characterizes eastern Abaco lagoon where it overlies the wackestone facies, accounting for 50% of the normal marine section. The N.M. wackestone typically grades downward into a dark gray restricted marine (brackish to hypersaline) skeletal wackestone, ≷70 cm thick, and then to a dark brown nonmarine soil zone, ≤16 cm thick, above bedrock. Radiocarbon dates indicate flooding of Abaco lagoon at least by 7,446 YBP at −10 m, followed by the transition from restricted to normal marine conditions as early as 4,716 YBP. Sedimentation rates increase from 16 cm/1,000 years for the restricted marine wackestone, to 58-104 cm/1,000 years and 216 cm/1,000 years for the N.M. wackestone and packstone facies, respectively. The windward lagoon setting illustrates the caution required in prediction of facies continuity perpendicular to carbonate bank margins. Recognition of an ancient windward lagoon sequence may have important implications regarding sea level history and paleogeographic reconstruction.

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Heterobathyal Benthic Foraminifera: Bathymetric Migrations as Oceans Change

Reconstructions of the past distribution of Quaternary deep-water benthic foraminifera from both the Atlantic Ocean and Mediterranean Sea show that the bathymetric range of most common species has changed substantially through time.

An Atlantic Ocean abyssal biofacies characterized by *"Epistominella" umbonifera* periodically migrated hundreds of meters as ice-age climates influenced deep-water production in polar latitudes. At the same time, bathyal biofacies, especially ones characterized by *Uvigerina* and *Globocassidulina,* extended their bathymetric ranges as much as 2 km deeper.

In response to the Quaternary stagnations and recirculation associated with sapropel deposition in the eastern Mediterranean, most benthic foraminifera changed their bathymetric distributions. Deep-water biofacies (*Globobulimina, Articulina)* shallowed as deep basins became anoxic; shallower biofacies (miliolids) extended their ranges as recirculation oxygenated the deep water.

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Sedimentation and Diagenesis of Upper Smackover Grainstone, Jay Field Area, West Florida

The examination of core and logs from a well 3 mi (5 km) southwest of the Jay field has given considerable insight into the upper Smackover facies distribution, diagenesis, and the application of recent models for the sedimentation and diagenesis of this Jurassic reservoir. A 63-ft (19 m) thick unit of oolitic and oolite-oncolite grainstones is recognized in the upper Smackover. High-angle inclined bedding, visible on both core and dipmeter, with a consistent 15 to 20° northeast dip, demonstrates the presence of oolite bars. These bars formed a barrier which affected subsequent deposition and diagenesis in the Jay field area. A complicated diagenetic history of marine and vadose cementation, and pervasive and selective dolomitization have left a unique imprint on the porosity and permeability of these rocks.

Dipmeter results and petrographic analysis of the grainstones indicate that cementation and diagenesis have not been uniform. Within the large-scale cross-strata, permeable beds are interstratified with tightly cemented or compacted, impermeable beds. Horizontal flow should be greatest along the strike of the inclined units, because the flow would remain within the permeable planes of the inclined strata. Thus, dipmeter correlation permits an interpretation of the direction of bedding permeability anisotropy produced by the inclination of the pore system.

The characteristics of sedimentation and facies distribution in the Jay field area have previously been compared with a modern analog from Joulters Cay in the Bahamas. The Trucial Coast of the Persian Gulf in the Abu Dhabi region may be a better model. The style of deposition and distribution of carbonate and evaporite sediments, and diagenetic characteristics in the grainstone barriers and lagoons closely fit the sedimentation and diagenetic pattern in the Jay Field area.

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Chemical Evolution of Brines from Modern Coastal Marine Sabkha

Certain minerals in ancient clastic and carbonate rocks such as selenite and iron sulfides are commonly taken as indicators of a sabkha environment. The wind-tidal flat area of Laguna Madre, Texas (a silicoclastic sabkha), is a modern locus for the deposition of these minerals and thus affords an excellent opportunity to determine the controls on their deposition. The purpose of this research is to study the chemical evolution of the subsurface brines associated with the mineral deposition.

A system of 20 well sites has been established along the 22-km width of the tidal flats to investigate the chemistry and the hydrology of the sabkha system. The chemistry and peizometric potential of the waters were determined at each site from two wells (depths of 1.9 and 3.8 m) and from a shallow trench dug to intersect the water table. The chemical data from two sampling periods (August 1979 to March 1980) were reduced by computer. Using Br^- as a conservative ion, the results of this study are as follows: (1) the concentrated waters (2 to 9 times the salinity of seawater) are typically NaCl solutions which are high in Mg^{2+}, K^+, and SO_4^{2-} and low in Ca^{2+} and HCO^-_3; (2) the major source of water is from Laguna Madre with minor contributions from continental ground waters; (3) the mixing zone of the two waters is on the continental side of the chloride plateau; (4) the sabkha hydrology is dominated by wind-generated flood recharge with localized evidence of evaporitic pumping and reflux; (5) the chemistry of the brines primarily reflects the degree of evaporation of the Laguna Madre waters and the extent of flooding; (6) the brines are all undersaturated with respect to halite and supersaturated with respect to dolomite, but vary in saturation state with respect to gypsum and calcite.

Previous work in this area, and the two sampling periods of this study indicate minor changes in brine geochemistry as a function of season. In general, the chemical nature of the brines from the Laguna Madre sabkha is similar to brines of other active coastal sabkhas; variations can be attributed to differences in climate, geomorphology, and hydrology.

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Products and Processes of Ancient Arid Coastline: Lower Cutler Group (Permian), Southeastern Utah

In Canyonlands National Park, the Ceder Mesa Sandstone consists of 700 ft (213 m) of large-scale trough, cross-bedded, well-sorted sandstone. It conformably overlies 1,100 ft (335 m) of interbedded sandstone, limestone, and shale of the Elephant Canyon Formation. Sandstones of both formations, formerly interpreted as shallow marine, are here interpreted as eolian due to occurrence of: (1) subcritically climbing translatent strata produced by migrating wind ripples; (2) unimodal southeasterly dips; (3) rare vertebrate fossils and trackways; (4) gypsum sand crystal pseudomorphs; and (5) abundant calcified plant roots. In contrast, limestones, conglomeratic sandstones, and shales of the Elephant Canyon contain diverse marine body and trace fossil faunas, and dip directions are widely dispersed.

Roots occur along twelve major bedding planes in the Cedar Mesa, several of which can be traced at least 16 mi (26 km). These planes are not channeled by overlying trough cross-beds. Planes do not climb downwind and are thus unrelated to migrating bedforms. Roots also occur along the planar tops of 15 eolian sandstone bodies in the Elephant Canyon, but are there overlain by fossiliferous marine carbonates. The planes are interpreted as eolian deflation surfaces resulting from decreased sand supply to a coastal dune field. A modern analogy is the Sabkha Matti south of the Persian gulf. Colonization by plants and growth of gypsum sand crystals was followed by transgression (Elephant Canyon) or by renewal of erg conditions (Cedar Mesa). Eustatic control of both sand supply and deflation is a strong possibility.

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Basin Evolution and Present Faulting Patterns Within Isthmus of Panama Volcanic Arc

The present foundation of Panama consists of a raised block of Upper Cretaceous or older oceanic crust within a plate convergence zone. The trend of the Panamanian volcanic arc is east-west. Although broken laterally, the structural pattern from the Pacific to the Caribbean includes a subduction complex crested by a coastal range, a fore-arc basin, followed by a volcanic arc, and a back-arc fold-thrust belt and retro-arc basin along the Caribbean margin. Plate interactions have been a prime mechanism in causing trans-isthmian faulting. The present boundary between Nazca (Panama basin) and Cocos plates is the Panama fracture zone. Faulting within this fracture zone partly cuts the fore-arc basin. Due north, in the Gulf of Mosquitos, there is morphologic evidence of faulting along the continental margin. The southeastward trend of eastern Panama is contrary to the convexity, relative to the underthrusting plates, of volcanic island arcs; thus, eastern Panama should trend toward the northeast and all of eastern Panama may have rotated up to 90°, from northeast to southeast. The Darien-Atrato basin is a fore-arc basin. East-west compression in eastern Panama is suggested by fault patterns lying perpendicular to the trend of the San Blas-Darien cordillera. There, inferred faults change trend from roughly north-south in the west to northeast-southwest in the east. Extension of these faults into adjacent basins is not known. Thus, one consideration in hydrocarbon exploration in Panama is the locating of faults.

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Seismic Stratigraphic Identification of Submarine Fans—Espirito Santo Basin, Offshore Brazil

Seismic stratigraphic analysis of the Upper Cretaceous/middle Eocene sedimentary section of the Espirito Santo basin reveals two distinctive, seismic supersequences which were deposited in open-marine conditions. Several submarine fan-forming episodes are identified. The lower supersequence of Late Cretaceous to Paleocene is a sedimentary wedge onlapping a tilted Albian/Cenomanian carbonate shelf. The upper supersequence, deposited from early to middle Eocene, displays a progradational pattern. Within this thick and well-defined Tertiary section, several depositional sequences are recognized, some closely related to global relative sea level changes.

The integration of data from 16 wells with seismic lines led to the identification and mapping of several seismic features which are interpreted as turbidite fans.

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Geologic and Geophysical Study of Cerro Prieto Geothermal Field, Mexico

The Cerro Prieto geothermal field is near the southwestern margin of the Colorado River delta, Baja California. The subsurface stratigraphy at Cerro Prieto is characterized by complex vertical and lateral variations in lithofacies, which is typical of deltaic deposits. The geothermal production zone is not a uniform reservoir layer overlain by a laterally continuous top seal of low-permeability strata.

The top of the geothermal-related hydrothermal alteration zone has a dome-like configuration which cuts across the sedimentary strata. Shales in the altered zone exhibit high densities and high resistivities on the well logs relative to those outside the zone. The geothermal producing intervals generally straddle or underlie the top of the altered shale zone.

Sandstones in the hydrothermal alteration zone commonly have fair to good porosities (15 to 35% or higher), which have resulted from the removal of unstable grains and carbonate cement by solution. Open fractures are unusual in the altered zone, based on core description. While fractures may be an important contributor to local reservoir permeability, secondary matrix porosity and permeability are considered to be more important volumetrically in the Cerro Prieto reservoirs.

Detection of geothermal anomalies in the Cerro Prieto region may be difficult from resistivity, magnetic, or gravity data. However, the occurrence of a reflection-poor zone coincident with the hydrothermal alteration zone suggests that the seismic reflection method may be a good approach to detecting these anomalies. Other types of geophysical data are necessary to eliminate alternate causes of reflection-poor zones on seismic profiles.

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Subtle Traps in East China Oil-Bearing Basins

Some oil-producing basins in eastern China, such as Songliao basin, Bohai Gulf basin, and Nanyang basin are extensively explored regions. In these basins, reserves in structural traps account for 34% of the total proved plus prospective, and 21% of the total estimated; in subtle traps, 7.6% of