deposition of sand by low-concentration to high-concentration, submarine density currents and associated tractive currents.

The fine to very fine-grained sandstones are well-cemented quartz arenites with porosities commonly 10 to 15% and permeabilities commonly around 0.1 to 1.0 md. Abundant fractures in the brittle sandstone provide the necessary reservoir permeability to allow commercial gas production.

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Tertiary Sea-Level Movements Around Southern Africa

Sedimentologic, micropaleontologic, and seismic-profiling data elucidate the history of Tertiary sea-level movements around southern Africa. These new data show that landward movement of the sea began in early late Paleocene time and continued into the early Eocene. The sea probably reached its maximum Paleogene height during the early Eocene, and is today represented by outcrops up to at least 204 m, and probably as high as 360 m, above sea level. A brief regressive pulse occurred during the middle Eocene, and renewed transgression in the late Eocene. A major regression followed, spanning all of Oligocene and early Miocene times. This regression exposed much of the continental shelf. It is clearly represented on seismic-reflection profiles as a widespread unconformity.

The major Neogene transgression began in the middle Miocene but probably only reached the present coastline by late Miocene time. This transgression continued into the early Pliocene, but was interrupted by a brief regressive pulse in the earliest Pliocene. Seas withdrew again in the late Pliocene. Units deposited during the Miocene-Pliocene transgression are today found up to at least 300 m above sea level.

This scheme should be viewed as showing only the gross movements of the seas around southern Africa during the Tertiary. Local subsidence or uplift may have caused one area of the coast to submerge or emerge earlier than another area. Nevertheless, the timing of these southern African transgressions and regressions closely parallels the timing recently established for sea-level movements in other parts of the world.

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Sedimentology of Some Precambrian Iron Formations

Six of the best known Precambrian iron-formation basins of North America display consistent patterns of sedimentation. In three of the basins, the iron formations are almost exclusively lutaceous, contain few sedimentary structures other than lamination, and include representatives of all four of James' sedimentary facies. In the other three basins, the iron formations are predominantly arenitic and contain a much wider variety of sedimentary structures. All four of James' facies are represented among their lutaceous members, but the arenitic portions belong only to the oxide and silicate facies. The predominantly arenitic iron formations are underlain by coarsening-upward, quartzose shelf sandstones, whereas the predominantly lutaceous iron formations are underlain by slate-turbidite sequences and/or pillow lavas. Five of the iron formations are overlain by slate-turbidite sequences, and the sixth is truncated unconformably. Several conclusions can be made. (1) The iron formations vary considerably in their internal sedimentary character and lie conformably between siliciclastic rocks deposited in a variety of marine environments. Hypotheses that restrict the deposition of iron formation to a nonmarine or to a specific marine environment are not likely to have broad applicability. (2) The sedimentary structures and the stratigraphic settings show that the lutaceous iron formations are relatively deep-water sediments; yet some belong to James' oxide facies. The dominance of ferric iron is not sufficient to prove a shallow-water depositional environment. (3) The similarities between the character of a given iron formation and that of the siliciclastic unit beneath it suggest a close environmental relation between the two.

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Slumps on Upper Continental Slope, Northeastern United States—Observations from Submersible

Many large sediment slumps have been mapped along the eastern continental slope of North America. Most of these features have been observed on high-resolution seismic profiles, but few have been observed from submersibles. Although seismic profiling is an effective means for mapping slumps, it has limitations. For example, it cannot be used to resolve small-scale features, especially on slopes greater than 15 to 20°. To define such features, slump and interslump areas along the uppermost continental slope in Lease Area 49 in the Baltimore Canyon Trough area and south of Georges Bank were examined by in-situ observations during 24 submersible dives. These dives revealed slump scars characterized by slopes of 20 to 45°, clay outcrops, and borings and depressions inhabited by a diversity of megabenthic crustaceans and fish. Below the scars, step topography, reverse slopes, and hummocky seafloor were observed. Small slumps were observed at shallower depths (170 to 366 m) than previously had been resolved by seismic profiles. In contrast, areas with no slumps were characterized by smooth, gently dipping (5 to 8°) seafloor and sparse fauna.

Slumps are potential geologic hazards to the siting of exploration wells, production platforms, and pipelines. Thus, this study is particularly relevant in light of recent discoveries of gas on the mid-Atlantic continental shelf.

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Sealing and Nonsealing Faults in Gulf Coast Salt Basin

This study was undertaken to investigate (1) the different situations of fault entrapment of hydrocarbons in Tertiary sediments of the Gulf Coast salt basin, and (2) the role of juxtaposed sediments in a sandstone-shale sequence in creating sealing and nonsealing faults.

Fault-controlled accumulations in the hydropressured Tertiary section were studied in 10 Gulf Coast fields located on low relief structures. Investigations were limited to traps associated with faults which restrict vertical migration of hydrocarbons, that is, where an accumulation is in contact with the fault. The relations observed among fault, lithology, and accumulation are (1) fault sealing, with hydrocarbon-bearing sandstone in lateral juxtaposition with shale; (2) fault nonsealing to lateral migration, with parts of the same sandstone body juxtaposed within the hydrocarbon column; (3) fault nonsealing to lateral migration, with sandstone bodies of different ages juxtaposed within the hydrocarbon column; and (4) fault sealing, with sandstone bodies of different ages juxtaposed within the hydrocarbon column. In some places these four relations are present at different levels along the same fault.

In the examples studied, faults nonsealing to lateral migration were observed only where parts of the same sandstone body are juxtaposed across a fault. With sandstone bodies of different ages juxtaposed, some faults are sealing and others are nonsealing to lateral migration, but sealing faults are the most common. The fault seal apparently results from the presence of boundary fault-zone material emplaced along the fault by mechanical or chemical processes related directly or indirectly to faulting.

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Ellenburger Group, Delaware Basin, West Texas

The Ellenburger Group in central and west Texas is part of a vast sheet of Lower Ordovician carbonate sediments deposited on the southern edge of the North American craton. In the west Texas area the Ellenburger, a 1,000 to 2,000-ft (300 to 600 m) section of dolomite, is extremely important as an oil and gas reservoir. Since the first discovery in 1928, the Ellenburger has produced more than 500 million bbl of oil in the Permian basin and, more recently, huge gas reserves have been established in the deep Delaware basin.

During deposition of the Ellenburger carbonate sequence, the predominant environment was probably similar to the area of carbonate mud and pelletal carbonate mud deposition on the Great Bahama Bank. Today the Delaware basin section is largely microcrystalline to coarsely crystalline dolomite with many sedimentary structures indicative of shallow-water to supratidal deposition. On the basis of textures, fabrics, and insoluble residues, the Ellenburger Group in the Delaware basin may be divided into three units. Generally, porosity is confined to the middle and lower units and is related to subaerial solution and associated brecciation. Tectonic fracturing, related to late Paleozoic deformation, apparently is responsible for greatly increasing permeability.

Several Ellenburger fields produce up to 50% carbon dioxide with methane. The carbon dioxide content increases in the west and south toward low-salinity formation water.

Ellenburger hydrocarbons probably were derived from the overlying Simpson (Middle Ordovician) shale.

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Sedimentary Subenvironments of Wilkins Peak Member of Green River Formation (Eocene), Wyoming

The Wilkins Peak Member of the Green River Formation is a nonmarine, closed-basin, dolomitic carbonate deposit that intertongues with siliciclastic deposits at the basin edges. A transect from the basin margin to the basin center reveals six major subfacies. (1) The alluvial-fan subfacies is poorly sorted boulder conglomerates, cross-bedded gravels, and horizontally laminated grits and sands. These are interpreted, respectively, as fan-apex incised channels; mid-fan channel-bar deposits; and fan-toe, shallow, braided channels. (2) Sand-flat subfacies consists of wedge-shaped sheets of dolomitic sands extending tens of kilometers into the basin center and changing from "Bouma-like" graded units (20 to 30 cm thick) near the basin edge to horizontally laminated or coarse graded beds (1 to 10 cm thick) toward the basin center. These are interpreted as having been deposited by decelerating sheetfloods. (3) Dry-mud-flat subfacies includes densely mud-cracked and graded dolomitic mudstone laminites and thin beds. These are interpreted as subaerial mud flats in which sheetflooding and in-basin, shallow debris flows were the important depositing mechanisms. (4) Nonsaline-ephemeral-lake subfacies is dolomitic mudstones with laminations composed of pinch-and-swell sand, a thick mud cap, and sparse deep mud cracks. These are interpreted as sporadically exposed, shallow-lake margins or isolated shallow ponds. (5) Perennial-lake subfacies is oil shales or finely laminated dolomitic mudstones that are rarely cracked. These are interpreted as having been deposited in a shallow but persistent lake. (6) Saline-ephemeral-lake subfacies consists of either dolomitic mudstones and oil shales disrupted by intrasediment salt-crystal molds, or massive trona and/or halite beds containing mud partings. These are interpreted as brine-soaked lake and mud-flat deposits, or deposits in very shallow brine pools.

These subfacies occur as asymmetric cyclic sequences 3 to 4 m thick that are interpreted as random sheetflood deposits superimposed on transgressive and regressive beds laid down in a shallow central lake which occasionally dried up. The small-scale lacustrine cyclic sequences probably provide delicate indications of minor climatic changes. These sequences not only provide a facies model for other deposits but also a possible criterion for predicting the large-scale geometry of less well-exposed basins.

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Compaction Effects in Fusulinid Limestone

Of 14 fusulinid genera in the Upper Pennsylvanian–Lower Permian Bird Spring Formation, only *Pseudoschwagerina?* shows evidence of deformation caused by compaction. Most deformation occurred in the outermost whorl; the wall and septa were jumbled, and the