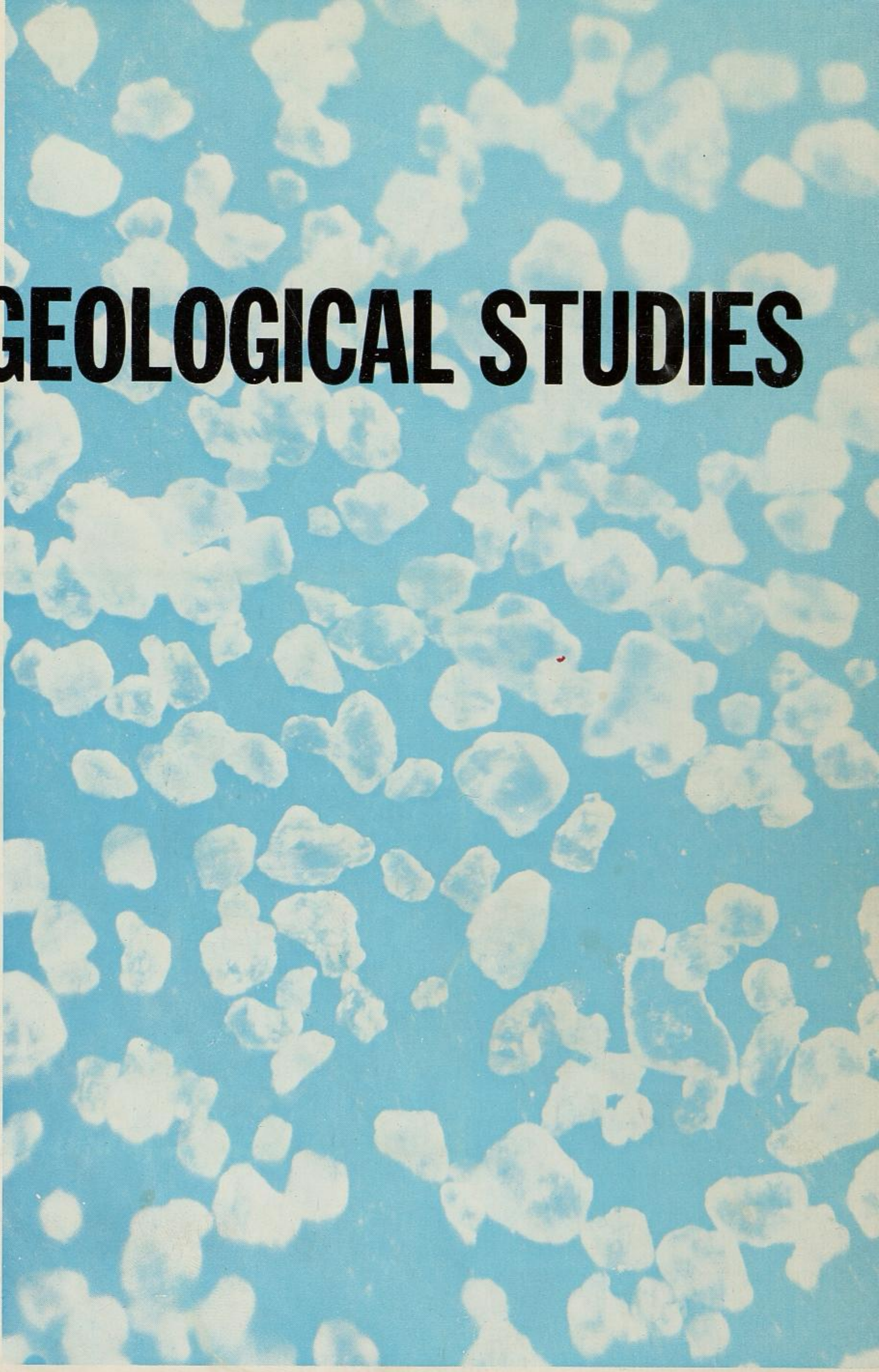
BAYLOR GEOLOGICAL STUDIES



SPRING 1962

Bulletin No. 2

BAYLOR UNIVERSITY - WACO, TEXAS
FOUNDED PRO ECCLESIA PRO TEXANA 1845

The Lower Cretaceous Paluxy Sand in Central Texas

WILLIAM A. ATLEE

"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.

THE BAYLOR UNIVERSITY PRESS
WACO, TEXAS

BAYLOR GEOLOGICAL STUDIES

BULLETIN NO. 2

The Lower Cretaceous Paluxy Sand in Central Texas

WILLIAM A. ATLEE

BAYLOR UNIVERSITY
Department of Geology
Waco, Texas
Spring, 1962

Baylor Geological Studies

The Baylor Geological Studies Bulletin is published semi-annually, Spring and Fall, by the Department of Geology at Baylor University. The Bulletin is specifically dedicated to the dissemination of geologic knowledge for the benefit of the people of Central Texas. The publication is designed to present the results of both pure and applied research which will ultimately be important in the economic and cultural growth of the Central Texas region.

Additional copies of this bulletin can be obtained from the Department of Geology, Baylor University, Waco, Texas. $1.00 postpaid.

CONTENTS

	Page
Abstract	5
Introduction	5
Purpose	8
Location	8
Procedures	8
Previous work	8
Acknowledgments	10
Lithology	10
Description	10
Areal distribution	12
Thickness	13
Paleontology	14
Stratigraphy	17
Facies relationships	17
Depositional environments	18
Age assignment	21
Economic geology	21
General features	21
Agriculture	21
Water supply	21
South Bosque oil field	21
Conclusions	22
References	23
Appendix I Localities	24
Appendix II Production from the South Bosque oil field, McLennan County, Texas	25
Index	26

ILLUSTRATIONS

Figures	Page
1. Index map	6
2. Nomenclature chart, Comanchean series, central Texas	7
3. Outcrop, isopach and locality map, Paluxy sand, central Texas	9
4. Cross sections, Paluxy sand and adjacent strata, central Texas A. Northwest-southeast cross section B. North-south cross section	11
5. Physiographic divisions, central Texas	12
6. Diagrammatic facies cross section, Trinity and Fredericksburg groups, central Texas	13
7. Fine grains of well sorted, frosted quartz sand, Paluxy formation, southern Erath County	15
8. Very fine grains of poorly sorted, frosted quartz sand, Trinity group, northern Erath County	15
9. Cross-bedded Paluxy sand beneath Walnut formation, Somervell County	16
10. Cross-bedded Paluxy sand beneath Walnut formation, Bosque County	16
11. Cross-bedded channel sand, Paluxy formation, Rough Creek, 5.5 miles northwest of Walnut Springs, Bosque County	19
12. Horizontal beds of Paluxy sand, Bosque County	20
13. Horizontal beds of Paluxy sand with thin indurated ledges, Bosque County	20

The Lower Cretaceous Paluxy Sand in Central Texas

WILLIAM A. ATLEE

ABSTRACT

The Paluxy formation is composed predominantly of fine to very fine-grained quartz sand. The Paluxy sand attains a maximum thickness of about 190 feet in northwestern Erath County and pinches out southward in southern Hill, McLennan, and Coryell counties. The formation is both vertically and laterally gradational with clay, marl, and limestone beds of the overlying Walnut formation. Downdip thinning results from interfingering with basinward facies of the Walnut formation.

Field and subsurface evidence indicates that the Paluxy formation is the basal formation of the Fredericksburg group. In the area studied the Paluxy sand is sharply separated from the limestone sequence of the underlying Glen Rose formation. Field observations and subsurface information suggest that the Glen Rose-Paluxy contact represents a hiatus of greater magnitude than the diastemal Paluxy-Walnut contact. The Paluxy-Walnut contact reflects the transgressive nature of the Walnut formation.

Several environments controlled the deposition of the Paluxy sands; conditions ranged from shallow marine to non-marine. Non-marine environments include fluvial and perhaps eolian dunes, characterized by steeply dipping beds. Marine environments include fluvio-marine and shallow shelf deposition, typified by thin, horizontal, evenly bedded sand and typical marine cross-beds.

Petrographic examination and comparison suggest a genetic relationship between the quartz sands of the upper Trinity group and the Paluxy formation. However, both sand units represent several cycles of deposition.

The Paluxy formation has several economic aspects beneficial to the central Texas area. Arenaceous soils developed upon the Paluxy formation are agriculturally important. Since 1902, oil has been produced from the Paluxy sand in the shallow South Bosque field, McLennan County. In the northern part of the area the Paluxy sand is an important aquifer; southward downdip the Paluxy water becomes less potable. Along the outcrop thick sections of homogeneous quartz sand are potential sources of material for glass manufacture.

INTRODUCTION[1]

The Comanchean series of Lower Cretaceous age in central Texas (fig. 1) is divided into three units: in ascending order these are the Trinity, Fredericksburg, and Washita groups. One of the few major stratigraphic problems which the noted geologist R. T. Hill left to later investigators of Comanchean stratigraphy (fig. 2) in central Texas, was the precise boundary between the Trinity and Fredericksburg groups or divisions.

Hill (1901, p. 118) subdivided the Comanchean series into "divisions." The term was ". . . intended to include subgroups of paleontologically or lithologically allied beds of strata" (*idem*). As further surface and subsurface investigations shed light on the true stratigraphic relationships of the formations which constitute these divisions, it became apparent that many cartographic units are both laterally and vertically gradational. Recently, Lozo and Stricklin (1956, p. 68) revised Hill's (1901) original "divisions" based on fossil assemblages and lithologic relationships to ". . . tectonic-sedimentary lithogenetic entities of subseries rank hereafter called divisions." These divisions continue to fulfill the stratigraphic requirements of the cartographically and lithologically defined group. The formations of the Fredericksburg group (fig. 2), as used in this report, consist of the Paluxy sand, Walnut clay, Comanche Peak limestone, and Edwards limestone.

[1]Modified from a thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1960.

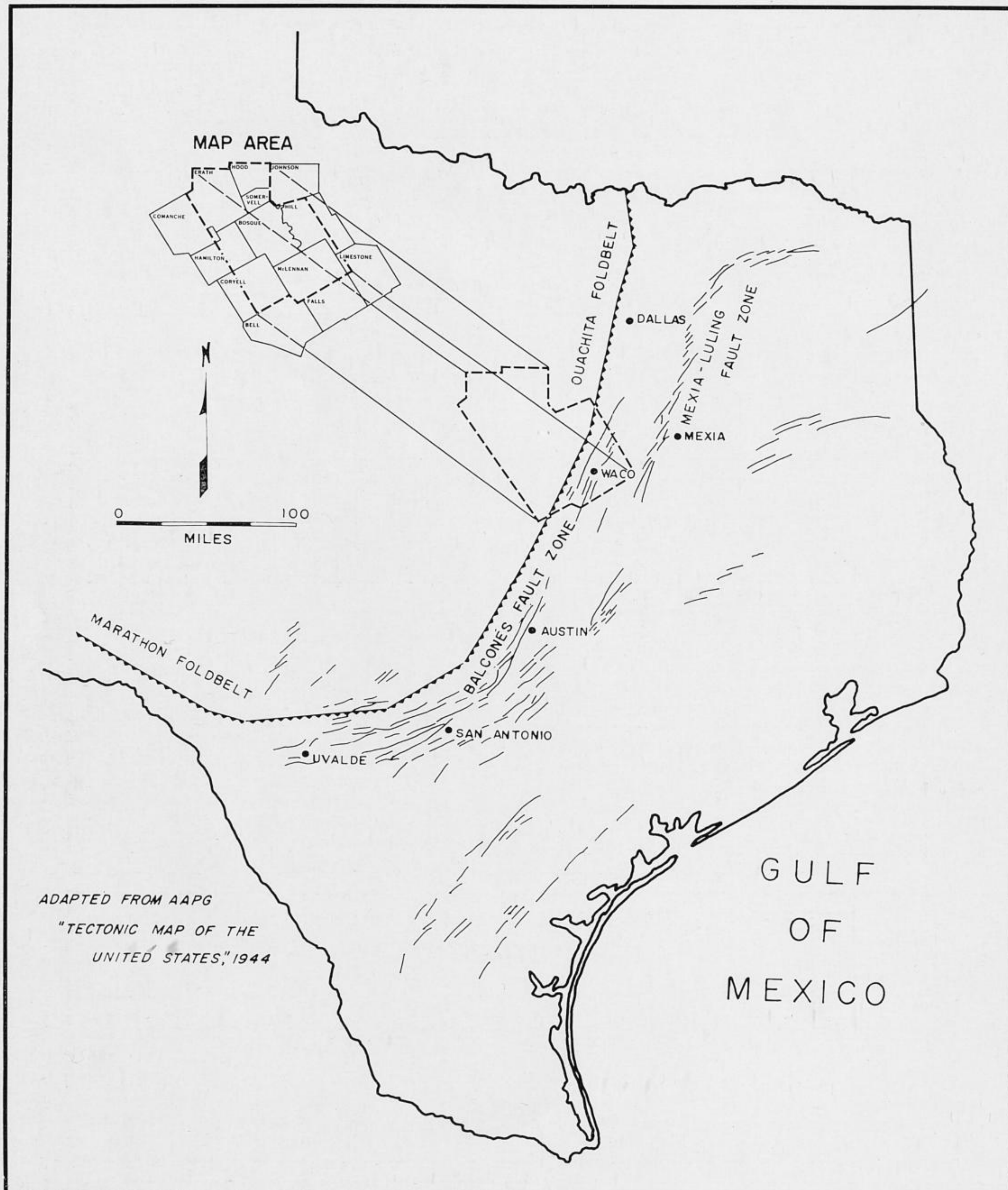


Fig. 1. Index map.

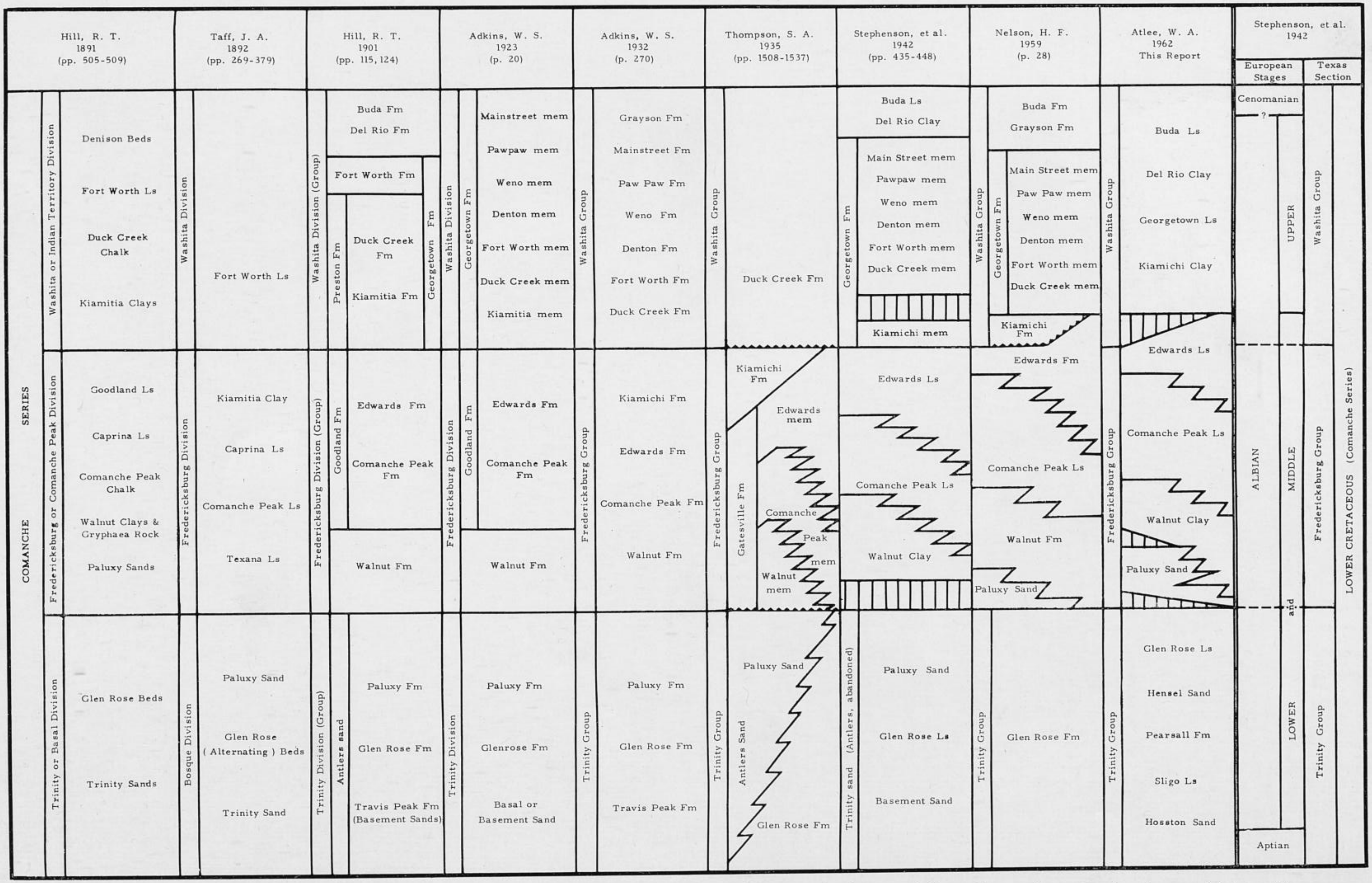


Fig. 2. Nomenclature chart, Comanchean series, central Texas. The chart is designed to illustrate historical development of Comanchean studies and major changes of interpretation. Precise correlation of members and formations in various columns is not necessarily intended.

PURPOSE

Various interpretations have been postulated for the lateral and vertical stratigraphic relationships of the Paluxy sand with the overlying Walnut clay and underlying Glen Rose limestone in central Texas (figs. 1, 2). The purpose of this report is to combine information obtained from surface studies with subsurface electrical log, drillers' log, and other well data to form a more complete and coherent picture of the stratigraphic relationships of the Paluxy sand within the area. Also included is a discussion of the general geology of the formation and its economic importance to central Texas.

LOCATION

The area of this report includes all or portions of McLennan, Bosque, Erath, Hood, Somervell, Hill, Coryell, and Hamilton counties (fig. 1) in central Texas.

PROCEDURES

Field and laboratory work was completed during the latter part of 1959. Outcrops of the Paluxy sand (fig. 3) were studied and the nature of upper and lower formational contacts was noted. Where both upper and lower contacts were exposed, the thickness of the Paluxy sand was measured by hand level and tape; for example, outcrop thicknesses were obtained at localities 6, 16, 17[2].

The absence of a distinct horizon with lateral continuity, either faunal or stratigraphic, makes correlation within the Paluxy sand of the outcrop area a difficult problem. Though the Paluxy formation may be divided into an upper and a lower sand unit in the subsurface of Bosque County (fig. 4-B) much more detailed investigation would be required to determine whether this subdivision can be extended into contiguous areas.

Areal control for surface stratigraphic data was provided by aerial photographic mosaics of Erath and Bosque counties, topographic maps, and previous geologic maps (Hill, 1901; Stose, *et al*, 1937; McBride, 1953). Surface samples from the outcrop belt were examined and compared. Paluxy sand samples were also compared with subsurface samples of Trinity sand from water wells in McLennan County. Several x-ray diffraction analyses of interbedded clays were made by Arthur O. Beall, Baylor University.

Subsurface investigation included a study and comparison of electrical logs, drillers' logs and well samples of the Paluxy sand. Except for United States Army Corps of Engineers core borings (locality 12) for alternate locations of the Whitney dam site (Hull, 1951), reliable subsurface data on the Paluxy sand in Bosque County are virtually nonexistent. Drillers' logs and personal communication with local drillers provided the principal source of subsurface information for that area. Subsurface information was used to prepare stratigraphic sections (fig. 4-A, B), and an isopach or thickness map (fig. 3) of the Paluxy sand.

PREVIOUS WORK

In 1846 Ferdinand Roemer, a German geologist, recognized strata now referred to as the Comanchean series as a distinctive lithologic and faunal unit of the American Cretaceous (1852), though he incorrectly classified these rocks as Turonian or Senonian in age.

In 1854 G. G. Shumard applied the name "Washita group" to strata near Fort Washita, Oklahoma. Two years later, Jules Marcou (1856) confirmed the existence of Lower Cretaceous strata in North America when he correctly identified and dated as Neocomian a group of fossils collected by G. G. Shumard from Texas and western Oklahoma.

In 1860 B. F. Shumard described the Cretaceous formations recognized in Texas and assembled them into a stratigraphic section. Some of the formations described by Shumard were named for geographic localities and others were named for faunal content; the paleontologic names have since been replaced with geographic names.

Little was known of the geology of the Paluxy sand prior to R. T. Hill's initial investigation of the Lower Cretaceous section which began in 1886. Hill (1887, p. 303) provisionally divided the Comanchean strata into a lower Fredericksburg and an upper Washita division following G. G. Shumard's (1854) use of "Washita group" and Roemer's (1852) reference to the rocks near the town of Fredericksburg, Texas. However, maximum development of the various rock units of these groups occurs in widely separated areas in Texas. In the Fredericksburg division Hill (*idem*) included B. F. Shumard's (1860) *Caprotina* limestone, now called the Glen Rose limestone. In 1888 Hill named the underlying Trinity division; at that time the *Caprotina* limestone was removed from the basal Fredericksburg division and placed in the Trinity division (Hill, 1901).

The Paluxy sand was named by R. T. Hill in 1891 (fig. 2) for characteristic exposures along the headwaters of the Paluxy River in Erath County and outcrops in the highlands adjacent to the town of Paluxy (locality 5), Hood County, Texas. Hill initially confused the Paluxy sand with older sands (Trinity) north of the type locality. Subsequent studies along the Brazos River valley in the vicinity of Comanche Peak, Hood County, revealed that the Paluxy sand constitutes a well defined and mappable lithologic unit between the Glen Rose and Walnut formations (Hill, 1891, p. 511).

Vanderpool in 1928 (p. 1088), citing Miser (1927), proposed that the name Paluxy be used for the upper sands which form a definite lithologic unit extending from Pike County, Arkansas, westward through southeastern Oklahoma into the typical Paluxy sands of north-central Texas. This proposal was based upon the recognized westward overlap of the lower part of the Trinity sands by upper sands in Oklahoma and Arkansas. Vanderpool concluded that the overlapping sands are younger than the Glen Rose-DeQueen formations in Oklahoma and Arkansas. Stanton (1928, p. 403) also suggested that the upper portion of the Trinity group north of the Glen Rose limestone pinch-out is Fredericksburg Paluxy equivalent. In a paper before the Geological Society of America at the 1936 Cincinnati meeting, R. T. Hill (1937) interpreted the Paluxy sand as the beginning of a cycle of sedimentation and suggested that it should, therefore, be classed as the basal unit of the Fredericksburg group.

In 1935, Thompson (p. 1534) proposed the name "Gatesville formation" (fig. 2) to include the Walnut clay, Comanche Peak limestone and Edwards limestone members. Theoretically, at least, the Paluxy sand is

[2]Locality references refer to fig. 3 and Appendix I.

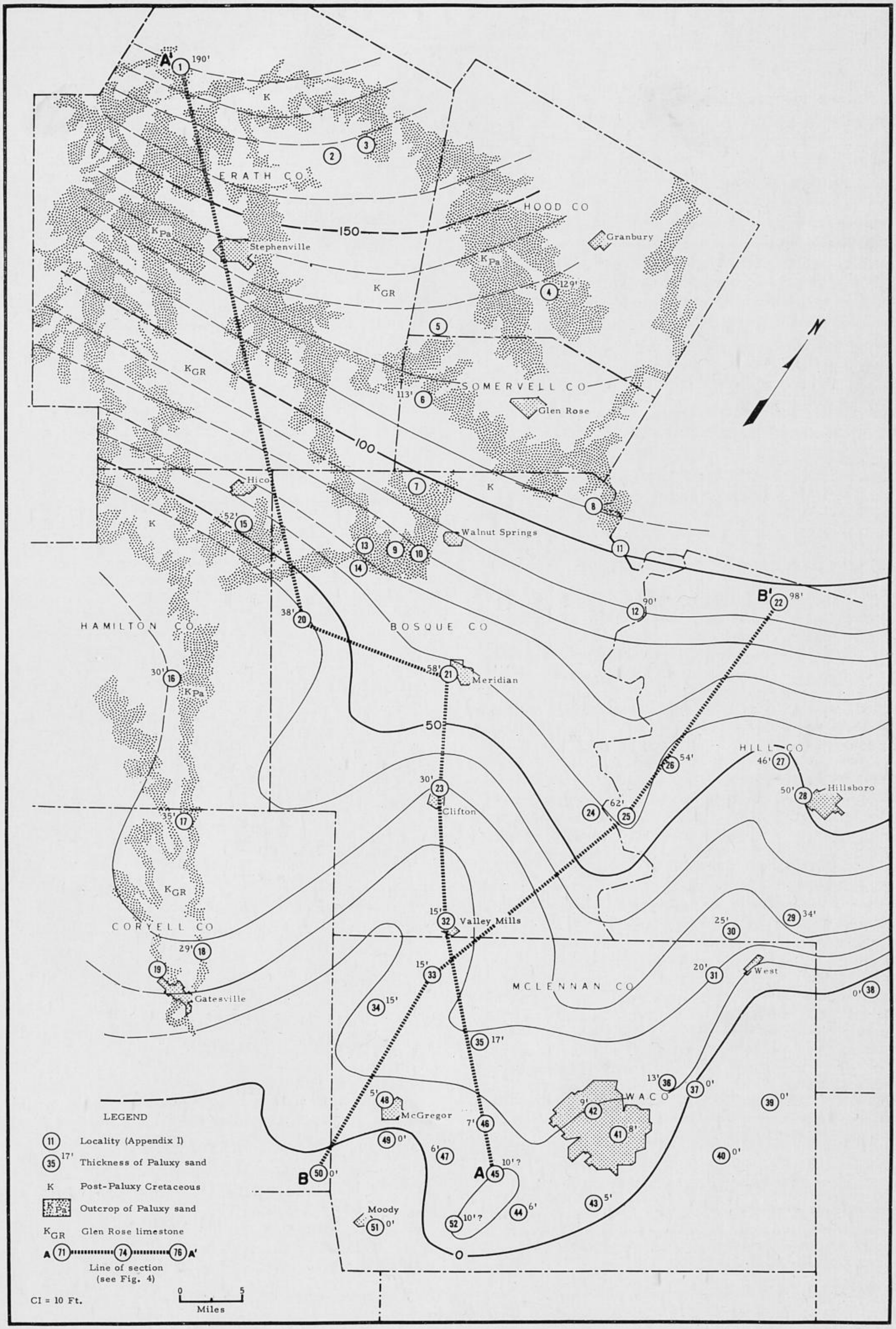


Fig. 3. Outcrop, isopach, and locality map, Paluxy sand, central Texas.

the lowermost member of such an integrated sequence representing a major distinct cycle of sedimentation. However, Thompson did not recognize the Paluxy sand in Coryell County and chose for the base of his Gatesville formation, a horizon in the Walnut formation which he believed to be the Walnut-Glen Rose contact.

Stratigraphic investigations were accelerated as more subsurface information became available from electrically logged wells. Surface and subsurface work by Lozo (1949) demonstrated that the Paluxy sand, commonly considered to be the uppermost formation of the Trinity group, is genetically the lowermost formation of the Fredericksburg group in central Texas. The stratigraphic position assigned the Paluxy formation by Lozo (1949, p. 85) is presently accepted by the writer.

ACKNOWLEDGMENTS

The writer wishes to express appreciation to Professors O. T. Hayward and James W. Dixon, Jr., Department of Geology, Baylor University, for suggesting the study and for guidance throughout preparation of this report. The writer is further indebted to the following: Dr. Frank E. Lozo and Dr. David L. Amsbury, Shell Development Company, for critical reading of the manuscript; Mr. Harry M. Batis, Chief Supervisor of the Railroad Commission of Texas, for furnishing production data on the South Bosque oil field; Mr. J. R. Thomas, Jr., Soil Scientist, United States Soil Conservation Service, for providing unpublished soils information; Mr. Clay C. Mooreman, for providing well cuttings from the Paluxy interval in the South Bosque oil field; and Mr. Roy P. Cypert, Texas State Board of Water Engineers, for providing unpublished drillers' logs. Illustrations were drafted by Messrs. Johnnie B. Brown and Moice A. Mosteller, Baylor University.

LITHOLOGY

DESCRIPTION

The Paluxy formation is composed predominantly of homogeneous, fine to very fine-grained, compact white quartz sand. Lenses and laminae of dark, impure clays are common. The sand is commonly called "packsand" because of the characteristic texture of the fine grains; the sand has also been called sucrosic because of the sugary texture. The sands are extensively cross-bedded and commonly laminated. Laminae normally are cyclic alternations of dark clays, organic material, and sand, possibly suggesting a seasonal influence upon sedimentation.

The color of the sand ranges from light-gray to red and locally there are thin deep purple or maroon beds and laminae. Such laminae may be seen south of Jonesboro (locality 17), Coryell County, and at other localities along the Paluxy outcrop. Scott (1930, p. 47) applied the term "Red Beds" to similar sands in Parker County. These are the only red sands in the area except for "Basement sands" in the basal part of the Trinity group. Coloration results from weathering of fine rounded grains of black hematite which stain adjacent quartz grains. These laminae appear to be of primary origin, and are separated by very thin beds of fine unstained quartz sand.

Abundant iron concretions occur along the outcrop at many localities, particularly in the highlands around Glen Rose, Somervell County. Numerous concretions have cores of white sand surrounded by concentric bands of iron oxide stained sand. Original or primary bedding passes entirely through these concretions, which demonstrates that Liesegang banding observed is an ionic diffusion phenomenon of post-depositional origin. Such concretions probably resulted from solution and reprecipitation of intraformational iron compounds by water in the immediate vicinity of organic material.

The grain size of the Paluxy sand varies: individual quartz grains range from 0.50 mm to 0.0625 mm in diameter. Over 90 percent of the grains commonly are between 0.25 mm and 0.0625 mm (fine to very fine sand) in diameter. The sand is normally well sorted, although it may rarely consist of two dominant grain sizes; this bimodal distribution may result from the mixture of two separately sorted sands and suggests rapid deposition. The grain size of the Paluxy sand is not necessarily less than that of the older Trinity sands. Figures 7 and 8 illustrate the marked contrast between typical Trinity sand from the outcrop north of Stephenville near Morgan Mill (locality 2) and typical Paluxy sand from the outcrop along U. S. Highway 281, south of Stephenville (fig. 3). Several periods of sand deposition within both the Trinity and basal Fredericksburg groups are suggested. Thus, there is no significant relationship between grain size and relative age of sand grains. Much of the Paluxy sand is petrographically identical to sand of the Trinity group.

The quartz sand of the Trinity group normally contains a more varied heavy mineral suite than the Paluxy sand—pyrite, chalcopyrite, magnetite, zircon, fluorite, topaz, and several less abundant minerals. At many localities, however, the Paluxy and Trinity sands are virtually devoid of heavy minerals. Unfrosted, commonly euhedral crystals of topaz normally occur associated with rounded and frosted quartz grains of the Paluxy sand. In addition to topaz, rounded tourmaline may be common and angular staurolite with mamillary overgrowths is rare.

Sand of the Trinity group along the Paluxy River near the town of Paluxy, Hood County (locality 5), contains predominantly well sorted, subrounded quartz grains. Beds contain from 4 to 14 percent calcium carbonate. A conspicuous 6-inch ledge of yellowish montmorillonite clay occurs about 6 feet below the base of the Glen Rose formation at this locality; this clay contains approximately 2 percent pyrite and some quartz grains. Thin, slightly calcareous, green, sandy clay beds within the sand contain approximately 40 percent white to gray opal or chalcedony grains.

Well cuttings of the Paluxy sand in the M & S Oil Company, #16 South Bosque unit, a producing well in

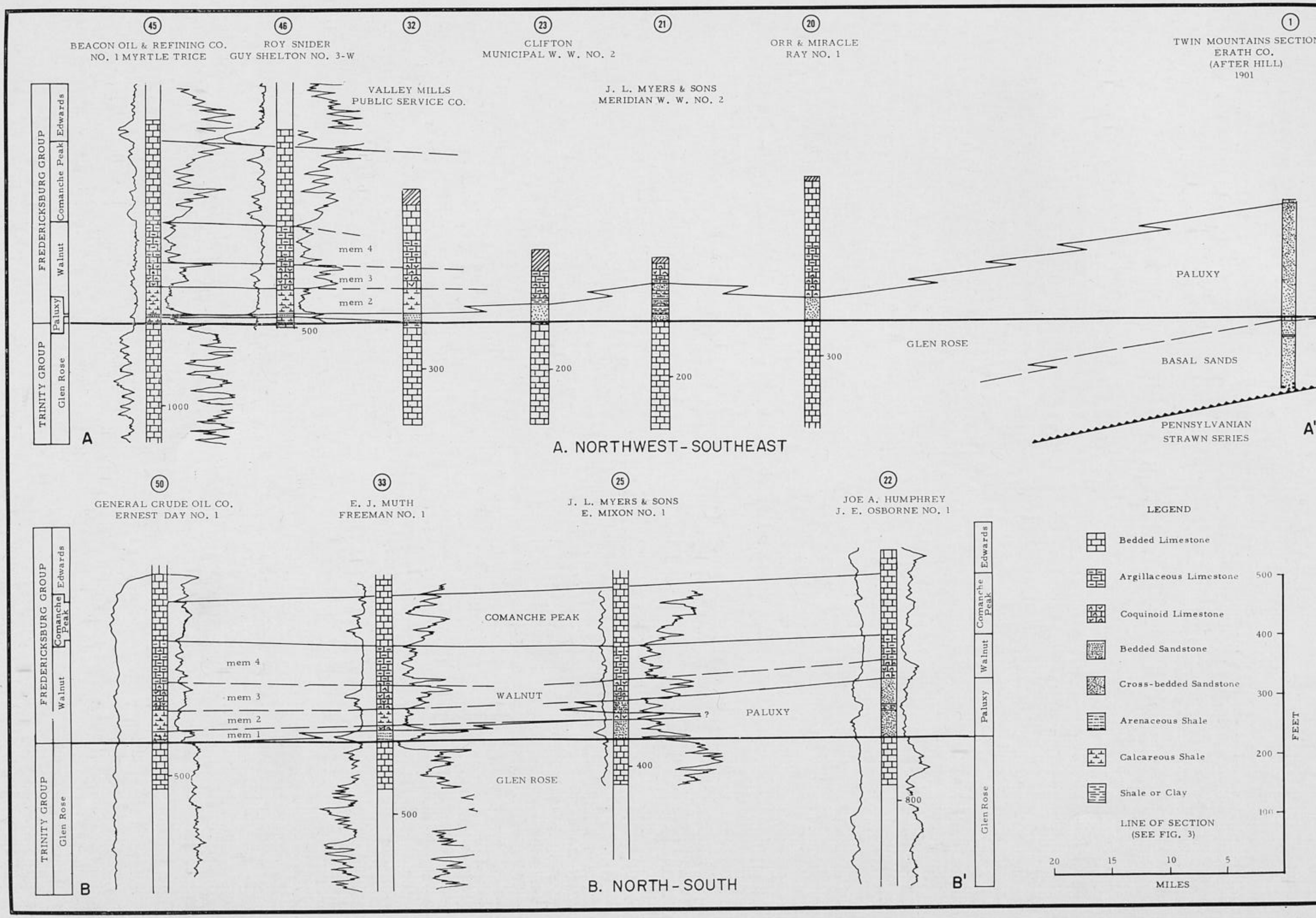


Fig. 4. Cross sections, Paluxy sand and adjacent strata, central Texas.

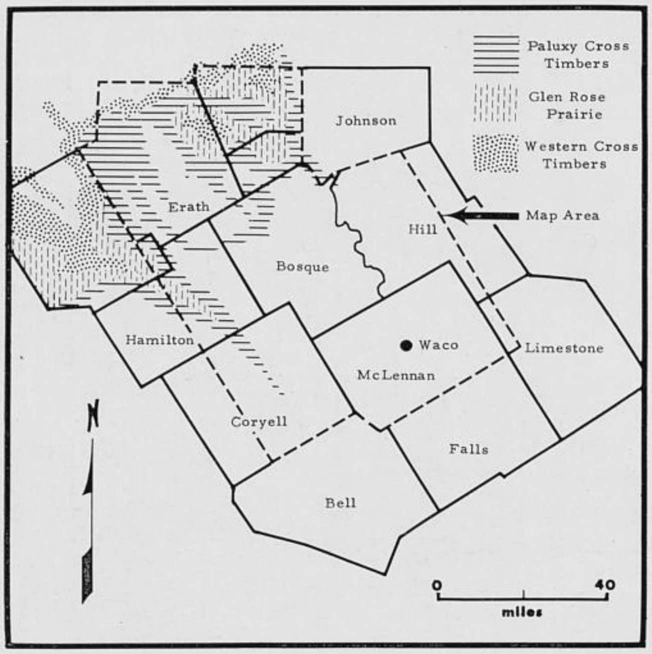


Fig. 5. Physiographic divisions, central Texas.

the South Bosque field, McLennan County, consist predominantly of very thin laminae of fine-grained, frosted and subrounded quartz sand. These are probably lenses or stringers, intercalated with thin crystalline limestone beds. Oil occupies the interstices of the sand and associated beds of crystalline limestone. The producing sand is typified by abundant octahedral pyrite crystals slightly larger than the quartz grains; crystal faces are commonly striated. The pyrite is probably of secondary origin formed by reducing action of carbonaceous materials upon iron compounds. The clay minerals of the Paluxy formation are mainly detrital material deposited in strandline or near-shore environments. A cursory investigation of the clay minerals within the Paluxy formation reveals considerable mineralogic variation. Kaolinite is associated with cross-laminated sands at locality 9 between Iredell and Walnut Springs, Bosque County; illite occurs in green clay near Brazos Point, Bosque County (locality 8). Kaolinite and minor amounts of illite occur in cream-colored clays of the Walnut formation 3 miles south of Meridian, Bosque County. The need for further study of clay minerals is indicated by variations in clay mineralogy and field observations, which suggest that these mineralogic variations may be related to differences in environment of deposition.

Salt is not known to occur within the Paluxy formation in the area investigated. However, in Parker and Wise counties the basal portion of the Paluxy sand is heavily charged with salt (Scott, 1930, p. 47).

AREAL DISTRIBUTION

The Paluxy sand which crops out in the northern part of central Texas, is especially well developed in Parker, Hood, Somervell, Erath, Bosque, Hamilton, Coryell, and Comanche counties (figs. 1, 3). The Paluxy sand thickens northward, merging with basal Trinity sands in Wise County to form a single rock unit, the Antlers sand, which is, in part, the stratigraphic equivalent of the Trinity and Fredericksburg groups (fig. 6). The Paluxy sand is present in the subsurface from Louisiana southwestward to Freestone and Limestone counties, Texas, where it grades to a shale and marl facies.

The outcrop of the Paluxy sand, often physiographically called the Paluxy Cross Timbers, together with the outcrop of the Trinity sands, comprise the Western Cross Timbers (fig. 5) which extends southward from Red River into central Texas. Only the Glen Rose Prairie separates the outcrop of these two sand units—Paluxy and Trinity—and where the Glen Rose limestone thins appreciably, such as in Erath County, this intermediate physiographic feature is absent. Prior to Hill's examination and correct interpretation of the Western Cross Timbers, those arenaceous outcrop belts had been thought to represent arms or inlets of the Tertiary sea, beds of extinct lakes, or channels of Quaternary rivers (Hill, 1887, p. 293). This belt, as the name implies, is a densely timbered area of stunted post-oak (*Quercus obtusiloba*), black-jack (*Quercus nigra*), and other small hardwoods. Scattered small clumps of live-oaks and shrubs occur in the northwestern portion of the map area. Other native vegetation consists of coarse bunch grasses composed largely of species of *Andropogons* and grama, with some short (buffalo) grasses.

The outcrop of the Paluxy sand approximately parallels the strike of Comanchean strata. The formation constitutes one of the major outcropping rock units in Hood, Somervell, Erath and Hamilton counties (fig. 3) and normally occupies the upper slopes of rolling hills capped by thin outliers of basal marl beds of the Walnut clay. In some areas, however, the Walnut clay has been completely eroded and only the friable Paluxy sand and derived soils cap the highlands. The Paluxy sand is exposed as far south as the mouth of Grass Creek on the Brazos River (locality 11), Iredell on the Bosque River, and Gatesville on the Leon River. The Paluxy sand also crops out along Cowhouse Creek and its tributaries in the Pidcoke-Copperas Cove-Fort Hood Village area (Lozo, 1959, p. 14). The width of the Paluxy outcrop naturally varies considerably depending upon the thickness of the formation, topography of the outcrop area, and degree of denudation of the overlying Walnut formation (fig. 3).

Soils of the Paluxy Cross Timbers area are composed of very fine-grained siliceous detritus from the underlying sand strata mixed with red clays derived from the overlying Walnut formation. The most extensive soil type of the region is the Windthorst fine sandy loam (written communication, J. R. Thomas, Soil Conservation Service). This soil type comprises brown, light-brown or reddish-brown surface soils which rest upon red, heavy, sandy, clay subsoils. In most places these soils grade at a depth of 2 or 3 feet into partly weathered sandstone. Topography developed in areas containing the Windthorst fine sandy loam is slightly more rolling than areas where other Cross Timbers soils occur; erosion is moderately severe on the Windthorst soils. These soils commonly occupy gentle slopes or rolling highlands, obscuring the Paluxy outcrop and formational contacts across broad areas.

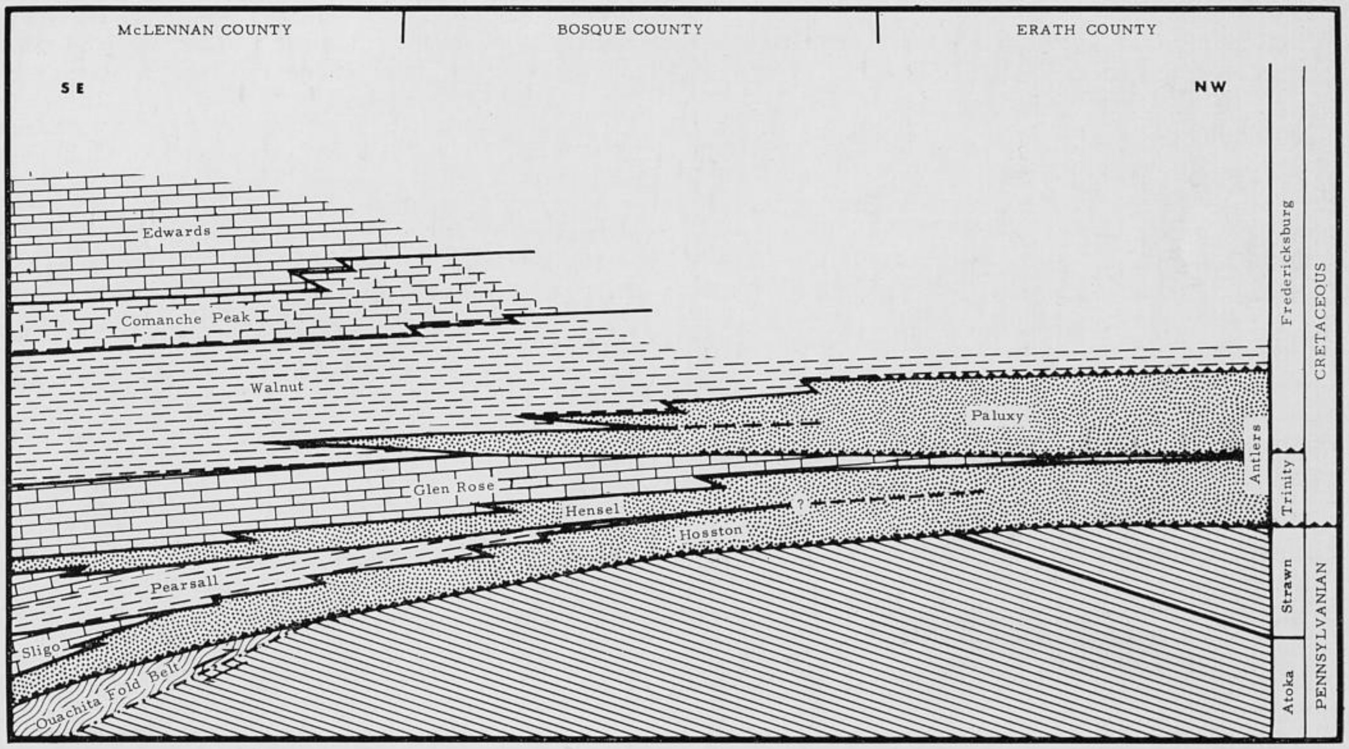


Fig. 6. Diagrammatic facies cross section, Trinity and Fredericksburg groups, central Texas.

THICKNESS

Within the area investigated the Paluxy formation thickens northward at about 2 feet per mile (fig. 3). Locally, however, the thickness of the Paluxy sand may vary erratically.

The thickest stratigraphic sections of Paluxy sand exposed within the area are preserved beneath basal limestone beds of the Walnut clay which cap Twin Mountains (locality 1) in northwestern Erath County and at Comanche Peak (locality 4) in Hood County. Hill (1901, p. 187) measured 190 feet of Paluxy sand at Twin Mountains. The yellowish sands are commonly friable, but indurated beds occur which are not sufficiently hard to form topographic benches. About 5 feet of thinly bedded, slightly arenaceous Glen Rose limestone separate the Paluxy sand from underlying sands of the Trinity group. The basal Trinity group at Twin Mountains consists of 22 feet of "packsand," 3 feet of arenaceous blue clay, and 90 feet of conglomerate and "packsand" which rest unconformably upon Pennsylvanian sandstone strata.

At Comanche Peak, 4.5 miles south of Granbury (locality 4), 129 feet of cross-bedded sand were assigned (Hill, 1901, p. 151) to the Paluxy formation. Cross-bedded Paluxy sand approximately 118 feet thick occurs fifteen miles south of Comanche Peak (locality 6).

Hull (1951) recorded 80 to 90 feet of Paluxy sand and shale in core borings at the alternate Whitney dam sites (locality 12). Local irregularities in the dominant direction of thinning are common since the formation is bounded by at least one significant unconformity (top of Glen Rose limestone) and may contain numerous diastems. Approximately 40 feet of cross-bedded sand are exposed at locality 9 midway between Iredell and Walnut Springs, Bosque County; however, the Glen Rose contact is obscured by sandy soil at this locality where as much as 80 feet of Paluxy sand occur.

Thickness data for the Paluxy sand in Bosque County came primarily from drillers' logs and personal communication with local drillers. Mr. Rufus Smith of Meridian, who has drilled many water wells in Bosque County, reported 18 to 25 feet of Paluxy sand at Meridian. This thickness does not include beds of shale and limestone encountered between the fossiliferous basal Walnut clay and the Glen Rose limestone. According to Mr. Smith, a well about 1 mile east of Meridian penetrated a sand streak, a thin limestone bed, and 10 to 15 feet of shale beneath the Walnut clay before the basal Paluxy sand section was encountered. This shale member of the Paluxy formation in Bosque County thickens eastward toward the Brazos River, separating the upper and lower sand strata. The shale interval can be recognized on electrical logs of the Joe A. Humphrey, #1 J. E. Osborne water well in northern Hill County (locality 22), and the J. L. Myers and Sons, #8 Santa Fe Railroad water well at Cleburne in Johnson County. Similar tongues of fossiliferous limestone, shale and oyster beds, if carefully traced, might prove useful for intraformational correlation. These beds lose their identity northward, however, and their utility is further hampered by channeling which locally removed some of these distinctive markers. The cumulative thickness of the Paluxy formation north and east of Meridian in Bosque County ranges from 50 to 110 feet in approximately 16 miles (fig. 3).

Thompson (1935) described the Fredericksburg section near the State Training School, 3.6 miles north of Gatesville, Coryell County. Thompson did not recognize Paluxy sand and erroneously considered the Walnut clay to be in contact with the Glen Rose limestone. Lozo (1949) found 29 feet of cross-bedded sand, lenticular sandstone, gray sandy shale and clay along Four

Mile Branch (locality 18) about 5,000 feet west of the State Training School; these sand beds are recognized as part of the Paluxy formation. A similar section of laminated and cross-bedded Paluxy sand occurs along Morgan Creek, 1.6 miles south of Jonesboro (locality 17). At this locality the sand section has thickened to about 35 feet. Approximately 30 feet of Paluxy sand are poorly exposed along Sycamore Creek about 10 miles east of Hamilton (locality 16). McBride (1953, p. 43) measured 52 feet of Paluxy sand 4.5 miles southeast of Hico (locality 15). He assigned a thickness of 27 to 60 feet to the sands in eastern Hamilton County and 25 to 50 feet in western Hamilton County.

In Hill County the Paluxy sand exhibits its maximum thickness in the northern part of the county; electrical logs (*e.g.* Joe E. Humphrey, #1 J. E. Osborne—locality 22) indicate 98 to 100 feet near the north county line (fig. 3). The sand rapidly thins southward to its pinchout in the southern part of the county (J. L. Myers & Sons, #1 Penelope—locality 38); it is only 45 feet thick between Hillsboro and Woodbury (C. Stubblefield, #1 Sumner—locality 27).

The Paluxy sand is thinner in McLennan County than in Hill or Coryell counties; the sand thickens northward and westward from the central part of McLennan County (fig. 3). The Paluxy sand is not identifiable on electrical logs of wells in southern and southeastern McLennan County; for all practical purposes the Paluxy formation is absent as an oil or water bearing horizon south of Waco. In contrast the Walnut clay thickens southward downdip where it appears to replace the sand of the Paluxy formation. The southward thinning of the Paluxy sand is, therefore, attributed to downdip replacement by successively older beds of Walnut lithology (figs. 4-B, 6). While principally limestone was being deposited in the Comanchean sea to the south, sand was accumulating in the northern region.

Twenty feet of Paluxy lithology occur at the Leon River near Gatesville (locality 19); southward these arenaceous beds are replaced by marl and thin limestone beds of the Walnut formation. No arenaceous beds at the Paluxy horizon were noted in cores and cuttings from the Fort Hood water well field between Belton and Killeen in central Bell County. Adkins and Arick (1930, p. 28) stated that the Glen Rose-Walnut contact in Bell County is disconformable; the disconformity occurs at the approximate position of the Paluxy sand to the north. The sands of the Paluxy formation pinch out (fig. 3) in southern Coryell County, in McLennan County between McGregor and Moody, along a line a few miles southeast of the Balcones fault zone, and in southern Hill County. It is interesting that the Kiamichi clay (Washita group, fig. 2) pinchout in McLennan and Coryell counties closely corresponds to the pinchout of the Paluxy sand. It is significant that the basinward (limestone) facies of the Fredericksburg group thickens rapidly southeastward from this limit of clastic deposition. These stratigraphic relationships may reflect a structural hinge line or break in regional depositional slope which controlled clastic sedimentation.

The following thicknesses have been reported for the Paluxy sand in other areas: Hill (1901, p. 188) reported 107 feet at Logans Gap and 90-95 feet at Round Mountain, Comanche County; and 135 feet at Hiner and 110-120 feet at Weatherford, Parker County. Hill (1901, p. 171) reported 140 feet of Paluxy sand at Decatur, Wise County, while Taff (1892, p. 316) reported 185 feet in the same area. In the valley of the Clear Fork of the Trinity River west of Fort Worth, the Paluxy sand is 100 feet thick (Taff, 1892, p. 316). Eaton (1956, p. 81) stated that in east Texas the Paluxy formation ranges from 200 to 400 feet thick distributed in two major facies—gray marine shales and nodular earthy limestones basinward, which grade northward into predominantly sand and sandy shale.

PALEONTOLOGY

The Paluxy sand contains remarkably few microfossils and megafossils. However, numerous pieces of silicified wood, some of considerable size, occur in the formation in Parker, Hood, Erath, Comanche, and Bosque counties. Large quantities of silicified wood were observed in Erath County; however, only one piece of fossil wood was found south of Erath County, that being at locality 9 in northern Bosque County. The abundance of fossil wood within the formation increases northward toward the source area of the sand. It is commonly present in massively cross-bedded sandstone.

Few microfossils were observed in the Paluxy sand from Coryell to Hood County. Many dark laminated clay beds contain microscopic fragments of lignitized wood, however, and rarely a leaf or bark impression was noted. Several molds of small unornamented pelecypods were observed in the formation at locality 14 south of Iredell. The original calcium carbonate shell is normally absent; iron stained cavities, as large as three-fourths of an inch are common. The bedding of the sandstone matrix passes around these fossils. Hard sandy lenses with calcareous cement rarely contain unornamented ostracod shells. Vanderpool (1928, p. 1085) noted that "ostracods as a class evidently have been able to thrive well under conditions decidedly unfavorable for the existence of other forms of life, especially the microscopic forms." The ostracod *Cypridea* aff. *wyomingensis* occurs in the Paluxy formation in a road cut along State Highway 16 about 1.5 miles north of Priddy, Mills County. One microscopic "turritella-shaped" gastropod shell filled with minute sand grains was observed in well cuttings of Paluxy sand from the South Bosque oil field.

Lozo (1949, p. 87) stated that core samples from below the basal Walnut shell bed at the Kopperl dam site in northeastern Bosque County (locality 12) yielded unornamented Ostracoda normally associated with the Glen Rose limestone. He further stated that so-called Fredericksburg Ostracoda and Foraminifera are sharply restricted to thin calcareous shale units interbedded with thin oyster shell limestone beds similar to those of the overlying Walnut formation.

Several fossiliferous horizons have been noted in the

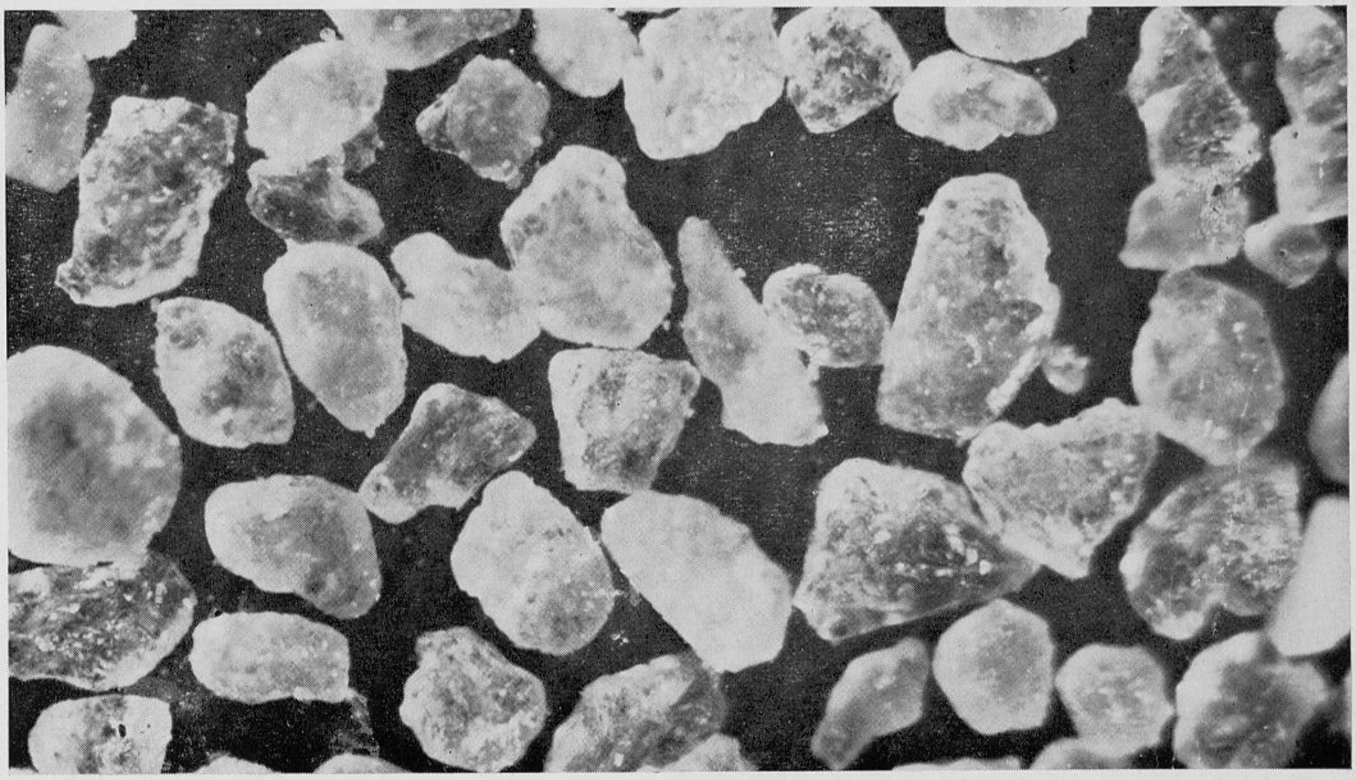


Fig. 7. Fine grains of well sorted, frosted quartz sand, Paluxy formation, southern Erath County. (x150)

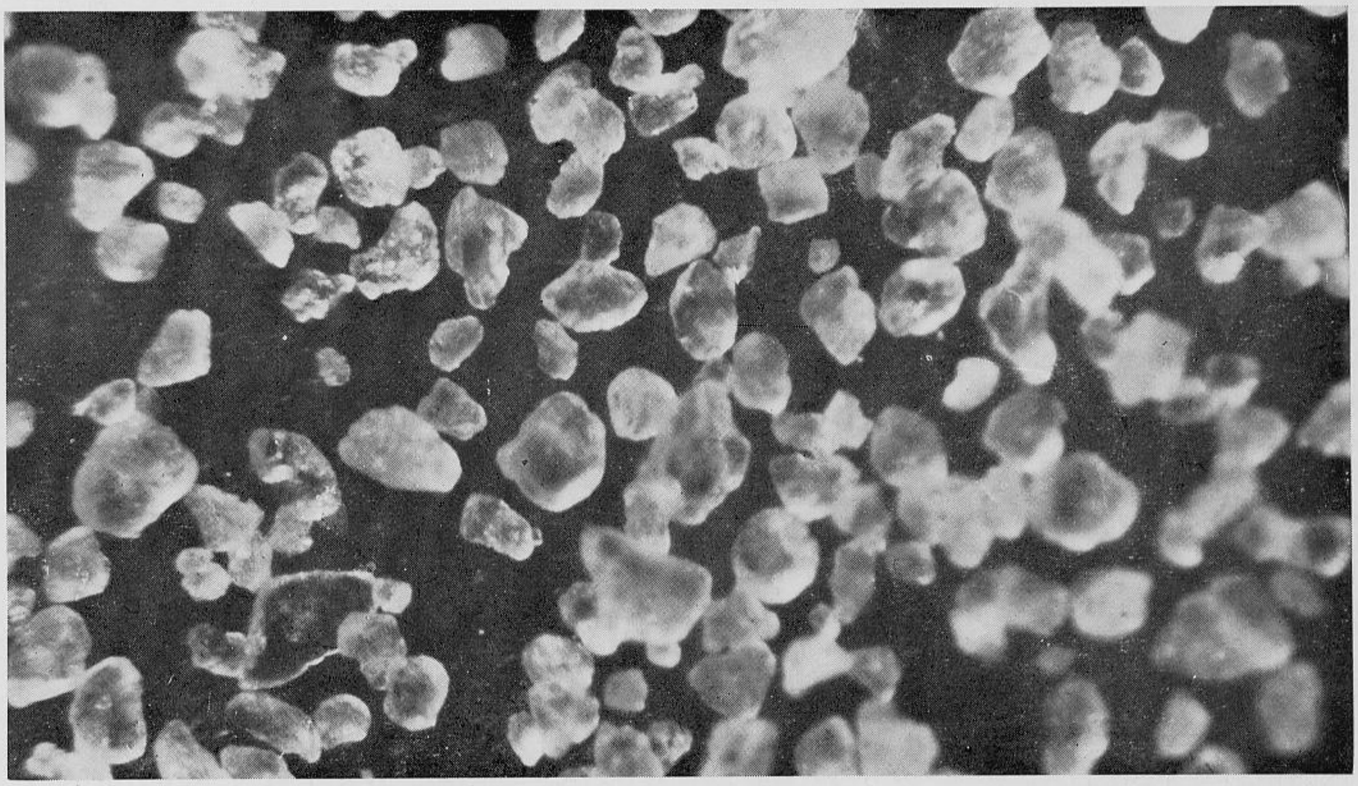


Fig. 8. Very fine grains of poorly sorted, frosted quartz sand, Trinity group, northern Erath County (locality 2). (x150)

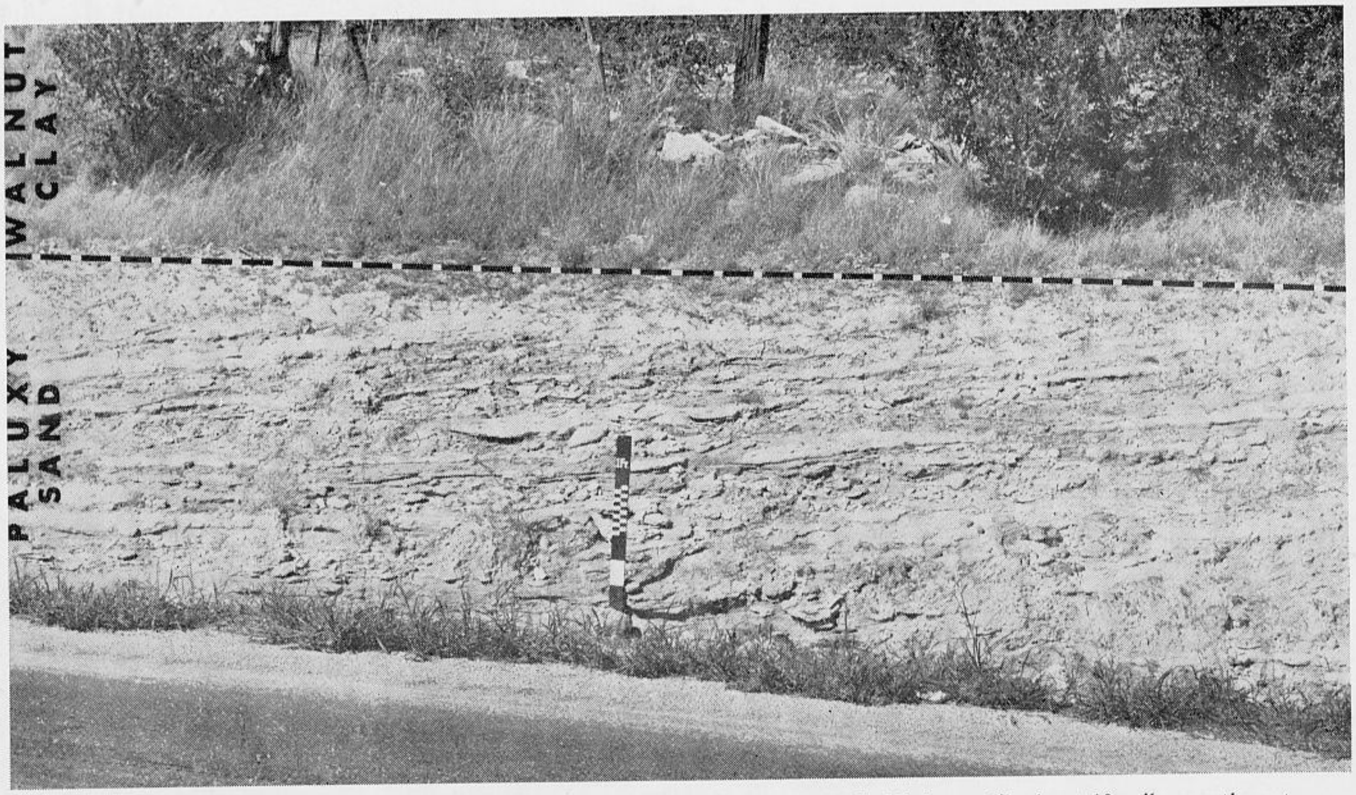


Fig. 9. Cross-bedded Paluxy sand beneath Walnut formation along U.S. Highway 67, about 10 miles southwest of Glen Rose, Somervell County (locality 6). View looking northwest.

Fig. 10. Cross-bedded Paluxy sand beneath Walnut formation along Farm Road 927, 5 miles southwest of Walnut Springs, Bosque County (locality 9). View looking northwest.

Paluxy or upper Antlers formation north of the map area. Hill (1901, p. 167) stated that along Sanchez Creek southwest of Weatherford, argillaceous bands within the Paluxy sand contain abundant calcified shells, mostly *Vicarya* and small pelecypods. Several specimens of rare fish, including the Pycnodontiae, also occur along Sanchez Creek. In western Cook and northwestern Wise counties the uppermost Paluxy sand contains the rare *Ostrea crenulimargo* Roemer, and *Exogyra texana* Roemer (*idem,* p. 171). These latter sand beds are undoubtedly the lateral equivalent of the Walnut formation of central Texas.

Fossil turtle bones were collected from massive, pastel green, very fine sand immediately below the base of the Walnut formation at locality 8 on Rock Creek, 1 mile southeast of Brazos Point, Bosque County. The turtles probably inhabited shores and coastal areas of the shallow Comanchean sea. In a road cut about 1.5 miles north of Priddy, Mills County, along State Highway 16 (approximately 23 miles west of Hamilton) the Paluxy sand contains turtle bones, gar scales, teeth and plates of unidentified vertebrates, as well as the ostracod *Cypridea* aff. *wyomingensis,* which is considered an indicator of brackish water environments.[3]

Ball (1937) described perhaps the best known occurrence of some of the oldest fossil angiosperms. Three types of deciduous tree leaves, a *Cinnamomum,* a *Sapindopsis,* and an *Aralisephyllum* were collected from the T. H. Cook farm about 7 miles northwest of Stephenville. Ball (*idem,* p. 529) reported imprints of these leaves within lenticular clay-ironstone nodules which weathered from red sandy clay. The nodules have a characteristic mammilated surface.

Ball (*idem,* p. 533) also stated that a comparison of the Glen Rose florule with that of the Paluxy sand indicates that the formations are not equivalent in age; he believed the two formations are separated by a hiatus. Furthermore, R. T. Hill advised Ball (*idem,* p. 533) that he had changed the Paluxy formation from the top of the Trinity division to the base of the Fredericksburg division largely on the presence of dicotyledons in the Paluxy sand.

The cinnamon tree, which is a small evergreen tree of the laurel family, is a present day native of India, Malaya, and Ceylon. Both the Araliaceous and the Sapinaceous orders of plants are also indigenous to modern tropical climates. Thus, the florule of the Paluxy formation indicates similar climatic conditions.

STRATIGRAPHY

FACIES RELATIONSHIPS

About 10 feet of basal Walnut clay form the summits of Twin Mountains (locality 1) in northwestern Erath County (fig. 3). The basal bed of the Walnut clay at this locality is a sandy limestone containing *Exogyra texana, Gryphaea pitcheri,* and *Cardium hillanum* (Hill, 1901, p. 187). A gradational contact separates arenaceous beds of the basal Walnut clay from 190 feet of underlying cross-bedded Paluxy sand.

The Paluxy-Walnut contact at locality 3 about 3 miles northeast of Morgan Mill, Erath County, is unconformable. A few feet below the contact several thin beds are transected by numerous vertical cavity fillings resembling filled molluscan borings. Each boring is approximately 1 inch in diameter, and filled with marl or calcareous sand, depending upon the composition of the overlying bed. It is postulated that the Paluxy-Walnut contact is diastemal throughout the northern part of the area included in this report. The Paluxy-Walnut contact has been described as gradational by Jameson (1959, p. 8). This lithologic gradation does not, however, necessarily indicate a conformable contact. Wave and current action in a body of water transgressing across an arenaceous surface would certainly incorporate older sands into the younger deposits. Furthermore, where the Paluxy sand is extensively cross-bedded, topset beds are always missing and foreset beds are sharply truncated by relatively horizontal beds of the basal Walnut formation (figs. 9, 10).

The Paluxy-Walnut contact at Comanche Peak (locality 4), Hood County, also reflects transgression of the Walnut clay. The basal 4 inches of the Walnut formation are calcareous sand; reworked fossils occur at the wavy formational contact.

The Paluxy-Walnut contact at locality 14, northwestern Bosque County, is also irregular. The basal bed of the Walnut clay at this locality contains abundant *Trigonia emoryi* Conrad and *Exogyra texana* Roemer. The valves of *Trigonia* are commonly sealed and intact; there is no indication of disturbance by wave action during deposition.

Test borings made near Kopperl (locality 12) for alternate dam site locations for the Whitney reservoir show a gradation from Walnut to Paluxy strata.

Near the mouth of Nolan Creek (locality 12), Hill County, the Walnut formation is 90 to 95 feet thick (fig. 3). At Whitney dam site, 16.5 miles southeast, the Walnut has thickened to 130 feet; the upper 80 feet are alternating beds of dense hard limestone, fossiliferous shale, and a coquinoid limestone principally composed of *Gryphaea marcoui* Hill and Vaughn and *Exogyra texana* Roemer in a limy matrix (Hull, 1951, p. 48). At Whitney dam the upper 80 feet of the Walnut formation probably correspond to Lozo's (1949, p. 88) Member 4; the lower 50 feet probably represent Lozo's Member 3. Logs of these test borings at Whitney dam site indicate 80 to 90 feet of Paluxy sand. Lignitic shale bands and pyrite seams in the lower part of the Paluxy may indicate an intraformational unconformity at this locality.

The Glen Rose-Paluxy contact is undoubtedly unconformable in the Kopperl area. Hull (1951, Pl. 14) described the basal Paluxy bed at Alternate Dam Site No. 1 (locality 12) as light gray-green sandy shale with the top 0.1 foot composed of sandstone, pyrite, lignite and shell breccia. Several feet of gradational beds between the Glen Rose limestone and typical cross-bedded

[3]*Cypridea* occurs in modern non-marine aquatic environments (less than 0.5°/oo and brackish-water environments (0.5°/oo-30.0°/oo at water depths normally less than 10 feet—swamps, marshes, rivers, bayous and bays.

Paluxy sand include about a foot of thinly laminated, dark-gray sandy shale containing a "pyrite plate" at the base and several feet of light-gray, hard compact calcareous shale and limestone chips.

Southward across the map area the Paluxy sand facies thins and is replaced by successively older, lower members of the Walnut formation (figs. 4, 6). Lozo (1949, p. 88) described the members of the Walnut clay as follows: *Member 4*—Interbedded yellowish, shaly to crystalline limestone and yellowish or grayish argillaceous limestone or marl with *Exogyra* and *Gryphaea* (the "*Exogyra texana* clay" of the type section). *Member 3*—Thin to massive-bedded, yellowish to white limestone, locally with reef characteristics; laterally replaced by thick, dense, crystalline, grayish, fossiliferous limestone and massive-bedded oyster shell beds (Adkins' Cedar Park member, 1932, p. 331; Hill's "*Gryphaea* rock," 1891, p. 512). *Member 2*—Yellowish (weathered) or bluish (fresh) marly clays with thin limestone bands containing a distinctive microfauna of alveolinids,[4] *Choffatella* (?)[5] and others. This unit, which is missing north of Hill County, is replaced northward in the Hill County area by the sand facies of the Paluxy formation (fig. 4-B). The fauna of Member 2 is absent in the sands because of unfavorable environment. *Member 1*—Medium to thick-bedded, grayish-white limestone, locally dolomitic in part, containing oysters, miliolids, and other fossils. A few miles south of Waco, McLennan County, the Paluxy sand is irregularly replaced (figs. 3, 4) by crystalline limestone and marl beds of the basal member of the Walnut clay which are mappable members of the Walnut clay in central Texas. These stratigraphic relationships of the Walnut clay and Paluxy sand led Lozo (1949) to place the Paluxy sand in the Fredericksburg group.

The unconformity at the base of the Paluxy sand, which is recognized in parts of Hamilton, Bosque, and Hill counties, is probably absent in the subsurface of southern McLennan County. Electrical logs of wells south of the Paluxy sand pinchout (fig. 3) in southern McLennan County reveal lateral continuity of the uppermost Glen Rose limestone beds. It is, therefore, probable that the Glen Rose-Walnut contact is conformable in southern and southeastern McLennan County. From 10 to 30 feet of marl and limestone beds, commonly recognized as basal Walnut formation south of the Paluxy sand pinchout, may represent basinward deposition to the southeast while the Glen Rose limestone was exposed to subaerial erosion to the northwest. Similarly, black shale or marl beds up to 8 feet thick are commonly recognized by drillers between the Paluxy sand and the Glen Rose limestone in southern Bosque County. The writer considers all these argillaceous beds to be intermediate between uppermost Glen Rose limestone and basal Walnut clay as recognized in the subsurface of central and southern McLennan County. These argillaceous beds, which are 20 feet thick in southern McLennan County, may be time-stratigraphic equivalents of the basal Paluxy sand which rests unconformably upon the Glen Rose limestone to the north. Imlay (1945, p. 1416) stated that some of the silty, shaly beds at the top of the Glen Rose limestone in south Texas are probably equivalent to the Paluxy sand of the outcrop area.

[4]Lituolid, not alveolinid; *Barkerina barkerensis* Frizzell and Schwartz, 1950.
[5]=*Stomatostoecha plummerae* Applin, Loeblich and Tappan, 1950.

Lozo (1949, p. 89) reported "sand" beds, occupying the Paluxy interval above the Glen Rose limestone in Burnet County, which were porous and largely composed of microscopic euhedral dolomite crystals containing rare quartz sand grains and calcite crystals. In Comal County "sandy" beds at the position of Member 3 of the Walnut formation (Lozo 1949, p. 88) are also composed of euhedral dolomite crystals. Dolomite is not present in Paluxy sand samples from the B & W Oil Company, #16 well near the south end of the South Bosque field, McLennan County. Secondary cementation by dolomite may, however, explain the absence of production in nearby wells.

DEPOSITIONAL ENVIRONMENTS

The source area from which sand of the Paluxy formation was originally derived includes the Arbuckle-Ouachita uplifts in Arkansas and Oklahoma, and the alternating sand and shale beds of onlapped Pennsylvanian and older strata in central Texas. Paleozoic rocks in these areas endured long periods of erosion prior to deposition of Cretaceous strata. Quartz grains were transported long distances and subjected to numerous cycles of reworking by wind and water as indicated by their relative purity, roundness, and absence of heavy minerals. Most of the Paluxy sand is undoubtedly reworked and redeposited sand of the basal Trinity group with which the Paluxy merges (fig. 6) north of Stephenville in Erath County. In northeast Texas, however, sands of the Trinity group and those of the Paluxy formation were presumably derived from Upper Jurassic clastic rocks which probably occurred to the northeast in Arkansas. Overlapped Upper Jurassic strata in the subsurface of northeast Texas (Waters, 1955, p. 1830) are composed of as much as 70 percent sandstone.

Vanderpool (1928, p. 1089) stated that sands of the Paluxy formation, although of less areal extent than the "Basement sands," indicate a rapid retreat and subsequent advance of the sea following deposition of the Glen Rose limestone. In addition, he stated (*idem*):

> "The Paluxy sands mark a hiatus in the marine Comanchean section. The lower part was deposited in the regressive Trinity sea that retreated beyond the line delimiting sandy sediments. The upper part of the Paluxy was laid down in the transgressive Fredericksburg sea. The hiatus represents a considerable time interval, sufficient to have accounted for marked changes in fauna."

The shallow Comanchean sea in which the Glen Rose limestone was deposited rapidly retreated southeastward toward the East Texas basin, pausing along an irregular front in the vicinity of Waco. Vast areas of basal Trinity sands were left exposed along the old strand line which occupied the upper margin of the gently sloping shelf. These sands were reworked and redeposited as upper Antlers and Paluxy sands (fig. 6) along the abandoned coast line and across the upper margins of the Glen Rose limestone shelf. Small streams probably transported much fine sand across the upper surface of the unlithified Glen Rose formation. Wave action in the shallow retreating sea also reworked fossiliferous lime muds in the upper part of the Glen Rose formation. The resulting "hash" of macerated shells and limestone pebbles was then exposed to subaerial erosion at which time the surface

Fig. 11. Cross-bedded channel sand, Paluxy formation, Rough Creek, 5.5 miles (airline) northwest of Walnut Springs, Bosque County (locality 7). Cross-beds in foreground dip S 25° E. View looking northwest.

became casehardened, pitted, and ocherous; sand was then spread across this surface by wind and water. Minor accumulations of evaporites may have been deposited in some localities during withdrawal of the Glen Rose sea. Appreciable quantities of salt immediately above the Glen Rose limestone in Wise and Parker counties (Scott, 1930, p. 49) suggest that isolated, restricted bodies of marine water remained to evaporate in shallow depressions as the sea withdrew from the region.

Sands of the Paluxy formation were undoubtedly deposited near the ancient Comanchean coast line. Dinosaur tracks have been reported by Booth (1956) from the Paluxy sand in Rough Creek, Flat Top ranch, Bosque County. Evidence from sedimentary structures —ripple marks, cross-beds, laminae—as well as grain size distribution and composition suggests that several depositional environments were probably responsible for the Paluxy formation. Absence or rarity of marine organisms, presence of brackish water ostracods (p. 17), abundance of plant remains, and diagnostic sedimentary structures suggest that some of the cross-bedded sands exposed in the area may have been deposited in a fluvial (fig. 11) or fluvio-marine environment. Internal, small-scale cross-bedding within cross-beds at some localities probably represents near-shore marine deposition by longshore currents.

Some of the sand may have been distributed by wind action. McKee (1952, p. 17) stated that two distinct processes are involved in the formation of dunes. One is saltation of the grains up the gentle windward slope of a dune; the other is avalanching by which sand grains, through repeated activity, move forward and downward on the lee side of a dune. In most areas only the avalanche deposits on the lee sides are permanently preserved. Thus, dunes are formed by forward movement of the dune sands by unidirectional winds, and by lee-side slumping; the topset beds are often destroyed prior to the preservation of the dune structure.

A characteristic feature of dune sands is the consistently higher range in angles of repose for subaerially deposited dune sands compared with corresponding subaqueous deposits. McKee (*idem*, p. 18) found experimentally that subaerial beds develop angles from 30 to 40 degrees with the horizontal, whereas subaqueous beds display dips from 20 to 35 degrees; this difference was found to be especially pronounced in lesser size grades.

The cross-bedded sand at locality 9 (fig. 10) midway between Iredell and Walnut Springs, Bosque County, strikes N 33°W and bedding planes dip northeastward at approximately 34 degrees. The angle of repose of cross-bedded sand at this and other localities suggests a non-marine environment characterized by sparse vegetation and abundant quartz sand. The northwest strike of Paluxy cross-beds throughout this region probably more or less parallels the transgressing Paluxy shoreline which lay southeastward at the time the dunes were developing. The prevailing wind at this locality was from the southwest, probably blowing in an inland direction.

Some of the sands of the Paluxy formation are not cross-bedded. At some localities sands are evenly bedded and contain thin calcareous beds (figs. 12, 13); at other localities the sand is massive. These horizontally bedded sand units may have been deposited in a subaqueous environment by sand-laden streams and longshore drift. Thus, introduced into a shallow marine environment, the sands were spread over the

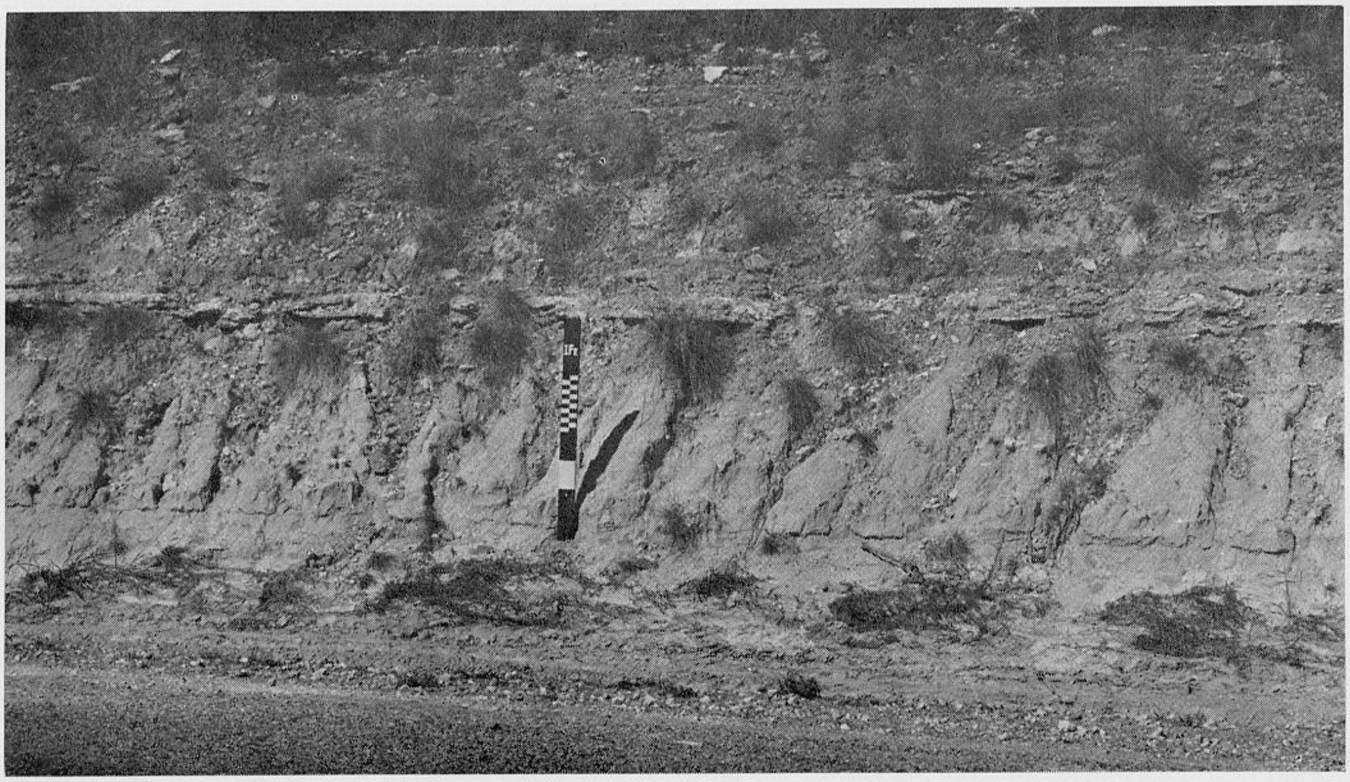


Fig. 12. Horizontal beds of Paluxy sand along Farm Road 927 near M.K.T. Railroad crossing, 4 miles southwest of Walnut Springs, Bosque County (locality 10).

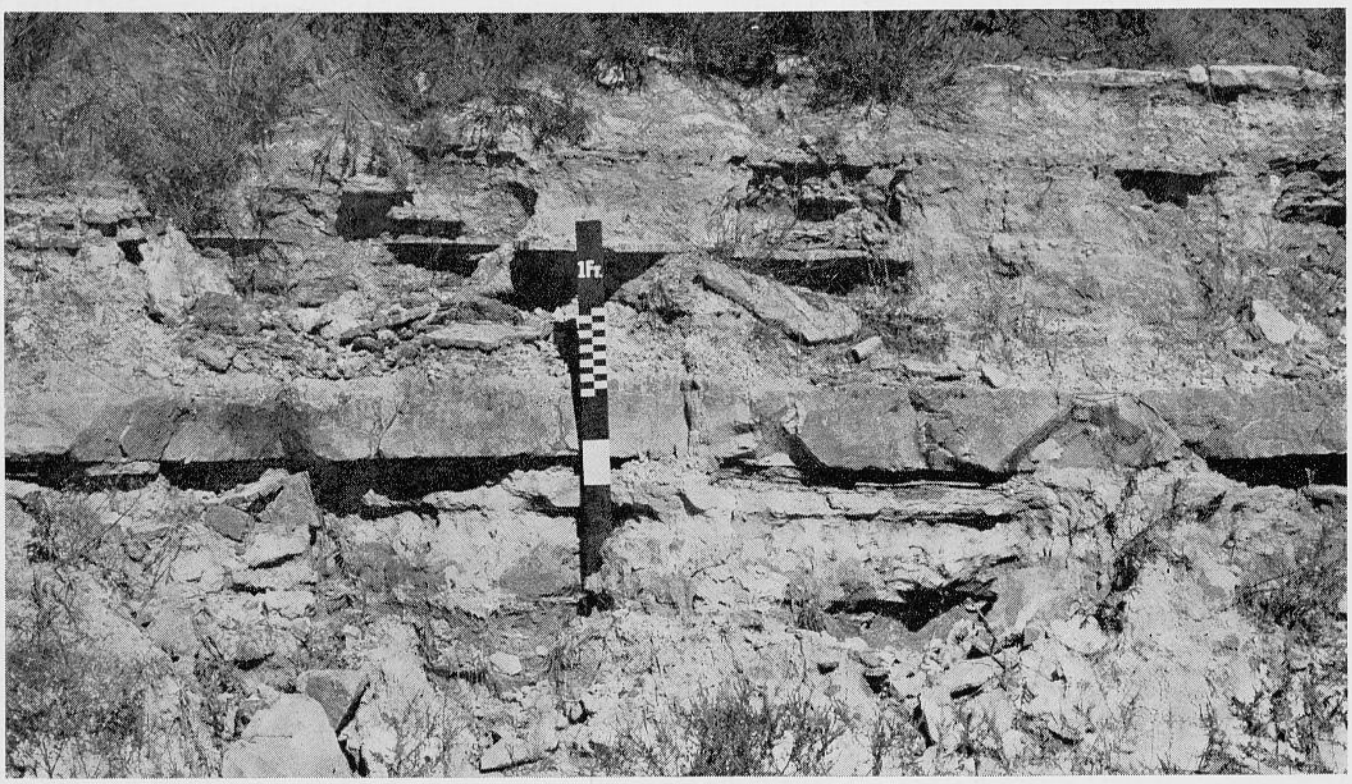


Fig. 13. Horizontal beds of Paluxy sand with thin indurated ledges along Farm Road 927, 2.2 miles east of Iredell, Bosque County (locality 13). A fossiliferous limestone bed similar to those occurring in the overlying Walnut formation immediately underlies these sandstone beds at this locality.

shelf-like area where transporting energy levels were widespread and uniformly sustained. The sand deposits were bedded by the winnowing and reworking action of waves.

AGE ASSIGNMENT

The formations which constitute the Fredericksburg group or division, as their names suggest, were first recognized and defined as rock units at specific geographic localities. The ingrained idea of the type locality or type area was prevalent during this initial phase of investigation. Comanchean formations throughout the region were erroneously considered synchronous. As the formations were mapped or traced beyond type localities, formation names were extended to embrace similar lithofacies believed to be age equivalent with rocks initially defined at the type locality. Continued surface investigations and the advent and refinement of subsurface stratigraphy revealed facies relationships between the formations of the Fredericksburg group which proved that distinctive lithologic units or facies (formations) were of different ages throughout the province. The introduction of this facies concept was followed by widespread use of the term "Fredericksburg" to denote a time-stratigraphic or time-rock unit rather than a stratigraphic or rock-unit (p. 5). Thus, the term "group" assumed a dual meaning.

The contact between the Fredericksburg and Trinity groups is based primarily upon the contained faunas and floras of these two units. Physical evidence and not paleontological evidence, however, was the basis for recognizing the Paluxy sand as the lowermost unit of the Fredericksburg group (Hill, 1937; Lozo, 1949). On the basis of sedimentary history, the age of the Paluxy sand in the area of this report is probably early Middle Albian (fig. 2). Scott, (1926, p. 159) placed the Paluxy formation in Lower Albian on the basis of paleontologic study and comparison. Concerning European correlation of the Fredericksburg beds, Scott (*idem*) stated:

> "The Aptian superior or Gargasian comprises the Travis Peak beds and all of the Glenrose [*sic*] with the exception of the uppermost beds of the latter which are sensibly at the limit of the Aptian and Albian and therefore referable to the so-called 'Clansayes' horizons, now included in the Albian.
> The Albian includes this transitional zone at the top of the Glenrose [*sic*], all of the Fredericksburg, and all of the Washita (The Vraconnian is considered as upper Albian). During all the Gargasian and lower Albian the sea was transgressive toward the north and west. The sea, however, up to the end of the lower Albian (that is throughout the Fredericksburg) remained relatively shallow, the deposits being represented by a neritic and nectic [*sic*] facies during the Walnut and Comanche Peak, and by a zoogene (Urgonian) facies during the Edwards."

ECONOMIC GEOLOGY

GENERAL FEATURES

The Paluxy sand is not especially important economically within the area, although it is an important oil producing horizon in northeast Texas. Scott (1930, p. 49) stated that some of the sand section had been analyzed to determine the suitability for glass manufacture, and that although the analyses were favorable, the sands had not been exploited for this purpose.

The Owens-Illinois Glass Company plant in Waco utilizes the iron-free quartz sand from the Comanchean outlier at Santa Anna, Coleman County, 135 miles west of Waco. This glass sand, which is commercially called the "Santa Anna sand," is in part at least, equivalent to the Paluxy sand of central Texas.

AGRICULTURE

The non-calcareous soil types developed upon the Paluxy sand are fairly productive. These soils are well suited for cotton, peanuts, sorghums, vegetables, and fruits, which are the principal crops grown. An average annual rainfall of 30 to 40 inches and an average annual temperature of 64 to 66 degrees make these fine sandy loams even more attractive for agriculture.

WATER SUPPLY

The first artesian wells in the region were completed in the Paluxy sand at a depth of 263 feet in the western part of Fort Worth. These wells provided Fort Worth with artesian water for many years during the late 1800's before the more important aquifers of the Trinity group were tapped (Hill, 1901, p. 437).

The Paluxy sand in the northern part of the area of this report is not an adequate source of artesian water because the formation has been excessively dissected by erosion. Several shallow non-flowing wells have been drilled for domestic use in the upland areas of Hood, Somervell, and Erath counties and a few dug wells in the outcrop area produce small supplies from the zone of saturation. However, the formation is not sufficiently confined hydrologically to yield water by artesian pressure. In this northern area the Paluxy sand is utilized only because of the greater depth to the "Basal sands" or Trinity reservoir. Although the Paluxy sand becomes a more important water reservoir southward as the hydrostatic pressure increases downdip, water production is only moderate and wells normally must be pumped. Furthermore, the sand thins downdip and water becomes less potable because of salts of iron, strontium, magnesium, and other soluble minerals. Water from the formation has been used in conjunction with water from sands of the Trinity group or Woodbine sand in several towns such as Hillsboro in Hill County, and Bosqueville and West in McLennan County.

SOUTH BOSQUE OIL FIELD

The South Bosque Field, which is the oldest Paluxy oil field in Texas, was discovered in 1890 about 8 miles southwest of Waco, McLennan County. The discovery well was reportedly the water well of Colonel William L. Prather. Several barrels of oil were bailed from the well before it was abandoned. It was not until 1902 that operators drilled for oil in the area. The first well, the exact location of which is unknown, was completed at a depth of 475 feet and produced 5 barrels of 42 gravity oil per day (Price, 1951, p. 24).

The field originally covered an area of about 1,370 acres (2.14 square miles) and extended from immediately southwest of the South Bosque community to Hog Creek. The South Bosque field is often divided into the north field and the south field separated by the Middle Bosque River. The north field did not develop until 1919 or 1920; the first well was the Riley Crane, #1 Stephenson located on the Mattie Reynolds 180 acre tract. The area of production has been mapped (Adkins, 1923; Price, 1951) as two highs on a small anticlinal structure with less than 25 feet of closure. The trap may, however, be attributable to a minor local dip reversal near the southward pinchout of the Paluxy sand. The anticlinal axis approximately parallels the trend of the nearby Balcones fault system; if structural, the trap probably is genetically associated with this fault system. An apparent anticlinal structure visible in the Georgetown limestone along Hog Creek in the vicinity of the field is, however, possibly no more than a reflection of bioherms (organic reefs) in the underlying Edwards limestone.

Production (Appendix II) from the field was never great but has been continuous for nearly 60 years. The erratic yearly production from 1902-1958 averaged 3,126 barrels, with a minimum yearly production of 1,610 barrels in 1950 and a maximum production of 10,711 barrels in 1953.

Two wells were completed by the M & S Oil Company of McGregor on the Clemmons Survey during the summer of 1959. The #15 South Bosque unit is located 150 feet from the south line of the Clemmons Survey and 1,350 feet from the west line of the survey; the #16 unit is located several hundred feet south of #15. The #15 unit well, which had a bottom hole pressure of 167 pounds per square inch, was perforated from 460 to 464 feet. This well is presently producing 4 barrels of 41 gravity oil with 30 percent water per day.

Price (1951, p. 26) attributed the production of the South Bosque field to lenticular basal Walnut sands ranging from 3 feet to less than 1 foot thick. The stratigraphic position and lithologic similarity of these sands with the Paluxy sand, which is known to thin downdip toward the field, leads the writer to believe that the pay zone is the Paluxy formation. A study of available electrical logs of the area further suggests that sand stringers which constitute the reservoir rock in the South Bosque field are downdip tongues of the outcropping Paluxy sand. Continuity between the producing horizon in the South Bosque field and the Paluxy sand at the outcrop is also evidenced by the relatively fresh water dilution or flushing of the brackish connate water in the South Bosque reservoir. In some instances fresh water has been encountered in sufficient quantities to create an inversion of the spontaneous potential curve on electrical logs of wells in the field.

CONCLUSIONS

(1) The Paluxy formation is replaced southward downdip by limestone and marl beds of the Walnut formation and is recognized as the lowermost formation of the Fredericksburg group.

(2) The Glen Rose-Paluxy contact is unconformable in the outcrop area, but becomes conformable downdip in the vicinity of Waco. The Paluxy-Walnut contact is locally unconformable or diastemal in the outcrop area, but becomes laterally gradational southward in the subsurface.

(3) Dark shale and marl beds occupying a position between the top of the Glen Rose limestone and the base of the Walnut clay southward beyond the pinchout of the Paluxy sand, were deposited in a regressive sea during late Lower Albian and early Middle Albian time.

(4) Quartz sands of the Paluxy formation have undergone numerous cycles of erosion, transportation, and deposition. The Paluxy sand is not necessarily composed predominantly of smaller grains than the basal sands of the Trinity group.

(5) The Paluxy sand, which pinches out southward in southern McLennan and Coryell counties, thickens northward toward the source area.

(6) The Paluxy sand of the map area was deposited in environments ranging from shallow marine in the south to non-marine in the north.

REFERENCES

ADKINS, W. S. (1923) Geology and mineral resources of McLennan County: Univ. Texas Bull. 2340, 202 pp.

——— (1932) The Mesozoic system in Texas *in* The Geology of Texas: Univ. Texas Bull. 3232, pp. 239-518.

——— and ARICK, M. B. (1930) Geology of Bell County, Texas: Univ. Texas Bull. 3016, 92 pp.

BALL, OSCAR M. (1937) A dicotyledonous florule from the Trinity group of Texas: Jour. Geology, vol. 45, pp. 528-537.

BOOTH, CHARLES CLINTON (1956) Geology of the Chalk Mountain quadrangle, Bosque, Erath, Hamilton and Somervell counties, Texas: Univ. Texas, unpublished master's thesis.

EATON, R. W. (1956) Resume of subsurface geology of northeast Texas with emphasis on salt structures: Trans. Gulf Coast Assoc. Geol. Soc., vol. VI, p. 81.

HILL, R. T. (1887) The Texas section of the American Cretaceous: Am. Jour. Sci., ser. 3, vol. 134, pp. 287-309.

——— (1891) The Comanche series of the Texas-Arkansas region: Geol. Soc. America Bull., vol. 2, pp. 503-524.

——— (1901) Geography and Geology of the Black and Grand Prairies, Texas: U. S. Geol. Survey, 21st Ann. Rept., pt. 7, 666 pp.

——— (1937) Paluxy sands, with further notes on the Comanche series (abs.): Geol. Soc. America Proc. 1936, pp. 79-80.

HULL, ARTHUR M. (1951) Geology of Whitney reservoir area, Brazos River, Bosque-Hill counties, Texas *in* The Woodbine and adjacent strata of the Waco area of central Texas: South. Meth. Univ., Fondren Sci. Ser. no. 4, pp. 45-65, 16 pls.

IMLAY, RALPH W. (1945) Subsurface Lower Cretaceous formations of south Texas: Am. Assoc. Petrol. Geol. Bull., vol. 29, pp. 1416-1469.

JAMESON, J. B. (1959) Stratigraphy of the Fredericksburg division of central Texas: Baylor Univ., unpublished master's thesis.

LOZO, FRANK E. (1949) Stratigraphic relations of Fredericksburg limestones, north-central Texas *in* Shreveport Geol. Soc. Guidebook, 17th annual field trip, Sept. 1949, pp. 85-91, 5 figs.

——— (1959) Stratigraphic relations of the Edwards limestone and associated formations in north-central Texas *in* Symposium on Edwards limestone in central Texas: Univ. Texas Pub. 5905, pp. 1-20.

——— and STRICKLIN, F. L. JR. (1956) Stratigraphic notes on the outcrop, basal Cretaceous, central Texas: Trans. Gulf Coast Assoc. Geol. Soc., vol. 6, pp. 67-79.

MARCOU, JULES (1856) Resume and field notes [on collections made during railroad survey]: U. S. 33d Cong., 2d sess., H. Ex. Doc. 91, v. 3, pt. IV, no. 2, p. 131.

MCBRIDE, W. J. (1953) The surface geology of Hamilton County, Texas: Univ. Houston, unpublished master's thesis.

MCKEE, EDWIN D. (1952) Report on studies of stratification in modern sediments and in laboratory experiments (Project nonr 164 (00), NR081.123): Office of Naval Research, 61 pp. (1957, Am. Assoc. Petrol. Geol. Bull., vol. 41, pp. 1704-1747).

MISER, H. D. (1927) Lower Cretaceous (Comanche) rocks of southeastern Oklahoma and southwestern Arkansas: Am. Assoc. Petrol. Geol. Bull., vol. 11, pp. 443-453.

NELSON, H. F. (1959) Deposition and alteration of the Edwards limestone, central Texas *in* Symposium on Edwards limestone in central Texas: Univ. Texas Pub. 5905, pp. 21-130.

PRICE, JOHN (1951) The South Bosque oil field *in* The Woodbine and adjacent strata of the Waco area of central Texas: South. Meth. Univ., Fondren Sci. Ser. no. 4, pp. 24-28.

ROEMER, FERDINAND (1852) Die Kreidebildungen von Texas und ihre organischen Einschlüsse: Bonn (Germany), Adolph Marcus, 100 pp.

SCOTT, GAYLE (1926) On a new correlation of the Texas Cretaceous: Am. Jour. Sci., ser. 5, vol. 12, pp. 157-161.

——— (1930) The stratigraphy of the Trinity division as exhibited in Parker County, Texas: Univ. Texas Bull. 3001, pp. 37-56.

SHUMARD, B. F. (1860) Observations upon the Cretaceous strata of Texas: Trans. St. Louis Acad. Sci., vol. 1, pp. 582-590.

SHUMARD, GEORGE GETTZ (1854) Remarks upon the general geology of the country passed over by the exploring expeditions to the sources of Red River under the command of Captain R. B. Marcy, U.S.A. *in* Exploration of the Red River of Louisiana in the year 1852: U. S. 32nd Cong., 2nd sess., S. Ex. Doc. 54, vol. 8, pp. 170-195 (1853).

STANTON, R. W. (1928) The lower Cretaceous or Comanche series: Am. Jour. Sci., ser. 5, vol. 16, pp. 399-409.

STEPHENSON, L. W., *et al.* (1942) Correlation of the outcropping Cretaceous formations of the Atlantic and Gulf Coastal Plain and Trans-Pecos Texas: Geol. Soc. America Bull., vol. 53, pp. 435-448. Correlation chart.

STOSE, G. W., *et al.* (1937) Geologic map of Texas: U. S. Geol. Survey, 1/500,000.

TAFF, J. A. (1892) Reports on the Cretaceous area north of the Colorado River: Texas Geol. Survey, 3rd Ann. Rept., pp. 269-379.

THOMPSON, S. A. (1935) The Fredericksburg group of the Lower Cretaceous: Am. Assoc. Petrol. Geol. Bull., vol. 19, pp. 1508-1537.

VANDERPOOL, H. C. (1928) A preliminary study of the Trinity group: Am. Assoc. Petrol. Geol. Bull., vol. 12, pp. 1069-1093.

WATERS, J. A., *et al.* (1955) Geologic framework of Gulf Coastal Plain of Texas: Am. Assoc. Petrol. Geol. Bull., vol. 39, pp. 1821-1850.

APPENDIX I

LOCALITIES[1]

Outcrop localities

1. Basal Trinity sands, 5 feet of Glen Rose limestone, Paluxy sand and Walnut clay capping Twin Mountains; approximately 2.5 miles west of State Highway 108, about 14 miles northwest of Stephenville, Erath County. (32°23'N; 98°23'W)[2]
2. Trinity sands well exposed in Straight Creek, 0.75 mile southwest of Morgan Mill, west of U. S. Highway 281, Erath County. (32°24'N; 98°10'W)
3. Paluxy sand in road cut, Farm Road 1189, 2.5 miles northeast of Morgan Mill, Erath County. (32°25'N; 98°08'W)
4. Upper Trinity and Lower Fredericksburg groups at Comanche Peak, 1 mile west of State Highway 144, 4.5 miles south of Granbury, Hood County. (32°23'N; 97°48'W)
5. Trinity sand, Glen Rose limestone, Paluxy sand and Walnut clay in the vicinity of Paluxy townsite, Hood County. (32°16'N; 97°54'W)
6. Paluxy sand in road cut (Glen Rose limestone to Walnut clay exposed), U. S. Highway 67, about 10 miles southwest of Glen Rose, Somervell County. (32°11'N; 97°53'W)
7. Paluxy sand exposed in Rough Creek, Flat Top Ranch, approximately 5.5 miles (airline) northwest of Walnut Springs, Bosque County. (32°05'N; 97°50'W)
8. Paluxy sand and lower Walnut clay in county road cut, about 1 mile southeast of Brazos Point, Bosque County. (32°11'N; 97°54'W)
9. Paluxy sand-Walnut clay contact in road cut on Farm Road 927, about 5 miles southwest of Walnut Springs, Bosque County. (32°01'N; 97°48'W)
10. Paluxy sand in road cut on Farm Road 927 at M.K.T. railroad crossing, 4 miles southwest of Walnut Springs, Bosque County. (32°01'N; 97°47'W)
11. Paluxy sand along Brazos River, immediately southeast of Grass Creek, Bosque-Johnson County line. (32°09'N; 97°33'W)
12. Paluxy sand described from 3 core holes by U. S. Corps of Engineers, Bosque-Hill County line at alternate Whitney dam sites on Brazos River near Kopperl. (32°06'N; 97°29'W)
13. Paluxy sand in road cut on Farm Road 927, 2.2 miles east of Iredell, Bosque County. (32°00'N; 97°50'W)
14. Upper Glen Rose limestone, Paluxy sand and lower Walnut clay in road cut on State Highway 6, 1.5 miles southeast of Iredell, Bosque County. (31°59'N; 97°51'W)
15. Paluxy sand in road cut on Farm Road 1602, 4.5 miles southeast of Hico, Hamilton County. (31°56'N; 98°00'W)
16. Upper Glen Rose limestone, Paluxy sand and lower Walnut clay in road cut and adjacent Sycamore Creek area, 1.5 miles southwest of Lanham on State Highway 22, Hamilton County. (31°44'N; 97°58'W)
17. Upper Glen Rose limestone, Paluxy sand and lower Walnut clay in road cut and along tributary of Leon River, 1.6 miles southeast of Jonesboro on State Highway 36, Coryell County. (31°36'N; 97°52'W)
18. Upper Glen Rose limestone, Paluxy sand and Walnut clay along tributary of Leon River, about 3,000 feet southwest of State Highway 36, 4 miles north of Gatesville, Coryell County. (31°29'N; 97°45'W)
19. Upper Glen Rose limestone, Paluxy sand and Walnut clay along the Leon River at western and southern edge of Gatesville, Coryell County. (31°26'N; 97°45'W)

[1]Refer to U. S. Army Map Service, Corps of Engineers, 1:250,000 scale topographic maps (Waco NH 14-3; Dallas NI 14-12; Abilene NI 14-11; and Brownwood NH 14-2).
[2]Latitude and longitude.

Subsurface localities (wells)

20. Orr & Miracle, #1 Ray, Bosque County. (31°53'N; 97°53'W)
21. J. L. Myers & Sons, #2 Meridian water well, Bosque County. (31°56'N; 97°40'W)
22. Joe A. Humphrey, #1 J. E. Osborne, Hill County. (32°12'N; 97°19'W)
23. Clifton, #2 Municipal water well, Bosque County. (31°47'N; 97°35'W)
24. J. L. Myers & Sons, #2 Murrey & Smith, Bosque County. (31°51'N; 97°23'W)
25. J. L. Myers & Sons, #1 E. Mixon, Hill County. (31°53'N; 97°21'W)
26. Layne Texas Co., #3 Whitney water well, Hill County. (31°57'N; 97°19'W)
27. C. Stubblefield, #1 Sumner, Hill County. (32°02'N; 97°12'W)
28. Layne Texas Co., #10 City of Hillsboro water well, Hill County. (32°01'N; 97°09'W)
29. J. L. Myers & Sons, #2 City of Abbott water well, Hill County. (31°53'N; 97°04'W)
30. R. M. Bass, #1 J. Gerek, Hill County. (31°50'N; 97°08'W)
31. C. P. Quinlan, #1 Prause, McLennan County. (31°47'N; 97°08'W)
32. Valley Mills Community Public Service Co. water well, Bosque County. (31°39'N; 97°28'W)
33. E. J. Muth, #1 Freeman, McLennan County. (31°36'N; 97°28'W)
34. Falcon Oil Co., #1 Henry Mattlage, McLennan County. (31°32'N; 97°30'W)
35. Hervie Meadows, #1 McKethan, McLennan County. (31°34'N; 97°21'W)
36. Lake View Water Company, #1 J. E. Passmore, McLennan County. (31°38'N; 97°06'W)
37. Layne Texas Co., #3 Connally Air Base, McLennan County. (31°39'N; 97°04'W)
38. J. L. Myers & Sons, #1 Penelope, Hill County. (31°53'N; 96°56'W)
39. Simon Korshoj, #1 Ferguson, McLennan County. (31°41'N; 96°58'W)
40. Mount Carmel Center, #1 water well, McLennan County. (31°36'N; 96°59'W)
41. H. C. Buchanan, #1 Buchanan, McLennan County. (31°33'N; 97°08'W)
42. Layne Texas Co., #3 Texas Water Company, McLennan County. (31°33'N; 97°10'W)
43. J. L. Myers & Sons, #1 Youngblood, McLennan County. (31°29'N; 97°06'W)
44. Gray Oil Co., #1 Warren, McLennan County. (31° 25'N; 97°11'W)
45. Beacon Oil and Refining Co., #1 Myrtle Trice, McLennan County. (31°27'N; 97°14'W)
46. Roy Snider, #3 W. Guy Shelton, McLennan County. (31°30'N; 97°17'W)
47. J. L. Myers & Sons, #2 Tilton, McLennan County. (31°26'N; 97°18'W)
48. City of McGregor, #3 water well, McLennan County. (31°27'N; 97°24'W)
49. Delta Drilling Co., #1 Horstman, McLennan County. (31°25'N; 97°23'W)
50. General Crude Oil Co., #1 Earnest Day, Coryell County. (31°21'N; 97°26'W)
51. J. L. Myers & Sons, #2 Moody water well, McLennan County. (31°19'N; 97°21'W)
52. Jet Oil Co., #1 Wills, McLennan County. (31°22'N; 97°15'W)

APPENDIX II

PRODUCTION FROM THE SOUTH BOSQUE OIL FIELD McLENNAN COUNTY, TEXAS[1]

Year	No. Prod. Wells at Years End	Yearly Production (bbls)	Cumulative Production (bbls)
1902-1932	Not Available	Not Available	57,450
1932	—	8,400	65,850
1933	60	8,550	74,400
1934	—	6,570	80,970
1935	—	3,480	84,450
1936	—	4,380	88,830
1937	30	4,531	93,361
1938	37	3,865	97,226
1939	54	3,402	100,628
1940	49	4,660	105,288
1941	49	4,297	109,585
1942	35	3,386	112,971
1943	35	2,766	115,737
1944	28	2,428	118,165
1945	28	2,550	120,715
1946	28	2,356	123,071
1947	28	2,656	125,727
1948	28	2,490	128,217
1949	2	2,370	130,587
1950	7	1,610	133,408
1951	8	2,709	136,117
1952	10	5,951	142,068
1953	14	10,711	152,779
1954	15	5,542	158,321
1955	17	4,805	163,126
1956	20	4,934	168,060
1957	24	5,249	173,309
1958	24	4,869	178,178
1959	24	4,614	182,792
1960	23	4,199	186,991
1961	—	3,900 (*est.*)	190,891 (*est.*)

[1]1902-1949 *after* Price, 1951.

INDEX

Adkins, W. S., 14, 17, 22
Alternate dam site, 17
Amsbury, D. L., 10
Andropogons, 12
Aralisephyllum, 17
Arbuckle-Ouachita uplifts, 18
Arick, M. B., 14
Arkansas, 18
  Pike County, 8

Balcones fault zone, 14, 22
Ball, O. M., 17
Barkerina, 18
Basement sands, 10
Batis, M. M., 10
Beall, A. O., 8
Booth, C. C., 19
Brown, J. B., 10

Caprotina, 8
Cardium, 17
Ceylon, 17
Choffatella, 18
Cinnamomum, 17
Cook, T. H., 17
Cypert, R. P., 10
Cypridea, 14, 17

Dixon, J. W., Jr., 10

East Texas basin, 18
Exogyra, 17, 18

Glen Rose Prairie, 12
Glen Rose-Paluxy contact, 17, 22
Glen Rose-Walnut contact, 14, 18
Gryphaea, 17, 18

Hayward, O. T., 10
Hill, R. T., 5, 8, 13, 14, 17, 21
Hull, A. M., 8, 13, 17
Humphrey, J. E., 13, 14

Imlay, R. W., 18
India, 17

Jameson, J. B., 17

Kopperl dam site, 14

Liesegang banding, 10
Louisiana, 12
Lozo, F. E., 5, 10, 12, 13, 14, 17, 18, 21

M & S Oil Company, 10, 22
Malaya, 17
Marcou, J., 8
McBride, W. J., 8, 14
McKee, E. D., 19
Miser, H. D., 8
Mooreman, C. C., 10
Mosteller, M. A., 10
Myers, J. L., 13, 14

Oklahoma, 18
  Fort Washita, 8
  southeastern, 8
Osborne, J., 13, 14
Ostrea, 17
Owens-Illinois Glass Co., Waco, 21

Paluxy Cross Timbers, 12
Paluxy-Glen Rose contact, 17
Paluxy sand, 10-22
  age assignment, 21
  clay minerals, 12
  color, 10
  depositional environments, 18-19
  distribution, 12
  economic geology, 21-22
  electrical logs, 18
  facies relationship, 17-18
  grain size, 10
  iron concretion, 10
  mineral composition, 10
  paleontology of, 14-17
  stratigraphy, 17-21
  thickness, 13, 14
  well cuttings of, 10-12
Paluxy shoreline, 19
Paluxy-Walnut contact, 17, 22
  at Bosque County, 17
  at Comanche Peak, Hood County, 17
  at Morgan Mill, Erath County, 17
Penelope, 14
Prather, W. L., 22
Price, J., 22

Quercus, 12

Red Beds, 10
Roemer, F., 8

Santa Fe Railroad, 13
Scott, G., 10, 12, 19, 21
Shell Development Company, 10
Shumard, B. F., 8
Shumard, G. G., 8
Smith, R., 13
Soil Conservation Service, 10, 12
South Bosque oil field, 12, 14, 18, 21, 22
  Mattie Reynolds, 22
Stomatostoecha, 18
Stose, G. W., 8
Stratigraphic units
  Albian, 21
  Antlers formation, 12, 17, 18
  Cedar Park member, 18
  Comanche Peak limestone, 5, 8, 21
  Comanchean series, 5, 8, 12, 21
  DeQueen formation, 8
  Edwards limestone, 5, 8, 22
  Fredericksburg group, 5, 8, 10, 12, 14, 17, 18, 21, 22
  Gatesville formation, 8
  Georgetown limestone, 22
  Glen Rose formation, 8, 10, 13, 14, 17, 18, 19, 21, 22
  Kiamichi clay, 14
  Neocomian, 8
  Paluxy formation, 5, 8, 10, 12, 13, 14, 17, 18, 19, 21, 22
  Santa Anna sand, 21
  Senonian, 8
  Travis Peak beds, 21
  Trinity group, 5, 8, 10, 12, 13, 17, 18, 21, 22
  Turonian, 8
  Walnut formation, 5, 8, 10, 12, 13, 14, 17, 18, 21, 22
  Washita division, 8
  Washita group, 5, 8, 14, 21
  Windthorst loam, 12
Stricklin, F. L., Jr., 5
Stubblefield, 14
Sumner, 14

Taff, J. A., 14
Texas, 8
  Bell County, 14
    Belton, 14
    Killeen, 14
  Bosque County, 8, 12, 13, 14, 17, 18
    Brazos Point, 12, 17
    Flat Top Ranch, 19
    Iredell, 12, 13, 14, 19
    Kopperl, 17
    Meridian, 12, 13
    Walnut Springs, 12, 13, 19
  Brazos River, 8, 12, 13
  Burnet County, 18
  Central, 5, 8, 10, 12, 14, 18, 21,
  Coleman County, 21
    Santa Anna, 21
  Comal County, 18
  Comanche County, 14
    Round Mountain, 14
  Cook County, 17
  Coryell County, 8, 10, 12, 14, 22
    Copperas Cove, 12
    Gatesville, 12, 13, 14
    Jonesboro, 14
    Pidcoke, 12
  Cowhouse Creek, 12
  East, 14
  Erath County, 8, 12, 14, 17
    Morgan Mill, 10, 17
    Stephenville, 10, 17, 18
    Twin Mountains, 13
  Fort Hood Village, 12, 14
  Fort Worth, 14, 21
  Four Mile Branch, 13
  Freestone County, 12
  Grass Creek, 12
  Hamilton County, 8, 12, 14, 17, 18
    Hico, 14
  Hill County, 8, 13, 14, 17, 18
    Hillsboro, 14, 21
    Whitney, 8, 13
    Woodbury, 14
  Hog Creek, 22
  Hood County, 8, 12, 14
    Comanche Peak, 8, 13
    Granbury, 13
    Paluxy, 10
  Johnson County, 13
    Cleburne, 13
  Leon River, 12, 14
  Limestone County, 12
  McLennan County, 8, 12, 14, 18, 22
    Bosqueville, 21
    McGregor, 14, 22
    Moody, 14
    Waco, 18, 21, 22
  Middle Bosque River, 22
  Mills County, 14, 17
    Priddy, 14, 17
  Morgan Creek, 14
  Nolan Creek, 17
  North-central, 8
  North-east, 18, 21
  Paluxy River, 10
  Parker County, 10, 12, 14, 19
    Weatherford, 17
  Red River, 12
  Rock Creek, 17
  Rough Creek, 19
  Sanchez Creek, 17
  Somervell County, 10, 12
    Glen Rose, 10
  South, 18
  Sycamore Creek, 14
  Trinity River, 14
  Wise County, 12, 17, 19
    Decatur, 14
Texas Board of Water Engineers, 12
Texas Railroad Commission, 12
Texas Training School, 14
Thomas, J. R., Jr., 10, 12
Thompson, S. A., 8, 13
Trigonia, 17

Vanderpool, H. C., 8, 14, 18
Vicarya, 17

Waters, J. A., 18
Western Cross Timbers, 12
Whitney Dam, 17
Whitney Reservoir, 17

BAYLOR GEOLOGICAL PUBLICATIONS*

Baylor Geological Society

1. Type electric log of McLennan County. 1"-100'; 1"-50'-$2.00.
2. Reptile charts—Comparison of flying and swimming reptiles. $0.10 each. Comparison of the dinosaurs. $0.10 each.
3. Guide to the mid-Cretaceous geology of central Texas, May, 1958. $4.50 per copy.
4. Location map of logged wells in McLennan County, 1959. 1"-1 mile, $7.50 per copy.
5. Layman's guide to the geology of central Texas, 1959, Out of print.
6. Collector's guide to the geology of central Texas, 1959. Out of print.
7. One hundred million years in McLennan County, 1960. Out of print.
8. Cretaceous stratigraphy of the Grand and Black Prairies, 1960. $5.00 per copy.
9. Popular geology of central Texas, west central McLennan County, 1960. Out of print.
10. Popular geology of central Texas, Bosque County, 1961. $1.00 per copy.
11. Popular geology of central Texas, northwestern McLennan County, 1961. $1.00 per copy.

Baylor Geological Studies

12. Holloway, Harold D. (1961) The Lower Cretaceous Trinity Aquifers, McLennan County, Texas: Baylor Geological Studies Bull. No. 1 (Fall). $1.00 per copy.

---

*Publications available from Baylor Geological Society or Baylor Geological Studies, Baylor University, Waco, Texas.

BAYLOR UNIVERSITY

GEOLOGY