margin or reef flat and the seaward, more steeply inclined upper slope or marginal escarpment.

The carbonate margins fronting detached platforms and attached shelves can be grouped as either open (Campeche, West Florida) or rimmed (Bahamas, Belize, Great Barrier Reef). Insular margin fringing/barrier reefs (New Guinea, Tahiti) and atolls (Eniwetok, Bikini) form a third major group. The shelf-slope boundary within these highly variable margins spans from shallow, abrupt, and distinct to deep, broad, and dimly defined.

The regional geologic setting, basement structure, and tectonic history are the primary controls determining carbonate buildup type and hence the general nature and location of the shelf break.

Once established, carbonate buildups are profoundly influenced by the available physical-energy flux. Where winds and waves are dominantly unidirectional, the margins of carbonate buildups acquire significant windward and leeward characteristics. Where the tidal range is elevated, tidal currents control sedimentation. Acting in conjunction with tectonic movement and the physical processes are geo- and glacio-eustatic-induced sea-level fluctuations. Other important factors influencing the carbonate shelf break are antecedent topography, fluvial-terrigenous sediment input, and oceanic circulation/upwelling.

The dominance of reefs and sand bodies at the carbonate shelf-slope boundary produces rocks with initially high porosities/permeabilities which may form good reservoir rocks. This boundary is also sensitive to climate change and sea-level fluctuation and therefore may contain detailed data on the geologic history of the entire carbonate buildup.

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Mineral Reactions in Shale Diagenesis

Compaction and lithification of muds (composed of normal terrestrial weathering minerals) into shales involves a major mineralogic change that has been followed in many sedimentary basins throughout the world. Unstable mineral components, such as potassium feldspar and mica, begin to decompose at temperatures around 60°C and the released chemical components react with dioctahedral smectite to produce mixed-layer illite/smectite, chlorite, and quartz. The extent of the reaction is highly dependent on temperature and time.

This diagenetic reaction may influence the rate at which liquid hydrocarbons are generated because the surface electrical charge of smectite—and therefore its efficiency as a catalyst—increases during the reaction. In addition, dehydration of smectite on its conversion to illite can lead to overpressuring of pore fluids that may be involved in migration of liquid hydrocarbons from the shale to reservoir rocks. The timing of liquid hydrocarbon and new pore-water generation, and overpressuring caused by smectite dehydration may be critical to the production potential of a sedimentary basin.

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Faunal Zonation of Cenomanian (Middle Cretaceous) Rudist Reef, Paso del Rio, Colima, Mexico

The Cenomanian (Middle Cretaceous) rudist reef at Paso del Rio, Colima, is the only reef known to contain *Immanitas,* a recumbent, caprinid rudist. Within the reef, four units are discernible. At the base is a siliciclastic-poor wackestone with upright caprinids. This grades upward into a silty, caprinid-Immanitine-radiolitid wackestone/packstone with caprinid and radillitid zones at the top. Overlying this unit is an argillaceous, Immanitine packstone. The reef is capped by a silty packstone (debris bed) containing *Immanitas.*

This reef represents a single cycle of framework evolution with a constructive and a destructive phase. The constructive phase is represented by the caprinid wackestone and the silty, caprinid-Immanitine-radiolitid wackestone/packstone. The caprinid and radiolitid zones at the top of the latter unit comprise the climax communities. The destructive phase is initiated by the reestablishment of *Immanitas* in the argillaceous, Immanitine packstone. The termination of the reef is evidenced by the debris bed, a silty, *Immanitas* packstone.

This zonation is somewhat similar to the zonation of Cretaceous rudist frameworks in the Caribbean reported by others with the following exceptions: (1) upright rudists at Paso del Rio are predominantly caprinids, whereas those in the Caribbean are predominantly radiolitids; (2) recumbent rudists at Paso del Rio are the caprinid *Immanitas,* whereas those in the Caribbean are the caprinid *Titanosarcolites* and the radiolitid *Biradiolites;* and (3) the two separate types of framework evolution described in the Caribbean are combined at Palso del Rio.

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Surface Geochemical Prospecting—Pro and Con

In the 40 years since surface geochemical prospecting was first developed, extensive studies have been made by major oil company research laboratories, academic institutions and geochemical service companies both in the United States and abroad. Despite this wealth of data, there are still conflicting opinions as to the value of surface prospecting in finding oil and gas.

There is ample evidence that many petroleum accumulations leak hydrocarbons to the surface via faults, fractures, unconformities, intrusions, and highly permeable sediments. Migration can occur in a wide range of concentrations from the visible to the invisible, as a discrete hydrocarbon phase or in solution. These migration mechanisms follow erratic pathways upward causing surface anomalies that may have prospecting value when combined with conventional geological and geophysical exploration methods plus an understanding of the ground-water flow regime. Upward migration is most likely in tectonically active areas, and least likely in quiet areas, especially where there are widespread barriers to migration such as evaporites.

The interpretations of these anomalies are best used in a regional sense since there is no known mechanism that will cause a subsurface pool to be outlined at the surface. Furthermore, the mixing of upward migrating hydrocarbons with near-surface generated hydrocarbons confuses the detailed local interpretations. Even regional evaluations can be risky since some areas with valid surface shows are studded with dry holes. Nevertheless, when no subsurface cuttings are available, surface prospecting can indicate, under favorable conditions, if an area is alive or dead with respect to hydrocarbons.

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Recognition of Shelf-Slope Break Along Tectonically Active, Ancient Continental Margins

Tectonically active continental margins include transform, protoceanic-rift, and subduction settings. Shelf-slope breaks in these settings tend to be transient in time and space. Wrench and fault-block systems feature irregularly shaped basins and uplifts that have abrupt vertical movements and facies changes. Subduction systems form elongate basins and ridges in response to the interplay of tectonics and sedimentation.

Because of the nondepositional character of narrow, tectonically controlled shelves, shelf-slope breaks commonly are expressed as unconformities separating shallow-marine/nonmarine and slope/basinal deposits. Alternatively, shelf and basinal deposits may be separated by a biostratigraphically compressed interval, including glauconite and phosphorite, which represents the clastic-starved shelf-slope break. Subtly expressed shelf-slope break deposits of active margins commonly are masked by abrupt sedimentation in adjoining areas along with abrupt facies migration. Consequently, bracketing deeper and shallower marine facies is the usual key to locating ancient shelf-slope breaks.

Basinal facies are distinctive in many wrench and fault-block systems, with two common sedimentary motifs: (1) ponded submarine-fan deposits displaying little proximal-to-distal facies segregation, and (2) clastic-starved sections of laminated (commonly biogenous) sediment reflecting anoxic conditions in isolated silled basins. These facies, together with slump-dominated slope facies, adjoin shelf-slope break deposits.

Variable geometries characterize subduction-controlled shelf-slope breaks, but generally, ancient deposits overlie highly deformed, deep-marine components (trench-slope and trench sediments) and are overlain by relatively undeformed fore-arc deposits. Underlying deposits may have exotic sources and may contain recycled materials. Overlying deposits consist of predominantly land-derived components.

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Origin, Depositional History, and Correlation of Miocene Diatomites Around North Pacific Margin

Distinctive Miocene diatomites and genetically related porcellanites form a remarkably widespread lithofacies within bathyal marine sequences around the margin of the North Pacific Ocean from Mexico to Korea. The Monterey Shale of California and the Onnagawa Formation of Japan typify these deposits. Planktonic correlations, radiometric dates, and oxygen isotope records indicate that the initial accumulation of the diatomites commenced in the early middle Miocene (15 Ma), coincident with initiation of a major climatic event marked by massive ice accumulation in Antarctica, steepening of the latitudinal temperature gradient, and increasingly vigorous surface circulation and primary productivity. Microfaunal and sedimentologic evidence demonstrates that the diatomites were commonly deposited in subsiding marginal basins characterized by sills intersecting intensified oxygen minima allowing preservation of laminated muds. Moreover, the diatomites occur within strikingly similar stratigraphic successions that suggest closely parallel tectonic, sedimentologic, and oceanographic development of Neogene marginal basins in this region. Typically, four major events can be recognized in these sequences: (1) deposition of Oligocene-lower Miocene volcanic rocks and continental and/or neritic marine clastics followed by (2) rapid margin subsidence, development of silled basins, and deposition of middle and upper Miocene diatomaceous sediments in essentially empty depocenters, (3) climatically induced elevation of the carbonate compensation depth and increasing influx of terrigenous debris in latest Miocene-earliest Pliocene time producing a carbonate-poor mudstone facies, and (4) introduction of rapidly deposited wedges of coarse terrigenous clastics during Pliocene-Pleistocene time that cap the underlying diatomites. This widespread and correlative stratigraphic pattern appears to be the combined product of (1) a major middle Cenozoic readjustment of Pacific plate margins resulting in synchronous development of Neogene marginal basins around the North Pacific rim and (2) coincident acceleration of diatom productivity in this region in response to severe deterioration of Neogene climate.

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Peat—Potential Energy Bridge for North Carolina

North Carolina has an estimated 1,000 sq mi (2,600 sq km) of peat land containing about 600 million tons of moisture-free peat. Because North Carolina is deficient in energy resources, there is considerable activity aimed at using this peat as a fuel.

Peat deposits in North Carolina are of three main geologic types representing the accumulation of organic matter in: (1) pocosins—broad shallow depressions on an uplifted sea floor; (2) river flood plains; and (3) Carolina Bays—elliptical depressions of unknown origin.

The largest pocosin deposits are : (1) Albemarle-Pamlico peninsula, 360 sq mi (936 sq km), 210 million tons moisture-free peat; (2) Dismal Swamp, 100 sq mi (260 sq km), 60 million tons; and (3) Croatan Forest, 40 sq mi (104 sq km), 23 million tons. These deposits normally range in thickness from 1 to 8 ft (0.3 to 2.4 m).

River flood-plain deposits are of unknown extent. Peat occurs as lenses in alluvial sands and clays and may attain a thickness of 25 ft (8 m).

Five to six hundred Carolina Bays from 0.2 to 3 mi (0.3 to 5 km) in length are scattered over the coastal plain. Many contain high quality peat up to 15 ft (5 m) thick.

Most North Carolina peat is black, fine grained and highly decomposed, with an ash content commonly less than 5%. Sulfur content is low (median 0.2%), and heating value is high (median to 10,300 Btu/lb moisture-free).

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Porosity Reduction During Diagenesis of Monterey Formation, Santa Barbara, California

In the Monterey Formation of the Santa Barbara coastal area, porosity decreases with increased burial diagenesis from an average of 60% in diatomaceous (opal-A) rocks to an average of 10% in rocks bearing diagenetic quartz. In carbonate-free siliceous rocks, porosity was lost principally in two abrupt reductions of 10 to 30% porosity during the two silica phase transformations (opal-A to opal-CT and opal-CT to quartz). Large differences in porosity among interbedded rocks with different silica phases show that porosity losses resulted directly from the two silica phase transformations rather than from specific conditions of temperature and burial depth. Porosity reduction was thus probably due to brief loss of strength during solution-precipitation of silica in the rocks. Similar compositions and different thicknesses of sedimentary