

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 non-bifurcating 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 overlapping 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 Saucian-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. Nanofossil 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, H₂S-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