of Johnson, Bretschneider, and Sverdrup and Munk. Whereas the curves are of the same form, there is a great amount of discrepancy. Burling's line is 15-25 percent below the other lines. Data from Lake Okeechobee, Florida, indicate that there is a transitional region between deep water and shallow water, where the wave height is affected by combinations of wavelength and depth of water.

The data from Lake Okeechobee align closely with Burling's results. However, Burling's observations were from a reservoir where the maximum fetch was about one km. In Okeechobee the fetch ranges up to 60 km. The Okeechobee study reveals that the proper method to define shallow-water waves should include fetch and wind velocities as well as the depth of water. The wave heights are lower than expected for lower wind velocities and higher than expected for higher wind velocities in shallow water, with limited fetch.

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Lithofacies Mapping, a Descriptive Tool for Ancient Delta Systems of Louisiana Outer Continental Shelf

Rocks of the Pliocene and Pleistocene Systems of the Louisiana outer continental shelf are divisible into three rock facies—massive sand, alternating-sand-shale, and massive shale. Similar to older Tertiary rocks of the inner shelf and coastal plain, these facies are related genetically to delta depositional systems. A description of the facies distribution for a discrete time interval can indicate the location of deltaic progradations and the approximate shape and seaward extent of their delta plains. The mapping technique requires a working definition of the individual rock facies to facilitate division of log-correlative time intervals into component facies. Separate isofacies contour maps are drawn simultaneously for each time interval, recognizing that deltaic progradations are shown by the massive sand isofacies map. The final lithofacies display map shows data relating to all three rock facies and thickness contours showing the distribution of massive sand and alternating-sand-shale facies.

An important interrelation exists between rock facies, structure, abnormal pore-fluid pressure, and the presence of hydrocarbons. Seismic techniques reliably can predict structure and abnormal pressure, and this knowledge can be integrated qualitatively into facies mapping where well control is lacking. Optimum sites for hydrocarbon accumulation can be localized by the recognition of deltas, the locale of their stillstands, and favorable structural and hydrodynamic trapping mechanisms.

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Paleodepositional Environments in Upper Jurassic Zuloaga Formation (Smackover), Northeastern Mexico

The Zuloaga Formation (Late Jurassic) is well exposed in the mountains of northeastern Mexico. It is stratigraphically equivalent to the Smackover Formation of the northern Gulf Coast. From 16 Zuloaga outcrops and a petrographic analysis of samples 12 distinct lithofacies are recognized within the formation.

The lithofacies and their inferred depositional environments are as follows (numbers 1 through 9 are shallow-water to supratidal deposits): (1) detrital facies—littoral marine to marginal marine to arid playa; (2) clean oolite facies—high-energy bar, shoal, or shelf; (3) muddy oolite facies—lagoon or shelf, washover; (4) clean pellet-fossil facies—medium to high-energy shoal and storm washover; (5) muddy pellet-fossil facies—intertidal to shallow subtidal; between shoals; (6) burrowed lime-mud facies—low-energy lagoon or low-energy shelf; (7) algal-laminated facies—very shallow subtidal to intertidal, possible supratidal; (8) oncolite facies—medium- to low-energy subtidal; (9) limestone-breccia facies—intertidal to supratidal storm deposit; (10) dolomite facies—environment unknown, possibly intertidal to supratidal; (11) evaporite facies—environment unknown, probably shallow, restricted lagoon; and (12) pelagic fossil lime-mud facies—low-energy shelf, deeper than facies 1 through 9.

The general range of paleoenvironments suggests a very shallow, slowly subsiding, trough-shaped epicontinental sea, the Mexican "geosyncline." A sequence of depositional environments, similar to those represented in the Mexican geosyncline area, may be expected east of the Tamaulipas Peninsula in the Mexican Gulf coastal plain. The Zuloaga Formation was deposited during a major marine transgression with many minor sea-level fluctuations.

The Zuloaga and Smackover Formations are very similar in lithology and depositional environments. Detailed studies of the Zuloaga may aid in defining facies relations in the Smackover, which is more difficult to examine because it does not crop out.

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Anomalous Brine Maps Yield Rapid Prospect Leads

Sediments in predominantly sand-shale basins have abnormally high salinity near faults and in the edgewater surrounding hydrocarbons. Anomalies can be seen readily when countywide maps are prepared on brine concentration at the top of the hydrocarbon-bearing zone. Faulting tends to yield a linear zonation of strong brines, whereas hydrocarbon anomalies appear similar to structural contours. About 80 percent of Gulf Coast fields have anomalous salinity waters in edge wells which are no more than 2,000 m from commercial production. Productive wells have redox potential which reduces SP and prevents accurate analysis.

Water composition is just one of the major variables used to evaluate a subsurface system. When combined with pressure gradients, temperature gradients, and redox-potential data, the hydrocarbon environment may be located within 2,000 m and classified with a rough production-probability index. Temperature gradients are influenced strongly by faulting and geopressure, whereas pressure anomalies correlate with the occurrence of gas and condensate production. For example, some counties in the Wilcox trend have most productive fields located over geopressure anomalies. The brine anomalies are on the edge of the abnormal pressure-gradient anomaly, which is opposite to the source of migration.

OXLEY, M. L., and DANIEL E. HERLIHY

Bryan Field—a Sedimentary Anticline

Although the Bryan field has existed as a producing structure since 1958, this is the first published data detailing the geologic history and origin of the structure. Drilling of the discovery well for the Jurassic (Cotton Valley) sediments was preceded by a detailed seismic program, which outlined an anticlinal feature corresponding to the shallow (Cretaceous) production.

On the assumption that the structure was a salt-cored anticline, the discovery well was permitted for 17,000 ft but was drilled to 21,105 ft before reaching salt. A reevaluation of the data reveals the Bryan field as a classic example of the sediment-cored anticline or turtleback structure. An unusual thickness of Haynesville sediments and a continued outward flow of salt into nearby salt-cored anticlines combined to produce the sedimentary structure which is the subject of this study.

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Preliminary Survey of Freshwater Early Tertiary Invertebrates from Trans-Pecos Texas

Freshwater invertebrates of early Tertiary age have been collected from eight scattered locations in Presidio and Brewster Counties in Trans-Pecos Texas. Most specimens are internal

molds of several gastropod genera of Eocene and Oligocene ages. Several specimens of a Paleocene pelecypod genus have been collected. Some small (10-25 mm in length), elliptical objects of uncertain paleontologic classification were found in Eocene, Oligocene, and lower Miocene.

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Geopressures and Secondary Porosity in Deep Jurassic of Mississippi

Deep drilling in the interior salt basin of Mississippi has revealed geopressured oil, gas, and water with high-pressure gradients. These geopressures are mainly in the Jurassic Smackover and Norphlet Formations, but also may be in overlying formations. The geopressures rise stratigraphically in a basinward direction and increase their gradients with depth. The highest documented Smackover pressure gradient in Mississippi is 1.06 psi/ft recorded in saltwater flows from a 23,455-ft wildcat. The highest Smackover gas gradient is 0.99 psi/ft at 22,250 ft. Pressure-gradient reversals are recorded in some parts of the basin.

Deep Smackover geopressures differ from relatively "leaky" geopressures in the Gulf Coast Tertiary in that they underlie nonshale crystalline seals with no transition zone. Deep Smackover geopressures cannot be predicted from compaction trends because cores reveal that geopressured Smackover sandstones are compacted severely, whereas their vuggy porosity is secondary in origin and is not a result of "undercompaction" related to geopressures as in the Gulf Coast Tertiary.

Geopressured gas mixes range up to 100 percent carbon dioxide and 78 percent hydrogen sulfide. The nature and distribution of these gases suggest they are late thermal migrants and late thermal metamorphic alterations of former oil reservoirs. The geopressures they have generated are young pressures in this "old" basin and are termed inflated and phase pressures, respectively. Associated geopressured acidic fluids appear to have dissolved available soluble minerals, thereby creating late secondary porosity in compacted sandstones which are now the deep gas reservoirs.

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Upper Depth Limits and Morphologic Variations of Foraminifera from Continental Slope and Abyss of Gulf of Mexico

Modern Foraminifera collected along three traverses across the Gulf of Mexico show that morphologic variations within species (clines) may serve as excellent indicators of bathymetry. Many species of Foraminifera are known to have restricted upper depth limits that can be used in making paleobathymetric interpretations. Penetration of Neogene offshore sediments of the Gulf of Mexico allows paleontologists to interpret paleobathymetry of sediment samples with a higher degree of accuracy through comparison of the ancient faunas with these modern counterparts.

Some depth-related morphologic variations of species, such as size, form, and ornamentation, are known to have importance in paleobathymetric interpretations and are useful in evaluation of an assemblage. The more obvious and important depth-related morphologic variations have been recorded for the genera *Uvigerina, Laticarinina, Gyroidina,* and *Hoglundina.* Genera which include especially significant depth-indicator species include *Gyroidina, Cibicides, Eponides, Oridorsalis, Cyclammina, Bulimina, Osangularia,* and *Alabamina.*

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Framework for Stratigraphic Interpretation of Dip Logs

Stratigraphic interpretations of dip logs have been attempted since the middle 1960s, with limited success. In many cases the dip-log information is not suitable for a stratigraphic interpretation. Deficient computation procedures for stratigraphic information and failure to remove postdepositional structural tilting are two common shortcomings.

Determination of the depositional environment of a sandstone requires consideration of (1) the paleocurrent dips within the sandstone, (2) dips in the units surrounding the sandstone, (3) and the depositional environment of the formation. Bar-type sandstones normally have internal paleocurrent dips in the same direction as the overlying shale dips. The paleocurrent dips in channel-type sandstones are perpendicular to the dips in the adjacent shales.

The sandstone interpretation generally should agree with a regional depositional model for sandstones. Marine-bar sands usually subparallel the regional depositional slope, whereas channel sands are perpendicular to the slope.

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Collapse-Fault Systems of Louisiana Gulf Coast

Collapse faulting is found circumscribing salt-withdrawal basins in the south Louisiana salt-dome province. The salt-withdrawal basins are the result of unusually large volumes of salt vacating a restricted area of the source salt bed to form peripheral salt intrusions. Such localized salt-withdrawal basins are not known in the upper Gulf Coast or interior salt basin because the salt intrusions in those areas are of smaller volume and more widely dispersed. In the lower Gulf Coast, areas are found where large intrusions of salt have occurred, salt domes are found clustered, or a salt ridge of extraordinarily large mass has risen. An abnormally steep-sided basin is associated with the unusually large intrusions of salt.

The sedimentary rocks overlying the salt-withdrawal area have collapsed periodically as salt was withdrawn and moved toward the surface at the periphery of the withdrawal area. The sedimentary collapse caused normal faulting parallel with, and on, the flanks of the newly initiated basin structure. The faulting, when viewed in cross section, tends to assume a conical configuration nearly conforming to the cross-sectional outline of the basin. These faults are referred to as collapse faults.

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Analysis of Energy Crunch

The peaking of domestic oil production in 1970 coincided with the first increase in the GNP unit cost of energy. Thus began the energy crunch that was well documented but unrecognized until the moratorium of Arab oil imports in 1973. Domestic drilling activity declined by more than 50 percent from 1956 to 1971. Corresponding average annual reserve additions declined by more than 30 percent. Restrictions on development of large reserves such as Prudhoe Bay resulted in loss of almost 2.5 million BOPD in 1974.

Industry is charged with irresponsibility but the record shows tremendous response to the crisis. Is there monopoly when the 30 largest companies account for less than 20 percent of U.S. drilling? About 600 operators drilled in the Rockies during 1973. Industry responded to increased prices with 30 percent more gas completions in 1973. In two provinces, first quarter 1974 stripper well recompletions increased by 100 percent. A study of Wind River basin indicates that even more incentives may be required to increase gas development in similar provinces.

It is uncertain that adequate incentives will be provided to meet the goal of energy self-sufficiency. Analysis of a recent U.S. energy model requires annual drilling of 53,000 wells to meet 1985 forecasts without depleting reserve/production ratios. Computer well-data files are available to assist the massive information analysis required for this task. Computer maps such as trend residuals assist in focusing exploration on the most favor-