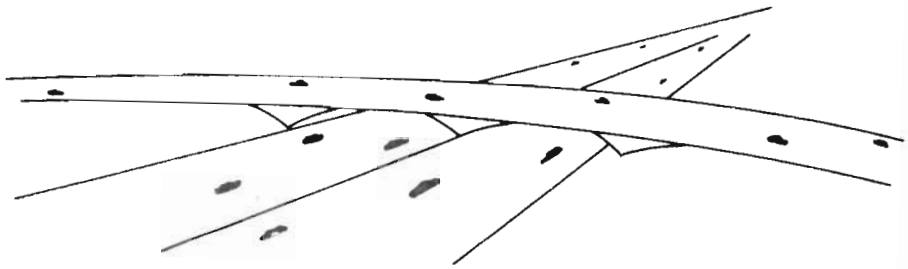

DEPARTMENTAL RESEARCH

Report Number: 63-3

GEOLOGY OF TEXAS HIGHWAY DEPARTMENT DISTRICT 11

TEXAS HIGHWAY DEPARTMENT

GEOLOGY OF TEXAS HIGHWAY DEPARTMENT

DISTRICT 11

by

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Research Report 63-3

Preparation of Geology Information
for use in the Texas Highway Department
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Conducted by

Lufkin District Laboratory
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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

A C K N O W L E D G M E N T S

The work was done under the supervision of Mr. Bob Walker, Senior Laboratory Engineer and under the general supervision of Mr. J. M. York, District Engineer, Texas Highway Department.

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GEOLOGY OF TEXAS HIGHWAY DEPARTMENT, DISTRICT 11

PART I

INTRODUCTION

This report was prepared and submitted as a portion of HPR-1(5), Research Project 1-8-63-63, jointly supported by the U. S. Department of Commerce, Bureau of Public Roads, and the Texas Highway Department. The report is intended to be presented in such a manner that personnel with little or no understanding of geology may identify the geologic formations and soils as they are encountered in construction, development of plans, designs, and other phases of engineering in the District. The contents of this report is primarily a summary of published information on the geology, physiography, structure, and soils of District 11 and is in no way intended to be a detailed account of source areas or physical properties of soils or geologic formations. Included is a glossary of geological terms found in the report.

PHYSICAL AND CULTURAL GEOGRAPHY

District 11 of the Texas Highway Department is located in the southeastern part of the state approximately 75 miles inland from the Gulf of Mexico. It includes the following nine counties: Nacogdoches, Shelby, Sabine, San Augustine, Angelina, Houston, Trinity, Polk, and San Jacinto.

The District covers 7,464 square miles and the area of the counties range in size from 564 square miles in Sabine County to 1,232 square miles in Houston County. Based on the 1960 census, District 11 had a population of 150,292 and a population density of 20 persons per square mile. Elevations in the District range from 100 feet in the southern part of the District in Polk and San Jacinto Counties to 600 feet in Nacogdoches County to the north. The average annual rainfall for the entire District is 47.1 inches. The temperature ranges from an average of 49° in January to 83° in July, with a mean annual temperature of 66°. Average length of growing season or continuous period free from killing frost is approximately 234 to 250 days, from the middle of March to the middle of November.

District 11 lies entirely within the major land division, the East Texas Timberlands. Four National Forests occur entirely or in part within the limits of District 11. They are Angelina National Forest, Davey Crockett National Forest, Sabine National Forest, and Sam Houston National Forest. All are administered by the Forest Service, U. S. Department of Agriculture with headquarters in Lufkin, Angelina County.

Water resources in the District are large due to relatively high rainfall, high frequency of major streams and reservoirs, and extensive productive aquifers.

PHYSIOGRAPHY

District 11 lies entirely within the Gulf Coastal Plain physiographic province; a gently undulating plain bordering the Gulf of Mexico. The Gulf Coastal Plain owes its general topographic features to the presence of relatively soft, nonresistant rocks alternating with sandstones and shales or the more resistant strata; a gentle gulfward dip of beds; low elevation above sea level; vegetation; and humid climatic conditions.

"The more resistant strata (rocks) underlying the Coastal Plain generally dip gulfward at angles slightly steeper than the present land surface, so that the more resistant strata break the gentle slope of the land with low, landward facing escarpments or cuestas." (Fisher, 1965, p. 24)

The principle escarpments in District 11 are the Kisatchie and Nacogdoches. The Kisatchie is supported mainly by the indurated sandstone and quartzitic rocks of the Jackson group and the Catahoula formation. It extends in an east-west direction through Trinity, northern Polk and just south of the southern boundry of Angelina, San Augustine, and Sabine Counties. Hills formed from the dissected front of the Kisatchie escarpment are well developed at Trinity, Trinity County, and near Fairmont, Sabine County.

The Nacogdoches escarpment, extending in a general east-west direction through Houston, Nacogdoches, San Augustine and Sabine Counties is supported by the indurated ironstones of the Weches formation.

Both the Kisatchie and Nacogdoches escarpments are not sharp in most places because the rocks are too soft and the climate too humid. However, maximum local relief does occur in places along the dissected cuesta fronts.

"The land between the main cuesta or escarpments and on the backslopes is generally rolling to undulating and hilly with prairies having a local relief of 100 to 200 feet. Streams flowing in their dendritic patterns within this area have flood plains of 1 to 10 miles wide and occur about 100 to 150 feet below the general elevation of the surrounding land. Flood plains are much narrower and farther below the general land surface where streams and rivers cut through cuesta fronts." (Fisher, 1965, p. 24)

Coastwise terraces in southern Polk and San Jacinto Counties have very little local relief, usually not exceeding 50 feet. Flood plains and terrace surfaces along major streams in this area are nearly level.

GENERAL GEOLOGY AND STRUCTURE

PART II

BRIEF HISTORY

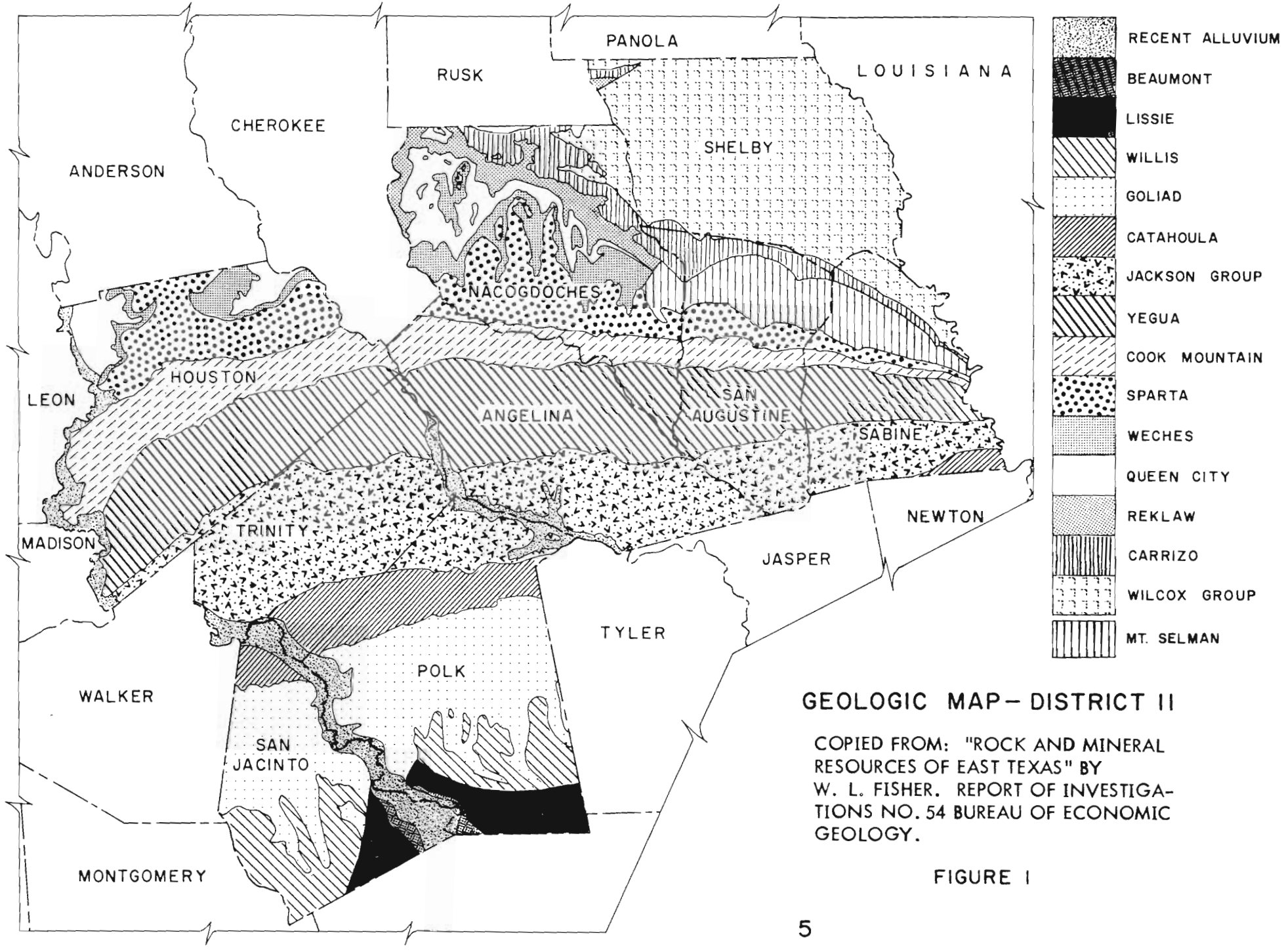
The sequence of rocks (formations) exposed in District 11 begins with the strata of Tertiary age that outcrop in the northeast part of the District in Shelby County. As one proceeds towards the south and southwest he encounters successively younger geologic formations at the surface. Rocks exposed in the District are inclusive of those from the lower Tertiary formations to rocks that are still in the process of formation at the present time.

By far the majority of formations exposed in District 11 belong to the Tertiary system and were laid down beginning approximately 70,000,000 years ago. These formations represent deposition of sediments during a time of emergence of the land mass and a regression of the wide spread Cretaceous Sea interrupted by local transgressions and regressions of the sea over the continental margins.

Covering the older Tertiary formations in places, particularly adjacent to the many streams and rivers of the District, are Pleistocene gravel terraces and alluvium deposits (see Geologic Map and Geologic Column of District 11, Figures 1 and 2).

LITHOLOGY AND DEPOSITIONAL HISTORY

The Tertiary deposits of District 11 consist primarily of sand, clay, silt, shale, and marl; with subordinate amounts of diatomaceous earth, volcanic ash, lignite, glauconite, and gravel. The method of deposition of these sediments were of two principal environmental types; marine and continental as well as intermediate types; deltaic, littoral (near shore) and lagoonal (brackish water). Throughout the Tertiary system the sea endeavored to advance over the land, and the heavily laden large streams and rivers constantly tried to build seaward a newly deposited land in the form of a deltaic plain. (Barton, pp. 359-382, 1930)



GEOLOGIC MAP – DISTRICT II

COPIED FROM: "ROCK AND MINERAL RESOURCES OF EAST TEXAS" BY W. L. FISHER. REPORT OF INVESTIGATIONS NO. 54 BUREAU OF ECONOMIC GEOLOGY.

FIGURE 1

EXPLANATION					
ERA	SYSTEM	SERIES	GROUP	FORMATION	MEMBER
CENOZOIC	QUATERNARY	PLEISTOCENE & RECENT		Alluvium, Sand Dunes, beach sand, and Terrace Deposits	
			HOUSTON	BEAUMONT	
				LISSIE	
	TERTIARY	PLIOCENE	CITRONELLE	WILLIS	
		MIOCENE		FLEMING (LAGARTO)	
		MIOCENE OLIGOCENE		CATAHOULA	
					CHITA
		EOCENE	JACKSON		
				WHITSETT	
				MANNING	
				WELLBORN	
				CADDELL	
			CLAIBORNE	YEGUA	CREOLA
					LUFKIN
					BRYAN
				COOK MOUNTAIN	MT. TABOR
					SPILLER
					LANDRUM
					WHEELOCK
				SPARTA	STONE CITY
			MT. SELMA	WECHES	THERRILL
					VIESCA
					TYUS
				QUEEN CITY	
					OMEN
					ARP
				REKLAW	MARQUEZ
					NEWBY
				CARRIZO	
			WILCOX	SABINE TOWN	
				PENDLETON	HIGH BLUFF
					SLAUGHTER CREEK
					BAYOU LENANN
				MARTHAVILLE	
			MIDWAY	HALL SUMMIT	BISTINEAU
					GRAND BAYOU
					LOGGY BAYOU
				LOGANSPORT	LIME HILL
					COW BAYOU
					DOLET HILL
				NABORTON	SUB-SURFACE IN DIST. 11
				PORTERS CREEK	

GEOLOGIC COLUMN OF DISTRICT 11

FIGURE 2

In some epochs the water forces prevailed and in others the land building processes predominated. At least 9 maximum transgressions of the sea occurred in the Cenozoic era and each transgression was followed by a maximum regression. During these major changes, numerous oscillations of the strand line of greater or lesser extent took place (Plummer, 1932, p. 529).

The lowermost rock (formations) of Tertiary age constitute the Midway group which is overlain by the Wilcox group. Both the Midway and Wilcox groups in District 11 were deposited in a deltaic environment and the formations of these groups reflect a cyclic depositional pattern characteristic of this type environment. The members of this cyclic pattern in ascending order are as follows: massive to broken sand member, Carbonaceous shale member, and a slightly calcareous silt and shale member which is locally glauconitic. The transition beds between these members in most places contain lignites. Insofar as possible, each complete cycle is designated a formation (Murray and Thomas, 1945, p. 54).

In a deltaic environment there are three contemporaneous, yet dissimiliar, types of deposits. Off shore, there is shallow marine deposition. Along the coastal apron are coastal marshes rich in organic material and containing many meandering streams and lakes which support an abundant brackish-water plant and animal life. These streams and lakes rework and sort sediments as they erode their banks at one place and deposit the eroded materials elsewhere. Along the strand line the marine materials and marsh deposits are closely and heterogeneously admixed by wave action. Marine shells are sometimes carried far back on the marsh by inundations resulting from tropical storms. Landward the marsh deposits grade into the fluviatile sands, gravels, silts, and clays of the broad river flood plains. Calcareous, back-swamp clays and peaty materials are common in this environment (Murray and Thomas, 1945, p. 69).

The Claiborne group of rocks in the District were deposited during a sequence of maximum transgressions and regressions of the sea.

"The Claiborne group contains fine to medium grained, light-colored, cross-bedded, loosely consolidated sands (Carrizo, part of the Queen City, Sparta, Bryan); glauconitic sands

and marls (Newby, Omen, Weches, Wheelock); and brown-gray clays and shales (Marquez, Therrill, Landrum, and Mt. Tabor). Gray lignitic clays and lignites are common throughout the sequence especially in the Queen City and upper parts of the Sparta and Yegua formations"(Fisher, 1965, p. 30).

The Jackson group of formations represents the last extensive marine invasion of the Cenozoic era. The group consists primarily of shallow-water, marine and beach deposits composed of medium and fine grained thin bedded to massive sands, silts, and sand clays which contain appreciable amounts of volcanic ash, fused tuff, and lignite. The Caddell formation or basal Jackson consists of slightly glauconitic silts and brown and gray shale. The Wellborn and Manning formations both include grayish sands and carbonaceous to lignitic silts and clays containing varying amounts of volcanic ash and fused tuff. The upper (Whitsett) formation of the Jackson group is primarily a clay sequence composed of brown-gray clays with interbeds of cream colored sand.

The Jackson group is overlain by the Catahoula formation, The Catahoula is largely non-marine in origin consisting largely of tuffaceous clays and sandy clays; interbedded with the sandy clays of tuffaceous sands and volcanic ash beds. There also are locally present rice sands, conglomeratic sandstones, and quartzite beds.

The Fleming formation overlies the Catahoula and is primarily a multi-colored clay sequence containing abundant calcareous concretions with interbeds of light colored sands. Sediments of the Fleming were deposited on a comparatively flat coastal plain in quiet waters of inland lakes, lagoons, and bays beyond the immediate shore line.

South of the Fleming formation, "terrace deposits of the Willis, Lissie, and Beaumont formations, consisting of basal gravels grading vertically to sands, silts, and clays prevail. Coastwise terrace deposits have equivalent units extending inland along major streams as upland terraces. Gravels and other alluvial deposits, similiar to older terrace deposits are currently being deposited along major streams in the District". (Fisher, 1965, p. 31) See Geologic Column of District 11, Figure 2.

STRUCTURE

The Tertiary deposits of District 11 generally dip to the south or southeast (Gulfward) at angles of approximately one degree. In local structures this rate of dip may greatly exceed one degree.

The Sabine Uplift is a relatively flat-topped, roughly quadrate dome approximately 80 miles long and 65 miles wide situated in northwestern Louisiana and northeast Texas. It is one of the major structural features of the Gulf Coastal Plain. The lowermost Tertiary, Midway, Wilcox, and lower Claiborne groups of Shelby, Nacogdoches, San Augustine, and Sabine Counties consitute the southern flank of the Sabine Uplift and reflect a large inlier of Midway-Wilcox and lower Claiborne sediment. The dip of these beds is generally radial away from the central part of the uplift.

Faulting along the Mt. Enterprise-Jarvis-Elkhart system is present in extreme northwest Shelby County. The system is an en'echelon system, aligned roughly parallel to the present coast and is downthrown to the north.

In northwestern Houston County a zone of faults enter the country from Anderson County about 10 air miles northwest of Grapeland. This zone of faults can be traced or conjectured in an eastwardly direction for about 6 miles before leaving Houston County approximately 2 miles west of the Grapeland-Palestine highway (U.S. Highway 287). The faults of this zone are downthrown to the north and may be recognized by the repetition of the Queen City-Weches-Sparta sequence (Stenzel, 1943, p. 19).

Local faulting occurs in the southern part of District 11 but will not be discussed because the faulting is seldom if at all reflected at the surface.

DESCRIPTION OF GEOLOGIC FORMATIONS

PART III

CENOZOIC ERA

TERTIARY SYSTEM

EOCENE SERIES

The Eocene Series in District 11 is composed of the Midway, Wilcox, Claiborne and Jackson groups. The formations comprising these groups constitute the majority of formations that outcrop in the District.

MIDWAY GROUP

The Midway group in District 11 represent the oldest geologic units exposed in the District. The only exposures of this group in the District occur in eastern Shelby County. The formations of the Midway group exposed in Shelby County are, in ascending order according to their age; the Logansport formation (Lime Hill member) and the Hall Summit formation. The geologic units below the Lime Hill members of the Logansport formation are sub-surface in District 11 and will not be discussed in this report.

LOGANSPORT FORMATION

Lime Hill Member - The Lime Hill member is the only representative of this formation present in District 11. It is the uppermost part (member) of the formation and is exposed in eastern Shelby County. The Lime Hill member is, as the name implies, a calcareous silt and shale. Where fresh, the beds are gray, buff, or black in color. Upon weathering, they change to light gray to khaki to red or reddish brown. The member is rather heterogeneous, and sudden lithologic changes, both vertically and horizontally, into more sandy phases are not uncommon (Murray and Thomas, 1945, p. 58).

HALL SUMMIT FORMATION

This formation crops out in eastern Shelby County adjacent to and west of the Lime Hill outcrop. Its outcrop occupies a much larger area than that of the Lime Hill. The Hall Summit formation has been divided into three members; a lower member (Loggy Bayou) consisting of massive to broken sands with subordinate amounts of sandy shale and clay ball conglomerates, middle carbonaceous shale (Grand Bayou) member and an upper calcareous silt and shale member (Bistineau)(Murrary and Thomas, 1945, p. 58). The entire Hall Summit formation is about 150 feet thick in Shelby County. The lower member (Loggy Bayou) is the most massive sand in the Midway and Wilcox groups in District 11. It reaches its maximum development west of Joaquin in Shelby County.

WILCOX GROUP

This Wilcox group in District 11 is comprised of three formations: Marthaville, Pendleton, and Sabinetown. The formations of this group crop out in the northeastern and eastern part of the District.

MARTHAVILLE FORMATION

Exposures of this formation occur in Central Shelby County, and in the extreme northeast corner of Sabine County. The formation consists of three un-named lithologic units or members; a basal sand member, a middle lignitic shale member, and an upper calcareous silt and clay member. Glauconitic (iron and potassium silicate) lentils are locally present in both the upper and lower members and the basal sand member is locally fossiliferous (Murray and Thomas, 1945, p. 60).

In Shelby and Sabine Counties the upper calcareous silt and clay member is the best developed of the three members in the formation. These calcareous beds are actually the only definite representatives of the Marthaville in Shelby County, as the lower and middle members are esentially "pinched out" across the area.

PENDLETON FORMATION

The Pendleton formation is exposed at the surface in Nacogdoches, Shelby, and Sabine Counties. The outcrop of this formation is the largest in areal extent of the Midway-Wilcox groups in the District. The thickness of the Pendleton is estimated to be 300 feet in Sabine County. The well known, highly fossiliferous exposures at the old Pendleton Ferry Landing, Sabine County, was designated as the type locality. The formation is divided into three members, in ascending order they are: the Bayou Lennan, Slaughter Creek, and the High Bluff (Wasem and Wilbert, 1943, pp. 95-181).

Bayou Lennan Member - The lower member or Bayou Lennan member from its base upward consists of glauconitic, fossiliferous sand grading up into lignitic silts and sands with thin seams of lignite. In Sabine County this member is approximately 90 feet thick and can be traced from the Sabine River well into northern Sabine County and probably exists through Shelby County. Good exposures of this member may be seen in the vicinity of Geneva, Sabine County.

Slaughter Creek Member - The Slaughter Creek member is about 60 feet thick. It consists of fossiliferous, glauconitic sand with pipe-like limonitic (hydrous iron oxide) nodules at the base which grades up into 15 to 20 feet of fossiliferous clays with glauconitic sand lentils near the top. Overlying the clays is 20 feet of non-fossiliferous sand with calcareous concretions. A persistent lignite seam occurs about 30 feet below the top of the member and is overlain by glauconitic, sparingly fossiliferous sand.

High Bluff Member - The High Bluff member contains about 130 feet of strata consisting of a basal glauconitic, fossiliferous sand overlain by silts and shales containing calcareous concretionary boulders. The silts and shales grade up into 65 feet of thin-bedded lignitic silts and sands. The upper 30 feet is cross-bedded sands (Murray and Thomas, 1945, p. 62).

SABINETOWN FORMATION

The Sabinetown formation is exposed at the surface along a narrow belt in Nacogdoches, Shelby, San Augustine and Sabine Counties. It is the thinnest unit of formational rank in the area. The Sabinetown is typically exposed at the high bluff on the Texas side of the Sabine River about 0.25 mile south of the old ferry landing near Sabinetown, Sabine, County, Texas. In the District the Sabinetown is a thin, though distinctive, formation. Two un-named members of the formation are recognized in Sabine County. The lower member is composed of about 32 feet of fine-grained greensand or glauconitic sand with shale and clay interbeds and concretionary (ironstone) siderite. The upper member consists of lignitic silty shale with some carbonaceous clay, silt, and sand. In places it is glauconitic. These two members reach their maximum development in Sabine County. The formation thins to the northwest along strike and locally in Shelby County, the lower member is missing. The maximum total thickness of the Sabinetown formation is about 60 feet in Sabine County and from 10 to 25 feet in Shelby County (Murray and Thomas, 1945, p. 64).

CLAIBORNE GROUP

The Claiborne group in East Texas, includes the beds between the base of the Carrizo formation and the top of the Yegua formation.

CARRIZO FORMATION*

The Carrizo formation outcrops in a narrow belt of approximately 3½ miles wide to a fraction of a mile wide in a northwest, southeast direction extending from northern Nacogdoches County to the Sabine River in Sabine County. At Sabinetown, in Sabine County, the formation is about 60 feet thick and increases to a maximum of 125 feet in San Augustine County. It decreases gradually in depth to the northwest. The uppermost part of the Carrizo is present in Shelby and Nacogdoches Counties.

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*Recent writers consider the Carrizo formation to be upper Wilcox, however, it is considered lowermost Claiborne for purposes of this report.

The surface expression of the Carrizo is a ridge of moderate relief covered by buff or gray sand and forested by a more or less thick growth of blackjack oak, sandy land hickory, poision ivy, and cucumber-leafed sunflower (Sellards, Adkins, and Plummer, 1932, p. 614).

The Carrizo formation, for the most part, is a continental deposit laid down by streams that deposited sediments on a flat coastal plain and built up a broad allvuial apron all along the coast.

"The epoch ended by a slow return of the sea, a decrease in the gradient of the streams, and a slow replacement of the continental deposits by shallow-water marine sediments of the Reklaw formation." (Sellards, Adkins and Plummer, 1932, p. 617)

In District 11, the Carrizo consists of massive to broken, fine-grained sands with small amounts of sandy shale and clay. The structure of the sands range from thin and even bedded to massive to highly cross bedded; their grain size varies from very fine to coarse; and their degree of sorting varies from good to poor.

"The basal strata are composed chiefly of rounded and subangular quartz grains which average about one-millimeter in diameter (No. 18 sieve)." (Sellards, Adkins and Plummer, 1932, p. 617) In places these grains are cemented with ferruginous material to form concretions. The upper strata is composed of finer grained, less ferruginous, and more uniformly textured sands.

The associated shales and clays occur as inclusions, pods, parting interbeds, and lenses. Disseminated glauconite is locally abundant at the top of the formation (Murray and Thomas, 1945, p. 65).

When fresh, the sediments of the Carrizo are generally light gray to white, but on the outcrop they are commonly stained some shade of red or brown.

REKLAW FORMATION

The Reklaw formation is exposed in northwest Nacogdoches County along the Angelina River and the Nacogdoches-Rusk County Line. The Reklaw outcrop then traverses Nacogdoches County in a southeastward direction extending to the Sabine River in Sabine County. The pinching out of the Queen City formation to the east across Nacogdoches County brings the Reklaw and Weches together making them practically inseparable for geologic mapping in eastern Nacogdoches, San Augustine, and Sabine Counties.

> "The surface exposure of the Reklaw is typically a gentle, rolling, mature topography characterized by red soils. The outcrop is less rugged and less forested than the Carrizo or the overlying Queen City formation. It may be described as a red prairie belt between two broad oak-forested ridges." (Plummer, Sellards and Adkins, 1932, p. 620)

Sediments of the Reklaw were deposited in shallow marine waters along a flat lying or gently inclined coastal plain where sediments accumulated in marine waters probably not over 15 fathoms deep.

The basal strata (Newby member) of the Reklaw formation consists of glauconitic sands and ferruginous sandstones. The upper or (Marquez member) is composed of brown-gray clays, slightly glauconitic black sandy clay, green glauconitic clay and shale, and a locally present gray and yellow gypsiferous clay. The presence of glauconite and the ferrugenious sand in the lower member results in iron ore and ferruginous sandstones capping many of the hills just above the Carrizo Reklaw contact. This is well exemplified in northern Nacogdoches County around the community of Pleasant Hill.

QUEEN CITY FORMATION

The Queen City formation crops out in northwest and northeast Houston County and in Nacogdoches County. In Houston County the exposures are separated by a large outcrop of the Weches and Sparta formations. The outcrop pattern of the Queen City in northwest Nacogdoches County is broken by outliers of the Weches formation. To the southeast the Queen City pinches-out between the greensands of the Weches and the clay, shale, and marl of the Reklaw formation.

The upper part of the Queen City which is exposed in Houston County, develops deep sandy soil which is usually light grayish-brown. The topography of this part of the Queen City is in places subdued to form extensive sand flats. The grass cover is sparce, leaving many spots of loose, bare sand. The oak trees grow very far apart producing a very loose stand. In Nacogdoches County the Queen City produces a gently rolling, mature type of topography of slightly more relief than the underlying Reklaw and is occupied largely by pine and oak forest. The sands where fresh, are light grayish-brown and resemble those of the Carrizo formation. The sands for the most part are slightly finer grained than those of the Carrizo. In Nacogdoches County, especially around the outliers of the Weches formation, the sands of the Queen City are stained shades of red or yellow due primarily to the leaching in of ferruginous minerals from the overlying Weches formation.

"The Queen City is largely a continental fluviatile deposit laid down by meandering and shifting rivers on a flat coastal plain. The strata merge gulfward with shallow-water beds that were in a part laid down in marshes and bays, in which plant detritus was abundant, and in part were delta deposits in shallow waters. The glauconite lentils may have been washed in from eroded Midway and Reklaw strata or may have originated in shallow marine waters." (Sellards, Adkins and Plummer, 1932, p. 633)

The composition of the Queen City varies both horizontally and vertically, but by far the greatest bulk is composed of a light gray, medium to very fine grained, cross-bedded, loosely consolidated sands. "The clay and sandy shale beds in the formation are lenticular, brown, impregnated with some organic matter, and in many places contain some lignitic sand and silt as thin laminae or as layers and thin lentils." (Plummer, 1932, p. 633) In Houston County the Queen City is devoid of lime and glauconite but in Nacogdoches County the formation becomes slightly glauconitic to glauconitic particularly in the lower one third (Arp and Omen members) of the formation.

WECHES FORMATION

The type locality of the Weches has not been definitely designated, however, the formation was named for exposures at Weches, Houston County. In District 11 the Weches crops out in northern Houston County in two areas insolated by the Anderson County Line and the Trinity and Neches Rivers. The Weches also outcrops in a rather tortuous belt extending in a southeastwardly direction through Nacogdoches, San Augustine, and Sabine Counties. In southeast Nacogdoches, San Augustine, and Sabine Counties the Queen City formation is missing in the section and the Reklaw and Weches formations are practically inseparable for geologic mapping and are consequently mapped together as the Mt. Selma group on the accompanying geologic map. In many instances the Weches formation occurs as outliers in either the Wilcox or the Queen City formation. One such outlier of the Weches has been mapped in southern Shelby County and is known locally as the "Dreka" iron ore.

The resistant ferruginous beds of the Weches produce a rugged topography of steep, high, flat topped hills, dissected by V-shaped valleys. Along the outcrop the Weches weathers to brownish-buff and brick-red and forms dark red, stoney clay soils. The average width of the outcrop in the District is approximately five miles and the average thickness of the outcrop in East Texas is 50 feet.

"The Weches sediments were deposited in moderately shallow, clear, marine waters, which deepened as the epoch advanced. The rolled and wave-worn shells at the base of the formation indicate a shallow littoral or beach facies. The thick beds of glauconite indicate an off-shore facies in which water was 200 to 600 fathoms deep. The material that accumulated at this depth was fine, calcareous ooze and colloidal silicate in the form of iron potassium silicate (K, Fe, Si_2O6 H_2O) which in the presence of sea water precipitates in the form of glauconite grains." (Plummer, 1932, p. 641)

In East Texas the Weches formation is subdivided into three members. The members and their constituents are as follows: The Tyus or basal member is composed of gray, powdery,

slightly glauconitic, calcareous marl. It has a gray limestone ledge or limestone concretions - one or the other of which is the outstanding component of the member. The Viesca member is the middle unit, and is composed of poorly bedded, fossil-bearing, clayey, and calcareous glauconite rock where fresh, and of red and brown clays and clay-ironstones with fossil coats where weathered. Glauconite is the outstanding component. The Therrill or upper member (recent writers have raised the Therrill to formational ranks) consists of black to black-green clay with iron sulfide (pyrite or marcasite) nodules, a small amount of glauconite and very few fossils where fresh, and of brown shales or yellow and red clays with some yellow calcareous clay-ironstone concretions where weathered. Clay is the outstanding component.

The glauconite consists of dark green or greenish black, spherical, oval, and elongated grains that average one millimeter (No. 18 sieve) in diameter. The glauconite, where it exists in beds, is for the most part free from sand but contains some clay or marl and an abundance of fossil shells. The Weches formation is the primary source of iron ore in East Texas. The iron ore of the Weches is altered glauconite in which the iron has been concentrated either by leaching out of the potash and silicates, a process that leaves the iron oxide in the form of a black, honeycombed, porous layer one to three feet thick; or the iron has dissolved and precipitated as a limonite seam along porous layers. It occurs also less commonly in the form of the carbonate ($Fe\ Co_3$) as round, biscuit-shaped concretions in impervious beds. "The glauconite beds are thicker, purer, more persistent, and more fossiliferous in the Weches than in other Claiborne formations." (Plummer, 1932, p. 644)

SPARTA FORMATION

The Sparta formation crops out in Houston, northern Angelina, Nacogdoches, San Augustine and Sabine Counties. The width of the outcrop varies from approximately ten miles wide in Houston County to approximately two miles in Sabine County.

In District 11 the Sparta occurs on the high ridges above the Weches formation and caps most of the ferruginous hills

along stream divides. In most places the sand is unconsolidated and erodes easily to form rounded, uneven slopes.

"The sediments of the Sparta formation are thought to be mostly continental in orgin. The basal sands were laid down on a beach and coastal plain in conjunction with the withdrawal of the Weches sea. The middle sands are mainly fluviatile deposits spread broadly over a flat terrain. The upper sediments were deposited along transgressing shoreline laid down in advance of the Cook Mountain sea." (Plummer, 1932, p. 654)

Most of the Sparta formation consists of gray or buff, loosely consolidated sands. Locally the sand contains some glauconite and weathers to reddish hues. The sand consists of rounded and subangular quartz grains about 0.5 mm in diameter (No. 35 sieve) mixed with a small percentage of exceedingly fine grains. The individual sand beds are separated by thin layers of finer material, shale or silt, which contain ferruginous material, and on weathering becomes indurated to form thin ledges or cardboard like partings impregnated with limonite. The basal Sparta is indurated at the Weches contact to a hard, yellow, thin-bedded, limonitic sandstone one to four inches thick. This induration is obviously secondary and probably due to lime derived from the underlying Weches.

The upper part of the Sparta has been redefined as the Stone City formation and mapped in Leon County, District 17 (Stenzel, 1938, p. 120). There are no maps in District 11 showing this unit; therefore, it is considered as Sparta and will be described as the upper beds of the Sparta formation. Gray and chocolate colored clays containing considerable carbonaceous matter are most prevalent in the upper part of the formation. The most conspicuous beds of the upper Sparta are glauconitic and muscovitic (a form of mica called muscovite, hydrous potassium, and aluminum silicate). In most places the glauconite content is small. Some layers are rich in this mineral, however, and these beds weather bright orange and yellow, a color which makes them very conspiciuous. There are locally some highly indurated sandstones in the upper beds of the Sparta formation.

COOK MOUNTAIN FORMATION

The Cook Mountain formation crops out in Houston, Angelina, Nacogdoches, San Augustine, and Sabine Counties. The outcrop trends in a general east-west direction and the width of outcrop thins from west to east. The width of the outcrop varies from nine miles in Houston County; six miles in Angelina County to approximately two miles in Sabine County. Typical exposures of this formation are at Cook Mountain (two miles west of Crockett) along U. S. Highway 287 north of Crockett, and along State Highway 21 southwest of Crockett, Houston County. In Angelina County a good representative section of the middle of the formation is exposed along Mill Creek northeast of Lufkin. Good exposures of the lower Cook Mountain beds occur in the vicinity of Macune in San Augustine County.

"The sediments of the Cook Mountain show much variation both in kinds of sediments and types of life which they contain. In the early part of the epoch, waters were shallow, and the fossils and aspect of the sediments indicate a shifting shore line in which continental, beach, and littoral conditions alternated. Toward the middle of the epoch, waters were deeper, more glauconite was formed, thin layers of calcium carbonate (limestone) mixed with sand and silt occurred and conditions were favorable for a varied animal life. Later waters shallowed, and the upper beds of the Cook Mountain were deposited in a littoral type of environment. The very uppermost beds show a gradual transition from marine to palustrine and continental deposits." (Sellards, Adkins and Plummer, 1932, p. 660)

The Cook Mountain has been divided into four members. These members have been mapped in the western part of the District in Houston County. It is believed that these same members or their equivalents extend throughout the District although they have not been mapped. The four members are, in ascending order: Wheelock, Landrom, Spiller and Mount Tabor.

Wheelock Member - The basal member, Wheelock, is madeup chiefly of gray, slightly calcareous, fossiliferous, glauconitic shales and marl. The shales and marl are generally light gray-green, bluish-gray, or slate gray. The shales are thin bedded to laminated. The Wheelock member locally contains subordinate limestone layers and clay-ironstone concretions.

Landrom Member - The lower portion of the Landrom consists of a very dark brownish-black, sparingly glauconitic, slightly calcareous, even textured shale of thin and regular bedding. Subordinate lentiles of glauconitic marine shales are interbedded in this part of the member. In the upper part of the member, the shales become more silty, micaceous and less plastic, resulting in a speckled light brown color. Locally the silty shales contain lignitized plant fragments.

Spiller Member - The Spiller member is primarily a gray or brown, lignitic, muscovitic sand having lenticular or cross-bedded structure. The induration of the sand beds is normally very slight. However, the upper beds of the Spiller locally contain an abundance of indurated sandstones.

Mount Tabor Member - The uppermost member is similar to the Landrom member in many respects. The member consists of interbedded silts and shales in the upper beds and chiefly brown shales in the lower beds. Subordinate beds of glauconitic marls and black impure limestones, both richly fossiliferous are included in this member.

YEGUA FORMATION

The Yegua formation occupies a forested, gently rolling, more or less sandy belt outcropping in a general east-west direction through Houston, Trinity, Angelina, Nacogdoches, San Augustine and Sabine Counties.

The Yegua is the uppermost formation of the Claiborne group. The sediments of this formation were deposited as the Cook Mountain sea withdrew, and thick series of fluviatile sands, and lacustrine clays were deposited over the marine, glauconitic clays and beach deposits of the Cook Mountain formation.

In general the formation is a heterogenious complex of layers of sand, clay, sandy clay, lignite, and carbonaceous clay lentils. None of these layers can be traced far or correlated from one core test to another, unless the tests are very close together.

"The Yegua consists of about 50 per cent sand, 26 per cent sandy clay, 22 per cent compact clay, 1 per cent lignite and 1 per cent bentonite." (Sellards, Adkins and Plummer, 1932, p. 671-672)

The sands of the Yegua are massive, laminated, cross-bedded, and made up of medium to fine grains averaging 0.2 mm in diameter (No. 70 sieve). The basal (Bryan member) is the most massive sand in the formation. Extensive sands also occur in the upper beds of the Lufkin member. On the outcrop the Yegua sands are usually a grayish-brown color. Much silicified wood and selenite (a gypsum form, hydrous calcium sulfate) are found associated with the sand and sandy clays of the Yegua.

The clays vary from dark brown and gray to greenish-gray. The dark colored clay is more common in the lower part (northern area of outcrop) and the light gray, green, and white clay occurs in the upper part (southern area of outcrop). The clay is colloidal and jointed, and most of it well laminated. In many places the clays are impregnated with enough ferruginous material to give them a reddish-brown color. The clays quite commonly contain ironstone concretions in the forms of flattened masses of ferruginous clay in which the original carbonate has been altered to limonite. Some of the flat concretions are more than a foot in diameter.

Lignite and bentonite is abundant throughout the Yegua, especially in Houston and Angelina Counties. On the outcrop, the Yegua formation is practically void of fossils.

JACKSON GROUP

The Jackson group includes the strata between the terrestrial Yegua and the Catahoula in East and Northeast Texas. The Jackson group outcrops in Houston, Trinity, Polk, Angelina, San Augustine, and Sabine Counties. This group represents the last extensive marine invasion of the Cenozoic era. The depositional history of the group begins with the advance of the sea over the Yegua deposits, one or more recessions of the sea

during the middle of the epoch, and the withdrawal of the sea towards the end. The group consists primarily of medium and fine grained, thin bedded to massive sands, silts, and sand clays which contain appreciable amounts of volcanic ash, fused tuff, fullers earth, and lignite.

"The volcanic ash deposits are associated with deposits of bentonitic clay, fullers earth, lignite, and quartzose sand and silt." For the most part the individual ash deposits are lenticular and discontinuous, although gross ash bearing units are presistent; two such units occur in the Jackson group in District 11. Most ash deposits were apparently carried and deposited by streams draining areas near a volcanic source. "Some of the ash deposits may represent original ash falls with little or no reworking after deposition." (Fisher, 1965, p. 330)

The Jackson group is commonly divided into four formations; in ascending order they are: Caddell, Wellborn, Manning, and Whitsett. These formationa are present in District 11, but they are not mapped.

CADDELL FORMATION

This formation is named for the small town of Caddell in San Augustine County. At fresh exposures in the District, the Caddell is a fossiliferous, glauconitic shale or marl. White fragile shells occur throughout, and disseminated glauconitic grains give the formation a greenish-gray color.

WELLBORN FORMATION

The Wellborn is primarily a sand sequence with subordinate amounts of shale, silt, volcanic ash, and lignite. The formation consists of a basal indurated sandstone, grading upward into cross-bedded sands, clays, and sandy shale. The upper beds are composed of an indurated sandstone varying in hardness. The most indurated sandstones are grayish-blue and have about the hardness of quartzite.

MANNING FORMATION

The Manning formation consists of interbedded clay, shale, sand, and some sandstone. The sandstone varies in thickness and hardness. Most of the sandstone strata are lenticular or discontinuous. Extensive sandstone deposits occur in the southern boundary of the Manning south of the town of Manning in Angelina County.

WHITSETT FORMATION

The Whitsett is essentially a sand unit, interbedded with layers of thin-bedded bentonitic clay, grayish shales, volcanic ash, and chocolate colored clay. A number of thin beds of lignite or dark brown lignitic shales are present especially in the lower portion of the formation. The sands of the Whitsett are gray to cream and are usually cross-bedded. The southern boundary of the Whitsett strikes through and near Sebastopol, Chita, Corrigan and through Fairmon and Hackley Ridge in Sabine County.

OLIGOCENE AND MIOCENE SERIES

CATAHOULA FORMATION

The Catahoula formation in District 11 crops out in San Jacinto, Trinity, Polk and southern Sabine Counties. The formation consists largely of tuffaceous clays, sandy clays, ashy sand, and sandstones. There are also locally present conglomeratic sandstones and quartzite beds. Much of the volcanic ash in the formation has been altered to fullers earth and bentonitic clay. The ash beds in the Catahoula are white, light gray, dirty gray, and greenish gray. The thickness of these beds range from a few inches up to 8 or 10 feet thick. The ash beds are usually interbedded with tuffaceous clay and tuffaceous sand.

Catahoula formation is non-marine in origin. The sediments were deposited by rivers and streams flowing over the flat coastal plain that existed after the withdrawal of the Jackson sea.

The basal member (Chita) is the most predominant sandstone in the Catahoula formation. The type locality of this member is along the north-facing escarpment near the town of Chita, Trinity County. There are several different facies in this sandstone; the most conspicuous is that which consists of coarse (pass 18, ret 35) quartz sand grains and grit with siliceous cement. At many places the quartz grains in this sandstone are about the size of rice grains which led Dumble (1918, p. 188) to refer to them as the "Rice Sands". The Chita quartzitic facies grades into sandy tuff, and at many places a conspicuous bed of tuff (volcanic ash) marks the base of the Catahoula formation. Several prominent sandstone units in the Catahoula occur above the Chita. The composition of these units is similar to that of the Chita.

MIOCENE SERIES

FLEMING FORMATION

The Fleming, west of the Brazos, is composed of two distinct and mapable units, the Lagarto and Oakville. In District 11 the two units are difficult if not impossible to differentiate. For purposes of this report, the Fleming is considered formational in rank and includes the undifferentiated Lagarto and Oakville units.

The Fleming outcrops in the southern part of the District in San Jacinto and Polk Counties. "The type locality for the Fleming are exposures along the Missouri, Kansas and Texas Railroad east of Corrigan and near the station of Fleming (Hampton) in Polk County". (Sellards, Adkins and Plummer, 1932, p. 729)

In District 11 the Fleming consists of yellow and green clays, gray sandy clays containing layers of pink and brown clay, and greenish or black clays which weather to a black loamy soil. Thin layers of chalky limestone and lentils and layers of cross-bedded sand are locally present particularly in the upper portion of the Fleming.

Toward the base of the formation, the Oakville clays are dark greenish-gray streaked with brown and purplish-gray shades. They contain much more sand than the upper beds. All the strata are calcareous and contain reworked Cretaceous fossils. Calcareous and ferruginous nodules are common throughout the Fleming, but are more abundant in the upper strata or that portion of the Fleming that is characteristic of the Logarto formation in South Texas (Sellards, Adkins, and Plummer, 1932, p. 728).

PLIOCENE SERIES

WILLIS FORMATION

The Willis formation in District 11 outcrops in San Jacinto and Polk Counties. The Willis as described in this report represent the upper sands of the Citronelle group of the Pliocene Series. These sands have been named for exposure in and around the town of Willis in Montgomery County.

The surface outcrop of the Willis is discontinuous. The sands occur on divides as patches or outliers on the Fleming (Logarto). In some places they take on the aspect of ancient upland terrace sands and gravels. In other places they constitute a wide belt of thickly wooded, sandy, and gravelly ridges. (Sellards, Adkins, and Plummer, 1932, pp. 762-763)

In San Jacinto County, the Willis is generally a red, coarse grained sand, locally indurated and contains varying amounts of gravel. To the east, in Polk County, the Willis becomes sandier with less gravel and the brick-red sands characteristic of the Willis in San Jacinto become brownish-yellow to yellow, with only occasional brick-red exposures.

The Willis is a fluvial deposit and the sediments and their composition depend upon the stream and the drainage area of the stream that deposited the sediments. The iron ore gravels of the Willis formation are reported as forming in its present location by weathering of ferruginous sand

to form limonite nodules. This ferruginous sand is reported to be eroded and washed down from the above and older glauconitic formations of the Claiborne group.

Many road gravel pits are located along the outcrop in Polk and San Jacinto Counties.

PLEISTOCENE SERIES

HOUSTON GROUP

The Houston group is comprised of two formations. In ascending order they are: the Lissie and the Beaumont formations. The formations of the Houston group outcrop in the extreme southern part of the District in Polk and San Jacinto Counties. The Houston group embraces the strata between the top of the Willis formation to the base of the Recent coastal silts and windblown sands.

"The strata of the Houston group consists of fine, gray and reddish-orange sand, yellow and gray clay, and silt. Sand predominates in the lower portion of the section and clays in the upper part. The sediments are unconsolidated, alluvial, deltaic, and brackish-water or lagoonal deposits." (Sellards, Adkins, Plummer, 1932, p. 780)

LISSIE FORMATION

The Lissie formation consists of sands, sandy clays, and clays with subordinate amounts of gravel. The sands are fine to medium and are usually loose and poorly sorted. The color of the sands are red, orange, or mottled red and gray. The sands are ferriginous and contain small amounts of clay balls.

BEAUMONT FORMATION

The Beaumont formation is primarily a multi-colored clay sequence. The formation contains much decomposed wood and other organic matter. None of this organic matter is mineralized or lignitized as is the wood in older formations. Locally the Beaumont contains occasional lenses of

silty sand. Coastward the formation contains oyster beds and an occasional bone or tooth of a vertebrate is found.

The clays of the formation are bluish gray, yellowish gray, black, and less commonly some shades of red. It is, in most places, calcareous in composition. The calcareous content of the clays increase toward the coast. The clays of Polk and San Jacinto Counties show a low content of lime and comparatively high silica content. In most places the clay is highly colloidal, and when wet forms a thick, waxey, very sticky gumbo.

A P P E N D I X

LOCATION OF OUTCROPS IN DISTRICT 11 ARE COPIED AND IN PART MODIFIED FROM: FISHER, W. L., "ROCKS AND MINERAL RESOURCES OF EAST TEXAS", REPORT OF INVESTIGATIONS NO. 54, BUREAU OF ECONOMIC GEOLOGY.

MIDWAY GROUP: Location of outcrops in District 11.

Shelby County:

1. Road cut, 3.6 miles east of Shelbyville, northeast along north side of F.M. 1820. (Hall Summit formation - Clay)

2. Road ditch, southeast of Pauls Store Community, on dirt road 0.3 mile northwest of Wimberly Cemetery, on the southwest side of road. (Hall Summit formation - Sandy clay)

3. Road cut, east of FM 139 and dirt road at Strong, 2.6 Miles along dirt road turn north at "T" intersection, go north 0.1 mile; section exposed on each side of road south of Half Branch (Hall Summit formation - clay)

4. Road cut, 5.3 miles west of Joaquin and junction of State Highway 7 and U.S. 84 along U.S. 84. Section exposed in south side of road and on the east side of road leading to Willow Grove Assembly of God Church (Lime Hill - sand and clay)

5. Road cut on east side of county road, 1.2 miles north of Campti. (Hall Summitt - clay)

6. Road cut on east side of County Road, 7.0 miles north of Campti (Lime Hill - sand)

WILCOX GROUP: Location of outcrops in District 11.

Nacogdoches County:

1. Clay pit of Acme Brick Company, north of Garrison on FM 95, 0.2 Mile north of intersection of FM 1087 and 95; clay pit south of plant (Pendleton formation - clay, sand lignite)

2. Road cut, 4.1 miles southeast of Garrison, from intersection of U. S. Highway 59 and FM 138. Section exposed on east side of FM 138. (Pendleton formation) Clay

3. Road cut, 0.55 mile east of Martinsville, along State Highway 7 from intersection of State 7 and FM 1274. Section exposed on each side of highway. (Wilcox and Carrizo formations - interbedded sand and clay)

Sabine County:

1. Road cut, north of Milam, 3.9 miles along State Highway 87, on west side of road. (Sabinetown formation - clay)

2. Road cut, south of Sexton on State Highway 87, 1.1 miles south of intersection of State Highway 87 and FM 330, on west side of highway. (Sabinetown formation - sand and clay)

3. Road cut, west side of State 87, 0.7 mile north of junction of State 87 and FM 276 at Isla. (Clay)

4. Road cut, 0.2 mile east of Dreka Fire Tower, turn south 1.0 mile on dirt road, turn east along dirt road 1.2 miles to South Bayou Blue. Section exposed south of Bayou on east side of dirt road. (Marthaville formation - sandy clay)

5. Road cut, east of Shelbyville on newly construction road, 0.7 mile south along State 87, turn east along dirt road 2.7 miles and 0.1 mile east of vacant store on north side of road. (Sandy clay)

6. Road cut, 6.1 miles southwest of Shelbyville along FM 417, 0.5 mile north of junction of FM 417 and 2140. Section exposed on east side of road. (Pendleton formation - clay)

7. Road ditch west of Center on FM 138, 0.2 mile west of Arcadia. Section exposed no north side of road. (Pendleton formation - sand and clay)

8. Road cut, on FM 138, 0.4 mile west of junction of U.S. Highway 96 and FM 138. Section exposed on south side of road. (Pendleton formation - sand and clay)

9. Road cut, FM 415, 7.5 miles north of junction of FM 415 and 138, 0.5 mile south of junction of State 87 and FM 415, on east side of road. (Pendleton formation - sandy clay)

10. Road cut, 6.5 miles south of Tenaha on US 96, south of Chicken Creek. Section exposed on east side of highway. (Marthaville formation - clay and sand)

CLAIBORNE GROUP:

CARRIZO FORMATION

Nacogdoches County:

1. Road cut, west of Garrison, 5.9 miles west of intersection of FM 95 and FM 1087 along FM 1087 and 0.4 mile east of road to Camp Tankawa. Section exposed north of road. Sand.

2. Road ditch, west of Garrison, 2.0 miles west of the Camp Tankawa road, along FM 1087. Section exposed on north side of road - sand.

San Augustine County:

1. Road cut, 1.1 miles west of junction of FM 1279 and 147, along FM 1279. Sand.

2. Road cut, southwest side of FM 711, 0.5 mile west of St. Matthew Church. Sand.

3. Road cut, east of San Augustine, from city limits 3.6 miles along State 21 turn north onto dirt road, travel northeast 1.5 miles and turn northwest at "Y" intersection and travel 0.6 mile. Section exposed on each side of road near top of hill. Sand.

4. Road cut, northwest of San Augustine along FM 711, 5.0 miles from junction of FM 711 and U.S. 96. Section exposed on north side of road - sand.

5. Road cut, northwest of San Augustine, along FM 711, 8.2 miles from junction of FM 711 and U.S. 96. Section exposed on each side of highway - sand.

Sabine County:

1. Road cut, north side of State 21, 1.9 miles east of junction of State 21 and FM 242, 0.1 mile west of Carrice Creek - sand.

2. Road ditch, 1.0 mile north of Adar Grove Church, 4.5 miles north of State 21, west side of dirt road - sandy clay.

REKLAW FORMATION

Nacogdoches County:

1. Road Cut, east of Cushing, 5.0 miles along State 204 from intersection of State 204 and FM 225. Section exposed on south side of highway - sandy clay.

2. Road cut, east of Trawick, 1.8 miles along State 204. Section exposed on north side of highway - sandy clay.

3. Road cut, 200 feet southeast of Cherokee-Nacogdoches County Line marker, along FM 343. Section exposed on each side of road -sand.

4. Road cut, south of Sacul, 0.6 mile south of intersection of State 204 and FM 1648, along FM 1648. Section exposed o east side of road - clay.

5. Road ditch, east of Sacul, 2.0 miles along State 204, turn north onto dirt road and travel 1.3 miles, turn east and travel 1.0 mile, turn south and travel 1.3 miles. Section exposed on east side of road, south of power line - clay.

6. Road cut, east of Cushing, 1.0 mile, turn north onto dirt road and continue 1.3 miles. Section exposed on west side of road - clay.

7. Road cut, west of Marthaville, 0.7 mile along State 7. Section exposed on south side of road, west of Terropin Creek - clay.

QUEEN CITY FORMATION:

Houston County:

1. Road cut, 0.3 mile north of intersection of State 21 and FM 227 along FM 227. Section exposed on west side of highway at curve - sand.

Nacogdoches County:

1. Road cut, west of Lilbert along FM 343 and FM 1648. Section exposed on north side of road - sandy clay.

2. Road cut, northwest Lilbert, north of junction of FM 343 and FM 1648, 1.25 miles along FM 1648, 0.25 mile south of Beech Creek Bridge. Section exposed on east side of road - clay.

3. Road cut, north of Lilbert, 3.55 miles north of junction of FM 343 and FM 1648 along FM 1648. Two miles north of Beech Creek Bridge. Section exposed on northeast side of road - clay.

4. Road cut, south of Sacul, 1.15 miles south of junction of State 204 and FM 1648, along FM 1648. Section exposed on west side of road - clay and sand.

5. Road cut, east of Cushing, 1.0 mile along State 204, turn north onto dirt road, continue 4.42 miles to "Y" intersection, turn east and continue 0.75 mile. Section exposed on each side of road - sand.

6. Road cut, east of Nat, 0.5 mile along FM 343. Section exposed on southeast side of road - clay - sand.

7. Road cut, east of Nat, 1.7 miles along FM 343. Section exposed on each side of road - interbedded sand and clay.

8. Road ditch, south of Douglass, 5.7 miles along FM 225 and State 21, east of Legg Creek. Section exposed on each side of road - sand.

9. Road cut, 0.55 mile north of intersection of State 21 and FM 1274 along FM 1274. Section exposed on each side of road - clay.

WECHES FORMATION:

Houston County:

1. Murchison Prairie, 2.0 miles east of Percilla (No. 29, Schoch, 1918, pp 20 - 170). Glauconite.

2. L. Williams headright, south of State 21 on Neches River, (No. 48, Schoch, 1918, pp 20 - 170). Glauconite.

3. D. McLeon headright, 3.0 miles east of Augusta (No. 50, Schoch, 1918, pp 20 - 170). Glauconite.

Nacogdoches County:

1. Road cut, 1.8 miles south of intersection of State 26 and 204. Section exposed on west side of road - clay.

2. One mile southwest of Chireno (No. 66, Schoch, 1918, pp 21 - 170). Glauconite.

3. Fifteen miles southeast of Nacogdoches (No. 65, Schoch, 1918, pp 21 - 170). Glauconite.

4. Eight miles northwest of Nacogdoches (Nos. 63 & 64, schoch, 1918, pp 21 - 170). Glauconite.

5. Simpson Hill, 4.0 miles northwest of Melrose (Nos. 59 & 60, Schoch, 1918, pp 21 - 170). Glauconite.

6. Southeast of Nacogdoches, 0.2 mile (Nos. 57 & 58, Schoch, 1918, pp 20, 21-170). Glauconite.

7. One Mile southwest of Chireno (No. 67, Schoch, 1918, pp 21-170). Glauconite.

Sabine County:

1. Road cut, 1.0 miles west of junction of State 21 and FM 242 0.2 mile west of King Cemetery on south side of road - sand.

2. Road cut, north of Milam, 1.6 miles on State 87 on west side of road - clay.

San Augustine County:

1. Road cut, west of San Augustine, along State 21, 8.4 miles from intersection of State 21 and US 96. Glauconitic sand.

2. Road cut, 1.3 miles west of intersection of US 96 and State 21, along State 21. Glauconitic sandy clay.

3. Road cut, south of San Augustine, along FM 2213, 2.3 miles from intersection of FM 2213 and State 21. Glauconitic sand.

4. Road cut, west side of FM 1196, 5.0 miles north of junction of FM 1277 and 1196, 0.2 mile north of cemetery southwest of San Augustine's Mt. Selma - Weches? - sand and clayey sand.

SPARTA FORMATION:

Sabine County:

1. Road cut, 1.1 miles north of intersection of FM 1592 and State 184, Section exposed west side of FM 1592 - sand.

San Augustine County:

1. Road cut, northwest of junction of State 147 and 103, travel west of State 103 for 5.0 miles, turn right onto FM 1277, continue northward 1.6 miles. Sand - clay.

2. Road cut, 3.4 miles north of San Augustine, along FM 1196 - sand.

3. Road cut, west side of FM 147, 4.5 miles south of junction of FM 147 and U.S. 96, south of San Augustine - sand.

Houston County:

1. Road cut, west side of FM 2022, 0.4 mile south of junction of FM 2423 and FM 2022 at San Pedro, northeast of Crockett. Sand.

2. Road cut, west side of State 19, 3.3 miles outh of junction of FM 2423 and State 19 in Grapeland - sand.

3. Road cut, side of county road and FM 227, west of Grapeland, 4.3 miles air-line distance southwest of junction of FM 227 and State 10 in Grapeland - sand.

4. Road cut, northeast side of county road, 5.0 miles northwest of end of FM 229, northwest of Crockett - sand.

5. Road cut, south side of FM 227, 1.0 mile southeast of junction of FM 227 and State 21, northwest of Crockett - sand.

6. Road cut, east of intersection of FM 228 and State 19, 1.4 miles turn north into dirt road, continue 2.7 miles. Section exposed on east side of road. Sand.

Nacogdoches County:

1. Road cut, west of Nacogdoches, 6.05 miles along State 7, from junction of State 7 and State 21, Section exposed on each side of highway - sand clay.

2. Road cut, west of Nacogdoches, 7.75 miles along State 7 from junction of State 7 and State 21, turn south onto dirt road, continue 2.9 miles. Section exposed on south side of road, east of Angelina National Forest - clayey-sand.

3. Road cut, south of Nacogdoches, 5.6 miles along US 59, turn east onto dirt road, continue northward 1.6 miles to "T" intersection, turn east and continue 1.25 miles to "T" intersection, turn north and continue 0.25 mile. Section exposed on each side of road - sand.

4. Road cut, southeast of Nacogdoches, 3.7 miles along FM 2259 from junction of FM 2259 and FM 1275. Section exposed on west side of road. Interbedded sand and clay.

5. Road cut, north of junction of State 103 and FM 1274, 5.25 miles along FM 1274. Section exposed on west side of road. Sand and clay.

6. Road cut, east of Melrose, 4.15 miles along State 21. Section exposed on north side of road. Sand.

7. Road cut, southeast of Melrose, 1.05 miles along State 21, turn southeast onto dirt road, continue 4.45 miles. Section exposed south of wooden bridge on east side of road at top of hill- sand.

COOK MOUNTAIN FORMATION:

Angelina County:

1. Road cut, 2.1 miles north of intersection of U.S. 69 and along FM 843, Section exposed on north side of road - clayey sand.

2. Road cut, 2.9 miles northeast of intersection of State 7 and State 103 along State 7, on north side of road - clayey sand.

3. Road cut, 1.0 mile east of intersection of State 7 and State 103 along State 103, on south side of road - sand.

4. Road cut, south side of State 103, 2.3 miles northwest of junction of State 103 and FM 2021 northwest of Lufkin - sand.

5. Road cut, west side US 59, 1.0 mile south of center of bridge crossing Angelina River, north of Lufkin - clay.

6. Road ditch, northeast of Huntington, 6.4 miles along FM 1669 to State 103, turn east on State 103 and continue 0.6 mile, turn north onto unsurfaced road, continue northward 0.2 mile, turn west and continue 0.3 mile, turn north and continue northward 1.0 mile, turn west and continue along unsurfaced road 2.0 miles. Section exposed on each side of road - clay.

7. Road cut, 1.1 miles north of intersection of State 103 and FM 2021, along FM 2021. Section exposed on south side of road in cut - clay.

Houston County:

1. Road cut, north side of State 7, 1.5 miles west of Kennard, 2.1 miles east of junction of FM 1733 and State 7 - sand.

2. Road cut, west side of FM 1733, 3.5 miles south of cross-roads in Cedar Point - clay.

3. Road cut, north side of FM 2180, 1.4 miles east of junction of FM 1280 and State 21 - sand.

4. Creek bed, 5.1 miles southeast of intersection of State 21 and FM 1733, along FM 1733. Section exposed on southwest side of road in Hickory Creek. Clay.

5. Creek bed & road ditch, south of intersection of State 21 and FM 1733, 6.6 miles along FM 1733, turn west onto dirt road and continue westward 1.2 miles - clay.

6. Road ditch, east of Crockett along State 7 to Berea, turn south onto dirt road and continue southward 2.9 miles to "T" intersection, turn west and continue 4.35 miles. Section exposed on each side of road - clay.

7. Road cut, northwest of Crockett, 4.8 miles from end of pavement on FM 2076, 0.7 mile west of Union Chapel. Section exposed on north side of road, clay.

8. Road cut, 1.6 miles east of end of pavement of FM 2076. Section exposed on each side of road - sand and clay.

9. Road cut, 1.5 miles north of intersection of FM 2022 and Loop 304 along FM 2022. Section exposed on east side of road - clay.

10. Alabama Ferry, east bank of Trinity River about 0.2 mile downstream from abandoned Alabama Ferry, 7.5 miles west. Southwest of Porter Springs - glauconite and clay.

11. Stream bank, Hurricane Bayou, north of Crockett (A. No. 52, B No. 47, Schoch, 1918, pp 20, 170) - Glauconite.

Nacogdoches County:

1. Road cut and ditch, southeast of Nacogdoches, 7.9 miles south of junction of FM 226 and FM 2259 along FM 226. Clay.

2. Road cut, southeast of Nacogdoches, south of junction of FM 226 and FM 2259, 9.1 miles along FM 226. Section exposed on west side of road, south of Bayou Lavaca - clay.

3. Road cut, east of Etoile, along State 103, at junction of State 103 and FM 1274. Section exposed on south, northwest, and northeast side of junction - clay.

4. Road cut and ditch, north of junction of FM 1274 and State 103, 1.1 miles along FM 1274. Section exposed on east side of road - clay.

5. Road cut, 2.4 miles north of junction of FM 1274 and State 103, along FM 1274. Section exposed on each side of road - clay.

Sabine County:

1. Road cut, north of Hemphill, north of intersection of State 184 and FM 1592, 0.6 mile on west side of road - sandy clay.

San Augustine County:

1. Road cut, 1.6 miles west of junction of US 96 and State 103, on State 103 - sandy clay.

2. Road cut, 0.6 mile south of junction of FM 705 and State 103 on FM 705. Sand.

3. South of San Augustine, along FM 705, 2.7 miles from intersection of FM 705 and State 103 - clay.

4. Road cut, northwest corner of State 147, at junction of State 147 and 103 south of San Augustine - clay.

5. Road cut, north side of State 103, 0.5 mile east of junction of State 103 and FM 1751 - Clay.

YEGUA FORMATION:

Angelina County:

1. Road cut, 2.0 miles east of Lufkin on FM 2109. Exposed laterally 175 feet along road - clay.

2. Clay Pit (active), Bennett Clark Company, east of Lufkin, 3.0 miles east of intersection FM 325 and FM 841. North side of unsurfaced road, 1.0 mile beyond end of pavement - clay.

3. Road cut, 4.4 miles northeast of Lufkin city limits along State 103 on south side of highway - sand.

4. Road cut, 1.1 miles south of State 94 and 0.6 mile east of Neches River, at Gilbert Community - sand.

5. Railroad cut, Texas Southeastern Railroad, 2.5 miles south of New Hope Community and 0.7 miles southeast of Granville Community on Texas Southeastern Railroad - clay.

6. Road cut, 3.4 miles west of Lufkin on State 103, 1.8 miles west of Alco Baptist Church sign, exposed on south side of road - clay.

7. Road ditch, north side of FM 10 southeast of small bridge, 0.7 mile northwest of Burke - sandy clay.

8. Road cut, south side of FM 2021, 0.9 mile south of Clawson and junction of FM 2021 and US 69, northwest of Lufkin - sand.

9. Road cut, northwest side of FM 842, 1.2 miles north of junction of FM 842 and State 103, east of Lufkin - clay.

10. Road cut, south side of FM 2109, 2.0 miles east of junction of FM 2109 and FM 328, east of Huntington - sand.

11. Road cut, east side of FM 1669, 2.0 miles south of junction of FM 1669 and State 103, east of Lufkin - sand.

Houston County:

1. Road ditch, northeast side of county road, across from church, 3.5 miles southeast of State 21 in Mapleton - sandy clay.

2. Road cut, south side of County road, 4.0 miles southeast of State 21 in Mapleton - sandy clay.

3. Road ditch, west side of county road, 4.7 miles southeast of Austonio - clay.

4. Road cut, northwest corner of junction of FM 1309 and FM 1280 near Smith Grove Church - sand.

5. Drainage ditch, west side of FM 233, 0.3 miles south of Hager Creek. south of Kennard - sand.

6. Road cut, west side of FM 232, approximately 3.0 miles south of junction of FM 232 and State 7, east of Crockett - sand.

7. Road ditch, north side of FM 1280, 4.8 miles east of junction of FM 1280 and State 21 in Austonio - sand and clay.

8. Road ditch, 0.1 mile west of Kennard along State 7, turn south onto dirt road and continue 1.3 miles to "Y" intersection , turn south and continue southward 1.7 miles. Section exposed on southwest side of road - sandy clay.

9. Road ditch, south of Weldon 1.4 miles along Weldon Fire Lookout Tower road. Section exposed on each side of road- sand and clay.

Sabine County:

1. Road cut, north of Bronson on east side of highway, 2.6 miles north of intersection of FM 1 and State 184 - clayey sand.

2. Road cut, north side of FM 944, 6.2 miles southeast of junction of FM 944 and State 87 in Hemphill - clay.

3. Erosion ditch, 50 feet south of FM 2426, 3.0 miles east of junction of FM 2426 and FM 1 in Pineland - clay.

San Augustine County:

1. Road cut, southwest along State 147, 4.7 miles fron junction of State 147 and State 103 - sand clay.

2. Road cut, west side of FM 705, 9.7 miles south of junction of FM 705 and State 103 near Macune - sand.

3. Road cut, east side of FM 705, 5.2 miles south of junction of FM 705 and State 103 - clay.

Trinity County:

1. Road cut, west side of county road, 1.4 miles north of Apple Springs - clay.

2. Road cut, east side of county road, 4.9 miles north of Apple Springs - clay.

3. Road ditch, east side of county road, 1.6 miles north of junction of county road and FM 358 - sandy clay.

4. Road cut, north of Apple Springs, 1.2 miles along dirt road from intersection of State 94 and FM 357. Section exposed on both sides of road - clay.

JACKSON GROUP:

Angelina County:

1. Clay pit (active), Magnet Cove Varium Corporation, 1.6 miles southwest of US 69 at Kitchens Cemetery, 1.7 miles south of Dolen Siding - clay.

2. Clay pit (active), Pennett-Clark Company, 1.2 miles west of US 69 and 0.2 mile north of county line - clay.

3. Test pit, Bakers Acres, on Farm land, 6.8 miles south of junction of State 63 and US 69 in Zavalla on US 69. Farm on right side of road with large sign at gate; drive through yard and double gate, down lane between fences through gate into large field, continue generally west to farm pond. Exposure in gully below dam - clay.

4. Quarry (abandoned) south of Bakers Acres. Due south of house at Bakers Acres across fence and small creek - sandy clay.

5. Pit, 0.2 mile east of US 69, west side of Texas and New Orleans Railroad, just north of Jasper-Angelina County Line - silty clay.

6. Road cut, 2.8 miles east of Diboll, on south side of FM 58 - clay.

7. Road cut, 7.5 miles southeast of Zavalla along State 63 on northeast side of road - sand.

8. Stream bank, 5.8 miles northwest of Jasper-Angelina County Line, along State 63, turn south onto unsurfaced road and continue southward 1.1 miles to cross roads, turn west and continue westward 0.7 mile to Wilkes Branch. Section exposed in west bank of creek - sand and clay.

9. Road cut, 2.4 miles northwest of Jasper - Angelina County Line along State 63. Section exposed on eachside of road - clay and sand.

10. Road cut and ditch, northwest of Angelina-Jasper County Line, 0.5 mile along State 63, turn east onto unsurfaced road. Continue eastward along road to "T" intersection, turn north and continue 1.5 miles. Section exposed on west side of road - clay.

11. Road cut, 5.6 mile southwest of intersection of State 63 and FM 1270, 0.3 mile east of end of pavement of FM 1270. Section exposed on north side of road - sand.

12. Stream bank, 0.2 mile west of end of pavement of FM 1270. Section exposed in banks of Burris Creek -sand and clay.

13. Road ditch, west of end of pavement of FM 844, 1.3 miles to "y" intersection, turn northwest and continue 1.3 miles to "y" intersection, turn south and continue 2.0 miles to "T" intersection. Section exposed 60 yards east of "T" intersection on north side of road - clay.

14. Clay pit (abandoned), Magnet Cove Barium Corporation, 1.0 mile southwest of US 69 at Kitchens Cemetery - clay.

Polk County:

1. Creek bed and bank, north of intersection of US 287 and FM 352, 2.9 miles along FM 352, turn east onto dirt road and travel 0.3 mile to "T" intersection, turn north and continue 2.3 miles to "T" intersection, turn east and continue along main-traveled dirt road 2.2 miles, turn west onto logging road and continue 0.5 miles, turn south onto dirt road and continue 0.05 mile to clearing, continue southward 150 feet to creek. Volcanic ash.

2. Road cut, and hillside, north of Corrigan, 7.7 miles along US 59 from intersection of US 59 and 287 - clay.

3. Stream bank, north of intersection of US 287 and FM 352, travel 2.9 miles along FM 352, turn east on dirt road and continue 0.3 mile to "T" intersection, turn north and continue 0.9 mile, turn east at "Y" intersection and continue along dirt road 0.7 mile, turn north on logging road, follow 0.5 mile to old camp site. Section exposed 150 feet east of camp site - volcanic ash.

4. Road cut, 3.6 miles east of north intersection of FM 1987 and US 59, along FM 1987, section exposed on both sides of road - volcanic ash.

Sabine County:

1. Road cut, 1.5 miles east of Pineland city limits on FM 2426 - sandy clay.

2. Road cut, south from Yellowpine on FM 2343, 2.7 miles to pavement end. 3.4 miles south of pavement end, and 0.6 mile north of Newton-Sabine County Line. - sand.

3. Road cut, FM 83, 1.0 mile east of junction of FM 83 and FM 1386 - silty clay.

4. Road cut, north of Magasco, on west side of FM 1, 0.3 mile north of intersection of FM 1 and Spur 1 - sand.

5. Road ditch, south of Pineland, 2.8 miles south of junction of US 96 and FM 1, along US 96, turn left onto dirt road 0.7 mile - sandy clay.

6. Road ditch, northeast side of State 87, 0.5 mile south of junction of State 87 and FM 2343 south of Yellowpine. Clay.

7. Road cut, north side of State 87, 1.5 miles south of junction of State 87 and FM 2343 in Yellowpine - sand.

8. Road ditch, west side of FM 1, 0.8 mile south of junction of FM 1 and FM 184 in Bronson - clay.

San Augustine County:

1. Road cut, 11.8 miles south of junction of FM 705 and State 103, on FM 705 - glauconitic sand.

2. Road cut, 1.0 mile east of Jackson on FM 705 - sand.

3. Road cut, northeast of FM 705, 7.5 miles north-northwest of junction of FM 705 and US 96 in Brookland - sandy clay.

4. Road cut, east side of FM 705, 9.7 miles south of junction of FM 705 and State 103 near Macune - sand.

5. Road ditch, south side of county road, 7.6 miles air-line distance southeast of junction of FM 2558 and State 147 in Broaddus - clay.

Trinity County:

1. Road cut on FM 230, 2.8 miles west of Trinity - sand & clay.

2. Road cut on FM 356, 13.4 miles southeast of Trinity - sand.

3. Road cut along FM 230, 1.2 miles west of junction of State 19 and FM 230 in Trinity - sand.

4. Road cut along FM 230, 2.2 miles west of junction of State 19 and FM 230 in Trinity - sand.

5. Road cut along State 19, 2.7 miles northwest of junction of State 19 and FM 230 in Trinity - sand.

6. Road cut along State 19, 1.3 miles southwest of Houston - Trinity County Line - sand.

7. Road cut along State 94, 1.4 miles northeast of Trinity City Limits - sand.

8. Road cut along State 94, 0.5 mile south of Glendale - sand.

9. Road cut along State 94, 2.9 miles northwest of junction of FM 355 and State 94 in Groveton - sand.

10. Road Cut along FM 355, 1.4 miles southwest of junction of FM 355 and State 94 in Groveton - sand.

11. Road cut along FM 355, 6.2 miles east of junction of FM 356 and FM 355, 7.0 miles southwest of Groveton - sand.

12. Road cut along FM 355, 5.5 miles southeast of Trinity City Limits - sand.

13. Road cut along FM 355, 7.2 miles southeast of Trinity City Limits - sand.

14. Road cut along FM 1280, 1.5 miles north of junction of US 287 and FM 1280, north of Groveton - sand.

15. Road cut along FM 1280, 1.8 miles south of Houston-Trinity County Line - sand.

16. Road cut along FM 358, 0.8 mile west of crossroads in Pennington - sand.

17. Road cut along FM 358, 3.6 miles north of Centerville Cummunity - sand.

18. Road cut along FM 358, 2.6 miles north of Centerville Cummunity - sand

19. Road cut along FM 357, 1.2 miles northwest of junction of FM 357 and State 94 in Apple Springs - sand.

20. Road cut along FM 357, 2.3 miles northwest of junction of FM 357 and State 94 in Apple Springs - sand.

21. Road cut along FM 357, 1.7 miles west of Centratia - sand.

22. Road cut along FM 2501, 1.6 miles east of Apple Springs - clay.

23. Road cut along FM 357, 3.8 miles south of Apple Springs - sand.

24. Road cut along FM 2262, 8.2 miles northeast of Groveton City Limits - sand.

25. Road cut along US 287, 0.2 mile north of Polk-Trinity County Line - sand.

26. Road ditch, north of Glendale, 1.2 miles, turn west onto dirt road at Glendale, continue 0.5 miles to "Y" intersection, turn north and continue 0.5 miles. Section exposed on each side of road - sand.

27. Road cut and ditch, north of Glendale, turn west onto dirt road at Glendale, continue 0.5 mile to "Y" intersection, turn north and continue 1.25 miles. Section exposed on each side of road - clay and volcanic ash.

28. Creek bank, 3.85 miles from Houston-Trinity County Line along FM 1280, turn south onto dirt road and continue 1.7 miles. Section exposed on north side of road in creek bank - clay.

29. Road ditch, 3.0 miles northeast of Glendale along State 94, turn north onto dirt road and continue 1.1 miles. Section exposed on each side of road - volcanic ash.

30. Road cut, 5.35 miles southeast of Houston-Trinity County Line along FM 1280, turn north onto dirt road and continue 1.0 mile. Section exposed on each side of road - clay.

31. Road cut, north of Groveton, 2.1 miles north of intersection of State 94 and US 287, along State 94. Section exposed on east side of road - clay.

32. Creek bank, 2.6 miles west of junction of State 94 and U S 287, along State 94, turn southeast onto dirt road and continue 0.9 mile. Section exposed on northeast side - clay and volcanic ash.

33. Road cut, southeast of Trinity, 2.2 miles along FM 356 from intersection of FM 356 and State 94. Section exposed on each side of road - clay.

34. Active clay pit of Olson Chemical Company, southeast of intersection of State 94 and FM 356, 0.6 mile along FM 356 turn south onto private road and continue 0.55 mile to plant; pit about 50 feet northeast of plant - clay.

35. Pit, 3.8 miles northwest of Trinity along State 19, turn west on FM 1893, travel 0.8 mile to end of pavement (Trinity-Walker County Line) continue 0.9 mile to dirt road on east side of road leading to an abandoned farmhouse, deposite east of farmhouse - volcanic ash.

CATAHOULA FORMATION:

Polk County:

1. Road cut and ditch, both sides of FM 352, 1.4 miles east of Corrigan - clay.

2. Sand pit, south side of FM 352, 4.6 miles east of Corrigan - sand.

3. Stripped slope, north side of US 287, 3.1 miles southeast of center of Corrigan - clay.

4. Stream bank, 2.5 miles southwest of Carmona along Bull Creek - sand.

5. Road cut, on FM 350 west of Livingston, 9.7 miles north of junction of FM 350 and US 190 - sand.

6. Road cut, on FM 350, 1.3 miles west of junction of FM 350 and US 59 - clay.

7. Road cut, on US 287, 4.9 miles southeast of Junction of US 59 and 287 - sandy clay.

8. Road cut, on FM 1987, 1.8 miles east of junction of FM 1987, and US 59 - sand.

9. Road ditch, southeast of Trinity-Polk County Line, 4.05 miles along FM 356. Section exposed on east side of road near top of hill - volcanic ash.

10. Road ditch, northeast of Onalaska, 0.3 mile north along FM 356, turn north onto dirt road, continue 2.4 miles to "T" intersection turn north and continue 1.1 miles to "Y" intersection, turn northwest and continue 0.2 mile. Section exposed on west side of road - volcanic ash.

11. Road ditch, west of Corrigan, 5.5 miles along US 287 from intersection of US 287 and US 59. Section exposed on north side of road - volcanic ash.

12. Road cut, northwest of Camden, 1.8 miles along FM 942 from eastern-most junction of FM 942 and FM 62. Section exposed on west side of road - volcanic ash.

13. Road cut and ditch, east of Corrigan, 7.4 miles along US 287 from intersection of US 287 and US 59. Section exposed on each side of road - clay.

Sabine County:

1. Road cut, 0.6 mile north of Jasper-Newton County Line. Soil conservation District sign on State 87 - silty sand.

2. Road cut, south side of State 87, directly across from Fairmont Cemetery, 1.0 mile south of Big Sandy Creek - clay.

3. Road cut, east side of FM 944, 0.4 mile north of Fairdale - sand.

Trinity County:

1. Vicinity of Chita, along FM 355, 3.3 miles east of junction of FM 355 and FM 356 - sand.

2. Road cut, on FM 356, 13.4 miles southwest of Trinity City Limits at Carlisle Community - sand.

3. Road cut, along FM 355, 3.1 miles east of junction of FM 356 and FM 355, 10.8 miles southwest of Groveton - sand.

FLEMING GROUP:

Polk County:

1. Road cut, south side of US 59, 1.2 miles southwest of Center of Livingston - sand and clay.

2. Road cut, south side of US 190, 6.1 miles west of Livingston - sand.

3. Road cut on US 190, 2.2 miles east of Livingston on south side of road adjacent to pipeline crossing. Section exposed on both sides of road - sand.

4. Road cut, 8.5 miles east of Livingston on US 190, south side or road - clay.

5. Road cut, 17.9 miles east of Livingston on US 190, 7.8 miles east of New Camp Ruby - clay.

6. Road cut, east side of US 190, 2.2 miles south of Livingston City Limits - clay.

7. Road cut, on FM 2500, 1.2 miles north of junction of US 190 and FM 2500 - sand.

8. Road cut on FM 2500, 6.0 miles north of junction of US 190 and FM 2500 - sand.

9. Road cut on FM 942, 2.4 miles west of junction of FM 942 and FM 2500 - clay.

10. Road cut on FM 350, west of Livingston, 1.1 miles north of junction of FM 350 and US 190 - sand.

11. Road cut, on FM 350 west of Livingston, 7.4 miles north of junction of FM 350 and US 190 - sand.

12. Road cut, on FM 62, 3.3 miles east of junction of US 59 and FM 62 - sand.

13. Road cut, on dirt road, 1.2 miles north of junction of FM 62 and FM 942 in Camden - clay.

14 Road cut on FM 1745, 2.9 miles northwest of junction of FM 942 and FM 1745 - sand.

15. Road cut, southeast of Trinity - Polk County Line, 1.2 miles along FM 356 - section exposed on each side of road - clay.

16. Gully, 2.4 miles northeast of intersection of FM 942 and FM 2500 along FM 942, turn west onto dirt road, continue 1.65 miles. Section exposed on each side of road west of Lime Branch - clay.

17. Road cut and ditch, west of intersection of FM 350 and US 59, 7.07 miles along FM 350. Section exposed on north side of road, 600 feet east of bridge over Meadow Creek - clay.

18. Road ditch, northeast of junction of FM 942 and FM 2500, 0.6 miles along FM 942. Section exposed on northwest side of road - clay.

19. Road cut and ditch, northeast of junction of FM 942 and FM 2500, 3.95 miles along FM 942. Section exposed on each side of road - clay.

20. Road cut, northwest of Camden, 1.8 miles along FM 942 from eastermost junction of FM 942 and FM 62 - section exposed on west side of road.

21. Creek bed, west of Livingston, 1.75 miles along US 190 from intersection of US 190 and US 59. Section exposed in Long King Creek - sand.

22. Hillside, 5.1 miles southwest of intersection of US 190 and FM 350, 0.15 mile west of end of pavement of FM 350. Section exposed on south side of road - clay.

23. Road cut, 1.05 miles west of end of pavement of FM 350 to "T" intersection, turn north and continue 1.75 miles. Section exposed on west side of road, north of wooden bridge - clay.

24. Road cut, southwest of Livingston, 1.8 miles along US 59 from intersection of US 59 and US 190. Section exposed on each side of highway - clay.

San Jacinto County:

1. Road cut, 0.4 mile east of junction of US 190 and FM 946 on southside of US 190 - sand.

2. Road cut, north side of US 190, 1.5 miles west of Junction of US 190 and State 156 at Pointblank, east of Blue Goose Store - clay.

3. Road cut, on FM 156, 2.9 miles south of junction of US 190 and FM 156 at Point Blank - sand.

4. Road cut on State 224, 4.4 miles northwest of junction of FM 156 and FM 224 in Coldsprings - sand.

5. Road cut, on FM 1725, 7.1 miles southeast of junction of FM 1725 and State 150 - sand.

6. Road cut on State 150, 0.7 mile 23st of junction of State 150 and FM 945 west of Evergreen - sand.

7. Pit, 300 feet west of FM 2025, 2.1 miles south of junction of FM 2025 and State 150 - sand.

8. Road cut on FM 946, 2.3 miles north of junction of State 156 and FM 946 - sand.

9. Road cut on FM 946, 8.2 miles north of junction of State 156 and FM 946 - sand.

CITRONELLE GROUP:

WILLIS FORMATION:

Polk County:

1. Road cut on FM 1276, 3.3 miles north of junction of FM 1276 and FM 943 - sand.

2. Road cut, on FM 1276, 7.8 miles south of junction of US 190 and FM 1276 - sand.

San Jacinto County:

1. Gravel pit, 0.1 mile east of State 150, 0.9 mile southeast of junction of FM 1514 and State 150 in Coldspring - gravel.

2. Gravel pit, 0.3 mile west of State 150, turn off State 150, 3.9 miles south of junction of State 150 and FM 222 - sand.

3. Road cut on FM 1725, 2.5 miles northwest of San Jacinto-Liberty County Line - sand.

4. Pit, road to pit turn off FM 1725, 11.6 miles southeast of junction of FM 1725 and State 150, east of New Waverly. Pit 1.9 miles from west of FM 1725 on dirt road, through iron gate at end of county road and left to pit, Iron Ore gravel.

HOUSTON GROUP:

LISSIE FORMATION:

Polk County:

1. Road cut, on FM 1988, 1.3 miles south of US 59 and FM 1988 at Goodrich - clay.

2. Road cut, State 146, 3.0 miles southeast of junction of State 146 and FM 1988 - clay and sand.

GLOSSARY OF GEOLOGIC TERMS

ALLUVIUM - Channel and floodplain deposits of streams and rivers

CONCRETION - An inclusion of inorganic material of different composition than the surrounding sediments

CONTINENTAL - Pertaining to the land masses.

CUESTA - An abrupt slope change formed on the up-dip side of resistent rock layers

DIATOMACEOUS EARTH - a light, friable material formed from remains of certain organisms

EMERGENCE - Withdrawal of the sea from the land masses

EN ECHELON - A sub-parallel arrangement

ESCARPMENT - A bluff or slope formed by resistent material or faulting

FERRUGINOUS - Iron-bearing

FLUVIATILE - Relating to stream action

GLAUCONITE - An iron rich mineral that weathers to iron ore

GYPSIFEROUS - Containing or relating to gypsum

HETEROGENEOUS - Not uniform in composition

INDURATED - Solidified or cemented into rock

LENTIL - A local lenticular mass of rock

LIGNITE - A soft black organic rock

LITHOLOGY - The study of rocks based on visual differences of samples and their composition

LITTORAL - Relating to the area between maximum and minimum tides

MARL - An impure chalk with varying amounts of clay

MINERALIZED - Replacement by some mineral form different than the original material

PALUSTRINE - Relating to marshy conditions

QUARTZITIC - A strongly cemented sandstone

REGRESSION - A retreat of the sea from the land masses

SELENITE - A calcium sulfate mineral

SIDERITE - An iron carbonate mineral

STRAND LINE - A line showing the position of the sea with respect to land areas in the geologic column

TERRESTRIAL - Relating to the land masses

TRANSGRESSION - An advance of sea level upon the land masses

TUFF - Stratified rock composed of sand-size particles of volcanic material

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28. "Geology of Sabine and San Augustine Counties, Texas", Road Design Division, Texas Highway Department, September 1951.

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