salts from the crystal lattice, causes upward ejection (relative to the subsiding solids) of dissolved salts. This is supported by positive ^{18}O-isotopes ($\delta_{18}O_{smow}$ up to +1.96 at bottom of hole 497), which make freshening of the pore waters by influx of meteoric water unlikely. If our hypothesis is correct, lowered chlorinities in sections of subtropical continental margins (high organic matter content!) might thus serve as an indicator for the occurrence of clathrates. Organic matter oxidation is associated with strong sulfate depletion (within one or a few meters from the sea floor), a pronounced increase in alkalinity (maximum between 50 and 250 m subbottom) and ammonia as well as phosphate (maxima between 100 and 200 m). Calcium and strontium remain uniformly low throughout the holes, Mg decreases markedly with decreasing chlorinity. The fact that chlorinity does not drop to zero in the clathrate zone suggests that only a portion of the pore water is tied up in clathrate formation.

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Facies Characteristics of Modern Size-Graded Shelf Deposits, Northwestern Gulf of Mexico

General decrease in grain size of modern surficial sediments with increasing water depth across the continental shelf off south-central Texas suggests that the sediments are in equilibrium with the hydraulic regime during fair weather conditions. The stratigraphic record, however, indicates storm-dominated shelf sedimentation resulting in zonation of sedimentary structures, bed types, and bed sequences. Three facies are defined.

Lower shoreface (water depth: 10 to 30 m): sediment has a significant fine sand component and occasional thin shell beds. Bioturbation is generally high with a diverse trace assemblage. Sand beds exhibit parallel to subparallel lamination with erosional basal contacts. Bedding relations define two major seqeunces: (1) thin, clean, laminated sand → thick, sandless, nonbioturbated mud → heavily bioturbated muddy sand with mottled tecture, and (2) thick, clean, laminated sand → interlaminated mud and sand → muddy sand with mottled texture. Both sequences are cyclic and result from variation in hydraulic energy related to storm events.

Midshelf (30 to 120 m): clayey silt sediment containing little sand and no shell beds. Sediments are moderately bioturbated; trace diversity is intermediate. The only physical structures are occasional parallel-laminated sand beds. Bed-type diversity is intermediate. Moderately thick mud beds are separated by thinly laminated or bioturbated, storm-related sand beds.

Outer shelf (120 to 200 m): clayey silt sediment (clay content greater than on the midshelf). Bioturbation and trace diversity are low. Bed-type diversity is low, and bedding relations simple. Thick, very thinly but faintly laminated, slightly bioturbated mud beds are separated by thin, heavily bioturbated, relatively clean sand beds (distal storm layers).

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Erosion of Old Slump-Scar on Nova Scotian Slope and Possible Mid-Slope Depositional Lobe

High-resolution seismic profiles and a long-range sidescan sonar (*Gloria* II) records have been used together to interpret a complex erosional pattern on the Nova Scotian continental slope. A steep uppermost-slope (200 to 500 m depth) is dissected by numerous small gullies which converge to form a single flat-bottomed, erosional channel below 700 m depth. The sidescan record shows these features to be confined to a lobate area, approximately 8 km wide. Seismic profiles outside this area show a smoother topography with greater continuity of parallel subbottom reflectors. The eroded area is interpreted as an old slump-scar which has been secondarily eroded by a gulley-channel system. Cores from the area are compatible with this interpretation.

At about 1,000 m depth, the incised channel cannot be recognized on either the seismic profile or the sidescan record. However, a profile in the predicted path of the channel shows a broad mound, approximately 5 km wide, with a relief of about 20 m. This has a rather similar profile to a suprafan of a submarine fan, with a small channel on the surface, possible buried channels and erosional surfaces in the subbottom. It is suggested that sediment from the channel system has been deposited in this deeper area to form a depositional lobe.

The mid-slope position of this possible depositional system has major implications for interpretation of ancient basin-margin sequences and the later erosion of a slump scar is important in terms of a potential hazard for placing bottom structures.

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Geology-Petrophysics of Levelland 12-Acre Tertiary Pilot, West Texas

The Levelland 12-acre (4.8 ha.) pilot was drilled during the latter part of 1972 on a double five-spot pattern, and underwent waterflooding from March 1973 until August 1979. On August 3, 1979, carbon dioxide flooding was initiated.

The purpose of this study was to define a stratigraphic zonation for the San Andres Formation (Permian) in and around the pilot, to obtain an accurate, quantitative, reservoir description to aid engineers achieve a historical match of the waterflood, and to evaluate the tertiary recovery efficiency of carbon dioxide flooding.

Excellent core control demonstrated that sedimentary deposition had occurred in an arid coastal carbonate-evaporite province similar to that which exists today on the Trucial Coast, Persian Gulf. Stratigraphic zonation was made using core data in conjunction with log data. A quantitative reservoir description was achieved by the following steps: (1) porosity calibration of the gamma ray-neutron logs; (2) permeability calculation from the calibrated porosity using available core data; (3) determination of the permeability cutoff for net pay; (4) determination of connate-water saturation from applicable native state cores; (5) determination of the reservoir zonation, and (6) computer generation of ϕH, KH, and H maps for individual reservoir zones and combinations of reservoir zones.

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Modern Carbonate Shelf-Slope Boundaries

The shelf-slope boundary along modern carbonate buildups on a worldwide basis demonstrates a high variability in morphology, structure, biogenic barriers, sediments, depth of occurrence, dominant processes, and general geologic history. This boundary is defined as the zone of maximum gradient change between the nearly horizontal shallow-water shelf 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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