some intercalated thin turbidites and enterolithic slump folds, whereas coarse turbidites were funneled into the deep basin plain. These hydrocarbon-saturated turbidite sandstones are derived from fluvial systems draining crystalline hinterland.

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Hydrocarbon Occurrences in Nonmarine, Pre-Salt Sequence of Cabinda, Angola

The nonmarine, pre-salt sequence of offshore Cabinda, Angola, is a prolific hydrocarbon producer. Thick, organic-rich, lacustrine shale was the source of the oil trapped in four distinct, nonmarine, reservoir rocks.

Subsidence followed by the formation of deep grabens introduced the Early Cretaceous rifting of the South Atlantic. The resultant basins of west Africa were filled with up to 2,500 m of nonmarine deposits. Aptian salt overlies the nonmarine deposits. Pre-rift and syn-rift strata are distinguishable in the pre-salt sequence and are separated by major unconformities. Hydrocarbons occur in both the pre-rift and the syn-rift strata.

The mostly clastic, pre-rift strata rest unconformably on metamorphic basement and were deposited in fluvial-lacustrine environments prior to active rift faulting. Today, the pre-rift strata are in tilted fault blocks dipping 20° or more. The Lucula Formation, a fine-grained sandstone in the pre-rift strata within these blocks, is one of the major productive reservoirs of West Africa.

The syn-rift strata, which unconformably overlie the pre-rift rocks, gradually filled the deep graben lakes produced by initial rift faulting. Organic-rich dolomitic shale, the source rock for both pre- and syn-rift reservoirs, grades upward into shallow-lacustrine green shale and carbonate rocks. The shallow-water, nonmarine carbonate rocks are important reservoirs. Final rifting caused gradual westward tilting and erosion of the syn-rift topography. Nonmarine carbonate rock and sand unconformably filled the resultant surface. Along the eastern margin of this basin fill, carbonate reservoirs produce oil.

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Tidal-Current Sand Waves in Vineyard Sound, Massachusetts

Response of bed forms to tides and storms was studied for 8 months on Middle Ground Shoal, Vineyard Sound, Massachusetts, which has a nearly bi-directional tidal ellipse parallel with the shoal axis. Bed forms are on three scales: sand waves (H, one to several m; λ, 20 to 200 m), megaripples (H, up to 1 m; λ, 1 to 20 m) and ripples ($H < 10$ cm; $\lambda < 1$ m). Ripples are superimposed on both sand waves and megaripples; megaripples are commonly superimpsed on large sand waves. Four transponder-navigated surveys with $\pm$ 1 m accuracy were made with 200-kHz narrow-beam echo sounding and side-scan sonar. Successive charts of sand-wave crest positions were inter-compared to measure sand-wave migration. One wave at the edge of the sand-wave field was studied during several deployments of a tetrapod instrumented with four acoustic-travel-time velocity sensors at 30, 50, 100, and 300 cm from the bed, a bottom camera, and a 4-mHz sonic profiler to record bed heights. Sand waves show a slight upslope component of migration. Flood and ebb waves are separated by a 100 to 200-m belt of symmetrical waves at the shoal axis; some crests are continuous across the entire shoal. Flood or ebb migration ranged from 2 to 28 m during the 8-month period, but certain segments of waves migrated much more than other segments. Superimposed megaripples, which migrate too rapidly for survey-to-survey correlation, were monitored by divers using a staked and measured line over a sand wave; these forms, with H up to 1 m and λ up to 20 m, migrated a full wavelength in up to several weeks.

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Rb-Sr Dating of Diagenesis—Epigenesis in Mesozoic Rocks, San Juan Basin, New Mexico

The Rb-Sr radiometric age determination method has been applied to problems of dating diagenesis-epigenesis in the southern San Juan basin, New Mexico. Nonmarine and marine units of the Morrison Formation (Late Jurassic) and Dakota and Mancos formations (Cretaceous) have been examined. Clay minerals from the $-2\ \mu$ fraction, when carefully characterized by X-ray and SEM techniques, are especially useful if maintained at low oxidation potential conditions since the time of the last diagenetic or epigenetic effect on the rocks. Montmorillonites, illites, and mixed layer montmorillonite-illite from the Westwater Canyon and Brushy Basin Members of the Morrison Formation yield a composite date of $130-140\pm15$ m.y.B.P., although the errors for individual units are larger. Chlorite-rich fractions penecontemporaneous with uranium mineralization in the Grants Mineral Belt yield dates of 139 ± 10 m.y.B.P. for early epigenesis and, where remobilization has occurred, dates commonly cluster about $110-120$ m.y.B.P. Dates on the Dakota Formation (93 ± 8 m.y.B.P.) and Mancos Formation (83 ± 7 m.y.B.P.) are consistent with K-Ar dates reported for these units. In general, low CEC clay minerals formed during or slightly later than sedimentation yield the most useful information; an exception is kaolinite-rich material which may prove to be more useful in determining the age of source area material.

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Geochronologic Evidence for Paleozoic Plutonic Activity in Florida Mountains, New Mexico

Plutonic rocks of the Florida Mountains, New Mexico, have been mapped both as Precambrian and as Mesozoic. Corbitt and Woodward demonstrated that the Floridas are bisected by the southern Cordilleran thrust belt, and Brookins reported Precambrian Rb-Sr dates from south of the thrust for granitic rocks while alkali granites-syenites from north of the thrust yielded scat-

tered, apparent dates ranging from Precambrian(?) to Paleozoic(?). R. E. Denison had earlier determined K-Ar and Rb-Sr mineral dates from the northern rocks to range from approximately 380 to 550 m.y.B.P., although these dates were considered spurious as plutonism in southern New Mexico has conventionally been assumed to be either Precambrian or Mesozoic-to-early Tertiary. Field relations for the northern block suggest some alkali granites-syenites are intrusive into the Bliss Formation (Cambrian-Ordovician) but younger than mid-to-late Paleozoic rocks, although the intrusive contacts have been questioned. New major and trace element chemical studies indicate a transition from alkali granite to syenite for the northern block and, more important, fresh material from drill cores has yielded Rb-Sr whole rock ages of 378 ± 19 m.y.B.P. (alkali granite suite) to 423 ± 24 m.y.B.P. (syenite suite) with a composite date of 405 ± 18 m.y.B.P. This age confirms Denison's work and argues for previously unrecognized Paleozoic plutonism in southern New Mexico, although it is not known at present whether this date represents a western extension of Ouachita-dates (i.e., parallel to the Texas lineament) or a separate, isolated event. Regardless, other apparent-Paleozoic dates from southern New Mexico must now be reexamined in light of the dates from the Floridas.

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Unusual Ponding of Sediments on Deep-Water Reef

The Florida Middle Ground is a deep-water coral reef on the outer continental shelf in the northeastern Gulf of Mexico. The reef consists of two parallel north-trending ridges, each about 50 km long and rising 11 m from the shelf to a depth of about 26 m. The ridges are separated by a broad, flat, sediment-filled valley about 8 km wide. The south end of the valley is partly occluded by irregular knolls. Station data (in transects) were collected over several seasons by Shipek grab, scuba team, and manned submersible. Detailed textural and constituent analyses of valley sediments reveal sand-sized carbonate material unlike the finer sands and silts found on the adjacent continental shelf. The percentage of terrigenous material in the valley is substantially less than that of the surrounding shelf.

Hurricanes, frequent storm fronts, the Gulf Loop Current, and semidiurnal tidal currents together comminute and erode ridge constituents. Those constituents transported between the ridges are mixed and trapped with shelf sediments. An accumulation of up to 5 m of sediment, over twice the thickness on the adjacent shelf, is ponded in the valley.

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Entrada Oil Fields of Southern San Juan Basin, New Mexico

Twenty-two years elapsed between the discovery of the first Entrada (Jurassic) oil field at Media, Sandoval County (T19N, R3W) in 1953 and the discovery of Eagle Mesa, Sandoval County (T19N, R4W) in 1975. In the last two years, four additional but similar pools have been found at Ojo Encino, McKinley County (T20N, R5W), Papers Wash, McKinley County (T19N, R5W), Snake Eyes, San Juan County (T21N, R8W), and Leggs, San Juan County (T21N, R10W). These recent successes resulted from regional geologic studies, a reevaluation of the Media field, and the employment of high-resolution seismic techniques and processing. Oil is trapped in Entrada eolian sand dunes that have been preserved by the overlying lacustrine limestone and anhydrite of the Todilto Formation. Hydrodynamic influences have tilted the oil-water contacts in some of the fields. The oil, which is believed to have been generated within the Todilto limestones, is of medium gravity and high pour point. The geology, drilling, completion, and production of sample fields are discussed.

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Diagenesis of Lower Coralline Limestone (Chattian), Maltese Islands

The sequence of diagenetic fabrics in the lower Coralline Limestone (Chattian) on the Maltese Islands suggests that there was one phase of early marine cementation followed by at least two periods of phreatic cementation. Cements of marine origin include fine fibrous cement on algal and foraminiferal debris, and clouded syntaxial overgrowths on echinoid fragments. A younger generation of clear overgrowths on echinoid fragments displays luminescent zones that are restricted to the lower Coralline Limestone and lower member of the Globigerina Limestone and can be correlated throughout the Maltese Islands. These clear overgrowths are phreatic and formed both before and during sediment compaction. Subsequent phreatic cementation produced fine to medium-grained, non-luminescing scalenohedral calcite crystals that postdate compaction. The final stage of phreatic cementation consists of fine to medium-grained equant void-filling spar that is non-luminescent. Vertical and lateral distribution of phreatic cements and compacted textures is irregular and discontinuous. In general, well-cemented horizons also show overcompacted textures.

The relative timing of these diagenetic features indicates at least two episodes of emergence and meteoric cementation related to the development of freshwater lenses within the lower Coralline Limestone. Erosional and unconformable horizons in the overlying Miocene formations may record times of freshwater alteration corresponding to periods of eustatic lowering of sea level and emergence of the entire central Mediterranean platform.

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Geologic History of Deep Southeastern Gulf of Mexico Basin—Seismic Stratigraphic Interpretation Ahead of Drill

A seismic stratigraphic analysis of multifold reflection data from the deep water part of the southeastern