Geological Circular 72-4

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DEPOSITIONAL SYSTEMS AND OIL-GAS RESERVOIRS IN THE QUEEN CITY FORMATION (EOCENE), TEXAS[1]

Edgar H. Guevara[2] and Roberto García[2]

ABSTRACT

Regional surface and subsurface studies indicate that thick deltaic (Queen City Formation) and thin shelf (Reklaw and Weches Formations) sequences compose the stratigraphic interval between the top of the Carrizo Sand and the base of the Sparta Formation. In East Texas, the Queen City Formation accumulated as part of a high-constructive, lobate delta system; and in South Texas, as part of a high-destructive, wave-dominated delta system. In South Texas, principal facies are meanderbelt sand, lagoonal mud, stacked coastal barriers, and prodelta shelf mud facies. In East Texas, delta plain, delta front, and prodelta facies are dominant; and in Central Texas, the principal facies are strandplain sands originated by southwestward longshore drift of sediments from the high-constructive delta system.

Facies distribution, composition, and size of the deltas in East Texas are similar to lobes of the Holocene high-constructive Mississippi delta system and to ancient deltas in the lower part of the Wilcox and in the Jackson Groups of the Gulf Coast Basin. Deltaic sediments of South Texas are comparable to Pleistocene high-destructive, wave-dominated facies on the Surinam coast, to the Holocene Rhone delta system, and to ancient deltas in the upper part of the Wilcox Group.

Queen City deltas prograded gulfward over shelf muds and glauconites of the Reklaw Formation; they are overlain by comparable shelf facies of the Weches Formation. In East Texas, deltaic facies wedge out eastward. Terrigenous clastics of the high-destructive deltas extend southward into Mexico.

Hydrocarbons are produced from thin strike-oriented sands downdip from the belt of maximum sand thickness of the high-destructive deltas in South Texas; only a minor amount of oil and gas has been obtained from delta front and distributary channel sands of the high-constructive deltas in East Texas.

INTRODUCTION

The Queen City Formation and its stratigraphic equivalents in the Texas Gulf Coast Basin (Middle Eocene, Claiborne Group) are composed of several terrigenous clastic depositional systems: high-constructive, lobate delta; high-destructive, wave-dominated delta; strandplain and shelf systems. The purpose of this paper is to describe these depositional systems and their component facies, as well as the relationship between these facies and petroleum occurrences in the Queen City Formation. The study is part of a basin analysis program of the Bureau of Economic Geology, The University of Texas at Austin, aimed at genetic interpretation and facies reconstruction of principal Texas stratigraphic units. This report is based on the results of M.A. theses at the Department of Geological Sciences, The University of Texas at Austin (Guevara, 1972; García, 1972).

The region considered in this report is in the Texas portion of the Gulf Coast Basin, bounded on the southwest by the Rio Grande and on the northeast by the Sabine River. It comprises an area of about 30,000 square miles (fig. 1), extending from outcrop downdip to the wedging out of the sands of the Queen City Formation or to the limit of available well control. About 1,200 electric logs were examined to establish the regional subsurface stratigraphy and to determine the gross facies content and distribution. About 800 of these logs were employed in the detailed delineation of facies.

The Queen City Formation is one of several Tertiary terrigenous clastic wedges that filled the Gulf Coast Basin by progressive offlap. It is made up principally of sands and muds with minor amounts of lignites and glauconites. The Queen City Formation is bounded by persistent glauconitic and marly muds of the overlying Weches and underlying Reklaw Formations (fig. 2). The Queen City Formation and equivalent stratigraphic units crop out in the Texas Coastal Plain along a belt extending from Webb County in South Texas, northeast to Nacogdoches County in East Texas. Subsurface extent of principal sand units ranges from 40 to 80 miles downdip from outcrop in an area extending northeast from Zapata County in South Texas to Angelina County in East Texas.

The lower boundary of the stratigraphic interval considered in this report (fig. 2) is the top of the Carrizo Sand (Wilcox Group) or, where developed, the Newby Glauconitic Sand Member of the Reklaw Formation. The upper boundary is the base of the progradational sands of the overlying Sparta Formation. This interval embracing the Queen City Formation ranges in thickness from approximately 200 feet in northeastern Texas to about 2,500 feet in South Texas. It includes the Reklaw (muddy and glauconitic), Queen City (sandy), and Weches (muddy and glauconitic) Formations in East Texas, and the Bigford (sandy and lignitic), El Pico Clay (muddy and lignitic), and Weches Formations in South Texas.

The study integrates surface and subsurface information. Outcrop investigation includes analysis of sedimentary structures, lithology, vertical and lateral relationship of specific facies, and vertical sequence. Typical exposures of each principal depositional facies of the Queen City

[1] Publication authorized by the Director, Bureau of Economic Geology, The University of Texas at Austin.

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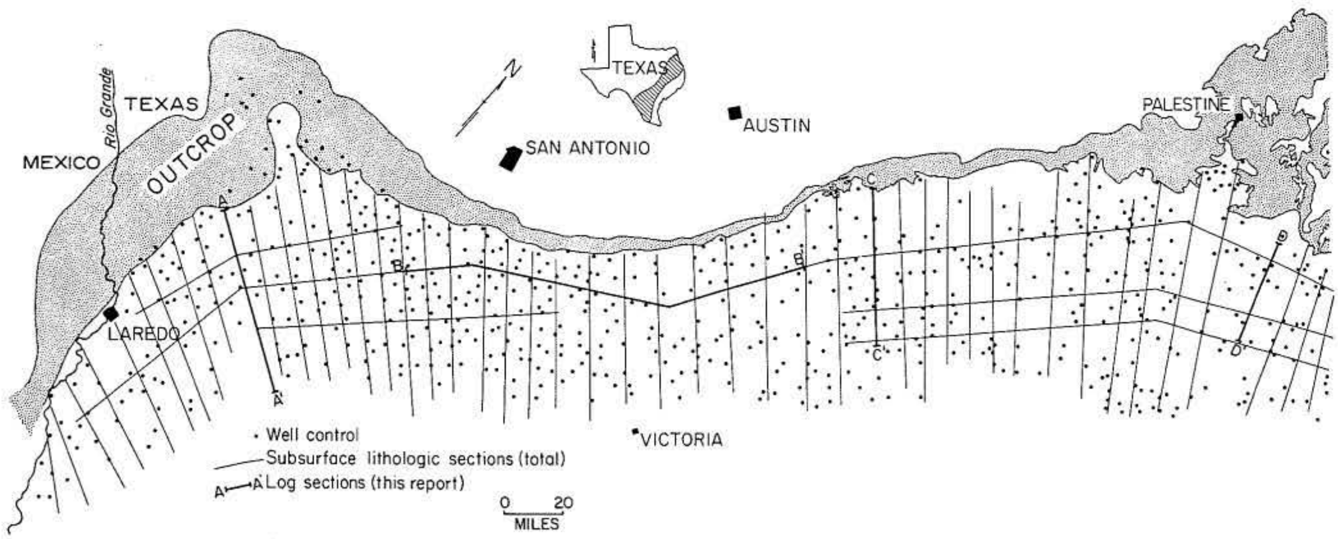

Fig. 1. Index to well locations and stratigraphic sections.

Formation and equivalent stratigraphic units are described. Subsurface study emphasized mapping of framework facies and preparation of dip and strike stratigraphic sections; from these, sand trends and the three-dimensional relationship of facies are interpreted. Forty-eight dip sections at ten-mile intervals, and three strike sections at 15-mile intervals were constructed (fig. 1). Net sand was determined from electric logs, and these values are used in the construction of the sand isolith maps.

Nomenclature employed in this report is informal and based on genetic units. Terminology is derived from the concept of depositional systems as applied by Fisher and McGowen (1967). According to Scott and Fisher (1969), depositional systems are "assemblages of process-related sedimentary facies." Genetic terms such as fluvial, deltaic, shelf, and strandplain designate the different depositional systems. Holocene depositional systems provide models for the recognition of ancient systems. Genetic units do not necessarily coincide with formal stratigraphic nomenclature. Genetically-related facies make up a depositional system, while formal lithostratigraphic units may include only one facies or several depositional systems.

The authors express their appreciation to W. L. Fisher and L. F. Brown, Jr., Bureau of Economic Geology, for their guidance throughout the research; to J. H. McGowen, E. G. Wermund, C. V. Proctor, Jr., and A. W. Erxleben, Bureau of Economic Geology, for critical reading and comments; and to A. J. Scott, R. O. Kehle, and L. J. Turk, Department of Geological Sciences, The University of Texas at Austin, for helpful criticisms and suggestions. Cartographic, editorial, and manuscript preparation was provided by J. W. Macon, Mrs. Lori McVey, and Mrs. Elizabeth Moore, respectively, Bureau of Economic Geology; J. Russell, Surface Casing Division, Texas Water Development Board, gave free access to the TWDB well-log library. Gratitude is expressed to Compañía Shell de Venezuela, Ltd., Caracas (E. H. Guevara) and to Texas Petroleum Company, Colombian Division, Bogotá (R. García), for full scholarships and leaves of absence granted to the writers while attending the Graduate School of The University of Texas at Austin. The writers acknowledge the research facilities provided by the Bureau of Economic Geology, The University of Texas at Austin.

QUEEN CITY DEPOSITIONAL SYSTEMS

The Queen City depositional systems were delineated by determining the geometry, association, and characteristics of the sedimentary facies based on outcrop information, correlation of electric logs, sand trends on isolith maps, and stratigraphic sections. In East Texas, sand facies of the Queen City Formation thin eastward along the strike and pinch out in subsurface just west of the Texas-Louisiana border. There, the glauconitic units of the overlying Weches and underlying Reklaw Formations merge to become a single lithostratigraphic unit, the Cane River Formation. Sands are well developed in the subsurface in South Texas (fig. 3a). Thin sands, mainly strike oriented and interbedded with muds, are the principal facies in the central Texas Coastal Plain (figs. 3a, b). Throughout the entire area, sands grade downdip to thick mud facies (figs. 4-7). The spatial relationship of sands and muds in the Queen City Formation (figs. 3-7) is similar to that of other Tertiary terrigenous clastic units in the Gulf Coast Basin, such as the Wilcox Group (Fisher and McGowen, 1967, 1969), the Jackson Group (Fisher *et al.*, 1970), the Yegua Formation (Fisher, 1969) and the Frio Formation (Boyd and Dyer, 1964). The Queen City Formation and equivalent stratigraphic units represent a significant episode of deltaic progradation in the Gulf Coast Basin. The underlying and overlying Reklaw and Weches Formations are fossiliferous and glauconitic units that represent extensive marine transgressions preceding and following the Queen City progradation (fig. 2).

Sand isolith trends in South Texas (fig. 3a) are similar to those displayed by the upper part of the Wilcox Group, which has been interpreted to represent high-destructive, wave-dominated deltas comparable to the Holocene Rhone delta system (Fisher, 1969). In contrast, sand distribution in East Texas (fig. 3b) resembles that of high-constructive, lobate deltas, such as those in both the lower part of the Wilcox Group (Fisher and McGowen, 1967, 1969) and in the Jackson Group (Fisher *et al.*, 1970), and typical of the Holocene Mississippi delta system. Deltaic facies in the

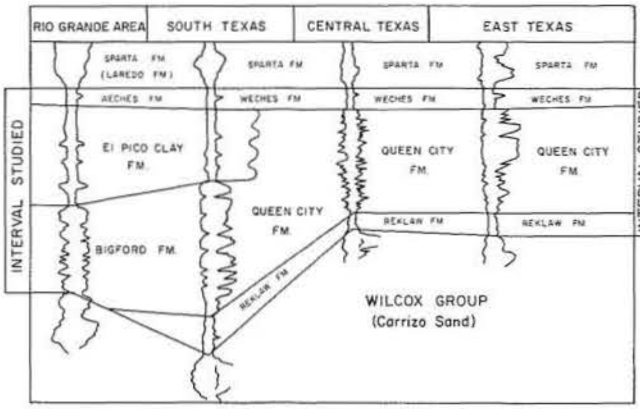

Fig. 2. Stratigraphic interval considered, Queen City and associated formations.

Queen City Formation are referred to as the Queen City high-destructive, wave-dominated delta system in South Texas, and as the Queen City high-constructive, lobate delta system in East Texas. Shelf facies in the lower part of the overlying Weches and underlying Reklaw Formations enclose the Queen City deltas (fig. 8). A strandplain system is delineated in the central part of the Texas Gulf Coast Basin, in an interdeltaic embayment between the main centers of deltation in South and East Texas. Deposits of the high-destructive deltas extend southward of the Rio Grande into Mexico. In the subsurface area northeast from central Nacogdoches and Angelina counties, glauconitic muds of the shelf facies make up the stratigraphic interval above the Carrizo Sand and below the prodelta muds of the Sparta deltaic sands (fig. 8).

HIGH-CONSTRUCTIVE, LOBATE DELTA SYSTEM, EAST TEXAS

High-constructive deltas (Fisher, 1968) are river-fed depositional systems comprising a complex of delta lobes that irregularly prograde the shoreline, with fluvial or fluvially-influenced processes predominating over marine processes. Fisher (1968) classified high-constructive deltas as elongate and lobate types, based principally on the external geometry of the deltaic sands. In elongate deltas, prodelta muds are generally thicker than in lobate deltas. The Holocene Mississippi delta system is an example of high-constructive delta complex. The Plaquemines and modern birdfoot deltas are examples of the elongate type; and the Lafourche and St. Bernard deltas of the Mississippi complex are lobate types (Frazier, 1967; Frazier and Osanik, 1969; Fisher, 1969).

Prodelta, delta front, and delta plain facies of the Queen City high-constructive, lobate delta system occur in East Texas (fig. 3b). Deltaic facies wedge out northeastward in the subsurface of Angelina and Nacogdoches counties, merging with shelf facies that extend into western Louisiana (fig. 8). Marginal deltaic strandplain facies occur in the central Texas Coastal Plain in the northeastern part of the interdeltaic embayment. Thin barrier-bar facies crop out locally in East Texas, probably associated with marine destruction of abandoned delta lobes.

DELTA-FRONT FACIES

Delta-front sands, including distributary channel-mouth bars and locally reworked sheet sands, delineate the net sand progradation of delta lobes. Vertically, the facies consists of interbedded sands and muds at the base and becomes sandier upward. This upward-coarsening sequence is reflected in the curves of electric logs, which show an inverted Christmas-tree shape (fig. 8). Delta-front facies crop out in East Texas. Five miles northeast of Gilmer (Upshur County) along Texas State Highway 155, on top of carbonaceous muds there is a progradational section about 18 feet thick. This section consists of three feet of interbedded clay and siltstone in the lower part; siltstones increase in abundance upward and sands predominate in the upper part of the exposed section. Sands display trough crossbedding and horizontal laminations, and in the upper part contain clay clasts and clay drapes. This sequence is interpreted as delta-front sand facies which prograded over lagoonal muds.

Delta-front facies are thin in outcrop but thicken downdip, ultimately grading into prodelta muds. Updip, the facies grade to lignite-bearing, delta-plain facies which are exposed in East Texas. In the subsurface, electric logs show individual progradational sequences generally 150 to 200 feet thick; the thickest progradational sequences include the distributary channel at the top. On electric logs, distributary channels are characterized by a box-like shape of the spontaneous potential and resistivity curves (fig. 8). Sand thickness and downdip progradation are generally greater between the Colorado and Trinity Rivers, where main sediment influx occurred (fig. 3b). Delta-front facies are only about 100 feet thick east of the Trinity River (fig. 4).

DELTA-PLAIN FACIES

The delta plain is the subaerial part of the delta. It consists of distributary rivers and associated levees, and of interdistributary areas with lakes, marshes, and swamps. Delta-plain facies are well exposed in East Texas. Lignites, distributary channel sands, and muddy interdistributary deposits delineate the main area of the delta-plain facies (fig. 3b).

Distributary-channel facies.—Sands of the delta plain are restricted to distributary channels and to crevasse splays which originated from them. After abandonment, distributary channels are filled with fine-grained sediments deposited from suspension. Sands and muds in the upper part of the Queen City Formation are exposed along U. S. Highway 69, one and a half miles south of Mount Selman (Cherokee County). Sands are fine grained, clayey in the lower part, and display large trough crossbedding, locally with discontinuous lignites one-half to one inch in thickness; in the upper part, tabular crossbedding and horizontal laminations are present. Overlying the sands are clays and silts showing laminations and small trough crossbeds which show up as color bands on weathering. Muds and glauconites of the overlying Weches Formation are at the top of the exposed section. These Queen City facies are interpreted as distributary-channel sands overlain by muds deposited by settling of suspended fines in the abandoned distributary channel and in the interdistributary areas. Glauconites and muds which are shelf facies of the Weches Formation represent destructional units of the Queen City deltaic facies.

Interdistributary deposits.—Areas of the delta plain between the distributary channels are occupied by many standing bodies of water where organic-rich muds are

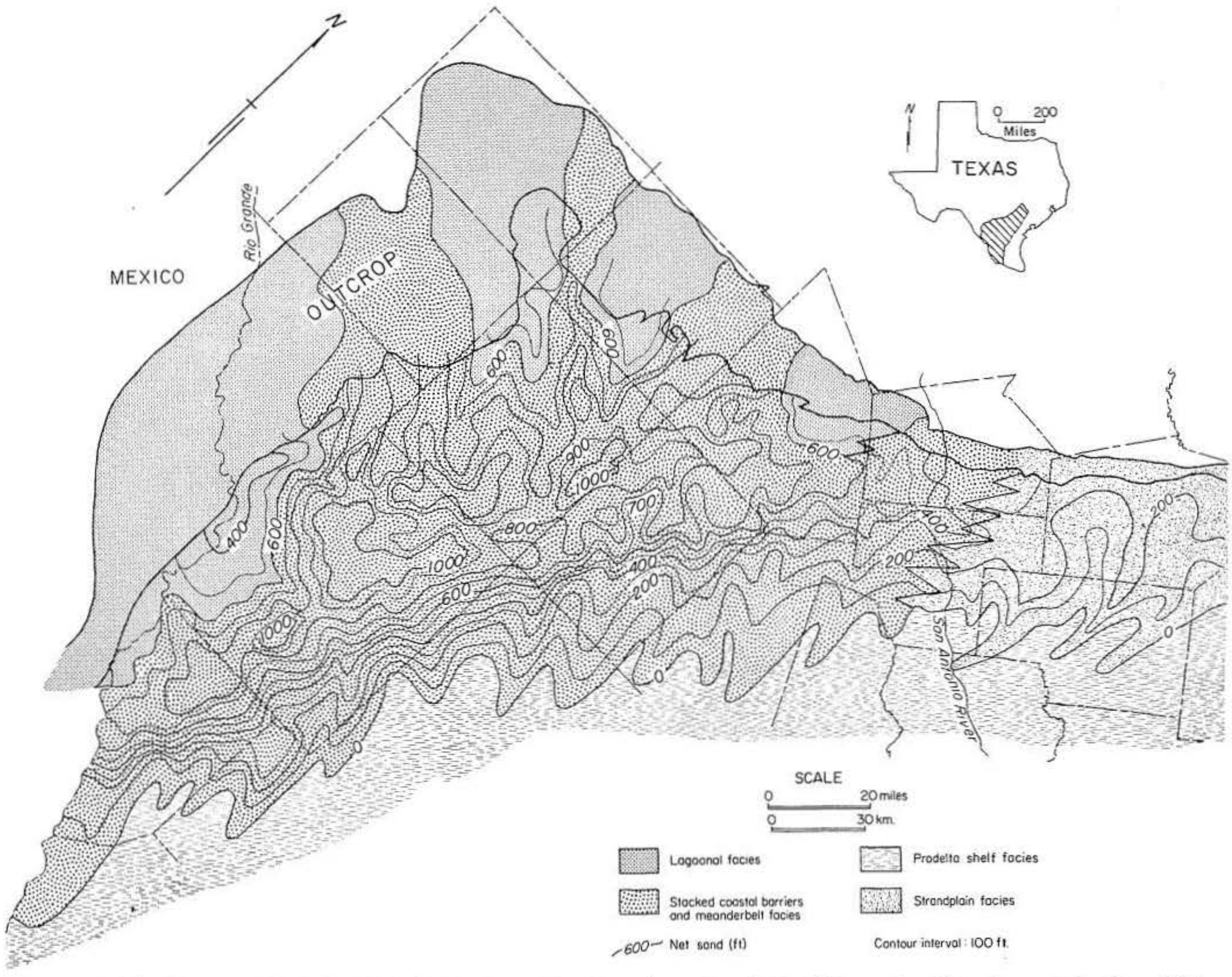

Fig. 3a. Sand isolith map and principal facies in the Queen City Formation and equivalent lithostratigraphic units, central and south Texas Coastal Plain.

deposited. Half a mile south of Mount Selman (Cherokee County), along U. S. Highway 69 there are about ten feet of thinly bedded carbonaceous clays and silts below the glauconites and muds of the Weches Formation. At the base of the section, about ten feet of trough crossbedded, fine-grained, clayey sands are overlain by about five feet of clays; higher in the section are light gray siltstones, reddish-brown clay and discontinuous lignite beds one-half to one inch thick. The section is interpreted as consisting of distributary-channel sands overlain by muds laid down in the later abandoned distributary channel; the overlying carbonaceous muds are interdistributary deposits.

Lignites, characteristic of delta-plain facies of high-constructive deltas, have been reported from the Queen City Formation by several authors. Fisher (1965, p. 268), in describing the occurrences of lignites in the Wilcox Group, mentioned lignites in the Queen City Formation cropping out in Anderson County. Stenzel (1938) noted sandy lignites in the headwaters of Spring Creek, about one mile south of Robbins (Leon County).

PRODELTA FACIES

Prodelta sediments are fine-grained, terrigenous clastics deposited from suspension seaward of the delta front. They are mainly laminated, non-fossiliferous to sparsely fossiliferous muds, with abundant land-derived organic detritus carried to the basin from the delta plain. The prodelta area slopes gently downward from the delta front to the floor of the basin. Within a progradational sequence, prodelta facies stratigraphically underlie delta-front facies. The prodelta is the thickest and volumetrically the largest facies in high-constructive delta systems. Prodelta muds are potential petroleum source rocks because of their high content of organic matter and the rapid deposition.

About 15 feet of greenish-gray, laminated clays with abundant plant remains are exposed approximately four miles northeast of Buffalo (Leon County) along U. S. Highway 79. The clays become silty as they grade upward and are interbedded with thin siltstones. These organic-rich clays are interpreted as prodelta facies, and the siltstones as

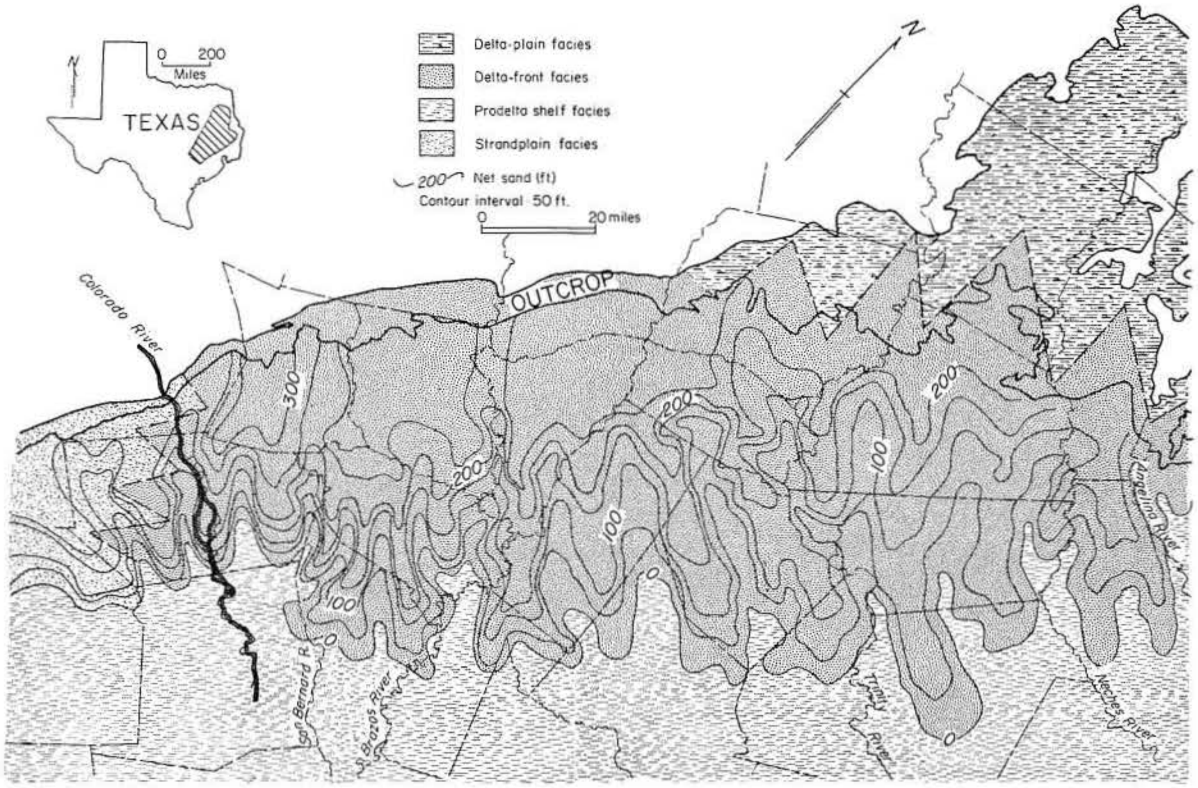

Fig. 3b. Sand isolith map and principal facies in the Queen City Formation, central and east Texas Coastal Plain.

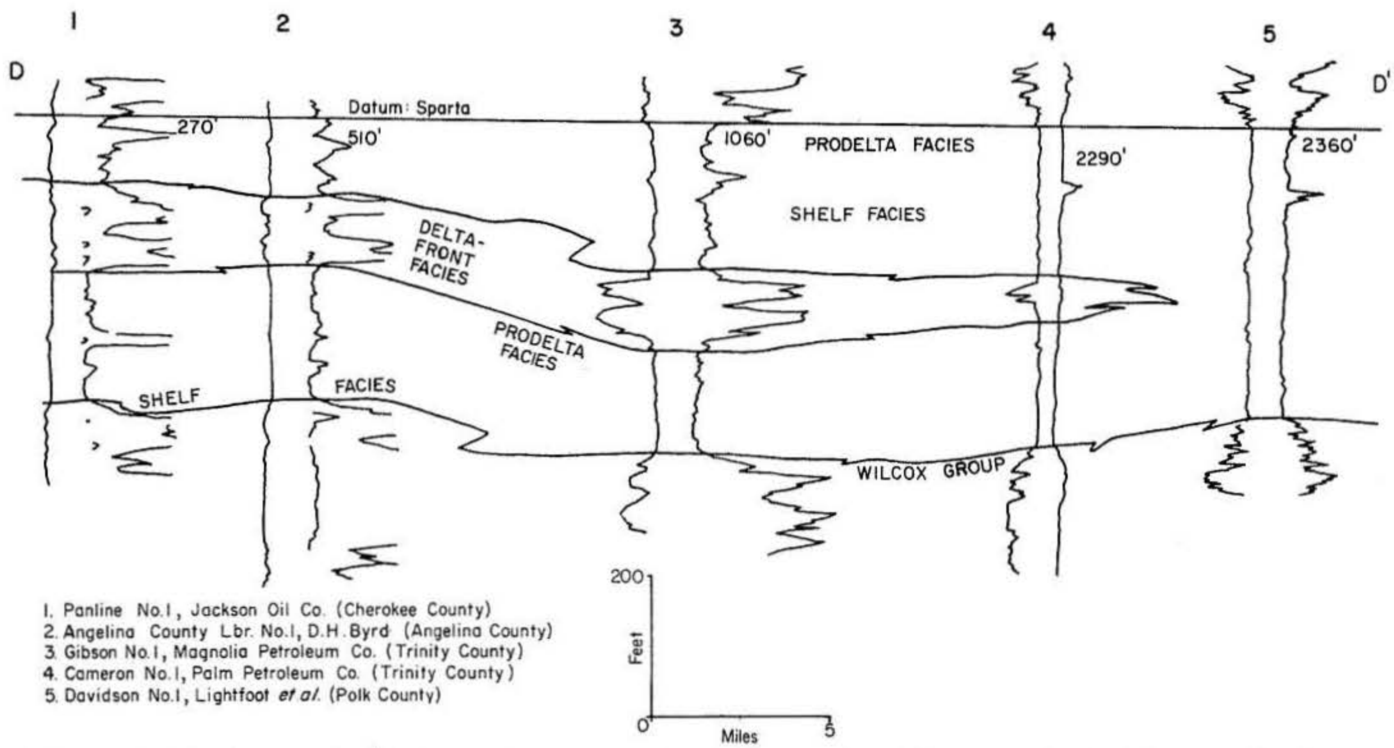

Fig. 4. Stratigraphic dip section D-D′, East Texas. Trinity and Angelina lobes of the Queen City high-constructive delta system. Location on figure 1.

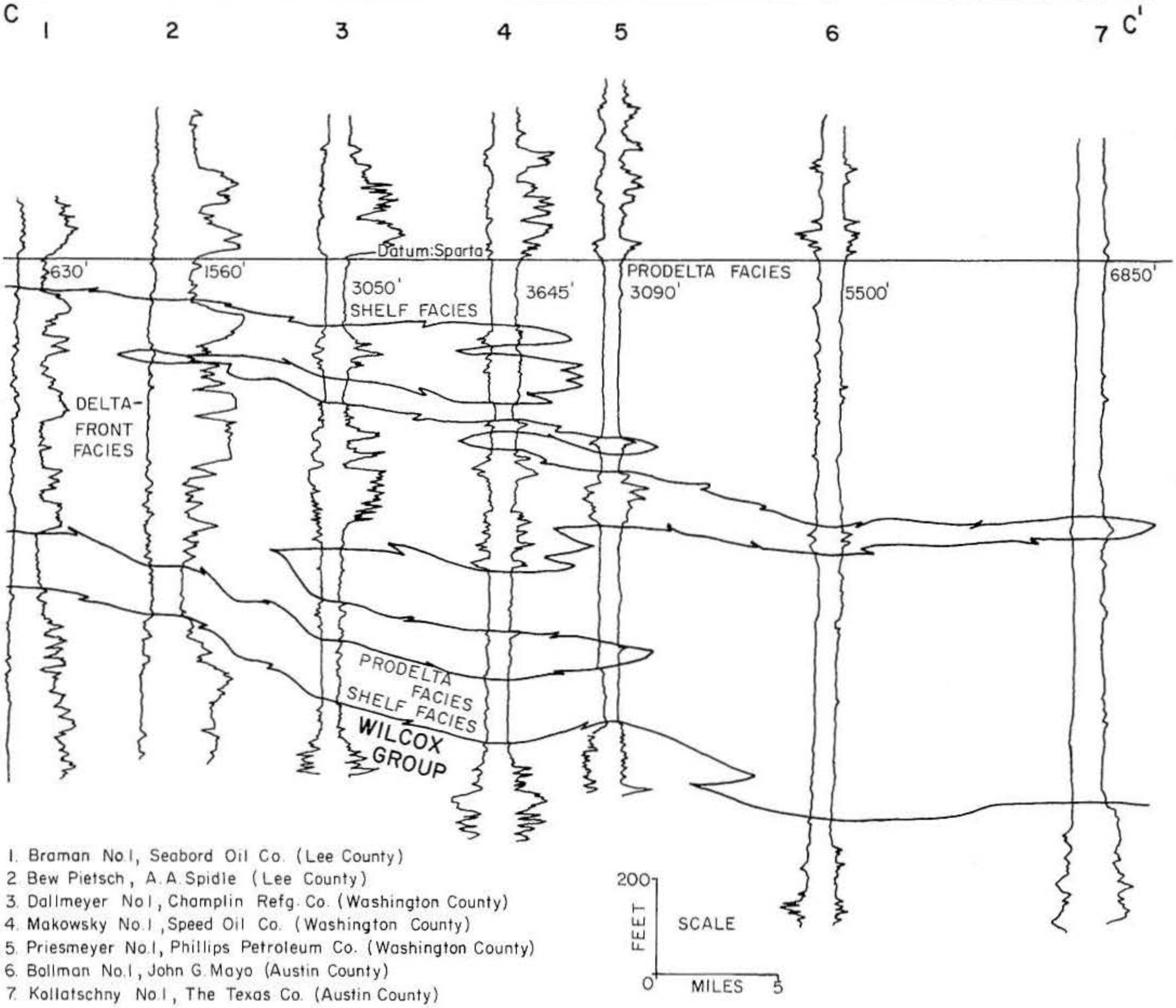

Fig. 5. Stratigraphic dip section C-C′, East Texas. Washington lobe of the Queen City high-constructive delta system. Location on figure 1.

the lower part of the overlying delta-front facies that make up the top of the exposed section. In the outcrop, prodelta facies are thin; they are best developed in subsurface, interfingering vertically and laterally with delta-front facies; prodelta deposits make up the stratigraphic interval equivalent to the Queen City Formation in the downdip distal part of the delta system (figs. 4,5). The facies merge northeastward with shelf sediments in East Texas. On electric logs, prodelta facies show an absence of spontaneous potential and resistivity deflections due to lack of porous, permeable beds (fig. 8).

MARGINAL DELTAIC FACIES

Deposits developed laterally to the main delta lobes consist of thin strandplain coastal barrier sediments, mostly reworked from the delta-front sand facies following abandonment of the site of deltation, and redistributed by longshore currents. Distributary channels prograding laterally to the main site of deltation locally deposited sandier facies in the delta margins.

Thin strandplain sands and interbedded muds occur in the delta margin in the interdeltaic embayment of the central part of the Texas Gulf Coast Basin. In East Texas, small barrier bar sands similar to modern delta margin islands developed locally marginal to the main sites of deltation, and are commonly associated with lagoonal carbonaceous muds. Five miles northeast of Gilmer (Upshur County) along Texas State Highway 155, there are about 20 feet of massive, bioturbated sands with burrows similar to those of the mud-shrimp *Callinassa*. In the middle of the exposed section there are carbonaceous muds overlying the burrowed sands, which, in turn, are overlain by sands at the top of the exposed section. Sands in the lower part of the section are interpreted as barrier sand facies, the coaly muds as lagoonal deposits laid down behind the contemporaneous sand barrier, and the sands at the top of the section as delta-front facies prograding over lagoonal deposits. Similar facies crop out about one-half mile farther

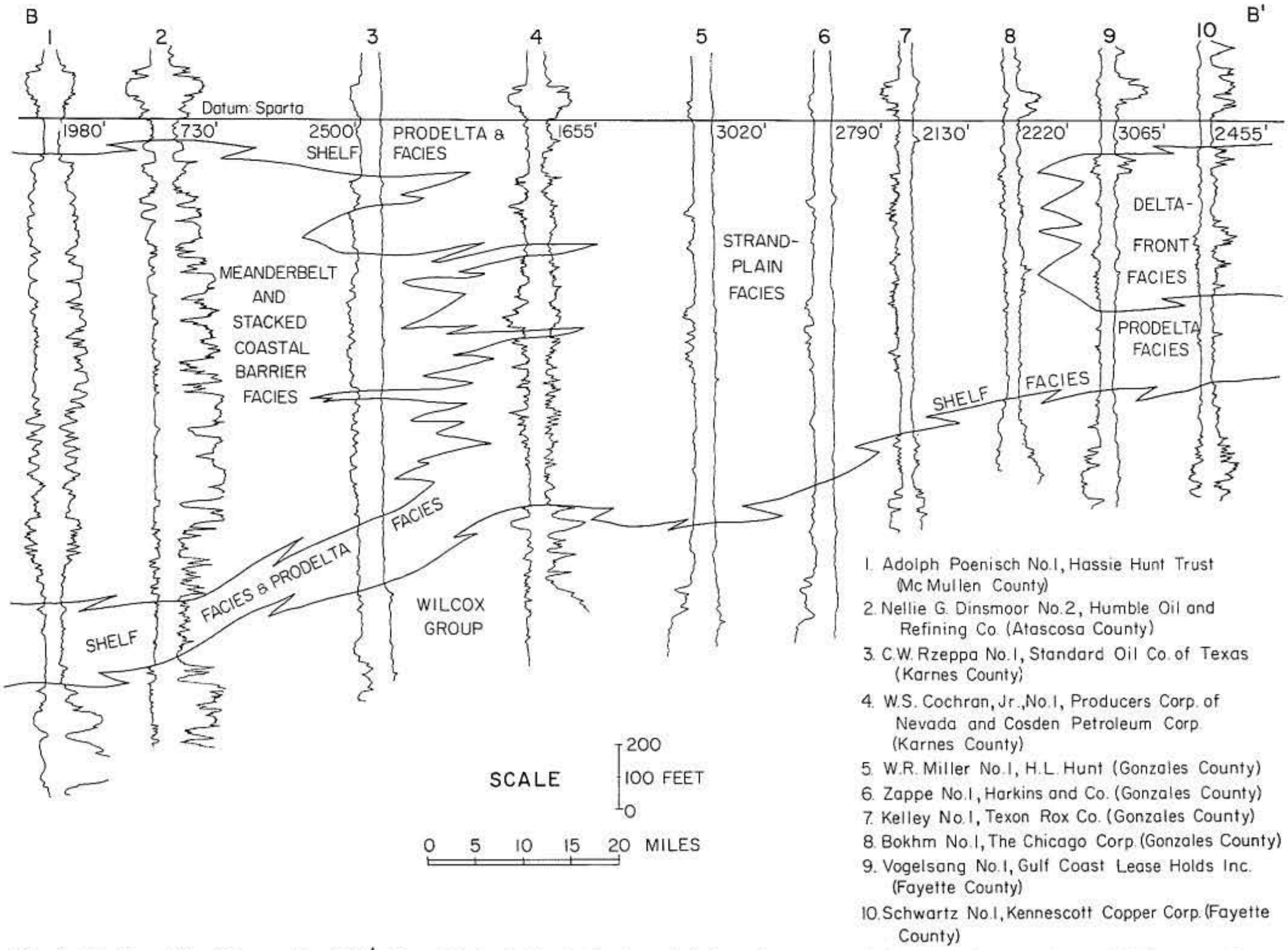

Fig. 6. Stratigraphic strike section B-B′. Strandplain facies in the interdeltaic embayment of the central Texas Coastal Plain. Location on figure 1.

northeast along the same highway, at the intersection with the road to the Gilmont fire lookout tower. Convolute bedding at this location is attributed to loading of sediments over the underlying water-saturated mud facies.

DELTA LOBES

Five areas of higher sand content in the interval studied are interpreted to outline lobes of the Queen City high-constructive delta system of East Texas (fig. 9). Defined on the net sand or isolith map and from stratigraphic sections, the lobes represent sites of maximum sand deposition and are separated by less sandy, interlobe facies. These lobes from southwest to east are: Washington, Grimes, Walker, Trinity, and Angelina lobes. The Washington, Grimes, and Walker lobes, located between the Colorado and Trinity Rivers, define the maximum progradation of the system. The Angelina and Trinity lobes are less extensive than those southwest of the Trinity River. Size and geographic distribution of lobes of the Queen City high-constructive delta system of East Texas are similar to those in the Jackson Group of the Gulf Coast Basin (Fisher *et al.*, 1970).

HIGH-DESTRUCTIVE, WAVE-DOMINATED DELTA SYSTEM, SOUTH TEXAS

High-destructive deltas (Fisher, 1968) are depositional systems fed by numerous small to moderately meandering or braided rivers with high ratio of bedload to suspended load. Numerous feeding streams are developed along the entire margin of the depositional basin. The rate of shoreline progradation is lower than that typified by high-constructive deltas, and associated carbonaceous deposits commonly are more poorly developed. Destructional or marine-influenced facies, which are important in this system, include shallow embayments with associated coastal-barrier sands and lagoonal mud facies. Fisher (1968) classified high-destructive deltas as tide- and wave-dominated, based on the predominance of either tidal or wave action. The Holocene Rhone delta system is an example of wave-dominated, high-destructive delta that displays extensive coastal barrier sand facies (Kruit, 1955; Oomkens, 1967, 1970).

The principal types of facies identified in South Texas are: fluvial meanderbelt, coastal barrier, and prodelta, which occur entirely in the subsurface; and lagoonal and strandplain-barrier bar which are developed both in outcrop and subsurface.

MEANDERBELT FACIES

The meanderbelt facies comprises belts of point-bar sands with a downdip trend generally parallel to the

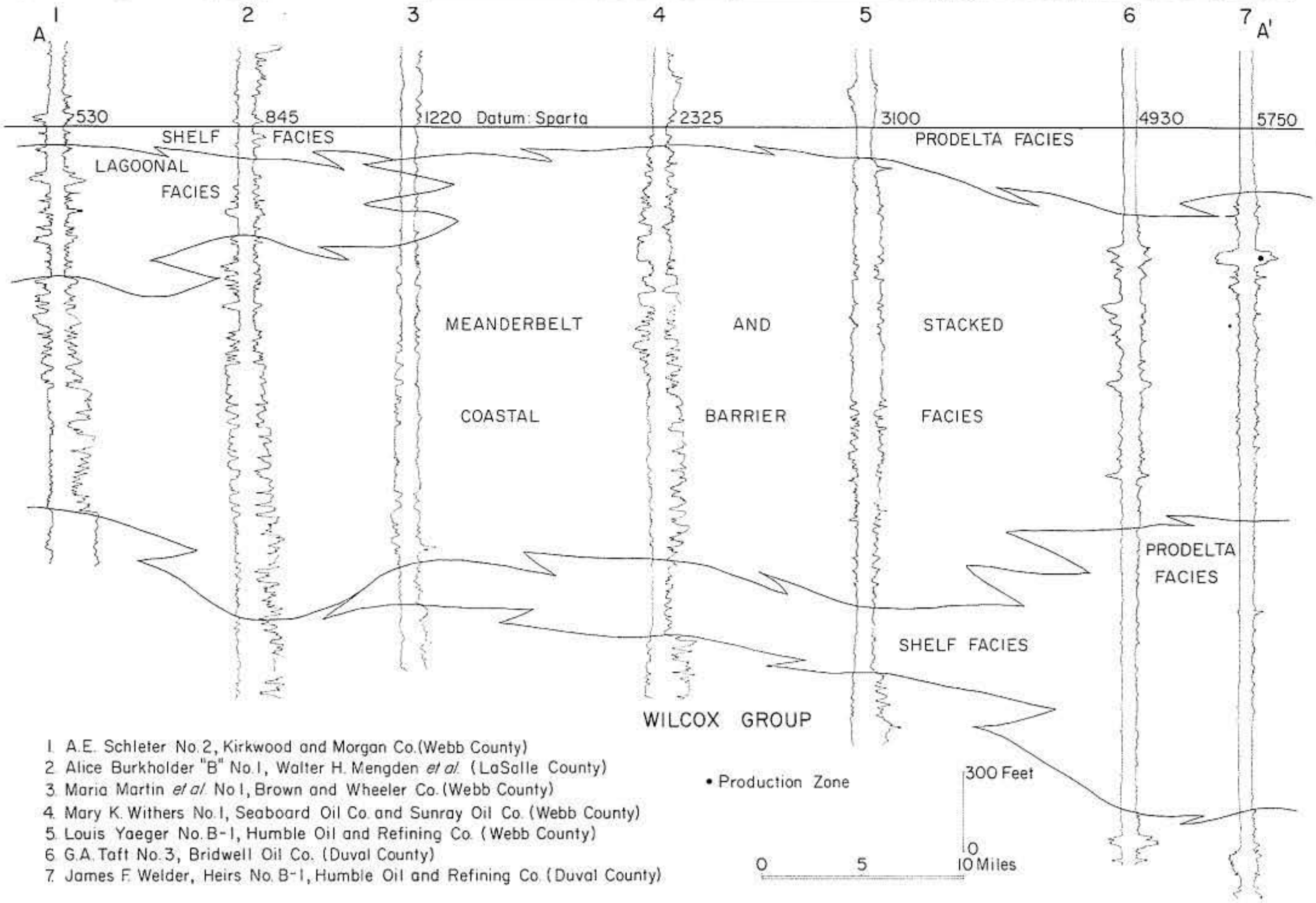

Fig. 7. Stratigraphic dip section A-A′, South Texas. Facies of the Queen City high-destructive delta system overlain by shelf facies, updip resting on Carrizo fluvial-deltaic sands, and downdip underlain by shelf facies. Downdip, deltaic sands grade to prodelta muds. Location on figure 1.

paleoslope. Fine-grained or mud-rich, fluvial, meanderbelt deposits have been defined by Bernard and Major (1963), Visher (1965), and Allen (1965) who proposed models characterized by texturally fining-upward sequences. These models contrast with the coarse-grained meanderbelt model (McGowen and Garner, 1970), characterized by a high sand/mud ratio and an absence of consistent trend in grain size. Coarse grained meanderbelt fluvial systems such as those of the Amite River (Louisiana) and the Colorado River (Texas), consist of multilateral or laterally persistent sand facies made up by a complex of partly preserved meanderbelt units, each ten to 25 feet thick, forming belts up to five miles wide. Mappable sand units composed of multilateral meanderbelt sand bodies up to 200 feet thick and 30 miles wide may occur. Moderate to large trough and foreset bedding associated with chute bars are common in these fluvial systems. Suspended load is low and overbank muds and levees are consequently not well developed; therefore, sands are the principal components of the facies.

About 25 feet of sand and clay are exposed in a road cut along U. S. Highway 79, approximately three and a half miles west of Floresville (Wilson County). Sandstones are coarse grained, a few inches to two feet in thickness, with moderate to large troughs and parallel laminations, clay drapes, and clay laminae. Approximately one-foot-thick lateral accretionary units are present, and no significant vertical variation of grain size occurs. These deposits are interpreted as coarse-grained meanderbelt facies. Very hard, medium-grained sandstones with similar sedimentary structures crop out along Farm Road 140, about 16 miles southeast of Uvalde in Zavala County. In the subsurface, meanderbelt sands of the Queen City are commonly fresh water bearing and display a blocky resistivity profile (fig. 8). Downdip, meanderbelt facies interfinger with stacked coastal-barrier sand facies (fig. 7).

COASTAL-BARRIER FACIES

Coastal-barrier facies within high-destructive, wave-dominated deltas are cuspate to arcuate sand bodies developed along the depositional strike, lateral to the channel-mouth bar facies. They are composed of sand transported from channel-mouth bars by longshore currents. They generally form chevron-like, thick sand axes (fig. 10). Waves and longshore currents, mainly in the surfzone and shoreface, are the most important processes in the barrier bar environment. Similar to shoreface units in barrier bar sands (Hayes and Scott, 1964; Bernard and LeBlanc, 1965; Bernard *et al.*, 1970), coastal-barrier facies grade from shelf muds at the base to sand at the top. Facies associated with coastal barriers include mud and thin sand bodies deposited in narrow, elongate lagoons that filled during delta construction and progradation (fig. 10). Coastal-barrier sand facies form elongate tabular bodies 30 to 100 feet thick along chevron-like, strike-oriented axes.

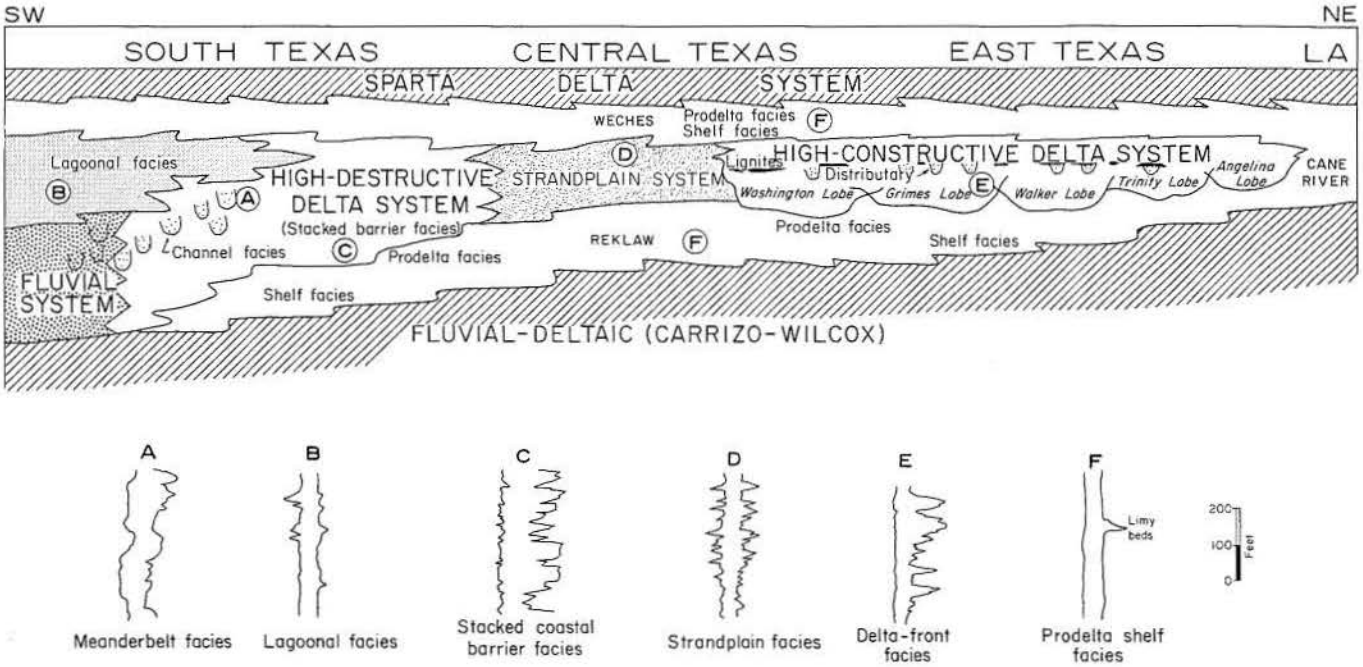

Fig. 8. Diagrammatic strike section parallel to the outcrop of the Queen City Formation and equivalent lithostratigraphic units, Texas. Facies relationship and representative electric logs.

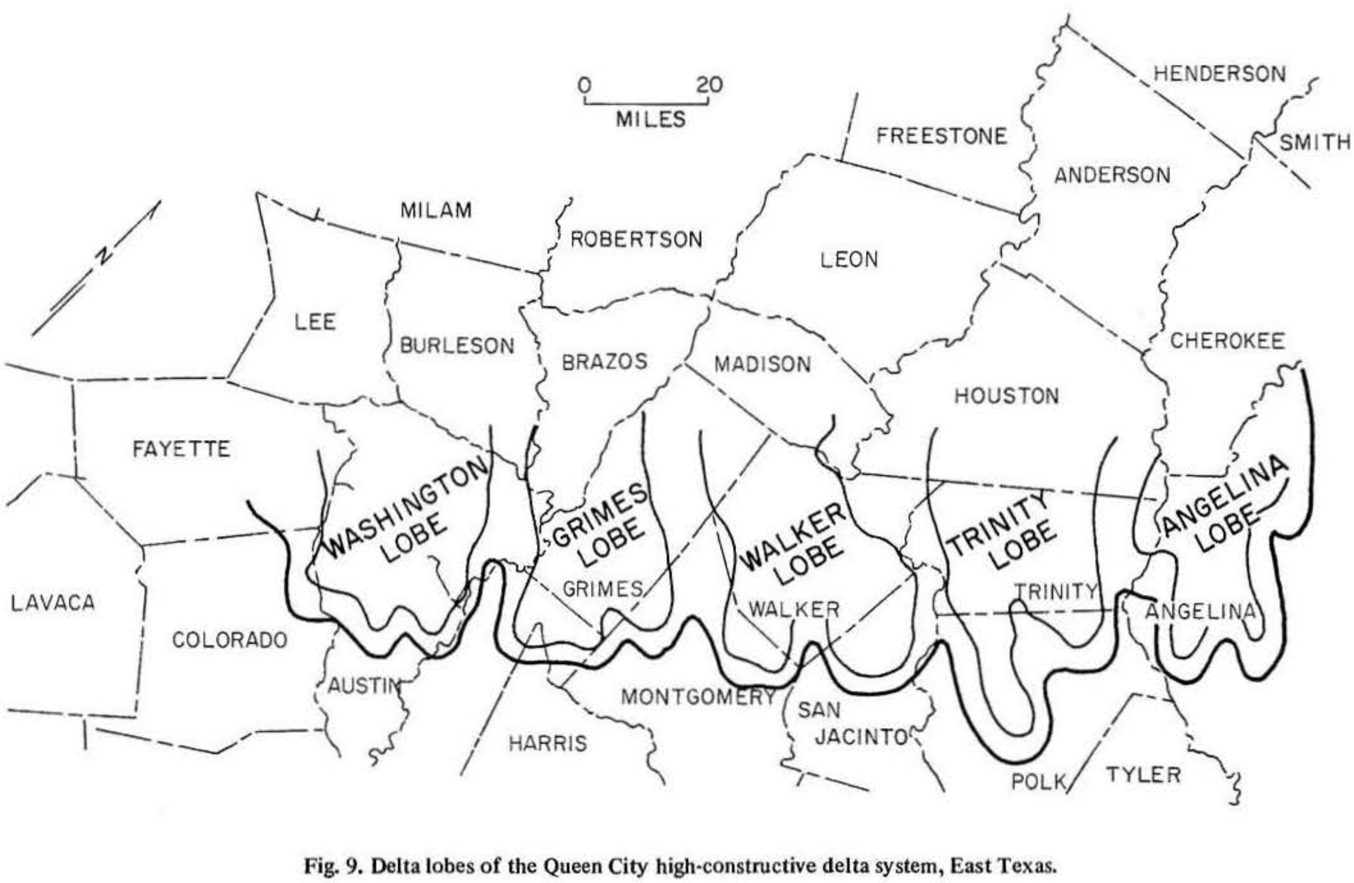

Fig. 9. Delta lobes of the Queen City high-constructive delta system, East Texas.

Coastal barriers accrete slowly seaward, and mark the shoreline progradation of high-destructive deltas. Modern examples of coastal barriers forming the principal component facies of high-destructive deltas include the Rhone delta system (Kruit, 1955; Oomkens, 1967, 1970), the Danube delta system (Zenkovich, 1967), the Grijalva delta system on the Tabasco coast, Mexico (Psuty, 1967), and the Holocene Nayarit coastal plain, Mexico (Curray *et al.*, 1969).

Medium- to coarse-grained sands crop out in beds ten feet thick, 22 miles northwest of Laredo (Webb County) along Farm Road 1472. Sands exhibit trough crossbedding, horizontal laminations, and burrows, similar to those of the mud-shrimp *Callinassa*. These sands are overlain by about two feet of lignitic clay. They represent barrier bar sand facies, and the overlying coaly muds represent both lagoonal mud facies and local fringing marsh deposits behind contemporaneous Queen City barrier bar sands.

Coastal-barrier sands are well developed in the subsurface of South Texas in Zapata, Webb, LaSalle, McMullen, Duval, Atascosa, and Live Oak counties. These sands are normally salt-water bearing, and range in thickness from 10 to 70 feet, with generally a box-like spontaneous potential and resistivity profile on electric logs. Coastal-barrier sand bodies are vertically stacked, indicating that similar depositional conditions occurred repeatedly. The stacked coastal barriers are the principal, diagnostic facies of the Queen City high-destructive delta system. Sand isolith contours (fig. 3a) indicate strike-oriented trends with sand maxima in the central part of Webb and LaSalle counties. The stacked coastal-barrier facies grade updip into lagoonal mud facies cropping out in western Webb and Dimmit counties. Coastal barriers, in turn, thin downdip, pinching out within prodelta mud facies (fig. 7). The downdip distal part of the high-destructive delta system is composed of thin barrier-bar sand facies which interfinger with prodelta muds. The barrier facies thus form a downdip series of cuspate, strike-oriented sand trends (fig. 3a), suggesting southwestern longshore currents. To the northeast, the barrier facies interfinger with strandplain facies in the interdeltaic embayment between the high-constructive deltas of East Texas and the high-destructive deltas of South Texas.

PRODELTA FACIES

Prodelta facies of the high-destructive delta system of South Texas do not crop out, but are extensively developed downdip in the subsurface. Queen City prodelta-shelf mud facies exceed 1,000 feet in thickness in the subsurface of Webb, Duval, and Live Oak counties. The facies are thin to absent updip at the subsurface of South Texas (fig. 7). Toward the Rio Grande, the fluvial-deltaic sands of the Carrizo Formation are overlain by those of the Bigford Formation, the muds of the Reklaw Formation being absent (fig. 2).

LAGOONAL FACIES

Modern lagoonal facies are developed landward of coastal-barrier islands. Wind-transported sand, clay deposited from suspension, and biogenic activity such as burrowing and root mottling may dominate depending on variable local conditions. Salinity commonly is variable, and is regulated by climate, fluvial discharge, low tides, and storm inundations. In general, lagoons are brackish and contain abundant mollusks, commonly with relatively low species diversity in highly restricted lagoon environments. Sedimentation is slow and laminated clays are common. Gypsum is deposited in many modern lagoons; thus thin layers of gypsum occur in ancient lagoonal deposits. Modern lagoonal facies, therefore, may consist of sands and clays, locally gypsiferous, with a large number of mollusks.

The Apalachicola delta system, along the northern Gulf Coast of Florida, includes lagoonal facies associated with high-destructive deltas. The delta is now mostly inactive, with deltation restricted to minor bayhead progradation (Fisher, 1969). The Rhone delta system (Kruit, 1955; Oomkens, 1967, 1970) exhibits lagoon facies associated with coastal-barrier sand facies, and the Holocene Nayarit coastal plain of Mexico (Curray *et al.*, 1969) includes elongate mud swales.

Lagoonal muds with some sands occur updip and landward of the Queen City stacked coastal-barrier and meanderbelt facies. Lagoonal mud facies crop out in a low-lying region with low hills capped by thin updip tongues of barrier-bar sands in Wilson, Atascosa, Frio, Zavala, Dimmit, LaSalle, and Webb counties (fig. 3a). Some sands are glauconitic and are commonly interbedded with impure lignites that have been mined locally in Webb County.

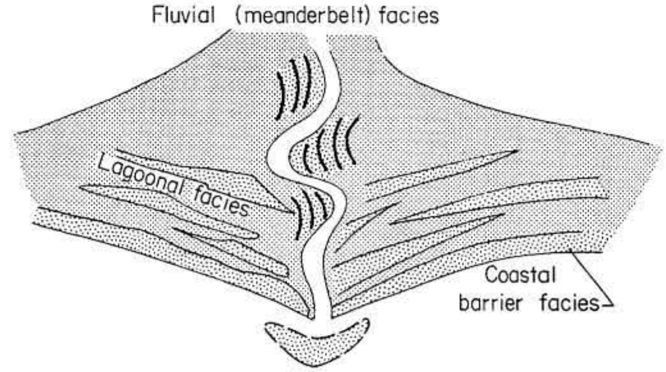

Fig. 10. Model of high-destructive, wave-dominated delta systems, with strike-oriented coastal-barrier facies and associated narrow lagoonal mud facies.

Sand and mud facies crop out 24 miles northwest of Laredo (Webb County) along Farm Road 1472. They consist of gypsiferous, calcareous clays, impure lignites, and calcareous sands with large concretions, probably of algal origin, similar to mounds in the Indio Lagoon system of the Wilcox Group (Fisher and McGowen, 1967, 1969). These deposits are interpreted as lagoonal facies of the Queen City high-destructive delta system.

Lagoonal muds extend downdip from outcrop for about 25 miles. The facies display an average thickness of 1,500 feet, thickening along the strike toward the Rio Grande. Downdip in South Texas, lagoonal facies interfinger with stacked coastal-barrier facies (fig. 7). A core from the San Ignacio No. 1, International Boundary and Water Commission, consists of greenish-gray claystones with abundant plant remains, interbedded with black, carbonaceous, laminated claystones, and calcareous, burrowed sandstones with mollusks. The core is interpreted as comprising lagoonal facies.

STRANDPLAIN SYSTEM, CENTRAL TEXAS INTERDELTAIC EMBAYMENT

Interdeltaic embayments are areas between main sites of deltation. Facies are commonly composed of muds and thin strandplain and barrier-bar sands derived from minor local fluvial influx, as well as from major deltas. These sediments are transported by longshore currents and littoral drift. The vertical sequence in strandplain sand facies is progradational, similar to that of shoreface facies in coastal barriers. The Nayarit coastal plain (Curray *et al.*, 1969) contains examples of strandplain systems with local fluvial influx, associated with high-destructive deltas. Modern examples of strandplain facies marginal to large delta systems occur in the northern part of the Gulf of Mexico, where longshore currents reworked and distributed sediments from the high-constructive Mississippi delta system to form the cheniers along the southwestern coast of Louisiana.

Strandplain facies in the Queen City Formation occur in the central Texas Coastal Plain, in western Fayette, Gonzales, northwestern Lavaca, DeWitt, and Goliad, and in northeastern Karnes and Wilson counties (figs. 3a, b). Strandplain facies were deposited in an interdeltaic embayment between the high-constructive deltas of East Texas and the high-destructive deltas of South Texas. Local small rivers and southwestern longshore currents supplied sediments to the interdeltaic embayment. Thin strandplain-coastal barrier sands interbedded with muds can be mapped in the central Texas Coastal Plain. Electric logs through the facies exhibit small, thin, sharp deflections of the spontaneous potential and resistivity curves (fig. 8). On isolith maps, strandplain facies generally display strongly strike-oriented sand trends composed of several thin individual sand bodies (figs. 3a, b).

SHELF SYSTEMS

The term shelf has three main usages in the literature: (1) structural, denoting a stable element in cratonic basins; (2) physiographic, describing a depth and gradient feature, as applied to modern continental shelves; and (3) environmental, referring to the processes and deposits. originating in equilibrium with the shelf environment. Shelf, as used in this paper, denotes a depositional environment, and refers to the sedimentary and biologic processes and resulting facies in equilibrium with the shelf environment. Studies on modern shelves, such as those by Curray (1965), Emery (1968), and Uchupi (1968) have provided an insight into the processes involved and the resulting deposits.

Shelf systems develop in the absence of significant terrigenous-clastic supply and, therefore, marine processes rework previously deposited (relict) sediments. Commonly reworked from submerged paralic facies, shelf sediments are slowly deposited, muddy, extensively bioturbated, and generally include biogenic and chemical components (glauconite, phosphorite, carbonates), as well as diversified fauna.

Fossiliferous and glauconitic shelf muds enclose the Queen City deltaic and strike systems throughout most of Texas. Sands, muds, and glauconites in the underlying Reklaw and overlying Weches Formations represent shelf facies (fig. 2). The Reklaw shelf sediments interfinger and grade upward into prodelta facies of the Queen City delta systems. In the Rio Grande area of South Texas, the underlying Reklaw shelf facies pinch out updip between the older Carrizo and the younger Queen City deltaic systems. In the subsurface area northeast from Angelina and Nacogdoches counties to western Louisiana, Queen City-equivalent shelf muds, about 300 feet thick, occupy the stratigraphic interval above the Carrizo sands and below the overlying prodelta facies of the progradational Sparta sands (fig. 8).

On electric logs, shelf facies show no deflections in the spontaneous potential curve. Due to marly layers, high, sharp readings in the resistivity curve (fig. 8) are common on electric logs throughout shelf facies. Prodelta shelf facies bounding the Queen City deltaic and strandplain systems were not differentiated because of their general similarities on electric logs, the scattered control in outcrop, and the unavailability of sufficient core samples through the facies.

Shelf facies bounding the Queen City deltaic and strandplain systems were deposited during marine transgressions following interruptions in clastic progradation into the Gulf Coast Basin. Termination of deltaic deposition resulted from shifting of the site of deltation or from tectonic movement that blocked the feeding stream network. The Reklaw shelf facies and those developed northeast from Nacogdoches and Angelina counties represent mainly reworked, destructional facies related to the underlying Carrizo Sand. Shelf sediments of the overlying Weches Formation are destructional facies of the Queen City deltaic systems. Some weathered glauconitic shelf facies in the Weches Formation are iron ores mined locally in East Texas.

SEDIMENT DISPERSAL

In South Texas, sediments were transported into the Gulf Coast Basin by a series of small stream complexes which deposited a fluvial system, represented by partially preserved meanderbelt facies (fig. 11). The streams drained a moderate-sized drainage basin of regional extent in what is now south central and southwest Texas. High-destructive deltas and lagoonal mud facies associated with coastal barriers provide evidence of the nature of the delta building. Prodelta mud facies that occur downdip in the high-destructive delta system are distal deposits in this dispersal system.

Maximum thickness of sand in the high-destructive delta system occurs in a belt of stacked coastal barriers oriented approximately parallel to the regional depositional strike (fig. 12a). Each of these sand trends is roughly lobate basinward, joined updip with axes of fluvial sands corresponding to approximately ten local meandering stream complexes, flowing from updip sources of terrigenous clastics. Marine redistribution of sediments developed the series of stacked barriers, which are the principal sand facies of high-destructive delta systems.

Minor sand input and no extensive progradation of the shoreline took place in the interdeltaic area of the central Texas Coastal Plain. There, deposits originated from marine reworking of sediments locally contributed by small rivers, and from sediments brought southwest by longshore drift from the high-constructive deltas in East Texas.

The facies tract of the high-constructive delta system of East Texas indicates that a major stream complex carried sediments from an extensive drainage area in the continental interior to the deltas developed in this part of the basin (fig. 11). The updip fluvial system deposited by this large stream complex has been removed by erosion. The stream, however, supplied a downdip, high-constructive delta system that covers much of East Texas. Sediment dispersal in East Texas consisted mainly of fluvial transport of mud-rich terrigenous clastics along the dip of the paleoslope, thereby extensively prograding the shoreline. Minor marine reworking of previously deposited, fluvially influenced facies occurred mainly along the delta margins. Areas of maximum progradation are outlined on the net sand isolith map by sand trends parallel to the paleoslope; sand maxima correspond to areas of maximum sediment input (fig. 12b). Orientation of the areas of maximum sediment input and progradation in East Texas suggest a source located to the northwest of this region. Thickness, lateral extent, and mud content in the Queen City high-constructive delta system of East Texas indicate a distant source of sediments and a large, integrated stream complex draining an extensive interior region.

Sediment dispersal in the shelf systems bounding the Queen City deltas and strandplain system was mainly strike-oriented, and consisted in reworking of the underlying deltaic facies by marine waves, tides, and longshore currents. No major sediment transport occurred along the dip of the paleoslope, and the resulting deposits are predominantly muddy with marls and glauconites extensively developed.

COMPARISON WITH OTHER DEPOSITIONAL SYSTEMS

Facies composition and distribution of the Queen City high-constructive delta system are comparable to those of lobate deltas such as the Lafourche lobe of the Mississippi delta system. Lobes making up the Queen City high-constructive delta system are strikingly similar in facies composition and geographic distribution to those in the Jackson Group (Fisher *et al.*, 1970). The system also resembles equivalent deltaic systems mapped in the lower part of the Wilcox Group (Fisher and McGowen, 1967; Fisher, 1969), and in the Yegua Formation (Fisher, 1969) (fig. 13). The Queen City high-constructive delta system of East Texas has an areal extent of about 15,000 square miles. This is comparable to the size of the Rockdale delta system in the Wilcox Group, which is about 24,000 square

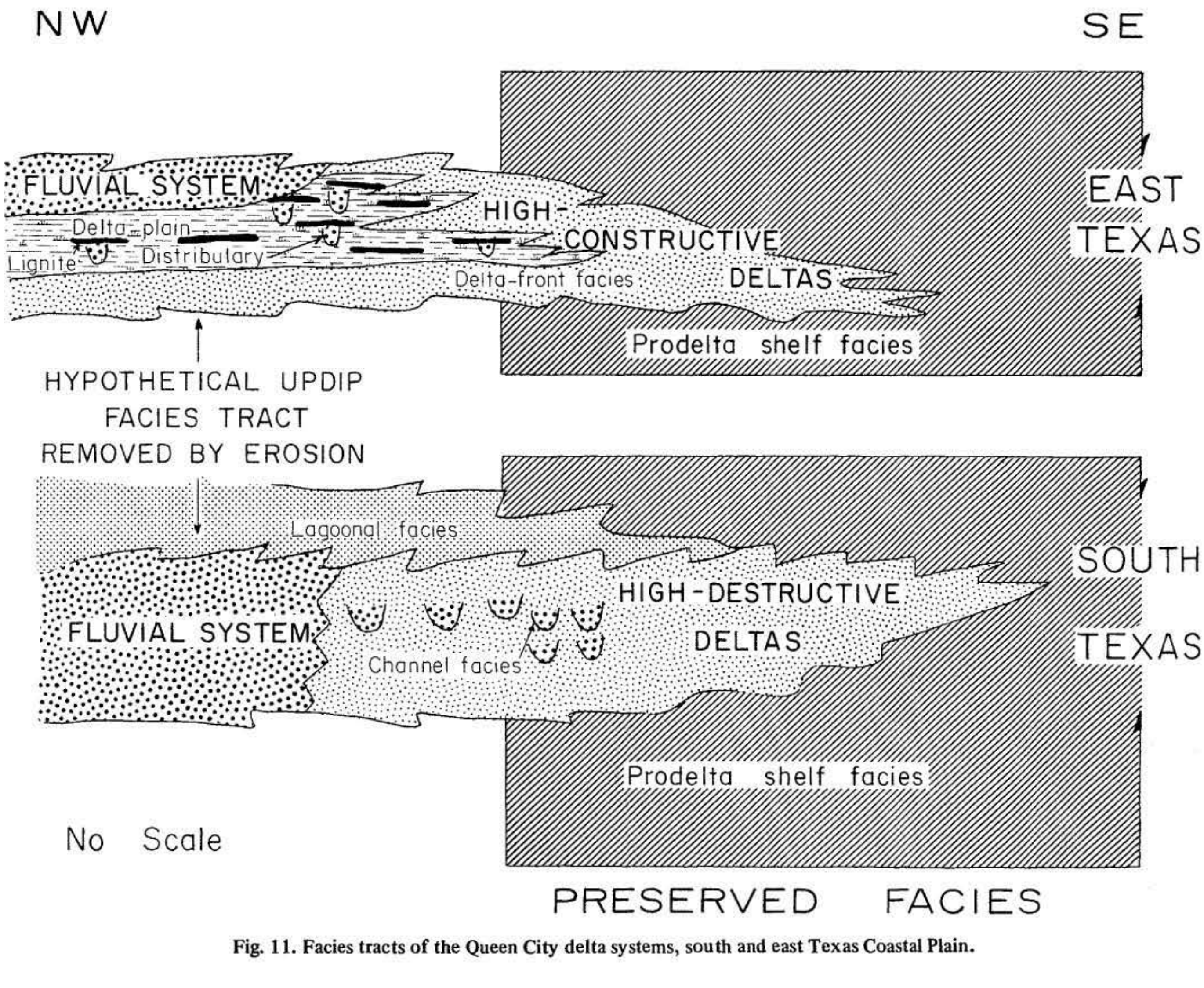

Fig. 11. Facies tracts of the Queen City delta systems, south and east Texas Coastal Plain.

miles (Fisher and McGowen, 1967); the Yegua delta system, which is 15,000 square miles (Fisher, 1969); the Fayette delta system, which is 10,000 square miles in the Jackson Group (Fisher *et al.*, 1970), and the Holocene Mississippi delta system, which is about 20,000 square miles (Frazier, 1967; Fisher and McGowen, 1967). The Mississippi delta system, which is comparable in composition and size to the Queen City high-constructive delta system of East Texas, has been built in the 6,000 years since the last rise in sea level (Frazier, 1967). By analogy, the Queen City high-constructive deltas may have been deposited in about 10,000 years, a very short time in the geologic record.

Facies composition of the Queen City deltas of South Texas resemble Holocene high-destructive, wave-dominated delta systems such as the Apalachicola of the northern Gulf Coast Basin, the Rhone delta system (Kruit, 1955; Oomkens, 1967, 1970), the Grijalva (Psuty, 1967), and the Nayarit coast (Curray *et al.*, 1969). Like Holocene high-destructive deltas, the Queen City high-destructive delta system was constructed by marine processes that extensively modified fluvial and fluvially influenced facies. Modern high-destructive, wave-dominated deltas characteristically have thin prodelta shelf mud facies. In the Rhone delta system (Oomkens, 1970), however, prodelta shelf facies reach 50 meters, five times thicker than the 10-meter-thick associated coastal-barrier sand facies. The Queen City high-destructive system possesses thick basal prodelta facies, which suggests a large fluvial supply of sediments during initial high-constructive deltaic progradation that formed an extensive deltaic platform. Younger Queen City deltaic sediments that were later deposited on this deltaic platform were strongly affected by marine processes which determined the facies composition and distribution of the resulting high-destructive delta system. Increased marine energy was applied to the delta probably because of decreasing compaction, which gave rise to a longer period of exposure of deltaic sands to winnowing and wave action.

The strandplain system of the central Texas Coastal Plain resembles the cheniers of the southwestern coast of Louisiana. The San Marcos strandplain-bay system of the Wilcox Group (Fisher and McGowen, 1967), and the northeastern part of the South Texas strandplain-barrier bar system of the Jackson Group (Fisher *et al.*, 1970) are Eocene strike systems comparable in facies composition and geographic location to the Central Texas strandplain system of the Queen City Formation. The system also resembles the strandplain along the Nayarit coast in Mexico (Curray *et al.*, 1969).

Like the Fayette delta system of the Jackson Group (Fisher *et al.*, 1970), the Queen City high-constructive deltas of East Texas grade northeast into mud shelf facies. The shelf system that developed in the subsurface in northeastern Texas and western Louisiana is similar in geographic location and facies composition to the Yazoo-Moodys Branch shelf system of the Jackson Group (Fisher *et al.*, 1970) of the Gulf Coast Basin.

Depositional systems delineated in the Queen City and equivalent stratigraphic units of the Claiborne Group are in general comparable to depositional systems delineated within other Tertiary stratigraphic units in the Texas part of the Gulf Coast Basin, and to those along the modern northwestern coast of the Gulf of Mexico (fig. 13). Thickness of the deltaic facies in South Texas and regional correlation suggest that the lower part of the high-destructive delta system of South Texas is older than the deltas of East Texas. Thus, deltation in South Texas probably started before that in East Texas. Except for these lower deltaic deposits of South Texas, high-constructive and high-destructive deltas developed contemporaneously in East and South Texas. These deltaic systems were separated by a strandplain system, and a mud shelf developed east of the high-constructive deltas in East Texas and western Louisiana. This areal distribution of depositional systems is different from that now existing in the northwestern Gulf of Mexico, and from that interpreted in other Tertiary stratigraphic units of the Texas Gulf Coast Basin. Coexistence of high-constructive and high-destructive deltas has not been recognized in ancient deposits of the Gulf Coast Basin. The South Texas high-destructive deltas point to local fluvial influx during Queen City deposition greater than that now taking place in the south Texas Coastal Plain, and greater than that so far recognized in Tertiary deposits of the Gulf Coast Basin.

DEPOSITIONAL SYSTEMS AND FORMAL STRATIGRAPHIC NOMENCLATURE

The Queen City Formation is a well established lithostratigraphic unit in Central and East Texas; in South Texas, the term has been used mainly for the subsurface units. The name Queen City has been applied to the sandy, nonfossiliferous to sparsely fossiliferous section between the dominantly shaly and richly fossiliferous Reklaw and Weches Formations. Queen City was introduced by Kennedy (1892) in East Texas, and early study of the unit was conducted by Wendlandt and Knebel (1929) as part of their studies on the Claiborne Group in East Texas. Plummer (1932) recognized a change of facies in the Queen City Formation in western Wilson County (south-central Texas) where the formation becomes clayey along the outcrop. Stenzel (1938) mapped and described the formation in Leon County, and subdivided the Queen City Formation in Cherokee County (Stenzel, 1953) into a lower member consisting of sands and carbonaceous shales (Arp Member), a middle dominantly glauconitic part (Omen Glauconitic Member), and an upper member composed of sands and carbonaceous shales, which he did not name. Dzilsky (1953) described the Queen City Formation in Nacogdoches County; Callender (1958) made a petrologic study of the formation in Bastrop County; and Smith (1958), in northwestern Louisiana, recognized the subdivisions of the Queen City Formation proposed by Stenzel (1953). In addition, Smith proposed Myrtis Member for the upper unnamed part of the formation. Eargle (1968) also pointed out that the Queen City Formation becomes clayey toward the southwest along the outcrop in South Texas, where the sandy units grade into clay and thin sandstone and limestone beds. Trowbridge (1923) applied the term Mount Selman Formation to Queen City equivalents in South Texas outcrop areas, a name originally applied in East Texas (Kennedy, 1892), and used by Wendlandt and Knebel (1929) for the undifferentiated stratigraphic interval embracing the Reklaw, Queen City, and Weches Formations. Lignitic claystones and coals of the Mount Selman Formation of South Texas were named El Pico Clay by Eargle (1968).

The sandy Queen City Formation is bounded above and

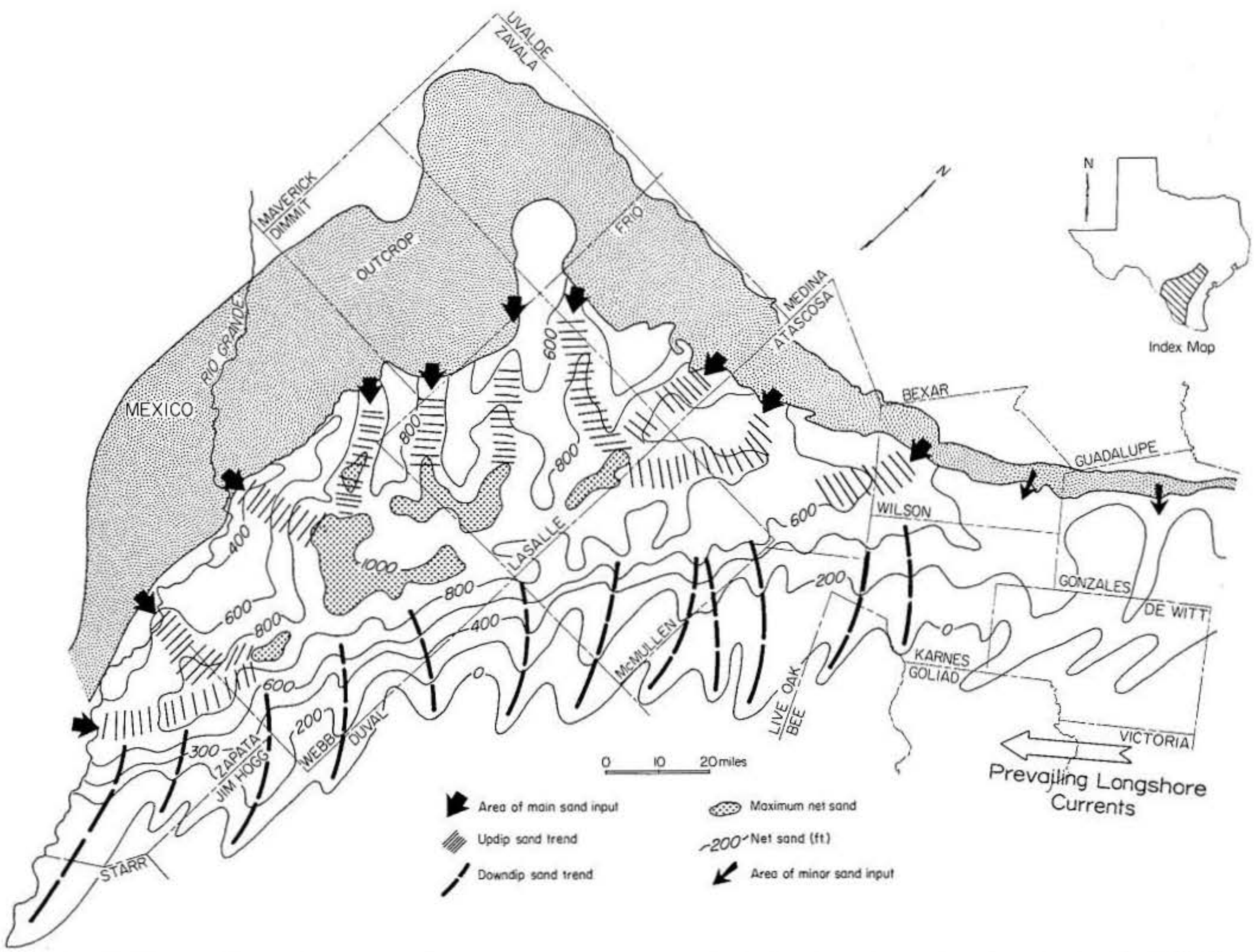

Fig. 12a. Principal sand trends in the Queen City Formation and equivalent lithostratigraphic units, central and south Texas Coastal Plain.

below by fossiliferous muds. Stenzel (1938) divided the underlying Reklaw Formation in Leon County into the lower Newby Glauconitic Sand Member and the upper Marquez Shale Member. The Reklaw Formation has been recognized in surface and subsurface in East, Central, and most of South Texas. The Reklaw Formation is not present above the Carrizo Sand in the Rio Grande area. Sands and lignites overlying the Carrizo Sand near the Rio Grande were called Bigford Formation by Trowbridge (1923).

Shaly, commonly fossiliferous muds above the Queen City Formation are formally designated Weches Formation (fig. 14). In Leon County, East Texas, Stenzel (1938) divided the Weches Formation into a basal marly and sandy Tyus Member, a middle fossiliferous and glauconitic Viesca Member, and an upper Therrill Member composed of silts and carbonaceous clays. Eargle (1968) considered that in South Texas the Weches Formation merges with El Pico Clay, and that they cannot be differentiated.

Existing formal nomenclature of the Gulf Coast Basin does not coincide with the genetic units making up the Queen City Formation and equivalent stratigraphic units (fig. 14). The muddy Reklaw Formation is composed of basal shelf sediments and overlying prodelta facies. The sandy Bigford Formation of South Texas is deltaic, composed of high-destructive meanderbelt and stacked coastal barrier facies. The sandy Queen City Formation is made up of similar high-destructive delta facies in South Texas, by strandplain facies in Central Texas, and by high-constructive delta facies in East Texas. Lagoonal muds in South Texas are genetically related to the high destructive deltas and occur mostly within the El Pico Clay, but some are included in the Queen City Formation of the subsurface. The muddy Weches Formation is traceable in subsurface throughout Texas; it is composed of shelf sediments in the lower part and prodelta facies in the upper part that are related to the overlying Sparta delta progradation. In East Texas, mud-shelf facies make up the stratigraphic interval between the top of the Carrizo Formation and the base of the Sparta prodelta facies; in western Louisiana, this shelf system makes up part of the Cane River Formation. Standard faunal zones in the Eocene of the Gulf Coast Basin have been based in part on foraminifers from fossiliferous shelf facies of the Reklaw and Weches Formations.

RELATIONSHIP BETWEEN FACIES AND PETROLEUM OCCURRENCES

Petroleum pools demand the existence of source rocks

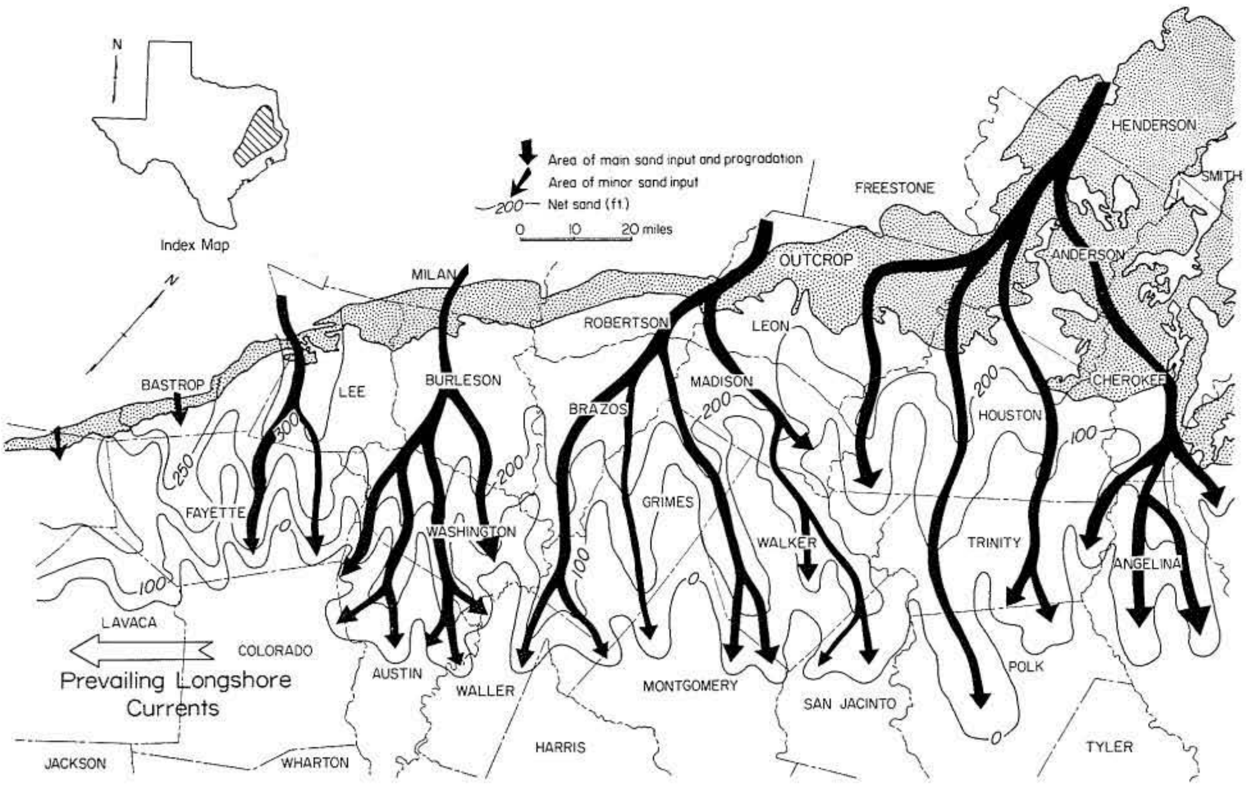

Fig. 12b. Sediment dispersal pattern, Queen City high-constructive delta system, east Texas Coastal Plain. Source areas located far to the northwest provided sediments transported along the dip of the paleoslope. Marine reworking of previously deposited sediments occurred mainly in the delta margins.

for generation of petroleum, reservoir rocks for storage, and traps for impounding commercial quantities of oil and gas. All these conditions are met in deltaic and related strike systems. Rapidly deposited, organic-rich prodelta muds are potential petroleum source rocks. Distributary-channel and delta front sand facies in high-constructive deltas, meanderbelt and coastal-barrier sand facies in high-destructive deltas, and barrier bar-strandplain facies in strike systems are good reservoirs. Growth faulting and differential compaction, processes normally taking place in deltaic systems, provide structures for petroleum accumulations. Marked lenticularity of sands and permeability barriers within sand facies are stratigraphic traps that may constitute undiscovered petroleum fields in many sedimentary basins.

Most petroleum accumulations in the Queen City section in South Texas occur in a belt along the depositional strike (fig. 15a). Reservoirs are cuspate-oriented, thin coastal-barrier sands in the downdip distal part of the deltaic system, basinward of the sand maxima and interfingering with prodelta muds. Pools produce gas and medium to light oil, and form *en echelon* trends of combined structural and stratigraphic traps (table 1). Non-commercial to minor productive petroleum accumulations of gas and heavy oil have been found in the areas of sand maxima. This probably reflects the lack of thick seal rocks and the thinness of the prodelta source beds in this area (fig. 7).

Meanderbelt and coastal-barrier facies are potential reservoir facies in South Texas. Meanderbelt facies have good permeability, but are commonly fresh water bearing in this area. Coastal barriers may be more important because of the high degree of marine reworking that provides better sorting and permeability in the upper-shoreface sand facies. Stratigraphic and structural traps related to the cuspate downdip trends (fig. 15a) remain to be discovered. The best targets in South Texas are thin coastal-barrier sands in the distal part of the high-destructive deltas between the zero and 200-foot sand isoliths (fig. 15a), where the thickest prodelta muds or potential petroleum sources occur.

In East Texas, small quantities of gas and heavy oil (table 2) have been produced from the high-constructive delta system (fig. 15b). Although not displaying any consistent trend because of the few known fields, pools occur in delta-front facies. Reservoirs are distributary-channel and delta-front sands, and accumulations are in combined structural and stratigraphic traps. There are three small abandoned fields in the Angelina lobe near the northeast pinchout of the deltaic facies, and three more fields have been discovered in the updip portion of the delta-front facies in the Washington, Grimes, and Walker lobes.

Paucity of petroleum production in East Texas from the high-constructive deltas appears to indicate that facies in

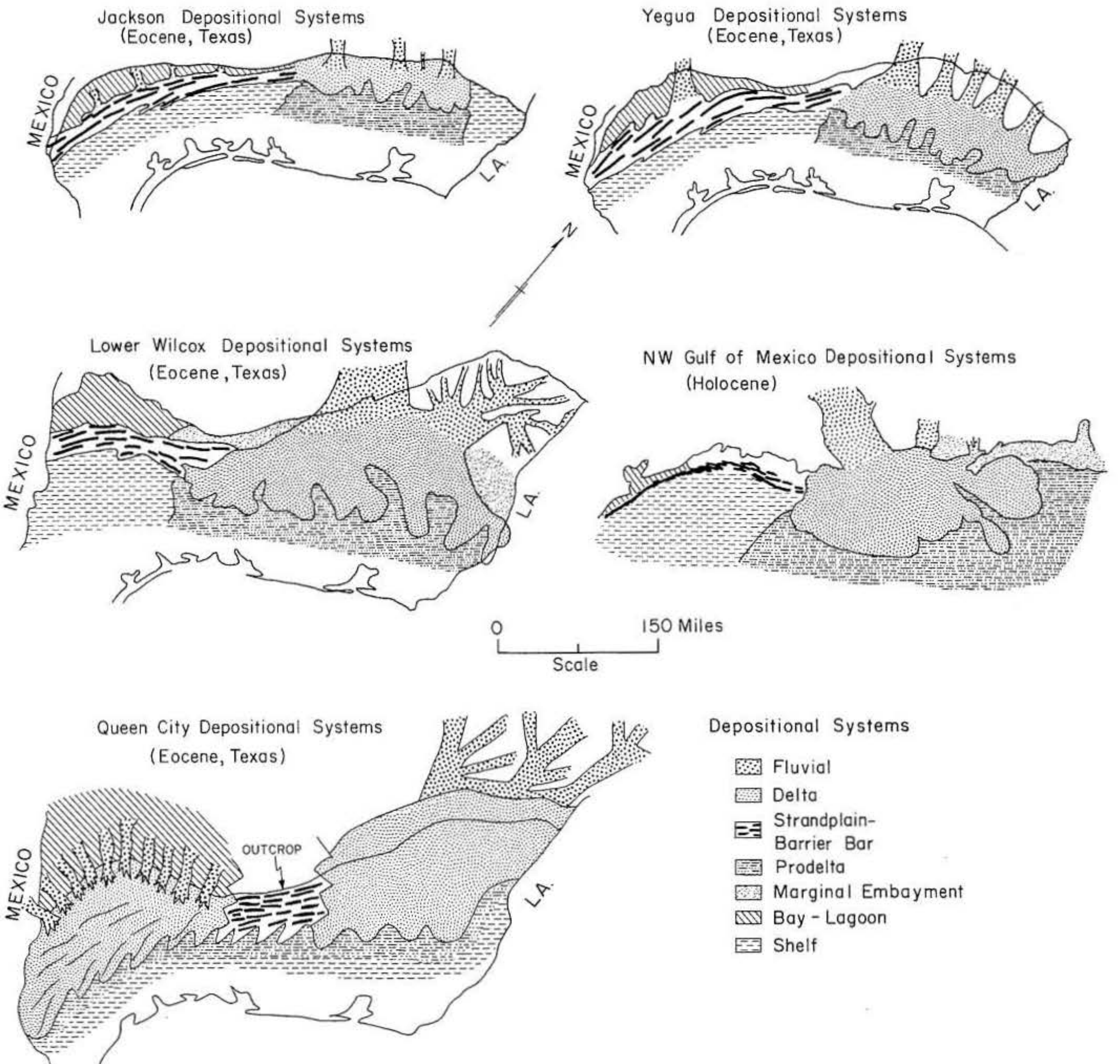

Fig. 13. Comparison between the Queen City depositional systems of the Texas Coastal Plain and ancient and modern depositional systems of the Gulf Coast Basin (after Fisher and McGowen, 1967; Fisher, 1969; Fisher *et al.*, 1970).

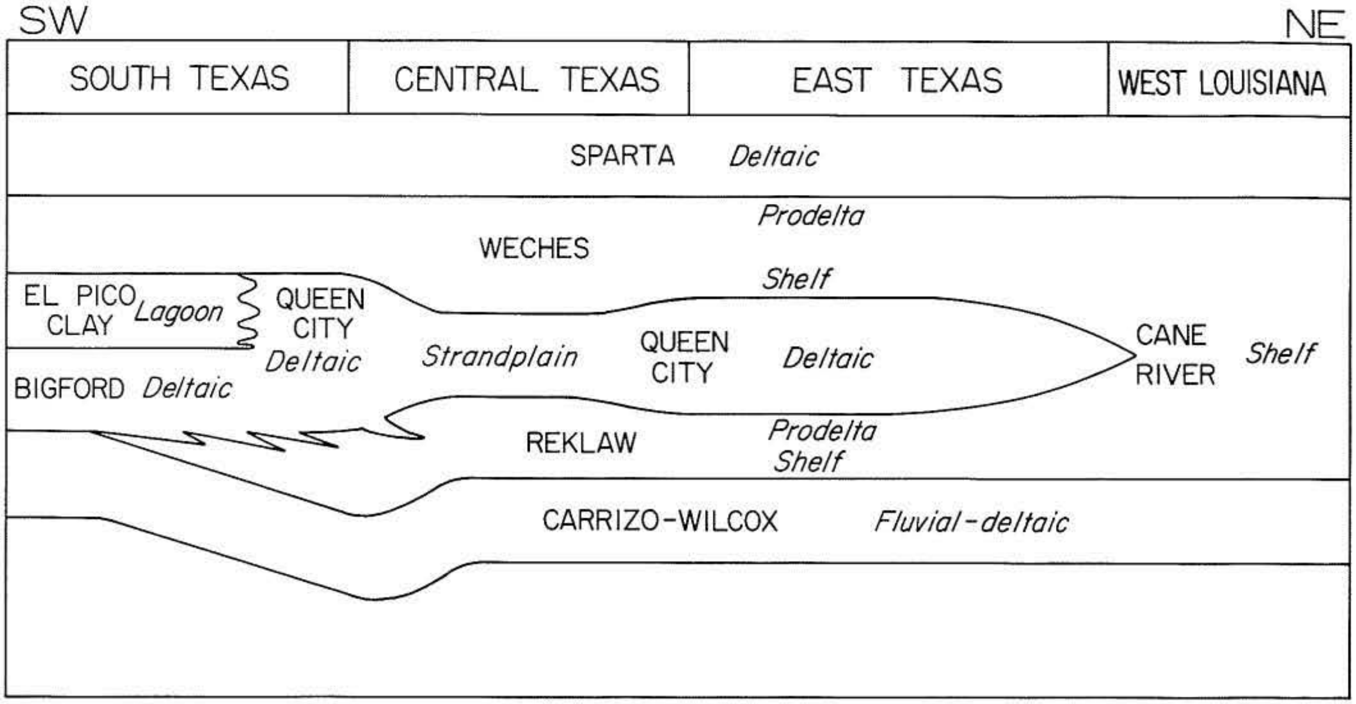

Fig. 14. Relationship between formal stratigraphic nomenclature and facies of the Queen City depositional systems.

this system have little economic potential. Absence of major accumulations is probably due to the absence of simultaneously occurring traps; thus, most hydrocarbons were lost during early migration. Clustering of small fields in the Angelina lobe are due to a combination of structures and effective sealing by the vertically and laterally bounding prodelta-shelf muds (fig. 8). Sand facies of the high-constructive deltas of East Texas probably contain some additional minor petroleum accumulations. Presence of good reservoirs (distributary-channel and delta-front sands) and petroleum source rocks (prodelta muds), as well as the reported shows and production, suggest that some small pools may be found in stratigraphic and combined stratigraphical and structural traps. Prospects are better in the Washington, Grimes, and Walker lobes, where thicker prodelta muds enhance the probability of petroleum generation. Lenticularity and variations of permeability in these deltaic sands constitute potential stratigraphic traps, and minor growth faulting provides structures for accumulations in adjacent delta-front sands.

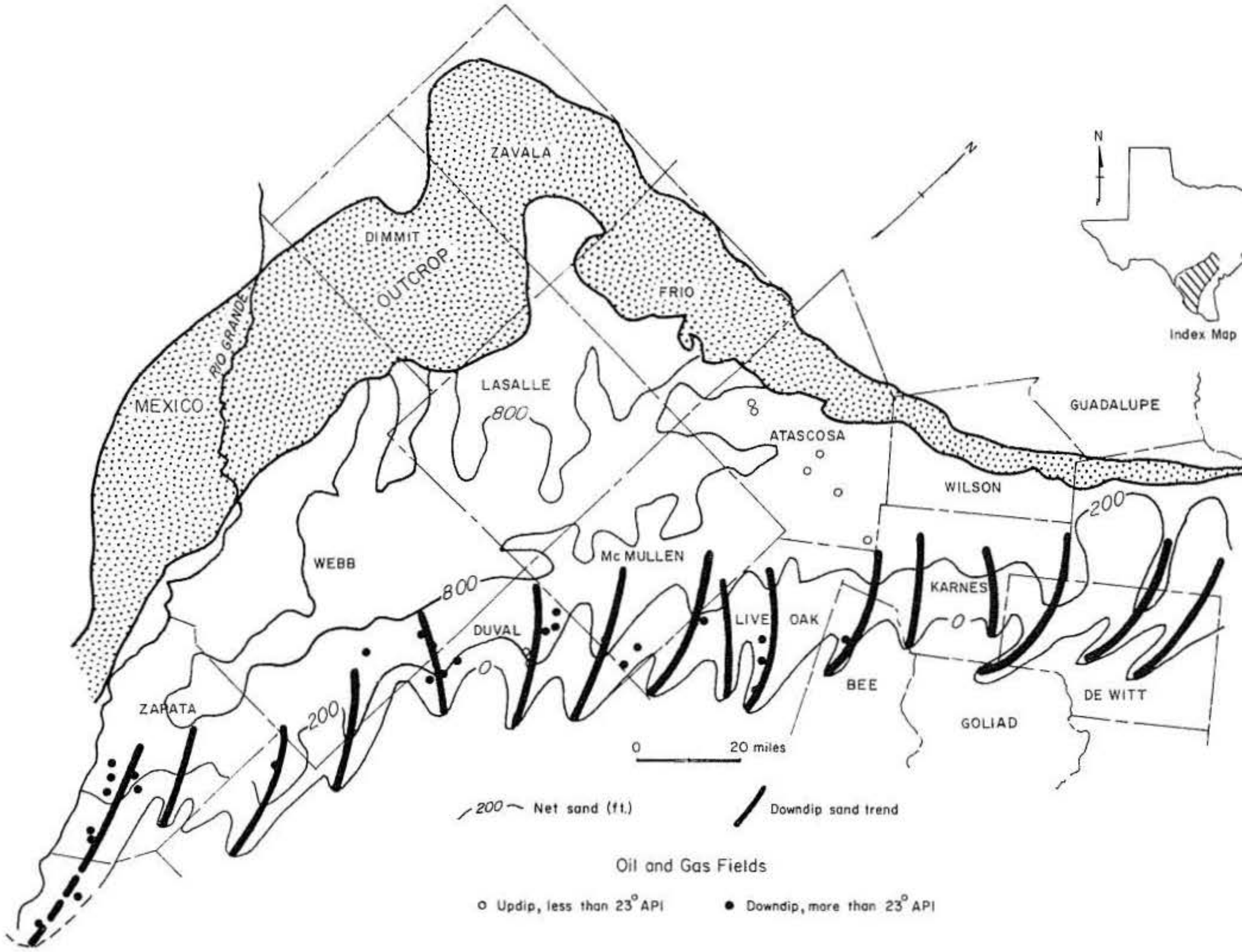

Fig. 15a. Producing and downdip potential petroleum trends in the Queen City high-destructive delta system, south Texas Coastal Plain.

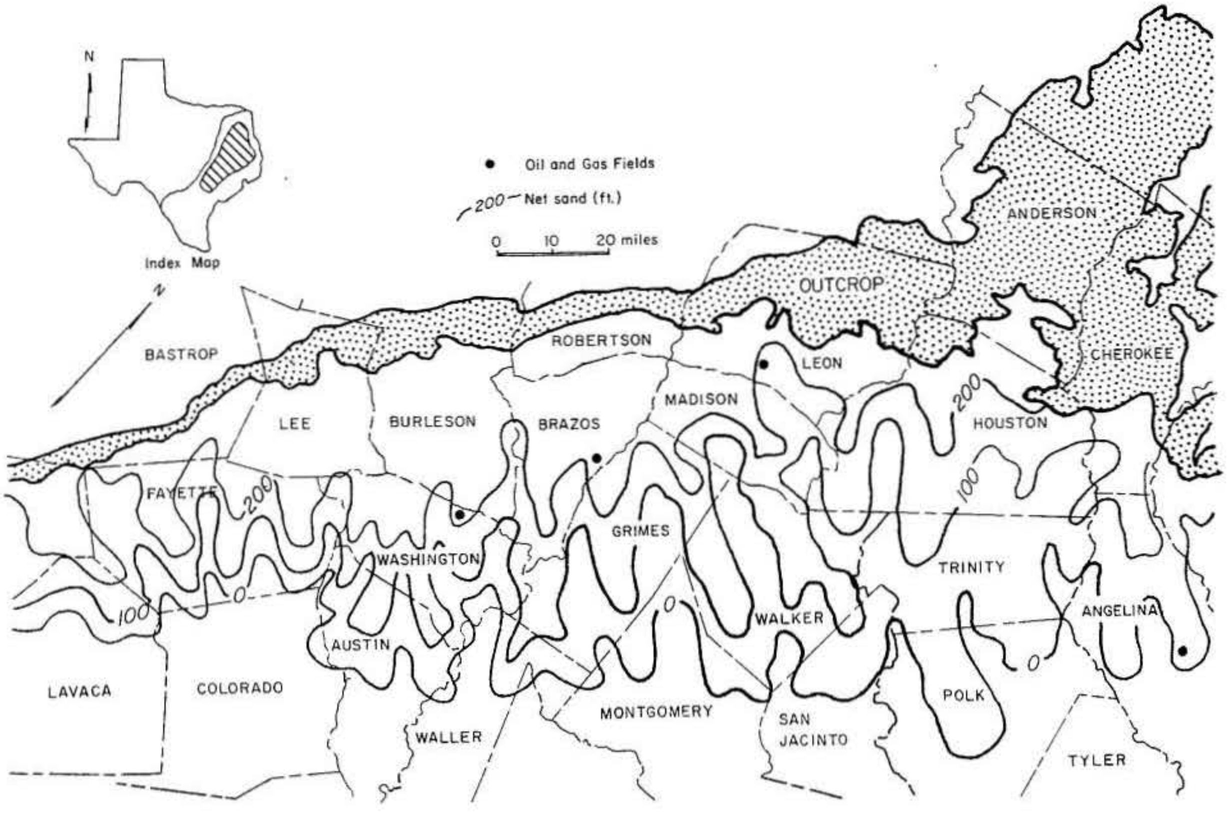

Fig. 15b. Petroleum occurrences in the Queen City high-constructive delta system, east Texas Coastal Plain.

TABLE 1. *Fields and petroleum production data, Queen City and equivalent reservoirs, in South Texas.**

Field	County	Average Production Interval	Specific Gravity A.P.I.	Wells Producing	Cumulative Production 1-1-68 Oil (bbls)	Gas (MCF)
Imogene South Queen City	Atascosa	5	20	1	10,700	11
Jourdanton Queen City	Atascosa	5	19-22	26	1,126,156	102
Muil Queen City Sand	Atascosa	3	21	3	106,051	13
Pleasanton South Queen City	Atascosa	4	19	2	189,187	22
Weigang Reklaw	Atascosa	3	29	2	9,894	2,694
Wherry and Green Reklaw	Atascosa	7	20	12	324,696	36
Pawnee Queen City 5000	Bee	6	37	0	741	N.D.
Hohler Queen City	Duval	5-12	52	3	492,708	1,016,888
Loma Novia	Duval	10	62	2	N.D.	486,033
Peters North 1st Queen City	Duval	16	36	8	915,786	17,376
Seven Sisters Queen City	Duval	2-52	58	2	4,256	1,177,417
Viggo Queen City	Duval	2	41	2	196,375	23,408
Government Wells North Queen City	Duval	N.D.	50	9	3,091,124	56,642
Hagist Ranch Queen City	Duval	126	42	23	3,652,057	193,442
Ronnie Queen City Sand	Frio	8	16	5	20,487	12
El Peyote Queen City	Jim Hogg	9	35	N.D.	51,475	N.D.
Clayton Queen City	Live Oak	2-7	36-75	51	3,317,058	2,355,157
George West Queen City	Live Oak	10-11	40	2	6,116	13,336
Kittie Burns Queen City	Live Oak	10	57	1	16,243	1,424,650
Sunset Queen City	Live Oak	4	42	N.D.	26,189	N.D.
Hostetter Queen City	McMullen	12-20	N.D.	7	210,709	22,855,758
Campana South Queen City	McMullen	8	N.D.	3	—	50,057
Little Alamo	McMullen	10	23	1	106,524	207
Moos Queen City	Webb	28	N.D.	N.D.	2,163	1,408,003
De Spain Queen City	Webb	2	N.D.	N.D.	N.D.	N.D.
Zapata Queen City	Zapata	4-19	N.D.	2	N.D.	362,610
Cinco de Mayo	Zapata	5-12	N.D.	11	N.D.	18,863,550
Echols	Zapata	20	N.D.	N.D.	N.D.	N.D.
Herlinda Vela Queen City	Zapata	31	23	N.D.	2,976	N.D.
Jennings Queen City	Zapata	4-8	37	11	218,103	1,723,952
Lopeno Queen City	Zapata	5	29	37	28,200	2,948,332
Harry J. Mosser	Starr	10	40	3	18,102	209
Pedernal Queen City	Starr	N.D.	N.D.	N.D.	105,489	2,310,283

*Source: International Oil Scouts Association (1968).
N.D. - No data.

TABLE 2. *Petroleum production information, Queen City and equivalent reservoirs, in East Texas.**

Field	County	Average Thickness Production Interval	Specific Gravity A.P.I.	Wells Pro-ducing	Cumulative Production 1-1-70 Oil (bbls)	Gas (MCF)
Clay Creek	Washington	9	18	1	N.D.	N.D.
Fergusson - Crossing	Grimes	6	N.D.	1	N.D.	15,789
Keith - 300	Leon	9	18	1	Non-commercial	N.D.
Calmar Hockley	Angelina	3	21	1	305	N.D.
Huntington	Angelina	8	24	9	21,311	N.D.
Roane	Angelina	22	24	2	3,536	10

*Source: International Oil Scouts Association (1970).
N.D. - No data.

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