terial on the recent and ancient clastic sediments has appeared during the past 5 years.

Many geologists do not believe that modern clastic deposition is representative of conditions which prevailed during the geoloic past and consequently they seriously question the value of research on recent sediments. Although I agree that several pre-Holocene depositional conditions probably do not exist at the present time, I am convinced that sediment studies of the Holocene have yielded valuable concepts and criteria which could not have been provided by other approaches.

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ALLUVIAL FANS AND FAN DELTAS: DEPOSITIONAL MODELS FOR SOME TERRIGENOUS CLASTIC WEDGES

Alluvial fans and fan deltas are constructed by similar processes; both require a highland and adjacent lowland for development. Alluvial fans are associated with interior basins, whereas fan deltas develop along coastlines. A fan delta is an alluvial fan which progrades into a marine body of water.

Modern alluvial fans are present in both arid and humid regions throughout the world, ranging from Arctic to lower latitudes. Geometry and facies are controlled by rate of basin subsidence, source material, and frequency and magnitude of floods. In arid regions, where fans are most common, principal processes include debris-flows, sieve deposition, and fluvial deposition. Processes are intermittent and commonly one is dominant. Debris-flows and sieve deposits are major contributors to the upper ⅓ to ½ of a fan. Sieve deposits are generally confined to the fan apex. Debris-flows, characterized by a heterogeneous mixture of clay- to boulder-size material, extend for considerable distances downfan where they grade to mudflows containing few large clasts. Debris-flows reflect a fine-grained source area. Fluvial processes are dominant on the distal fan.

Humid-region fans, *e.g.*, Kosi River fan of India, are constructed entirely by fluvial processes during large annual floods. Compared to arid-region fans, humid-region fans have a low slope from apex to toe, are large in areal extent, and thin in cross section. Humid-region fans also contain smaller clasts, less fine material in the upper fan, and sediment is better sorted. Source-area vegetation aids in breakdown of rock material into smaller particles than under arid conditions. Erosion is great in humid areas because of intense flooding.

Alluvial fans in closed drainage basins commonly are associated with lakes. Where alluvial fans build into basins with through-flowing streams, braided-stream deposits of the distal fan are interbedded with floodplain deposits.

Fan deltas may be distinguished from alluvial fans only by the nature of related facies. Modern fan deltas develop in areas of high or low rainfall, from deserts to tropical rain forests, and are associated with a wide range of marine depositional environments, *e.g.*, reef-lagoonal to submarine fan association. Types of depositional environments associated with fan deltas are determined by such factors as tidal range, shelf width, and climate.

Fan deltas differ considerably from modern oceanic (high-constructive) deltas which are constructed by continuously flowing, large rivers characterized by a large suspension-load/bed-load ratio. Deltaic plains of oceanic deltas generally are covered by dense vegetation, whereas subaerial parts of fan deltas are virtually barren. Oceanic deltas have ragged lobate or digitate margins indented by interdistributary bays; fan deltas commonly have a smoothly arcuate distal end with no interdistributary bays. Prodelta deposits associated with oceanic deltas are commonly the thickest delta facies; equivalent facies of fan deltas are comparatively thin.

Fan-delta deposits are continually reworked by marine processes. Deposition is sporadic, therefore marine processes are effective in redistributing prodelta sediment. Marine currents redeposit sediment along the distal fan as beaches and associated berms, and within adjacent shallow marine areas as thin sand sheets and local fan-margin islands or spits.

Many ancient clastic-wedge deposits from Precambrian to Pleistocene ages are alluvial-fan systems. Deposits composing these systems become finer in the direction of transport. Lacustrine or fluvial deposits commonly are associated with the finer grained alluvial-fan deposits. Ancient alluvial fans are known from the (1) Precambrian of Texas, (2) Devonian of Norway, (3) Carboniferous of Canada, (4) Permian-Triassic of England, (5) Triassic of the Connecticut Valley, and (6) Pleistocene of California.

Ancient fan deltas have been described as fanglomerates, continental deposits, and tectonic deltas. Subaerial facies have the same character as ancient alluvial fans but are associated with marine facies ranging from turbidites to tidal-flat deposits. Ancient fan deltas occur in the (1) Devonian of New York and Northwest Territories, (2) Pennsylvanian-Permian terrigenous clastics shed off the Ancestral Rockies, Amarillo Mountains, Wichita Mountains, and Arbuckle Mountains, (3) Miocene of Texas and California, and (4) the Pleistocene of Baja California.

Fan deltas and possibly high-destructive deltas prograded shorelines and filled basins during early geologic periods, prior to evolution of terrestrial vegetation. High-destructive deltas are produced by marine reworking of river-borne sediment. Streams associated with high-destructive deltas are characterized by short duration peak discharge which allows sediment deposited at the mouths to be immediately reworked into spits and beach ridges. Lag time between precipitation and runoff was short and the fluvial systems which developed these 2 delta types were either braided streams or coarse-grained meander belts.

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FACIES PATTERNS IN MARBLE FALLS GROUP, SOUTHEAST BURNET COUNTY, TEXAS

Morrowan carbonates and clay of the Marble Falls Group accumulated on part of a broad structural platform, the Texas craton, that was bordered on the east by the Fort Worth basin. A myriad of carbonate facies formed on landward parts of the platform, whereas a relatively thick uniform sequence of dark-gray spiculitic carbonate mudstone accumulated at its seaward margin. As much as 6,000 ft of Mississippian and Pennsylvanian shale and sandstone fill the segment of the Fort Worth basin adjacent to the carbonate platform.

Facies patterns in the Marble Falls Group are closely related to depositional setting. Changes in setting are a consequence of transgression, regression, and accumulation during transgression and regression. The response of facies patterns to changes in setting is recorded in the composition, geometry, and distribution of the facies.

Four distinctly different vertical and lateral progressions of facies are evident in the Marble Falls Group. This progression lends itself to recognition of 4 depositional phases.

The vertical sequence for each phase results from lateral shifts of 1 or 2 facies tracts that are unique to each phase. As a consequence each phase can be described by means of 1 or 2 generalized facies models.

In places where porosity is fabric-selective, the models should allow prediction of reservoir geometry. They also may be useful in predicting target directions, and in locating the updip limits of potential stratigraphic traps.

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DEPOSITIONAL SYSTEMS IN WOODBINE FORMATION (UPPER CRETACEOUS), NORTHEAST TEXAS

The Woodbine Formation is composed largely of terrigenous sediment eroded from Paleozoic sedimentary and weakly metamorphosed sedimentary rocks of the Ouachita Mountains in southern Oklahoma and Arkansas, and subsequently deposited in a complex of nearshore environments along the margins of the broadly subsiding Northeast Texas basin. Three principal depositional systems are recognized in Woodbine rocks—a fluvial system, a high-destructive delta system, and a shelf-strandplain system. Their recognition is based on a regional outcrop and subsurface investigation in which external geometry of framework sandstone was integrated with lithology, sedimentary structures, fossil distribution, and bounding relations.

Two components of the fluvial system, a tributary channel sandstone facies and a meander belt sandstone facies, are developed in the Dexter Member (lower Woodbine) northeast of a line from Dallas to Tyler. On the south and southwest, a high-destructive delta system is persistent throughout the entire Woodbine section. The 3 component facies of the delta system are: progradational channel-mouth bar sands; coastal barrier sands, deposited along shore adjacent to the channel mouth; and prodelta-shelf muds. The Lewisville (upper Woodbine) shelf-strandplain system, developed in the northern third of the basin marginal to principal deltaic facies, is composed of 2 facies: shelf muds and strandplain sands that accumulated along shore.

Near the end of Woodbine deposition, but before transgression by Eagle Ford seas, emergence of the Sabine uplift resulted in erosion of Woodbine sediments, which were subsequently redeposited along margins of the uplift as the Harris sand.

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PENNSYLVANIAN DELTAIC STRATIGRAPHIC TRAPS, WEST TUSCOLA FIELD, TAYLOR COUNTY, TEXAS

Hydrocarbon occurrence in Strawn (Pennsylvanian) sandstones in West Tuscola field, near Abilene in Taylor County, Texas, is the result of stratigraphic entrapment in deltaic sandstones. The origin of the reservoir rock in the field area and the overall geometry and internal character of the deltaic complex were determined from the vertical sequence in numerous cores of the Gray sandstone and associated units and from numerous E-logs of uncored wells.

The vertical succession of deltaic facies consists from base to top of a progradational sequence (prodelta and delta front), an aggradational unit (delta plain–marsh and interdistributary bay), and an overlying "transgressive" shallow-marine interval. Reservoir sandstones are present within the delta-front facies as stream-mouth-bar deposits, known locally as the "Gray sandstone."

The stream-mouth-bar sandstones within the West Tuscola reservoir are lenticular, highly irregular in outline, and have varying trends of porosity; these are characteristics to be anticipated in deltaic deposits. Such features present problems in developing effective secondary-recovery methods and in predicting occurrences of other deltaic sandstones.

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DEPOSITIONAL MODELS OF SANDSTONES

Determination of the depositional environment for sandstone bodies generally improves the accuracy in estimating sandstone reservoir trends. Depositional framework is best understood by comparing the geometric and internal features of each sandstone to those of models, which are sand and sandstone deposits of known depositional environment. The different environments are distinguishable most commonly, not by a unique property, but by diagnostic combinations of the various features, such as trend, width, thickness, nature of contacts, sequence of sedimentary structures, textural sequence, and constituents. These characteristics are catalogued for 18 different environments, ranging from eolian to deep-marine basin floor, and models of alluvial valley, alluvial plain, and deltaic environments are illustrated.

The Pennsylvanian Kisinger Sandstone, which crops out in north-central Texas, was deposited in a deep and narrow valley by a westerly flowing river. Each textural sequence of massive-bedded conglomerate, crossbedded conglomeratic sandstone, and convolute-bedded sandstone represents a genetic unit formed at one position of the river, which was 200–300 ft wide. The fine-grained sandstone and carbonaceous shale in the upper 30 ft of the 150-ft section were deposited under near coastal conditions as the valley filled in response to a continued rise of sea level.

The Pennsylvanian Robinson Sandstone in southern Illinois was deposited by a river flowing west-southwest on an alluvial plain. Unidirectional medium-scale and small-scale crossbedding, upward decrease in grain size, and sharp basal and lateral contacts indicate stream deposition. The absence of allochthonous pebbles suggests deposition on a plain rather than in a valley. The absence of marine indicators suggests alluvial rather than deltaic conditions.

The Davis sand (Yegua) in the Hardin field of southeast Texas was deposited by a deltaic distributary. A width-thickness ratio of approximately 30, and abrupt lower and lateral contacts, together with interstratification and the microfauna of equivalent beds, are suggestive of deposition near the mouth. The narrow width of 1,250 ft suggests further that the sand represents a genetic unit, with insignificant lateral migration.

Most of the Cretaceous Newcastle Sandstone in North Dakota represents deposition on a broad, slowly subsiding deltaic plain which formed as streams advanced west-northwestward from South Dakota, and southward from Saskatchewan. In the deltaic complex Skull Creek prodeltaic clays underlie delta-margin