Maverick basin of the Rio Grande embayment is a series of overlapping sand bars striking northeast-southwest. Grain-size plots and core descriptions indicate that these bars developed in a shallow-marine shelf environment. There are as many as five cycles of sand sedimentation, all but one having established production. These sandstones have a cumulative production of over 50,000 bbl of oil since 1948. Over 30,000,000 bbl of oil has been produced from stratigraphic-type fields discovered since 1970. Stratigraphic-type fields have produced over 90% of the total production. Structural traps, caused by differential compaction over volcanic necks, account for the remainder. Torch field, associated with a volcanic neck in Zavala County, and Sacatosa field, a stratigraphic trap in Maverick County, are typical. The depth and density of control, as well as the subtle expression of the traps, leave many prospective areas.

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Independent Geologists—Endangered Species

During the last 5 years, while constantly complaining about a supposed lack of competition in the extractive industries, the U.S. Congress and administrative regulatory agencies have focused their power to make this "lack of competition" real. Current examples are: (1) in the SEC, the constant effort to broaden the definition of a security and bring the attendant registration and disclosure requirements to bear on the most mundane joint venture; (2) in the Congress and the SEC, the pressure to bring about accounting changes limiting independents' access to equity markets and encouraging sellouts and mergers; (3) in the IRS, grotesque definitions of joint ventures as partnerships, partnerships as corporations, and farmouts as income; (4) in the FERC, strained interpretations of gas contracts as "convenants running with the land" in order to introduce the principle of administrative confiscation of mineral rights without due process. The ponderous weight of the regulatory hand weighs most heavily on the independent geologist who has no legal or accounting staff.

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Stratigraphy and Exploration Geology of Marble Falls Group, Llano Uplift to Southern Part of Fort Worth Basin

The Marble Falls Group is a Lower Pennsylvanian carbonate complex that crops out in a discontinuous arcuate belt rimming the east, north, and west sides of the Llano uplift. The carbonate beds accumulated on the eastern part of the Texas craton, which sloped toward the adjacent Fort Worth basin. Three units within the Marble Falls Group have been mapped in the outcrop area. They are informally referred to as the "lower limestone," "middle shale," and "upper limestone." The same tripartite subdivision is evident in the subsurface north of the Llano uplift in Lampasas, Mills, Hamilton, Comanche, and Brown Counties.

Marble Falls gas production in the southern part of the Fort Worth basin is almost exclusively from the upper limestone. The upper Marble Falls forms several northeast to southwest-trending carbonate-bank complexes. The bank complexes terminate abruptly and pass laterally into shale and dark spiculitic limestone. Both structural and stratigraphic traps are evident within the bank complexes. Pottsville field in Hamilton County is a steep-sided structural trap from which 10 wells have produced approximately 33 Bcf of gas at depths of 2,600 to 2,900 ft (792 to 884 m). Santa Anna field in Coleman and Brown Counties is a large stratigraphic trap discovered in 1928. More than 100 gas wells have been completed in Santa Anna field. Early production records are not available. However, the incomplete data that are published substantiate the fact that Santa Anna is a large, economically attractive field, in which many wells have produced at least 1 to 2 Bcf of gas at depths of 2,300 to 2,400 ft (700 to 732 m).

Porosity tends to develop within three facies of the upper Marble Falls limestone: phylloid algal limestone, stromatoporoid limestone, and oolitic carcarenite. At the outcrop, the algal, stromatoporoid, and oolitic facies are most prevalent near the edge of bank complexes. However, they are by no means restricted to the outer part of the banks. Fractures related to a system of mostly down-to-basin normal faults enhance permeability in many places.

Structure is complicated and difficult to perceive without seismic data. Even where seismic data are available, standard isopach mapping techniques cannot be employed because there are no continuous shallow seismic reflectors. Moreover, topographic highs capped by Edwards Limestone outcrops tend to yield poor-quality records.

In spite of the problems inherent in exploring a structurally and stratigraphically complex area, there are undoubtedly undiscovered, commercially attractive gas fields in the southern part of the Fort Worth basin. The high exploration risk is to some extent offset by shallow depth, low acreage costs, and the attractive nature of potential targets.

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San Andres Facies Patterns, Palo Duro and Dalhart Basins, Texas

Regional facies analysis of San Andres/Blaine (Guadalupian, Permian) strata of the Palo Duro and Dalhart basins by use of cores, cuttings, and well logs is of interest for hydrocarbon exploration. San Andres rocks are composed of dolomite, anhydrite, and salt and exhibit basinward (southerly) facies changes from supratidal to subtidal. Supratidal facies reflect many features of modern, low-relief coastal sabkhas.

Lower San Andres strata include five mappable cyclic units; each cycle is comprised of (1) subtidal to intertidal shelf carbonates (basal transgressive facies), (2) lower sabkha, nodular and bedded anhydrite, and (3) upper sabkha salt formed in brine ponds and evaporating pans. Cycles represent repetitive progradation of facies to the south through time. Salt beds pinch out in the central and southern parts of the Palo Duro basin and mark the basinward limit of the upper sabkha evaporating terrane. Upper San Andres intertonguing anhydrite beds and salt, representing lower to upper sabkha progradational couplets, reflect dominance of sabkha sedimentation during upper San Andres deposition. The overall genetic aspect of the stratigraphy is a general southerly facies shift through time.

Porosity is best developed in subtidal dolomite facies. Facies mapping delineates areas of potential porosity preservation and is important to explorationists predicting updip San Andres porosity trends and pinchouts.

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Design and Function of Oil and Gas Traps

Oil and gas are found in traps. If we can understand what is going on in traps, we should be able to look back along the migration trail with special insight as to what has happened. That insight could even extend all the way back to the "source."

Traps are the most logical places for hydrocarbon mixtures to be put together as distinct oil and gas fluids. It follows that traps are not just passive receivers or containers of hydrocarbon mixtures put together elsewhere. Effective oil and gas traps of different well-known styles have a very important feature in common: structurally and stratigraphically, they are designed to discharge waters from depth. Thus they function as active focal mechanisms to gather and process feedstock waters carrying hydrocarbons and other organic materials. It is a forced-draft system. The concept adds an exciting new dimension to the anticlinal theory. It honors all factual observations around oil and gas deposits.

Very simply, the most important function of a trap is to leak water while retaining hydrocarbons. The water can leak because the enclosing membranes and cover are water-soaked, like a wick. The hydrocarbons and other organic materials are separated from the waters as they pass through the trap. The separation is caused by abrupt changes in pressure, temperature, and possibly salinity—those changes being related to the basic change in direction of feedstock (water) movement from lateral to upward. Coalescence of hydrocarbons makes bubbles or globules which cannot move so easily as water. The ultimate composition of a trapped hydrocarbon mixture depends on the respective residence times of the various components of that mixture which in turn depend on (1) what the water carries to the trap, (2) what the trap retains, and (3) the pore-volume exchange rate.

SANNES, TORSTEIN, Saga Petroleum U.S., Inc., Houston, Tex., and E. D. MINIHAN, Marshall R. Young Oil Co., Fort Worth, Tex.

Waveland Field, Unique Structural and Stratigraphic Trap

Waveland field, located in Hancock County, Mississippi, and currently being developed, was discovered in 1965 by Humble Oil and Refining Co. Gas Unit 1, Sec. 22, T8S, R15W. One additional field well was drilled, a northwest diagonal in Sec. 16, T8S, R15W. After these two field wells were completed and put on production, there was no additional development until 1975, when lease blocks were assembled by Phillips Petroleum Co., Saga Petroleum, Marshall R. Young Oil Co., and others.

There is no massive deposition of Ferry Lake Anhydrite in the area. Because of the lack of massive anhydrite, actual definition of the formations of the Trinity Group (Lower Cretaceous) is difficult to impossible. However, it is interpreted that the primary reservoir of Waveland, a porous limestone, is the Mooringsport Formation.

The depositional environment of the Mooringsport limestone reservoir is extremely complex because of the influence of the large regional carbonate banks on the south. For convenience, the Mooringsport porosity zones are lettered A through G. To date, the A and B zones are the primary contributors to production. The B zone may be subdivided within the field proper.

The reservoir rock is best described as a two-porosity system—matrix porosity (range 6 to 12%) and vugular porosity (range 7 to 16%) directly related to the mineralogy, lithology, and diagenetic history. Matrix permeability is generally low, not exceeding 2 md and usually less than 1 md. Fractures are essential for good productivity and intense fracturing is present in all the higher crestal positions.

The Waveland field comprises the crestal 19,000 productive acres (7,600 ha.) of a north-to-south-elongated nose having no apparent structural closure, fault closure, or north dip at the Mooringsport limestone level. Structural elevation at the Mooringsport level is a major factor in determining hydrocarbon saturation, but no direct relation has been found among pore-throat size, rock type, porosity, structural elevation, and hydrocarbon saturation. The Waveland field is a complex combined structural and stratigraphic trap.

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Evidence for Wrench Faulting, Southern Val Verde Basin, Southwest Texas

A structural analysis in the southwest Edwards Plateau area included four 15-minute quadrangles in Edwards, Kinney, and Val Verde Counties, Texas. Seven rock units of the Cretaceous Comanche Series and two units of the Cretaceous Gulf Series crop out. Subsurface Paleozoic foreland facies rocks of the southern Val Verde basin are present in the northern study area; the Devils River uplift, partly blanketed by allochthonous upper Paleozoic metamorphic rocks, underlies the southern part. A pronounced east-west-trending fault zone which cuts through the center of the study area is at least 55 mi (88 km) long and 1 to 2 mi (1.6 to 3.2 km) wide. This trend, named the Carta Valley fault zone, is characterized by a complex series of en echelon, northeast-oriented faults which are cross-cut by a lesser number of northwest-trending faults. These faults bound a series of grabens, downthrown by 200 to 300 ft (60 to 91 m), which are as large as 3 sq mi (7.7 sq km). Nine gently dipping, northwest-plunging, en echelon anticlines parallel the south side of the fault zone. The con-