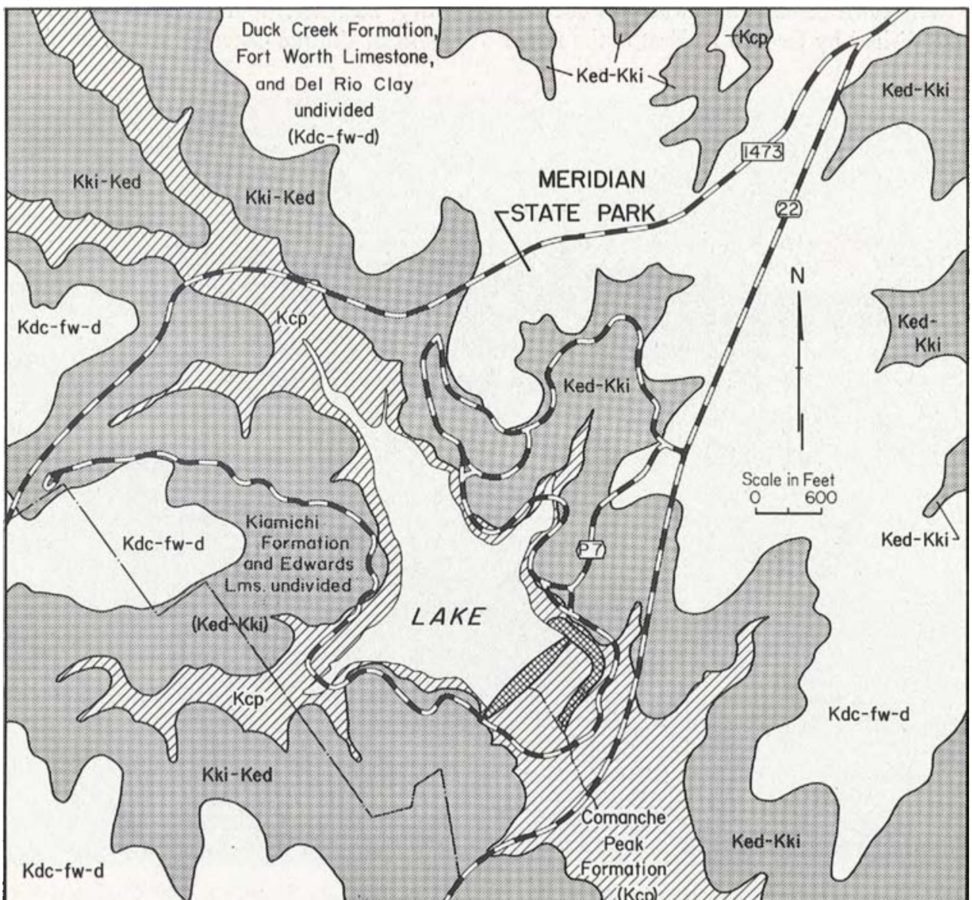

FIG. 73. Geologic map of Meridian State Recreation Park.

common along the reef margins. The Comanche Peak Formation is about 100 feet thick. It includes some hard limestone layers but most of the formation is nodular marly limestone. Fossil clams, oysters, ammonites, and snails are common. The Walnut is mostly a marl or marly clay formation. Fossil oysters, sometimes in thin ledges, sometimes in clumps, are common and there are also fossil clams, snails, sea urchins, and ammonites.

Rocks capping the highest hills and slopes above the resistant Edwards Limestone are underlain by the Kiamichi, Duck Creek, Fort Worth, and Denton Formations. The Fort Worth is mainly limestone and forms most of the rocky ledges in the upland. All of the latter formations are fossiliferous.

FIG. 74. Small reef-like mound in the Edwards Limestone at Meridian State Park. Note soil development and manner in which the cedar tree roots extend along top of bedrock. (Photograph by Texas Parks and Wildlife Department.)

MISSION SAN FRANCISCO DE LOS TEJAS STATE HISTORIC PARK

Ross A. Maxwell

Mission San Francisco de los Tejas (fig. 75) was the first mission established in East Texas (1690) and was on the site of the Tejas Indian village of Nabedache. The mission was close to the Neches River, a few miles southwest of the present town of Weches, in Houston County. It struggled to survive, partly due

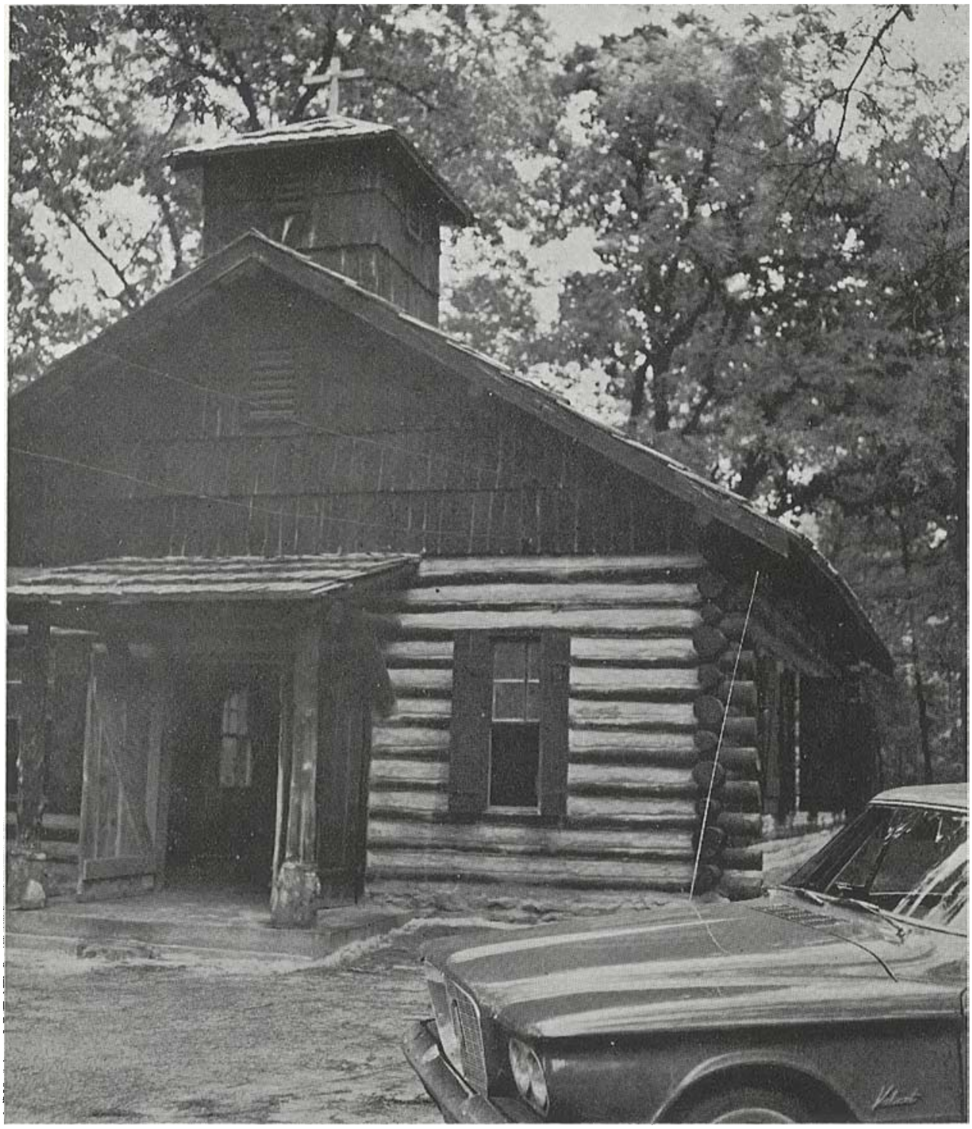

FIG. 75. Mission Tejas restored. The mission is on the Weches Formation. (Photograph by Texas Parks and Wildlife Department.)

to lack of supplies and also to the unfriendliness of the Tejas Indians. The mission was burned and abandoned in 1693. A second attempt was made in 1716 to establish a mission (Mission Nuestro Padre San Francisco de los Tejas), but these efforts were also abandoned in 1718. The third attempt was made in 1721, when it was learned that a village of the Neches tribe of the Tejas Indians had moved to the old mission site. This third mission (San Francisco de los Neches) existed for about 8 years and for part of that time was successful, but when the presidio was moved in 1729, the missionaries also left and there were no more attempts to establish a mission in East Texas.

Mission Tejas State Park (118 acres) is on State Highway 21, about 22 miles northeast of Crockett and a few miles southwest of Weches, Houston County (Pl. I). It is within the Davy Crockett National Forest and was acquired in 1957 by Legislative Act from the Texas Forest Service. It is an undeveloped area, but camping and picnicking are permitted. Developments under construction include modern rest rooms with showers and modern camping units. Federal and State-appropriated matching funds will permit construction of trailer and tent camping units, service and storage building, rest rooms, roads, parking facilities, and the necessary utilities. There are opportunities for nature study in the forest and visitors may see a replica of the old mission.

The rocks at Mission Tejas State Park are in the Weches Formation (table 1). They were mapped by Stenzel (1943-1944) and also studied by Fisher et al. (1965). The mission was near the type locality of the Weches Formation, which was deposited in shallow marine waters and contains much glauconite. In places where there are thick glauconitic beds and the soluble ingredients leach there is a concentrated residue of iron oxide. These ferruginous layers resist erosion and often cap hills and ridges throughout the outcrop area of East Texas. Where there is less concentration of iron oxide the formation underlies prairie areas, and there is sharp contrast to the oak-covered sandy soils of the underlying Queen City and overlying Sparta Formations. Fossils, including snails, clams, oysters, and foraminifers, are abundant at many places.

MONAHANS SANDHILLS STATE SCENIC PARK

Gus K. Eifler, Jr.

Monahans Sandhills State Park is on U. S. Highway 80, 5 miles east of Monahans in Ward County (Pl. I). The park comprises approximately 4,000 acres, mostly covered by sand dunes, and is often called the Sahara of the Southwest (fig. 76). Among the State Parks, Monahans Sandhills is fairly young and owes its establishment in 1956 indirectly to the late Roy Bedichek of The University of Texas at Austin. In his book "Adventures with a Texas Naturalist," Bedichek (1947) urged that the area be preserved and used as a park. Conrad Dunagan and other citizens of Monahans succeeded in getting a county fund for the purchase of a half section of land and for the acquisition of a 99-year lease on the rest of the land. Funds for the park operation are currently appropriated by the State.

Because water is available at shallow depths throughout much of the sandhills country, Indians used the area for meetings and temporary camps. It was a regular stop on the Comanche war trail extending from Oklahoma across Texas and deep into Mexico. The first white men to report on the sandhills were Spanish explorers who learned about the water from the Indians. Later Captain R. M. Marcy, en route to Santa Fe, New Mexico, from Fort Smith, Arkansas, crossed

FIG. 76. Note sharp crestline of active dune in foreground. As the windblown sand reaches the dune's crest it slides down the steep slope and the dune moves forward. Dunes partly stabilized by vegetation in background. (Photograph by Texas Parks and Wildlife Department.)

the sandhills, which he said were 17 miles wide. Other early explorers described them as much wider. The great northbound cattle drives of the 1860's and 1870's avoided the sandhills, which became a nuisance and an oddity. However, in 1880 the Texas and Pacific Railroad selected Monahans as a water stop, the only one between Big Spring and the Pecos River. Ten years later a hotel was built which served as a nucleus of the growth of Monahans.

About 1-1/2 miles beyond the park entrance is the headquarters building where visitors go for rest and refreshments. Souvenirs and mementoes of the park are also available there. Near the park entrance is a modern museum of glass and stone. As an aid to understanding the natural and historical background of the area, the museum provides permanent botanical, geological, archeological and historical exhibits. Special displays of art, crafts, antiques, and science are shown from time to time. The park provides no cabins or other facilities for overnight visitors at this time. Picnicking is the major form of recreation, for which the park has supplied ample tables, grills, and shelters. Funds from a Federal grant and State matching funds will provide tent camping units, a trailer camp sewage dump station, additional rest rooms, roads and parking facilities, and the necessary utilities. At headquarters, a well supplies an abundance of potable water. Climbing the sand dunes is enjoyed by both young and old; paved roads lead to many of the higher dunes. A special attraction is the "buggy ride" down a dune slope in a specially designed jeep that skids over the sand in roller-coaster fashion. From a 65-foot tower, one can get a panoramic view of the entire park.

The shifting sands of the park support scant vegetation, mostly small desert plants, such as the prairie yucca, but local growth of miniature oaks and mesquites appear as small forests among the dunes. These trees grow to heights of only 3 to 4 feet but bear acorns and beans in abnormal abundance. Although many kinds of animals inhabit the dunes, they are seldom seen. They include the gray fox, coyote, jackrabbit, badger, skunk, armadillo, bobcat, pack rat, and kangaroo rat. The great lobo wolf, once an inhabitant, disappeared soon after the early settlers arrived.

Perhaps the most interesting feature of the park is the nature trail. Here one can see footprints of both large and small animals, or perhaps catch a glimpse of a pack rat or coyote (fig. 77). The moving sand has uncovered prehistoric remains such as the extinct camel and mastodon. Arrowheads, pottery, and other Indian artifacts are still being found along the trails.

The park is located near the edge of the Edwards Plateau where it fades westward into the Fort Stockton Plateau (Pl. I). In this area, a vast sea of windblown sand completely blankets the shallow bedrock of Triassic and Cretaceous sandstone. The sands are Quaternary in age and are divided into two formations. The older or lower is the Judkins Formation and the younger is the Monahans Formation (table 1). The Judkins is composed of quartz sand which is slightly indurated by silt and clay that sifted downward into the pore space of the sand. The grains of sand are mostly clear but some have a surficial stain of iron oxide which gives a reddish-brown color to the formation. Practically all of the sand grains are rounded and "frosted," features resulting from collision and abrasion while the grains were being transported. The Judkins Formation was deposited during a relatively arid time when winds formed extensive dunes. These were modified by ancient erosion and the entire sand surface became weathered. The formation is about 6 feet thick but originally was much thicker.

The Monahans Formation lies unconformably upon the more extensive Judkins and is approximately 30 feet thick.

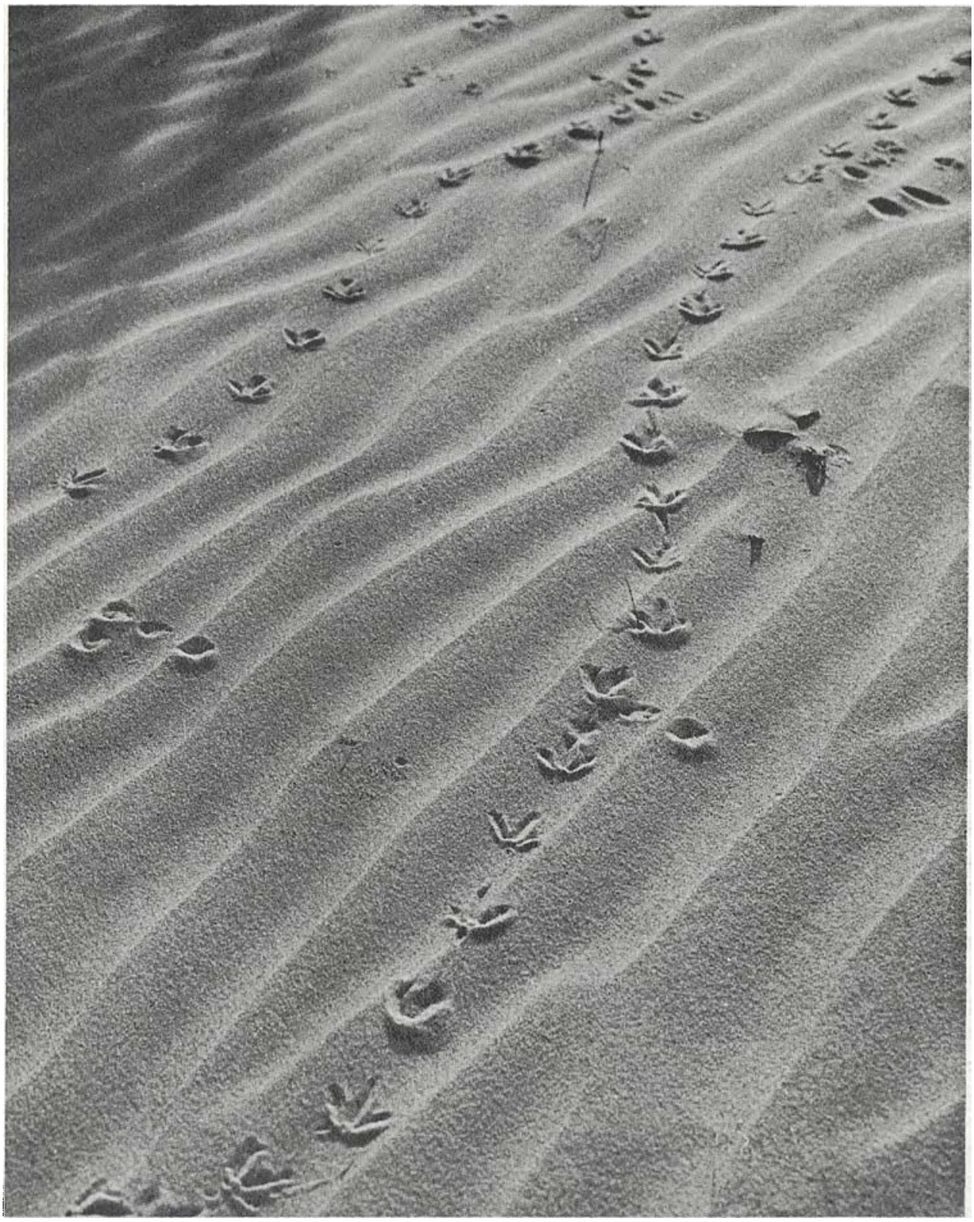

FIG. 77. Ripple marks and bird and rabbit tracks in the active sand dune at Monahans State Park. (Photograph by Texas Parks and Wildlife Department.)

The formation is composed of clear well-sorted grains of quartz sand, which are rarely coated with iron oxide. The sand ranges in color from light gray to golden yellow. Being essentially free of silt, clay, or other cement, the sand is easily moved by the wind. The dunes are smooth mounds, elliptical to circular in ground plan, and range up to 40 or 50 feet in height. Some are fixed in position by vegetation, others are being shifted and modified by the wind.

MONUMENT HILL STATE HISTORIC SITE

Ross A. Maxwell

Monument Hill State Historic Site (3.94 acres) is in Fayette County on Loop Road 92, off U. S. Highway 77, about 3 miles southwest of La Grange. It is here that the victims of the Mier Expedition (1842)—death lottery for the men who drew black beans—and those Texas heros of Captain Nicholas Moseby Dawson's volunteers, who were killed at Salado Creek, are interred in a common grave. The bodies of these heros were removed from their original burial sites and reburied with full military honors at Monument Hill on September 18, 1848. The old tree under which Captain Dawson recruited his ill-fated expedition still stands in La Grange.

The park site was acquired in 1956 by deed from the Archbishop of San Antonio. The tomb and memorial shaft, with the Texas history that they represent, are of principal interest. Rest rooms and picnic tables are on the grounds.

Monument Hill is on top of the inface of a cuesta formed by a resistant sandstone ledge in the Oakville Formation (table 1). The bluff is formed by the Moulton Sandstone Member, which in the La Grange area is near the base of the middle Oakville; at Monument Hill the Moulton Sand-

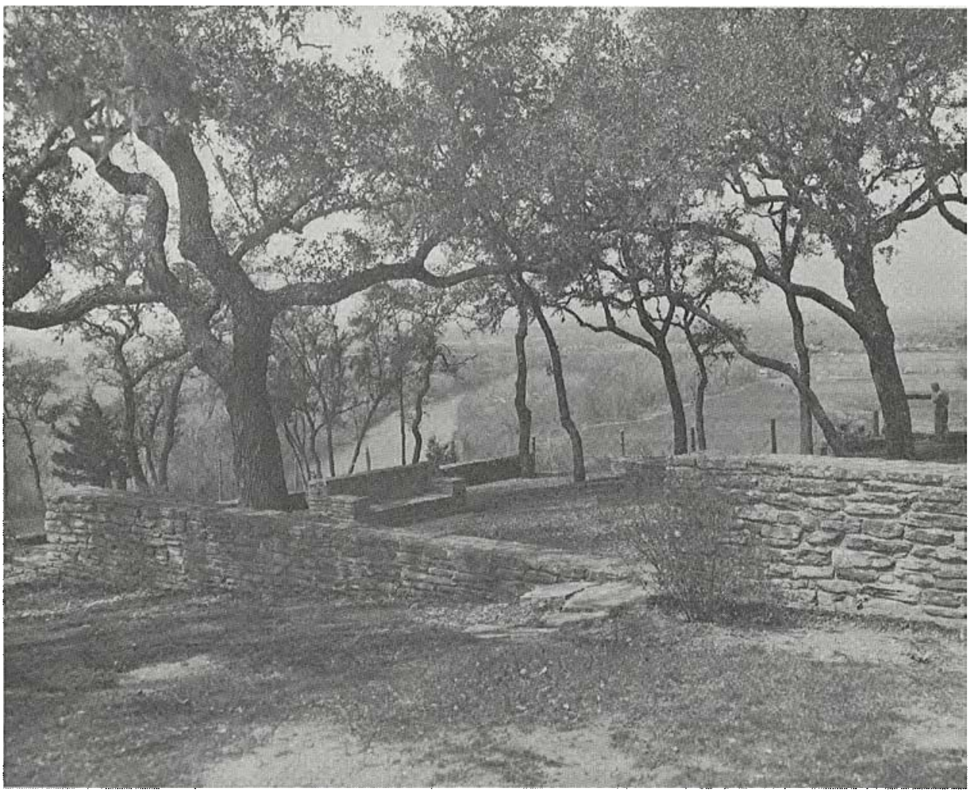

FIG. 78. Rest area at Monument Hill overlooking the terraced Colorado River valley. Outskirts of La Grange at upper right. Masonry wall constructed of Moulton Sandstone member of the Oakville Formation. Colorado River with cultivated terrace to right. (Photograph by Texas Parks and Wildlife Department.)

stone is about 40 feet thick (fig. 78).

The Oakville Formation is of continental origin and was deposited by several coastal streams on a relatively flat surface. The streams shifted their channels many times, as shown by the cross-bedded and channel-filled sandstone deposits and the lenticular nature of the sandstone and shale beds throughout the formation. The Oakville beds both above and below the Monument Hill caprock are mostly calcareous gray clay and shale with lenses and irregular beds of sandstone. Many of the Oakville beds contain reworked invertebrate fossils from the Cretaceous rocks, some of which can be identified. This indicates uplift along the Balcones fault zone which permitted the rejuvenated streams to pick up a load of sediments and fossils that were redeposited during the Oakville epoch. In some mudflats and overflow area between the stream channels fossils of both carnivorous and herbivorous Tertiary mammals have been found.

The Catahoula Formation underlies the Oakville and is mostly greenish-gray noncalcareous clay and sandstone with lenticular beds of volcanic ash (fig. 79). The source of the pyroclastic materials is not known and this has been a matter of speculation for years. Some geologists have suggested that the source is from volcanoes in Mexico. Others think it is from the mountains in West Texas, some say it is from outside the State, and some have speculated it is from a nearby source.

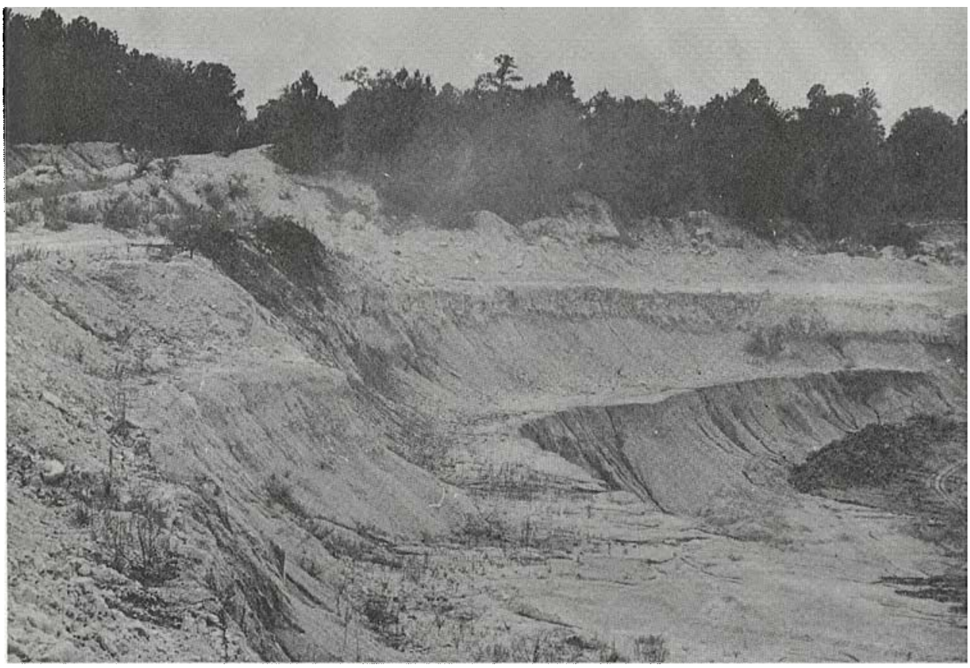

FIG. 79. Catahoula Formation. The top ledge is indurated volcanic ash. Slope below is bentonitic clay (altered volcanic ash). Lower ledge is good quality commercial bentonitic clay. Bentonitic clay is used in the bleaching industry. (Photograph by L. Edwin Garner.)

MOTHER NEFF STATE RECREATION PARK

Ross A. Maxwell

Mrs. I. E. Neff, mother of Governor Pat Neff, willed to the State of Texas (June 2, 1916) a 6-acre tract with a pecan grove along the Leon River in Coryell County. Although Mrs. Neff left only a small plot for "religious, educational, fraternal, and political purposes," this tract has often been referred to as the beginning of the State Parks System of Texas. The area has now been enlarged to 259 acres and is reached by Farm Road 107 (Park Road 14) and State Highway 237, off U. S. Highway 81 (Pl. I), about 9 miles west of Moody. The newer area (253 acres) was acquired in 1934 by deeds from private owners.

Pat M. Neff served as Governor of Texas from January 18, 1921, to June 20, 1924, and was later President of Baylor University. He was instrumental in the organization and appointment of the first Texas State Parks Board created in 1923. His personal interest in the State parks was shown in 1924, when he traveled more than 8,000 miles through 82 counties delivering 110 speeches in support of the State parks. His arguments for State parks emphasized recreation and a park system that would permit "Texans to know Texas."

Facilities and activities within Mother Neff State Park include camping, group camping, shelters, picnicking, rest rooms, showers, hiking, nature study, fishing, and a tabernacle that is free for religious services.

Coryell County is mostly in a dissected plains area that is capped by the Edwards Limestone (*see also* Meridian State Park, pp. 139–141). In order to get a good view of the rocks from an automobile, the most interesting route is from Belton to Moody and thence to the park. State Highway 317 at Belton starts on the Georgetown Formation and ascends through the Del Rio, Pepper, and into the Eagle Ford Formation (table 1). The town of Moody is on a divide capped by the Lake Waco Member of the Eagle Ford. Park Road 14 descends across the formations mentioned above and into lower stratigraphic units. In the park, the highlands are capped by the Edwards Limestone and the slopes along the Leon River are underlain by the Comanche Peak Formation. The Edwards is about 50 feet thick, contains some mound-like reefs (fig. 72), and fossils include rudistids (horn-coral-shaped clam), foraminifers (one-celled animal shells), and various shell fragments along the reef margins. A reef near Mother Neff State Park has been described and photographed by Nelson (*in* Lozo et al., 1959, pp. 65-66 and Pl. II, p. 167).

The underlying Comanche Peak Formation is mostly nodular marly limestone about 100 feet thick that contains various fossil shells, mostly clams and oysters. The terrace at the pecan tree grove was cut in the Comanche Peak Formation and the terrace surface is covered with alluvium deposited by the Leon River. Thin alluvial deposits also cover some of the hilltops that are capped by the resistant Edwards Limestone. A diagrammatic sketch of the formations exposed in the park has been published (Rodda et al., 1966, p. 131, fig. 21).

PALMETTO STATE SCENIC PARK

Ross A. Maxwell

Palmetto State Park is noted for its wide variety of plants, rare birds, sphagnum moss, peat bogs, mud boils or mud volcanoes, mineral water, and historical events. The Texas State Parks Board acquired title to 198 acres of Ottine Swamp and adjacent land on September 11, 1933, and named the area Palmetto State Park from the dwarf palmetto that grows there. The CCC established a camp (Company 873) at Ottine in 1934 and began construction of the park facilities that year. The principal park building was made with massive sandstone blocks from the Reklaw Formation (table 1) and has a palmetto-frond thatched roof. Its style of architecture was so unusually appealing that the National Park Service selected the main building as one of the eleven outstanding refectories in the United States.

The park can be reached from U. S. Highway 183 south from Austin toward Gonzales (Pl. I). It is near Ottine, about 3 miles west of the highway. Shearer et al. (1956) included a summary, with pictures, of the history, geology, and botany; he also included a list of the plants, birds, butterflies, amphibians, and reptiles.

The village that is now Ottine was founded by Adolph Otto, a German emigrant, who was a resident of Prince Solms' colony at New Braunfels. Herr Otto moved to the San Marcos River in 1879, locating at a site where the permanent-flowing river would furnish water power for a cotton gin. A small agricultural community developed around the gin and soon there was a blacksmith shop, lumber yard, two general merchandise stores, drug store, barber shop, church, and tavern. The trade area was extended with the completion of a railroad spur from Gonzales, and the post office was established in 1892. The name Otto was proposed for the post office, but this suggestion was not acceptable because there was already an Otto in Hardin County. A compromise suggestion that incorporated the letters "Ott" from the founder's name and "ine" from Christine, a daughter-in-law, was acceptable and the village was formally designated Ottine.

The surface rocks in the vicinity of the park belong to the lower Eocene of Tertiary age and crop out on the rolling surface of the Gulf Coastal Plain. They consist of sandstone and shale that dip southeasterly toward the Gulf of Mexico, are locally highly ferruginous (iron bearing), and were deposited under nonmarine conditions. The Carrizo Sandstone, older of the two formations in the vicinity, crops out at Ottine and is exposed for a few miles toward the west (table 1). This rock is weakly consolidated, weathers to a sandy soil, and forms an environment favorable to certain plant species. The overlying Reklaw Formation contains both sandstone and clay. A ferruginous sandstone ledge in that unit caps the prominent escarpment that overlooks the swamp area from the east.

The San Marcos River flows southeastward down the slope of the coastal plain crossing the strike of the Carrizo and Reklaw Formations. In this area the river has cut through the Reklaw and into the Carrizo to a level almost 100 feet below the surface at Ottine. About 40 to 50 feet above the present river level is a well-defined river terrace cut in the Carrizo Sandstone, and a second terrace occurs near the river level. On these terraces are remnant scars of the river's earlier channel; some of the lower scars are now occupied by swamps. Water seepage and small springs emerging from the Carrizo Sandstone furnish the moisture to maintain the swampy conditions, and it is in the swamps that the peat bogs and mud volcanoes occur (fig. 80).

Fenneman (1906, pp. 91-92), near the beginning of this century, reported that some of the larger mud volcano cones were as much as 5 feet high and about 30 feet in diameter. Water accompanied by gas was seen bubbling from the top of some cones and oozing from the sides

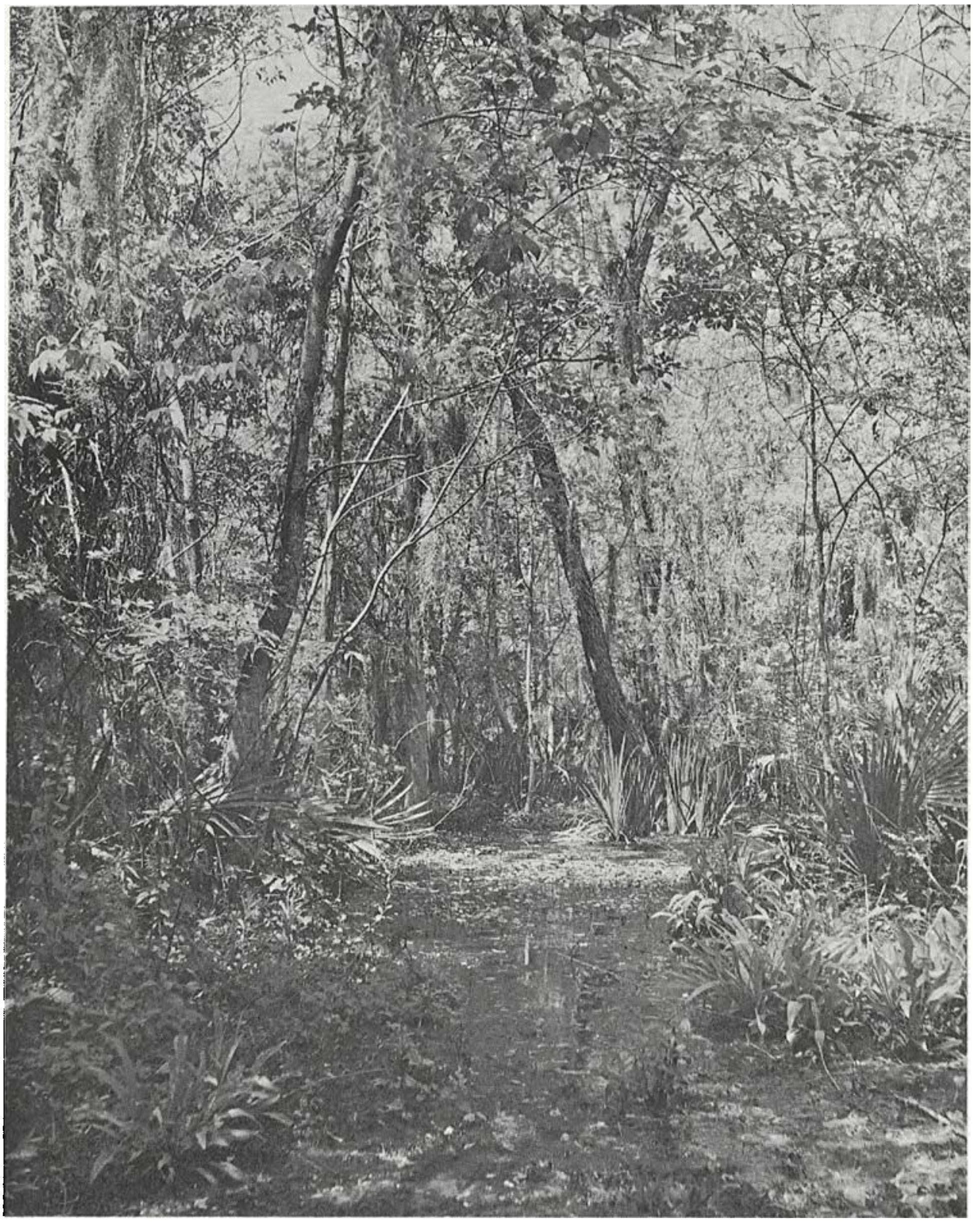

FIG. 80. The light patch in central foreground is a mud boil in a peat bog. The vegetation that accumulates in these highly acid waters is slowly converted to peat. Dwarf palmettos, that gave the name to this south-central park, grow in right foreground. (Photograph by Texas Parks and Wildlife Department.)

of others. The bog surface in which the cones occurred was covered with a sphagnum growth so strong that a man, supported by a plank under his feet, could jump up and down causing the entire mound to shake. Fenneman attributed the source of the gas as coming from the underlying formations and emerging at places where the gas could find a passage to the surface. Clay particles were moved along the conduit by the gas and when finally ejected at the surface built the cone. Boiling sand pools along the river bank were also noted by Fenneman. Since that time, all of the large mud volcanoes are extinct and only a few of the small cones are periodically active.

Peat accumulations in the bogs along the San Marcos River have been of some economic importance (Chelf, 1941). Peat is a brown or black, spongy organic substance formed by the accumulation of organic plant matter in poorly drained bogs and marshes. It consists of a mass of partially disintegrated moss, ferns, leaves, sedges, algae, grass, rootlets, and partially decayed wood; when pressed together, it forms a soft spongy layer beneath the living moss, fern, and sedge cover of the marsh.

Because of the humus content, water-absorbing qualities, acid properties, and cleanliness, peat has been used extensively by Texas florists, gardeners, and horticulturists to condition alkali soils, to lighten and enrich heavy clay loams, to propagate seedlings and for potting plants. During and immediately following World War II, peat from outside the park area was used to supply the local market.

The peat bogs found on both sides of the San Marcos River provide an environment for several exotic plants and the area is of unusual scientific interest because of the wide variety of plant species. The dwarf palmetto, from which the park is named, grows with all the luxury of plants found in their normal eastern range, which is along river bottoms bordering the Gulf Coast in the area from Texas to Florida. There are also orchids, wild iris, yellow-eyed grass, hibiscus, arrow leaf, and many other flowers. Ferns, six or eight different kinds, range from tiny floating forms to the majestic cinnamon fern that stands 6 feet tall. The sphagnum moss, a plant common in the north and east, is rare in the Southwest. The white primrose violet that grows in the moss is also a long way from its normal range. The areas adjacent to the river have a dense undergrowth above which are the large Spanish-moss-covered trees that add to the sub-tropical appearance of the area. In the adjacent meadows are a wide variety of grasses that include types found in the salty coastal region, the wetter prairie areas, the Central Texas blackland soils, and the semiarid deserts of West Texas.

In season the uplands are covered with blankets of phlox, bluebonnets, white daisy, and other flowers too numerous to list. The deep red Drummond's phlox grows in abundance and its range is nowhere east of the Brazos River or north of Milam County. It was somewhere in this area that Thomas Drummond collected phlox seed in 1830 and sent it to the Royal Botanical Gardens in Edinburgh, Scotland. From these seeds, plants were distributed to other botanical gardens all over Europe. The plants responded to cultivation and since that time more than 150 varieties of phlox have been developed.

It is also interesting to note that the bluebonnet (*Lupinus subcarnosus*), which is largely confined to the same areas as Drummond's phlox, is the official State flower. This species is found only in sandy soils and differs from the deep blue flower of *Lupinus texensis*, commonly found on the black soils of Central Texas.

Warm sulfur spring water in the Ottine area was recognized by the early settlers and a part of the village's early fame was due to this mineralized water. The Gonzales Warm Springs Foundation obtains water for their activities from a well drilled for oil in 1910. The water was encountered in the Wilcox Formation (table 1) at a depth of 1,548 feet. The well flows at an average rate of 124 gallons per minute and the temperature of the water is 101°F. The Foundation's hospital is near the park and the water's therapeutic values are widely acclaimed by many patients.

Visitor facilities at the park include camping, rest rooms, picnicking, hiking, and nature study. The headquarters building is available for special meetings; also confections, curios, and cold drinks are available. A Federal grant matched by State appropriation will provide trailer and tent camping units, nature trail, additional rest rooms, parking areas, utilities, and landscaping.

PALO DURO CANYON STATE SCENIC PARK

Ross A. Maxwell

Palo Duro Canyon State Park is about 28 miles south of Amarillo and is reached via State Highway 217, off U. S. Highway 87 about 12 miles east of Canyon (Pl. I). The park is administered by the Parks and Wildlife Department and was created in 1933 when the Texas State Parks Board acquired 15,103 acres in the most spectacular part of the canyon through a public revenue bond issue. The name Palo Duro is an Indian term meaning "hard wood," which refers to the canyon's supply of juniper (cedar) brush from which the Indians made their arrows. Juniper and mesquite are the dominating native flora, except along the stream banks which are lined with cottonwood, chinaberry, and hackberry trees. Most of the larger native fauna have been exterminated, but deer, coyote, and many smaller mammals, numerous birds, and several kinds of reptiles still inhabit the canyon. Aoudad sheep have been introduced and antelope are abundant in the adjacent plains.

The scenery and recreational activities at Palo Duro Canyon State Park are closely related to the geologic features. The park road winds along the canyon bottom and fords Palo Duro Creek on five low-water crossings (fig. 81). Trails lead to unique geologic phenomena such

FIG. 81. Aerial view of Palo Duro Canyon that includes upper two-thirds of park. Note the rough topography, slump and boulder pits along canyon walls, horizontal layers in the rock, flat surface of plain with sink-hole depressions, road and Palo Duro Creek in canyon's bottom. Also see geologic map, figure 82. (Photograph by Pape Photo Records, Inc., Amarillo, Texas.)

as the Spanish Skirts, where the eroded varicolored clays take the shape of a Spanish dancer's twirling skirt; Devil's Slide, a knife-edge spur eroded from a promontory jutting from the canyon wall; the Lighthouse, an eroded rock column; Capitol Peak, an eroded peak with dome-shaped top; intricately folded gypsum beds, and many other features. A ski-lift takes riders close to the canyon wall, 300 feet above the valley floor, where the changing light and shadows enhance the beauty of the rocks. A miniature train ride, with narration, carries visitors into one of the side canyons that otherwise would be difficult to reach. Saddle horses are available for those who wish a longer trip but most visitors hike along winding trails that lead to countless erosional features among the highly colored rocks.

The park's facilities benefited from a one-quarter million dollar renovation, expansion, and improvement program during the 1967–1969 biennium. Probably most vital was construction of a new water system. The water is brought from Lake Meredith, 10 miles north of Borger, Texas; the water purification plant, within the park, is comparable in size to that of a small city. Miles of distribution lines permitted renovation and expansion of trailer camp sites, camp shelters, campgrounds, rest rooms, showers, and picnic areas.

Sandwiches, coffee, confections, cold drinks, groceries, camping supplies, film, and souvenirs are available at Coronado Lodge. A new concessions building on the canyon floor will permit expansion of the above services at a more convenient location for most visitors. Regular dining services and cabins are not available at Palo Duro Canyon.

Various stage productions depicting pioneer history, early-day activities, and musical drama are enjoyed at the amphitheater nightly from July 1 through Labor Day. The original amphitheater and its productions were started, with meager essentials, by efforts of the Panhandle Heritage Foundation, Inc., now headquartering in nearby Canyon, Texas. The demand for and the popularity of these programs grew; the present setting comprises a complex of modest buildings, arranged around the open-air theater, all nestled in a curve of land by a 600-foot high bluff that forms the stage backdrop. Recent improvements include a more adequate stage, dressing rooms, storage space, paved parking area, lighting system, and shop.

The historic background of Palo Duro Canyon goes back to the early Indians, among them being the Wichita, Kiowa, Cheyenne, Arapaho, and later the Apache and Comanche. It was a winter campground for the plains tribes as attested by numerous campsites, characterized by stone artifacts, hearths, bedrock and boulder mortars, occasional pictographs, trade beads, potsherds, and other specimens. Palo Duro Canyon is especially associated with the Comanches, located as it is in the heart of their historic range after 1700; in 1874 it was the site of their last roundup when General R. S. Mackenzie administered a decisive defeat to the largest concentration of Comanche warriors (Albee, 1874).

The coming of the white man was heralded when part of Coronado's expedition is reported to have stayed in Palo Duro Canyon during the winter of 1541 (Windship, 1896). Later the Spanish and Mexican traders used the canyon as a camp. The United States' interest in the southern Great Plains, of which Palo Duro Canyon is a part, goes back to the early 19th century, when Major S. H. Long passed through the Texas Panhandle in 1820, and Zebulon Pike unsuccessfully tried to find the source of the Red River (Neashum, 1939, pp. 45-46). The ill-fated Texas—Santa Fe Expedition experienced great difficulty in crossing Palo Duro Canyon in 1841 (Kendall, 1847, pp. 227-230), and it was not until 1852, when Captain R. B. Marcy followed the Red River to its source, that Palo Duro Canyon was explored (Marcy, 1854, p. 110). Following the Comanches' defeat by General Mackenzie in 1874, the area was opened to settlement. The cattle industry started in 1876 when Colonel Charles Goodnight drove 16,000 head of cattle from Colorado to Palo Duro Canyon and started his home ranch (Haley, 1934, pp. 7-8). The cattle entered the canyon single file by the old Indian trail directly east of the present city of Canyon. It took two days to get the herd to the canyon floor, and mules packed the dismantled chuck wagon and supplies down the narrow trail. About 10,000 buffalo were stampeded from the canyon in order to preserve the grass for the cattle. The cattle industry grew rapidly and dominated the land utilization not only in the canyon but also on the adjacent plains until 1930, when the Canyon Chamber of Commerce obtained a lease permitting recreational use of a part of Palo Duro Canyon.

Palo Duro Canyon State Park is in the Llano Estacado province (Pl. I). The surface of that high plain was built by eastward-flowing streams that deposited their loads of rock debris east of the Rocky Mountains, and the plains surface is so generally flat that if all the windmills and other man-made structures were removed, there would be little to see but the unbroken horizon where the earth and sky appear to meet.

Some streams, like the Red River and its tributaries, have notched the eastern borders of the Llano Estacado and eroded great furrows into its surface. Palo Duro is the most spectacular of the canyons, and probably its greatest appeal is the suddenness of the abrupt change from the monotonous flat surface of the plains to the precipitous canyon walls where the flat-lying, highly colored rocks that underlie the Llano Estacado are exposed.

Palo Duro Creek has its source in eastern New Mexico, near the western edge of the Llano Estacado. The upper drainage is a dry, shallow draw and it continues eastward as such for about 40 miles. In western Randall County, the valley is about 50 feet deep and a quarter of a mile wide; springs begin to appear along the stream banks. The springs increase in number eastward and at Canyon, where the Palo Duro is joined by Tierra Blanco Creek, there is sufficient spring water to cause considerable erosion in the soft rocks; from that point eastward, the canyon deepens rapidly.

Palo Duro Canyon was not cut by a single stream, for in many places the canyon walls are notched by tributary drainage, of which Timber Creek, Sunday Creek, Little Sunday Creek, North Cita Creek, and South Cita Creek are the best known (fig. 82, in pocket). Like the main Palo Duro, the slope of the side canyons is abrupt, and commonly they expose precipitous cliffs several hundred feet high. Between the tributary drainage are numerous topographic eminences like Fortress Cliff, many small pinnacles, mesas, buttes, and peaks. Mesquite Park, the site of the popular prairie-dog town, is the largest mesa. Its northern edge forms the main canyon wall but it is virtually isolated from the plains by the upper drainage of Little Sunday and North Cita Creeks.

Erosion of the alternating hard and soft rock layers is responsible for conspicuous rock benches and commonly gives rise to various fantastically shaped remnants. The principal features developed in the weaker shales are forms commonly produced in the development of badlands. Rock columns or "hoodoos" are common; some are like the Lighthouse where erosion has left a 75-foot-high stack of shale capped by a sandstone ledge. The Devil's Tombstone is an example of where a boulder slumped from above and the surrounding soft shale was eroded away, leaving a boulder-capped pedestal.

The main Palo Duro Canyon averages about 1-1/2 to 2 miles in width throughout the park. At places where the main canyon is joined by tributary drainage, the width is considerably increased, depending upon the length and size of the side canyons. The canyon's average depth in the park is about 650 to 700 feet. At the park's eastern boundary, about three-quarters of a mile east of the Randall-Armstrong County line, the canyon is about 2-1/2 miles wide and 750 feet deep; along State Highway 284, about 15 miles east of the park boundary, the canyon has increased in width to 7 miles and in depth to 850 feet; about 20 miles farther downstream, the canyon walls have widened and flattened sufficiently so that most of the spectacular abruptness is lost.

All the rocks in the Palo Duro Canyon region are of sedimentary origin; they are comparatively flat or have a slight but regular dip toward the east and belong to three geologic eras: Paleozoic, Mesozoic, and Cenozoic (table 1). The oldest rocks belong to the Permian System and were deposited during the last epochs of the Paleozoic Era. As the Permian sea withdrew from the continent, certain closed basins retained water that evaporated, forming salt and gypsum deposits. Some of the evaporites are interbedded with shale and sandstone deposited by streams that periodically flowed into the closed basins. The rocks, except for the salt and gypsum, commonly have a distinctive red color and are referred to as "red beds."

At the close of the Permian the continent was uplifted, and the Texas Panhandle was subjected to widespread erosion. Late in the Triassic, first period of the Mesozoic Era, streams that probably head in the area that is now the Rocky Mountains deposited mud and sand in the Texas Panhandle. The sea invaded parts of Texas during the Jurassic Period but the Panhandle remained dry. During the Cretaceous, the sea was widespread in Texas and undoubtedly covered the Panhandle area, but uplift at the end of the Mesozoic Era permitted erosion to strip all Cretaceous-age rock from the Palo Duro Canyon area. In the Texas Panhandle this erosion seemed to have continued throughout most of the Tertiary. During the Pliocene Epoch (table 1), the Rocky Mountains were uplifted and east-flowing streams deposited a broad piedmont alluvial apron (Ogallala Formation) forming the flat surface of the Llano Estacado.

Rocks exposed in the bottom and lower slopes of Palo Duro Canyon are Permian (table 1). Like the Pennsylvanian rocks in North-central Texas, the units change rapidly from place to place, and because of the Llano Estacado cover, these rocks cannot be traced with certainty eastward into Oklahoma or into North-central Texas where the Permian sequence is better exposed. This has led to confusion and some disagreement among geologists as to the correct correlation and names of the formations. The oldest rocks exposed in the canyon's bottom are brick-red shales and soft red sandstones, both containing streaks of white crystalline gypsum (satin spar). Some of the shales and sandstones are interstratified with one or more ledges of hard, white gypsum about 8 to 10 feet thick. One exposure of this rock is near the mouth of Sunday Canyon where the gypsum bed is highly folded (fig. 83), and several small exposures of the gypsum ledge may be seen along the lower canyon walls for a distance of 5 miles. The largest continuous exposure of the hard white gypsum ledge is near the mouth of North Cita Canyon and it is traceable most of the distance to the State Highway 284 crossing in central Armstrong County. Here it forms benches along the inner canyon wall about 100 to 125 feet above the bed of Palo Duro Creek. Some geologists have called this the Cloud Chief Gypsum but others include both the gypsum and red-bed units in the Quartermaster Formation.

Most of the red beds, whether they overlie or are below the gypsum ledges described above, are composed of brick-

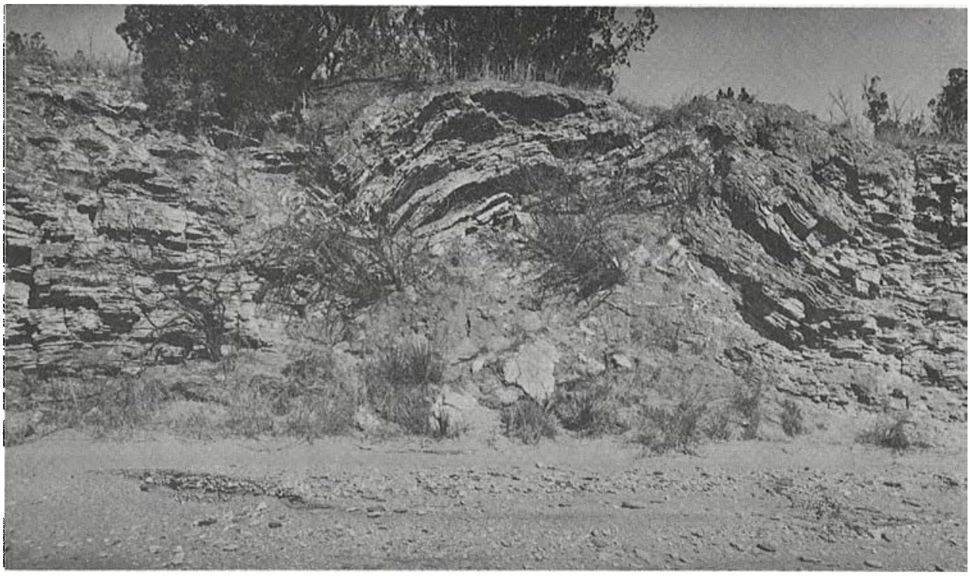

FIG. 83. Highly folded gypsum beds exposed in Sunday Canyon. The red beds, that in some places are exposed both above and below the gypsum, are slightly deformed. This type of folding is believed due to volumetric change when anhydrite takes on water and forms gypsum.

red shale, sandy clay, and soft red sandstone. Interbedded with the brick-red materials are some areas with mottled colors. These are commonly light greenish-gray circular or oval-shaped spots that give a polka-dot effect on the brick-red background. In some places the polka dots pass into irregular streaks and not infrequently into thin greenish-gray beds that extend for considerable distance laterally. Also some of the brick-red shale contains crystalline gypsum (satin spar) in bands up to 3 inches thick. The satin spar is normally white but in some places it is tinged with pink or blue. The thickest beds are associated with sandstone and are parallel to the bedding. When the satin spar bands occur in shale they are most likely to form criss-cross patterns, traversing the bedding at various angles (fig. 84).

The Triassic rocks form the middle canyon wall at Palo Duro Canyon; they are subdivided into the Tecovas and Trujillo Formations (table 1). The Tecovas is the older and overlaps the eroded surface at the top of the Quartermaster Formation. It includes highly colored shale and some soft friable sandstone. On color, the formation can be divided into three units. The lowest unit consists mainly of maroon, lavender, and yellow shale that is streaked and mottled with white, the middle zone is mostly maroon shale, and the upper interval is light yellow to sulfur-yellow shale. The line of color separation is not sharp; sometimes one color grades into another or a color may disappear. The colors of the Tecovas rock, however, contrast sharply with the brick-red shale in the Quartermaster and the color demarcation between the two formations is distinct even from the canyon's rim.

The Trujillo Formation, youngest of the Triassic rocks, consists of several ledges of hard, cross-bedded sandstone and conglomerate interbedded with red and gray shale. In most places there are three sandstone or sandstone and conglomerate ledges, but the number can increase to four or five ledges, and in a few places there are only two. In Palo Duro Canyon there is commonly a well-defined cliff-forming sandstone ledge near the middle

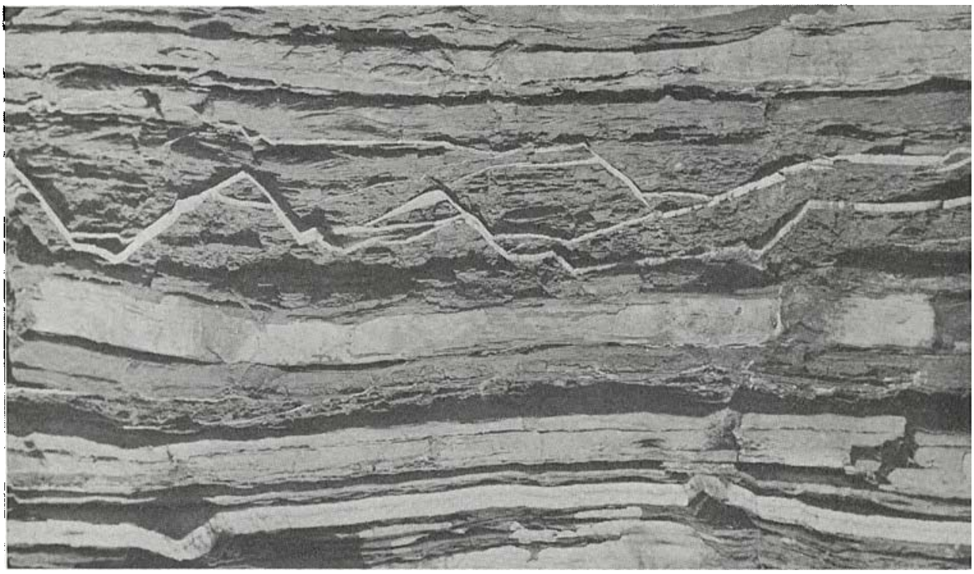

FIG. 84. The white gypsum bed (satin spar) near bottom of picture is essentially parallel to the sandstone. The thin gypsum beds above are joint filling in clay and cut the bedding at various angles. These deformed beds are believed to be due to volume changes in the gypsum following deposition. Solution of the gypsum decreases the volume and permits beds to settle. The addition of water causes increase in volume and buckling in adjacent soft rocks. Also see figure 83.

of the Triassic rock sequence (fig. 85). This is the basal Trujillo Sandstone, which is normally a hard, fine-grained, yellowish-gray or yellowish-brown rock but locally it may be cross-bedded and conglomeratic. The second sandstone ledge is coarse grained, cross-bedded, gray, brownish gray or red, and normally is conglomeratic (fig. 86). It overlies an interval of maroon, red, or gray shale and is in turn overlain by shale. The upper sandstone ledge is much like the middle bed and frequently forms a conspicuous ledge or cliff. Normally, but not always, this member is overlain by red or maroon shale that represents the top of the Trujillo Formation. This, in turn, is covered by the Tertiary rocks that cap the surface of the Llano Estacado. In places where the clay is absent due to post-Mesozoic erosion, the Tertiary rocks rest upon the upper sandstone ledge in the Trujillo.

The Tertiary debris blanket that caps the Llano Estacado is a heterogeneous mixture of clay, sand, marl, chalk, caliche, and gravel (fig. 87). At different places in the Great Plains these deposits have been given different names, but the term Ogallala Formation is generally accepted in the Texas Panhandle. Due to the nature of their origin, one would expect a wide variety in size and kind of material, but in general a coarse gravel bed rests directly upon the eroded surface of the Trujillo Formation and forms the caprock ledge on the canyon's rim. The colors of the Ogallala vary from place to place and also with the kind of material. The caliche and clay are commonly white, buff, or flesh, the sandstone is brown, the marl gray, the chalk is white, and the gravel has a wide variety of colors. They are in marked contrast to the maroon, lavender, and yellow colors of the Triassic and the brick-red shale in the Permian. The thickness of the deposit also varies from place to place, depending upon the irregularities in the upper Trujillo surface. Where the Trujillo is thick, probably a hill on the old eroded surface, the Ogallala is commonly thin; in valleys where the Trujillo is

FIG. 85. Sandstone in the basal Trujillo (Triassic) Formation. This unit is commonly a ledge formed near the middle of Palo Duro Canyon.

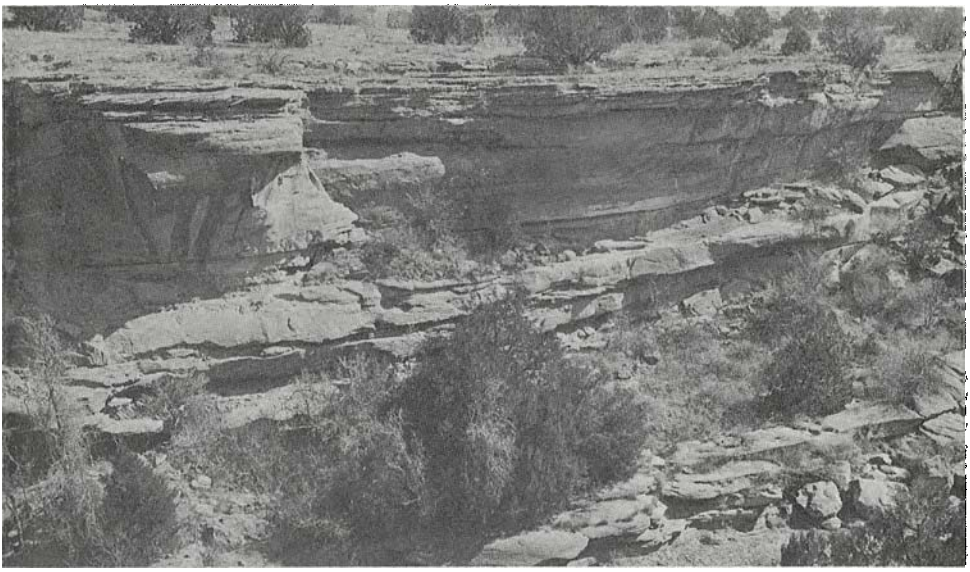

FIG. 86. Trujillo Sandstone. At many places this is the middle ledge in the wall at Palo Duro Canyon. Normally this sandstone unit is more resistant to erosion and the bedding is more uniformly developed than the lower Trujillo ledge (fig. 85). Erosion of the soft layers permits undercutting and the development of overhanging shelters.

thin, the Ogallala may be thick. The average Ogallala thickness in the Texas Panhandle is 75 to 125 feet.

Above the Ogallala Formation, and often difficult to distinguish from it, are some beds (table 1) that were deposited during the Ice Age (Pleistocene). These include sand, gravel, and silt in fluviatile terraces; clay and silt in playa deposits; lacustrine clay, sand, and gravel

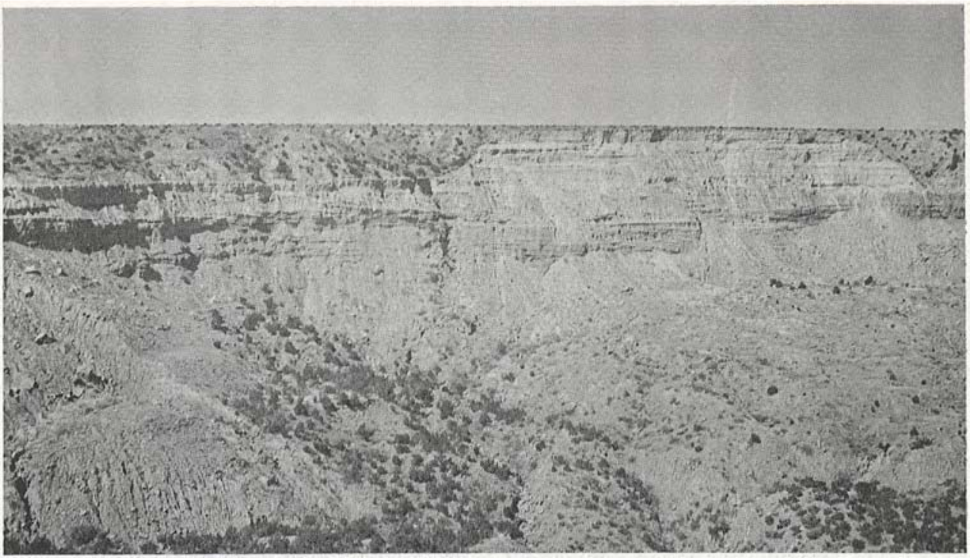

FIG. 87. The rim rock at Palo Duro Canyon; the top ledge is the Ogallala Formation. Note ledges of Triassic sandstone in middle canyon wall and the softer Permian, mostly clay, in the badland area in foreground.

FIG. 88. Windblown sand deposits of the dust-bowl days in the High Plains area suggest how the cover sand deposits of the Pleistocene may have accumulated a million years ago.

beds; windblown cover sand; sand, silt, and clay with caliche nodules, containing molluscan and vertebrate fossils; and sand, silt, and flaggy limestone, also fossiliferous (collectively shown as windblown cover sand (fig. 88)). These materials are widespread in the Texas Panhandle Plains and it is from them that many of the extinct mammal remains have been collected.

The Llano Estacado's surface is pitted with many depressions that range in size from 10 to a few 100 feet and occasionally some of them are 1 mile or more in diameter; the depth varies from a few inches to 20 or more feet. Most have oval shape and are scattered irregularly on the surface. In some places, however, they occur in chains, almost in a straight line, and in these one or both ends of the depression may be notched in the direction of the chains. A few of the larger and in some cases the deepest depressions contain permanent water; several of them are intermittent lakes, but the majority are dry throughout most of the year.

Some of the dry circular pits have a crack or hole near the center through which the water escapes most freely. Commonly the irregularly shaped depressions end abruptly in a fissure at one end. A few of the prairie streams disappear in such a fissure and again emerge from a crevice or cave, forming a spring. This suggests that many of the depressions are over a joint along which water seeps downward into the subsurface. A chain of depressions probably formed above a major joint, and in places where the surface streams disappear in a crevice the underground course of the water moves laterally along a fissure until it emerges as a spring.

The pits and depressions that dot the surface of the Llano Estacado are not buffalo wallows, as has been suggested, but are caused by groundwater action. The prominent gypsum beds in the Quartermaster Formation have been mentioned. Gypsum also occurs in variable amounts within some layers of the Triassic rocks in the Ogallala and Pleistocene deposits. Gypsum is soluble in water and where bodies of gypsum are dissolved in the subsurface, the weight of the overlying rock may permit the surface rocks to settle, forming the sink. These are the same processes that form sinkhole topography in areas underlain by limestone.

Ground water is present throughout most of the Llano Estacado. The largest yields are from the saturated sand and gravel beds in the Ogallala Formation, and water drawn from relatively shallow depths is used for extensive irrigation. Windmills in the ranchland areas attest to the presence of ground water and the absence of windmills is an indication that the underlying rocks are clay, silt, marl, or caliche which have a low porosity and yield very little water.

In several places along the Palo Duro Canyon rim, water seeps from the basal Ogallala gravel where it rests on the impervious Trujillo Shale. The springs range in size from small seeps to yields of perhaps 5 gallons per minute. The largest springs come from either the middle or lower sandstone ledges in the Trujillo. Blue Spring, about 4 miles north of the park boundary, is the largest and is in a beautiful side canyon to Palo Duro. The flow is about 15 gallons per minute and the stream formed by the emerging water passes through a canyon 50 to 75 feet deep that is choked with huge boulders. Frequently the water stands in pools but in some places it races around boulders forming small rapids. The canyon is lined by juniper trees, some of which are 3 feet in diameter and 40 feet high.

ROAD LOG FOR PALO DURO CANYON STATE PARK

Modified after West Texas State College, Geol. Soc. Third Annual Palo Duro Field Trip, April 21-22, 28-29, 1961, Canyon, Texas.

Mileage

0.0 *Park entrance:* From the park entrance to Coronado Lodge, the road winds southeastward along the north rim of Timber Canyon crossing the windblown cover sand and the Ogallala Formation.

0.8 *Coronado Lodge:* The lodge rests on Ogallala Formation near the contact with the underlying Trujillo; it was built from blocks of Trujillo Sandstone. This is one of the best views of the canyon and toward the south and east, most of the formation

Mileage

can be identified by color. The brick-red shale in the canyon's bottom is the Quartermaster; above is an interval of purple, lavender, and yellow shales forming the lower canyon slopes. This is the Tecovas Formation. The overlying Trujillo Formation includes the red shale and the brownish sandstone ledges that form the main cliffs and cap many of the peninsula-like spurs and islands that jut from the canyon wall. The Ogallala Formation forms the canyon's rim.

From the lodge to the canyon entrance, the road is mostly on the Quaternary wind-blown sand; in part on the Ogallala Formation. The top is a bed of wind-laid silt (loess) that contains calcareous concretions. Below the loess is a bed of white caliche formed by ground-water action and a gray sandstone, containing horse teeth, that was deposited in a lake. In the Ogallala is a brown laminated sandstone containing silicified plant roots; it is a stream deposit. The basal unit is a reddish sandstone and conglomerate deposit consisting of water-worn fragments of sedimentary, igneous, and metamorphic rocks, and worn fossil shells that were probably derived from the Cretaceous formations and were eroded from the Palo Duro Canyon area before the Ogallala Formation was deposited. The conglomerate also contains chert nodules, some of which contain opal-lined cavities.

1.9 Erosional unconformity between the Ogallala and Trujillo formations exposed in the road cut on the inside of the hairpin curve. The reddish basal conglomerate of the Ogallala rests on the greenish shale of the Trujillo Formation.

2.1 *Turn-out to right:* In the road cut above the turn-out the upper Trujillo Shale forms a short slope that contains fossilized wood. Below is a brown marl-pebble conglomerate forming a small ledge. The conglomerate contains leaf imprints and a few fossil teeth and bones from an extinct amphibian. Then there is a red shale forming a long slope down to the gray sandstone on which the turn-out is located. The gray sandstone contains many rounded concretions; some of them were cracked and the cracks healed with white calcite, others contain leaf imprints. In the road cut below the turn-out, red shale, gray pebbly conglomerate, and gray sandstone units of the lower Trujillo are exposed.

2.3 Trujillo-Tecovas contact in deep road cut on right. The red-stained sandstone of the basal Trujillo rests on the orange shale of the upper Tecovas Formation.

2.5 A turn-out to left. The guard rails are Trujillo Sandstone. The massive gray-white sandstone at the level of the turn-out is a Tecovas Sandstone ledge that underlies the upper orange shale. Its surface shows two sets of nearly vertical joints that permit the sandstone to break into blocks and slump down the canyon walls. The sandstone contains numerous small concretions, in some places there are veins of green copper minerals, and a few teeth of a crocodile-like reptile have been found. The Tecovas shales also contain concretions and some of them (geodes) are lined with calcite crystals. Fossils include bones of extinct reptiles, lung fish, and fragments of mineralized wood.

2.7 Tecovas-Quartermaster contact. The light gray to purplish sandstone and shale of the basal Tecovas rest on the banded brick-red and white shale of the Quartermaster Formation. To next stop, the road winds between boulders (both Tecovas and Trujillo) that have slumped from the canyon walls (fig. 89).

3.4 Miniature railroad (Sad Monkey) station, picnic area, and campground. In the arroyos west of the railroad station the Quartermaster Formation is clearly and conveniently exposed. Here the formation consists of brick-red shale, with layers of white shale and veins of white gypsum, some of which are folded into small anticlines and synclines.

The south face of Goodnight (Triassic) Peak shows an excellent view of the formations. The peak's top is capped by the hard, cliff-forming, lower sandstone ledge of the Trujillo Formation; the varicolored shales and soft sandstones of the Tecovas Formation form the middle slopes; and brick-red and white banded shales of the upper Quartermaster Formation form the base (fig. 90).

3.6 Bridge over Timber Creek. Gently arched Quatermaster beds in steep road cut to right.

3.7 Trail to right leads to an underground gully washed from the shale in the Tecovas and Quartermaster Formations, to Catarina Cave, and to the Spanish Skirts. The brick-red shale of the Quartermaster forms the lower part of the Skirts and the upper part is formed by the Tecovas.

4.0 Skylift from canyon floor to top of Timber Mesa gives an elevated view of the Spanish Skirts, Devil's Tombstone, and the Lighthouse.

FIG. 89. Blocks of Tecovas Formation and Trujillo Sandstone that have slumped from the canyon wall.

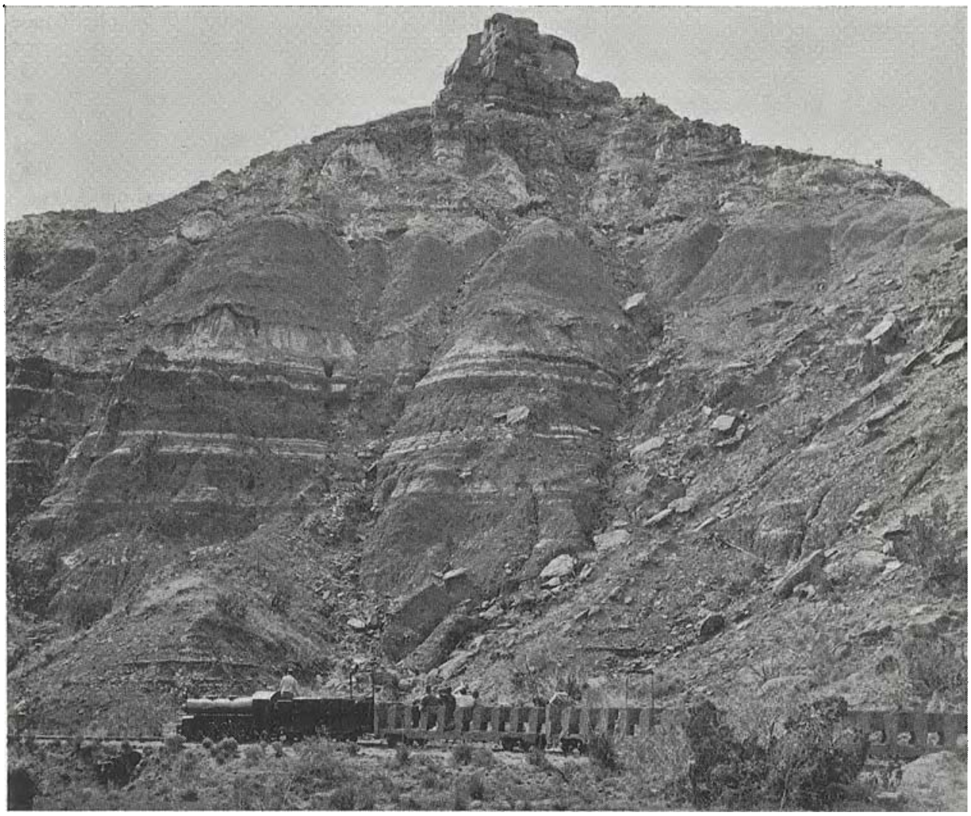

FIG. 90. Basal Trujillo Sandstone ledge at top of Goodnight Peak; Tecovas Formation in upper slope and Quartermaster Formation at base; miniature railroad in foreground. (Photograph by Texas Parks and Wildlife Department.)

Mileage

4.2 Crossing No. 1, Palo Duro Creek. Near the crossing is a low flat grass-covered area, less than 1 acre in size, locally called the "swamp." It was formed when Palo Duro Creek changed its course (cut-off meander). Water is available in sand and gravel at shallow depths; the porous rocks are recharged by the creek from surface runoff.

4.4 Road to right leads about 3 miles to the Lighthouse (outside the park). The Lighthouse is an erosional remnant in the Trujillo Formation. A hard sandstone ledge forms the caprock which protects the soft underlying shale (fig. 91). The caprock on the nearby Devil's Tombstone slumped from above, and the shale on which it rests was eroded away leaving a boulder-capped pedestal (fig. 92).

Near the mouth of Sunday Canyon are ledges of massive gypsum that are intricately folded (fig. 83, p.), but the shale above and below the gypsum shows very little deformation. This suggests that the force causing the folding was in the gypsum ledge itself. Although most gypsum deposits are the result of deposition by the evaporation of water, gypsum can be formed by the alteration (hydration) of pre-existing anhydrite ($CaSO_4$). When anhydrite absorbs water and changes to gypsum ($CaSO_4 \cdot H_2O$) the volume increase caused by the chemical addition of water to the anhydrite may range from 33 to 62 percent (Krause and Hunt, 1928, p. 285) causing the many local disturbances in rock strata; this is a reasonable explanation for the folded gypsum beds observed in Sunday Canyon. Udden (1924) explained deformed gypsum beds at other places in West Texas by this process.

5.2 Crossing No. 2, Palo Duro Creek. Good view of Capitol Peak on skyline to the right (upstream) and Fortress Cliff to left (downstream).

5.3 Road to right leads to Capitol Peak, an erosion remnant on the south side of Little Sunday Canyon. The peak's top is lower Tecovas; Quartermaster Formation forms the base. Out in front of Capitol Peak is an erosion profile in the Quartermaster Formation locally called the "Sleeping Indian."

5.4 Fortress Cliff on the left (east), the longest relatively straight high rim along the canyon. It was formed by a recent landslide. Probably the rocks broke along a vertical joint similar to those seen at mileage station 2.5. This permitted the great blocks of Ogallala and Trujillo Formations to tumble from the canyon wall and slide to the lower slopes.

5.6 Crossing No. 3, Palo Duro Creek. Fortress Cliff to left (upstream).

5.8 Crossing No. 4, Palo Duro Creek. To left (downstream) good exposure of red beds in the Quartermaster Formation.

FIG. 91. The Lighthouse. A resistant Trujillo Sandstone ledge forms the caprock and protects the less resistant underlying shale and thin layers of sandstone.

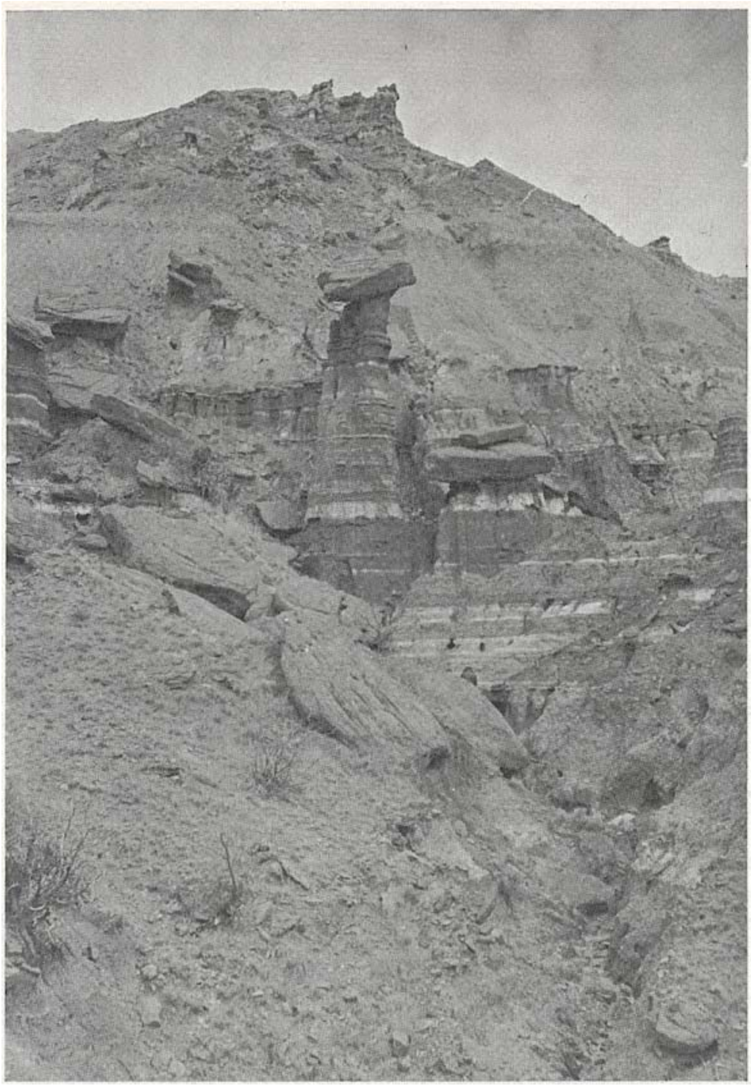

Fig. 92. Devil's Tombstone. Erosion has removed the soft material from around a boulder leaving a column. To the left are other "tombstones" being formed.

Mileage	
6.2	Crossing No. 5, Palo Duro Creek.
6.4	Rock Garden. Huge boulders from the Trujillo Formation, the results of an extensive landslide.
6.5	Spring to left (east). Rainwater sinks into the landslide material and on reaching the surface of the underlying impervious shale, it moves down the slope and emerges as a spring in the valley.
	Historic marker: Mackenzie's defeat of the Cherokees.
6.6	Road to right (west) leads to the Devil's Slide, a knife-edge erosion spur in the lower Tecovas and upper Quartermaster Formations.
6.9	Picnic area in cottonwood grove on right, locally known as Cow Camp.
7.4	On left (east) excellent unconformable contact between purplish shale in the Tecovas Formation and brick-red shale of the Quartermaster Formation.
7.8	The Loop, end of road.

PORT ISABEL LIGHTHOUSE HISTORIC SITE

L. Edwin Garner

Port Isabel Lighthouse, constructed in 1852 (fig. 93), is located near the southern end of Padre Island. Bricks were shipped by schooner from Louisiana; the walls are 4 feet thick at the base and taper to the top. The core and stairs are of cast iron that also came by sea. Because of its location, the lighthouse was used as a lookout for Mexican raiders; during the Civil War, it was a military objective, held and used as a lookout post alternately by both Confederate and Union troops. After the Civil War, the light continued as a navigation aid until 1888; the service was reinstated in 1895 but was permanently discontinued as a Coast Guard beacon in 1905; however, the light still appears on current navigation charts. The lighthouse was originally built for $7,000 but in 1952 was restored at a cost of $23,500 from original plans found in government files.

The park consists of 0.552 acre of land acquired in 1950 by deeds from private owners. It is located in the town of Port Isabel on State Highway 100 off U. S. Highway 77 (Pl. I).

Sediments of this area consist of sands and clays which were deposited as a part of the Rio Grande deltaic plain during Recent time. Laguna Madre, a high salinity lagoon, is adjacent to Port Isabel and is bounded on the eastern side by Padre Island. Terrain of the area is very gently rolling to flat and vegetation consists of grasses with a few scattered trees.

FIG. 93. Port Isabel Lighthouse. The only damage by Hurricane Beulah was four broken window panes. (Photograph by Texas Parks and Wildlife Department.)

POSSUM KINGDOM STATE RECREATION PARK

L. F. Brown, Jr.

Possum Kingdom State Park (2,621 acres) is in Palo Pinto County at Possum Kingdom Lake on the Brazos River. It is off U. S. Highway 180, at Caddo, and is reached by Park Road 33, about 32 miles northeast of Breckenridge (Pl. I). The lake was named for the numerous opossums that are native to the area; in pioneer days there were also turkey, deer, buffalo, and other game.

Col. Samuel Cooper made a tour of Indian villages along the Brazos in 1850 and reported that the six tribes living in the area were Anadarkos, Ioni, Caddos, Wacos, Keechi, and Tawakonis. The Comanche Trail that led to the northeast across the Red River was a few miles from the Keechi village in the area now known as Bone Bend. Col. Cooper recommended that a military post be established near the Caddo village at the mouth of Caddo Creek on the Brazos River. Fort Belknap was established at the mouth of Caddo Creek on June 24, 1851, but on November 1, 1851, it was moved to a site south of the present town of Newcastle which had been recommended by Capt. Randolph B. Marcy. Fort Belknap became one of the largest and most important posts in North Texas prior to the Civil War.

In 1854, the Texas Legislature enacted legislation which enabled the United States Departments of War and Interior to proceed with the establishment of an Indian reservation in unsettled West Texas. Capt. Marcy selected a site of almost 37,000 acres, 12 miles south of Fort Belknap where the Brazos River makes three great bends. The northern limit of the reservation was Calaveras Street in the present city of Graham and the southwestern limits were just outside the town of South Bend.

By 1858 antagonism toward the Indians was high. Governor Hardin R. Runnels and General Sam Houston appealed to the federal government to move the reservation out of Texas. Before the federal government could select a suitable location in the Indian Territory of Oklahoma, two incidents brought the issue to a climax. These were the murder of Choctaw Tom's hunting party and the Marlin ranch Indian fight; this prompted the immediate abandonment of the two Indian reservations on July 31, 1859.

Oliver Loving and Charles Goodnight, two prominent cattlemen of Texas, settled in the area in 1855 and 1856, respectively. They became partners in the ranching business in 1866 and in June of that year, blazed the Loving-Goodnight cattle trail westward to New Mexico and Colorado. Loving was shot by the Indians near the Pecos River in 1867 and died at Fort Sumner, New Mexico, on September 26, 1867. Goodnight brought Loving's body back to Weatherford where it was interred. He then left Palo Pinto County in 1876 and established the first ranch of the plains country in Palo Duro Canyon.

Possum Kingdom Lake is noted for black bass fishing and water sports. The park was acquired in 1940 by deed from the Brazos River Authority. Facilities and activities include cabins, camping, open shelters, picnicking, rest rooms, showers, groceries, swimming, fishing, fishing pier, boat rental, boat ramp, and water skiing.

A visitor to Possum Kingdom State Park enters the area traveling northeastward along Park Road 33, which is built on top of the westward-sloping Home Creek Limestone (fig. 94). About a mile from the lake, the road turns northwestward and descends about 200 feet from the Home Creek Limestone bluffs, through the Colony Creek Shale to the underlying Ranger Limestone. The Ranger Limestone is exposed along most of the lakeshore

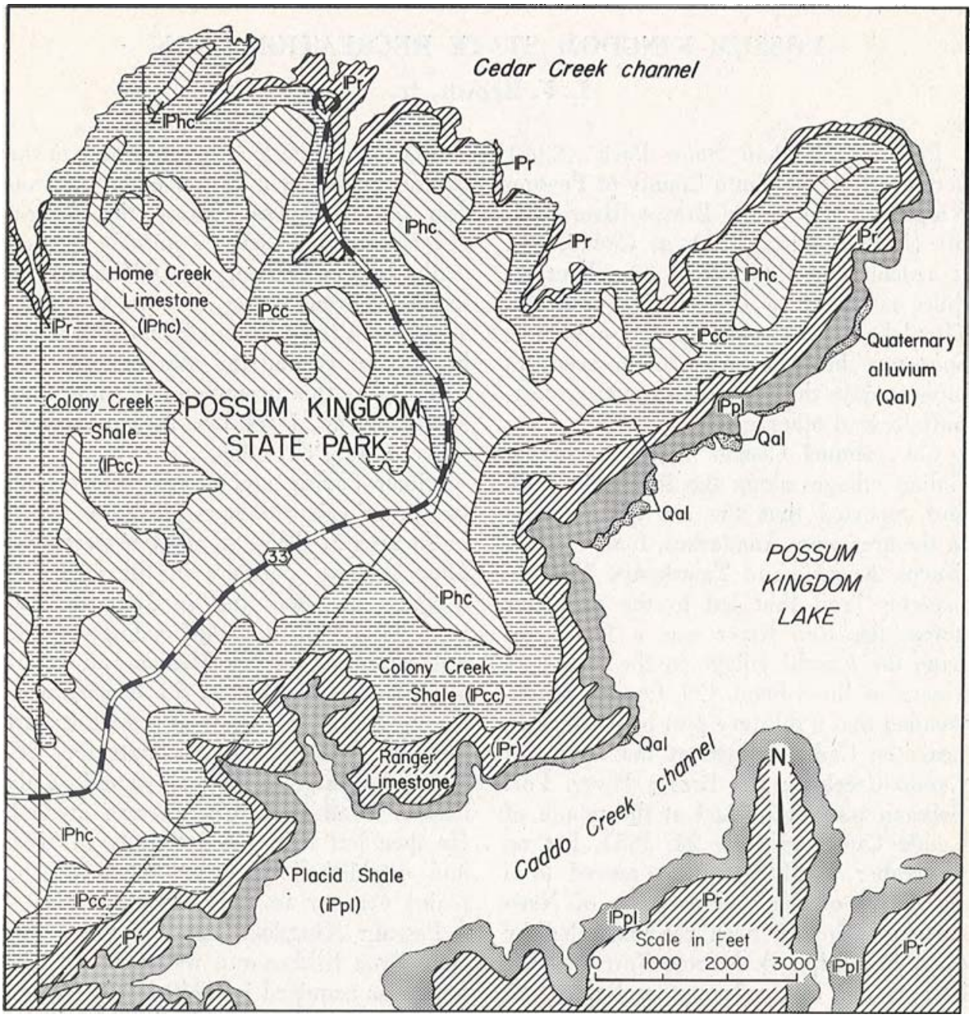

FIG. 94. Geologic map of Possum Kingdom State Recreation Park.

in the park, but on the southeast side of the prominent finger of land which extends northeastward into the lake, the Placid Shale crops out beneath the Ranger Limestone.

The thick beds of limestone and shale exposed in the park are the upper part of the Canyon Group (table 1) which were deposited approximately 280 million years ago during the Pennsylvanian Period in shallow, open-marine water. At that time the park area was located on a broad shallow-water shelf at the eastern edge of the West Texas or Permian Basin. Above and younger than the Canyon strata are thin limestones, coals, delta and river sandstones and shales of the Cisco Group (table 1) deposited near the ancient shoreline as it slowly shifted westward. Some of these Cisco rocks, which originated from sediment washed westward in ancient rivers from the buried Ouachita Mountains of Central Texas, are exposed along the road from Caddo to the park.

Visitors who have a highway map or topographic map of the area can easily locate many great bends or meanders in the Brazos River. In fact, Possum Kingdom Lake is a sinuous, long, narrow lake which fills a deep meandering canyon cut into Canyon limestone strata by the Brazos River during the Ice Age. This entrenched meandering river is evidence to geologists that North-central Texas has been slowly rising inch by inch during the past tens of thousands of years, while the Brazos River has eroded its way through more than 200 feet of rock. In the last few thousand years the river has deposited thin layers of sand and clay alluvium, or bottomland, across its flat valley floor. This Quaternary alluvium (fig. 94) is mostly covered by waters of the lake within the park, but small patches of alluvium are exposed in the eastern park of the park along the old Caddo Creek channel. The park is partially surrounded by lake water (fig. 94) which filled the valleys of Cedar Creek on the north and Caddo Creek on the south.

Each year the area around Possum Kingdom Lake is visited by geologists from all over the United States and many foreign countries. They are especially interested in the thick Canyon Group limestones exposed in the steep canyons of the area. These limestones are of interest to petroleum geologists because they are equivalent to thick limestone oil reservoirs deep beneath the surface in West Texas.

Following the 1948 discovery of the great limestone Horseshoe Atoll oil field at a depth of 7,000 feet near Snyder in Scurry County, geologists became intensely interested in studying limestones of the same age at the earth's surface where it would be possible to observe carefully these ancient marine formations.

Several of these Canyon limestones crop out in the Possum Kingdom Lake area. One of the limestones called the Winchell Limestone (fig. 95) is exposed southeast of the park near Morris Shep-

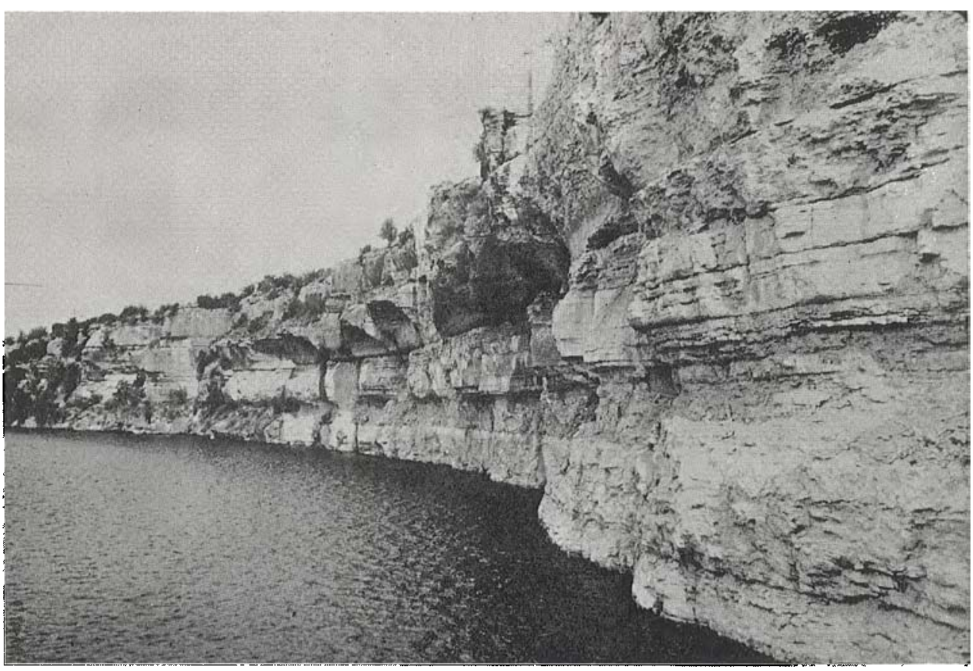

FIG. 95. Winchell Limestone exposed in bank of Brazos River at Possum Kingdom Lake. Here the Winchell is 165 feet thick but it thins to about 11 feet thick in a distance of 3 to 4 miles toward the southwest. This is not a true reef but more like a bank that is traceable in the subsurface for tens of miles. Broken fossil shells and algae are abundant throughout surface exposures and also in the subsurface. (Photograph by L. F. Brown, Jr.)

ard Dam. The Winchell Limestone is an atoll or limestone bank; it has been studied by many geologists who have compared it to modern atolls and reefs in the Pacific Ocean and Bahama Islands. The Winchell Limestone atoll and the entrenched Brazos Valley can be observed from a lookout picnic area atop the steep bluff at the northeast end of Morris Sheppard Dam (just off Farm Road 2353 and State Highway 16 northeast of Brad). Although the dam site is outside the park, it is another interesting place to visit when in the Possum Kingdom area.

Fossil marine invertebrate animals and algae occur in most of the Canyon limestones, and locally the visitor can find abundant fossils in the shale formations. Some fossils in the area include brachiopods, snails, clams, sponges, and corals. Possum Kingdom State Park provides the visitor with an unusual opportunity to hike up and down steep canyons and bluffs cut into rocks that were once sediments on the floor of an ancient inland sea.

SAN JACINTO BATTLEGROUND STATE HISTORIC PARK AND BATTLESHIP "TEXAS" HISTORIC SITE

L. Edwin Garner

San Jacinto Battleground State Park is located 3 miles from Deer Park via State Highway 134, a short distance from downtown Houston (Pl. I). The 440-acre site was acquired September 1, 1965, by Act of the Texas Legislature. Present facilities and activities include picnicking, the San Jacinto Monument and museum, and historical studies. A federal grant, matched by State funds, will be used to construct picnic units, rest rooms, roads, parking area, utilities, and landscaping.

The site is the location of the famous battle between the Texas and Mexican armies which on April 21, 1836, won independence for Texas. Led by General Sam Houston, 910 Americans completely routed the Mexican forces numbering over 1,200 under the command of General Antonio Lopez de Santa Anna. The battle lasted 18 minutes and casualty lists showed 630 Mexicans killed, 208 wounded, and the remainder taken prisoners as against only nine Texans mortally wounded and 30 wounded less seriously.

The San Jacinto Monument, erected during 1936-1939 with Federal and State funds at a cost of approximately $1,500,000, is 570 feet high and is built of reinforced concrete faced with Texas fossilized buff limestone from the Walnut Formation (fig. 96). The museum proper, which forms the base of the monument, is 125 feet square. The shaft is 47 feet square at its foundation, tapering to 30 feet square at the observation tower. At the apex of the monument is a star 35 feet high, weighing 220 tons. A chronological history of Texas, from the Indians to Statehood, is depicted in the museum.

Moored at the battleground and open to visitors is the U. S. S. Texas, only survivor of the dreadnought class, a veteran of two world wars and a dozen campaigns. The battleship was presented to the State of Texas by the United States Navy.

The gently rolling terrain covered with grasslands and wooded areas (mostly oak trees) is part of the Gulf Coastal Plain. Soils are tan to dark gray sand and clayey loams. Underlying the soil is part of the Beaumont Formation (table 1). These sediments consist of sands, silts, and clays and were deposited by meandering streams and rivers which emptied into the Gulf of Mexico during late Pleistocene time.

FIG. 96. Back lighting effect on San Jacinto Monument. This structure rests on a substantial foundation in the Beaumont Formation. Note the star near the apex of the monument. It is 35 feet high and weighs 220 tons. (Photograph courtesy of Texas Parks and Wildlife Department.)

SAN JOSE MISSION NATIONAL HISTORIC SITE

Ross A. Maxwell

Mission San Jose y San Miguel de Aguayo was established by Father Margil in 1720. It is in the San Antonio River valley about 8 miles south of the Alamo and may be reached by U. S. Highway 281 south from San Antonio (Pl. I). The mission was dedicated to St. Joseph and named in honor of him and the Marquis San Miguel de Aguayo, who was governor of Coahuila and Texas from 1720 to 1722 (Johnson, 1947, pp. 19-22).

The geologic history of the area, ground water, soil, vegetation, and climate are sufficiently similar to the conditions found at the Alamo (pp. 34-35) that a discussion of these natural phenomena is not repeated. The principal geologic difference in the two nearby sites are that San Jose Mission is on a higher and older terrace in the San Antonio River valley and that the bedrock beneath the river terrace at San Jose is the Navarro Formation (table 1).

The missionary priests at San Jose taught the Indians the ways of Christianity and how to farm, dig ditches, bring water from the San Antonio River to irrigate their crops, and build houses in a manner similar to those used during the establishment of the Alamo. There was also a church, convent and cloister, prefecture, small homes for the converted Indians, workshops where the Indians made clothing, pottery, and tools for the mission, and a granary and grist mill.

The first church was a simple stone-adobe structure finished and dedicated in 1731. This church was later torn down and the most elaborate church in the mission system was erected on the site. In order to decorate the new church, the padres obtained the services of Pedro Huizar, a sculptor, whom they brought from Spain. The church's front panel is about 20 feet wide and above the door is a figure of the Virgin of Guadalupe. Figures of St. Joseph, St. Dominic, and St. Francis are also included. Delicate carvings of leaves, shells, and cherub heads are abundant. Huizar's masterpiece was creation of the Rose Window, a round highly decorated window that is still considered one of the most beautiful designings in America. Worship services are still held regularly in this beautiful old mission church.

The granary was finished in 1726 and is the oldest of all the mission buildings that remain standing in the San Antonio area. Its "flying stone buttresses" are unique in America, its vaulted roof is a construction marvel, and it was built without the aid of modern machinery or scaffolding.

San Jose Mission was secularized during the last decade of the 18th century. The King of Spain deeded the granary to the heirs of Pedro Huizar and it remained the property of his descendants until the San Antonio Conservation Society bought the granary in 1930. All the mission buildings had been neglected for many years, but in 1933 the Conservation Society began reconstruction work on some of the structures and much has been accomplished since that time. All structures that have been replaced were built to look like the old mission buildings and the activities within the mission give an atmosphere of the Mission Era. In the mission walls are shops where Mexican craftsmen, some of whom are descendants of the Mission Indians, produce fine work in metals and pottery.

San Jose Mission is administered by an operating board under the sponsorship of the Texas Parks and Wildlife Department and the Archbishop of San Antonio, in cooperation with the National Park Service.

SAN SABA MISSION HISTORIC SITE

Ross A. Maxwell

Mission San Saba de la Santa Cruz, on the San Saba River near Menard, is owned jointly by the County of Menard and the State. It was dedicated as a State Historic Site on June 19, 1961. Due to normal weathering, poor building materials of the time, and floods on the nearby river, the mission deteriorated until it became little more than piles of rubble. There are 25 acres of State-owned land but no accommodations. The area may be reached via U. S. Highway 83 south from Abilene or by east-west State Highway 29 west of Llano (Pl. I).

San Saba de la Santa Cruz mission was established in 1757 through the efforts of Fray Alonso Geraldo de Torreros and his cousin Pedro Romero de Torreros, a wealthy Mexican mine owner and philanthropist. Don Diego Ortiz de Parrilla was appointed to command the presidio, which he named San Luis de las Amarillas (the name was changed to Real Presidio de San Saba in 1761), and Father Torreros became head of the mission. The group arrived at the San Saba River on April 18, 1757.

Following establishment of both fort and mission, the missionaries and soldiers awaited the arrival of the Apaches who had requested protection from the northern tribes, mainly the Comanches. They appeared in small numbers, always promising to return, but would not stay because they said they feared an attack by the Comanches. On March 2, 1758, the Comanches announced their presence by a raid on horses at the presidio. On March 16, 1758, a large Comanche band attacked the mission and all but three occupants were killed. These were Father Molina, a soldier, and a mule driver, who barricaded themselves in a building, survived the fire that burned the mission, and escaped under cover of darkness. The mission was never rebuilt, but the old compound was used to corral cattle on overland drives to market.

The presidio was successfully defended against the attack that followed burning of the mission, but future attacks were frequent. From 1762 on, Captain Felipe Rabago y Teran, who replaced Parrilla, sustained almost continuous warfare with the Comanches and other northern tribes, and by 1767 a battle became a daily occurrence. The garrison remained at the presidio until late 1768 or early 1769 (conflicting dates), when it was removed to San Fernando de Austria south of the Rio Grande.

The first description of rocks and fossils in the area was made by Ferdinand Roemer (1847). Roemer visited the area with an exploring party of German colonists under the leadership of Count Meusebach, who was from the recently settled community of Fredericksburg. Rocks in the area of the mission include Hensell Sand and alluvium along San Saba River valley, Walnut Clay in low slopes at the edge of the river valley, and above the Walnut about 25 feet of marly Comanche Peak Limestone followed by massive Edwards Limestone (table 1) well exposed in a road cut south of Menard. Most of the rock used to build the mission was probably Edwards Limestone. A good exposure of *Exogyra texana*-bearing Walnut Clay is near the south city limits of Menard.

STEPHEN F. AUSTIN STATE HISTORIC PARK

L. Edwin Garner

Stephen F. Austin State Park is located 6 miles east of Sealy, off U. S. Highway 90 on Park Road 99 (Pl. I). It consists of 664 acres of land in Austin County and was acquired in 1940 by deeds from the San Felipe Park Association and Corporation of San Felipe de Austin, to preserve historic points of interest such as the homesite of Stephen F. Austin, the old boat landing and ferry, the replica of Austin's log cabin, museum, and others. It is the original location of Austin's colony and was the first capital of Texas.

Renovated old structures and newly built facilities—including water storage tank and distribution lines, swimming pool, bath house, headquarters building, concessions building, individual screened shelters, group shelter, trailer campsites with table and grill, picnic area with tables and grills, and a sewage treatment plant—were dedicated on May 25, 1968.

Physiographically the park is in the Gulf Coastal Plain and the Brazos River valley. Soils are reddish-brown to tan sandy loams. Gently rolling wooded slopes and flat fields are typical of the area (fig. 97). Wooded areas are mostly oak trees. Geologic units in this area are the Willis and Lissie Formations (table 1). The Lissie is the only unit within the park but Willis caps most of the high hills north of the park. Both rock units are the result of alluvial deposition and are of Pleistocene age. Sands and gravels in the Lissie Formation can be seen along the banks of the Brazos River.

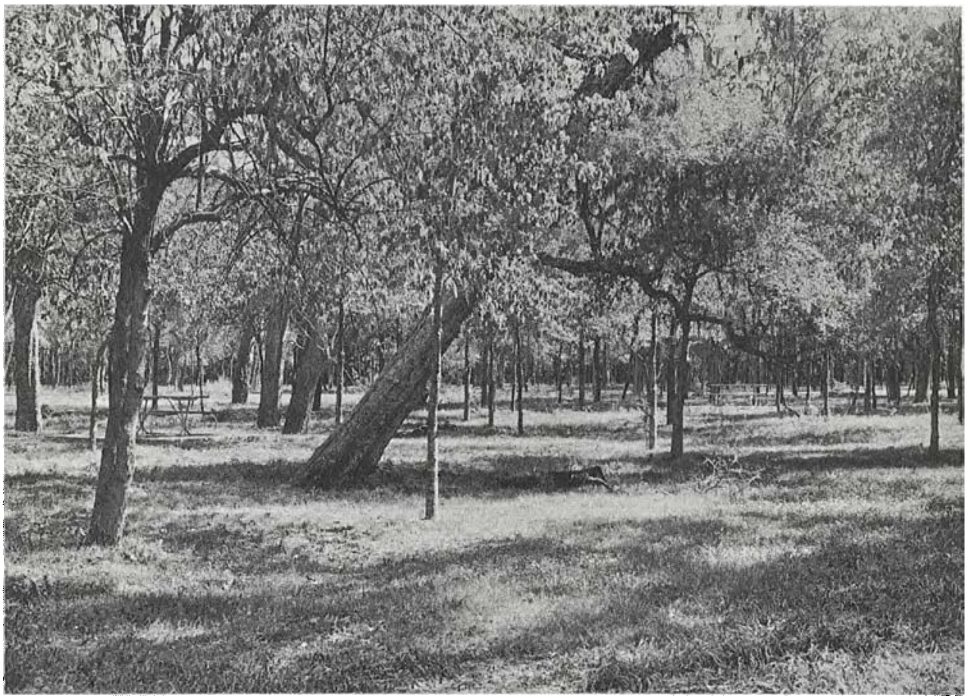

FIG. 97. Flat wooded terrace cut on sands of the Lissie Formation along banks of the Brazos River. (Photograph by Texas Parks and Wildlife Department.)

TIPS STATE RECREATION PARK

Ross A. Maxwell

Tips State Park (31.3 acres) is on the Frio River in Live Oak County about 1 mile west of Three Rivers and is accessible from U. S. Highway 281 (Pl. I). The park was acquired in 1925 by deeds from private owners and is leased for 99 years to the City of Three Rivers. In 1913, when Col. Charles R. Tips founded the city he established a glass factory and granted a parcel of land for a park. The park is undeveloped; camping, picnicking, and fishing are the only activities.

The park is underlain by the Catahoula (Gueydan) Formation and alluvium along the Frio River (table 1). The Catahoula is a sequence of land-laid pyroclastic materials interbedded with fluviatile deposits (fig. 79, p. 148). The lithology changed along the outcrop belt; there is a noticeable increase in the amount of volcanic ash from east to southwest in the coastal plain. Locally there are areas in which the deposition of secondary silica makes the rocks very hard. In the park the gray tuffaceous silt is only semi-indurated, but it forms ledges sufficiently resistant to provide footings for a small dam. Throughout most of the immediate area the Catahoula has alternating beds of hard and soft, massive, cream to yellowish-white, lumpy mudflow tuff. Farther southwest there are beds of impure volcanic ash. Bailey (1926) described the formation, which he called the Gueydan, in considerable detail.

TYLER STATE RECREATION PARK

Ross A. Maxwell

Tyler State Park, in Smith County, is about 10 miles north of Tyler, rose capitol of Texas. The city has an annual Rose Festival, which brings thousands of visitors to the area, and many of the rose bushes in the United States are grown within a 10-mile radius of Tyler. About 25 miles to the east is the center of the East Texas oil field which made Tyler an oil capital with headquarters offices for practically all phases of the industry; there are a few oil wells within the park. The city also has railroad and machine shops. manufacturing plants for furniture, clothing, and fertilizer, cottonseed oil milling, and various food-processing plants.

The park, consisting of about 994 acres, can be reached from Farm Road 14, off U. S. Highway 69, north from Tyler (Pl. I). Primarily it is a recreational area that was acquired during 1934-1935 by deeds from private owners. A 65-acre lake is within the park. About $1,000,000 was obligated to renovate existing structures and to add new facilities at Tyler State Park during the 1967–1969 biennium. The facilities included interpretative and headquarters buildings; nature trail; additional trailer camp sites with water, electrical and sewage connections; additional camp shelters with water, table, and grill; picnic areas with water and tables; rest rooms and showers. There are also swimming, fishing, fishing dock, boat ramp, and snack lunch facilities. No water skiing is allowed.

The area now included in Smith County was a part of the land grants made by the Mexican government to David G. Burnet in 1826 and to Vicente Filisola in 1831. Prior to that time, the Caddo and associated Indian tribes lived in the area until about 1818 when the Cherokees gained control. J. C. Hill explored the area, organized an immigration party in Tennessee, and founded a settlement about 8 miles southeast of present Tyler in 1838. These citizen-soldiers defeated the Cherokees, who were driven from the area in 1839. The county was organized in 1846 and named for General James Smith. Tyler became the county seat in an election on August 8, 1846. During the Civil War, Tyler was an important supply point for the Confederacy. There was a commissary, iron foundry, ammunition plant, and Camp Ford, a Confederate prison camp, which housed as many as 6,000 Federal prisoners at one time.

Smith County lies within the pine and post-oak belts of East Texas and there are also gum, elm, maple, and hickory trees. The land surface is hilly to undulating with many springs and flowing streams. The annual rainfall is about 41.5 inches and the altitude range is about 300 to 600 feet.

The general geology of the park is shown on the Tyler Sheet of the Geologic Atlas of Texas. Throughout most of the East Texas Basin, there is a rhythmic alternating succession between marine and continental deposition. In most places massive sandstones are either delta deposits or were laid down by streams on a land surface. The fossiliferous clays are mostly shallow-water marine beds. The glauconitic clay and sandy clay beds were deposited during a change in the position of the shoreline, and the lignite beds were formed in swamps or lagoons on a low continental area above the shoreline.

Most of the rocks in the park belong to the Queen City Formation, mostly clay or sandy clay beds that were deposited in shallow-water marine environment (fig. 98). These rocks contain a few imprints of clams, oysters, and snails, and there are also a few thin beds of lignite. Some of the hill slopes are underlain by ferruginous glauconitic sandstone in the Weches Formation that contains a few plant remains, mostly leaves, sticks, and stems. A few of the highest hills are capped by the Sparta Sand, a continental deposit, that has fragments of fossil wood.

Fisher et al. (1965) reported on the rock and mineral resources of East Texas. This report describes the economic use and development of mineral resources at a few localities near the park. Plate I of that paper shows the oil and gas fields; Plate II shows the geographic distribution of some of the geologic formations mentioned above; Plate III indicates where samples of both ceramic and non-ceramic clay were collected and tested; and Plate IV shows localities where detailed studies of the sandstone deposits were made.

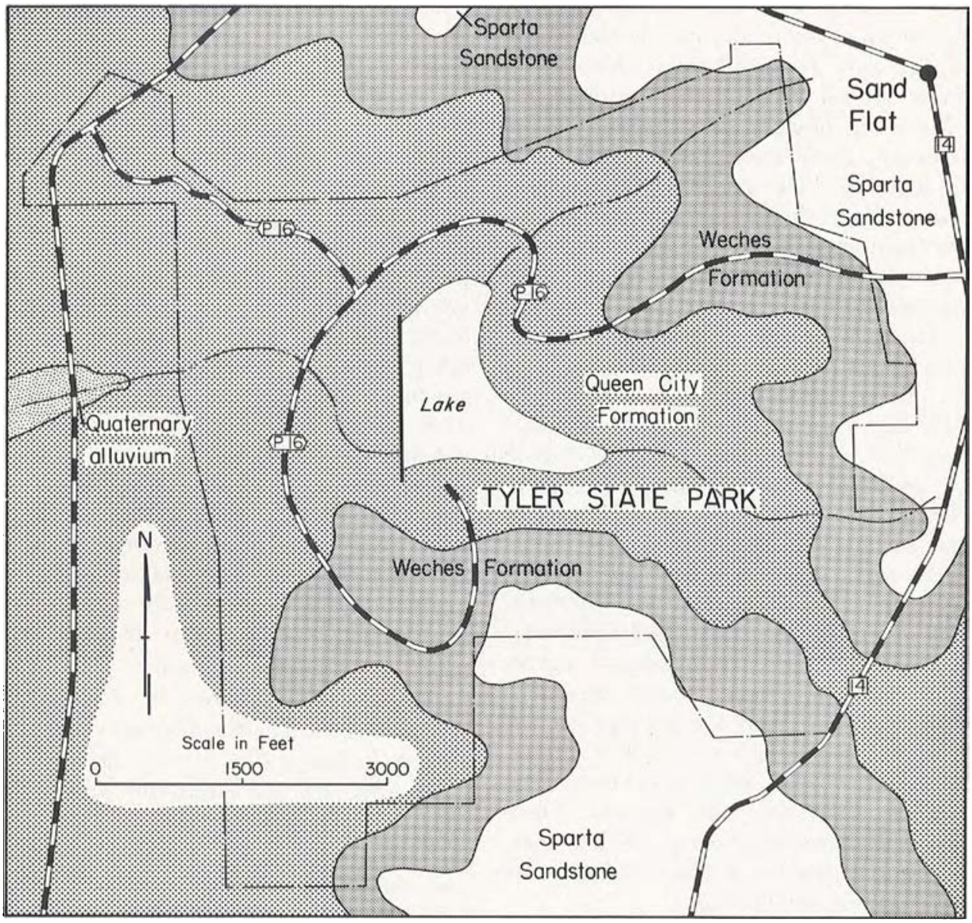

FIG. 98. Geologic map of Tyler State Recreation Park.

VARNER-HOGG PLANTATION STATE HISTORIC PARK

L. Edwin Garner

Varner-Hogg Plantation State Park is located 2 miles north of West Columbia on a county road off State Highway 35 (Pl. I). The park consists of 52.67 acres of land donated to the State of Texas in 1958 by Miss Ima Hogg, last surviving child of Governor James Hogg. The plantation was owned in the late 1800's by Martin Varner, a member of the Austin colony's "Old Three Hundred," and was bought by Governor Hogg in 1901. The first rum distillery was established in 1829 by Varner, and the remains of a sugar mill are on the plantation. In 1920 the old Varner mansion was restored and became the home of Governor Hogg until his death. Rooms in the mansion are now arranged to depict events in early Texas history. Guided tours, a museum, picnicking, and rest rooms are available.

The park site is within the Gulf Coastal Plain. Terrain is very gently rolling; the vegetation consists of grasslands and wooded areas with large oak and pecan trees. Soils are tan to dark gray sandy and clayey loams which provide the rich farmland. Sediments are composed of sands, silts, and clays deposited on the deltaic and alluvial plain of the Brazos River. They are of Recent age but are similar to sediments deposited in the Beaumont Formation a few miles to the northeast of the park (table 1).

VELASCO STATE RECREATION PARK

L. Edwin Garner

Velasco State Park, in Brazoria County, is an undeveloped beach that lies between high and low tides along the Gulf of Mexico. It is accessible from State Highways 332 and 35 near Freeport (Pl. I). Bryan and Surfside beaches are the most popular sections in the park. A favorable climate contributes to the year-round activities, which include swimming, surfing, fishing, picnicking, and camping.

The park was established by Legislative Act in 1939 to commemorate the Battle of Velasco, fought in 1832. The Velasco Treaty between Mexico and Texas was signed in 1836; Velasco was also a temporary capital of Texas. A nearby point of interest, off State Highway 36, is the Peach Point plantation home of Stephen F. Austin.

The early inhabitants of the area were the Karankawa Indians. About 1821, a ship bringing supplies and immigrants to the Texas colony of Stephen F. Austin entered the Brazos River by mistake, rather than the appointed meeting place, the Colorado. A small colony of settlers left the ship and attempted a settlement but failed due to hardships and Indians. Later settlement attempts (1824-1828) were more successful and soon the townships of Velasco and Quintana were thriving ports. Many early colonists arrived in Texas through these ports, and much of the early commerce passed through them. There were a customhouse, salt works, and trading posts.

The area is on the coastward edge of the Gulf Coastal Plain and consists entirely of open Gulf beach. No soils are developed on the sediments within the park and the vegetation is very sparse. Deposits consist of sand deposited during Recent time by longshore currents and waves (table 1). In some places, small sand dunes have been built by the prevailing landward winds.

WASHINGTON-ON-THE-BRAZOS STATE HISTORIC PARK

Ross A. Maxwell

Washington-on-the-Brazos State Park (70.9 acres) is in Washington County off State Highway 90 and Farm Road 912; it is about 19 miles northwest of Brenham and 7 miles southwest of Navasota (Pl. I). The park was acquired in 1916 by deeds from private owners. There are camping, picnicking, and rest room facilities, an amphitheater, auditorium, and museum. Several houses built during the Texas Republic era have been moved to the park and renovated.

Washington was the first settlement in Stephen F. Austin's land grant colony (1821). The park includes the site where the Texas Declaration of Independence was drafted, the first Republic of Texas Constitution written, and the first capitol of the Republic (1836). Because of the threatened approach of the Mexican Army, the capitol was moved to Houston, but Washington was the Republic's capitol in 1842 and again in 1845; it became the first county seat of Washington County (1837) and was the home of Anson Jones, the last President of the Republic of Texas. Annually the park is the center of Texas Independence Day celebrations.

In 1822 Andrew Robinson began operating a ferry across the Brazos River at Washington and he built a tavern in 1830. John W. Wood laid out a townsite on the west side of the Brazos in 1830, but it was not until 1833 that the first residence was built. By 1836 Washington had two hotels, some 50 houses, a population of perhaps 100 people, and was incorporated in 1837. The capitol was moved to Austin in 1845; this all but killed Washington, but prosperity was revived by river steamer shipping, and for about 10 years Washington was an important entrance port for Central Texas. The population rose from about 1,000 in 1850 to about 4,000 in 1860. Since the town did not give right-of-way or other necessary property to railroads, it was therefore bypassed, but railroads ended the river shipping industry, business in Washington declined rapidly, and by 1885 the population had dropped to about 200. R. A. F. Penrose, Jr., reported in 1889 that the houses were abandoned, windows and doors were locked, nailed shut, or tumbling to pieces, that he saw only four people, and that the storekeeper said that business was very dull in Washington (*see* Fairbanks and Berkey, 1952, pp. 121-122).

At nearby Independence is the first site of Baylor University, which was established in 1845 and moved to Waco in 1886. The columns of the old Baylor Female College are still standing.

The park area is on a terrace cut by the Brazos River into the Oakville Formation. In this area the Oakville consists mostly of calcareous clay and shale with some soft sandstone beds. The hard resistant sandstone unit like that which underlies Monument Hill (pp. 147–148) is not present. Most of the surrounding area is brush covered or in fields and there are very few exposures of the underlying bedrock.

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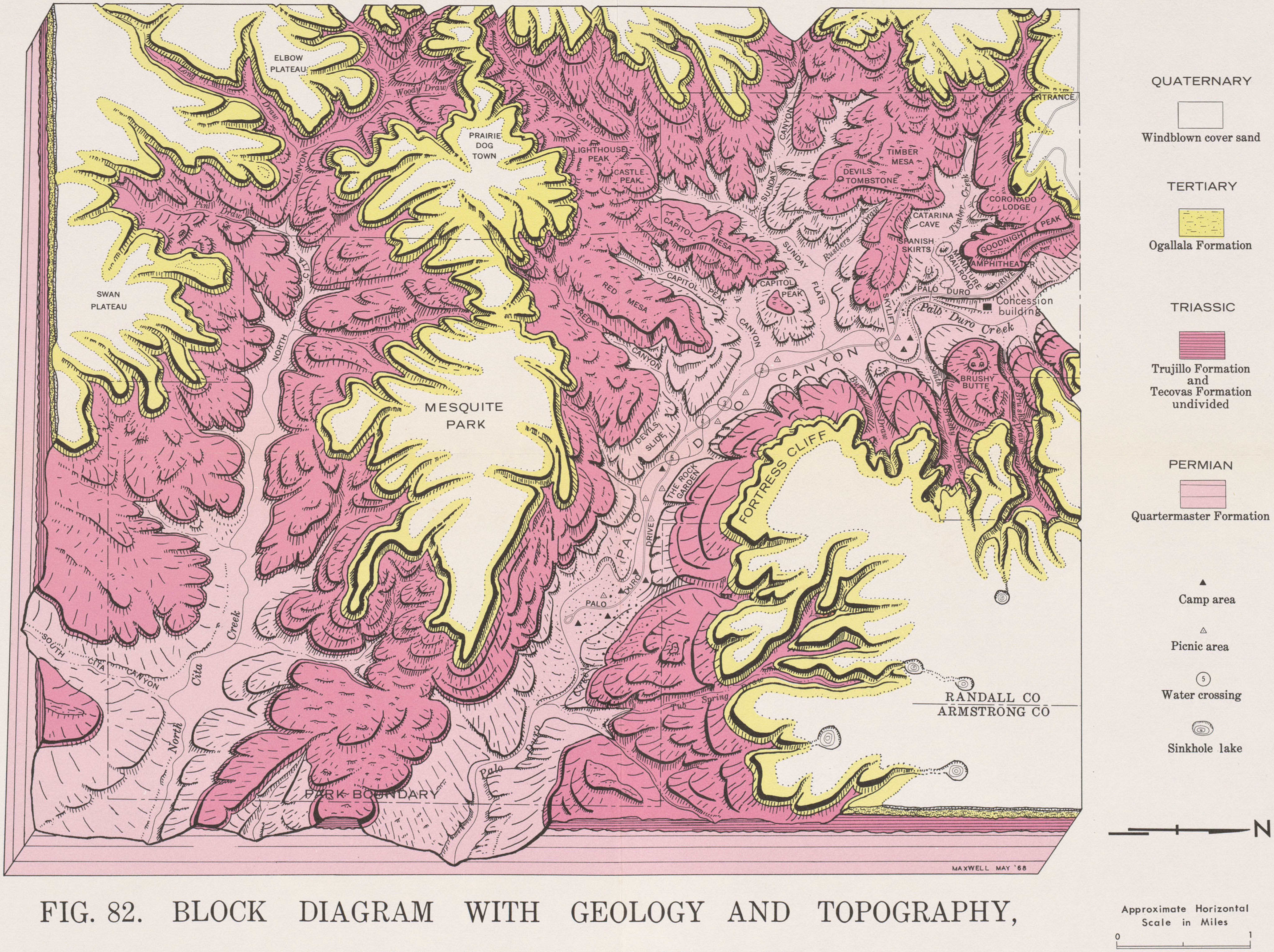

FIG. 82. BLOCK DIAGRAM WITH GEOLOGY AND TOPOGRAPHY, PALO DURO CANYON STATE PARK

PHYSIOGRAPHIC DIAGRAM OF TEXAS AND LOCATION OF STATE PARKS

TABLE 1. CHART OF TIME AND ROCK UNITS IN TEXAS

ERA	SYSTEM AND/OR SERIES	GEOLOGIC UNITS AND AGE OF ROCKS THAT MAY BE SEEN IN THE STATE PARKS: TRANS-PECOS TEXAS AND PANHANDLE HIGH PLAINS	NORTH-CENTRAL AND CENTRAL TEXAS AND THE GULF COASTAL PLAIN	NORTHEAST AND EAST TEXAS
CENOZOIC	QUATERNARY: RECENT	Alluvium Windblown sand **BALMORHEA (also see Aguja, Taylor, and Austin Formations)**	Alluvium Terrace gravel deposits **BENTSEN-RIO GRANDE BRAZOS ISLAND PORT ISABEL LIGHTHOUSE VARNER-HOGG PLANTATION VELASCO GOOSE ISLAND**	Alluvium Terrace gravel deposits
CENOZOIC	QUATERNARY: PLEISTOCENE	Fluvial terrace deposits Playa deposits Tahoka Formation Windblown cover sand Tule Formation Blanco Formation Monahans Formation Judkins Formation **MONAHANS**	Beaumont Formation terrace gravels and sand dune deposits Lissie Fm.: Montgomery Fm., Bentley Fm. **INDIANOLA** **SAN JACINTO** **FANNIN, LAKE CORPUS CHRISTI, STEPHEN F. AUSTIN**	Fluviatile terrace deposits Willis Formation
CENOZOIC	TERTIARY: PLIOCENE	Ogallala Formation **BIG SPRING (in part) MACKENZIE (in part) PALO DURO (in part)**	Goliad Formation **GOLIAD GEN. ZARAGOZA BP.**	Goliad Formation
CENOZOIC	TERTIARY: MIOCENE	Davis Mountain Volcanic Group Wild Cherry Fm. Mount Locke Fm. Barrel Spring Fm. Sheep Pasture Fm. upper rhyolite lower rhyolite McCUTCHEON VOLCANIC SERIES **DAVIS MTS.** South Rim Formation	Fleming Formation Oakville Formation **MONUMENT HILL WASHINGTON** Catahoula (Gueydan) Formation **TIPS**	Fleming Formation **HUNTSVILLE MARTIN DIES, JR.** Oakville Formation Catahoula Formation
CENOZOIC	TERTIARY: OLIGOCENE		Frio Formation Vicksburg Formation	Frio Formation Vicksburg Formation
CENOZOIC	TERTIARY: EOCENE	Chisos Formation Canoe Formation Hannold Hill Formation	Jackson Group: Whitsett Formation, Manning Formation, Wellborn Formation, Caddell Formation Claiborne Group: Yegua Fm., Crockett (Cook Mountain) Fm., Sparta Ss., Weches Fm., Queen City Fm., Reklaw Fm, Carrizo Ss. **FALCON** **BUESCHER** **PALMETTO** **BASTROP** Wilcox Group: Sabinetown Fm., Rockdale Formation, Seguin Formation	Jackson Group Yegua Formation Crockett Formation Sparta Sandstone Weches Fm. **MISSION TEJAS** **DAINGERFIELD** **JIM HOGG** **GOV. HOGG** **TYLER** **ATLANTA** Queen City Fm. Reklaw Formation Carrizo Sandstone Sabinetown Formation Rockdale Formation Seguin Formation **CADDO LAKE**
CENOZOIC	TERTIARY: PALEOCENE	Black Peaks Formation	Midway Group: Wills Point Formation, Kincaid Fm. **FORT PARKER OLD FORT PARKER LOCKHART**	Wills Point Formation
MESOZOIC	GULFIAN (UPPER CRETACEOUS)	Javelina Formation Aguja Formation Pen Formation Boquillas Fm.: San Vicente Member, Ernst Member Chispa Summit Formation **BALMORHEA (beneath the alluvium in valley; see Alluvium)**	Navarro Group: Kemp Formation, Corsicana Formation **SAN JOSE MISSION** Taylor Group: Bergstrom Fm., Pecan Gap Chalk, Sprinkle Fm. **ALAMO** Austin Group: Big House Formation, Burditt Chalk, Dessau Chalk, Jonah Limestone, Vinson Chalk, Atco Chalk Eagle Ford Group: South Bosque Formation, Lake Waco Formation Pepper - Woodbine Formations	Kemp Clay Corsicana Marl Nacatoch Sandstone Neylandville Marl Pecan Gap Chalk Wolfe City Sandstone Lower Taylor Formation Gober Chalk **BONHAM** Brownstown Marl Blossom Sandstone Bonham Clay Ector Chalk Eagle Ford Formation Woodbine Group
MESOZOIC	COMANCHEAN (LOWER CRETACEOUS)	Buda Limestone Del Rio Clay Santa Elena Limestone Loma Plata Fm. Sue Peaks Formation Benevides Fm. Del Carmen Limestone Finlay Ls. Telephone Canyon Fm. Maxon Ss. Cox Ss. Glen Rose Limestone Bluff-Yearwood Fm. Yucca Fm. Eagle Mountain Sandstone Espy Limestone DEVILS RIVER LIMESTONE Shafter Fm. Presidio Fm. ANTLERS FORMATION **ABILENE (see also Clear Fork)** **BIG SPRING (also see Dockum)**	Buda Limestone Del Rio Clay - Grayson Marl Wichita Group: Georgetown Formation, Kiamichi Formation Fredericksburg Group: Edwards Ls., Comanche Peak Fm., Walnut Clay **CLEBURNE** **MERIDIAN** **MOTHER NEFF** **LAKE WHITNEY** Trinity Group: Glen Rose Limestone, Hensell Ss., Cow Creek Formation, Hammett Formation, Sycamore Formation **BLANCO, GARNER, KERRVILLE** **LYNDON B. JOHNSON (See Wilberns) SAN SABA MISSION**	Buda Limestone Grayson Marl Main Street Formation **EISENHOWER BP.** Pawpaw Formation Weno Formation Denton Formation Fort Worth Formation Duck Creek Formation Kiamichi Formation Goodland Limestone **EISENHOWER** Walnut Clay Paluxy Fm. **ACTON** Antlers Formation (The Antlers Formation is also recognized in parts of the High Plains. See Abilene and Big Spring.)
MESOZOIC	JURASSIC	Malone Formation		
MESOZOIC	TRIASSIC	Bissett Congl. Dockum Group: Trujillo Fm., Tecovas Fm. **BIG SPRING (see Antlers)** **PALO DURO (see Ogallala)**		
PALEOZOIC	PERMIAN	Ochoa Group: Quartermaster Formation, Cloud Chief Gypsum Guadalupe Group: Tessey Formation, Capitan Limestone, Word Formation, Cathedral Mtn. Formation Leonard Group: Skinner Ranch Formation, Lennox Hills Formation **ABILENE**	Whitehorse Formation Pease River Formation Clear Fork Formation Wichita Group: Lueders Formation, Clyde Formation, Belle Plains Formation, Admiral Formation, Putnam Fm., Moran Formation, Pueblo Formation **FORT GRIFFIN**	
PALEOZOIC	PENNSYLVANIAN	Gaptank Formation Haymond Formation Dimple Limestone Tesnus Formation	Cisco Group: Harpersville Formation, Thrifty Formation, Graham Formation Canyon Group: Caddo Creek Formation, Brad Fm., Winchell Fm., Graford Formation **POSSUM KINGDOM** **LAKE BROWNWOOD** Strawn Group: Whitt Formation, Lone Camp Formation, Millsap Lake Formation Smithwick Shale Marble Falls Limestone	
PALEOZOIC	MISSISSIPPIAN	Caballos Novaculite	Barnett Formation Chappel Limestone	
PALEOZOIC	DEVONIAN	Caballos Novaculite	Houy Formation Bear Spring Formation Stribling Formation Pillar Bluff Limestone	
PALEOZOIC	SILURIAN	Fusselman Dolomite	Starcke Limestone	
PALEOZOIC	ORDOVICIAN	Maravillas Chert Woods Hollow Chert Fort Peña Formation Alsate Shale Marathon Limestone	Burnam Limestone Ellenburger Group: Honeycut Formation, Gorman Fm., Tanyard Formation **LONGHORN CAVERN**	
PALEOZOIC	CAMBRIAN	Dagger Flat Sandstone	Wilberns Formation **LYNDON B. JOHNSON** Riley Formation	
PRECAMBRIAN		Van Horn Sandstone Lanoria Quartzite Hazel Formation Mundy Breccia Caster Limestone Allamoore Formation Carrizo Mountain Group	Quartz porphyry dike (llanite) Sixmile Granite Oatman Creek Granite Town Mountain Granite Red Mountain Gneiss Big Branch Gneiss Packsaddle Schist Valley Spring Gneiss **INKS LAKE**	

EXPLANATION

BP.	Birthplace
Fm.	Formation
Ss.	Sandstone
Ls.	Limestone
Congl.	Conglomerate

The areas are not designated as to recreation and scenic parks, historic parks, and historic sites; the designations are in the text.

Ross A. Maxwell Sept. 1967