The results of this study may be applicable to other areas of Cotton Valley deposition in northern Louisiana and northeast Texas.

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Fourmile Creek and Splunge Fields, Black Warrior Basin, Monroe County, Mississippi

Fourmile Creek and Splunge fields contain dry gas reserves of about 17 and 35 Bcf, respectively, in Mississippian Chesterian sandstones at depths less than 1,800 ft (549 m). Both are combination structural-stratigraphic traps. The trap at Fourmile Creek is formed by simple drape of an isolated sand body on a structural nose. Splunge is more complex, having at least four separate sand bodies, two faults, and 200 ft (61 m) of vertical closure.

The fields are in the north part of the Black Warrior basin in an area of gentle south-southwest dip broken by a few, major, regional, down-to-the-basin, normal faults. No evidence of Mississippian growth is present on these faults, and production is not related to them. Smaller, more local faults which are downthrown in the opposite direction do help form traps.

The producing sandstones appear to be marine and possibly fluvial, high energy deposits in a southwestward thickening wedge of sedimentary rocks between the *Millerella* and Bangor limestones.

Discoveries at Splunge and Fourmile Creek fields resulted from exploratory efforts based on very sketchy subsurface data. The primary target of the play was thick, Devonian, tripolitic chert porosity in a large fault and pinchout trap. No hydrocarbons were found in the Devonian, probably because of late fault movement. Serendipity can not take full credit for the discoveries because the wells were drilled on prospective structural anomalies and potential of the Mississippian sandstones was recognized prior to discovery.

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New Smackover Production at Anahuac, Northeastern Mexico, Opens up Jurassic Possibilities in Rio Grande Embayment

The first proved commercial gas production in the Smackover trend of the Rio Grande embayment was found at Anahuac, northeastern Mexico, 40 mi (64 km) southwest of Laredo, Texas. The discovery well tested 34 MMCFGD. Further discoveries can be expected from future exploration in this trend. The reservoir is a porous macrodolomitized lagoonal facies of the Norvillo Formation (Smackover equivalent). Methane gas is trapped by the pinch-out of the dolomites against red beds across the plunging Salado arch.

Development drilling has shown that, with normal stimulation techniques, commercial production is restricted to the more porous dolomitized calcarenites. These are believed to have been deposited around the shores of a lagoon and possibly are related to a hingeline which can be identified on seismic sections. Special fracturing techniques may improve recovery from the tighter dolomitized calcilutites.

Problems with overpressures in the reservoir raise the cost of drilling operations. Nearly equal quantities of nitrogen associated with the methane reduce the value of the accumulation. Despite these considerations, it is believed that this small stratigraphic field is a worthwhile economic prospect at present gas prices.

Interest in the Anahuac area was stimulated by a reevaluation of wells drilled in the area between 1960 and 1965. This reevaluation was based on a detailed stratigraphic-petrographic study, supplemented by a critical reappraisal of electric logs and operational data. Similar studies of old wells elsewhere in the Rio Grande embayment could lead to the recognition of gas accumulations previously overlooked.

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Form and Composition of Mississippi Fan

The Mississippi fan is a lobe-shaped prism of muddy Quaternary sediments extending for about 800 km from near the present Mississippi River delta to the Sigsbee abyssal plain. The Mississippi trough and smaller, filled depressions notch the shelf edge near the fan apex. These depressions apparently channeled detritus across the outer shelf and upper slope and acted as point sources of fan sediment. Upper, middle, and lower subdivisions of the fan are identified on the basis of seafloor gradient and relative smoothness, seismic character, and influence of salt structures. The upper fan is in water depths from about 1,000 to 2,500 m and has an irregular, hummocky topography with an average surface gradient of about 1°. Structural and topographic complexities in this part of the fan have resulted from salt diapirism, slumping, and possibly current scour. Dart-core lithologies consist of clay, silt, and uncommon, very fine-grained sand.

The middle part of the fan is characterized by a low gradient ($<0.25°$), moderately smooth surface, and complex internal structures as shown by seismic profiles. Mid-fan deposits thin from 1,300 to 800 m toward the southwest and southeast, and near-surface sediments are clays and silts. Widespread intervals of chaotic seismic response—interpreted as slump and slide deposits—are present adjacent to the depositional loci of the fan. Interbedded units of continuous reflectors probably are turbidites, hemipelagites, and possibly contourites.

The lower fan is very smooth, nearly flat, and grades into the Florida and Sigsbee abyssal plains. Quaternary silt and clay in the lower fan are interpreted as turbidites and pelagites. Associated seismic reflections are continuous and converge toward abyssal-plain areas.

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Geothermal Exploration from Deep-Well Data

Logs from more than 500 deep wells have been studied, covering Florida and adjacent parts of Georgia and Alabama, as part of a massive effort to assess the geothermal potential of the area. Within peninsular Florida, two favorable anomalies were confirmed, and other attractive areas were outlined—but not studied in detail—in the Florida panhandle and adjacent states.

Bottom-hole temperatures were used as the basis for several kinds of maps: geothermal gradient, temperature at 1,000 m, temperature at 2,000 m, and depth to 100°C (typically within 4,000 m of the surface, in the anomalous areas). Unlike earlier maps which used county averages, the present work was done on the basis of single-well readings, thereby providing more detail, as well as more noise.

Ground-water movement at shallow depths distorts the shallow-data field, so that measured heat-flow values taken from water wells, although confirming the general results from deep wells, provided lower numeric values. The deep-well bottom-hole temperatures are known not to be equilibrium values, but the errors in BHT measurements tend to reduce the actual gradients (increases in temperatures near the surface, decreases in temperatures near the bottom) and, therefore, the map anomalies are conservative approximations.

Radioisotope anomalies, from shallow-water sources, also confirmed the two anomalies. One of these was explored further by gravity methods, and may be related to deep structural control.

Two types of information, missing from most geothermal studies based on existing well logs, can be supplied in most instances. One is an estimate of fluid transmissibility, which can be based on ordinary procedures, well-known in the oil industry, for obtaining porosity values and permeability indications from logs. This will be important in exploitation of relatively low-temperature geothermal sources, such as those in the southeastern states, where circulation of water in large quantities may be necessary. The other is an estimate of thermal conductivity of deep rocks. This last value can be obtained by direct measurement on cores, or can be computed from the equation

$$K_h = kV_p^a \rho^b$$

where V_p is sonic velocity (to be read from the CVL), and ρ is mass density. This estimate of thermal conductivity can be used to convert thermal gradient values to heat-flow values.

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Oil Prospects in Gulf of Mexico Region

Assessment of the relative merits of poorly explored regions can be made on the basis of a structural-sedimentologic analysis of information from as few as one per region. The pertinent variables are (1) mean-grain size, (2) sorting or clay content, (3) organic matter, and (4) rate of burial. This information is readily available from cores or samples, and reasonably good estimates can be made from modern log suites. For a "most attractive" rating, the possible reservoir beds in a well to be studied should have the mean size in the sand category, and sorting should be good to excellent (very little clay or fine silt); associated rocks should have a relatively high content of organic matter; and the indicated burial rate should be high.

A less satisfactory assessment, using these same concepts, can be made on the basis of general geologic knowledge, without well data. Under these circumstances, the required sedimentologic information can be approximated from knowledge about climate and source lands, and the rate of burial can be estimated on the basis of regional geologic knowledge.

These techniques do not apply in dominantly carbonate or evaporite sections, and hence cannot be used, as stated, in the Florida and Yucatán areas. For the rest of the coastal plain and continental shelf of the Gulf of Mexico region, application of the four basic ideas indicates that the most attractive targets are in the states of Louisiana and Tabasco (and directly adjacent areas), and that lesser production can be expected as one moves along the coast away from these prime targets. Hence, north Tamaulipas, south Texas, and the Florida panhandle should be less attractive targets, although there is nothing in the model to indicate that they are barren.

Quick burial commonly (but not invariably) is associated with large river deltas. The deltas of the Grijalva-Usumacinta and Mississippi Rivers meet this requirement. The delta of the Rio Grande, on the other hand, is not so attractive, even though burial rates may have been high: the sedimentologic data are not so encouraging as in Louisiana and Tabasco.

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The Oil Industry and Coastal Zone Management in Louisiana

The Federal Coastal Zone Management Act of 1972 (P.L. 92-583) provides incentives for states to plan and implement management programs to guide public and private uses of lands and waters in the coastal zone. Many states, including Louisiana, are in the planning phase of program development. A coastal zone bill has been prepared for consideration by the Louisiana Legislature during the 1976 session. The bill calls for creation of a 15-member Coastal Commission and preparation of specific management guidelines. Close government-industry cooperation is essential for preparation of effective guidelines involving oil and gas operations, and initial contacts have been made to establish this working relation. In addition to adherence to existing air and water quality standards, these guidelines undoubtedly will incorporate recognition of such factors as ecosystem integrity and function, maintenance of natural water flow and circulation patterns, trends in land/water ratios, changes in water freshness or salinity, erosion of Gulf of Mexico shores, and cumulative environmental impacts within hydrologic units and marsh types. A comprehensive assessment of techniques will be required to mitigate the effects of such activities as brine disposal, road building, canal dredging, pipe-laying, spoil disposal and the construction and operation of processing plants, storage facilities, and refineries.

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Early Cretaceous Shelf Margin in Northern Mexico and South Texas

In seven outcrop sections in the Monterrey-Saltillo area of Mexico the Lower Cretaceous Cupido limestone and the underlying Taraises shale and black lime mud-