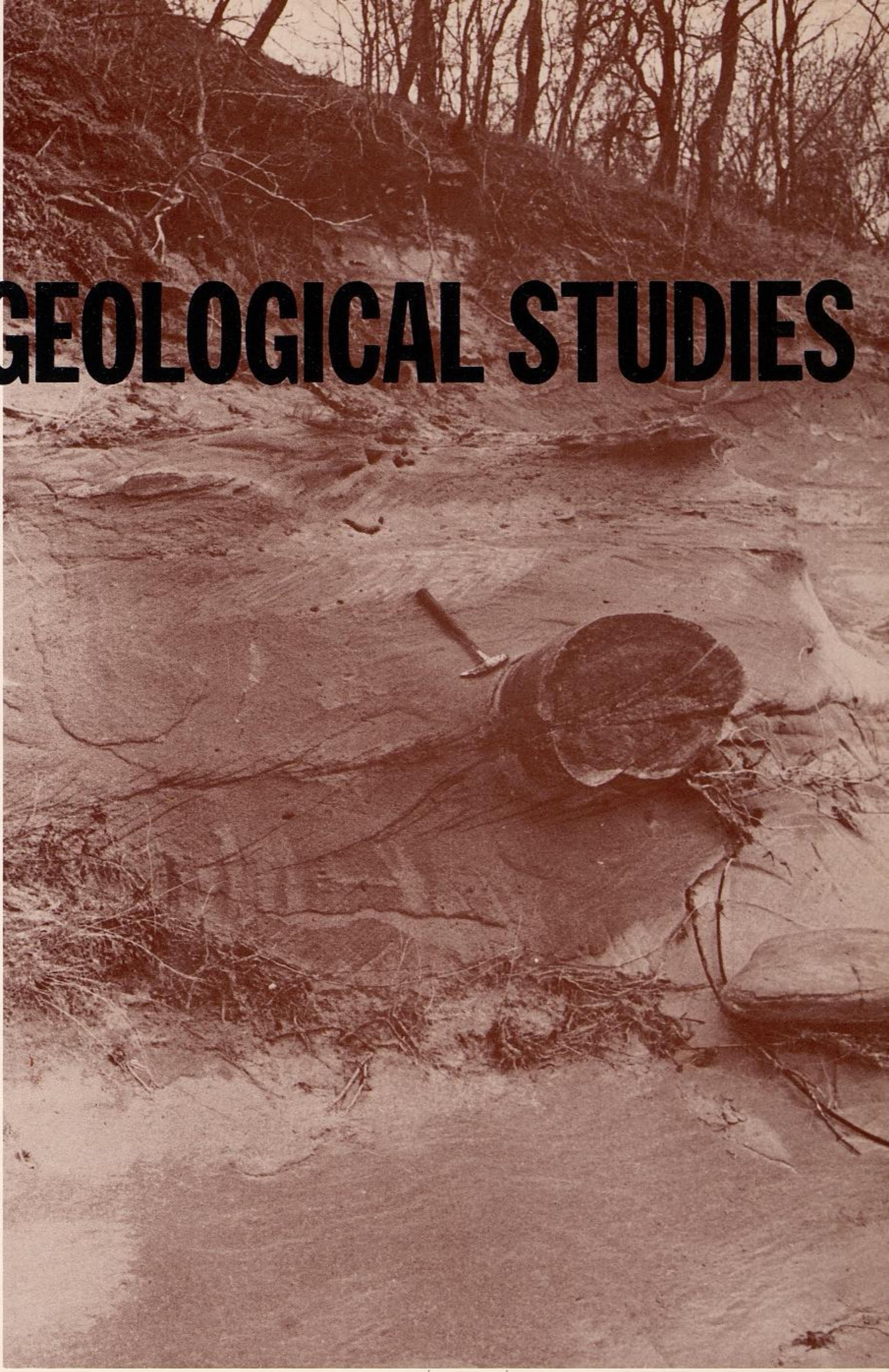
BAYLOR GEOLOGICAL STUDIES



FALL 1979

Bulletin No. 37

Stratigraphy of the Simsboro Formation, East-Central Texas

BOBBY H. BAMMEL

"Creative thinking is more important than elaborate equipment--"

FRANK CARNEY, PH.D.
PROFESSOR OF GEOLOGY
BAYLOR UNIVERSITY
1929-1934

Objectives of Geological Training at Baylor

The training of a geologist in a university covers but a few years; his education continues throughout his active life. The purposes of training geologists at Baylor University are to provide a sound basis of understanding and to foster a truly geological point of view, both of which are essential for continued professional growth. The staff considers geology to be unique among sciences since it is primarily a field science. All geologic research including that done in laboratories must be firmly supported by field observations. The student is encouraged to develop an inquiring objective attitude and to examine critically all geological concepts and principles. The development of a mature and professional attitude toward geology and geological research is a principal concern of the department.

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BAYLOR UNIVERSITY
Department of Geology
Waco, Texas
Fall, 1979

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Stratigraphy of the Simsboro Formation, East-Central Texas

Bobby H. Bammel

ABSTRACT

The Simsboro Formation (Eocene) is the middle formation of the Wilcox Group in east-central Texas. It is underlain by the Hooper Formation and overlain by the Calvert Bluff Formation throughout the study area. The upper Simsboro-Calvert Bluff contact is generally conformable, and the lower Hooper-Simsboro contact is disconformable.

The Simsboro outcrop belt extends from northern Freestone County southwestward to central Bastrop County. The Simsboro Formation is believed to be part of the Mt. Pleasant Fluvial System, the main feeder for the Rockdale Delta System.

The Mt. Pleasant Fluvial System has been divided into three sections: (1) the tributary channel section, (2) the slightly meandering section, and (3) the highly meandering section. The Simsboro Formation was apparently deposited in the highly meandering channel section, which can be further divided into five subenvironments: (1) point bar, (2) scour pool and fill, (3) chute channel, (4) overbank, and (5) abandoned channel.

Five lithologic facies are recognized within the Simsboro Formation: (1) the point bar facies consisting of massive cross-bedded kaolinitic sand, (2) the chute bar facies consisting of massive lenticular sand bodies, (3) the overbank facies consisting of interbedded thin layers of finely laminated sand and clay, (4) the chute channel lag facies consisting of sand and mudstone conglomerate, and (5) the abandoned channel facies consisting of homogeneous sandy and/or silty clay.

Kaolinitic clay and quartz sand make up the bulk of the Simsboro deposits. The kaolinitic clay was apparently formed by the acid leaching of: (1) the Cretaceous shales of central and north-central Texas and (2) igneous alkaline rocks possibly from the ancestral Rocky Mountains of New Mexico and Colorado. Most of the quartz sand apparently weathered from the ancestral Rocky Mountains.

Evidence suggests that a hot, humid, tropical climate existed during deposition of the Simsboro Sand. The area was well drained with slightly acidic waters and highly oxygenated conditions. Kaolinite and quartz occur together as a natural product of tne intense weather environment which existed at the time of deposition.

INTRODUCTION*

PURPOSE

One of the most distinctive lithologic units within the Tertiary of east-central Texas is the massive, extensively cross-bedded, kaolinitic sand known as the Simsboro Formation. It is characterized by a mixture of pure quartz sand and pure kaolin clay and displays typical fluvial sedimentary structures.

The regional depositional environment of the Wilcox Group of Texas has been extensively studied (Fisher and McGowen, 1967; McGowen and Garner, 1970). Although there have also been numerous localized petrologic studies (Adams, 1957; Kohls, 1967) and speculations as to its provenance (Todd and Folk, 1957; Callender and Folk, 1958), there have been no detailed stratigraphic works dealing with the Simsboro throughout its entire outcrop area in east-central Texas.

The present study was undertaken in order to broaden

*A thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1977.

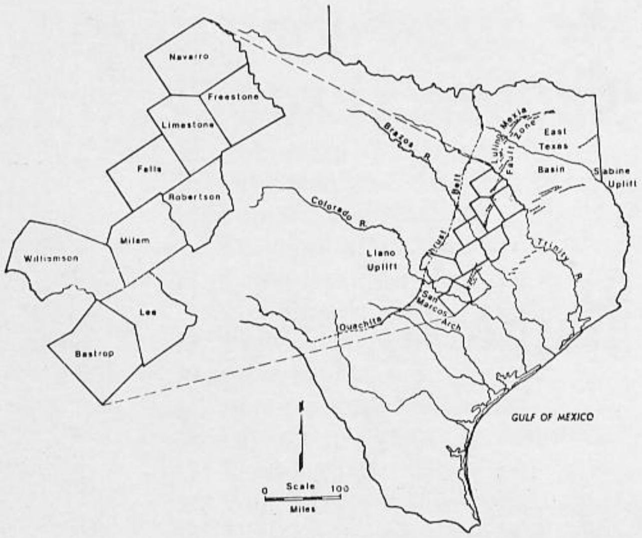


Fig. 1. Index map showing relationship of area of study to major geologic features in Texas.

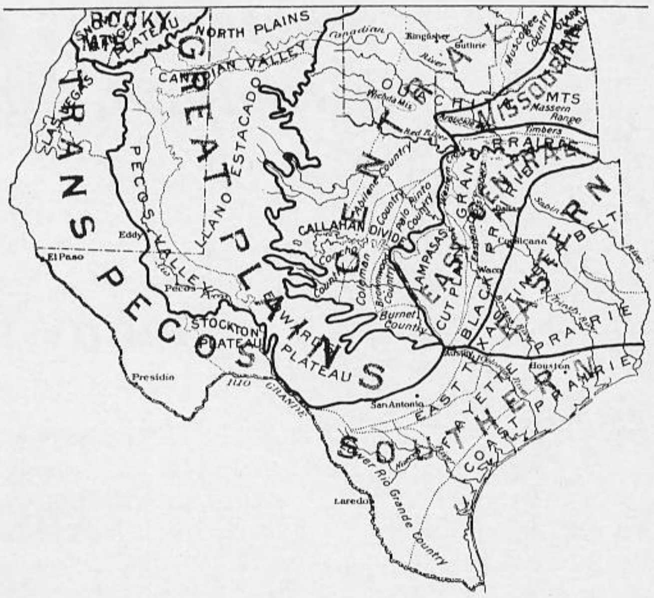


Fig. 3. Hill's final classification of the physiographic provinces of Texas (Hill, 1900, p. 1).

the scope of the earlier investigations, to undertake additional studies which might contribute to a more complete and accurate interpretation of Simsboro deposition, and to consider its stratigraphic significance in the Wilcox Group.

This investigation considers the following major criteria in compiling and interpreting data pertaining to the geologic history of the Simsboro Formation: (1) regional geologic setting, (2) gross lithology and sand body configuration, (3) sedimentary structures, (4) distribution of facies, and (5) postulated paleogeochemical environments.

LOCATION

This study is based on a number of measured sections and outcrops in east-central Texas, including parts of Navarro, Freestone, Limestone, Robertson, Milam, Lee, Williamson, and Bastrop counties (Figs. 1, 2). It lies entirely within the east Texas Timber Belt (Fig. 3) which was described by Hill (1900, p. 8) as "a hilly belt of sandy timber land, corresponding to the outcrop of the Eocene formations." This area is characterized by a low rolling topography with widespread woodlands (Fig. 4) and with grasslands where the trees have been cleared away. The woodlands are a maze of small post oaks (Fig. 4), and the grasslands are spotted with numerous gopher mounds (Fig. 5). In some areas the Simsboro forms an inconspicuous ridge that may be 30 to 40 feet above the surrounding areas (Fig. 6). Southward in Bastrop County, pine trees are more common.

"The substructure is sandy and unconsolidated and is occupied by a greatly branching drainage system" (Hill, 1900, p. 8). Soil profiles measure from 3 feet on ridges to 20 feet in low areas, thereby destroying sedimentary structures in Simsboro outcrops (Fig. 7). Burrowing animals may also erase sedimentary structures to a depth of 20 feet (Fig. 8).

The study area is bounded on the northeast by the Trinity River and on the southwest by the Colorado River. Waco, Temple, and Austin lie to the west of the area. The area of investigation extends 5 miles to either side of a line drawn between the communities of Teague, Bremond, Rockdale, and Elgin (Fig. 2).

The study area lies within the East Texas Basin, to the west and southwest of the Sabine Uplift, and to the east of the Texas Craton (Fig. 1). The Luling-Mexia fault zone lies immediately to the west of the study area in Freestone, Limestone, Falls, and Robertson Counties and to the east of a study area in Milam, Lee, Williamson, and Bastrop Counties.

PREVIOUS WORKS

The first reference in American literature to Cenozoic strata in Texas was made by William Maclure (1809, p. 411-428) as he compiled a geologic map of the United

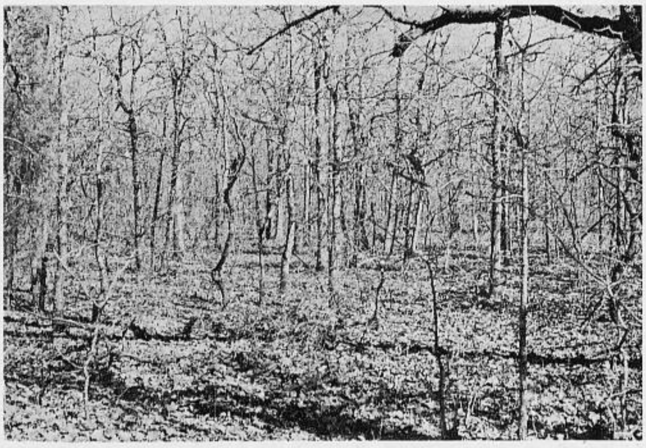


Fig. 4. East Texas Timber Belt. Vegetation shown here is chiefly post oak, which is typical of Simsboro outcrop belt.

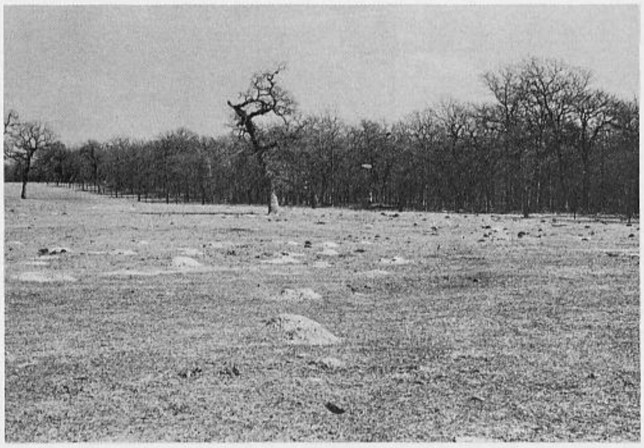


Fig. 5. A cleared field south of Rockdale in the outcrop belt of the Simsboro Sand. Note the numerous sand pocket gopher mounds common throughout the Simsboro outcrop belt.

Fig. 7. Soil profile in Simsboro Formation; entire section here is part of soil profile. The Simsboro outcrop belt is characterized by deep sandy soils, so that many supposed outcrops of Simsboro Sand are actually major soil profiles.

States. He referred to the unconsolidated sediments of the coastal province as alluvial rocks. In 1824 John Finch (p. 31-43) suggested that Maclure's alluvial stratum was equivalent to the Tertiary formations of Europe.

"The first systematic work of a geological nature done in east Texas was by Dr. Ferdinand Roemer, who visited Texas in 1845-47; but even he, as also most succeeding investigators, quickly moved into the Cretaceous and Paleozoic regions lying in the western part of the state" (Penrose, 1889, p. 5). Roemer visited Texas in the interest of future German colonization and published several papers between 1847 and 1889 giving accounts of his geological observations. In 1849 Roemer compiled the first map to show the Cretaceous-Eocene contact in Texas.

In 1848 C. S. Hale (p. 354-363) published the first sections of the lower Cenozoic formations in the Gulf Coast area of Alabama. Another paper on the lower Cenozoic geology of Alabama was published in 1850 by Tuomey. In 1860 Hilgard (p. 110-123) became the leading authority on the early Cenozoic strata. He offered the first comprehensive descriptions of the Cenozoic as a whole and named it the Northern Lignitic Group. In this he included all of the lower Cenozoic strata from the base of the Midway to the base of the Claiborne (Fig. 9). In 1869 Hilgard (p. 340) separated from his Northern Lig-

Fig. 6. View of topographic ridge on skyline formed by Simsboro Sand. This is typical of the outcrop belt of the Simsboro throughout the study area.

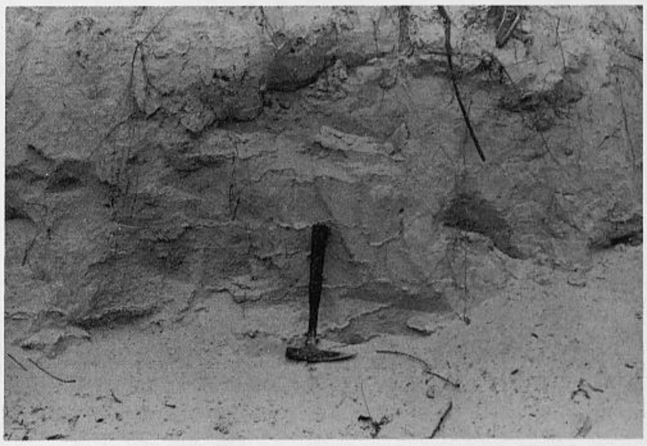


Fig. 8. (Locality 14) Friable quartz sand of the A horizon extensively reworked by the burrowing mammals, chiefly pocket gophers.

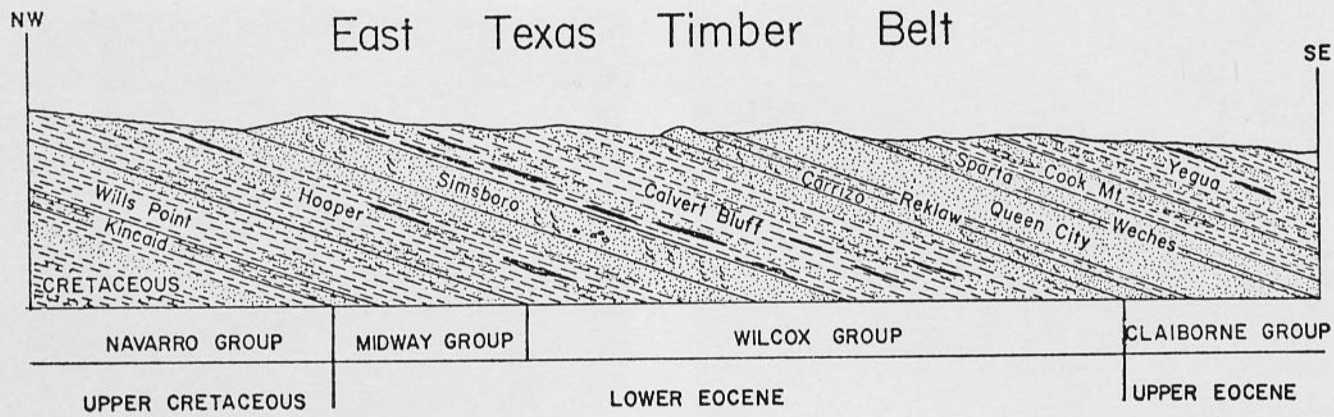


Fig. 9. Diagrammatic cross section through East Texas Timber Belt showing geology and topography.

nitic Group the Flatwoods Beds, the present Wilcox Group. After this, the lower Cenozoic rocks were called different names in different regions by various workers. In 1906 Crider was the first geologist to use the term "Wilcox." The name Wilcox was adopted by the United States Geological Survey in 1912 in a publication by Bailey Willis. Subsequently, it was applied by Deussen (1914, p. 37-51) in describing strata overlying the Midway and underlying the marine beds of the Claiborne Group in east Texas. The term "Wilcox" is now well established within the study of Gulf Coast geology (Plummer, 1932, p. 571-573).

The name "Simsboro" was originally proposed by W. A. Reiter in a personal letter to F. B. Plummer on October 27, 1932 (Fig. 10). Plummer, though, is credited with the first official designation in 1932 (p. 586) for his description of exposures near Simsboro, Texas.

Plummer (1932, p. 574) divided the Wilcox Group into three formations: (1) the Seguin (oldest), (2) the Rockdale, and (3) the Sabinetown (youngest). The Rockdale Formation was in turn subdivided into three members: (1) Butler clay (oldest), (2) Simsboro sand, and (3) Calvert Bluff (youngest). He described the Simsboro (Plummer, 1932, p. 586) as "gray soft sand containing fossil wood, lumps of water-rolled clay, seams and lentils of blue-gray clay that in some places are chocolate brown, and a little lignite."

Subsequent studies were made of the Simsboro dealing with the industrial utilization of sand and clay by Broman (1936), Whitcomb (1939), Hoeman, Redfield, and Stoecker (1945), Hoeman and Redfield (1946), Pence, DeBeck, and Shurtz (1948), and DeBeck (1948).

After Plummer's review of Cenozoic Geology of 1932, Storm (1945, p. 1304-1335) summarized current knowledge of the Gulf Coast region of Texas and Louisiana in one paper. In this he suggested that this region "affords exceptional data and facilities, perhaps the best in the world, for the study of clastic sedimentation" (Storm, 1945, p. 1304). In 1948 Echols and Malkin (p. 11-33) were the first to discuss the Simsboro in a regional study (Fig. 11) in which they related it to oil production in the Wilcox. In 1951 Stenzel (p. 1815-1828) became the first geologist to recognize the Simsboro as a formation.

Todd and Folk (1957, p. 2545-2566) made a detailed petrographic study of the Carrizo Formation and the overlying Newby Member of the Reklaw Formation (Basal Claiborne Group) in Bastrop County. They concluded that the detrital sediment comprising the Carrizo and Newby sands in Texas was originally derived from the southern Appalachian or Ouachita Mountains, rather than the Rocky Mountains of the western United States. They speculated that the resurgence of terrigenous sedimentation in both the eastern and western Gulf Coast, after the retreat of the Cretaceous sea, was the result of tectonism and uplift (not folding) in the southern Appalachians. This tectonic pulse, designated the "Mitchell

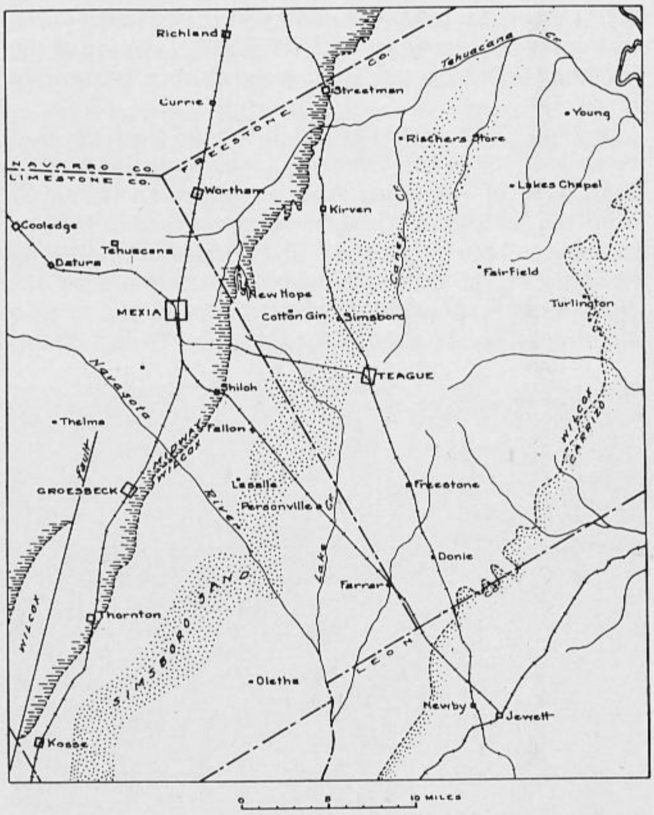


Fig. 10. Outcrop of the Simsboro Sand in Limestone and Freestone Counties according to a map furnished by W. A. Reiter (Plummer, 1932, p. 587).

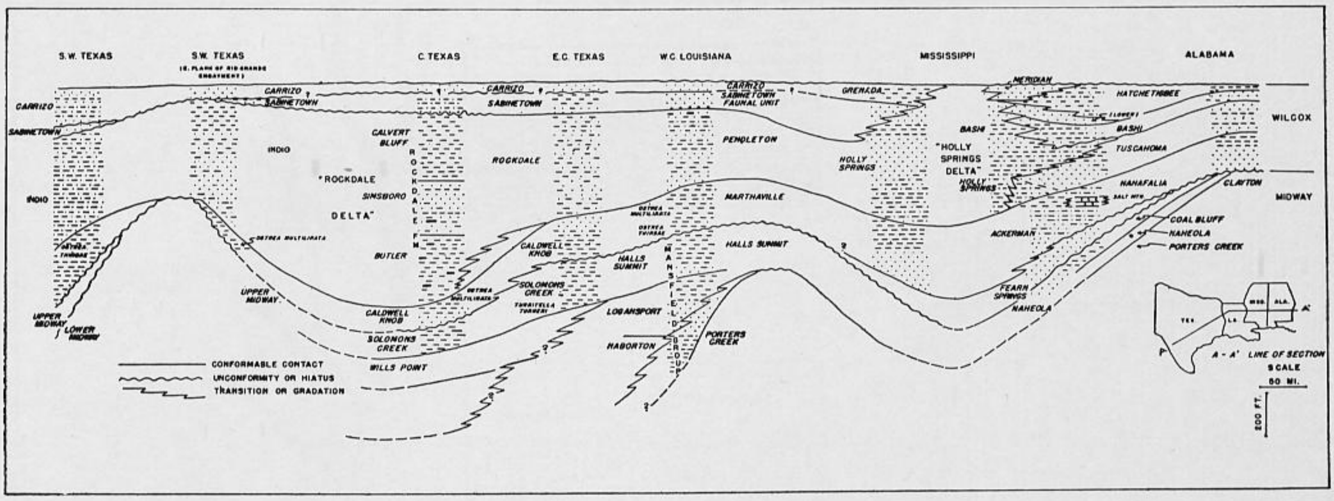


Fig. 11. Restored strike section representing updip conditions at close of Wilcox time (Echols and Malkin, 1948, p. 14).

uplift" (Todd and Folk, 1957, p. 2564), began in early Eocene time and culminated with the deposition of great thicknesses of basal Claiborne sediments.

In a subsequent study in 1958, Callender and Folk (p. 257-269) considered the importance of idiomorphic zircon as a key to volcanism in the lower Tertiary sand of central Texas. As a result they divided these sands into two groups—volcanic and nonvolcanic. The Wilcox and lower Claiborne formations (early Eocene) were considered nonvolcanic because of the minor amounts of idiomorphic zircon present. Beginning with Yegua deposition, volcanism apparently increased into early Oligocene time.

As open pit mining operations in the Simsboro became common, geologists took advantage of the subsequent exposures and began studying in greater detail the depositional environments. Kohls (1967, p. 184-204) was the first to make a significant contribution toward the reconstruction of depositional environments within the Simsboro Formation. He concluded that the Simsboro was deposited as a continental, fluvial complex grading southward into marine, beach deposits. On the basis of mineralogy, grain size, sedimentary structures, and geometry of sedimentary bodies, Kohls divided the Simsboro into six lithologic types: (1) Channel deposits—extensively crossbedded, medium-grained sand with kaolin clay pellets, (2) Flood-plain deposits—illitic-kaolinitic, thinly laminated, silty clay, (3) Bar deposits—tabular cross-stratified fine-grained sand, (4) Lake basin deposits—white, kaolinitic silty clay, (5) Orthoquartzite deposits—hard, siliceous, fine-grained sand, and (6) Swamp or lagoonal deposits—gray carbonaceous, kaolinitic, slightly silty clay.

Concurring with Todd and Folk (1957, p. 2545-2566), Kohls believed that most of the Simsboro detritus was derived from the Ouachita Mountains with minor contributions from the southern Appalachians and Cretaceous rocks of Texas.

The first regional depositional study of the entire Wilcox Group by Fisher and McGowen (1967, p. 105-125) considered the Wilcox of east Texas to have been deposited in a complex fluvio-deltaic system (Figs. 12, 13). The Simsboro was interpreted as a highly meandering channel facies of the Mt. Pleasant Fluvial System which was the main feeder for the Rockdale Delta System (Figs. 12, 13). Sedimentary structures within the formation led Fisher and McGowen to subdivide the Simsboro into three subfacies: (1) chute bars, (2) lower point bars, and (3) scour pool (Figs. 14, 15).

Later in a related work, McGowen and Garner (1970, p. 77-111) studied coarse-grained point bars in which they used the Simsboro as one example. They concluded that upper point-bar deposits (fine-grained small trough sets and parallel-inclined laminae) are not found in depositional systems in which only medium- to coarse-grained sand is supplied to the area. In the Simsboro, they found foreset and trough cross stratification most common.

PROCEDURES

Three phases were involved in this study: (1) literature review, (2) field work, and (3) laboratory investigation. A review of the available literature related specifically to the Wilcox Group and Simsboro Formation initiated the investigation. Also a more generalized literature study was made concerning fluvio-deltaic depositional systems, sedimentary structures and their significance, and early Tertiary stratigraphy of the Gulf Coast region. During field work, outcrops were located using topographic maps published by the U.S. Geological Survey (scale 1:24,000), and by driving all available roads in the study area. The outcrops were then measured and described, samples collected, and photographs made. Laboratory investigations included megascopic and microscopic examination of the field samples. After the bulk samples were inspected with the naked eye and the hand lens, friable sand samples were washed, sieved, and examined under the binocular microscope for size range, composition, and texture. Heavy mineral separations were achieved by the use of heavy liquids, and minerals were identified by petrographic techniques. Thin sections were made of highly indurated and artificially impregnated sand samples, after which they were petrographically examined.

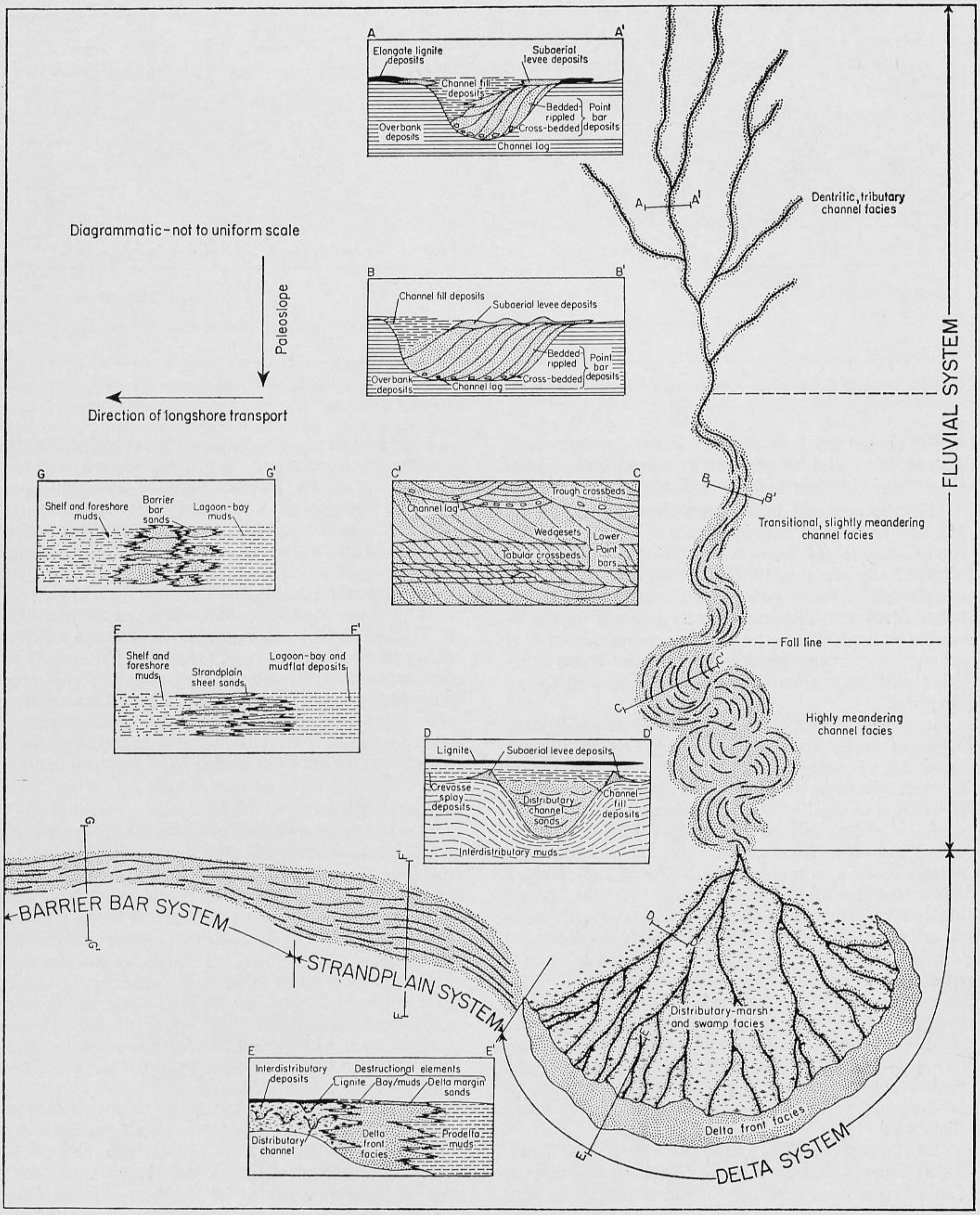


Fig. 12. Idealized sand-dispersal system in various depositional systems, Wilcox Group, Texas (Fisher and McGowen, 1967, p. 121).

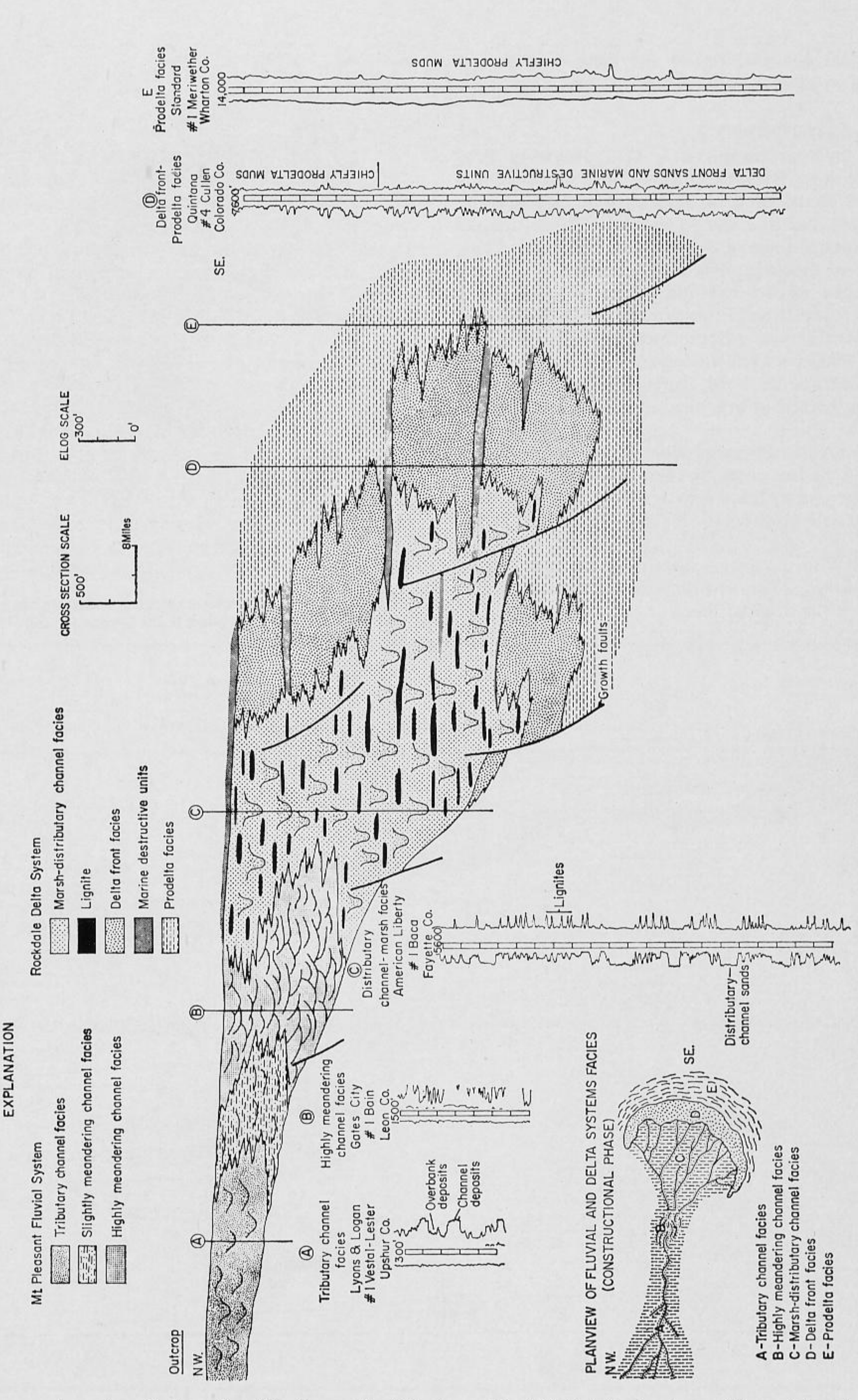


Fig. 13. Diagrammatic stratigraphic dip section of Mt. Pleasant Fluvial System and Rockdale Delta System shows relation and character of principal component facies (Fisher and McGowen, 1967, p. 109).

Mineralogical composition of the clay samples was determined by the use of the X-ray diffractometer.

ACKNOWLEDGEMENTS

I extend my appreciation to Dr. O. T. Hayward, Professor of Geology, Baylor University, who suggested this project and contributed to field studies, cartography, photography, and manuscript revision. Special thanks are also extended to Dr. J. N. Namy and Dr. R. G. Font, Professors of Geology, Baylor University, for giving freely of their time and making significant contributions toward the completion of this project. Dr. J. L. McAtee of the Baylor Chemistry Department contributed generously of his extensive knowledge in clay mineralogy and clay identification. Dr. F. M. Hurst of the Baylor Biology Department helped in botanical identification of petrified wood.

I am indebted to Dresser Industries of Kosse, Texas, for allowing me free access to their pit area and drilling records. Also appreciation is extended to Mr. Fred Reagen of Dresser Industries for his assistance while at the plant.

Finally, I wish to express my sincere appreciation to my wife, Sharlyn, for her critical review of the manuscript and typing of the original thesis.

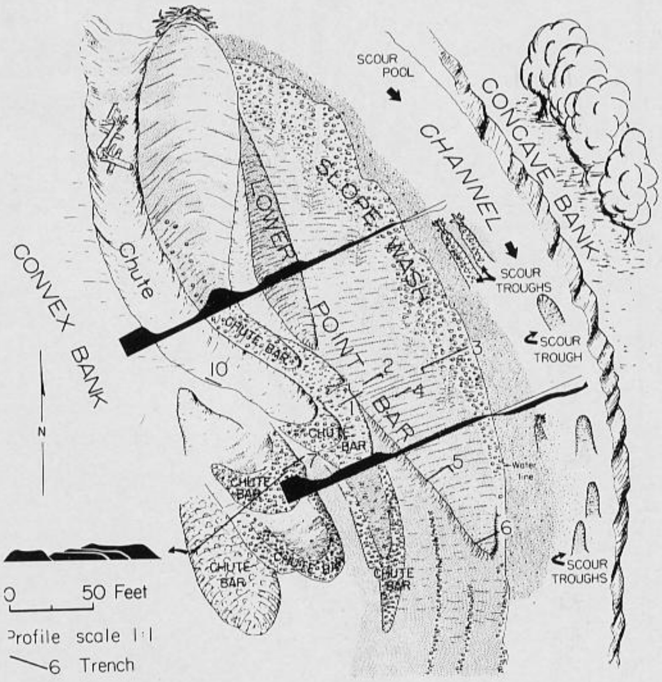


Fig. 14. Idealized plan view (sketch) of coarse-grained point-bar and chute-bar environments found in the Simsboro Sand (McGowen and Garner, 1970, p. 81).

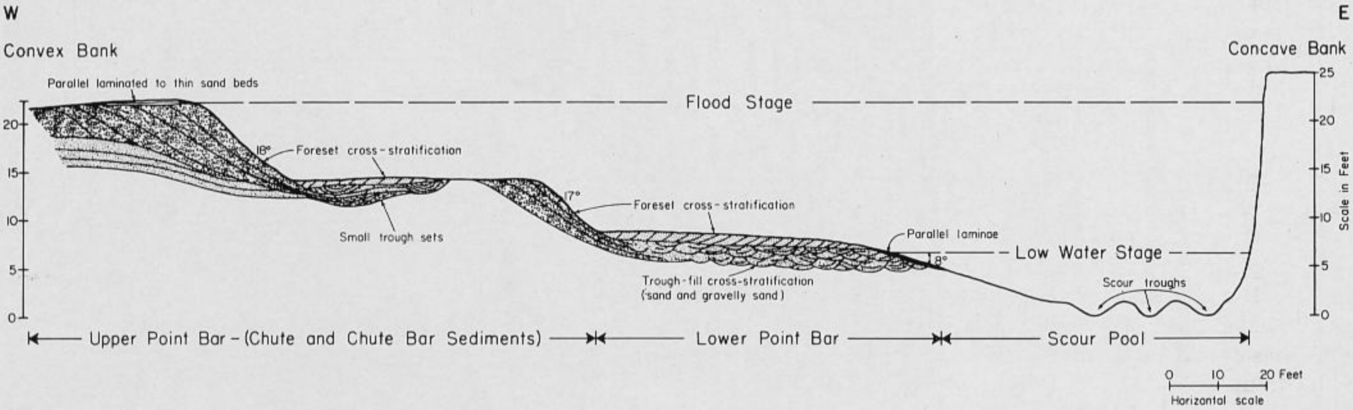


Fig. 15. Profile and stratification types from scour pool to crest of highest chute-bar found in the Simsboro Sand (McGowen and Garner, 1970, p. 83).

GEOLOGY

STRUCTURAL RELATIONSHIPS

Within the study area the Simsboro Formation crops out in a narrow band 150 miles long and from 1 to 4 miles wide (Fig. 8). Thicknesses vary from 75 to 350 feet causing a conspicuous narrowing and widening of the outcrop band. In the immediate outcrop area the Simsboro strikes north 36° east and dips southeastward at approximately 80 feet per mile. The dip increases in magnitude to the southeast (Bebout et al., 1976, p. 9).

Deposition of the Wilcox Group in east and east-central Texas occurred within the East Texas Basin, a subsiding trough. Subsidence was gradual and consistent throughout. In the subsurface (Bebout et al., 1976, p. 9) strata do not show a marked increase in thickness, leading to the belief that deposition was progradational.

A broader view of the region reveals that the Central Texas Platform, the San Marcos Arch and the Sabine Uplift (Fig. 1) also affected eposition of the Wilcox Group. During Eocene time the Central Texas Platform

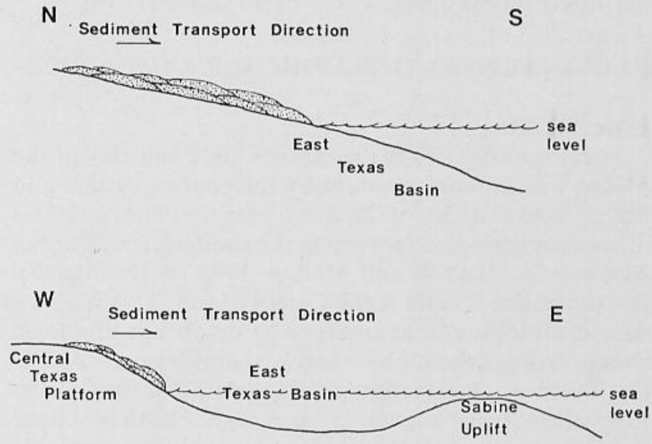


Fig. 16. Diagrammatic cross section of structural provinces in which the Simsboro was deposited. Notice that the Simsboro is entirely terrigenous and that the time equivalent marginal deltaic sediments (Hooper Formation) were deposited further out into the East Texas Basin.

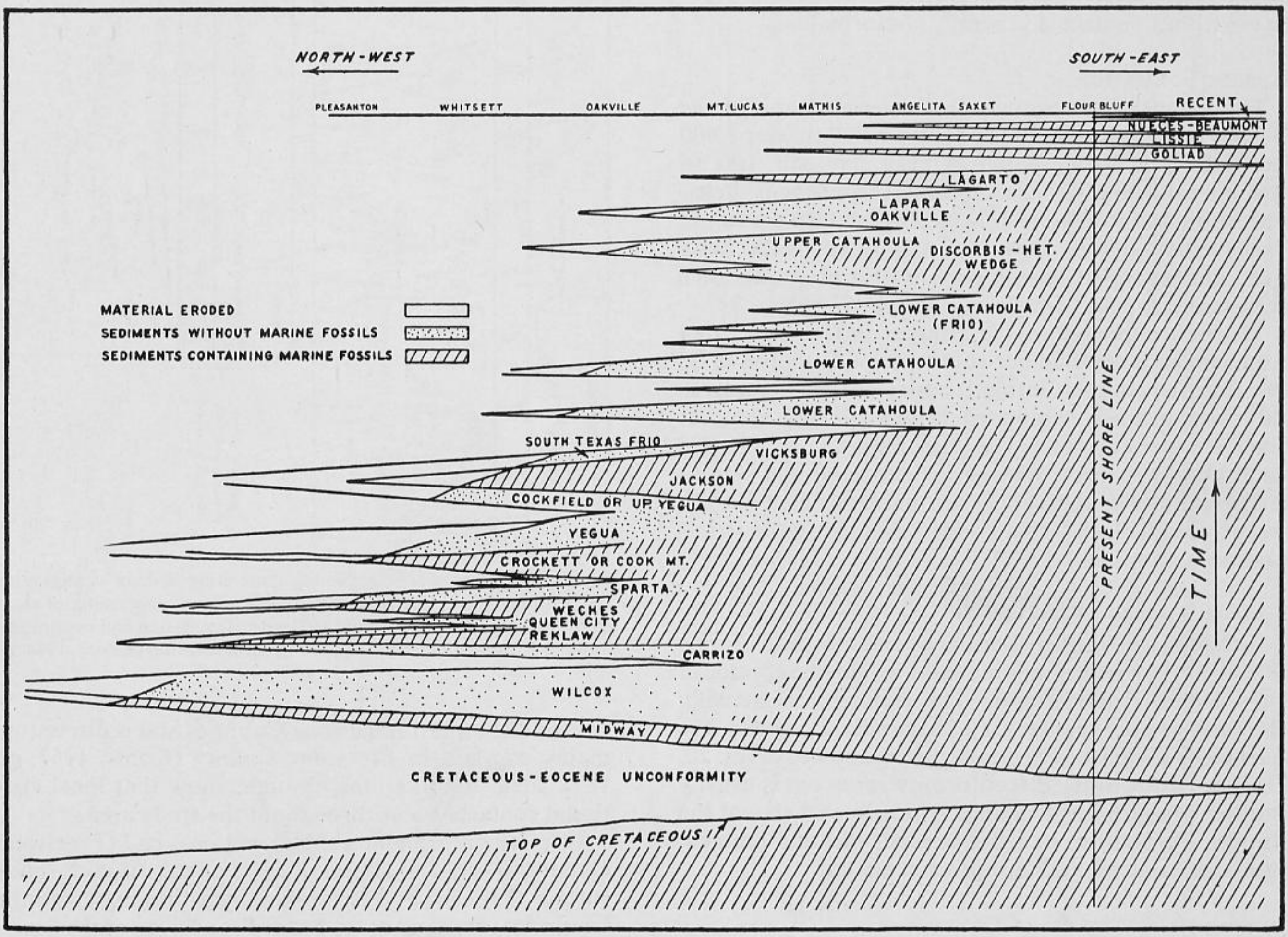


Fig. 17. Diagrammatic representation of changes in strand lines, Gulf Coast formations, during the Cenezoic Era. Sedimentation went on continuously outside a position probably somewhere near the present shore line (Storm, 1945, p. 1318).

was a positive area subject to weathering and erosion (Fig. 16). To the east the Sabine Uplift and to the southwest the San Marcos Arch were submarine highs, which confined and funneled sediments from the west and northwest into the East Texas Basin (Figs. 11, 16).

REGIONAL STRATIGRAPHIC RELATIONSHIPS

Introduction

In east-central Texas the marine shale and clay of the Midway Group are overlain by the coarser deltaic and fluvial sand and clay of the Wilcox Group. The contact is disconformable and represents the sudden retreat of the Midway Sea (Echols and Malkin, 1948, p. 15; Fig. 17). Overlying the Wilcox is the Carrizo Sand. This is also a disconformable contact marked by an abrupt lithologic change from carbonaceous clay and argillaceous sand of the Wilcox to clean yellow or orange sand of the Carrizo Formation (Fleischhauer, 1974, p. 10-12). Both the upper and lower contacts of the Wilcox are usually recognizable in the subsurface (Figs. 18, 19).

The Simsboro Formation is the middle formation of the Wilcox Group in east-central Texas. It is underlain by the Hooper Formation and overlain by the Calvert Bluff Formation throughout the study area. The lower Hooper-Simsboro contact is disconformable. The upper Simsboro-Calvert Bluff contact is generally conformable.

Hooper Formation

The Hooper Formation is the lowermost unit of the Wilcox Group (Fig. 2). It ranges from 800 to over 1,000 feet thick and is composed of gray clay, silt, fine to medium sand, and thin discontinuous lignite beds. Petrified wood and ironstone concretions are also common. This formation was apparently deposited in the delta front and interdistributary regions of a progradational delta (Coleman and Gagliano, 1965, p. 67-80).

The best exposure of the Hooper in the study area crops out in a railroad cut southeast of Cameron (Fig. 20). Here the Hooper Formation is composed of remarkably regular finely laminated brown silt and clay. At other Hooper exposures (Localities 44, 45, 49; Fig. 21) the lithology varies from interbedded sand and clay to thicker tabular beds of sand, clay, and sandy clay. Within the interbedded sand, small scale, low-angle cross stratification is common.

Hooper-Simsboro Contact

Although the Hooper-Simsboro contact is disconformable, it marks a very minor hiatus as would be expected in fluviodeltaic sedimentation. The contact was actually observed at only one locality (Appendix II) where it is marked by a lignite and/or petrified wood bed (Figs. 22, 23). The nature of the disconformity varies but is usually marked by a lithologic change from silt and clay of the Hooper Formation, to cross-bedded, medium-grained, kaolinitic sand of the Simsboro Formation.

Simsboro-Calvert Bluff Contact

The Simsboro Formation is conformably overlain by the Calvert Bluff Formation in Bastrop, Milam, Robertson, and southern Limestone Counties and is disconformably overlain in Freestone County (Kohls, 1967, p. 187). Field observations, though, show that local erosional contacts occur throughout the study area.

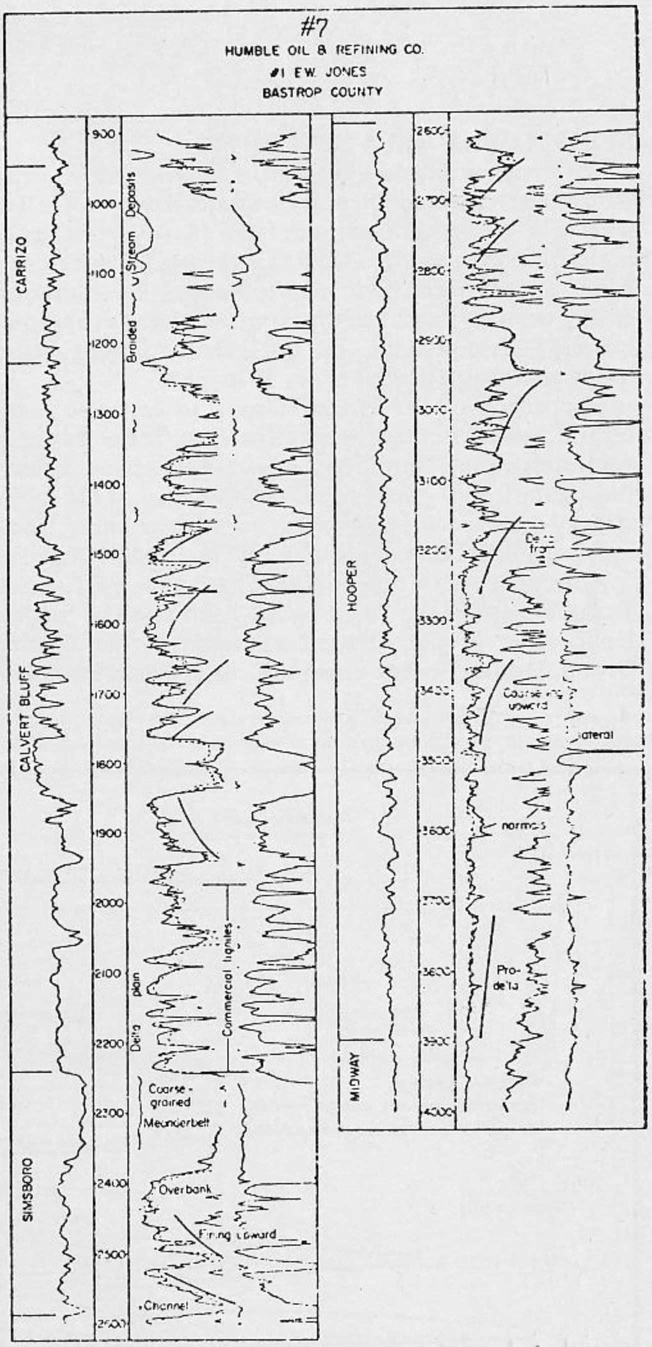


Fig. 18. Representative electric log illustrating Wilcox stratigraphy and sedimentation. Notice how there is a general coarsening of sediments beginning at the base of the Hooper Formation and continuing into the Simsboro Formation. See Fig. 2 for location (Kaiser, 1974, p. 20).

One disconformable contact at Locality 7 (Freestone County) shows 5 to 10 feet of relief on the disconformity surface (Fig. 24) and is marked by a lithologic change from white clay and cross-bedded sandstone of the Simsboro Sand to dark gray and brown sand, silt, and clay of the Calvert Bluff Formation. However, only 50 yards

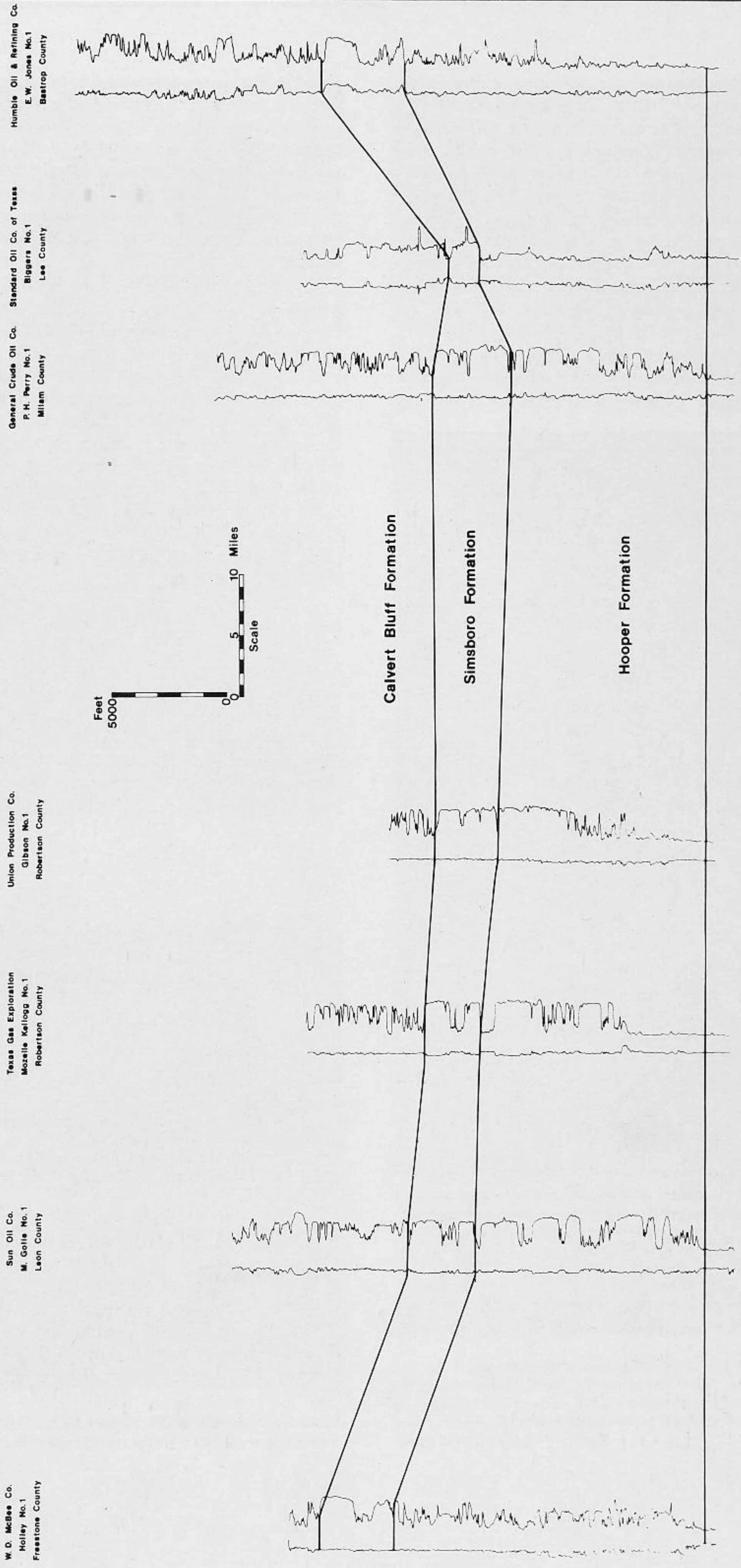


Fig. 19. Subsurface electric log cross section. See Fig. 2 for locations.

from this exposure the contact becomes conformable (Fig. 25). Another disconformable contact is marked by a lithologic change from fine sand, with distinctive climbing ripples, to an overlying bed of limonite concretions (Fig. 26). Conformable Simsboro-Calvert Bluff contacts are usually marked by a lithologic change from medium-grained, cross-bedded kaolinitic sand, to silty clay, to lignite (Fig. 27). The upper limit of Simsboro deposition is marked by the top of the silty clay. In areas not characterized by a lower Calvert Bluff lignite, the contact is marked by a dark carbonaceous clay (Fig. 28).

Calvert Bluff Formation

The Calvert Bluff Formation is the uppermost unit of the Wilcox Group in the study area (Fig. 2). It is composed of gray sand which weathers red and buff, and varies in texture from coarse quartzose sand to very fine silty clay, interbedded with black lignitic beds and carbonaceous clay (Plummer, 1932, p. 586). Petrified wood and ironstone concretions are also common throughout. Typically the Calvert Bluff ranges from 800 to 1,200 feet thick. The lowermost 200 feet is economically important, providing Texas with its largest commercial lignite source.

The best exposure of Calvert Bluff encountered in the progress of this study was at the type locality of the Calvert Bluff Formation on the Brazos River in Robertson County (Locality 38; Appendix II). Here the formation is composed largely of interbedded, dark lignitic clay, fine sand, lignite, and ironstone concretions (Fig. 29). Carbonized wood and other plant material are common, suggestive of a swamp environment. Small scale flaser bedding in the sand beds implies current activity alternating with periods of quiescence (Reineck and Singh, 1975, p. 98). This formation was deposited in distributary channels, marshes, and swamps landward from the delta front of the Rockdale Delta (Fisher and McGowen, 1967, p. 112).

Simsboro Lateral Relationships

Northeast and southwest of the study area, the Simsboro can no longer be defined as the entire Wilcox section becomes primarily sandy mudstone (Fisher and McGowen, 1967, p. 110). In the subsurface the Simsboro extends eastward where it can generally be recognized downdip for several miles (Fig. 19). Approximately 10 miles downdip the Simsboro grades into deltaic sediments and can no longer be differentiated.

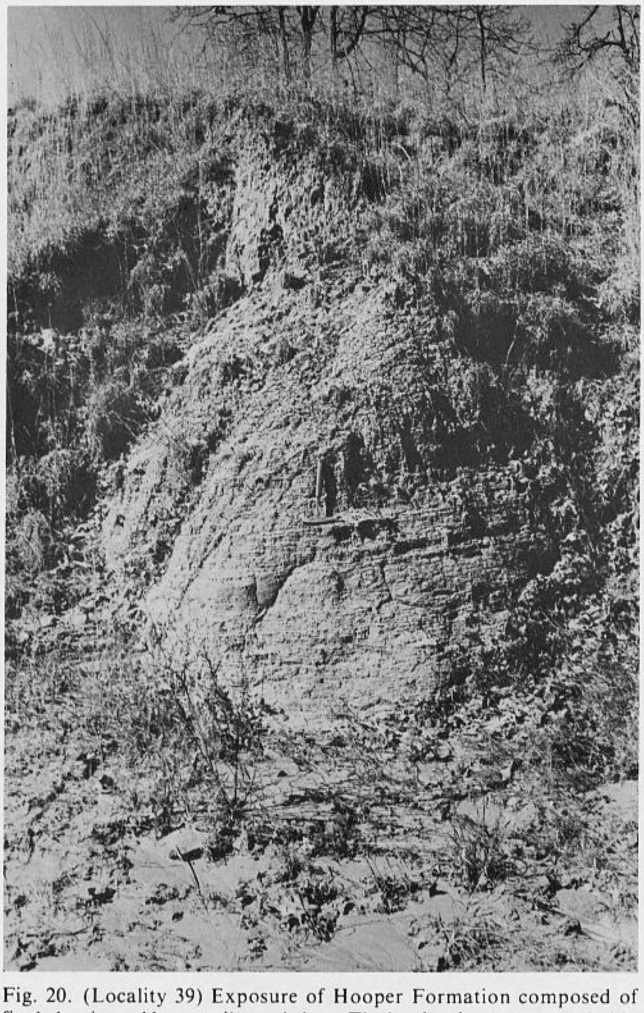


Fig. 20. (Locality 39) Exposure of Hooper Formation composed of finely laminated brown silts and clays. The laminations are remarkably regular with little variation throughout. This is the best exposure of the Hooper Formation encountered in this study.

Fig. 21. (Locality 44) The Hooper Formation here consists of gently inclined beds of sand and clay. Height of the outcrop is approximately 15 feet.

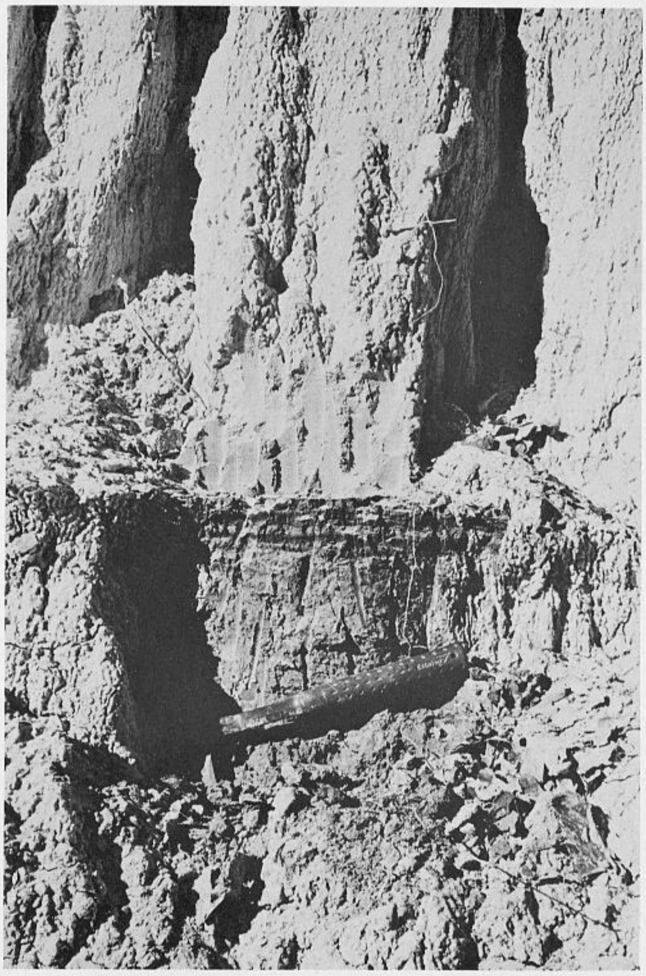


Fig. 22. (Locality 49) The Hooper-Simsboro contact here is disconformable, marked by a layer of lignite and fragmented petrified wood. The Hooper Formation consists of clay, sand and lignite overlain by clean, white sand of the Simsboro Formation.

Fig. 23. (Locality 49) Disconformable Hooper-Simsboro contact. Notice the abrupt nature of the contact in lower one-third of photo.

Fig. 24. (Locality 7) Photo of disconformable Simsboro-Calvert Bluff contact. Notice local relief along the contact here at approximately 8 feet.

Fig. 25. (Locality 7) The Simsboro-Calvert Bluff contact is conformable here. The dark bed, in the middle of the photograph, is the lignite which marks the base of the Calvert Bluff Formation.

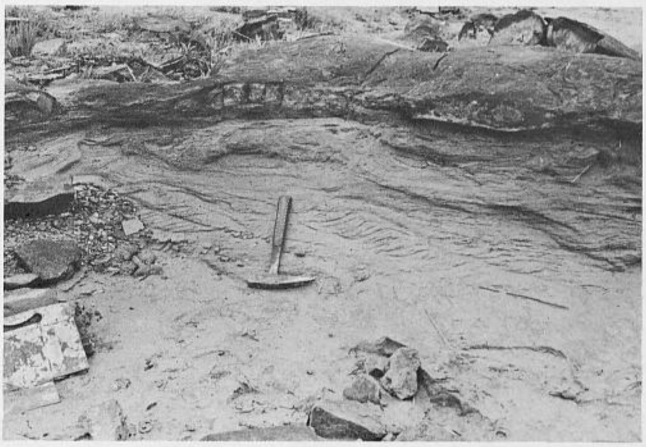


Fig. 26. (Locality 38) Disconformable Simsboro-Calvert Bluff contact along Brazos River, near Calvert, Texas. Notice how climbing ripples in the Simsboro Formation are truncated by the limonite concretionary layer in the Calvert Bluff Formation. The climbing ripples are within the point-bar facies.

STRATIGRAPHY

The Simsboro Formation may be divided into five facies based on lithology, sedimentary structures, and bed geometry. These facies are, in order of abundance: (1) point-bar facies, (2) chute-bar facies, (3) overbank facies, (4) chute-channel lag facies, and (5) abandoned-channel facies.

POINT-BAR FACIES

The point-bar facies (Fig. 30) is by far the most widely distributed deposit within the Simsboro Sand comprising more than 60 percent of the entire formation. The point-bar facies consists of coarse-grained kaolinitic sand, (Appendix I) composed of quartz, kaolinitic clay, chert, and muscovite. Approximately 75 to 90 percent of the rock is quartz, 10 to 20 percent kaolinitic clay, 0 to 3 percent chert, 0 to 2 percent muscovite, and the remaining 0 to 5 percent is composed of potassium feldspar, carbonized plant fragments (Fig. 31), petrified wood, biotite, or heavy minerals. The sand fraction at Localities 40, 41 and 42 contains 3 to 5 percent potassium feldspar while most of the other sampled localities contain less than 1 percent. The sand and coarse silt fraction ($>$.03mm) ranges from sublitharenite to almost pure quartzarenite, with the clay fraction consisting of almost pure kaolinite (Fig. 32).

The most diagnostic property of the point-bar facies, other than lithology, is its massive nature and conspicuous cross-bedding (Fig. 33). A typical section consists of 20 feet or more of 1 to 3 feet cross-stratified beds stacked vertically. Vertical stacking of multidirectional cross-bedded sands, such as this, is termed "multilateral" (Pettijohn, 1965). These multilateral sand bodies range up to 200 feet thick and as much as 30 miles wide (Fisher and McGowen, 1967, p. 110). Usually each cross-stratified unit or bed is truncated at the top by the bedding plane of the overlying unit.

The most common types of cross-bedding are: moderate-scale foreset cross-stratification (Fig. 34), moderate- to large-scale trough cross-stratification (Fig. 35), and large-scale foreset cross-stratification (Fig. 36). Cross-bedding is locally accentuated by red and white laminae (caused by groundwater percolation), and by sand and pebble-sized clay chips (Fig. 37). Thin (5 to 15mm) dark lignitic-micaceous laminae (Fig. 31) are common in this facies. Climbing ripples were found at one locality (Fig. 26).

Scattered throughout this facies are found highly indurated massive sandstone concretions (Fig. 38). Some concretions contain pronounced cross-bedding typical of the facies while others are structureless and contain petrified wood as their core (Fig. 39). Concretions occur as either silica (Fig. 40) or calcite (Fig. 41) cemented.

Most of the sand within this facies is fine to medium grained (0.125mm to 0.5mm), although both coarse (0.5mm to 2mm) and very fine (0.0625mm to 0.125mm)

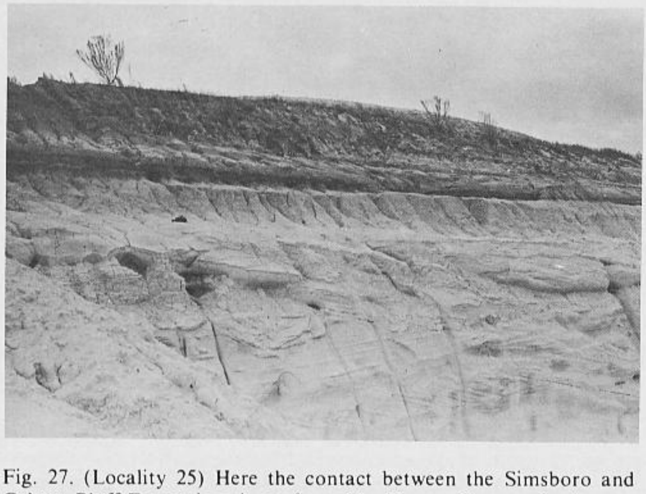


Fig. 27. (Locality 25) Here the contact between the Simsboro and Calvert Bluff Formations is conformable. The medium-grained cross-bedded sands of the Simsboro Formation grade upward through a gray clay section into the lower lignite of the Calvert Bluff Formation.

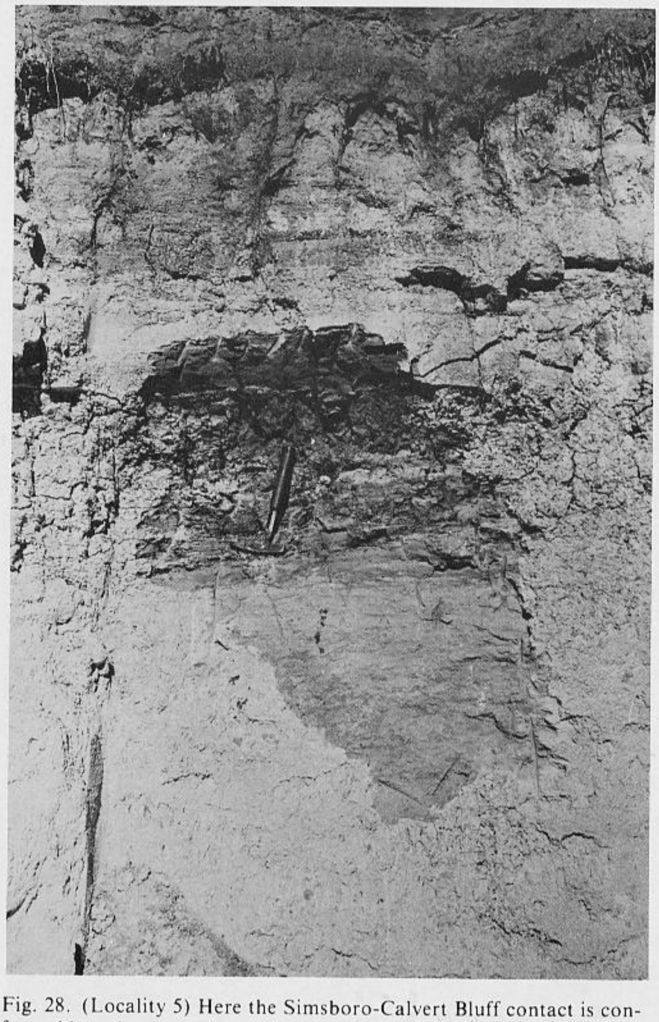


Fig. 28. (Locality 5) Here the Simsboro-Calvert Bluff contact is conformable and occurs where light colored sand and clay of the Simsboro grade upward into dark carbonaceous clay of the Calvert Bluff Formation.

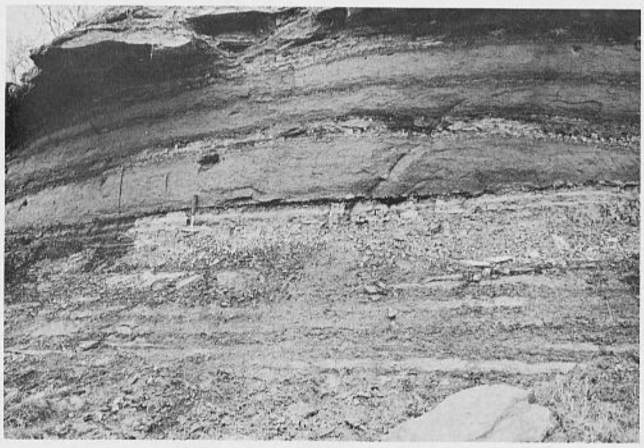


Fig. 29. (Locality 38) Calvert Bluff Formation at the type locality on the Brazos River near the town of Calvert, Texas. Here the section consists of dark carbonaceous sands and clays uniformly bedded.

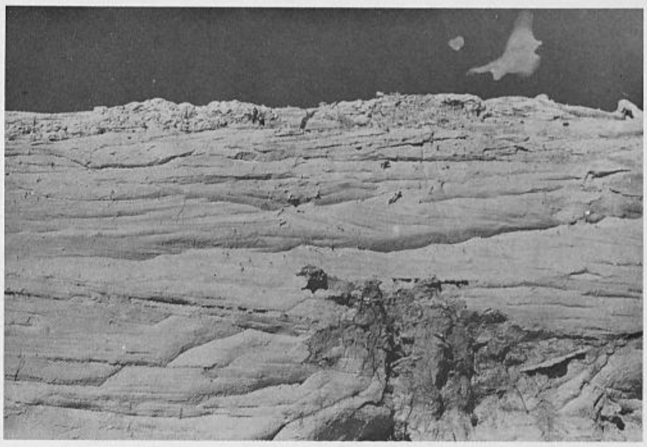


Fig. 30. (Locality 25) Point-bar facies of the Simsboro Formation. Notice particularly the multistacking of cross-bedded sand units.

sand is common in some rock sequences (Appendix I). This facies is considered texturally "immature" because: (1) it contains more than 5 percent clay, (2) the major portion of sand grains are sub-angular to very angular (Fig. 42), and (3) the sand fraction is very poorly sorted (Folk, 1968, p. 102; Fig. 43). Within the fine to medium fraction, the sand is bimodal containing about 0 to 5 percent well-rounded grains (Fig. 44).

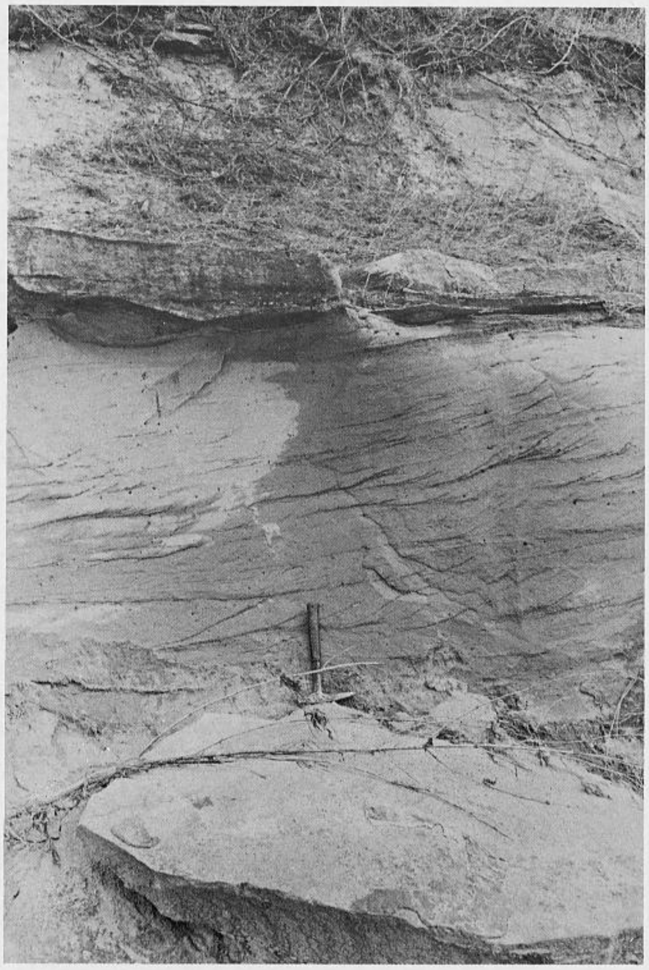


Fig. 31. (Locality 38) Foreset cross-stratification of the Simsboro Formation is accentuated by dark lignitic-micaceous laminae at this locality. This type of cross-bedding is typical of point-bar facies.

PETROGRAPHY OF THE POINT-BAR FACIES

Most of the quartz displays slightly undulose extinction typical of the "plutonic" type (Folk, 1968, p. 70; Fig. 45). Also common (3 to 10 percent) is the "volcanic" type characterized by straight sides, straight extinction, and clear appearance (Figs. 46, 47). Stretched and recrystallized metamorphic sand grains were rarely present.

Chert occurs as angular to rounded and is fine to coarse grained in size. It appears as dark specks in the otherwise white rock. Muscovite is also conspicuous

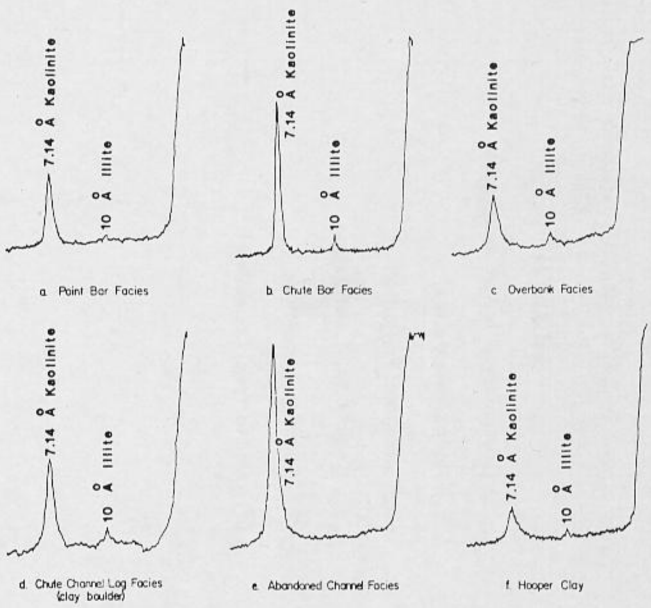


Fig. 32. Typical diffraction patterns of clay minerals in the Simsboro facies. Note particularly that kaolinite is the dominant and sometimes only clay with illite an occasional minor constituent.

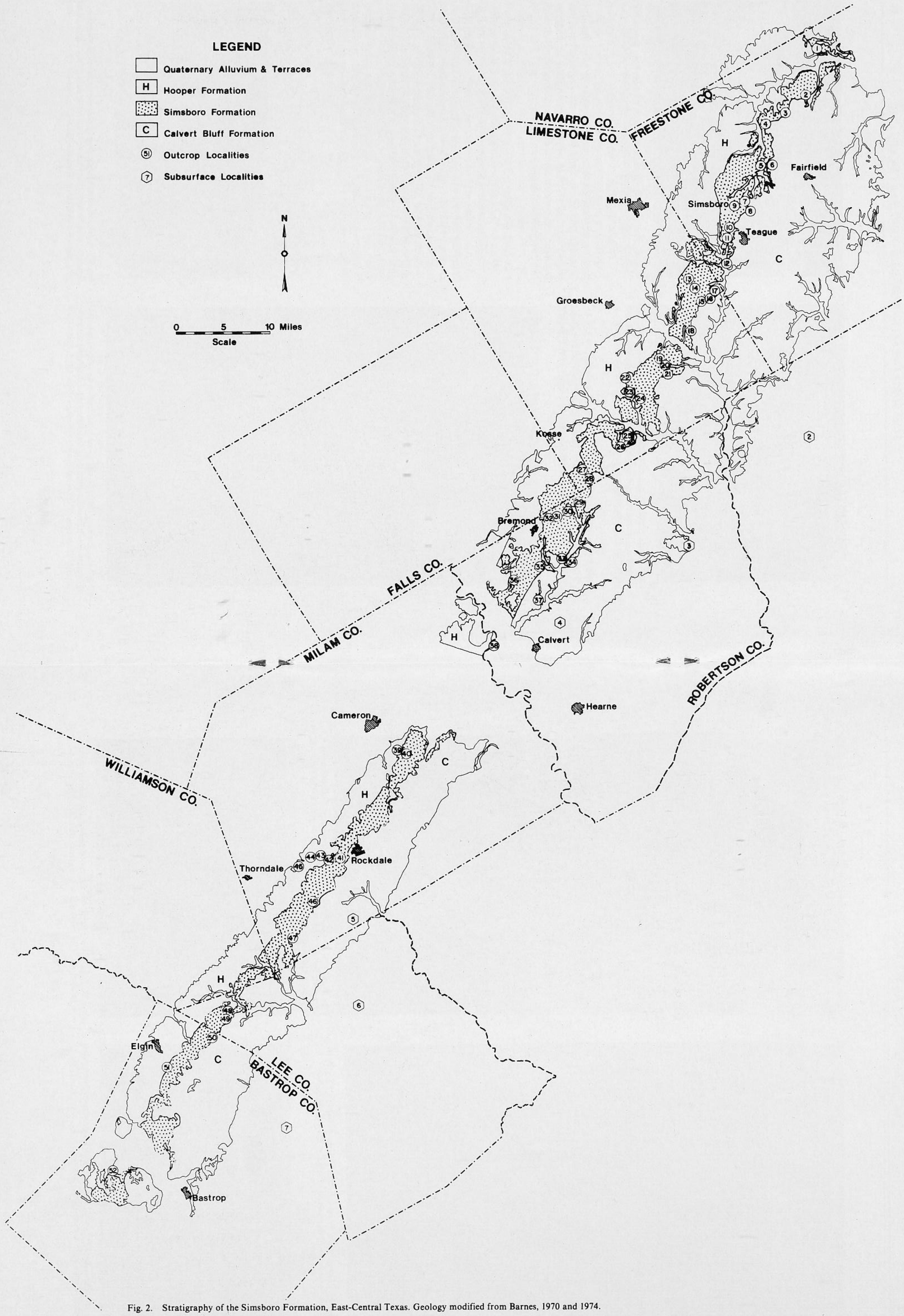


Fig. 2. Stratigraphy of the Simsboro Formation, East-Central Texas. Geology modified from Barnes, 1970 and 1974.

because of its high reflectance. Plates of muscovite may range in diameter up to 4mm.

The clay fraction of this facies is dominantly kaolinite (>95 percent) with some illite (Fig. 32). The clay occurs within the facies in four forms: (1) kaolin pellets (Fig. 48), (2) authigenic kaolin accordions (rod-like kaolinite crystals) (Fig. 49), (3) kaolin pseudomorphs after muscovite (Fig. 50) and potassium feldspar (Fig. 51) grains, and (4) disseminated kaolin and illite found adhering to the quartz grains (Fig. 52).

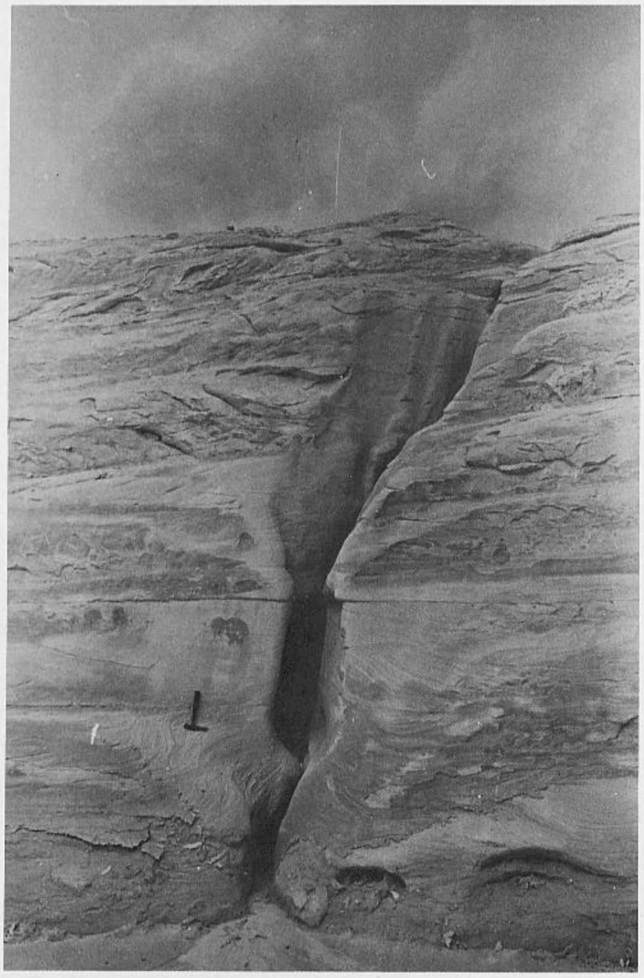


Fig. 33. (Locality 25) Point-bar facies of the Simsboro Formation. Notice the massive nature and abundance of cross-stratification.

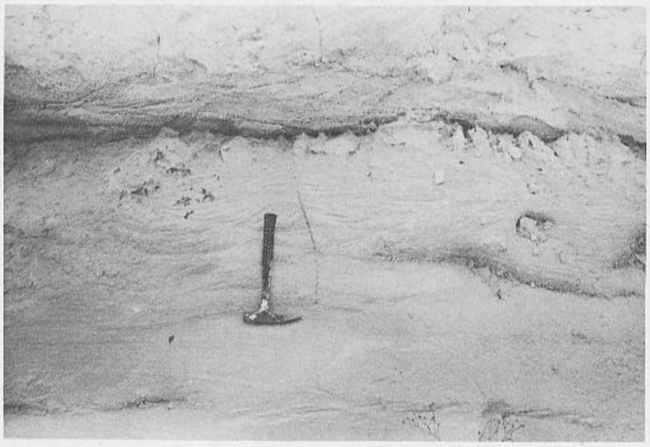


Fig. 35. (Locality 25) Trough cross-stratification of the point-bar facies, Simsboro Formation. Notice the dimensions of the individual troughs.

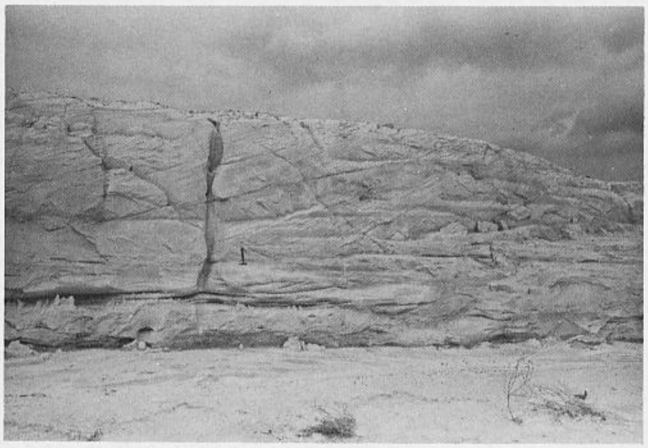


Fig. 36. (Locality 25) Point-bar facies, Simsboro Formation, with large-scale foreset cross-stratification. Notice in photograph there are two major crossbedded units.

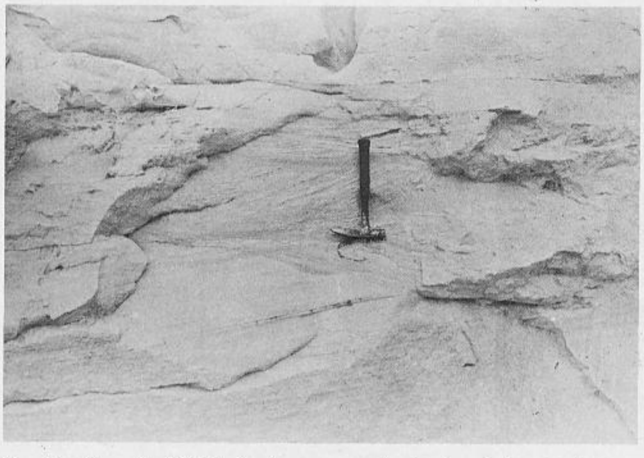


Fig. 34. (Locality 25) Typical exposure of point-bar facies. Notice the moderate-scale foreset cross-stratification.

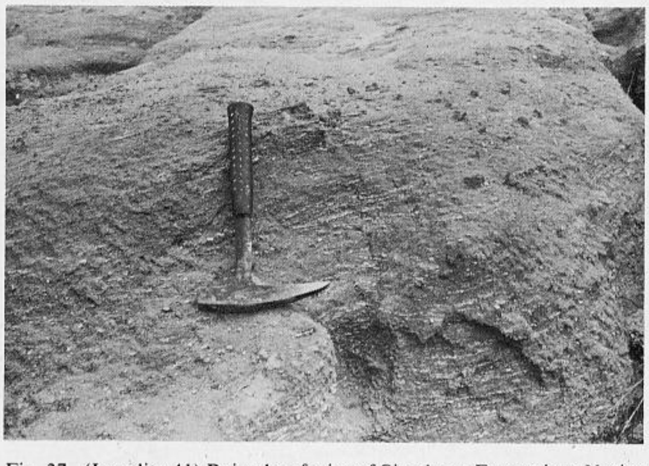


Fig. 37. (Locality 41) Point-bar facies of Simsboro Formation. Notice the pebble-sized clay chips which accentuate cross-bedding.

Fig. 38. (Locality 38) Massive sandstone concretion, typical of the Simsboro point-bar facies. Notice how the cross laminae continue uninterrupted through the concretion.

Fig. 39. (Locality 38) Massive sandstone concretion containing a core of petrified wood. Notice the lack of bedding structures in the concretion.

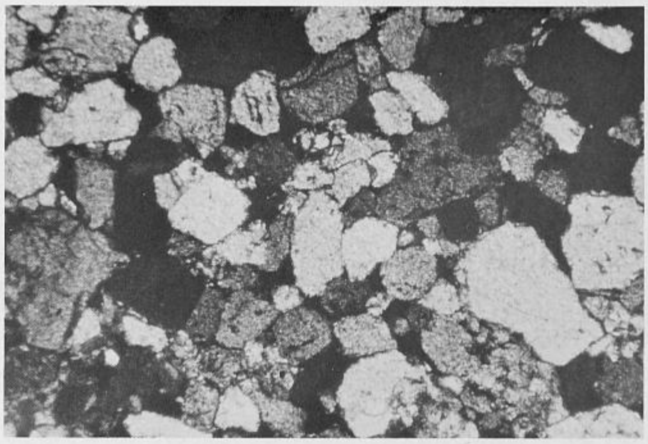


Fig. 40. (Locality 25) Thin section (x150) of silica-cemented sandstone concretion (X-nicols).

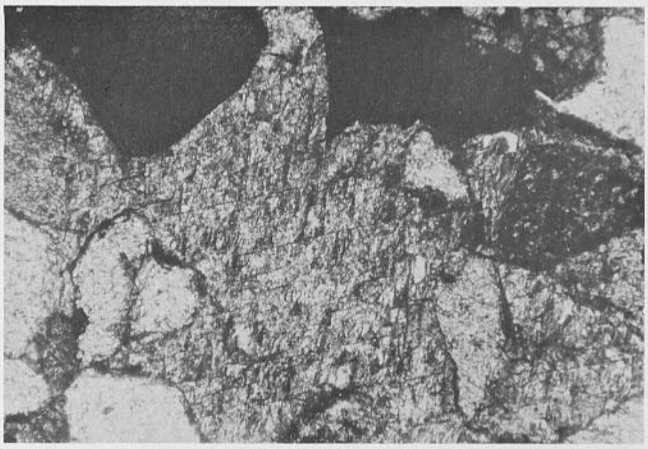


Fig. 41. (Locality 38) Thin section (x430) of a sandstone concretion showing calcite cementation. Notice distinctive calcite cleavage traces (X-nicols).

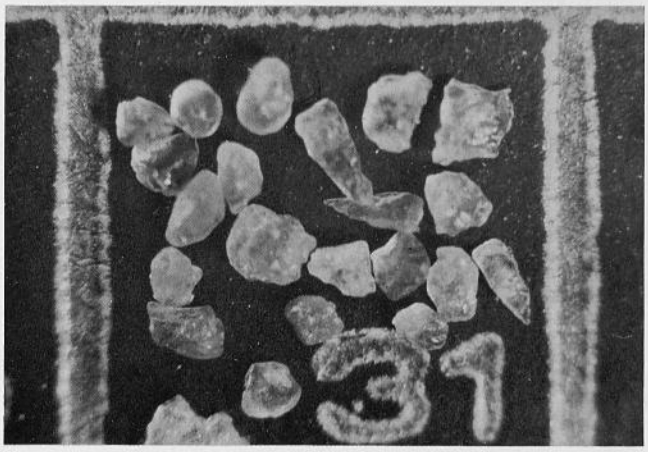


Fig. 42. (Locality 25) Photomicrograph (x85) of sub-angular to angular medium-sized quartz and sand grains.

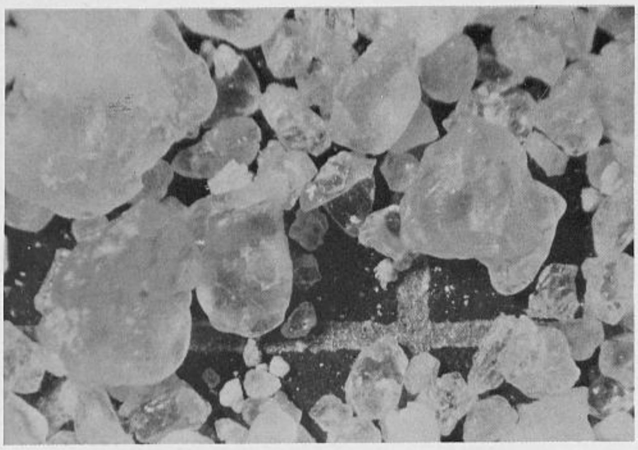


Fig. 43. (Locality 41) Photomicrograph (x140) of medium-sized quartz sand grains. Notice angularity and poor sorting.

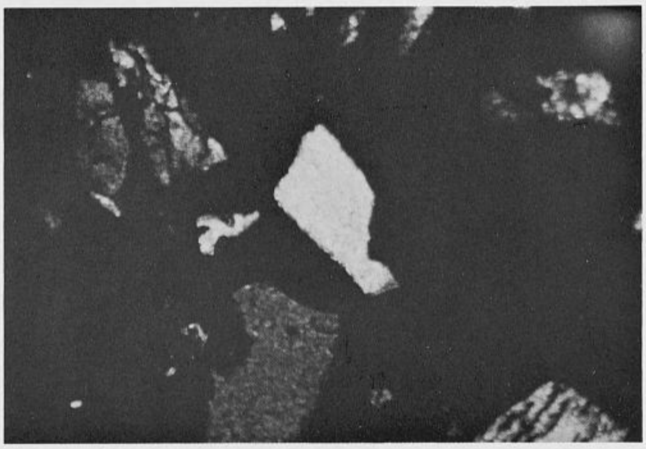


Fig. 46. (Locality 7) Photomicrograph (x150) of thin section of a quartz grain of volcanic origin. Notice straight sides and straight extinction (X-nicols).

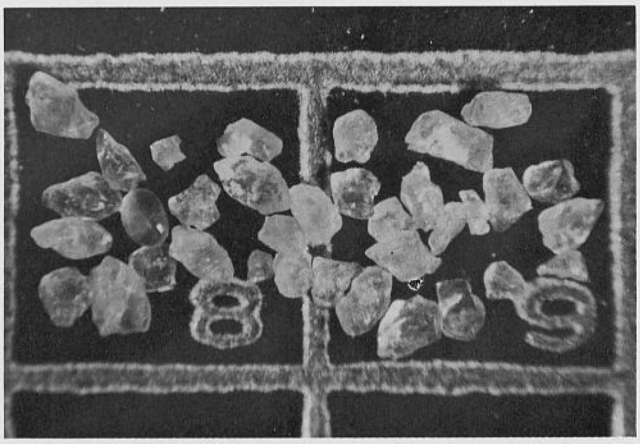


Fig. 44. (Locality 41) Photomicrograph (x55) of medium-sized sand grains. Notice the one medium well-rounded grain in the center of square number 8. Such rounded grains make up to 5 percent of the sample volume.

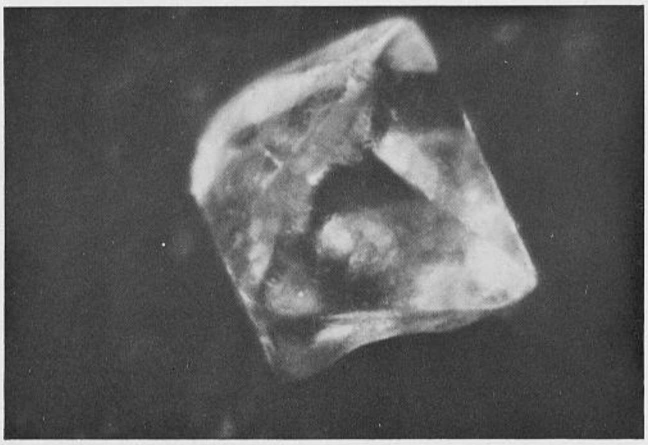


Fig. 47. (Locality 25) Photomicrograph (x340) of medium-sized hexagonal bipyramidal volcanic quartz grain. Such quartz grains are visible in most sand samples to the extent of 1 or 2 percent.

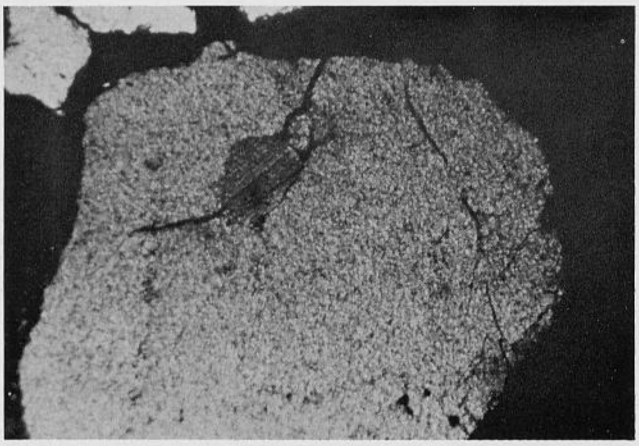


Fig. 45. (Locality 41) Photomicrograph (x430) of thin section of plutonic quartz grain with inclusion. Notice slightly undulose extinction (X-nicols).

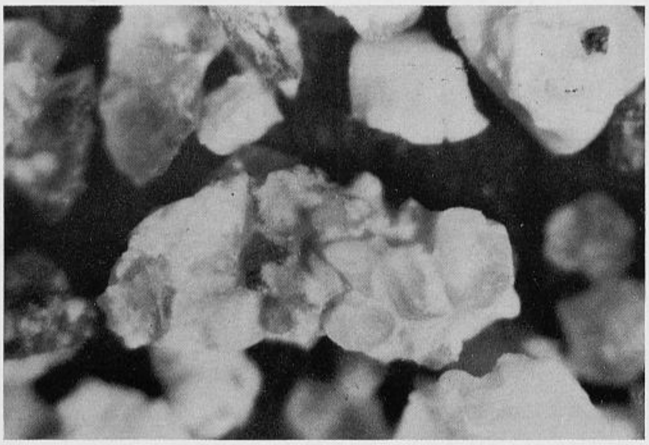


Fig. 48. (Locality 13) Photomicrograph (x140) of medium-sized clay pellet with quartz silt imbedded within it. Such pellets are common within the point-bar, chute-bar, and chute-channel lag facies.

The kaolin pellets are white and usually enclose scattered silt-sized quartz grains (Fig. 48). They range from discrete spherical bodies to ones which have been completely distorted by the pressure of neighboring quartz grains (Fig. 53).

Typical of both the authigenic kaolin and the kaolin pseudormorphs is a silky luster. The authigenic kaolin occurs as rod-like accordions (Fig. 49) composed of many crystalline layers. The pseudomorphs are characterized by their shape and relict cleavage planes (Figs. 50, 51).

Throughout the facies a small amount of disseminated clay is found adhered to the quartz grains. Because most of the clay occurs as sand-sized grains (pellets, authigenic books, and pseudomorphs), the rock preserves its original porosity and permeability. For this reason the Simsboro is an excellent aquifer in the region. If the clay fraction had occurred as a matrix, then permeability would have been destroyed (Kohls, 1967, p. 200; Fig. 53).

CHUTE-BAR FACIES

The chute-bar facies is most typically exposed at Locality 13 (Figs. 2, 54), and it is a fine- to medium-grained kaolinitic quartz sand (Appendix I). Mineralogically and petrographically this facies is identical to the point-bar facies except in two respects: (1) the chute-bar facies contains little or no coarse-grained sand and (2) the chute-bar facies contains no petrified or carbonized plant fragments.

The distinguishing characteristic of this facies is its bed geometry (Fig. 54). This white to light-gray sand occurs filling large channels up to several hundred feet in length and several tens of feet in depth (Kohls, 1967, p. 187). In an outcrop exposure the channels appear as lenticular-shaped sand bodies associated vertically and laterally with overbank and chute-channel lag deposits. Although trough and festoon cross-bedding are present, they are usually not well developed or visibly pronounced.

OVERBANK FACIES

The overbank facies consists of thinly laminated (5 to 20mm) grayish sand, silt, and slightly carbonaceous clay (Fig. 55). Usually the facies is found in the upper Simsboro Formation near the Simsboro-Calvert Bluff contact.

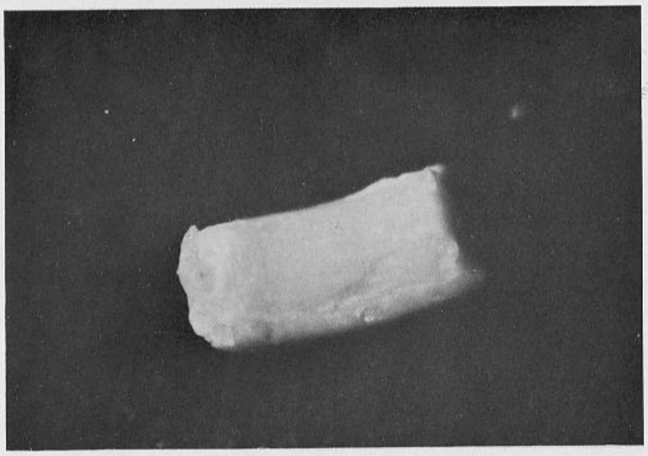


Fig. 49. (Locality 25) Photomicrograph (x140) of medium-sized authigenic kaolin "accordion."

Fig. 51. (Locality 41) Photomicrograph (x140) of medium-sized grain of kaolin pseudomorphs after potassium feldspar.

Fig. 50. (Locality 7) Photomicrograph (x140) of medium-sized grain of kaolin pseudomorphs after muscovite.

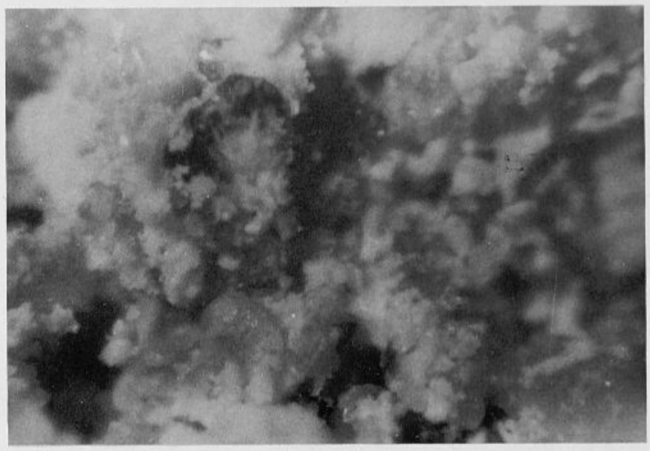


Fig. 52. (Locality 13) Photomicrograph (x140) of freshly broken surface of friable sand. Notice the disseminated clay flakes adhering to the quartz grains.

The sand and silt fraction is composed dominantly of quartz (90 percent), with lesser amounts of muscovite (5 percent), chert (3 percent), and other rocks and minerals. Muscovite appears more common than it really is because it occurs as larger grains and is highly reflective. The sand is dominantly fine to very fine grained (.25 to .0625mm) with some medium grained also present (Appendix I). Most of the quartz grains range from subangular to very angular and display straight to slightly undulose extinction.

Clay, within the facies, occurs in three forms: (1) as a clay matrix within the sandy and silty layers, (2) as thinly laminated layers of clay, and (3) as small clay pebbles. In each case the clay is dominantly kaolinite, but it contains a greater percentage of illite than does the clay of the other facies. Occasionally, thin seams of clay pebble conglomerate are found interbedded with the laminated sands and clays.

This facies is most typically exposed at Locality 30 in Robertson County where it is approximately 15 feet thick. At other localities it ranges from 1 to 10 feet in thickness. Other than the thin laminations, no sedimentary structures were observed.

CHUTE-CHANNEL LAG FACIES

The chute-channel lag facies of the Simsboro is probably the most spectacular deposit within the formation. It ranges from a clay pebble to clay boulder conglomerate (Fig. 56). Abundant angular gray clay pebbles, cobbles, and boulders are found in a sand matrix.

The clay clasts are randomly oriented (Fig. 57) and poorly sorted for clay pebbles and boulders may occur in

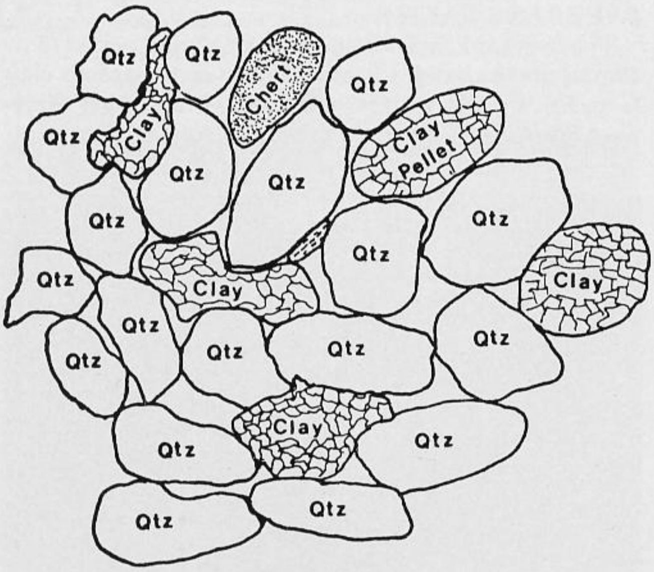


Fig. 53. Diagrammatic representation showing the effect of clay on the porosity of the Simsboro Sand. Note that the framework of the rock results in preservation of porosity (Modified from Kohls, 1967, p. 200).

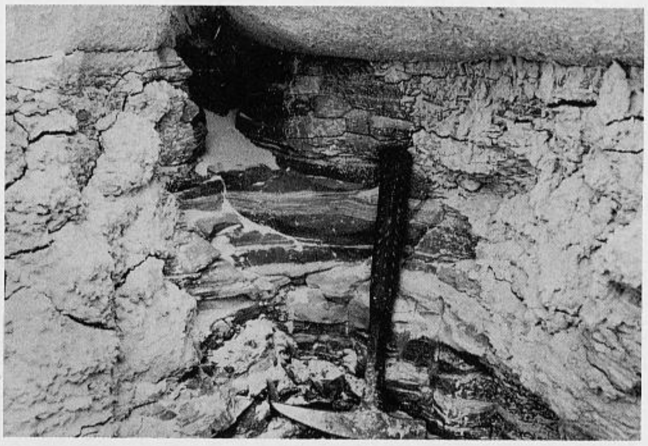


Fig. 55. (Locality 25) Finely laminated sand and clay of the overbank facies. This facies is usually preserved only in the upper Simsboro Formation.

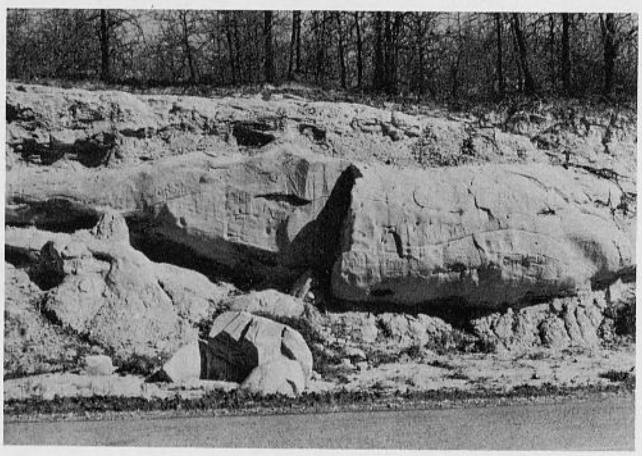


Fig. 54. (Locality 13) Lenticular sand body characteristic of the chute-bar facies. Notice its massive nature.

Fig. 56. (Locality 13) Mudstone conglomerate interbedded with lenticular sand bodies of the chute-channel lag and chute-bar facies. The mudstone conglomerate is the characteristic deposit of the chute-channel lag facies.

close proximity. Many of the clasts have thin brown silty layers and thin parallel laminations (Fig. 57). Other clasts are composed of very fine-grained homogeneous clay and exhibit concoidal fracture (Fig. 58).

Clay also occurs in the sand matrix as: (1) kaolin pellets, (2) authigenic kaolin accordions, (3) kaolin pseudomorphs, and (4) as disseminated clay. Clay occurrence in the sand matrix is identical to its occurrence in the point-bar facies. Again the clay is found to be dominantly kaolinite with lesser amounts of illite (Fig. 32).

The sand matrix is similar to the chute-bar facies sand except no sedimentary structures were observed.

These clay conglomerate deposits occur as lenticular bodies associated vertically and laterally with both the point-bar facies and the chute-bar facies.

ABANDONED-CHANNEL FACIES

The abandoned-channel facies consists of laterally continuous beds of fine-grained homogeneous clay and silty clay. It is typically exposed at Locality 16 and usually occurs in the uppermost part of the Simsboro Formation.

Lithologically the facies is characterized by the predominance of clay and lack of sand. The clay is gray, weathers to a light gray, and exhibits concoidal fracture when dry or moist (Fig. 59). As the clay becomes more silty, it no longer exhibits distinct concoidal fracture. When wet the clay becomes plastic and sticky. The clay is dominantly kaolinite with some illite present (Fig. 32).

The clay and silty clay are homogeneous without visible sedimentary structures. Both laterally and vertically this facies is associated with the point-bar and overbank facies.

Fig. 58. (Locality 13) Randomly oriented homogeneous clay, typical of the chute-channel lag facies. Notice the concoidal fracture characteristic of the pure clay clast.

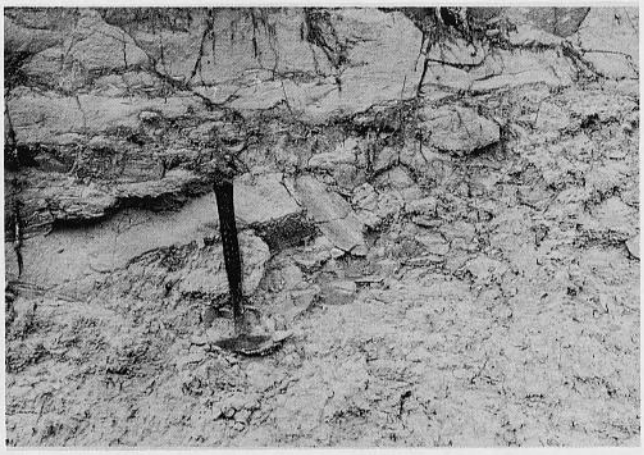


Fig. 57. (Locality 13) Randomly oriented clay clast with thin laminations marking relict bedding; this is typical of the chute-channel lag facies. The clay clast to the right of the hammer is thought to have been originally deposited as an overbank deposit.

Fig. 59. (Locality 16) Massive clay bed of the abandoned-channel facies. Notice the concoidal fracture of the clay.

PALEONTOLOGY

In most stratigraphic studies of this type, fossils are a major consideration in determining environmental conditions. However, throughout the study area no animal fossils were found, but silicified wood and carbonized plant materials were present at most localities. Most notable was the silicified wood found at Localities 41 and 49. At Locality 41 several silicified logs were found in horizontal position (Fig. 60), whereas at Locality 49 a thin bed of silicified and carbonized wood was present (Fig. 61). Nowhere was there found fossil wood in growth position.

Based on thin sections the silicified wood was identified as the angiosperm, *Salix sp.* (Figs. 62, 63), more commonly known as "Willow" (Hurst, 1977, oral communication). Today willow trees flourish best in humid climates close to a stream or river (Hurst, 1977, oral communication). Carbonized wood and plant fragments were scattered throughout the Simsboro, but they could not be identified by conventional means.

The absence of fossils in the Simsboro is a reflection of the conditions of sedimentation and diagenesis, rather than a lack of preservable material. Most animal and plant remains were destroyed because of the high permeability of the sands.

Fig. 60. (Locality 40) Silicified log in the point-bar facies. Notice that the log is in horizontal position, and not in growth position. Apparently the log was hollow before it was silicified.

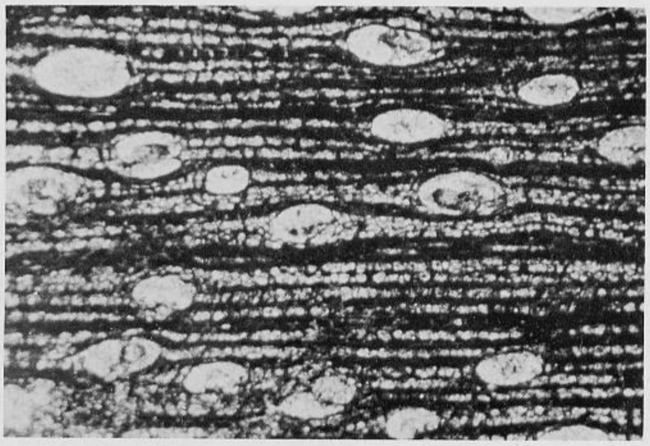


Fig. 62. (Locality 49) Photomicrograph (x150) of thin section of fossil wood identified as *Salix sp.* This is a transverse cross section.

Fig. 61. (Locality 49) Layer of silicified and carbonized wood marking the Hooper-Simsboro contact. Note that the wood occurs as fragments and was apparently fragmental when it was deposited.

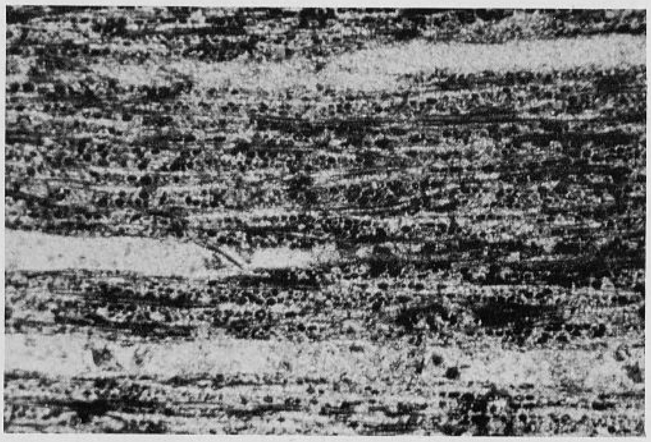


Fig. 63. (Locality 49) Photomicrograph (x150) of thin section of fossil wood identified as *Salix sp.* This is a transverse cross section.

PROVENANCE

It has been suggested that the most probable and major source area for the Simsboro was the Ouachita Mountains and surrounding areas of Oklahoma and Arkansas. A "minor amount of well-rounded, reworked grains was supplied by supermature Cambro-Ordovician and/or Cretaceous sedimentary rocks" from the continental interior. The high-grade metamorphic minerals are believed to have been ultimately derived from the southern Appalachians (Todd and Folk, 1957, p. 2545-2566; Kohls, 1967, p. 202). However, this theory is here rejected for several reasons.

It is doubtful that the Ouachita Mountains could have supplied the detritus necessary to form the Simsboro Sand. The clastic formations of the Ouachita Uplift are dominated by fine- to very fine-grained sand, displaying strain shadows and undulatory extinction (Goldstein, 1959, p. 97-116). The Simsboro, however, is dominated by medium-grained sand displaying straight extinction. Also, no novaculite grains from the Arkansas Novaculite Formation are found in the Simsboro Sand. The lack of "Ouachita-type" sand in the Simsboro points away from a Ouachita source area.

It is unlikely that a northeastern source area (i.e., Ouachita Mountains) could account for the remarkably uniform lithology throughout the Simsboro. If the source area had been to the northeast, some type of mineralogic, petrographic, or sedimentologic differentiation would be expected from north to south. However, this does not occur.

The regional sedimentary dip and strike of the Late Cretaceous, Tertiary, and Quaternary rocks of Texas indicate that deposition has been continuous and supplied largely from northwestern sources. Today we find modern Texas rivers flowing from the northwest of central Texas. During deposition of the Simsboro Sand, the same basic hydrodynamic system probably prevailed with the uplift of the Laramide orogeny supplying the initial gradient. A humid, subtropical climate in the sediment source area is indicated by the lithology, texture, size, and amount of detritus supplied to the study area. "The trends of the major drainage basins in Texas may have been established as early as Eocene" (Epps, 1973, p. 36). The Simsboro "extended a considerable distance northwest of the present outcrop, probably coincident with the general courses of the main Wilcox stream systems" (Fisher and McGowen, 1969, p. 36). The suggestions of a northeastern source area were based purely on mineralogic data with little regard to hydrodynamics.

In an extensive study of the heavy minerals present in the Simsboro, Kohls (1967, p. 195) found that zircon, tourmaline, and rutile comprised 80 percent or more of the non-opaque suite. These three minerals are indicative of acidic igneous and high-grade metamorphic rocks (Mason and Berry, 1968). Although many of these are rounded and probably reworked from older sediments, some are euhedral crystals (Fig. 64) and indicate first cycle sedimentation. These euhedral and angular first cycle minerals probably originated in the high-grade metamorphic and acidic igneous rocks of the Rocky Mountains. The heavy mineral suite remains essentially constant throughout the length of the Simsboro outcrop belt, suggesting not only a northwestern source but suggestive of a single northwestern source rather than a series of individual streams.

The major portion of the quartz sand in the Simsboro is of the common or plutonic type (Folk, 1968, p. 70) with as much as 10 percent volcanic type. Most of the sand is angular and appears to be first cycle. Very little of the sand appears to be of a reworked or metamorphic origin as might be expected if the Ouachita Mountains or southern Appalachians were the source area.

The most probable geographic locations of the Simsboro source are: (1) the Rocky Mountains of New Mexico and Colorado and (2) the Mesozoic and Paleozoic sediments of north Texas and eastern New Mexico and Colorado. The Rocky Mountains supplied the most (>90 percent) of the detritus.

Fig. 64. (Locality 21) Photomicrograph (x340) of doubly terminated fine-sized zircon crystals. Notice euhedral form indicative of volcanic origin, and the well preserved crystal form suggestive of first cycle seidments.

OCCURRENCE AND FORMATION OF KAOLINITE WITHIN THE SIMSBORO

Kaolinite occurs within the Simsboro as: (1) clay pebbles, cobbles, and boulders, (2) beds of clay and silty clay, (3) clay pellets, (4) pseudomorphs after potassium feldspar and muscovite, (5) disseminated clay and (6) kaolin accordions.

The kaolinite was derived from two major sources: (1) the acid leaching of igneous alkaline rocks in the Rocky Mountains and (2) the physical and chemical weathering of the Cretaceous shales of central and north Texas.

Igneous alkaline rocks of the ancestral Rocky Mountains consisted primarily of feldspars and micas. Plagioclase feldspar and biotite were the first to kaolinize; very little, if any, survived transport. Potassium feldspar and muscovite did not kaolinize quite as rapidly with some still present in the rock. Leaching of the potassium feldspar and muscovite continued during active transport and now continues during diagenesis.

Much of the kaolinite in the Simsboro Formation may have been derived from Cretaceous shales undergoing erosion at the time of Simsboro deposition. These shales are composed principally of marine smectites with lesser amounts of illites and kaolinites (Fig. 65). Smectites will alter into kaolinite under proper conditions. Although illite is more stable than smectite, illite too will become kaolinite if weathering is prolonged or intense enough.

Not only was kaolinization of potassium feldspar and muscovite common during diagenesis of the Simsboro, but also neoformation of kaolinite accordions occurred. "Kaolinite is a diagenetic product common in the course of evolution of permeable sediments subject to the circulation of acid waters which ensure underground evolutions similar to those occurring during weathering: hydrolysis of silicates, release of ions, combination of silica and alumina into minerals of the kaolinite family" (Millot, 1970, p. 327).

DEPOSITIONAL HISTORY

Preceding the earliest Wilcox sedimentation, the Midway was a time of marine deposition. Midway rocks extend far inland as a rather thin wedge (Fig. 17) and reflect a period of slow marine deposition (Storm, 1945, p. 1321).

Toward the close of Midway deposition, a retreat of the seas was accompanied by a change in sedimentation. The marine deposits of the Midway Group were overlain by the coarser deltaic clastics of the Wilcox Group. The Midway-Wilcox contact is considered to be disconformable. The absence of a widespread unconformity suggests that this sharp transition was due more to "a climatic change, the uncovering of coarser source rocks, and possible isostatic adjustment" (Echols and Malkin, 1948, p. 16-17) than to tectonic factors in the Gulf Coast.

Earliest Wilcox (Hooper) sedimentation was rapid in comparison to Midway and prograded rapidly seaward. In the study area, Hooper sediments are characteristically prodelta clay and silt. As sedimentation continued, the Hooper graded upward into coarser delta-front silt and sand (Fig. 18). The Hooper marks the beginning of a major progradational phase, possibly triggered by uplift of the Laramide Rocky Mountains and/or a significant change in climate to a more humid phase, which had as its culmination the deposition of the Simsboro Formation. Apparently much of the Hooper and Simsboro are time equivalent as updip Simsboro deposition and downdip Hooper deposition occurred simultaneously.

In any one area, the Hooper-Simsboro contact marks the end of deltaic and the beginning of fluvial deposition. The Simsboro was deposited by a highly meandering fluvial system immediately upstream from the delta-front environment of the Hooper (Fig. 12). Deposition was not continuous in any one area for the fluvial system was characterized by recurrent lateral migration (Fig. 66).

Deposition of the Simsboro Sand was very rapid even in comparison to the Hooper Formation. Clay and silt deposits (Figs. 27, 28) of the upper Simsboro Formation suggest that deposition suddenly slowed. This may have been the result of a regional climatic change or of river avulsion and the generation of a new river mound.

Kemp—Dominantly Smectite (Barnes, 1970).

Taylor Marl—70% of Lower Taylor Marl is Smectite with some Illite, Upper Taylor Marl is dominantly Smectite (Beall, 1964, p. 16-19).

South Bosque—Dominantly Smectite (Burket, 1965, p. 25-26).

Lake Waco—Dominantly Smectite (Burket, 1965, p. 28).

Pepper—20% Smectite, 20% Illite, and 20% Kaolinite (Burket, 1965, p. 29).

Del Rio—10% Smectite, 20% Illite, 20% Kaolinite (Burket, 1965, p. 35).

Fig. 65. Mineralogic composition of central Texas Cretaceous shales upon which the Mt. Pleasant Fluvial System is believed to have developed.

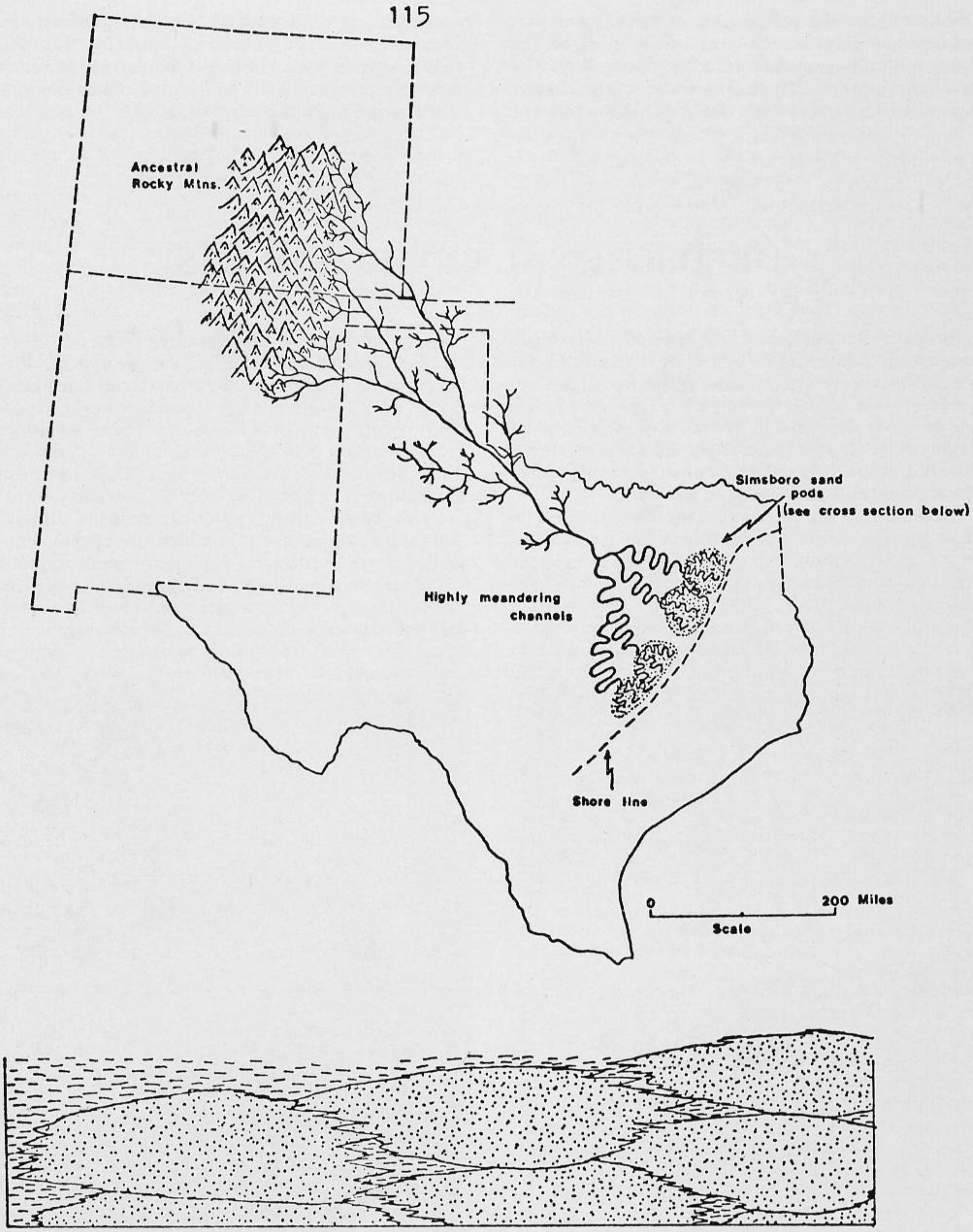


Fig. 66. Diagrammatic map of postulated Simsboro River system and cross section of pod-like sand bodies which were deposited by this system as the Simsboro Formation. Each pod was deposited at a different time as the river meandered by avulsion. This interpretation is suggested by the uniformity of sediment types throughout the extent of the Simsboro outcrop area.

Following Simsboro deposition, extensive lignites and carbonaceous clays accumulated as delta-plain blanket peats on subsiding abandoned deltas during lower Calvert Bluff deposition. These delta-plain clays and lignites are overlain by more coarsely clastic distributary channel deposits and/or delta-front sequences, indicating the start of another progradational phase (Fig. 18). Wilcox sedimentation ended with deltaic deposition and was unconformably overlain by braided stream deposits of the Carrizo Sand (Kaiser, 1974, p. 17).

DEPOSITIONAL ENVIRONMENTS

The Simsboro Formation was deposited as a highly meandering channel facies of the Mt. Pleasant Fluvial System which was the main feeder for the Rockdale Delta System (Fisher and McGowen, 1967; Figs. 12, 13). The Simsboro was deposited in five subenvironments which roughly correlate with the stratigraphic facies previously described: (1) point bar, (2) scour pool, (3) chute channel, (4) overbank, and (5) abandoned channel.

The most dynamic of the subenvironments, where the major portion of the sediments accumulated, was the point bar. Deposition on point bars results from lateral migration of meandering rivers during floodstage (Reineck and Singh, 1975, p. 231). Point-bar deposits in the Simsboro are composed of extensively cross-bedded fine- to coarse-grained kaolinitic sand. These deposits have been divided into lower point-bar and upper point-bar features (McGowen and Garner, 1970, p. 15-19; Figs. 14, 15, 67, 68). The lower point-bar deposits are characterized by small foreset cross-bedding (Figs. 31, 34) small trough-fill cross-bedding (Fig. 35); the upper point-bar deposits are characterized by large foreset cross-bedding (Fig. 36). The lower point-bar sediments were deposited during both normal and floodstage. The upper point-bar rocks indicate high energy and extreme flooding and were deposited on the convex bank when the thread of maximum velocity shifted from the concave toward the convex bank. Ideally, point-bar deposits display an upward fining sequence in which the upper point-bar deposits are overlain by climbing or small ripples and ultimately by a mud drape. In most places, the uppermost fine-grained part of the sequence was eroded away before the next sequence was deposited. Deposition of these fine upper sequences was limited because most of the sediments supplied to the system were too coarse (McGowen and Garner, 1970, p. 15-19). Climbing ripples which occur at Locality 38 not only indicate the waning stages of a flood, but also mark the close of Simsboro fluvial deposition in the area (Fig. 26).

Petrified wood is commonly found in the upper point-bar deposits (Fig. 60). The appearance and attitude of the logs suggest that they were washed in during floodstage (Fig. 69) and then were gradually covered by successive flooding. Preservation of the wood occurred only when rapid burial was achieved.

The scour pool and fill subenvironment (Figs. 14, 15, 67) is genetically related to the point bar, but it occurs in

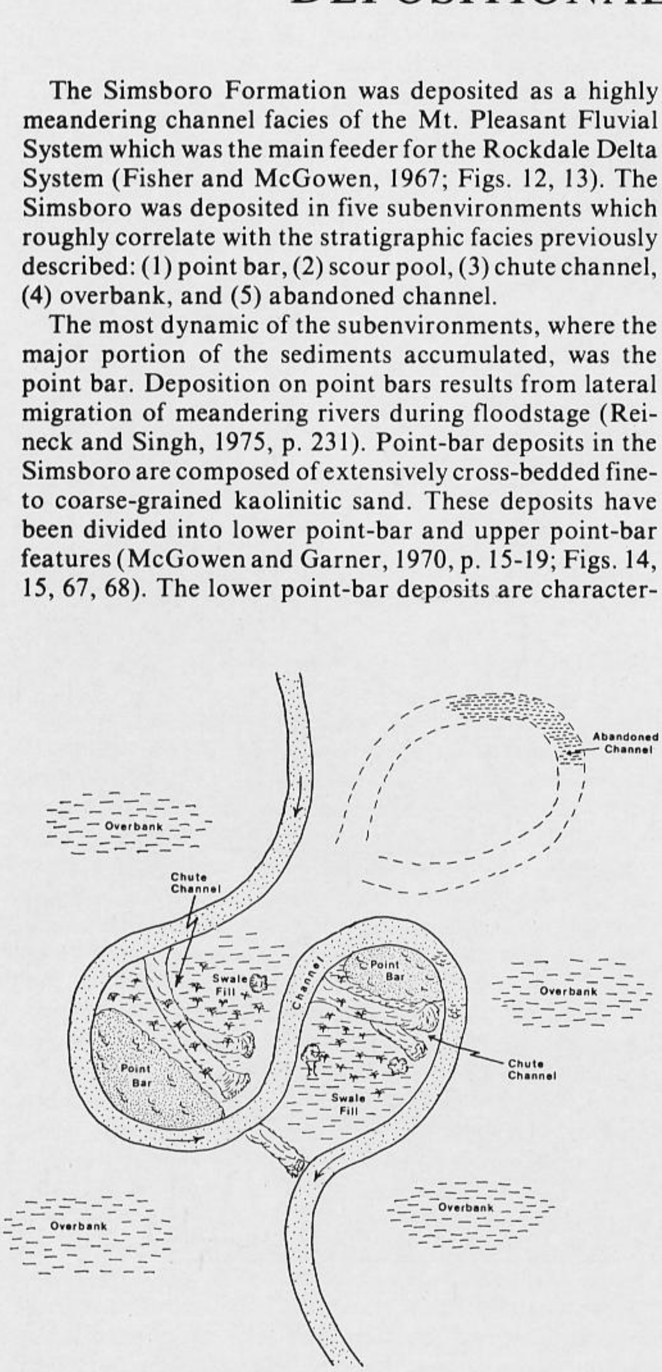


Fig. 67. Idealized plan view of postulated Simsboro depositional environments.

Fig. 68. Upper point-bar surface of modern Brazos River sediments. Notice the lower point-bar and river in left of picture. It is thought that the point bars during Simsboro deposition were similar in appearance.

the channel proper. Scour-pool and fill deposits are composed of fine-to coarse-grained kaolinitic sand and occur as lenticular-shaped bodies interbedded with point-bar deposits (Fig. 70). Scour-pool and fill deposits are either featureless or display trough-fill and festoon cross-bedding. The lack of sedimentary structures in the featureless sand bodies suggests that they were deposited in tranquil or low-water conditions. Trough-fill and festoon cross-bedding are indicative of a somewhat higher energy environment (minor to moderate flooding). This cross-bedding formed in response to scour and fill occurring on the channel floor. After troughs were scoured out by the action of flowing water, sand slowly refilled these troughs layer by layer.

Although overbank or floodplain sedimentation was common during Simsboro deposition, little record of this subenvironment is preserved. Finely laminated clays, silts, and sands are typical of this environment (Fig. 55). Sedimentation occurred in the broad flat areas adjacent to the channel and point-bar areas (Fig. 67). Floodplains act as settling basins, in which suspended fine-grained sediment settles down from overbank flows. After the sediment-laden water leaves the confined channel, it rapidly spreads out into a sheet and loses its sediment-carrying capacity. Deposition begins with a sand layer becoming silty upward. Occasionally small-scale cross- and ripple-bedding is developed. The sand and silt layers then grade upward into a finely laminated clay as the water ceases to flow. Thus each successive flood or pulse is marked by a sand-silt-clay unit a few centimeters (Fig. 55) to several decimeters (Fig. 71) thick.

Highly meandering rivers, such as those responsible for Simsboro deposition, do not have well-developed floodplains. In these rivers velocities of overbank flows are very rapid; commonly current velocities up to 50 cm/sec are recorded (Leopold and Wolman, 1957). In such cases flood-plain deposits consist not only of muddy sediments, but also of an abundance of sand.

Abandoned channel deposits occur in channel areas that have been abandoned because of cutoff processes or avulsion, i.e., by the sudden abandonment of a part or the whole of a channel course (Reineck and Singh, 1975, p. 248; Fig. 72). Fine-grained clay and silty clay are typical of this environment.

Fig. 69. (Locality 3) Point-bar on the modern Brazos River. Notice the chute channel and the drift wood in middle and lower part of photo. It is thought that this is similar to point-bars of Simsboro time.

Fig. 70. (Locality 3) Trough cross-stratified sand body interbedded with foreset cross-stratified sand body; interpreted as interbedded scour pool and lower point-bar deposits.

Fig. 71. (Locality 25) Truncated clay and sand layers in a massive sand section. This is interpreted as evidence of successive major floods.

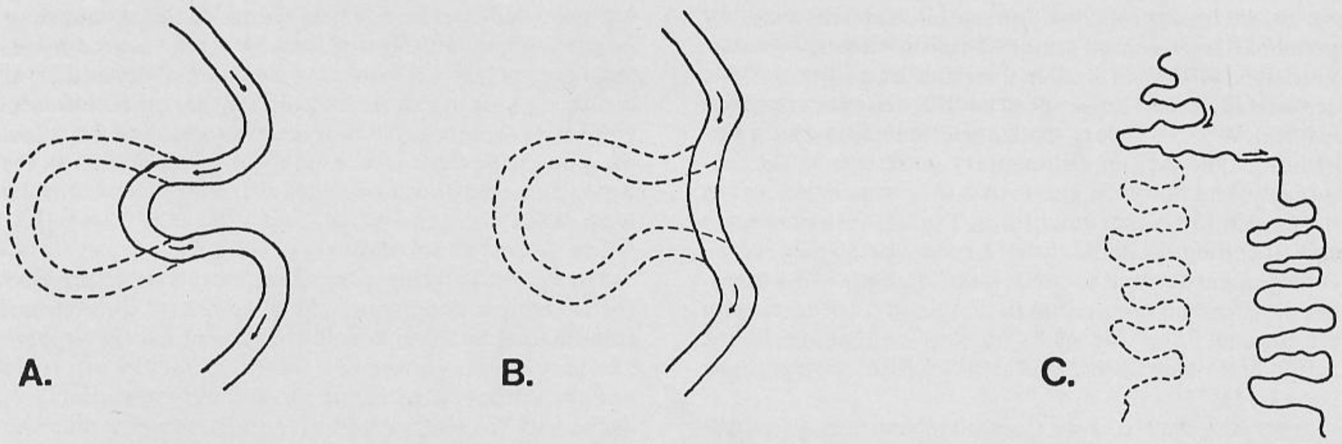


Fig. 72. Diagram showing three modes of abandoning river channels. A. Chute cut-off, B. Neck cut-off, C. Avulsion. All three of these may have been involved in Simsboro deposition, but avulsion is considered the method which best explains the very wide exposure of Simsboro deposits (Modified after Allen, 1965, p. 119).

The cutoff process occurs when the stream shortens its course and thus locally increases slope. Two types of stream cutoff are known (Fisk, 1944); (1) chute cutoff occurs when a stream in a meander loop shortens its course by cutting a new channel along the swale of a point bar (Fig. 72-A) and (2) neck cutoff occurs when a stream cuts a new channel through the narrow neck between two meander loops (Fig. 72-B). These processes, together with avulsion (Fig. 72-C), were common during Simsboro deposition. However, the great outcrop width of Simsboro exposure is best explained by avulsion.

Abandoned channel deposits are usually preserved only in the upper Simsboro, and in many cases mark the Simsboro-Calvert Bluff contact (Fig. 27). These deposits resulted from avulsion of the channel course rather than local meander cutoff. Fluvial deposition in the area of avulsion was quickly terminated and low-energy deltaic sedimentation began. Avulsion and local meander cutoff occurred throughout Simsboro time, but the fine-grained sediments characteristic of this facies were largely later destroyed when fluvial deposition returned to the area.

Behind and slightly above the point-bar environment, deposition of the chute channel environment occurred (Fig. 67) during exteme floodstage. Chute deposits consist of: (1) chute-bar deposits and (2) chute-channel lag deposits. Chute-bar deposits are massive lenticular fine- to coarse-grained sand deposits (Fig. 54), usually with small kaolinitic clay pebbles and interstitial clay. Chute bars are both lateral and vertical accretionary deposits and develop downcurrent from chutes (Fig. 14). They develop only under rapid-flow conditions of extreme flooding. Sediments forming the chute bar were transported as a sand-water-clay slurry or heavy fluid (McGowen and Garner, 1970, p. 6)

The chute channel lag subenvironment was characterized by the deposition of clay pebble to clay boulder conglomerates found in a sand matrix (Fig. 56). As indicated by relict bedding (Fig. 57) or homogeneous texture (Fig. 58) within the larger clay clasts, the clay was initially deposited as overbank or abandoned channel clay. Frequently the laminated clay was initially deposited as swale fill (Fig. 67) on the convex bank, and later ripped up during flooding as a temporary chute channel came through the area. In other cases, the laminated clay was initially deposited on the concave bank and later caved into the stream as the water undercut the sediments (Figs. 14, 67). The homogeneous clay (Fig. 58) was initially deposited as a result of channel abandonment and then later ripped up as a chute channel re-entered the area.

Drift wood was commonly washed into the chute channels (Fig. 69), with only a small fraction of it being preserved.

The Simsboro is composed dominantly of two constituents: quartz and kaolinite. Both quartz and kaolinite are extremely stable under surface pressure-temperature conditions. Quartz is also stable in most geochemical weathering environments except under extreme alkaline conditions. For the most part, quartz is originally crystallized in igneous rocks and undergoes only physical weathering thereafter. Kaolinite, on the other hand, is usually a product of weathering and forms by the acid leaching of certain igneous rocks. Kaolinite is not commonly found in slightly basic marine waters.

The overall predominance of these two minerals indicates a highly active weathering environment in which only the most stable minerals could survive complete transport. A tropical or semi-tropical climate existed in Arkansas and most of Texas during early Eocene time, which apparently gave rise to slightly acidic waters. As the Mt. Pleasant Fluvial System drained from the Rocky Mountains through central and north-central Texas, most of the igneous minerals together with the clays derived from Cretaceous outcrop areas were extensively weathered and transformed into kaolinite.

The abundance of kaolinite also indicates that the area was well drained. It is a mineral typical of continental weathering in which solutions percolate and are purified of unstable ions. Kaolinite does not form or will itself alter if the area becomes stagnant or a basin of accumulation for ions. The formation of kaolinite depends on the continuation of a well-drained area (Grim, 1968, p. 578-594).

The widespread occurrence of muscovite throughout the Simsboro appears inconsistent with a highly weathering environment. Muscovite is only moderately stable and will readily decompose in acidic weathering environments. However, muscovite is unique in that because of its platy occurrence it can be transported even under tranquil conditions. Its presence indicates that deposition of the Simsboro was rapid enough to prevent decomposition of at least a part of the muscovite. Preservation of the muscovite also indicates that transport from the source to the study area was continuous with little intermittent ponding, and that the source area consisted of alkaline igneous rock of a type which would provide muscovite flakes larger than 4mm in diameter.

The overwhelming lithologic similarity exhibited throughout the Simsboro indicates that it was deposited by one major river system (Fig. 66), the Mt. Pleasant Fluvial System (Fisher and McGowen, 1967, p. 107).

As the river entered the study area, extensive meandering occurred as the river tried to extend its length in response to the drastic environmental change just downstream where it began deltaic deposition. Apparently the Simsboro was deposited in pods as the river shifted its course from time to time because of avulsion (Fig. 66). The river remained in one area as long as subsidence kept pace with deposition, whereupon it shifted position to a more favorable gradient.

In two respects the Simsboro deposits around Rockdale are slightly different from the rest of the formation: (1) they contain 3 to 4 percent more potassium feldspar, and (2) they contain an overall coarser fraction (Appendix I).

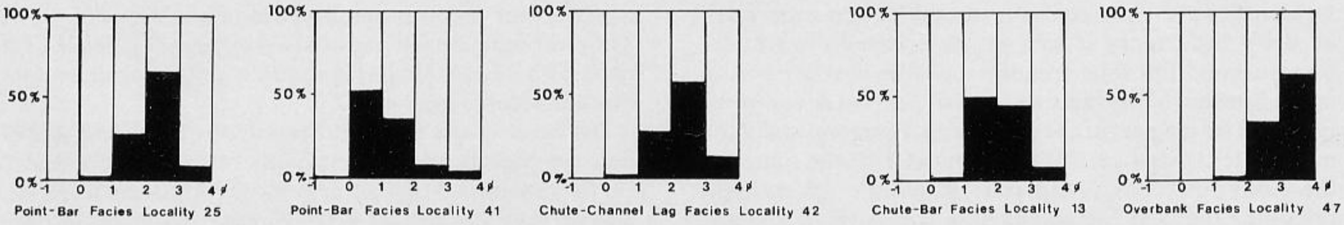
These slight differences suggest that at the time of deposition of this "pod" there was a minor orogenic pulse in the source area. Other pods can be recognized in a geologic map where thickening and thinning of the Simsboro outcrop belt can be seen (Figs. 2, 66).

CONCLUSIONS

1. The Simsboro Formation, of the Wilcox Group, crops out as a gentle escarpment in Freestone, Limestone, Falls, Robertson, Milam, Williamson, Lee, and Bastrop Counties.
2. The Simsboro Formation was deposited in the highly meandering channel facies of the Mt. Pleasant Fluvial System, the main feeder for the Rockdale Delta System.
3. The Simsboro Formation can be divided into five facies on the basis of lithology, sedimentary structures and bed geometry: (1) point bar, (2) chute bar, (3) overbank, (4) chute channel lag, and (5) abandoned channel.
4. The Simsboro Formation was deposited in five subenvironments: (1) point bar, (2) scour pool and fill, (3) chute channel, (4) overbank, and (5) abandoned channel.
5. The kaolinite in the Simsboro was formed by the acid leaching of: (1) Cretaceous shales of central and north-central Texas and (2) igneous alkaline rocks of the Rocky Mountains of New Mexico and Colorado.
6. The major portion of the sand in the Simsboro was weathered from the Rocky Mountains of New Mexico and Colorado. Minor amounts of well-rounded, reworked sand grains were derived from the Mesozoic and Paleozoic rocks of central and north-central Texas.
7. The paleogeochemical environment at the time of Simsboro deposition was dominated by a hot, humid, tropical climate. The area was well drained with slightly acidic waters and well-oxygenated conditions.
8. Few fossils are preserved because of the unfavorable geochemical conditions at the time of deposition.
9. Within the Simsboro Formation, pure quartz and pure kaolinite are found together as a natural function of a severe weathering environment.

APPENDIX I

SAND HISTOGRAMS



Typical Histograms of facies within the Simsboro showing percentages of sand grain sizes present.

APPENDIX II

LOCALITIES

Locality 1. Freestone County (31°56′N, 96°08′W; Winkler Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in a tributary of Little Sandy Creek on the northeast side of county road, 1 mile south of FM 416, 2.5 miles east of St. Elmo.

Locality 2. Freestone County (31°51′N, 96°10′W; Stewards Mill Quadrangle). Simsboro Formation, consisting of medium-to coarse-grained cross-bedded sand. Exposed in bar ditch on east side of county road, 1 mile north of Bonnerville and intersection with FM 833.

Locality 3. Freestone County (31°49′N, 96°13′W; Stewards Mill Quadrangle). Simsboro Formation, consisting of interbedded sand and clay lenses. Exposed in road cut on both sides of FM 833, one-quarter mile north of Stewards Mill.

Locality 4. Freestone County (31°48′30″N, 96°14′30″W; Stewards Mill Quadrangle). Simsboro Formation, consisting of extensively weathered featureless medium-grained sand. Exposed in road cut on east side of U.S. 77, 0.1 mile south of junction with FM 833.

Locality 5. Freestone County (31°44′30″N, 96°14′30″W; Fairfield Quadrangle). Simsboro and Calvert Bluff Formations, consisting of fine- to medium-grained sand grading upward into beds of fine sand, silt, and carbonaceous clay. Exposed in road cut on north side of FM 27, 4 miles west of Fairfield.

Locality 6. Freestone County (31°44′30″N, 96°14′30″W; Fairfield Quadrangle). Calvert Bluff Formation, consisting of fine sands, silts, and carbonaceous clays. Exposed in road cut on north side of FM 27, 3.8 miles west of Fairfield.

Locality 7. Freestone County (31°41′30″N, 96°17′W; Teague North Quadrangle). Simsboro and Calvert Bluff Formations, consisting of medium-grained cross-bedded sands overlain by beds of lignite, clay, and fine sand. Exposed in abandoned clay pit 3 miles east of Simsboro on north side of county road.

Locality 8. Freestone County (31°40′30″N, 96°16′30″W; Teague North Quadrangle). Simsboro Formation, consisting of medium- to coarse-grained cross-bedded sand. Exposed in bar ditch on east side of county road, 1 mile north of intersection with FM 1367, which is 2.5 miles north of Teague.

Locality 9. Freestone County (31°40′30″N, 96°18′30″W; Teague North Quadrangle). Simsboro Formation, consisting of fine- to medium-grained sand. Exposed in road cut on north side of county road, 1 mile east of Simsboro.

Locality 10. Freestone County (31°39′N, 96°18′W; Teague North Quadrangle). Simsboro Formation, consisting of fine- to medium-grained sand interbedded with beds of clay. Exposed in clay pit by Upper Club Lake on county road, 1 mile west of Teague.

Locality 11. Freestone County (31°38′N, 96°18′W; Teague North Quadrangle). Simsboro Formation, consisting of white medium-grained cross-bedded sand. Exposed in railroad cut at southwest corner of Lower Club Lake, 1 mile west of Teague.

Locality 12. Freestone County (31°35′N, 96°19′W; Teague South Quadrangle). Simsboro Formation, consisting of weathered fine- to medium-grained sand. Exposed in bar ditch on south side of county road, 3 miles south of Teague, and one-quarter mile east of Holman Creek.

Locality 13. Limestone County (31°33′30″N, 96°23′W; Fallon Quadrangle). Simsboro Formation, consisting of massive lenticular sand bodies interfingering with mudstone and sand conglomerate. Exposed in road cut on both sides of FM 39, 10 miles southeast of Mexia.

Locality 14. Limestone County (31°33′N, 96°22′30″W; Teague South Quadrangle). Simsboro Formation, consisting of homogeneous medium-grained sand. Exposed in road cut on northeast side of FM 39, 11 miles southeast of Mexia.

Locality 15. Limestone County (31°31′30″N, 96°21′W; Teague South Quadrangle). Simsboro Formation, consisting of white medium-grained sand interbedded with thin clay beds. Exposed in road cut on northeast side of FM 39, 2 miles northwest of Personville.

Locality 16. Limestone County (31°31′30″N, 96°21′W; Teague South Quadrangle). Simsboro Formation, consisting of white medium-grained sand grading upward into a massive bed of white clay. Exposed in abandoned clay pit on county road to Brown's Lake, one-quarter mile east of junction with FM 39.

Locality 17. Limestone County (31°32′30″N, 96°20′30″W; Teague South Quadrangle). Simsboro Formation, consisting of cross-bedded medium- to coarse-grained sand. Exposed in bar ditch on northeast side of county road to Brown's Lake, 1.5 miles east of junction with FM 39.

Locality 18. Limestone County (31°28′30″N, 96°23′30″W; Box Church Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in bar ditch on county road, 4 miles southeast of Center, on 1.25 miles southwest of Lost Prairie.

Locality 19. Limestone County (31°26′N, 96°26′30″W; Box Church Quadrangle). Simsboro Formation, consisting of cross-bedded medium- to coarse-grained white sand. Exposed in road cut on east side of FM 937, 4 miles north of Oletha.

Locality 20. Limestone County (31°25′30″N, 96°26′W; Box Church Quadrangle). Simsboro Formation, consisting of interbedded cross-bedded sand, clay, and mudstone conglomerate. Exposed in road cut on east side of FM 937, 3.5 miles north of Oletha.

LOCALITY 21. Limestone County (31°25′N, 96°25′30″W; Box Church Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in bar ditch on east side of FM 937, 3 miles north of Oletha.

LOCALITY 22. Limestone County (31°24′N, 96°30′W; Thornton Quadrangle). Simsboro Formation, consisting of fine- to medium-grained sand. Exposed in road cut on county road, 2 miles southeast of Davis Prairie Community, which is 2 miles east of Thornton.

LOCALITY 23. Limestone County (31°23′N, 96°30′W; Thornton Quadrangle). Simsboro Formation, consisting of cross-bedded medium- to coarse-grained sand. Exposed in old pit on south side of FM 1246, 5 miles east of Thornton.

LOCALITY 24. Limestone County (31°22′30″N, 96°29′W; Box Church Quadrangle). Simsboro Formation, consisting of weathered cross-bedded medium-grained sand. Exposed in road cut on north side of FM 1246, 4 miles west of Oletha.

LOCALITY 25. Limestone County (31°19′N, 96°30′15″W; Kosse East Quadrangle). Simsboro and Calvert Bluff Formations, consisting of white, cross-bedded, medium-grained kaolinitic sand grading upward into beds of fine sand, silt, clay, and lignite. Exposed in active Dresser Atlas sand and clay pit on FM 2749, 2 miles north of intersection with State Highway 7.

LOCALITY 26. Limestone County (31°17′30″N, 96°30′30″W; Kosse East Quadrangle). Simsboro Formation, consisting of white, cross-bedded, medium-grained kaolinitic sand. Exposed in abandoned claypit on west side of FM 2749, 1 mile north of intersection with State Highway 7.

LOCALITY 27. Limestone County (31°16′N, 96°35′W; Kosse East Quadrangle). Simsboro Formation, consisting of medium- to coarse-grained cross-bedded sand. Exposed in road cut on county road, 4 miles southeast of Kosse.

LOCALITY 28. Limestone County (31°15′N, 96°35′W; Petteway Quadrangle). Simsboro Formation, consisting of gray medium-grained sand. Exposed in stream cut on county road, 5 miles southeast of Kosse.

LOCALITY 29. Robertson County (31°12′30″N, 96°36′W; Petteway Quadrangle). Simsboro Formation, consisting of cross-bedded medium- to coarse-grained sand. Exposed in small stream cut on west side of county road, 9 miles south of Kosse.

LOCALITY 30. Robertson County (31°12′N, 96°37′W; Petteway Quadrangle). Simsboro Formation, consisting of finely laminated clay, sand, and sandy clay. Exposed in road cut on White Rock Road, 4 miles east of Bremond.

LOCALITY 31. Robertson County (31°11′N, 96°38′30″W; Bremond Quadrangle). Simsboro Formation, consisting of clay bed with sand above and below it. Exposed in road cut on White Rock Road, 2.5 miles east of Bremond.

LOCALITY 32. Robertson County (31°11′N, 96°39′30″W; Bremond Quadrangle). Simsboro Formation, consisting of red-purple hematite cemented sandstone. Exposed in road cut on north side of White Rock Road, 2 miles east of Bremond.

LOCALITY 33. Robertson County (31°07′30″N, 96°37′30″W; Owensville Quadrangle). Simsboro Formation, consisting of white sandy clay. Exposed in road cut on north side of FM 46, 5 miles southeast of Bremond.

LOCALITY 34. Robertson County (31°07′N, 96°37′W; Owensville Quadrangle). Simsboro Formation, consisting of interbedded sand and clay. Exposed in bar ditch on north side of FM 46, 6 miles southeast of Bremond.

LOCALITY 35. Robertson County (31°06′30″N, 96°39′30″W; Hammond Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in stream cut on county road, 3 miles south of Bremond.

LOCALITY 36. Robertson County (31°05′30″N, 96°42′30″W; Hammond Quadrangle). Simsboro Formation, consisting of cross-bedded sand and mudstone conglomerate. Exposed in road cut on west side of State Highway 6, 0.5 mile south of Hammond.

LOCALITY 37. Robertson County (31°03′N, 96°40′W; Hammond Quadrangle). Calvert Bluff Formation, consisting of sand and mudstone conglomerate. Exposed in road cut, 4.5 miles south of Hammond on State Highway 6, then 3 miles east on county road.

LOCALITY 38. Robertson County (30°59′N, 96°45′30″W; Maysfield Quadrangle). Simsboro and Calvert Bluff Formations, consisting of cross-bedded sand overlain by silt, clay and lignite. Exposed on bluffs along Brazos River where FM 979 bridge crosses river.

LOCALITY 39. Milam County (30°49′N, 96°56′W; Cameron Quadrangle). Hooper Formation, consisting of finely laminated silts and clays. Exposed in railroad cut of the Atchison-Topeka and Santa Fe, 4 miles south of Cameron.

LOCALITY 40. Milam County (30°48′30″N, 96°56′W; Cameron Quadrangle). Simsboro Formation, consisting of cross-bedded sand and hematite cemented sand. Exposed in railroad cut of the Atchison-Topeka and Santa Fe, 4.5 miles south of Cameron.

LOCALITY 41. Milam County (30°38′30″N, 97°02′30″; Rockdale West Quadrangle). Simsboro Formation, consisting of cross-bedded medium- to coarse-grained sand. Exposed in railroad cut of Missouri-Pacific, 2 miles west of Rockdale.

LOCALITY 42. Milam County (30°38′30″N, 97°03′30″W; Rockdale West Quadrangle). Simsboro Formation, consisting of sand and mudstone conglomerate. Exposed in railroad cut of Missouri-Pacific, 3 miles west of Rockdale.

LOCALITY 43. Milam County (30°38′30″N, 97°04′W; Rockdale West Quadrangle). Hooper and Simsboro Formations, consisting of interbedded, inclined layers of sand and clay, overlain by white clayey sand. Exposed in railroad cut of Missouri-Pacific, 4 miles west of Rockdale.

LOCALITY 44. Milam County (30°38′N, 97°05′W; Rockdale West Quadrangle). Hooper Formation, consisting of slightly inclined beds of fine sand, silt, and clay. Exposed in railroad cut of Missouri-Pacific, 4.5 miles west of Rockdale.

LOCALITY 45. Milam County (30°37′30″N, 97°06′30″W; Rockdale West Quadrangle). Hooper Formation, consisting of layers of fine sand, silt, and clay. Exposed in railroad cut of Missouri-Pacific, 5.5 miles west of Rockdale.

LOCALITY 46. Milam County (30°34′N, 97°04′30″W; Alcoa Lake Quadrangle). Simsboro Formation, consisting of sand with several thin layers of clay. Exposed in abandoned gravel pit, 0.125 mile west of Alcoa Lake.

LOCALITY 47. Milam County (30°31′N, 97°07′30″W; Thorndale Quadrangle). Simsboro Formation, consisting mostly of medium-grained sand interbedded with several thin layers of clay. Exposed in abandoned pit, 7 miles southeast of Thorndale on county road, or 2 miles west of Bingham Cemetery.

LOCALITY 48. Lee County (30°23′N, 97°14′W; Lexington Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in road cut on west side of county road, 2 miles north of intersection with FM 696, in western part of county.

LOCALITY 49. Lee County (30°23′N, 97°14′W; Lexington Quadrangle). Hooper and Simsboro Formations, consisting of clay and silt overlain by medium-grained sand and clay. Exposed in abandoned clay pit on west side of county road, 1.5 miles north of intersection with FM 696, in western part of county.

LOCALITY 50. Bastrop County (30°22′N, 97°16′W; Elgin Quadrangle). Calvert Bluff Formation, consisting of sand, silt, and carbonaceous clay beds. Exposed in clay pit, 4 miles north of Butler and then 0.5 mile west on FM 696.

LOCALITY 51. Bastrop County (30°19′N, 97°21′W; Elgin Quadrangle). Simsboro Formation, consisting of medium-grained sand. Exposed in a bar ditch, 2.5 miles south of Elgin, then 0.1 mile west.

LOCALITY 52. Bastrop County (30°08′30″N, 97°27′W; Bastrop Quadrangle). Simsboro Formation, consisting of weathered medium-grained sand. Exposed in road cut on private dirt road down to Wilbargers Bend from US 290, 9 miles west of Bastrop.

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