marine shelf containing sporadic patch reefs; a predominantly siliciclastic slope.

Numerous basinward-trending channels, commonly about 35 m deep and 400 m wide, are incised into the shelf and slope systems. The channels were cut and filled by shelf-derived, saline density currents. Breaches created by storms in the shoal complex allowed dense saline water, which had accumulated in the lagoon, to spill basinward as gravity-driven underflows beneath the less dense normal-marine waters. The bottom-hugging currents dissected the shelf and slope systems eroding deep basinward-trending channels. Large volumes of lagoonal sediments were moved through the channels in traction transport, ultimately filling the channels. Eventually the flows that maintained the channels ceased, resulting in channel abandonment and annealing of the shelf shoals and a return to normal shelf and slope processes.

The sandstone-filled channels extend as subparallel nonbifurcating features far into the basin environment and thus differ markedly from radially branching submarine fan channels. In contrast to offlapping lobes observed in submarine fan deposits, the Delaware Mountain Group channels are probably backfilled, resulting in onlapping siliciclastic packages.

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Microfossils from Type Relizian and Luisian Stages of California

Kleinpell designated the strata of the Monterey Formation in Sec. 28, T28S, R14E, as the type locality of the Luisian Stage. Microfossils from this section, however, were never described; instead, the Luisian Stage was characterized by foraminiferal faunas in strata from Reliz Canyon that overlie strata of the type Relizian Stage. The two Relizian and three Luisian Zones described by Kleinpell can be recognized in the benthic foraminiferal faunas from recently collected samples from Reliz Canyon. This sequence of zones cannot be recognized in benthic foraminiferal faunas of the type Luisian section or in the nearby Wilson's corner section, partly because the Reliz Canyon faunas represent deeper and more diverse faunas than those from the type Luisian area.

In the Reliz Canyon section, benthic foraminiferal faunas diagnostic of the Saucesian-Relizian boundary coincide with the base of the *Helicosphaera ampliaperta* Zone. The Relizian-Luisian boundary as indicated by the benthic foraminifers occurs near the *H. ampliaperta-Sphenolithus heteromorphus* boundary. Poor preservation and limited exposures prevent a more definitive calibration. Occurrence of late Luisian benthic foraminifers with meager floras containing *Cyclogargolithus floridanus* suggests an age no younger than the lower part of the *Discoaster exilis* Zone. In the type Luisian section, benthic foraminifers diagnostic of the Luisian Stage occur both above and below strata designated by Kleinpell as type Luisian. Nannofossil floras in the lower part of the type section are indicative of the *S. heteromorphus* Zone and diatoms diagnostic of the *Denticulopsis lauta* Zone and the lowermost part of the *D. hustedtii-D. lauta* Zone also are present. Sparse radiolarian faunas are dominated by long-ranging species, typical of present-day California-current faunas.

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Resedimented Deposits and Evolution of Thornton Reef (Niagaran) Northeastern Illinois

The significance of the Thornton reef, long established as a major reef model by paleoecologic studies, is enhanced by the recent recognition that significant volumes of the reef were deposited by submarine sediment-gravity flows and that these resedimented deposits document a distinct stage of reef growth. The Thornton reef (2 km diameter) is an erosionally truncated carbonate buildup that consists mostly of flank beds that dip steeply (30 to 40°) and radially away from the reef's center. The flank beds are thin, even, continuous, and consist of syndepositionally cemented crinoid wackestone and packstone. They were deposited by in-place sediment accumulation. In contrast, the resedimented conglomerates, which comprise 10 to 20% of the reef, occur as wedges, tongues, and sheets 0.1 to 25 m thick of lithoclast/skeletal wackestone/packstone. Lithoclasts range from 1 mm to 20 m across, and are made up of wackestones and boundstones. Debris flows were probably responsible for the thick boulder-bearing tongues and sheets in the interreef facies. A more prevalent and enigmatic resedimented deposit consists of steeply dipping (to 15°) wackestone/packstone conglomerate wedges that mantle the reef's outer margin. These are interpreted as the product of grain cascades down the reef flank.

Clasts in the resedimented deposits, derived from the now-eroded part of the reef are more stromatoporoid-rich and faunally diverse than the contemporaneous flank. This difference is attributed to a more energetic environment in the eroded part of the reef. There is no evidence in these clasts for lagoonal restriction, emergence, or shallow-water surf action.

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Applications of Fluid Inclusion Studies to Reservoir Diagenesis and Petroleum Migration: Smackover Formation, U.S. Gulf Coast, and Fateh Field, Dubai

The Smackover trend of the United States Gulf Coast is a prolific producer of oil and gas. The distribution of porosity is partly controlled by precipitation of late, void-filling calcite. The timing of the formation of these cements is interpreted from fluid inclusion geothermometry. In general, the fluid inclusion filling temperatures closely approximate those of the formation of the calcite and indicate that cementation occurred near the maximum depth of burial. The trapped fluid is a dense calcium-rich brine, consistent with modern formation fluids. The geochemistry of the fluid inclusions reflects the environment of diagenesis; for example, H_2S-rich inclusions occur in cements from deep, dolomitic, reservoirs.

The Fateh field, offshore Dubai, has estimated petroleum reserves of 2.3 billion bbl of oil. Production is principally from the Mishrif Formation, an Upper Cretaceous rudist reef complex. Late, coarse-grained, calcite cements partly occlude porosity. These cements contain both aqueous and oil-bearing fluid inclusions. Fluid inclusion geothermometry indicates temperatures consistent with the geothermal gradient indicating a Miocene age for cement deposition. Since oil was trapped during growth of the calcite cement, petroleum generation and migration are also Miocene in age. Preliminary analyses of the oil trapped in inclusions show it to be different than the oil in the reservoir. The oil trapped in the inclusions may be an early generated, less mature, oil.

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Distribution of Foraminifera on North Florida Atlantic Inner Continental Shelf

Total (living and dead) foraminifera in 194 sediment samples from the Atlantic inner shelf, between the Georgia-Florida border and Cape Canaveral, were studied to determine the distribution of principal assemblages. North of 29°10′N (vicinity of Daytona Beach), the inshore zone contains a typical assemblage with relatively low species diversity, dominated by *Elphidium* and *Ammonia.* Seaward of this zone, to the limit of sample coverage (23 km offshore), there are two interspersed assemblages, both more diverse than the inshore assemblage. One assemblage, dominated by *Elphidium* and *Quinqueloculina,* is found mostly on medium to coarse sand; the other, an *Elphidium/Quinqueloculina/Cibicides* assemblage, predominates on fine sand substrates. From 29°10′N south to Cape Canaveral, few samples contain assemblages characteristic of the northern sector. The inshore assemblage contains increasing numbers of *Quinqueloculina* while the offshore zone contains mainly a *Elphidium/Quinqueloculina/Hanzawaia* assemblage. In the inshore zone, several species more characteristic of the fauna farther seaward appear in the samples. Available evidence suggests that this occurrence is primarily the result of onshore transport of tests rather than changes in inshore environmental factors.

Because of the irregular shelf topography of the study region, depth and distance seaward are not as directly related as on flatter shelves, making it possible to compare the relative importance of these factors to assemblage composition. This comparison shows that in both sectors there is a significantly greater correspondence to distance offshore than to water depth.

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Overview of Geothermal Exploration on Western Slopes of Mt. Hood, Oregon

Since 1977, Northwest Geothermal Corp., the U.S. Geological Survey, the Oregon Dept. of Geology and Mineral Industries, and the U.S. Dept. of Energy have cooperatively explored the western slopes of Mt. Hood, Oregon, for geothermal water suitable for direct utilization. The high regional heat flow of the Cascade Mountains provided the impetus for the exploration. A possible magma chamber associated with Mt. Hoodenhanced the prospect. The anticipated resource is deep circulating meteoric waters.

The stratigraphic history of the western Mt. Hood area is one of andesitic volcanism from late Oligocene to Holocene. The Miocene basalts of the Columbia River Group interrupt and locally interfinger with this sequence. A large quartz diorite stock of questionable age is exposed immediately southwest of Mt. Hood.

The regional structural setting has been interpreted to be a right lateral wrench tectonic system resulting from north-south compression. Major northwest-trending right lateral faults with some vertical component, and northeast-trending antithetic faults were mapped. Low amplitude en-echelon west-northwest-trending folds are present in the younger rocks. An older northeast-trending fold pattern, coupled with thrusting, was mapped in the basalts of the Columbia River Group.

The exploratory drilling program was designed to develop stratigraphic, structural, and hydrologic information, as well as to establish the geothermal gradient. The initial 564-m observation well in the Old Maid Flat area of Mt. Hood yielded a conductive gradient of 67°C/km. Gradients on the western side range from 20 to 83°C/km. Two deep tests (1,220 m and 1,837 m), funded by DOE, have been drilled. Both wells, while finding no fluids, have conductive gradients to total depth.

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Cretaceous Black Shales in Angola Basin of South Atlantic Ocean

Conditions favorable to deposition of black shales in the deep ocean occurred several times during the Cretaceous. Anoxic sediments were laid down in the South Atlantic during two distinct periods, the Aptian-early Albian and the late Albian-Coniacian. At site 530 of DSDP Leg 75 in the Angola Basin, black shales averaging 5.1% and containing up to 16.5% organic carbon were found in a late Albian-Coniacian turbidite sequence. Shipboard analysis shows most of the organic matter to be of marine origin, although several layers contain some terrigenous material. Based upon Rock Eval pyrolysis and the absence of significant amounts of light hydrocarbons, all of this organic matter is classified as immature. Thicknesses of the black shale layers are generally several centimeters or less, and they are separated by fine-grained turbidites containing less than 0.3% organic carbon. These Aptian-Coniacian shales seem to be the result of downslope density flows of shelf-edge sediments rich in organic matter. Preservation of organic matter was a result of rapid burial, not by stagnant basin waters. Furthermore, this mode of preservation appears to be responsible for the Cretaceous black shales throughout the South Atlantic.

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Recent Benthic Foraminiferal Biofacies from Northeast United States Continental Slope and Rise

Several bathymetrically consistent Recent benthic foraminiferal biofacies have been recognized from the continental slope and rise between Cape Cod and Cape Hatteras. Faunal assemblages are dominated by *Globobulimina/Bulimina* (upper slope), *Uvigerina peregrina* (lower slope), *Hoeglundina elegans* (middle rise), and *Nuttalides umbonifera* (lower rise). These biofacies are associated with various hydrographic and substrate conditions.

Uvigerina peregrina dominates the benthic foraminiferal fauna in water depths between 1,000 and 2,500 m. This species has been used as an indicator of bathyal water depths, deep-water paleotemperatures between 3 to 4°C, or water of low oxygen content. However, interregional correlations between *U. peregrina* and water depth or temperature are not always maintained. On the continental slope and rise, the species is not associated with low oxygen in the water column. The highest abundances of *U. peregrina* closely coincide with maxima of organic carbon and silt within the slope sediments. This suggests that its distribution may be influenced by low oxygen in the sediments or adjacent bottom waters, rather than by low oxygen water masses.

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