the midwestern to the eastern states.

On the west coast, Pacific Gas Transmission Company, a Pacific Gas & Electric subsidiary, will upgrade existing lines from the U.S.-Canadian border to northern California. Interstate Transmission Associates (Arctic) will construct a pipeline extending from the U.S.-Canadian border near Kingsgate, B.C., to the Nevada-California border which will transport Arctic natural gas to various markets in the western United States, including the Pacific northwest and southwest. Southern California Gas Co. will transport gas from the California border to serve markets in central and southern California.

WAYNE, C. J., Dept. of Geology, Florida State Univ., Tallahassee, Fla.

Effect of Artificial Sea Grass on Wave Energy and Nearshore Sand Transport

The emplacement of offshore, artificial sea-grass beds directly influences nearshore sand transport. Artificial sea grass will decrease wave energy because of bending of the fronds, increased bottom drag, internal deformation, and refraction. The latter three effects change as a result of the increased bottom slope caused by the sea grass beds. In turn, the mean longshore current and longshore component of wave power are reduced. Total wave power and incident angle to the beach specifies the longshore component of wave power (P_L) which is equated to the quantity of sand moved per unit distance (dq/dx).

The average bending moment per individual frond was calculated to be approximately 2.0 lb-in. A dense bed of sea grass has the potential to reduce wave energy by 20 percent, on the basis solely of energy lost to bending. The reduction of wave height, corresponding to the energy loss, results in decreased wave power per unit distance expended at the breaker zone.

Ginsburg and Lowenstam reported that *Thallassia testudinum* offers a suitable substrate for many benthic communities. Algae, foraminifers, bryozoans, *etc.*, attach to the fronds, whereas mollusks, echinoderms, and crustaceans use the network of baffles for protection and food gathering. These organisms add substantially to the binding ability of the grass, and sediment will be accumulated readily within the bed. Variations in the type of community present will depend on wave energy (turbulence), temperature of the water, tidal range, and salinity. In areas of low-wave energy, embankments may grow forming a series of offshore bars which further will influence approaching orthogonals.

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Depositional Environments Interpreted from Stratigraphic, Seismic, and Paleoenvironmental Analyses, Upper Wilcox, Katy Field, Texas

Upper Wilcox deposits at Katy field in southeastern Texas are composed of terrigenous clastic facies. These rocks are the uppermost beds of the Wilcox Formation (late Paleocene to early Eocene), which crops out in central Texas and extends basinward to a known total subsurface thickness of 9,100 ft at Katy field. The upper Wilcox is 1,800 ft thick at Katy; however, only the upper 800 ft were included in this study. Analyses of the regional stratigraphy, structural trends, and paleobathymetric relations indicate that beds were deposited by high-constructive and destructional delta systems marginal to the subsiding Gulf of Mexico basin; resultant deltaic and interdeltaic facies ultimately were transgressed by open-shelf environments.

The depositional interpretation in vertical sequence begins with prodelta silty clay at the base and coarsens upward to very fine and fine-grained sands in a typical progradational delta-front sequence. Progradation was repeated after subsidence, yielding a second series of delta-front and overlying fluvial facies. The next vertical sequence consists of thinly laminated and burrowed silty clay and thin sand beds which locally are slumped and microfaulted, and sand units containing shale clasts. These thin units represent a period of minor sediment influx and consist mainly of interdeltaic marsh to offshore silty clay and destructional delta-front sand; local distributary channels cut into the bay-marsh transition facies. The third vertical sequence is largely offshore silty clay, thin glauconite beds, and thin silty sand units which transgressed the area as a result of increased subsidence. Local relict shoreline sand beds were deposited during temporary stillstands as the shoreline shifted landward.

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Calcareous Nannoplankton of Salt Mountain Limestone (Jackson, Alabama)

A sample of the Salt Mountain Limestone (Paleocene) from Jackson, Alabama, has yielded a diverse nannoplankton flora. Preservation differs greatly between species. Some forms are well preserved whereas others have been subjected to extensive dissolution and/or recrystallization. Placoliths generally are well preserved, but the centers of many specimens are obscured by pelatoid overgrowths. Many specimens also bear sparry extensions of isolated shield elements.

The presence of *Discoaster gemmeus*, and the absence of recognizable specimens of *Discoaster nobilis* and *Heliolithus riedeli*, places the Salt Mountain Limestone within the *Discoaster gemmeus* Zone. This suggests that the Salt Mountain Limestone is older than the Nanafalia Formation which has been placed in the *Heliolithus riedeli* Zone. Toulmin suggested that the Salt Mountain Limestone was an offshore facies equivalent of the *Ostrea thirsae* beds of the Nanafalia Formation.

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Evolution of Interior Mesozoic Basin and Gulf of Mexico

The evolution of the Interior Mesozoic basin is presented in terms of an evolving Gulf of Mexico which had its origin with the rifting and breakup of Pangea, particularly with the separation of North and South America. This Mesozoic event was preceded by the formation of Pangea in the late Paleozoic when plate collision produced the Appalachian-Ouachita-Marathon orogeny. As a result of this orogenic episode of plate collision and accompanying crustal dislocation along three major transcurrent-fault systems, the Texas, Wichita, and Mississippi megashears, a proto-Atlantic was closed and a distributive pattern of pre-Mesozoic rocks was created that was to have a lasting effect on the shape of the Interior Mesozoic basin.

Rifting in the Early Triassic created an incipient Gulf of Mexico with associated peripheral grabens that defined the shape of Mesozoic sedimentation. Crustal thinning and attenuation accompanied the divergent rifting of Pangea and early sedimentation in rift grabens are represented by the Eagle Mills Formation. Deltaic prisms are postulated, coincident with the three megashears, and represent the positions of ancestral Rio Grande, Red, and Mississippi Rivers. They augment the continental redbeds of the grabens formed during early rifting and the succeeding marine-shelf sediments of a diverging plate margin and constitute exploratory objectives.

The thick evaporite deposition, represented by the Werner evaporite and Louann Salt, in a shallow basin on a subsiding-plate margin is the result of a unique combination of events. The updomed rift margin of the trailing plate formed a restricting barrier that allowed the continued influx of sea water into the attenuated and rifted part of the plate that was subsiding to form the Interior Mesozoic basin. The sea water, on encountering the highly saline waters of thissubsiding basin, initiated rapid salt deposition by the brine-mixing method. Eastward rotation of Mexico into its present position deepened the Gulf of Mexico and peripheral rifting aided in continued submergence with normal marine deposition being established in Late Jurassic time.

DISTINGUISHED LECTURE ABSTRACTS

BERNOULLI, DANIEL, Univ. of Basel, Basel, Switzerland

New Views on Alpine Tethys Evolution Based on Joides Results

In the western central Atlantic, deep-sea drilling during Leg XI has revealed Late Jurassic to Cretaceous pelagic sediments that closely resemble Mesozoic sedimentary rocks exposed in the circum-Mediterranean orogens. This discovery is to be expected according to the concepts of plate tectonics because Alpine-type mountain ranges originate from the elimination and deformation of ocean basins and continental margins. In this context, the ophiolite belts of the central Mediterranean area are interpreted as remnants of oceanic crust and lithosphere which have been emplaced tectonically on the continental margins during Alpine orogeny. More specifically, close time correlations between the central Atlantic and Tethyan associations and palinspastic reconstructions suggest that the central Atlantic and the Alpine-Mediterranean Tethys had, during their early evolution, a parallel paleotectonic development and also were, at least from the Late Jurassic onward, connected directly to each other.

In the Alpine-Mediterranean region Mesozoic pelagic facies are present in both true oceanic and continental-margin settings. In the latter, these facies overlie Bahamian-type platform carbonate rocks lying ultimately on a continental crust. The oldest, Triassic, pelagic sediments were deposited in basins resulting from early rifting. Ophiolites of possible Late Triassic age reported from Turkey suggest that a small ocean was formed in the eastern Mediterranean area at that time.

During the Early Jurassic, the continental margins of the evolving Tethys were affected by block faulting and many of the former shallow-water sites were submerged; in these regions platform sedimentation was replaced by pelagic and turbiditic carbonate sedimentation and generally is analogous to the Cretaceous-to-recent geologic history in the Blake Plateau and the deeper troughs of the Bahamian region. Joides results and the magnetic-anomaly pattern suggest that this phase of block faulting 180 m.y. ago coincided with early rifting in the central Atlantic. The opening of this part of the Atlantic obviously implies translational movements between Africa and Eurasia and, in fact, a more or less synchronous opening in the central Mediterranean Tethys is confirmed by radiometric data and the age of the oldest sediments. Transform movements are suggested by the local abundance of tectonic breccias in the oceanic realm (ophicalcites) and by indications of compressive movements as early as Late Jurassic.

The oldest sediments recovered from the central Atlantic are greenish-gray and red, slightly nodular limestones of Late Jurassic age. These limestones are very similar to the Tethyan Ammonitico Rosso. However, the Ammonitico Rosso occurs in deeply submerged continental margin settings—different from what is observed generally; the first sediments deposited on the newly formed oceanic crust in the central Mediterranean were not pelagic limestones but radiolarites. As these radiolarites encroach locally on the deeply submerged continental margin, they may reflect a different current system resulting in a higher position of the calcite-compensation depth.

From the Tithonian onward, white and gray chalky limestones and nannoplankton oozes were deposited in the western Atlantic and most of the deep parts of the Tethys. The transitional contact with overlying black clays indicates that compensation depth was reached in the truly oceanic realm during the "middle" Cretaceous. However, the occurrence of ophiolitic olistoliths in the Mediterranean association indicates the tectonic emplacement of large ophiolite nappes in thelateEarly Cretaceous and a diverging history of central Atlantic and Tethys from that time forward.

A quantitative evaluation of the different plate movements in the Tethyan realm is still far from being reached, but comparisons of deformed and undeformed continental margins and ocean basins may help to provide some of the premises for such an attempt.

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Environmental Impact of Offshore Petroleum Operations

The state of Louisiana has more offshore petroleum platforms than all other states combined. The adverse environmental impact of these offshore "rigs" and their attendant operations is minimal, despite claims to the contrary by certain environmentalists, congressmen, and citizens.

Every day, many fishermen and divers leave the coastal Louisiana area and venture offshore to take advantage of some of the finest fishing and most interesting diving in the United States. Almost without exception, these fishermen and divers go to rig platforms because of the concentration of marine life near these structures.

Offshore platforms not only favor fishing because they provide food and shelter for marine life, but also offer protection to the recreationalist should a boat break down or severe weather endanger him, and give navigational aid to the mariner. The offshore petroleum industry has created these unique features in the Gulf of Mexico. Burning flares, abandoned platform locations, working rig sites, underwater completion installations, buried pipelines along the Gulf floor, and underwater vents which allow volatiles to bubble to the surface attract concentrations of, and become havens for, fish.

Both commercial and sport fishing have increased in the Gulf since the offshore petroleum industry was born in 1947 off Grand Isle, Louisiana. Gulf Coast fish tonnage doubled from 1940 to 1950 and again from 1950 to 1960. The tonnage increased 31 percent from 1960 to 1970. Louisiana, with her offshore platforms, has supplied the bulk of the fish production over the past five years—1969 through 1973—Louisiana's contribution to the total Gulf catch has ranged between 62 and 67 percent. Converted to percentage of total United States fish input for the same period, Louisiana has supplied between 21 and 28 percent of the entire United States catch of commercial fish.

No state surpasses Louisiana's annual catch. Because of its large fish concentration, offshore Louisiana is a growing attraction for fishing vessels from other states and nations too. Louisiana's fishing waters are so rich that new fisheries have been created for the United States. The Gulf trawl fishery for large croakers is one example.

Drilling production has not harmed permanently the marine life off the Louisiana coast, or the environment in which this life flourished. The petroleum industry is striving to insure that it can continue to make this claim.

DAVIS, GREGORY A., Consultant, Portland, Ore.

Plate Tectonic Models for Thrust Faulting in Southwestern United States

The Cordilleran orogenic belt of western North America is the product of sedimentational, magmatic, and tectonic processes along a continental margin initially formed by rifting in late Precambrian time. Deformation in the orogen is attributable to diverse interactions of the North American and various oceanic plates across that rifted margin. Phanerozoic deformation in the western United States largely has been due to convergent-plate interactions. As a consequence, thrust faulting is the most characteristic expression of pre-middle Tertiary Cordilleran orogenesis. Episodes of plate convergence may have been accompanied