both hiatuses and preserved sediments are approximately 1-2 m.y. The inferred Miocene glacial epochs are of the same duration as the glacial epochs of the Pliocene-Pleistocene. Oligocene hiatuses are found in all of the world's oceans, indicating cold bottom-following waters. Evidence (e.g., hiatuses or ice-rafted material) demonstrates the occurrence of Eocene continental glaciers in Antarctica. Interaction between the three planetary orbital parameters of eccentricity, tilt, and precession apparently control much of long-term climate change, with the dominance of eccentricity dictating glacial cycles. Continuity of climate pattern for the Tertiary is indicated, given constancy of planetary motion. Miocene, Frio, and Wilcox hydrocarbon reservoirs in the Gulf Coast should be reviewed in terms of a more subtle climatic model to refine interpretation of known depositional sequences.

MADDOCKS, ROSALIE F., Univ. Houston, Houston, TX

Ostracoda of Cretaceous-Tertiary Contact Sections in Central Texas

At the Littig Quarry in Travis County, the Navarro claystones yield sparse ostracod assemblages with low species diversity and equitability, dominated by *Haplocytheridea,* which suggest stressful coastal environments with rapid sedimentation. The ostracod assemblages in the overlying Midway glauconitic claystones are fully marine, moderately diverse, and characteristically Paleocene but sparse, except in the three condensed zones, the lowest of which marks the disconformable contact.

At Walkers Creek in Milam County, the Navarro assemblages are richer and of normal marine, nearshore aspect, with moderate diversity but low equitability, dominated by *Cytherella.* They belong to the "*Cythereis*" *lixula* interval zone, but perhaps not to the youngest part. The condensed zone at the disconformable base of the Midway yields a fully Paleocene fauna with moderately high diversity, either younger or farther offshore than at Littig, with a few reworked specimens of Cretaceous species.

On the Brazos River in Falls County, the Navarro claystones yield assemblages of offshore aspect with moderate species diversity and equitability; they belong to the upper part of the "*Cythereis*" *lixula* zone. A barren sandstone ledge marks a turbidite deposit at which a few Cretaceous species disappear. The claystones above this ledge have sparse, fragmentary assemblages, which gradually become more abundant, more diverse, and better preserved but less equitable upward, reflecting offshore but somewhat stressful conditions with intense naticid predation. *Brachycythere plena, Bairdoppilata suborbiculata,* and other characteristic Paleocene species appear one by one through this 3-m transitional interval, as holdover Cretaceous species gradually disappear, until a fully Paleocene fauna is established.

MALEK-ASLANI, MORAD, Tenneco Oil Co., Houston, TX

Plate Tectonic Controls of Hydrocarbon Traps in Carbonate Rocks

Recent advances in understanding depositional environments and diagenesis of carbonate rocks provide a wealth of information regarding the nature of carbonate hydrocarbon traps. Projections of such data from control wells to unexplored areas are somewhat limited in scope because of paucity of data. This problem is particularly acute in frontier regions, where observations from only a few wells must be projected into a vast unexplored area.

The effects of eustatic sea level fluctuations on the carbonate facies are another focus of recent research. Undoubtedly, sea level fluctuations greatly influence the environmental and diagenetic stratigraphy of carbonate rocks. Additionally, the subsidence mechanisms in various types of basins profoundly control the morphology and distribution of carbonate facies.

This paper documents the various influences of synsedimentary tectonics on development of carbonate traps in various plate tectonic settings. Understanding such models allows projection of environmental and diagenetic data from a limited number of control wells into the sparsely explored areas.

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Upper Jurassic Norphlet Hydrocarbon Potential Along Regional Peripheral Fault Trend in Mississippi, Alabama, and the Florida Panhandle

Recent Upper Jurassic Norphlet oil discoveries associated with the West Bend fault system in Clarke County, Alabama, and Foshee fault system in Escambia County, Alabama, have renewed interest in exploring for hydrocarbons along the regional peripheral fault trend in Mississippi, Alabama, and the Florida Panhandle. The recently discovered Chavers Creek and Sizemore Creek oil fields and the Strickland 10-4 2 oil discovery in Escambia County, Alabama, are upthrown to the Foshee fault system. The trapping mechanism at Chavers Creek field is a faulted salt anticline, and the petroleum trap at Sizemore Creek field is an elongate salt anticline. The 1985 Womack Hill Field Unit 14-5 oil discovery in Clarke County, Alabama, is upthrown to the West Bend fault system. The petroleum reservoirs at Chavers Creek and Sizemore Creek oil fields include eolian and wadi sandstones of the Norphlet Formation. Porosity is estimated to be 11-22%, and permeability is estimated to be 14-47 md. Oil gravity in Chavers Creek field is 42.7° API, and that in Sizemore Creek field is 59.9° API.

The Norphlet oil discoveries in Clarke and Escambia Counties, Alabama, and the existence of established productive Norphlet hydrocarbon fields in Mississippi, Alabama, and the Florida Panhandle demonstrate the petroleum potential along the regional peripheral fault trend in central and eastern Mississippi, southwestern Alabama, and the Florida Panhandle. The key to successful prospecting for hydrocarbons along this fault trend is to delineate faulted salt anticlines or other salt anticlines and identify reservoir-grade eolian, wadi, and marine sandstones of the Norphlet Formation.

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Sources of Pleistocene and Holocene Sand for Northeast Gulf of Mexico Shelf and Mississippi Fan

Grain shape, surface texture, and mineralogic analyses were conducted on the Pleistocene and Holocene sands of the northeast Gulf of Mexico shelf and the Mississippi fan to determine their sources. Two distinct petrologic provinces of sand are present in this area: the Mississippi province, characterized by spherical quartz grains derived from older strata in the drainage basin of the Mississippi River, and the eastern Gulf province, characterized by a mixture of spherical and elongate quartz grains. The former is derived from Cretaceous and Tertiary coastal plain strata; the latter is derived from sedimentary and crystalline rocks of the southern Appalachian Mountains.

Sand distribution patterns of these two provinces on the northeast shelf are distinct; Mississippi province sands are found in the western part of the shelf near the Mississippi delta, while Eastern Gulf province sands are found throughout the remaining parts of the shelf. However, sands of the Mississippi fan are a mixture of Mississippi and Eastern Gulf province sand. Glacial sand is uncommon in both the Holocene and Pleistocene deposits of the Mississippi province.

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Fluid-Flow Patterns in Central Tuscaloosa Trend, Louisiana

Contoured hydraulic-head cross sections constructed from well logs in the central Tuscaloosa gas trend of Louisiana provide information about fluid flow near the hydropressure-geopressure interface. Extensive head inversions correspond to long, dip-oriented convolutions of the interface. The inversions occur where permeable, hydropressured, massive sandstone facies in the lower Tuscaloosa underlie geopressured Eagle Ford Shale updip of fault zones that preserve geopressures downdip. Thus, regional fluid pressure regimes in the Tuscaloosa and Eagle Ford are predominantly structurally controlled, with some lithofacies control updip.

Hydraulic-head trends indicate an overall pattern of regional upward flow from depth, with highest hydraulic gradients corresponding to the top of the Austin Chalk in most places. This pattern is complicated by inversions—which are nearly horizontal and tend to show high hydraulic gradients—and by a sharp, upward-protruding head peak that becomes nearly vertical along a trend above the Lower Cretaceous limestone shelf edge. This peak represents the escape of highly pressurized fluids from depth along a preferred path, which may be fault controlled.

Highest hydraulic gradients occur locally and regionally where fluids flow from geopressured shale toward permeable, hydropressured sandstone. Salinities are also reported to show a regional increase toward

hydropressured, sandy, updip facies of the Tuscaloosa. Thus, reverse osmotic effects are probably unimportant. The head peak above the Lower Cretaceous shelf edge, although characterized by relatively low hydraulic gradients, could be a locus of membrane filtration at the top of Tuscaloosa sandstone if bypassing of reverse osmosis by fluid escape along faults has been minimal. The role of permeable Tuscaloosa sandstone as a sink for fluids near the top of geopressure may have localized gas along the producing trend.

MCNULTY, CHARLES L., DANIEL S. NEYBERT, and DONALD F. REASER, Univ. Texas at Arlington, Arlington, TX

Foraminifers of Lower Ojinaga Formation (Cretaceous), Southern Quitman Mountains, Hudspeth County, Texas

Three partial sections of the lower Ojinaga Formation were measured in the southernmost Quitman Mountains, near the Rio Grande. The lower Ojinaga is composed largely of medium-gray to black, variably calcitic shale, except for dark, flaggy, calcarenitic limestone and shale in the basal 20 m and for a few thin limestones and a dolomite above. Thirty-two residues and 75 thin sections were studied.

The foraminiferal populations are overwhelmingly planktonic; plankton-benthos ratios exceed 99:1 without exception. The fauna consists primarily of *Hedbergella amabilis* Loeblich and Tappan, *H. brittonensis* Loeblich and Tappan, *H. delrioensis* (Carsey), *H. planispira* (Tappan), *H. simplex* (Morrow), *Rotalipora cushmani* (Morrow), *R. montsalvensis* Mornod, *R. brotzeni* (Sigal), and *R. greenhornensis* (Morrow), although *Heterohelix* occur sporadically and poor preservation obscures possible *Praeglobotruncana* and *Whiteinella*. In addition to foraminifers, calcispheres and radiolarians equal or exceed the foraminifers in many samples. In varying proportions, the three taxa form minute laminae, commonly microscopically cross-bedded and disconformable in the calcarenitic biogenic limestones. Juvenile ammonites and protoconchs are common at the top of the section. Inoceramid prisms, oyster fragments, and fish debris occur in the coarser and thicker laminae.

The sequence sampled is generally correlative with the middle and upper Cenomanian and the lower Turonian. A more precise correlation suggests middle Cenomanian and lower Turonian with an intervening unconformity, although the taxonomic foundation is questionable.

The microfauna is markedly pelagic and typical of midbathyal or deeper depositional environments. The dark color and general lack of bioturbation suggest the possibility of bottom anoxia and consequent absence of benthic forms, but tests for organic carbon show only a modest elevation of total organic carbon, with a maximum of 2.7%.

The microscopic sedimentary structures of the biogenic flaggy limestones testify to gentle but definitely tractional current action at bathyal depths.

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Petrology of Sunniland, Forty Mile Bend, and Bear Island Fields of South Florida

The Sunniland and Forty Mile Bend fields were the first two oil producing fields of south Florida. The Sunniland field was discovered in 1943, and the Forty Mile Bend field was discovered 10 years later. These two fields are oil productive from the Cretaceous Sunniland formation, and their pay zones are biostratigraphically and lithologically similar. A similar lithology is also found in the pay zone of the Bear Island field, discovered in 1972. The relatively great time span between field discoveries is indicative of the slow pace of exploration in south Florida at that time. In the early 1970s, increased drilling (from 2 to more than 15 wells/year) resulted in the discovery of eight more fields. Since exploration started 73 years ago, only a little over 200 wells, both wildcat and development, have been drilled in this basin. Although exploration methods initially relied on gravity and magnetics, subsequent geophysical methods have proved disappointing. Effective exploration in this area applies to petrology, sedimentology, and electric-log response. Because the biostratigraphy of the Sunniland formation pay zone is not the same in all fields, three fields having similar biostratigraphic pay zones were investigated.

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Magnetotelluric Soundings in Ouachita Thrust Belt of Central Texas

A 25-station, 84-line-mi, remote referenced magnetotelluric (MT) traverse across a portion of central Texas has been recorded and analyzed. Among the geologic and geophysical elements crossed are the Ouachita foreland, the frontal and interior zones, and the rimming gravity maximum.

MT signatures of the allochthonous Ouachita facies have been established with the aid of well control and are correlated along the traverse. Both conductive foreland facies and the underlying resistive Precambrian can be traced beneath the resistive frontal thrust zone, but become indeterminate along the central part of the traverse, owing to abrupt thinning of the Precambrian resistor. Well control suggests that this resistive basement is correlative with the Grenville-age granitic basement of the nearby Llano uplift. A thick conductive interval of metasedimentary(?) basement material underlies Paleozoic rocks along the central portion of the traverse. This conductive basement appears to dip steeply beneath the Llano-type resistive basement and subcrops on the foreland flank of a basement antiform coincident with the rimming gravity maximum.

Still another resistive basement interval appears deep within the basement near the central portion of the traverse, and shallows abruptly to the southeast to form the core of the basement antiform coincident with the rimming gravity maximum. Stratigraphic relationships within the Precambrian basement suggest that the resistive basement, which cores the basement antiform, may be older than the conductive metasedimentary(?) and resistive Llano-type basement, and that the basement beneath the Ouachita trend is of North American affinity at least as far south and east as the rimming gravity maximum.

The MT signature of the subthrust foreland facies is truncated on the crest of the basement antiform coincident with the rimming gravity maximum. The geometry of the truncation suggests that the frontal thrust zone may have detached from the age-equivalent foreland facies near the present crest of the basement uplift, and that the distance between the foreland facies truncation and the foreland facies–frontal thrust zone boundary may serve as a crude minimum estimate of frontal thrust zone translation (about 60 mi).

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Correlation of Beds Within Ferry Lake Anhydrite of Gulf Coastal Plain

The Lower Cretaceous Ferry Lake Anhydrite is one of the most distinctive, widespread sedimentary units within the Gulf coastal plain. The formation extends from east Texas across southern Arkansas, northern Louisiana, central Mississippi, and southern Alabama, all the way to south Florida where it has been correlated with anhydrite beds of the Punta Gorda formation. The formation consists of alternating carbonates, claystones, and sulfate beds (altered from original gypsum to anhydrite during burial) deposited in a predominantly subaqueous environment within a broad lagoon located shoreward of an extensive reef fringing the shelf edge.

Highly resistive anhydrite beds within the Ferry Lake Anhydrite, and within formations above and below, may be correlated across east Texas, Arkansas, Louisiana, and Mississippi, using a network of closely spaced electrical logs. The geographic distribution of these anhydrite beds is variable. Some anhydrite beds may be traced across the entire area, whereas other beds are less widespread. The difference in geographic distribution of these beds reflects the variation in size and configuration of the extensive lagoonal sea in which they were deposited. Water depth, positive conditions around stable areas, subsidence, duration of each evaporitive pulse, and areal salinity variation are among the factors that controlled the thickness of individual beds accumulating within the lagoon.

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Modern Foraminiferal Species Diversity Patterns vs. Tidal Response: Louisiana-Mississippi Salt Marshes

Twenty-eight modern bottom samples from marshes in Hancock County, Mississippi, and Pearl River, Louisiana, yielded variable foraminiferal populations (total = live plus dead) during May and June 1981. Fourteen stations were sampled twice—at "peak" high and low tides.

We identified 22 benthic species of foraminifera in the samples (counts of approximately 300 specimens/sample); no planktonic species occurred. Diversity patterns [S = number of species, H(S) = Shannon-