in Relation to Lignite Development in East Texas

Lignite development will place major demands on groundwater supplies. The Simsboro Formation and the Calvert Bluff Formation (a major lignite host) of the Wilcox Group between the Colorado and Trinity Rivers constituted a test case to evaluate water availability and quality. Aquifer geometry (sand versus mud) was determined by comparing environmental geology maps and subsurface sand-percent and net-sand maps constructed from electric-logs. The combined maps correlate well and show that the Calvert Bluff consists of a complex interfingering of coarse channel sands and fine interchannel muds. Sand outcrop areas several tens of square kilometers separate much larger interchannel areas with few and minor sands. The Simsboro consists of two parts—a thick multilateral sand (300 to 700 ft or 90 to 212 m) in most of the southern outcrop belt and a series of channel sands (100 to 200 ft or 30 to 60 m) interspersed with muds in the northern belt. Sands of the northern Simsboro belt are more like the Calvert Bluff channel sands than like the thick Simsboro sands.

Available hydrologic data suggest that Simsboro and Calvert Bluff sands have high hydraulic conductivity (6 to 20 m^3/m^2/day); interchannel muds have low hydraulic conductivity (1 to 2 m^3/m^2/day). Water compositions in the Simsboro and Calvert Bluff are similar and evolve similarly. Near-surface water has a Ca-Mg-HCO_3 composition, low in total dissolved solids (<500 mg/l). The water evolves over a depth range from 300 to 1,200 ft (91 to 364 m) to a Na-HCO_3 water (~1,000 mg/l). Change in composition probably results from ion exchange with clays (Ca^{++} for $2Na^+$) and solution of calcite (which contributes more Ca^{++} for exchange and increases HCO_3^- concentration). Correlation of composition with amount or percent sand has not been demonstrated. Poor-quality water is largely restricted to shallow wells (<100 ft or 30 m) in muddy parts of the Calvert Bluff.

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Enhanced Oil Recovery

In the United States, known fields contain about 300 billion bbl of oil which will not be recovered because of economic and technological limitations. This oil is the target of Enhanced Oil Recovery (EOR).

However, even given reasonable improvements in oil price policy and process technology, the success of EOR projects is not guaranteed. The high cost of the injected materials and the necessity of maintaining certain critical conditions at the injection front will require much more geologic assistance to the reservoir engineers than has been provided for conventional recovery processes.

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Queen City Formation in East Texas Embayment—Record of Riverine, Tidal, and Wave-Dominated Processes

Five distinct facies are recognized in Queen City exposures between the Trinity River valley and Louisiana boundary. These facies (fluvial, deltaic, tidal flat, barrier, and tidal delta) display distinctive suites of physical and biogenic structures, with substantial differences in paleocurrent pattern.

Fluvial influx was mainly from the northwest, possibly with minor contributions from the Sabine uplift on the east. A marginal alluvial plain was transected by sandy braided streams and sinuous mixed-load channels. Very small, high-constructive shoal-water deltas and crevasse subdeltas developed mainly along the northwestern embayment margin, prograding rapidly across the shallow shelf. Barriers may have originated as destructive components of delta abandonment or as contemporaneous strike-fed features marginal to the main delta complex in the west. In either event, barriers are poorly preserved, possibly because of transgressive ravinement, but more likely because they were never developed on a major scale. Flood-tidal deltas formed at the mouths of microtidal estuaries. Like some modern analogs, they are significantly larger than comparable mesotidal features. They also exhibit features reflecting storm processes. Extensive back-barrier or bay-margin intertidal and subtidal flats and shoals reflect the interplay of tidal and wave-generated processes, leaving a characteristic record of variable physical energy and flow patterns.

Regional depositional patterns were largely controlled by (1) location of the east Texas embayment with respect to the major deltaic depocenter, resulting in an eastward decrease in sediment supply; (2) configuration of the broadly funnel-shaped embayment which may have augmented tidal range; and (3) transition from overall progradational character, with local transgressions, to a major marine transgression that culminated in shelf sedimentation of the overlying Weches Formation.

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Distribution of Volcanic Activity in Time and Space in Gulf Coastal Province

Volcanic activity has been an integral part of the history of the Gulf coastal province, which may come as a surprise to many who consider the Gulf Coast to be a mature quartzose sedimentologic province. Volcanic products, including intrusive and extrusive igneous rocks, tuff, glass, bentonite, and volcanic rock fragments, are known from nearly every geologic stage since the beginning of deposition of the Gulfian Series.

Violent activity has been recorded in two periods of Gulf Coast history: (1) during Woodbine-Eagle Ford-Austin time in the Mississippi embayment and (2) during Oligocene to Miocene time in the Rio Grande embayment. The opening of the Gulf of Mexico during the Triassic was accompanied by volcanism. The southwestern Gulf of Mexico has been the site of the latest activity, in the 17th and 18th centuries.

Volcanic activity has not driven off adjacent accumulations of oil and gas as might be suspected. However, it may have impact for exploration and production of oil and gas. Consideration of local volcanic sources can alter current sedimentologic models of the Gulf coastal province. Accelerated diagenetic processes can complicate petroleum production in the vicinity of volcanic centers.

Considering a history of active volcanism, the Mississippian and Rio Grande embayments may be reconsidered as small aulacogens.

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Chemical Differentiation of Temperate and Tropical Limestone-Derived Soils

Chemical analyses of soils formed by the weathering of limestone bedrock in the U.S. Gulf Coast, Missouri, Tennessee, Mexico, and Guatemala were used to determine whether any significant differences were present that would allow identification of soils of rocks weathered under tropical as contrasted with temperate climatic conditions. Over 100 samples were analyzed for their major oxides (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, and TiO_2) and, for selected samples, certain trace elements were determined as well (Ba, Zn, Sc, La, Ce, Eu, Lu, Rb, Hf, Cr, and Co). X-ray diffraction analyses were also carried out on representative samples for each climatic zone.

Cluster analysis was then applied to the chemical and mineralogic data to determine the number of distinct limestone soils that could be identified and to compare soils from the two major climatic regions. Discriminant analysis was then used to test whether the tropical soils were, truly, different from their temperate-zone counterparts.

Variation in trace-element chemistry was not found to be particularly useful in differentiating samples from the two climatic zones but was useful in establishing depositional patterns within a given region. Variations in the major oxide chemistry were useful, however, as climatic-zone indicators and were also found to reflect tectonic conditions in the adjacent land areas at the time the carbonates were being deposited offshore and diagenetic changes that have occurred since deposition.

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Facies, Diagenesis, and Porosity Relations of Buda, Georgetown, McKnight, and West Nueces Carbonate Rocks of Maverick Basin

Through much of Dimmit and northern Webb Counties, the Buda and Georgetown limestones are remarkably homogeneous; both consist of very dense algal calcisphere, *Globigerina, Inoceramus,* and echinoderm wackestones and packstones; calcispheres constitute the predominant biotal component in both.

In central and western Dimmit County dolomitization produced secondary intercrystalline porosity in several Georgetown intervals; these voids are now filled with solid hydrocarbon. In this area gas is produced in the Georgetown from tertiary voids which were formed when fresh groundwaters dissolved replacement anhydrite after hydrocarbons had accumulated in secondary intercrystalline voids. The Buda has no reservoir potential in this area.

Westward from eastern Dimmit County, the McKnight and West Nueces change facies from oobiograinstones and packstones to biopelgrapestone grainstones and packstones to biopelwackestones in western Dimmit County. The McKnight exhibits well-developed depositional and diagenetic cycles. These cycles record interaction of the following: (1) eustatic fluctuations in sea level, (2) regional progradation of supratidal, intertidal, and subtidal facies during stillstands of sea level, (3) changes in climate from arid to semiarid or subhumid, (4) continuous subsidence. Consequently, the McKnight has been subjected to highly complex multicycle diageneses that include freshwater diagenesis, dolomitization, anhydritization, silicification, and dedolomitization. Anhydrite layers of the upper and lower "anhydrites" were formed by replacement of carbonates. Secondary intercrystalline porosity in dolostone layers has been filled by what is now solid hydrocarbon which accumulated at shallow depths. Gas production in the McKnight, throughout the area, is from tertiary anhydrite molds which were created after solid hydrocarbons had accumulated in secondary voids. Much dickite cement also is present in secondary voids in the McKnight.

The West Nueces apparently contains no anhydrite, but tertiary anhydrite molds were abundantly formed and then largely filled by carbonate cements, as were primary and secondary voids. Reservoir potential of the West Nueces probably has not been properly evaluated.

Because mechanisms of anhydrite emplacement are so poorly understood, the distribution of porosity, formed by its dissolution, is unpredictable.

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Gulf Coast Lignite—Status Report

Gulf Coast lignite occurs mainly in Eocene strata with the majority of the resources in the lower Eocene Wilcox Group. Strippable resources in the Gulf Coast area are about 20 to 25 billion short tons (18 to 22.5 billion Mg) of which one-half are in Texas. Grade (5,000 to 7,000 Btu/lb or 11,630 to 16,282 kJ/kg, 20 to 50% moisture, 10 to 40% ash, and 0.5 to 2% sulfur) decreases from west to east and with progressively younger stratigraphic units. Seams are typically 2 to 10 ft (0.6 to 3 m) thick; differences in continuity and grade can be correlated with depositional system.

Large acreages are under lease—2.5 million acres (1,000,000 ha.) in Texas alone. At the near-surface, development drilling is most common whereas exploration drilling is now under way for deep-basin lignite. Deposit size depends on end use, for example, a 150 million ton (135 million mg) reserve for power plants and 15 million tons (13.5 million mg) for industrial boilers. Mining is by dragline or scrapers at less than 120 ft (36 m) and stripping ratios of less than 10:1; minimum seam thickness is 2 ft (0.6 m). Reclamation cost is approximately $1,000/acre ($400/ha.). Bucket-wheel excavators are inevitable as multiseam thin-bed deposits are mined at increasing depths.

All current production is in Texas and was about 21 million tons (19 million Mg) in 1978. Almost all the production is pulverized fired in mine-mouth plants where lignite-produced energy costs 50¢ per million