ognition is enhanced by color differences between paleosols developed on the scoured and scour-fill deposits, is a valuable indicator of climatically and/or tectonically controlled base level changes in continental basins. Because paleosols preserve the record of nondeposition and nonerosion and are useful in identifying periods of degradation, their analysis is essential to reconstructing the complete geologic history of alluvial sediments.

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Puerto Rico Trench: Site of a Shallow-Water Tertiary Basin and Regional Tectonic Implications

Until late Eocene time, the Bahamas platform extended to the present Virgin Islands, as demonstrated by magnetic, gravity, and refraction data. This interpretation is confirmed by the presence of widespread outcrops of middle Cretaceous through early Pliocene shallow-water bank carbonates below 5,200 m depth in the trench. Crustal thickness beneath this bank is 18-25 km. Igneous and metamorphic rocks from the base of the trench's southern slope are chemically very different from subduction-zone rocks.

Waters of the carbonate bank (300 × 100 km in size) transgressed southward after early Eocene time. During late Eoene time, the bank's southern margin was near today's shoreline where down-to-the-north growth faults formed. Along the bank's northern margin, block faulting produced a graben above the site of the modern Puerto Rico Trench. During middle Eocene to early Pliocene time, shallow-water deposition extended from a position presently 5,200 m deep in the trench to central Puerto Rico, an exceptionally stable block at least 100 km wide.

During middle Eocene time, the Beata Ridge dextral shear cut the trench off north of Hispaniola. In early Pliocene time, the Mona Canyon dextral fault zone cut across the trench, and strong northward tilting commenced. The trench's present southern slope is mainly a dip slope, inclined about 5°. The Puerto Rico Outer Ridge formed by lateral and upward movements of mantle materials that withdrew from beneath the sinking trench. Petroleum prospects presently are limited to the Tertiary (4,000 m thick) and to a coastal zone 20-25 km wide (to 2,000 m water depth). Traps are mainly fault seals and stratigraphic pinch-outs.

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Expert System for Computer Interpretation of Beach and Nearshore Facies

A user-friendly, rule-based expert system has been designed for interpretation of lithofacies characteristics of beach and nearshore depositional environments. Recently, similar expert systems have been widely applied in medicine, business, and mineral exploration.

The expert system runs on a VAX 780 (trade name). By incorporating knowledge and understanding of an expert, the system can interact with a user the way an expert consultant would. Interaction consists of a series of questions about lithology, sedimentary structures, and bioturbation of the lithofacies observed in outcrop or core. Uncertain responses are allowed and incorporated into the reasoning. Dialogue varies in different consultations because questions asked by the system depend on users' responses to previous questions. The result is an evaluation of the likelihood that the deposit under consideration is actually a beach or nearshore deposit. Significant lithofacies characteristics, the reasoning used in reaching the conclusion, and pertinent references are provided.

Expert systems for other depositional environments are being designed. As their availability increases, geologists without easy access to experts on a particular depositional environment will have expert consultants as close as a computer terminal. Also the ability of the system to explain its reasoning and provide references lends the system to instructional uses.

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Impact of Early Diagenesis of Eolian Reservoirs, Great Sand Dunes National Monument, Colorado

Dune and associated alluvial and playa deposits at Great Sand Dunes National Monument, Colorado, provide an excellent opportunity to study early diagenetic development of vertical and horizontal permeability barriers in recent eolian deposits (> 10 ka). Cements observed include calcite, aragonite, protodolomite(?), amorphous silica, iron hydroxide, smectite, trona, and halite. Cementation is controlled by the availability of water, with several hydrologic subenvironments producing different cements.

Evaporative cementation in dunes adjacent to playas is commonly dominated by trona and halite, but calcite, aragonite, and amorphous silica also bind the sediment. These cements are generally most concentrated in fine laminations where capillary action has pulled water into dunes. Iron hydroxides, calcite, and amorphous silica precipitate at the interface between ground water and streams or lakes, where the pH gradient may exceed 5 pH units (pH 5.7-11.5). Subsequent movement of the ground-water table can result in cross-cutting cement zones.

Early cementation in dunes prevents deflation and provides a mechanism for preservation of the reservoir unit. Intense cementation may permanently occlude porosity, or leaching may reestablish well-interconnected porosity. An understanding of the extent and composition of early cement zones can be used to improve hydrodynamic models for production and enhanced recovery.

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Source Rock Characteristics, Los Molles and Vaca Muerta Shales, Neuquen Basin, West-Central Argentina

Major hydrocarbon-producing trends of the Neuquen basin occur along its northeastern margin (Eastern Shelf) and along an east-west-trending structural high in the southern half of the basin (Neuquen Dorsal). Sediment thickness increases northward from the Neuquen Dorsal and westward from the Eastern Shelf into the Neuquen Embayment, a region that has been relatively unproductive for hydrocarbons.

Major source rocks are the Lower to Middle Jurassic Los Molles Formation and the Upper Jurassic to Lower Cretaceous Vaca Muerta Formation. Los Molles shales are immature to moderately mature on the Neuquen Dorsal: vitrinite reflectance (R_o) = 0.3-0.8%; thermal alteration index (TAI) = 1+ to 2; total organic carbon (TOC) = 2.0-5.0%. However, they are severely altered in the deepest part of the Neuquen Embayment (R_o = 2.5-3.0%; TAI = 3+ to 4; TOC = 1.1%). Organic matter is woody on the Neuquen Dorsal but is coaly in the Neuquen Embayment. Clay minerals are smectite and mixed layer illite-smectite on the Neuquen Dorsal whereas illite and chlorite are present in the Neuquen Embayment.

Similarly, Vaca Muerta shales are immature on the Neuquen Dorsal and along much of the Eastern Shelf (R_o = 0.3-0.5%; TAI = 1 to 2−), but are mature throughout the Neuquen Embayment (R_o = 0.7-1.3%; TAI = 2-3). The lower part of the unit is a bituminous black shale (TOC = 2.5-6.5%). The dominant visual kerogen type is amorphous (Al). Clay minerals change from smectite to mixed layer illite-smectite with decreasing expandability toward the deepest part of the Neuquen Embayment.

The lack of correlation between areas of source rock maturity and major hydrocarbon production suggests long-distance fluid transport out of deep portions of the basin.

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Geochemical Conditions in Sediment Containing Gas Hydrates of Active and Passive Continental Margins

Two sites of the Deep Sea Drilling Project in contrasting geologic settings provide a basis for comparison of the geochemical conditions associated with marine gas hydrates in continental margin sediments. Site 533 is located at 3,191 m water depth on a spitlike extension of the continental rise (Blake Outer Ridge) on a passive margin in the Atlantic Ocean. Site 568, at 2,031 m water depth, is in upper-slope sediment of an active accretionary margin (Middle America Trench) in the Pacific Ocean. Both sites are characterized by high rates of sedimentation (greater than 30 m/m.y.), and the organic carbon contents of these sediments generally exceed 0.5%. Anomalous seismic reflections that crosscut reflections from sedimentary layers and parallel reflections from the sea floor suggested the presence of gas hydrates at both sites. During coring, small samples of gas hydrate were recovered at subbottom depths of 238 m (Site 533) and 404 m (Site 568). The principal gaseous components of the gas hydrates were methane, ethane, and CO_2. Residual methane in sediments at both sites usually exceeded 10 ml per liter of wet sediment. Carbon isotopic compositions of methane, CO_2, and ΣCO_2 followed parallel trends with depth, suggesting that methane formed mainly as a result of biologic reduction of oxidized carbon. Salinity of pore waters decreased with depth, a likely result of gas hydrate formation. The small samples of gas hydrates observed visually in cores confirm that gas hydrates are present at these sites, but much of the direct evidence for gas hydrates may be destroyed during the coring and recovery process.

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Benthic Foraminiferal Biofacies in Stevens Sandstone: Relationships to Water-Mass Oxygen Levels in Late Miocene San Joaquin Basin, California

The Stevens sandstone is an extensive and complex sequence of late Miocene turbidite sandstone and mudstone within the Monterey Formation of the San Joaquin basin. To date, the paleoenvironmental analysis of benthic foraminifera in such facies is limited largely to general inferences of paleobathymetry. A different approach uses multivariate analytical methods to classify biofacies and interpret them with respect to modern ecologic concepts derived from studies of Holocene faunas in the southern California borderland. Cluster and factor analysis help define 4 recurrent biofacies in the Coles Levee area: an agglutinated species biofacies (ASB), *Uvigerina subperegrina* biofacies (USB), *Bolivina vaughani* biofacies (BVB), and mixed calcareous biofacies (MCB). Ordination (principal components) plots of environmentally significant species indicate that the biofacies reflect a gradient in oxygen concentration of late Miocene water masses. The BVB and MCB represent the highest oxygen levels, the USB low but not dysaerobic levels, and the ASB the lowest oxygen concentrations. Ordination also shows that downslope transport of faunas and carbonate dissolution are also important in forming Stevens biofacies. Stratigraphic distribution of biofacies defines systematic shifts in oxygen concentration, probably linked to climate. These late Miocene biofacies variations were previously attributed to paleobathymetric changes. The distribution of species not restricted to the defined biofacies, plus the paleoenvironmental analysis presented here, argues against paleobathymetry as a complete explanation. This analytical approach shows the potential for greatly increasing our understanding of foraminiferal biofacies in submarine-fan environments.

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Stratigraphic Significance of Uvigerinid Foraminifers in Western Hemisphere

Uvigerinid foraminifers increasingly are recognized as particularly useful paleobathymetric indices, and current data also provide easily applied bases for their use in biostratigraphic interpretation. Thus, use of many forms of the family Uvigerinidae occurring in the Western Hemisphere can expand utilization of these important forms and provide uniformity in nomenclature and classification.

Uvigerina and related genera illustrate lineage concepts and facilitate paleobathymetric considerations. These biostratigraphic interpretations, based on life ranges of commonly occurring benthonic species, are applicable widely in areas lacking the critical warm-water planktonic organisms normally used in dating.

The genus *Tiptonina* (type species *Siphogenerina nodifera*) and the species *Uvigerina praehubbardi* are proposed as new.

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Depositional Facies and Diagenetic Fabrics of Falmouth Formation (Upper Pleistocene), Jamaica

The upper Pleistocene Falmouth Formation of Jamaica was deposited in shallow, open-marine environments similar to those on the modern northern shelf. Depositional facies include coralgal boundstones, coral-algal grainstones, foram-algal packstones, echinoid molluscan wackestones, and terrigenous grainstones. Submarine cementation of Falmouth sediments occurred as micritic and/or isopachous bladed rinds composed of magnesian calcite, as well as aragonitic coral overgrowths. The Falmouth limestones were subsequently exposed to meteoric water because of eustatic sea level fall and regional tectonic tilting related to the Cayman shear zone to the north. Isotopic reequilibration and carbonate-mineral stabilization are presently at an intermediate stage. Meteoric and mixing-zone diagenetic processes that have affected this unit include: sparry calcite cementation, aragonite dissolution and inversion, incongruent dissolution of high-magnesian calcite, selective dolomitization, and neomorphism of micritic matrices. Neomorphic fabrics within the Falmouth are spherulitic sparry calcite, microspar, and structure grumuleuse. Isotopic reequilibration coincides with the degree of diagenetic alteration. Carbon and oxygen delta values are lighter in precipitative meteoric cements than in neomorphic constituents. The trend toward negative isotopic composition with increasing age of limestone strata can be shown here to be disguised by exposure to sea spray, organic involvement, and abnormally rapid (nonequilibrium) rates of precipitation. Modern subsurface hydrogeologic environments contain distinctive diagenetic fabrics and isotopic signatures, and are defined by water-flow rate, pore-water chemistry, and rock permeability and porosity.

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Geomorphic Indicators of Deeper Seated Structure on the Southern Margin, East Texas Basin

Surface geomorphic features are frequently difficult to relate to potential productive structures, but in the East Texas basin there appears to be a significant correlation between surface features and oil fields.

The surface topography overlying the East Texas basin gives little indication of subsurface structure. However, conspicuous to southeastern Houston County on the southern margin of the East Texas basin, and to a large part of the entire basin, is a series of northwest- and northeast-trending stream and topographic alignments. These mappable linear geomorphic features (termed lineaments) may indicate fracturing, faulting, and jointing, and thus may be a clue to subsurface structure.

The lineaments of southeastern Houston County were mapped and analyzed on a local scale, and those of Houston, Cherokee, Trinity, and Angelina Counties were mapped and analyzed on a more regional scale. Both the local and regional scale lineament analyses indicated preferential orientations of north 30° west and north 30° east. These lineaments are thought to reflect fracturing and faulting although field reconnaissance could not confirm this.

It is suggested that gravity slide of the East Texas basin gulfward from the updip edge of the Louann Salt provided the tensional forces necessary for major lineament formation. However on a more local scale there is a correlation between lineaments and productive fields.

Areas of minimum lineament density on the lineament-density contour maps represent subtle subsurface structural highs and, conversely, areas of maximum lineament density on the lineament density contour maps represent subtle subsurface structural lows. Therefore, petroleum potential is generally limited to areas of minimum lineament density.

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Processes Involved in Salt-Dome Development I: Dynamic Effects

In a study of the dynamical interplay of salt and sediment using buoyancy pressure as the driving force, we find that (a) salt cannot become buoyant until a critical depth of sediment is reached corresponding to a porosity of 25-30%, (b) viscosity plays virtually no role in the development of diapiric salt structures on a geologic time scale, (c) both overpressure and the lateral cohesive strength of overlying sediments retard the development of a dome by delaying the initiation of diapirism and suppressing the later growth of the salt structure, (d) the formation of a "mushroom cap" on a diapiric structure can be caused both by differential impedance provided by the sediments and by differential buoyancy of salt, although relative importance of the 2 mechanisms is unknown at present, and (e) the draping of sediments over a diapiric structure and rim synclinal development can be modeled easily provided that the sediments