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By

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DEPOSITIONAL SYSTEMS IN THE WILCOX GROUP OF TEXAS AND THEIR RELATIONSHIP TO OCCURRENCE OF OIL AND GAS[1]

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ABSTRACT

Regional investigation of the lower part of the Wilcox Group in Texas in outcrop and subsurface indicates seven principal depositional systems. These include: (1) Mt. Pleasant Fluvial System developed updip and in outcrop north of the Colorado River; (2) Rockdale Delta System, present primarily in subsurface, chiefly between the Guadalupe and Sabine Rivers; (3) Pendleton Lagoon-Bay System in outcrop and subsurface largely on the southern flank of the Sabine Uplift; (4) San Marcos Strandplain-Bay System, occurring in outcrop and subsurface mainly on the San Marcos Arch; (5) Cotulla Barrier Bar System in subsurface of South Texas; (6) Indio Bay-Lagoon System developed updip and in outcrop of South Texas; and (7) South Texas Shelf System, an extensive system entirely within subsurface of South Texas. The Rockdale Delta System, consisting of large lobate wedges of muds, sands, and carbonaceous deposits, is the thickest and most extensive of the lower Wilcox depositional systems. It grades updip to the thinner terrigenous facies of the Mt. Pleasant Fluvial System. Deposits of the Rockdale Delta System were the source of sediments redistributed by marine processes and deposited in laterally adjacent marine systems. Delineation of depositional systems and, more specifically, delineation of component facies of the various systems, permits establishment of regional oil and gas trends which show relationship of producing fields and distribution of potentially producing trends.

INTRODUCTION

The Wilcox Group (Lower Eocene) is a thick sequence of predominantly terrigenous clastic sediments and volumetrically a significant part of the large terrigenous fill of the western Gulf Coast Province. It is an economically important group of rocks, providing oil, gas, and fresh-water reservoirs as well as deposits of lignite, ceramic clay, and industrial sand.

Area of study includes approximately 40,000 square miles in the Texas Gulf Coastal Plain, extending from the Sabine River on the east to the Rio Grande on the south, and in a 100- to 300-mile wide belt including outcrop and subsurface. Subsurface control consisted of approximately 2,500 electric logs, supplemented by lithologic control based on outcrop descriptions and cuttings and cores of strategically located wells. Fifty stratigraphic dip sections and 15 strike sections were prepared at spacings of 8 to 10 miles to determine three-dimensional relationships of principal lithologic units. Emphasis in outcrop study was on mapping of principal rock units, interpreting primary sedimentary structures, and determining fossil composition.

This report is preliminary, being part of a continuing, larger study of the Wilcox Group in Texas which has been under way at the Bureau of Economic Geology for the past two years; it is regional in context. Herein, consideration is restricted to the lower part of the Wilcox Group, including the sequence underlain by marine muds and clays of the Midway Group and normally overlain by marine or lagoonal muds of the middle part of the Wilcox Group. The Carrizo Formation and the upper part of the Wilcox Group are not considered here.

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TERMINOLOGY AND DEPOSITIONAL SYSTEMS

The stratigraphic terminology employed is informal. Reference is made to existing, defined, formal stratigraphic units (chiefly in outcrop) where applicable. Establishment of a formal stratigraphic terminology throughout the extent of the Wilcox Group (outcrop and subsurface) awaits further study. The terminology used derives from the concept of depositional systems or complexes, employed recently, for example, in connection with modern sediments and depositional environments of the South Texas coast (Hayes and Scott, 1964) and in reference to the Frio Barrier Bar System of South Texas (Boyd and Dyer, 1964). In study of modern sediments emphasis is generally placed not only on description of specific environments and two-dimensional distribution of sediments and environments but also on analysis and integration of facies, with fabrication of facies tracts and three-dimensional

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

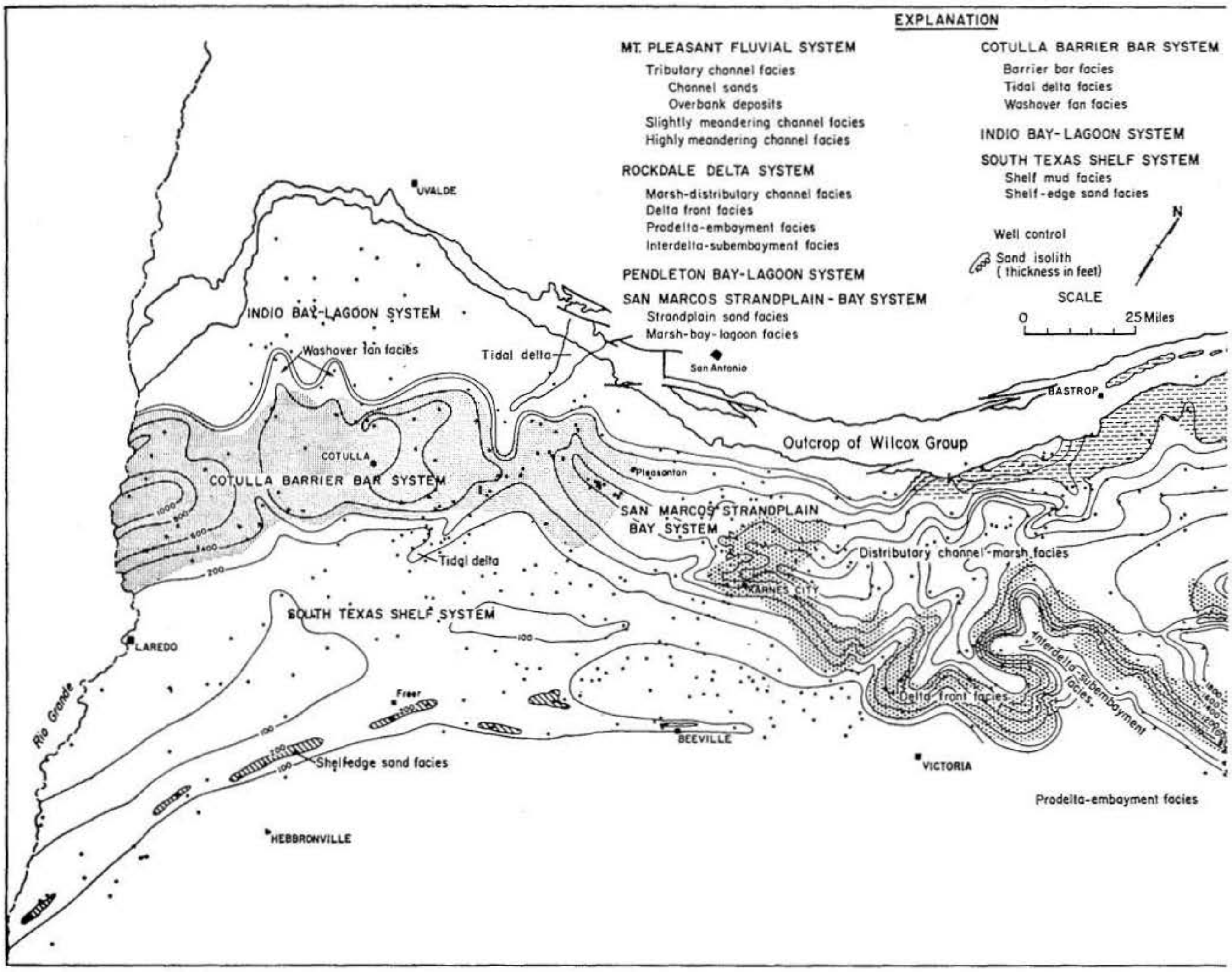


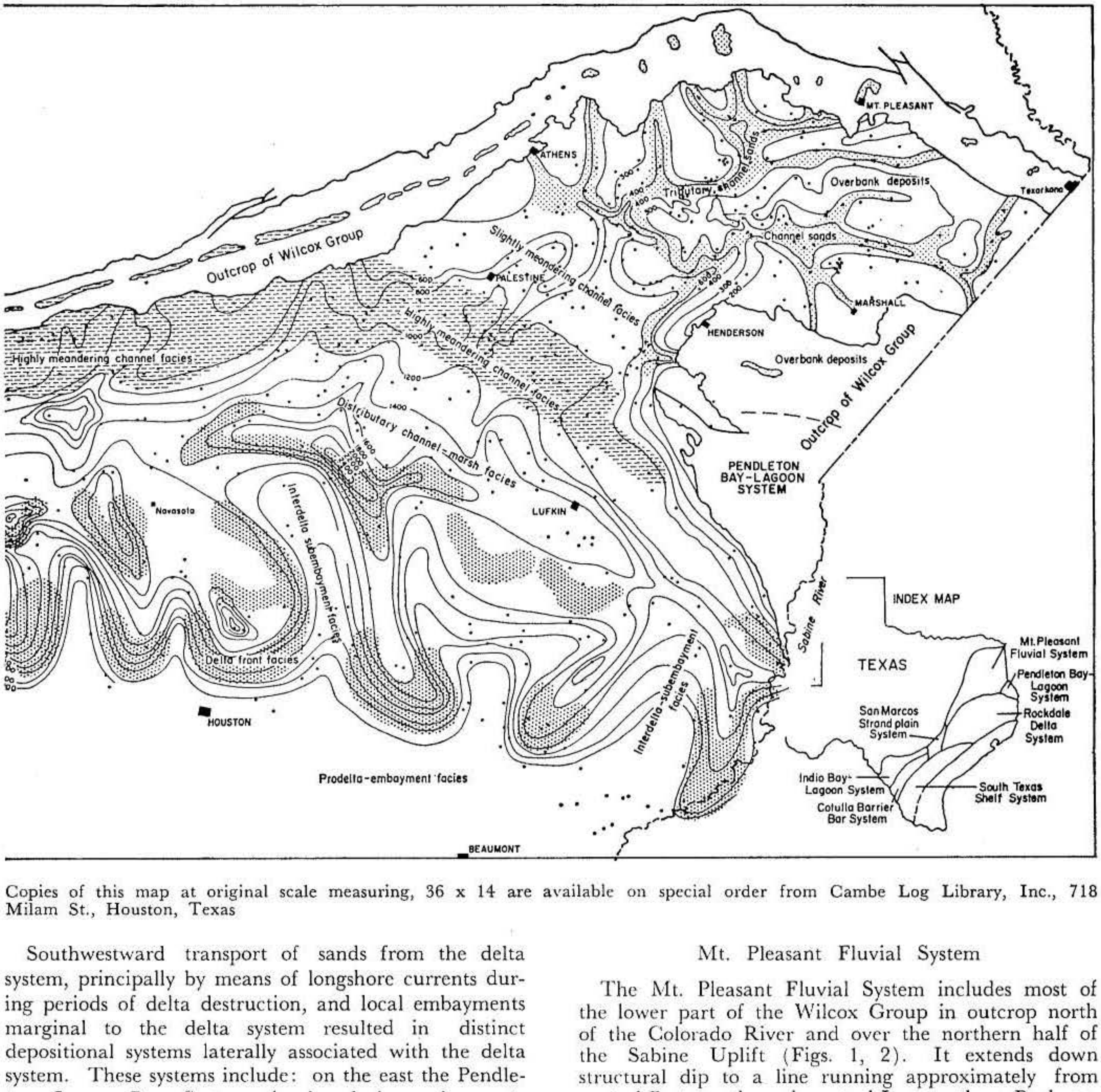
Figure 1. Principal depositional systems, lower part of Wilcox Group, Texas

depositional models of known depositional complexes or systems. These approaches are significant in interpretation of ancient sediments, especially in regional analysis. More emphasis is placed on lithologic and fossil composition, sedimentary structures, and distribution, geometry, and relationship of component facies than on consideration of regional correlation and persistence of locally established formal stratigraphic units.

The principal unit here employed is the *depositional system,* recognized by specific criteria and designated by a genetic term, e. g., delta system; a delta system includes one or more deltas. Components of a depositional system are referred to simply as facies, e. g., the delta front facies or distributary channel facies of a delta system. Smaller scaled components are designated by such terms as units, beds, or deposits. Basically, the concept of depositional systems in ancient sediments, fabricated principally from integration of facies, involves recognition of large-scale natural, genetic units comparable to modern depositional systems readily apparent from physiographic characteristics.

PRINCIPAL DEPOSITIONAL SYSTEMS

Seven principal depositional systems are recognized in the lower part of the Wilcox Group of Texas (Fig. 1). The dominant depositional element is the large Rockdale Delta System, comprising large lobate wedges of muds, sands, and carbonaceous deposits, chiefly lignites (Fig. 1). Maximum lower Wilcox sedimentation, with sequences up to 5,000 feet thick, occurred during deposition of this system. It occurs principally in the subsurface and grades up depositional slope and up structural dip to thinner terrigenous clastic facies of the Mt. Pleasant Fluvial System, present in outcrop northward from the Colorado River. A large part of the original fluvial system apparently was deposited updip of the present outcrop with only a part of the system preserved in the East Texas Basin.



Copies of this map at original scale measuring, 36 x 14 are available on special order from Cambe Log Library, Inc., 718 Milam St., Houston, Texas

Southwestward transport of sands from the delta system, principally by means of longshore currents during periods of delta destruction, and local embayments marginal to the delta system resulted in distinct depositional systems laterally associated with the delta system. These systems include: on the east the Pendleton Lagoon-Bay System developed in embayments marginal to the delta system, on the southwest the San Marcos Strandplain-Bay System developed proximal to the delta system, and the Cotulla Barrier Bar and complementary Indio Bay-Lagoon Systems developed more distally from the main area of deltation. Contemporaneous sedimentation in systems marginal and lateral to the delta system was relatively slow with sequences generally less than one-fourth the thickness of the delta system. Gulfward from the Cotulla Barrier Bar System and in part lateral to the Rockdale Delta System is the South Texas Shelf System, marked chiefly by muds and by relatively minor sands.

Mt. Pleasant Fluvial System

The Mt. Pleasant Fluvial System includes most of the lower part of the Wilcox Group in outcrop north of the Colorado River and over the northern half of the Sabine Uplift (Figs. 1, 2). It extends down structural dip to a line running approximately from central Bastrop, through central Lee, northern Burleson, southern Robertson, central Leon, northern Houston, southern Cherokee, and central Nacogdoches counties. South and downdip from this line the system grades to the Rockdale Delta System (Fig. 3); laterally it grades to embayed marine facies developed marginally to the fluvial and delta systems. Three more or less distinct facies, based on (1) sand body geometry, (2) sand isolith pattern, (3) internal sedimentary structures, (4) vertical sequence in structures and textures, (5) grain size, and (6) relative amounts of channel and overbank deposits, are recognized (Figs. 1, 2, 3). These facies principally reflect different fluvial environments.

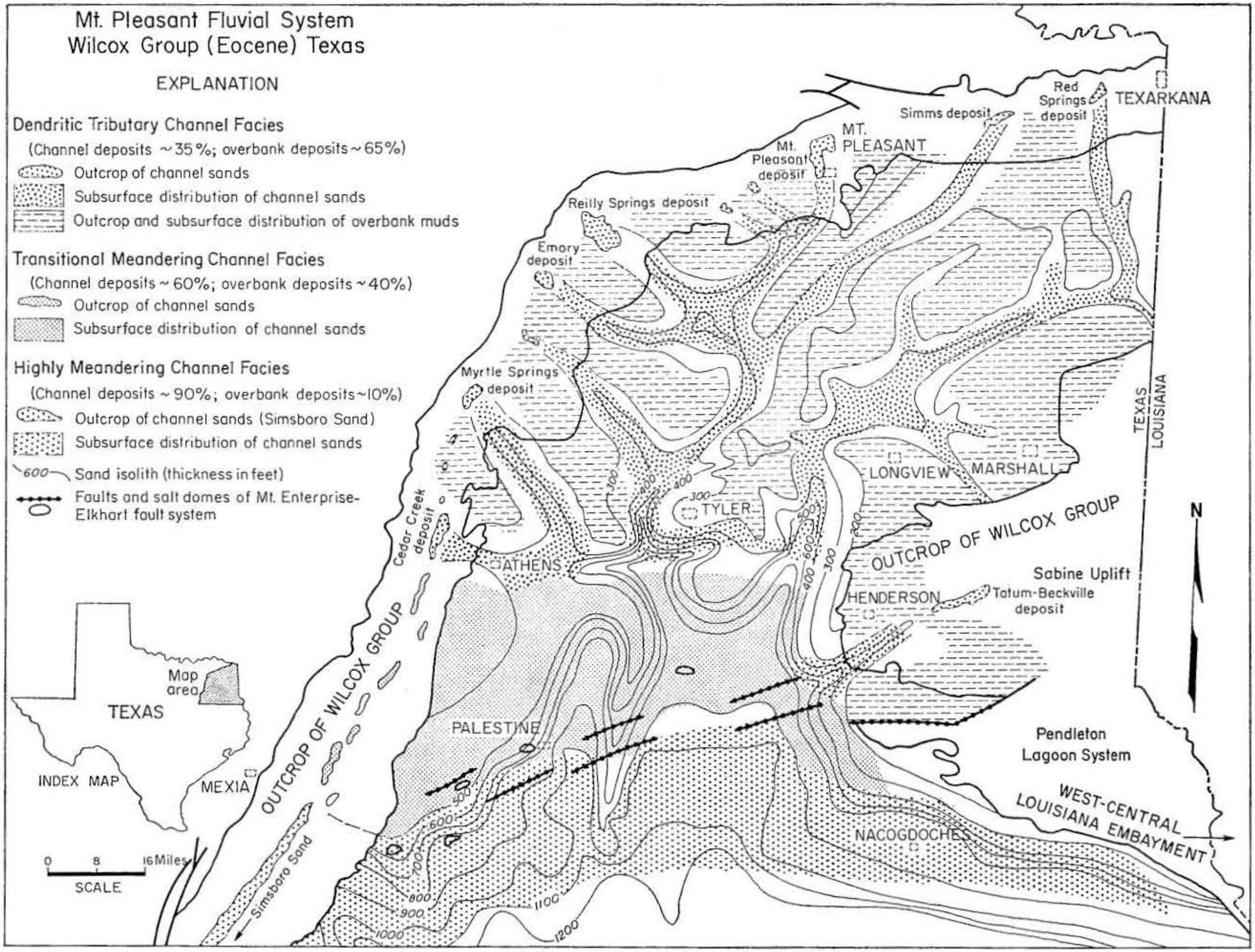


Figure 2. Outcrop and subsurface distribution, Mt. Pleasant Fluvial System, Wilcox Group, Texas (For well control, see Fig. 1)

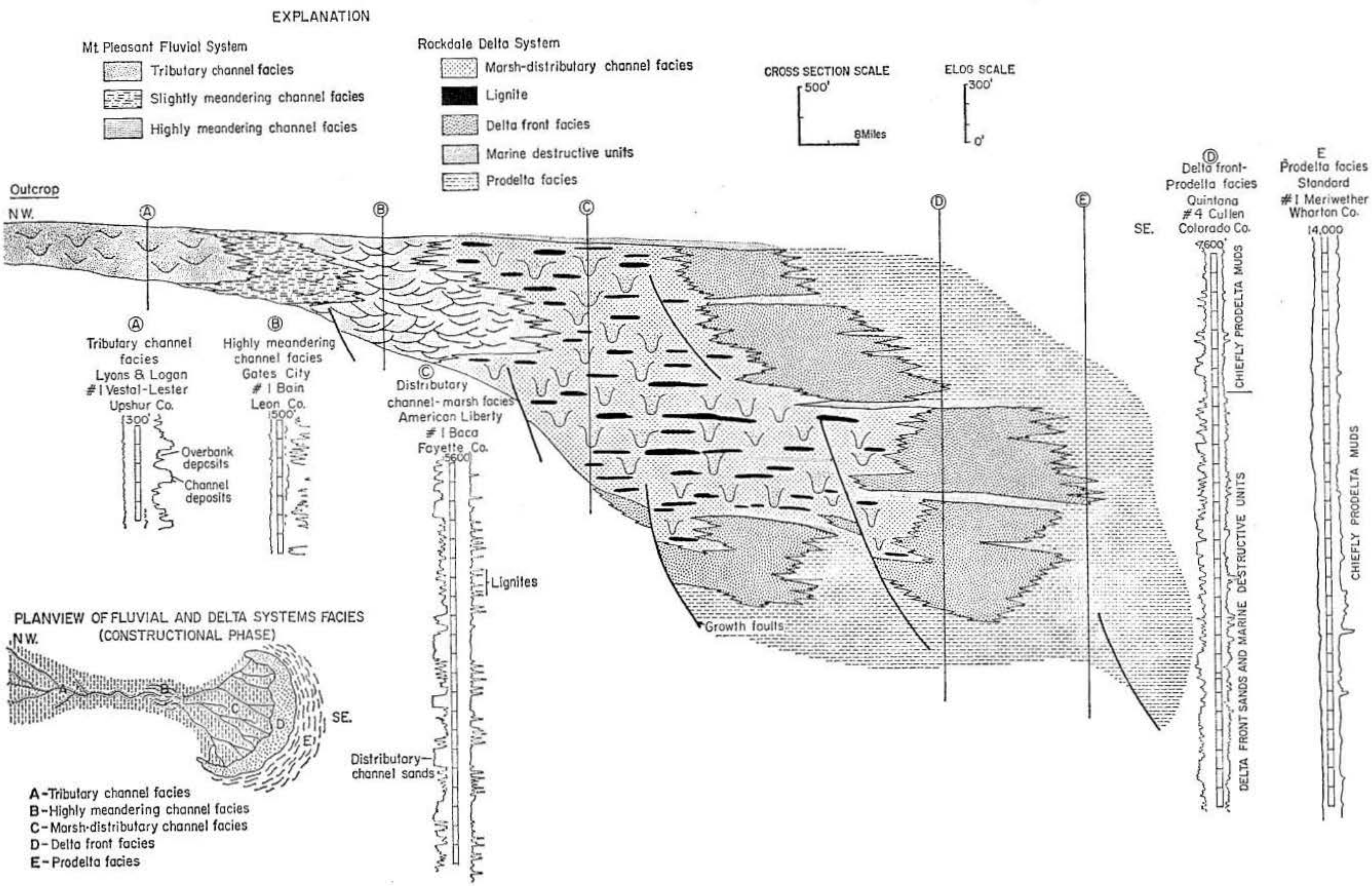


Figure 3. Diagrammatic stratigraphic dip section of Mt. Pleasant Fluvial System and Rockdale Delta System, showing relationship and character of principal component facies

Tributary channel facies

In northernmost Wilcox outcrops, from central Van Zandt County northeastward to Texarkana and in outcrop over the northern part of the Sabine Uplift, sand deposits occur in definite, separated areas (e. g., Mt. Pleasant, Reilly Springs, Simms deposits); clays and muds crop out in intervening areas. Isoliths of sand units outline elongate bodies with an overall dendritic, tributary pattern (Fig. 2). The fluvial facies defined chiefly by this pattern extends from outcrop southward in the subsurface to a line from southwestern Smith to west-central Rusk counties. The tributary channel facies varies from about 300 to 800 feet thick, commonly increasing in thickness downdip and toward the axis of the East Texas Basin; it consists of about 40 percent sand or channel deposits and about 60 percent mud or overbank deposits. The overbank (or nonchannel) muds are chiefly laminated, light to moderate gray, containing minor amounts of carbonaceous matter. Individual sand units range from 5 to about 80 feet thick and occur as channel deposits with flat tops and convex downward bases. Bases of channels are characterized by channel lag of granules to fine gravel with a few angular clay pebbles. Sands are cross-bedded; in lower parts of the channel deposits, sands display trough or festoon cross-beds and in upper parts show wedge sets of cross-beds. Upper parts of channel sands are horizontally bedded. Sands in this facies are mostly fine grained to locally medium grained; mean sand grain size averages about 0.14 mm with range in mean of about 0.11 to 0.25 mm; channel sands typically fine upward. Channels are cut into underlying and laterally adjacent overbank muds. Sinuous, elongate, narrow lignite deposits commonly occur laterally adjacent to channel sand deposits; these apparently accumulated as peat bogs in depressions along higher stream terraces (a common occurrence of modern peat bogs in inner Gulf Coastal Plain) or in abandoned stream courses. Clays within and immediately adjacent to sand channel deposits are chiefly kaolinitic; feldspars are mostly weathered. Clays of overbank deposits are, by contrast, largely nonkaolinitic — mostly illitic, chloritic, and montmorillonitic; feldspars of overbank muds are generally unweathered.

Slightly meandering channel facies

Down depositional slope in the fluvial system a transitional facies is characterized by uniform to slightly dendroid sand isolith (Figs. 1, 2) patterns which are less dendritic than in the tributary channel facies. This change in pattern probably represents a slight meandering of the original stream system. Channel sand deposits are more numerous within this facies than in the tributary channel facies; they make up about 60 percent of the total facies with 40 percent represented by overbank deposits. The facies ranges in thickness from about 500 to 800 feet; it occurs in outcrop from central Freestone, through western Henderson, into southern Van Zandt counties and extends downdip in the subsurface to a line running from central Freestone, through central Anderson, central Cherokee, and into northwestern Nacogdoches counties. In addition to containing a higher percentage of channel deposits, individual sand bodies in this facies are slightly more extensive, and sands are slightly larger in mean grain size than those of the tributary channel facies. Primary sedimentary structures of sands, relationship of channels to clay mineral distribution and lignite deposits, outlined above, are similar for the two facies.

Highly meandering channel facies

A distinct facies is developed in the Mt. Pleasant Fluvial System immediately down depositional slope and down structural dip of the Mt. Enterprise-Elkhart fault zone and associated salt domes to the southwest (Figs. 1, 2). Within this facies sands predominate; overbank muds make up less than 10 percent of the total facies. Sand isoliths are uniform with sands in the facies (=Simsboro Sand of outcrop) forming persistent units. For such units as these, Pettijohn et al. (1965) suggested the term multilateral. These bodies are made up of multiple channels which trend at various angles to strike of the sand isoliths. Aggregate thickness of sand in the facies ranges from 600 to 1,100 feet. Individual sand units, comprising numerous superposed and multilateral channel deposits, are up to 30 miles wide. Areas along strike between the more extensive sand units are made up of greater amounts of overbank mud deposits. Sands of the facies have a mean average about 0.22 mm and are much coarser than sands in upslope fluvial facies. Sand channel deposits that make up the multilateral sand bodies cut down and laterally into underlying and adjacent channel sands. Channels are broadly convex downward and are characterized by a basal, locally conglomeratic, zone displaying festoon or trough cross-bedding representing channel lag deposition; this zone is overlain by a thin unit with tabular cross-beds, in turn overlain by a zone of wedge set cross-beds (epsilon bedding of Allen, 1963). The tabular and wedge cross-bedded sands probably represent lateral deposition as the toe and lower parts of point bars. The horizontally bedded and rippled zones, characteristic of the upper parts of many point bar deposits, are rarely preserved in this facies as the channel lag and lower point bar deposits are succeeded disconformably by channel deposits of a similar sequence. Within the preserved channel sequence only a slight degree of upward fining is shown. The relatively small amount of clay in this facies is highly kaolinitic. Lignite deposits, typically associated with channel deposits in upslope fluvial facies, are not preserved in the highly meandering channel facies. Lateral continuity and permeability of the sands make this facies a significant aquifer.

The highly meandering channel facies constitutes the most downslope facies of the Mt. Pleasant Fluvial System, grading down depositional slope or southeastward to the distributary channel-marsh-swamp facies of the Rockdale Delta System. It thus heads the delta system, extending in outcrop from central Bastrop northward to southern Freestone counties and in subsurface from central Bastrop northeastward to western Nacogdoches counties (Fig. 1). In central Bastrop and western Nacogdoches counties this facies changes abruptly to marine muds of the San Marcos Strandplain-Bay and Pendleton Lagoon-Bay Systems, respectively.

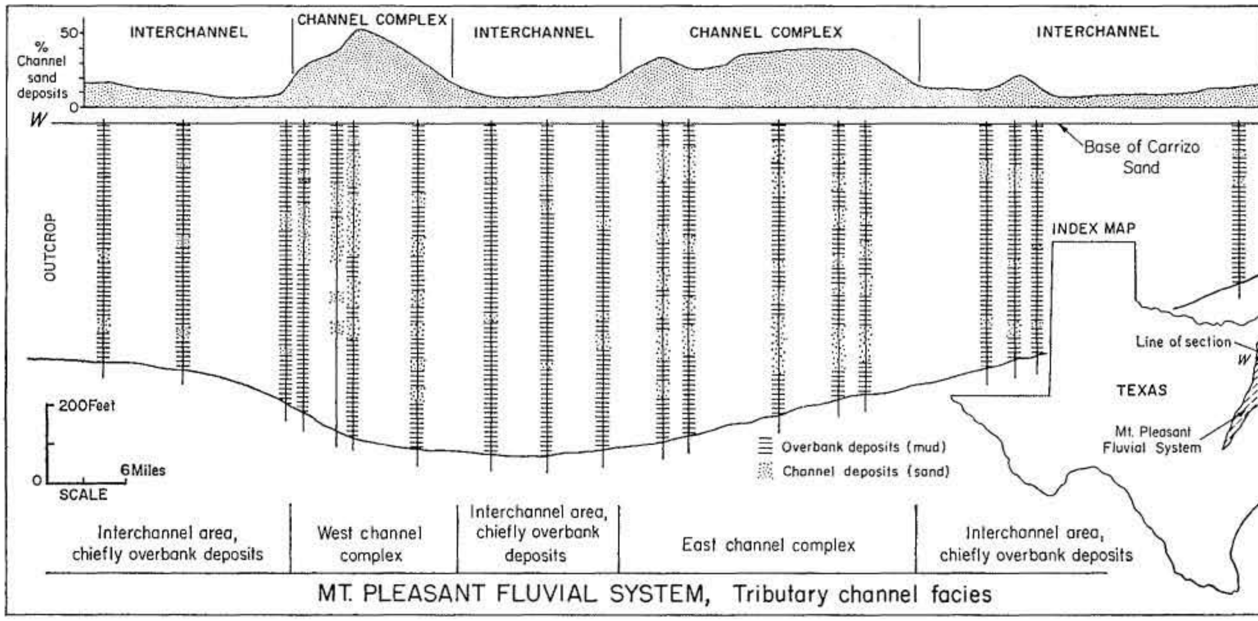


Figure 4. Diagrammatic stratigraphic strike section of Mt. Pleasant Fluvial System, Wilcox Group, Texas

Within narrow belts marking these transitions, fluvial sands of the facies, which were modified by marine processes, are very well sorted and fine grained and locally redeposited as local beach, barrier bar, and strandplain deposits.

Multistory sand bodies

A characteristic feature of sand bodies in the fluvial facies containing relatively high proportions of overbank muds (tributary channel and slightly meandering channel facies) is vertical persistence or stacking (Fig. 4). Successive sand bodies are roughly superposed with complementary interchannel areas void of significant channel deposits. This feature, termed multistorying by Feofilova (1954) has been noted in several facies containing channel sand deposits (e. g., Mueller and Wanless, 1957; Friedman, 1960; Potter, 1963; Brown et al., 1967). Some variation in degree of stacking occurs, but vertical persistence is sufficient to show a fluvial drainage pattern exhibited by composite sequences similar to patterns of individual sand bodies. Controlling factors involved in multistorying are not well known; occurrence in relatively high mud facies suggests a possible control by differential compaction, though regional structure is, in at least some cases, the more fundamental control (L. F. Brown, personal communication, 1967).

Rockdale Delta System

The Rockdale Delta System, following designation of Echols and Malkin (1948), is the dominant depositional system of the lower Wilcox Group in Texas, comprising areally about 60 percent and volumetrically about 80 percent of the known lower Wilcox (Fig. 1). It was the ultimate depositional site of most sediments transported through the fluvial system and the principal source of sediments redistributed and deposited in associated barrier bar, strandplain, bay-lagoon, and shelf systems.

The Rockdale Delta System occurs down structural dip of the fluvial system, with southern limit marked by a line extending from north-central Karnes northward to central Bastrop counties and an eastern limit by a line from central Nacogdoches through northern San Augustine and Sabine counties to the Sabine River; the downdip limit is beyond existing well control (Fig. 1). Maximum thicknesses of 3,500 to 5,000 feet are along the central axis of the system situated chiefly along drainage of the modern Brazos River and roughly coincident with structural axis of the Houston Embayment. Laterally and along existing structural strike the delta system generally, but not uniformly, thins to about 1,500 feet in the southwestern part of the system and to about 1,000 feet in the eastern part.

Criteria for recognition of this part of the lower Wilcox Group as a delta system include: (1) composition and bounding relationships of component facies, (2) external geometry of skeletal sand facies, (3) position in relation to laterally associated depositional systems, and (4) contrasts in rates of deposition with thick, rapidly deposited terrigenous clastic sequences (constructional units) alternating with thin, slowly deposited, relatively persistent marine and marsh deposits (destructional units). Details of these criteria are discussed subsequently.

Principal facies

Four regional facies constitute the Rockdale Delta System. Down depositional slope and down structural dip of the highly meandering facies of the Mt. Pleasant Fluvial System, the lower Wilcox consists of an extensive facies of sand units alternating with mud and silt units with numerous beds of lignite (Fig. 3). Farther downdip this facies changes rather abruptly to thick, massive sands, which in turn grade down structural dip and along structural strike to thick, uniform mud sequences. The alternating sand and mud-lignite sequences are interpreted as distributary channel and interdistributary deposits accumulated on delta plains; the massive sand facies represents delta front deposits laid down chiefly as distributary mouth bars; the downdip thick mud sequence represents deposition as prodelta facies. Mud sequences along strike of the delta front sand facies are interpreted as interdelta facies.

(1) *Distributary channel-marsh-swamp facies.* The facies consisting of alternating sand and mud-silt-lignite units is an areally extensive facies of the Rockdale Delta System (Fig. 3). It contrasts markedly with the immediate upslope fluvial facies chiefly in terms of sand body geometry and relative proportion of channel and nonchannel deposits. The fluvial facies show crossbedding structures and textural features indicative of channel lag and lateral point bar deposition in highly meandering streams. The result is relatively persistent, uniform, multilateral sand units with very few nonchannel deposits preserved. These sands change down structural dip and down depositional slope to isolated, elongate, narrow sand bodies interspersed in nonchannel muds and associated with lignites, similar to the tributary channel and slightly meandering facies of the Mt. Pleasant Fluvial System. These facies differ significantly, however, in that the channels in the delta system are thicker, symmetrical in cross section, generally nonerosive at base, and show a distributary rather than a tributary pattern in plan. Symmetry in cross section, nonerosive bases, and thickness suggest accumulation of these sands as bedload deposits in relatively straight, stabilized streams in which accumulation by downward accretion was afforded principally by compactional subsidence of the channel sands in a framework of interchannel muds. Such features characterize certain modern delta plain distributary channels and contrast with the lateral deposition in point bars of meandering, highly sinuous streams. Muds and silts, making up about 60 percent of this facies, apparently accumulated as subaerial levee, crevasse splay, lacustrine, and flood basin interdistributary deposits.

Two kinds of lignites occur within the distributary channel-marsh facies, both distinct from the elongate lignite deposits of the fluvial system. One type, which is tabular in shape but only local in extent, probably represents peat accumulation in local interdistributary depressions similar to origin of interdistributary peat in the Mississippi Delta System as discussed by Fisk (1960). A second type is also tabular in shape but much more areally extensive; this type probably developed as a regional, landward facies of marine, delta destruction. Further distinctions between fluvial and delta plain lignites are made on basis of grade and composition. Fluvial lignites are more variable in composition than delta lignites and contain high percentages of woody materials consistent with a swamp origin. Delta lignites are slightly higher in grade and contain relatively low percentages of woody material, suggesting organic production by marshes. Regional variations in Wilcox lignites (Fisher, 1963) reflect differences in depositional origin. More detailed distinctions of delta lignites or coals could probably be made in terms of origin as fresh-water, brackish, or saline marsh accumulations.

(2) *Delta front facies.* Downdip the distributary channel-marsh-swamp facies changes abruptly to a thick sand facies in which lignites are absent and mud content is low (Fig. 3). These sands are mostly fine grained, generally much better sorted than fluvial and distributary channel sands. Commonly, they show thin, multidirectional, ripple cross laminae and other current features. Plant and detrital lignite fragments occur locally. Individual sand units are generally 200 or more feet thick; in plan, external geometry is lobate or lunate. They are interpreted as distributary mouth bars representing delta front deposition. The high percentage of sand in this facies resulted from deposition of bedload of delta plain distributary channels debouching into relatively quiet marine-water reservoirs; the muds were carried in suspension farther seaward, accumulating as prodelta deposits. Relative cleanness, good sorting, and multidirectional current features indicate winnowing and reworking of sands in this environment by both channel and open-water currents under shoal conditions existing in the delta front environment. Redistribution of delta front sands and lateral coalescing of constructive delta front deposits result in a more or less continuous, arcuate delta front sand facies for most of the Rockdale deltas.

(3) *Prodelta facies.* The farthest downdip sections of lower Wilcox penetrated by wells generally consist of relatively uniform, thick sequences of dark muds (Fig. 3). These contain moderately large amounts of very finely comminuted and disseminated organic matter, show laminations marked commonly by slight textural and color variations, and have a marine fauna exceedingly low in numbers and species diversity. This mud facies interfingers with and grades updip to the delta front sand facies and represents deposition from suspension seaward from the delta front and river mouth as prodelta facies. Thickness and downdip extent of the facies are difficult to determine, primarily because few wells have penetrated significant thickness of the lower Wilcox in these downdip areas. However, the few deep wells drilled indicate that the facies is very thick and probably the thickest facies of the delta system; approximately 4,000 to 5,000 feet have been recorded in some deep wells.

(4) *Interdelta, subembayment facies.* Sequences encountered in areas between principal delta lobes are similar in some respects to the prodelta facies (Fig. 1). They consist principally of mud, much of which is laminated as in the prodelta facies. The interdelta facies is thinner than the prodelta facies and in addition contains several thin, burrowed mud units or thin units of fossiliferous silts and very fine-grained sands, commonly containing small amounts of glauconite. These thin units accumulated more slowly than the laminated muds and in areas not directly affected by deltation. The interdelta facies grades directly up structural dip to marsh facies of the delta plain and does not grade through the delta front sand facies.

Delta destructive units

Delineation of a thick terrigenous clastic sequence such as the Rockdale Delta System into component and individual deltas is a time-consuming task. Basically, it involves recognition and correlation of thin marine units formed in the process of marine destruction of the constructive delta mass. During periods of high sediment influx, the above described tract of delta facies (distributary channel-marsh-swamp, delta front, prodelta) is established, and with progradation and basin and compactional subsidence, a thick terrigenous sequence accumulates. With cessation of sediment influx through either a diminished source area or more commonly with upstream avulsion resulting in abandonment of the previous drainage system and establishment of a new network, compaction of the water-saturated sediments of the constructed delta mass exceeds the rate of deposition. At this point the delta lobe, or at least marginal portions of it, is subjected to marine encroachment, involving reworking or destruction of the constructive delta surface. Rate of sedimentation during destruction is very low, primarily involving marine reworking of underlying delta sediments; as a consequence, units are relatively very thin. In the Rockdale Delta System, marine destructive units consist of very well-sorted, fine-grained, slightly glauconitic, commonly bioturbated sand, shell detritus, and muds either burrowed or containing a marine fauna. These units were deposited chiefly only on the lower parts of the abandoned delta plain. Landward destruction of the abandoned delta plain involved extensive marsh growth, coincident with compactional subsidence, resulting in laterally extensive lignite deposits. These lignites contrast with the thinner, local lignites which formed as interdistributary peats. The marine destructive units apparently represented deposition in environments comparable to delta destruction environments in the modern Mississippi System, with marine sands originating under conditions similar to those of the Chandeleur Islands and the burrowed or fossiliferous muds as open bay deposits similar to those of Breton Sound.

Following recognition of delta destruction units and their facies relationships in delta systems, those of maximum areal extent are studied in detail; areal extent of these thin units can be determined only by careful correlation of closely spaced wells over a wide area. By this means the delta system is subdivided and smaller delta units mapped. Determination of sand content of such subdivisions permits isolith mapping of skeletal elements of the delta (distributary channel and delta front facies) and along with mapping of component facies allows delineation of specific delta lobes. Most delta destructive units are restricted areally to a specific, underlying, constructive delta lobe. However, as delta construction is a relatively rapid process and delta destruction a slow process, destruction of one delta lobe may persist during the construction, subsidence, and subsequent initiation of destruction of an adjacent lobe so that destructional units of two or more lobes may be in part contemporaneous. Recognition of widespread destructive units permits larger scale, though only approximate, subdivision of delta systems.

Individual deltas in Rockdale Delta System

To date we have mapped and delineated 16 principal deltas within the lower Wilcox Rockdale Delta System (Fig. 5). These exhibit the component facies and facies pattern as described above. Striking, and significant in another context considered later, is the vertical stacking of individual deltas and the persistence of interdelta subembayments within the delta system. Further, the Rockdale deltas show a marked coincidence with modern coastal plain streams (Fig. 5).

Through mapping of several delta destructional units we have been able to delineate three main phases of deltation in the Rockdale System, in addition to outlining principal individual deltas. The initial phase of deltation resulted in three relatively small deltas situated roughly along drainage of the modern Colorado, Brazos, and Trinity Rivers (Fig. 5). These range in area from 200 to 350 square miles with thicknesses on the order of 300 to 500 feet. A second or intermediate period of delta building resulted in the largest, thickest, and most prograded deltas of the system. The larger deltas of this phase, up to 2,000 square miles in area, were constructed along the axes of the modern Guadalupe, Colorado, and Brazos Rivers; the smaller deltas, 500 to 700 square miles in area, developed along the axes of the modern Sabine and Neches Rivers. The Brazos and Colorado deltas (Fig. 5) are the thickest, with maximum thickness of 1,500 feet, exclusive of the prodelta facies. A terminal phase of deltation involved delta construction in all areas of intermediate phase deltation as well as construction of a large delta situated primarily in Angelina, Houston, and Trinity counties (Angelina Delta). These terminal deltas are comparable in size and thickness to the underlying, intermediate phase deltas but do not extend as far down structural dip.

Although individual deltas within the Rockdale System vary in size and sediment volume, a more significant variation occurs in shape of the delta lobes (Fig. 6). One type, shown by the intermediate phase delta constructed in the area of the Trinity River, the four intermediate and terminal deltas constructed in the area of the Neches and Sabine Rivers, and to some extent the three initial phase deltas, has an elongate, narrow shape resembling outline of the modern birdfoot delta and certain of the initial deltas of older delta complexes as delineated by Frazier (1967) in the Mississippi Delta System. The other type, shown by the other presently mapped deltas of the Rockdale System, is more or less lobate or rounded in shape, similar to premodern, presently abandoned deltas of the Mississippi System. If a delta line is drawn in the same manner in which bayline maps are commonly made (Lowman, 1949), the elongate, narrow birdfoot deltas of the Trinity, Neches, and Sabine Rivers extend considerably beyond the line, suggesting progradation into deeper waters, as is the case with the modern, deep-water birdfoot delta of the Mississippi System (Fig. 6). These Rockdale deltas are associated

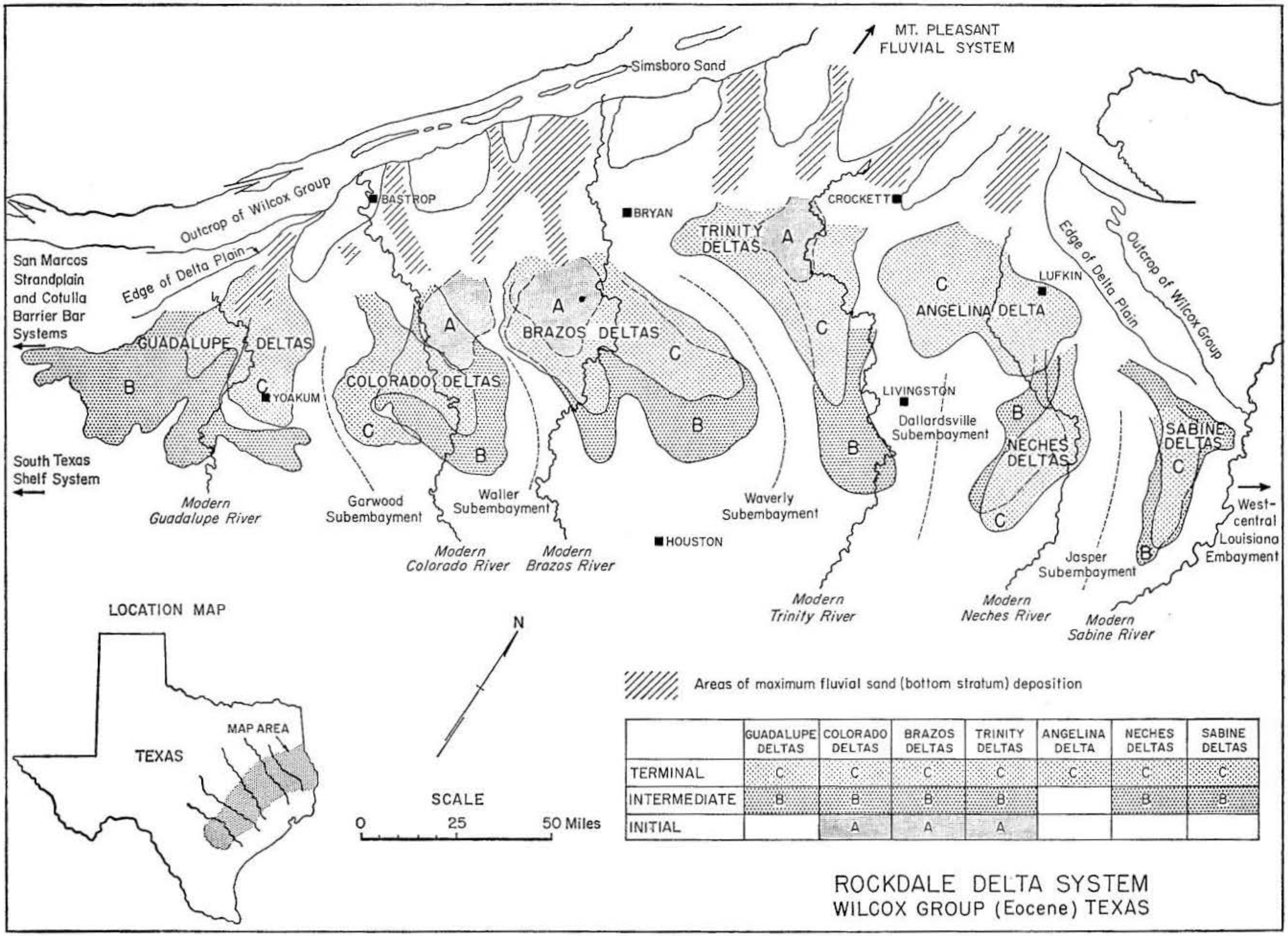


Figure 5. Distribution of principal deltas, Rockdale Delta System, Wilcox Group, Texas; lobal outline drawn at distal margin of delta front facies (For well control, see Fig. 1)

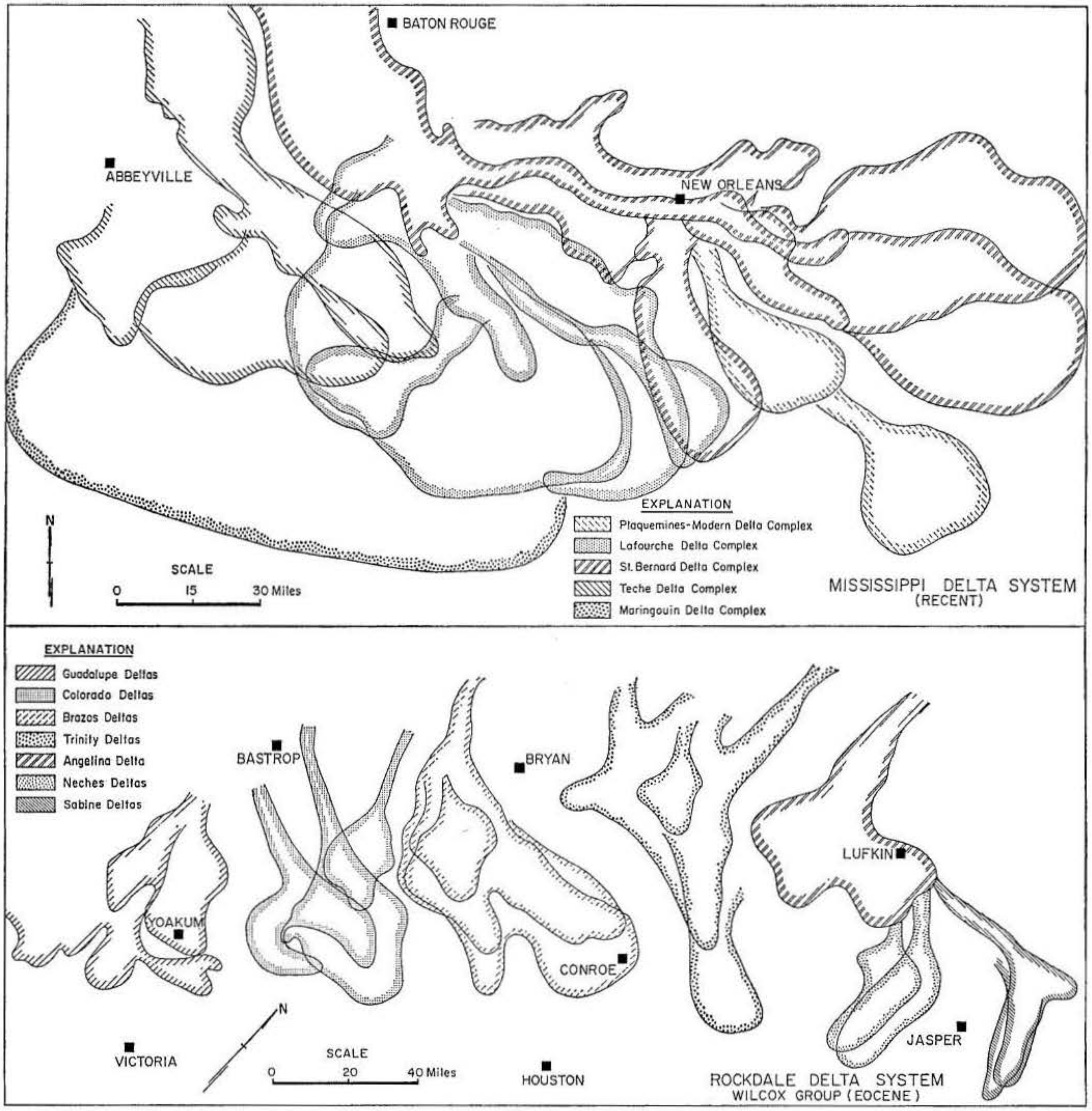


Figure 6. Comparison of size, distribution, and arrangement of principal delta lobes of the Mississippi Delta System (Recent, southeastern Louisiana) (modified from Frazier, 1967) and Rockdale Delta System, Wilcox Group (Eocene, Texas)

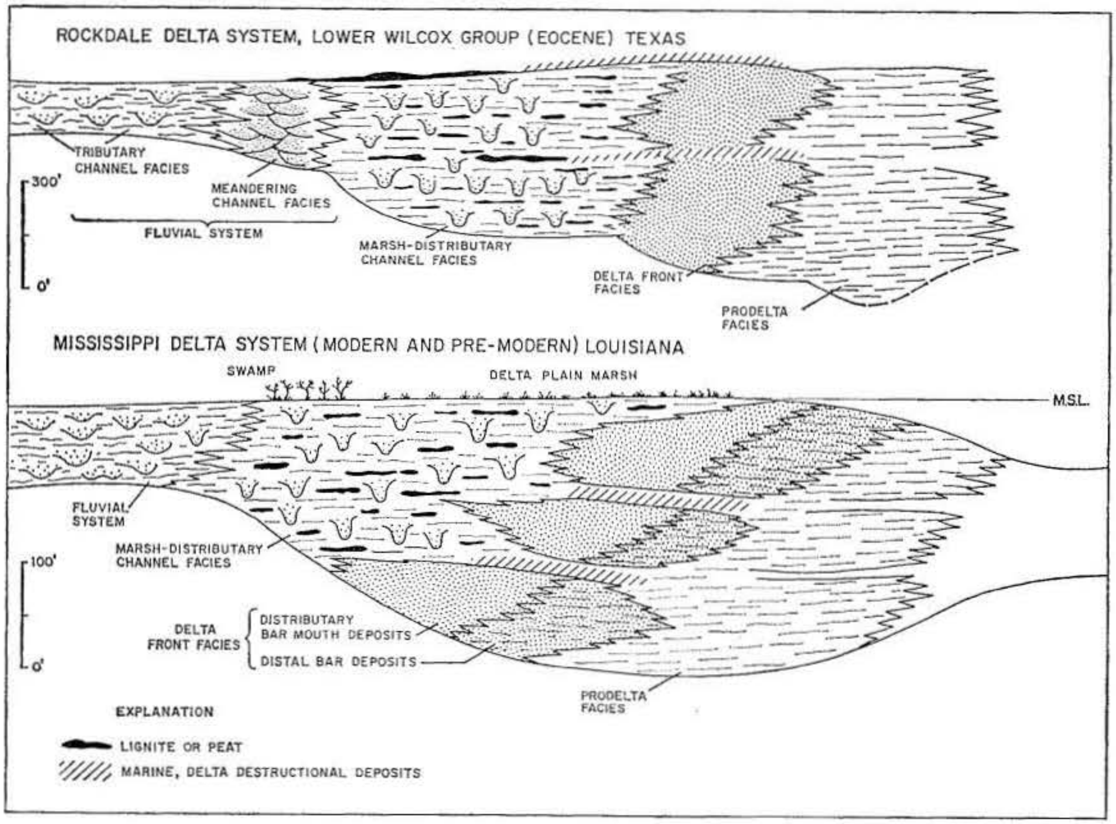


Figure 7. Comparison of component facies of Mississippi Delta System (modified from partly hypothetical cross section in Coleman and Gagliano, 1964) and Rockdale Delta System, Wilcox Group Texas

with a sequence relatively high in mud, strenghtening the analogy with the sand-poor, deep-water birdfoot delta of the Mississippi. The initial phase deltas similarly represent progradation over underlying thick muds. By contrast, the lobate or rounded deltas of the Rockdale System consist of relatively large proportions of sand, suggesting construction as shoal-water deltas analogous to the sand-rich lobate, shoal-water deltas of the modern Rhone (Kruit, 1955) and premodern Mississippi (Fisk, 1955, 1961).

Vertical stacking or approximate superposition of individual deltas within the system, persistence of interdelta subembayments, and coincidence of Rockdale deltas and modern drainage have been mentioned. The controlling factor or factors, like those of the multistoried channel sands in upslope fluvial facies of the Mt. Pleasant System, are not fully understood. Such features are apparently common in fluvial systems containing relatively high percentage of muds and may be common in delta systems as well, though few ancient delta systems have been mapped and studied. Maps of delta systems in the Pennsylvanian of the Eastern Interior Basin (Wanless et al., 1963) and the modern and premodern deltas of the Mississippi System (Kolb and van Lopik, 1966; Frazier, 1957) (Fig. 6) indicate some degree of vertical stacking, though perhaps not as pronounced as in the Rockdale Delta System. Significant in this regard is not only the approximate coincidence of Rockdale deltas and modern coastal plain drainage, but also the coincidence of other Eocene delta systems (Yegua and Fayette) and Pleistocene delta systems along these axes. Certainly, compactional subsidence is a possible factor, though the more important control probably is tectonic. Structural control is indicated by the occurrence of growth fault zones coincident with the thicker facies of the Rockdale Delta System (Fig. 3).

Comparison with Mississippi Delta System

Certain similarities between the Eocene Rockdale and the Recent Mississippi Delta Systems, both built into the Gulf Coast Basin, have been noted. These include similarities in shape, occurrence, and position of shoal-water, lobate deltas and deep-water, birdfoot deltas, and in vertical stacking of individual deltas. The two systems are comparable in area (Fig. 6). A most significant similarity of the two systems is the distribution of component facies (Fig. 7), in which the high sand delta front facies is bounded up-delta or landward by a relatively high mud and organic facies (distributary channel and marsh-swamp facies) and off-delta or seaward by a high mud facies (prodelta facies). Significance of such bounding facies in delta sequences was emphasized by Coleman and Gagliano (1964); we judge delineation of such bounding facies along with determination of external geometry of the skeletal elements (distributary channel and delta front sands) and delineation of delta destructive units as the best regional criteria for recognition of ancient deltas or delta systems.

Pendleton Lagoon-Bay System

Marginal to the Rockdale Delta System and along the southern part of the Sabine Uplift (chiefly Shelby and northern parts of San Augustine and Sabine counties), the Wilcox Group is predominantly a mud facies. This facies includes parts or all of several formally defined stratigraphic units (Pendleton, Marthaville, Hall Summit, Lime Hill, Converse, Cow Bayou, Dolet Hills, and Naborton Formations); it occurs partly in outcrop and partly in subsurface. The facies is designated informally as the Pendleton Lagoon-Bay System (Fig. 1); it is approximately 1,000 feet thick in Texas, comparable in thickness to fluvial facies along strike but thicker than updip fluvial facies and thinner than downdip delta facies. The Pendleton System consists chiefly of laminated to locally bioturbated muds with local lenses and beds of very fine to fine-grained, sparingly glauconitic, massive to cross-bedded sands and fine-grained, broken, massive to cross-bedded, lignitic sands. Certain of the muds are gypsiferous; clay-ironstone concretions are common. Lignites are locally common, though they are relatively impure, thin, and discontinuous. The system contains a few more or less discrete units with marine fossils. Faunal composition is chiefly molluscan, with a few foraminifers and ostracodes; fossil occurrence is mostly in the sparingly glauconitic units. Species diversity is moderate to low but not so low as to suggest highly abnormal salinities, at least for fossiliferous units. Mollusks comprise largely a bank and mud infauna characterized by several thick-shelled forms. The fauna of the Pendleton System has been described by Barry and LeBlanc (1942).

The Pendleton System is underlain by marine clays of the Midway Group (Porters Creek Formation) and overlain by sands of the Carrizo Formation. A large part of the facies is contemporaneous with delta facies (Sabine deltas of the Rockdale System) to the west and south, though the upper part of the system is contemporaneous with other Wilcox depositional systems not considered here. To the west and north the Pendleton System grades to the various fluvial facies of the Mt. Pleasant System; it extends east into Louisiana but its extent in that direction has not been determined.

The lithologic and biologic composition of the Pendleton System and its situation marginal to the Rockdale Delta System suggest deposition in low-energy lagoons, bays, and mudflats marginal to the delta system, comparable to marginal environments of the Mississippi Delta System. Deposition was chiefly marine under conditions of varying degrees of restricted to open circulation; the system opened seaward primarily to the southeast with greater brackish and freshwater influence to the west and north where the system grades to fluvial facies.

San Marcos Strandplain-Bay System

In outcrop south of the Colorado River, the highly meandering channel sand facies of the Mt. Pleasant System changes abruptly to a facies primarily of muds which locally contain marine fossils (Fig. 1). This facies persists in outcrop through southern Bastrop, Caldwell, Guadalupe, and northern Wilson counties and extends a short distance downdip into the subsurface; it includes the Hilbig facies of Claypool (1933). The faunal and lithologic composition of the facies is very similar to that of the Pendleton System. A similar origin is suggested, with deposition in embayments and on mudflats along the opposite margins of downslope fluvial facies of the Mt. Pleasant System and delta facies of the Rockdale System. In outcrop, muds of this facies are continuous below the downslope facies of the Mt. Pleasant System (highly meandering channel facies or Simsboro Sand) northward to about midway between the Brazos and Trinity Rivers, where the muds grade to fluvial and delta facies of earliest Rockdale deltation (initial phase, Fig. 5). The northern extent of this mud facies includes at least parts of units formally designated the Hooper and Seguin Formations. Southwestward displacement of the facies is contemporaneous with subsequent large scale deltation in the lower Wilcox Rockdale System (intermediate and terminal phases, Fig. 5).

Downdip and marginal to the shoal-water deltas of the southwestern part of the Rockdale System (Guadalupe deltas) muds grade to a facies consisting of interbedded sands and muds. Sands are generally fine grained, well sorted, at least sparingly glauconitic, and commonly contain a few detrital shell fragments. They occur as elogate bodies parallel to depositional strike to chiefly tabular or sheet sands. Individual sand and mud units are approximately 50 feet thick. Muds are similar to those of the updip mud facies but commonly pyritic and slightly gypsiferous. Carbonaceous materials are locally present as thin lignitic stringers. This interbedded sand and mud facies is approximately 1,200 feet thick, occurring chiefly in southwestern Gonzales, Wilson, southwestern Karnes, and eastern Atascosa counties. Composition of the facies and its position marginal to shoal-water deltas of the Rockdale System suggest an origin analogous to the Recent chenier system of southwestern Louisiana. Muds accumulated in low energy environments ranging from mudflat to open bay, contemporaneous with periods of active deltation. During marine destruction of the adjacent sand-rich, shoal-water deltas, sands were redistributed laterally by prevailingly southwestward longshore currents with deposition of the elongate to sheet sands in a strandplain marginal to the delta system. Transgression and regression of relatively thin marine units in this facies were thus related to periods of active deltation and delta destruction. Such subsurface sands as the Poth and Bartosch are typical of this facies. In reference to their origin and area of principal occurrence, the updip mud and downdip sand-mud facies developed along the southwestern margin of the Rockdale Delta System are designated the San Marcos Strandplain-Bay System.

Cotulla Barrier Bar and Indio Bay-Lagoon Systems

Southwestward along depositional strike, sheet and elongate sand bodies of the San Marcos System grade to facies of elongate sand bodies arranged parallel to depositional strike. Sands are generally fine grained, very well sorted and locally glauconitic; internal structures are not known, due to lack of cores. Thickness of individual sand units ranges upward to 100 feet, with aggregate sand thickness of 400 to 1,000 feet for the facies. Sand isoliths show an extensive elongate sand unit oriented parallel to depositional strike. This belt of sand trends northeast-southwest and occurs in western Atascosa, southern Frio, northwestern LaSalle, southeastern Dimmit, and northwestern Webb counties (Fig. 8). Updip from this sand belt, occurring in southern Bexar, northern Atascosa, northern Frio, Zavala, western Dimmit, and northwestern Webb counties and extending to the outcrop, is a predominantly mud facies including most of the Indio Formation of formal stratigraphic definition (Fig. 8). The facies is characterized by thin-bedded, laminated to locally burrowed muds, large calcareous cemented fine-grained sand concretions, and a few beds or lenses of sand and massive clay. Muds are mostly gray to buff, gypsiferous to calcareous, and locally pyritic. Lignites in this facies are impure and discontinuous, contrasting significantly with lignites of the fluvial and delta systems. Sands are of various textures, though chiefly fine grained; they are massive or flaggy but not notably cross-bedded; ripple marks are common in the flaggy beds. Chief cement is siliceous, but it is locally calcareous or ferruginous associated with small ironstone concretions. Certain of the sands are very slightly glauconitic. Marine fossils are common in this facies, and like other lower Wilcox facies containing marine fossils, composition is chiefly molluscan; species diversity is low to moderate. Thick-shelled mollusks are most common. A few thin units contain significant numbers of foraminifers, mostly textulariids and globiginerids. Shark teeth and fish scales occur locally. Some clay units locally contain fossil plants.

The lower Wilcox sand and mud facies of South Texas described above are judged to have originated as extensive barrier bar and complementary lagoon-bay systems and are here designated, respectively, the Cotulla Barrier Bar System and the Indio Bay-Lagoon System. Source of sand deposited as the barrier bar system was from shoal-water deltas of the Rockdale System situated to the northeast; sands were transported laterally by prevailingly southwestward longshore currents. In the San Marcos Strandplain System, situated intermediate to the delta and barrier bar systems, the adjacent delta system served not only as a source of sands but also, through periods of active and inactive deltation, as a control for the distribution of the sheet sands. Accumulation of sand in the barrier bar system was sufficiently distant from the delta system for it to have had any direct control on sand distribution. The principal distinction in sand accumulation in these two systems is chiefly sheet or tabular sand units in the San Marcos System and elongate sands in the Cotulla System. Similar patterns in sand dispersal are shown in the modern and premodern marginal marine sand systems southwest of the Mississippi Delta System. In addition, accumulation of sands in relatively narrow elongate belts in the barrier bar system, as opposed to sheet sand accumulation in the strandplain system, facilitated development of extensive, landward mud facies — the Indio Bay-Lagoon System. Development of a distinctive lagoon-bay system is thus a complement of the barrier bar system.

Other features substantiate interpretation of these South Texas, lower Wilcox facies as barrier bar and bay-lagoon systems. First, sand isolith patterns depicting the lagoonal side of the barrier bar system are generally more irregular than those of the seaward side; further, the transition from sand to mud is more abrupt on the lagoonal than on the seaward side. Such features are typical of modern barrier bar systems. Secondly, in southeastern Frio and northeastern LaSalle counties, sand isoliths of the Cotulla Barrier Bar System are sharply indented on the lagoonal side; a less pronounced indentation occurs on the opposite or seaward side. Position and configuration of these indentations suggest former existence of tidal channel, a feature common to modern barrier bars. Under such conditions flood and ebb tidal surges move through a channel or inlet in the bar, accreting sand in the form of tidal deltas both within the lagoon and onto the foreshore of the bar. Presence of anomalous thickness of sand in the Indio Lagoonal-Bay System updip of the terminus of the inferred tidal channel (in northeastern Frio and southeastern Medina counties and extending into outcrop) probably represents accumulation as a lagoonal tidal delta (Fig. 8). Lobate extension of sand on the foreshore side of the bar and immediately south of the inferred tidal channel (east-central La Salle County) probably represents a delta constructed by ebb tide transport of sand through the tidal channel. Assuming origin of the above described features as a tidal channel and complementary tidal deltas, the position of the deltas in respect to the channel as well as the shape and configuration of the tidal channel substantiate the inference of a prevailing southwestward transport of sediment by means of longshore currents. Thirdly, lobate lagoonward extensions of sands in northeastern and north-central Dimmit County (Fig. 8), without associated isolith indentations indicative of tidal channels, possibly represent deposition as washover fans, with sand carried into the lagoon by storm surges. This feature is also common to modern barrier bars (Andrews, 1966).

South Texas Shelf System

Downdip and seaward of the Cotulla Barrier Bar System a predominantly mud system characterizes the lower Wilcox of South Texas. This system extends over an area of about 3,000 square miles in southwestern Karnes, northern Goliad, northern Bee, north Live Oak, McMullen, northwestern Duval, Webb, Zapata, and western Starr counties (Fig. 1). It is relatively uniform in thickness throughout much of its extent, ranging from about 1,000 to 1,500 feet, but it thickens northeastward toward the Rockdale Delta System and southward along the Rio Grande. Principal lithologic component is mud; aggregate thickness of sand in the system is generally less than 200 feet (Fig. 1). Individual sand units vary in number, commonly 8 to 10, and in thickness, generally 10 to a maximum of about 100 feet; average thickness of sand units is about 30 feet. Muds are variable in composition, though generally light to moderate gray to olive or

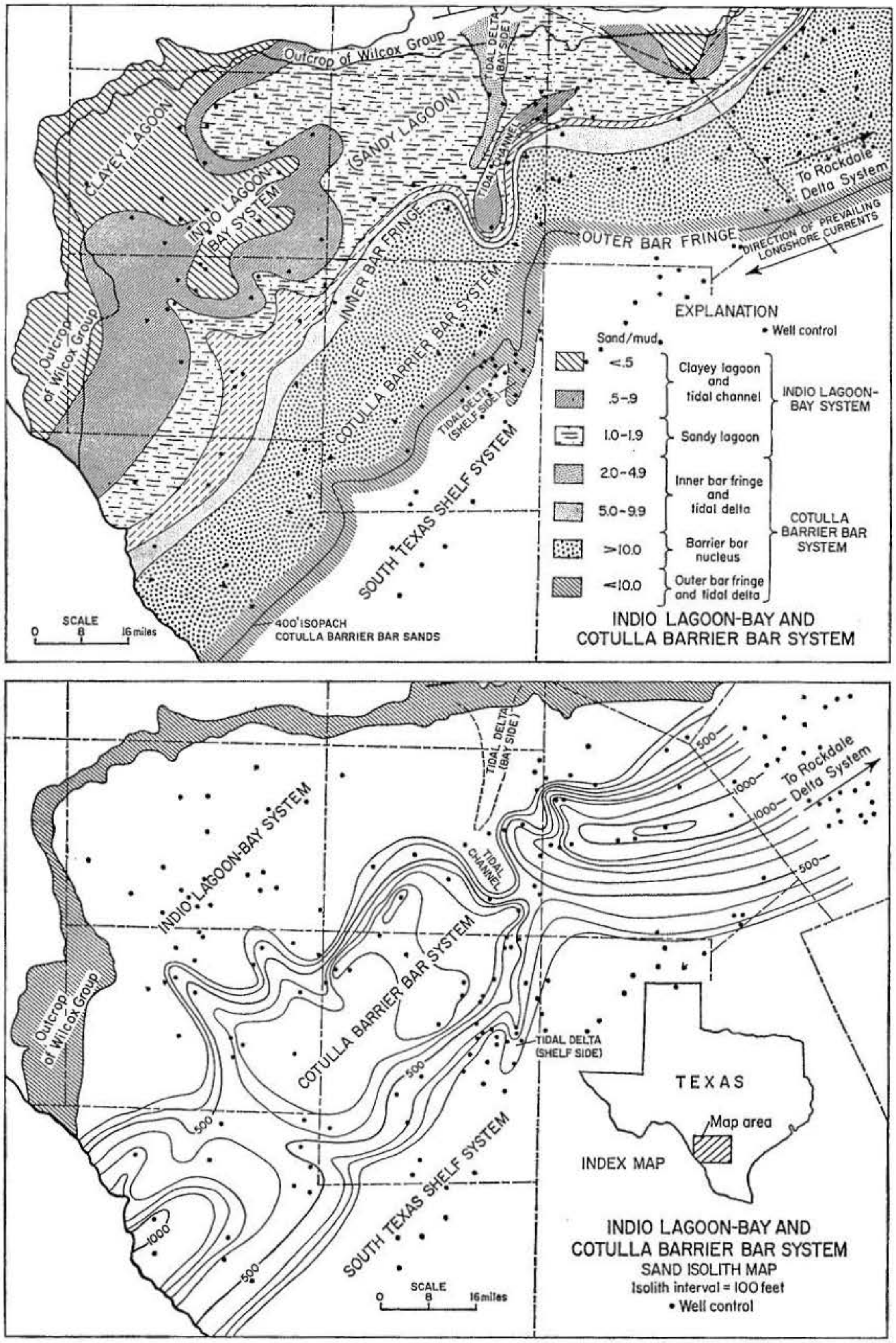


Figure 8. Sand/mud ratio map and sand isolith map of Cotulla Barrier Bar System and Indio Bay-Lagoon System, Wilcox Group, Texas

buff, and laminated to extensively burrowed; marine fossils and glauconite pellets are common. Muds are commonly calcareous, though a few are pyritic or carbonaceous. The sands are very fine to fine grained, well sorted to muddy, slightly glauconitic, and commonly contain detrital shell fragments. Faunal diversity is moderate; composition is chiefly molluscan, but thick-shelled forms are not predominant as in other lower Wilcox marine facies; foraminifers are common and a few echinoderms are present.

Relative uniformity of this system, its predominantly mud composition, its marine fauna, and its position relative to other depositional systems suggest deposition on an extensive, shallow-water continental shelf; the system is here designated the South Texas Shelf System. Part of the Falls City Formation, as proposed and described by Hargis (1962), is included in this system.

Origin of the relatively thin sand units in the South Texas Shelf System is not clear. External geometry of the sand units is not well known, but existing control suggests both laterally persistent sheet sands, more numerous updip toward the Cotulla Barrier Bar System, and elongate, northeast-southwest-trending sand bodies. Source of sands was probably the Rockdale Delta System to the northeast like that of updip sand systems, but mode of transport and dispersal of the sands is unknown. Relatively sharp indentations in sand isoliths of the southwestern lobes of the Guadalupe deltas of the Rockdale Delta System (Fig. 1) suggest possible submarine channeling of the deltas during periods of delta destruction with possible dispersal of sands across the shelf by southward-flowing turbidity currents. (Submarine channeling in the Wilcox as reported by Hoyt (1959) is associated with an upper Wilcox system.) Another explanation of these sands, and one we judge more probable, is accumulation as barrier bars during periods of initial marine destruction of more gulfward-projecting delta lobes. The origin thus is similar to origin of the Cotulla Barrier Bar System but with only minor accumulation downdip and principal accumulation updip in the Cotulla System. Sheet sands of the shelf system possibly are related to marine transgression associated with periods of delta destruction; shelf edge, marine reworking of certain shelf sands was likely. Extensive mud deposition in this system was probably contemporaneous with periods of active deltation in the Rockdale Delta System, though muds of the two systems are compositionally distinct; amount of mud deposition on the shelf is small in relation to amount of contemporaneous prodelta mud deposition.

SAND DISPERSAL PATTERNS

The dispersal pattern of coarser fraction sediments (generally sand) in a terrigenous clastic system provides significant clues to the origin of specific facies and also provides a basis for the integration of various facies and systems. Transport, dispersal, and deposition of the coarser fraction sediments normally involve higher energy elements within a system, so that geometry of sand bodies effectively outlines skeletal units of the system. Within the various depositional systems of the lower Wilcox, several modes of sand transport and deposition occur, each resulting in sand units with distinct geometries, structures, and textures (Fig. 9). Principally, the pattern involves dispersal through several fluvial facies in which only a relatively small part of the sand was permanently stored or preserved, through separate delta facies in which bulk of deposition represented permanent storage. Marine redistribution of a relatively small part of the sand deposited in the delta front facies, chiefly of shoal-water deltas, resulted in accumulation of sand in marginal strandplain, barrier bar, and shelf systems (Fig. 9). Sand bodies of the fluvial system and distributary channel sand bodies of the delta system regionally trend normal to depositional strike; sand bodies of the delta front facies of the delta system and those in the shelf system trend roughly parallel to depositional strike; those of the barrier bar and strandplain systems closely parallel depositional strike.

The most upslope, preserved element of the lower Wilcox sand dispersal pattern consists of elongate channel sands with dendritic, tributary distribution; ratio of nonchannel or overbank muds to channel sands is high. Down depositional slope, ratio of nonchannel muds to sands decreases and individual sand bodies increase in width, a result of deposition by increasingly meandering streams. A zone of highly meandering stream deposition as judged from the dominance of point bar structures, resulted in a fluvial facies made up chiefly of extensive, multilateral sand bodies with very little associated nonchannel muds. Immediate upslope bounding of this facies by a fault system (present day Mt. Enterprise-Elkhart system) or threshold (Tyler Basin threshold) known to influence deposition in several other Cenozoic and Mesozoic units, suggests a possible fall line or at least a local gradient change that resulted in sand deposition. Once such a zone was established, weak bank conditions of streams traversing it would contribute to a high degree of meandering or lateral shifting. A similar high sand fluvial facies in sand dispersal patterns of Upper Pennsylvanian units in the Eastern Interior Basin is reported by Potter (1963).

The next downslope element in the sand dispersal pattern is elongate sand bodies showing a distributive network; these are associated with relatively large amounts of nonchannel muds (Fig. 9). Channel sand accumulation was chiefly by downward accretion through compaction, as indicated by the generally nonerosive bases of the distributary channels and compactional features of underlying muds.

Principal deposition of sand in the delta system occurs in the delta front facies, built up of distributary mouth bars. Where delta front sands are built as elongate, narrow sand facies (bar finger sands of Fisk, 1961) in relatively high mud frameworks and under deeper water conditions (birdfoot deltas), sand storage is chiefly permanent. Such is apparently the case of the elongate delta fronts of deltas characteristic in the eastern part of the Rockdale System where the delta fronts are not associated with marginal barrier bar

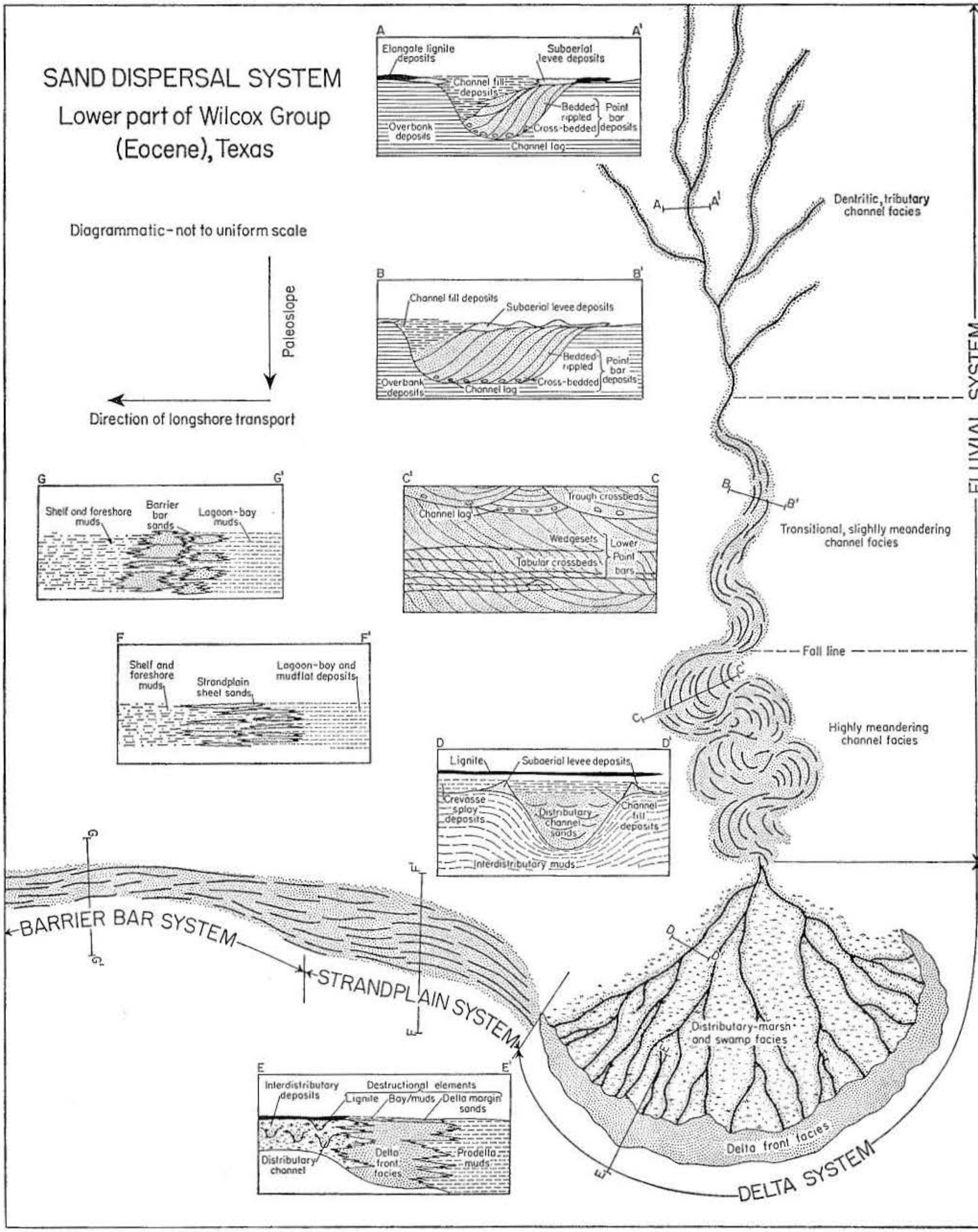


Figure 9. Idealized sand dispersal system in various depositional systems, Wilcox Group, Texas

and strandplain sands. Where the delta front is constructed as a lobate to rounded facies of sand-rich, shoal-water deltas (typical of deltas in the southwestern part of the Rockdale System), part of the sand may be redistributed laterally by marine destruction of the deltas and transported by longshore currents. In such situations two main types of sand bodies accumulated, though both have a common source. Adjacent to the delta system, accumulation generally occurred as relatively thin, areally persistent sheet sands, making up a strandplain system. Down longshore current and more distally from the delta system, sand accumulated as more narrowly restricted, elongate barrier bars with complementary development of a landward, distinct, lagoon-bay system.

A final pattern of sand dispersal, not shown on Figure 9 but possibly occurring as a part of lower Wilcox depositional systems, is transport and deposition by means of turbidity currents. Sharp indentations in sand isoliths of certain of the shoal-water deltas in the Rockdale System (Guadalupe and Colorado deltas) may reflect mud-filled, submarine canyons with cutting and subsequent filling associated with specific stages of delta construction and destruction. Such a feature has been documented in a higher Wilcox system (Hoyt, 1959) and submarine channeling is well known from several modern delta systems; similar features in lower Wilcox systems are probable. Under such conditions delta sands eroded during channeling would be carried down depositional slope by turbidity currents and deposited as fans at the first major flattening of the slope. Mode of dispersal visualized is similar to that outlined by Walker (1967) for near-source submarine fans associated with the Pennine delta in the Upper Carboniferous of northern England. Verification of such fans in the lower Wilcox awaits more extensive drilling of very deep downdip wells.

DEPOSITIONAL SYSTEMS AND BASIN TECTONICS

We have used the concept of depositional systems not only as an approach to interpreting certain rock units and facies of the Wilcox Group but also as a basis for establishing criteria for recognizing large scale, regionally developed depositional units. Many sedimentary basins, and notably the Gulf Coast Basin, contain very thick and large masses of terrigenous clastic rocks. Application of certain criteria for recognition of specific depositional environments and utilization of detailed depositional models are facilitated first by outlining major depositional systems involved in the basin fill.

The nature of a sedimentary basin, especially its structural or tectonic attitude, is critical to the concept of depositional systems in two ways: (1) volume of sediment or magnitude of sequences involved and (2) variation in distribution of component facies. First, in a relatively unstable basin where subsidence is generally a response to sediment load (as we judge the case of the Gulf Coast Basin during Wilcox deposition), sites of deposition of particular facies are maintained. Thus a barrier bar system, for example, can be constructed of several individual barrier bars with the main features and facies tract of the individual barrier bar preserved in the larger system. Essential difference in the two is size. The magnitude of the Cotulla Barrier Bar System here recognized in the lower Wilcox of South Texas is closely comparable to other barrier bar systems recognized elsewhere in the Gulf Coast Basin — Frio Barrier Bar System (Neogene) of South Texas (Boyd and Dyer, 1964) and Terryville Barrier Bar (Jurassic) of southern Arkansas and northern Louisiana (Thomas and Mann, 1966).

Secondly, the tectonic nature of the basin markedly influences the distribution of component facies within a depositional system, though composition and character of component facies of a given depositional system may be very similar in different structural basins. For example, delta systems developed in relatively stable basins such as the Pennsylvanian delta systems of the Eastern Interior Basin, commonly show extensive progradation; sections within such systems show a vertical succession of component facies with prodelta muds overlain by delta front sands, in turn succeeded by delta plain and fluvial facies. By contrast, delta systems in rapidly subsiding, unstable basins, such as the Gulf Coast Basin, commonly do not show pronounced vertical succession of facies but rather pronounced lateral facies that tend to persist vertically. Within any particular part of the delta system, therefore, a vertical sequence chiefly shows only a single component facies of the system.

OCCURRENCE OF OIL AND GAS

A well-established generalization in Gulf Coast geology is that occurrence of oil and gas is regionally controlled by depositional facies and locally entrapped by structures coincident with depositional facies containing optimum reservoirs. The environmental control of oil and gas occurrence in terrigenous clastic rocks has been emphasized particularly by Rainwater (1963). Distribution of depositional facies in the context of the regional deposition system of which they are a part explains control of known accumulations and provides a basis for outlining regional, potentially productive trends. In the lower Wilcox of the Texas Gulf Coast, five, possibly six, main oil and gas trends are defined in relation to depositional systems established herein (Fig. 10). These include: (1) delta trend (chiefly delta front constructional and marine destructional sands), (2) strandplain trend, (3) barrier bar trend (including tidal deltas), (4) shelf trend, (5) shelf-edge trend, and (6) a possible submarine fan trend not yet defined.

Oil and gas accumulation in the lower Wilcox from north-central Karnes County northeastward to the Sabine River is closely controlled by distribution of specific deltas of the Rockdale Delta System. Principal reservoirs are delta front sands and immediately associated marine reworked sands of delta destruction; existing fields are largely coincident with a relatively narrow belt determined by the more distal fringes of delta front sands (Fig. 10). Interfingering of delta front sands with adjacent marine prodelta muds provides

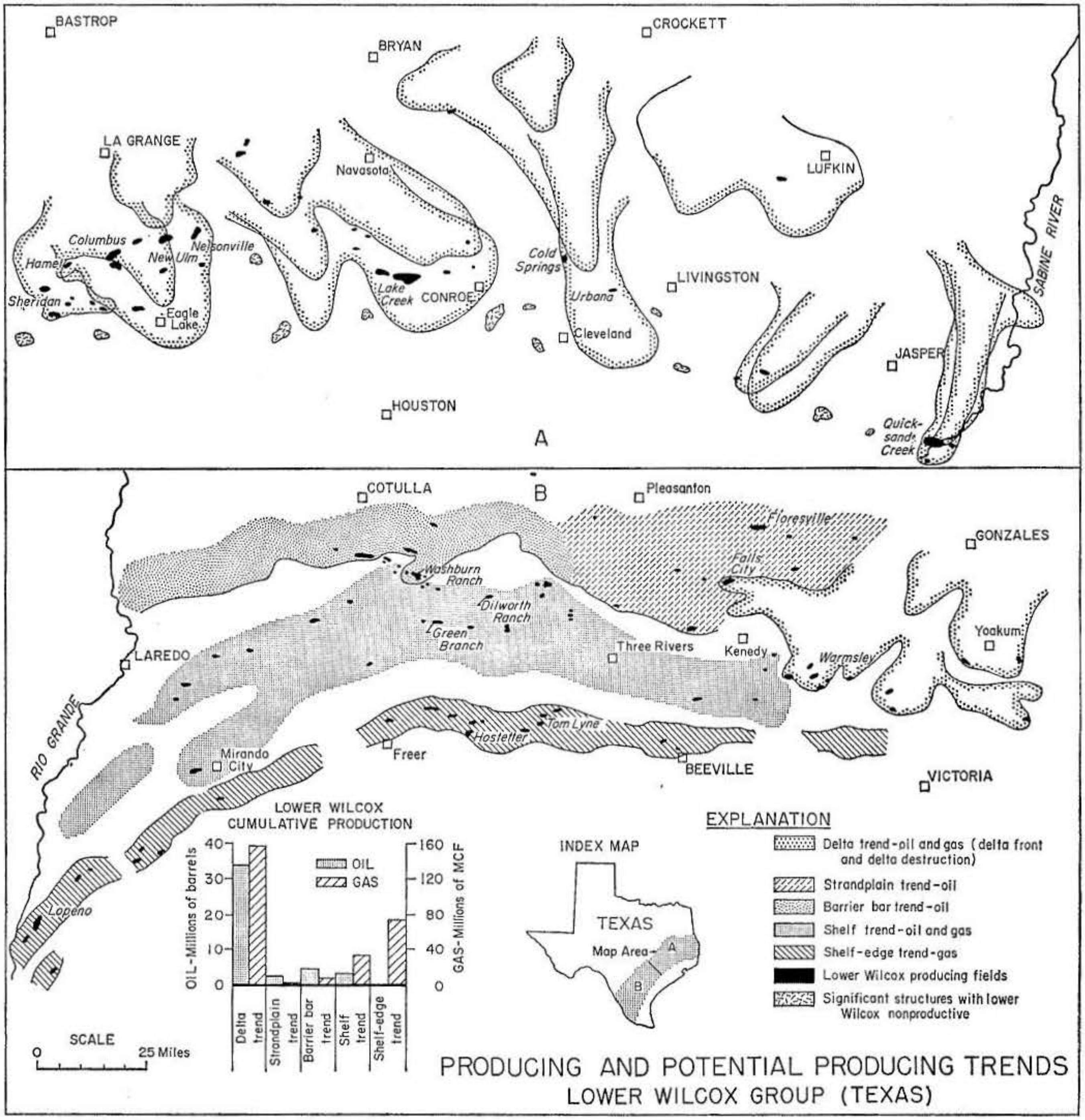


Figure 10. Producing and potential-producing oil and gas trends, lower part of Wilcox Group, Texas (For well control, see Fig. 1)

the multipay reservoirs, typical of many of the large, delta front fields (e. g., Falls City, Sheridan, Columbus, Lake Creek, New Ulm, Quicksand Creek). Marine clays deposited over delta front sands during stages of marine destruction of delta lobes locally provide effective seals for sand reservoirs. Not only do known producing fields coincide with distribution of delta sand units, but numerous large scale structures situated along structural trend of lower Wilcox production within the delta system are notably nonproductive due to location in sand-poor interdelta subembayment facies (Fig. 10). Growth faults and diapiric structures are associated with zones of thick deposition such as the delta front; structures associated with these features are locally important traps.

Marginal to the delta trend is the strandplain trend, controlling oil accumulation chiefly in the lower Wilcox of northwestern Gonzales, Wilson, northwestern Karnes, and eastern Atascosa counties. Areally extensive sheet sands interbedded with dominantly marine muds result in a wide producing trend; this trend includes the farthest updip lower Wilcox production.

Sand units on the seaward side of the Cotulla Barrier Bar System constitute the barrier bar trend which extends as a narrow trend from northern McMullen, southwestward across La Salle through western Webb counties. Most of the established production from this trend is in east-central La Salle County associated mainly with a shelf side tidal delta of the Cotulla System. Providing entrapping structures exist, additional discoveries in the barrier bar trend are likely; significantly, the trend occurs at shallow depths. Production to date from this trend has been chiefly oil with relatively minor amounts of gas.

Several lower Wilcox fields have been developed in the sand reservoirs of the South Texas Shelf System. With exceptions of Green Branch and Dilworth Ranch, however, fields are small. Individual sand units within this extensive system tend to be sporadic in distribution and not easily definable. Further, many sands are muddy with low permeabilities. Production to date has been primarily gas with small amounts of oil.

A final, main lower Wilcox trend is here referred to as the shelf-edge trend (Fig. 10). Sands of this trend are a part of the South Texas Shelf System, though their origin is not fully understood. They form a fairly well-defined, narrow trend extending from the southwestern margin of the Rockdale Delta System through central Bee, central Live Oak, northwestern Duval, southeastern Webb, eastern Zapata, and western Starr counties. Producing sands in this trend may have originated as barrier bars similar to elongate sand bodies updip on the remaining part of the shelf system and in the Cotulla System. Their distinction and downdip occurrence suggest possible shelf-edge reworking and cleaning as a result of the higher energies associated with such a zone.

If occurrence of submarine fan deposits, as considered above, is indicated by very deep drilling, an additional lower Wilcox trend may be established. Most likely area of such sand development would be downdip of the major shoal-water deltas of the Rockdale System, chiefly in Goliad, Victoria, Jackson, and Wharton counties. Identification of such a trend will require extensive and very deep drilling.

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