sparse in the nonmarine sediments of the upper Morrison, are common in the marginal-marine deposits of the lower Dakota and are extremely abundant and taxonomically diverse in the nearshore-marine lithofacies of the upper Dakota and lower Mancos. The distribution of most trace fossils reflects strong control by substrate and environmental facies; however, several taxonomic and ethological variants of a few ichnogenera demonstrate a lack of such control.

The "Jackpile Sandstone" of the upper part of the Morrison Formation contains only a few trace-fossil structures; many of these can be ascribed to the ichnogenus *Planolites*, the only trace-fossil type present in all stratigraphic units investigated in this study. The paludal and strand-line deposits of the lower Dakota contain abundant *Skolithos* and *Planolites*, and *Ophiomorpha*, which displays transition in form to a small variety of *Thalassinoides*, "Reed(?) molds" also are common in the lower Dakota sandstones.

Shallow-water marine sandstones of the upper Dakota are intertongued with the lower Mancos shales and are characterized by an abundance of trace fossils. Well-developed *Ophiomorpha* and *Teichichnus* structures show transition in form to a small variety of *Thalassinoides* and are probably ecovariant forms made by the same organism. Additional ichnogenera studied include large polygonal *Thalassinoides, Asterosoma, Arenicolites, Zoophycos, Chondrites, Crossopodia, Gyrochorte, Pelecypodichnus, Planolites,* and *Skolithos*. The presence of *Zoophycos* is of particular interest because of its usual association with deep-water deposits. The large *Thalassinoides* and *Asterosoma* structures appear to be restricted to the deeper water sandstone deposits of the upper Dakota.

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TECTONIC FRAMEWORK OF MACKENZIE DELTA DETERMINED FROM GRAVITY DATA

The MacKenzie delta is the most exciting petroleum exploration area in North America. It is situated at the confluence of three orogenic belts: the north-trending Richardson Mountains; the northwest-trending British and Barnes Mountains; and the northeast-trending Aklavik arch-Campbell uplift. Within the delta are local and regional structures which correspond in strike to all 3 of these tectonic trends. A recently completed, extensive gravity survey clearly reveals these structures.

The main tectonic elements of the delta from the gravity data are: a large northeast-trending basement high and parallel system of growth faults that bound the delta on the east; the adjoining northeast-trending Kugmallit trough; the Campbell uplift on the southeast margin of the delta; the Aklavik-Tunnunuk arch; a regional basement high in the Beaufort Sea parallel with the coast; large, northwest-trending, anticlinal folds; faults bounding the major positive structures; and probable diapirs.

The present delta was a Cretaceous depocenter. Cretaceous sandstones, shales, and conglomerates thicken abruptly across faults into the Kugmallit trough. Oil and gas discoveries to date in the delta are from Cretaceous and Cretaceous-Tertiary sandstones on structures indicated by pronounced gravity maxima. However, Paleozoic rocks may be at drillable depths on some of the structures and are possible objectives. Numerous, very large structures prospective for hydrocarbons delineated by gravity data are of 4 types: (1) regional arch (regional gravity maximum); (2) large, linear fold, with a dense core (large linear gravity maximum); (3) large linear fold, with a low-density core (relatively small gravity maximum); and (4) probable diapirs (round to oval gravity minima).

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RELATIONS OF CRATONIC AND CONTINENTAL-MARGIN TECTONIC EPISODES

The Phanerozoic history of continental cratons is marked by repeated global episodes of 3 types: (1) oscillatory—generally elevated or oscillating with respect to sea level; marginal and submarginal areas subject to highly differentiated uplift and subsidence; periodicity of oscillations and uplifts 10^5-10^6 years; wave lengths of intracratonic tectonic elements 10^1-10^2 km; duration of episodes 10^7-10^8 years; (2) emergent—progressively elevated in time; without significant topographic relief; tectonically undifferentiated below wave lengths of 10^3; duration 10^6-10^7 years; and (3) submergent—progressively depressed below sea level to form widespread epicontinental seas; subepisodes (10^6-10^7 years) of differential subsidence to form basins and arches ($\delta = 10^2$-10^3 km); duration 10^7-10^8 years.

Time relations of cratonic episodes are (1) oscillatory—much of Cenozoic, including present and period from Pennsylvanian to Early Jurassic (time spans of Appalachian-Hercynian, Laramide and Alpine orogenies); (2) emergent—latest Precambrian, early Middle Ordovician, Early Devonian, *etc.* (lacunal intervals between accumulations of cratonic sedimentary sequences); and (3) submergent—time spans of Caledonian, Antler-Acadian, and Nevadian orogenies.

In plate-tectonic terms, the present is characterized by high spreading rates and by convergent boundaries of oceanic and continental plates relatively remote from cratonic margins. These probably were the prevailing conditions during times of oscillatory cratonic behavior. Emergent cratons, by historical analysis, appear to be related to quiescent episodes at continental margins, possibly reflecting spreading-rate minima. Submergent cratons would seem to coincide with times of active plate convergence involving oceanic margins of cratons expressed by obduction and subduction at such margins.

Differences in cratonal tectonic habit may represent responses to either or both time-variable factors in continent-margin tectonics: variation in lateral stress transmitted to cratons from their margins, and variation in thickness, and thus in flexural rigidity of the continental lithosphere.

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HALITE CRYSTALLIZATION IN SUPRATIDAL SALINA, OMETEPEC LAGOON, BAJA CALIFORNIA, MEXICO

Supratidal flats of the Colorado River delta are sites of active evaporite formation. Major evaporite minerals are gypsum and halite. Flooding of the flats by Gulf waters several times per year causes the Ometepec Lagoon to be covered by a standing body of water not deeper than 2 ft. After the initial stage of gypsum crystallization, halite forms until evaporation reduces the standing brine to a ground-water brine. The dominant growth mechanism of halite is a competitive upward growth of cubes which nucleate on the brine-pan floors. The upward advancing edges of the cubes produce chevron grains, an internal inverted V-structure caused by rapid alternations of fluid inclusion-rich and inclusion-free zones. Entrapment of brine inclusions represents a rapid growth stage, whereas the inclusion-free zones represent slow-growth periods. Very rapid fluctuations in growth rates seem necessary during crystallization of chevron halite. The very shallow depths of Salina Ometepec brines are extremely susceptible to rapid changes in growth-rate-control factors such as brine temperature, concentration, and rate of evaporation. These factors in turn are dependent on air temperature, humidity, wind, *etc.* If the assumptions are made that (1) inclusions are dependent on growth rate, and (2) growth rate is controlled by various combinations of the above factors, it is logical to conclude that chevron halite is a characteristic feature of halites produced in environments of rapidly fluctuating growth rates. Brine depths of these environments would be expected to be very shallow, as it is difficult to envision the necessary rapid fluctuations in a deep body of brine.

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CALCIFICATION AT FANNING ATOLL

Alkalinity, pH, and salinity measurements were made during the summer of 1972, in the lagoon of Fanning Atoll, Line Islands. These measurements were used to estimate water residence time and the rate of various CO_2 flux processes, particularly calcification.

Residence time of water in the lagoon is about 1 month, and the calcification rate is about 1,000 g $CaCO_3$ m^{-2} yr^{-1}. This rate is less than a third of what might have been anticipated on the basis of coral standing crop there. The lagoon water is supersaturated with respect to $CaCO_3$, but is significantly less so than is the adjacent open-ocean water. Possibly the metabolic process of calcification is limited by this lowered saturation state.

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CITY AND STATE REGULATIONS AFFECTING OIL INDUSTRY

No abstract available.

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METAMORPHISM OF SEDIMENTARY ORGANIC MATTER

Organic constituents both in fine-grained rocks and reservoirs undergo chemical and physical changes in both the diagenetic and metamorphic realms. Four factors affect the final products—the original kind of organic material and its diagenetic state, heat due to geothermal gradient and metamorphism, time, and subsequent alteration in the reservoir.

In the diagenetic realm, algal debris is readily convertible to potentially hydrocarbon-rich, amorphous debris (floccules) through the action of organisms and suitable water chemistry. Phytoclasts, such as cuticle and spores, are more resistant, but also can be converted. High-carbon-structured fusinite is relatively inert to diagenesis or low-grade metamorphism.

Three facies of organic metamorphism with increasing temperature/time are recognized. The immature facies has abundant methane, trace quantities of C_2-C_{14} hydrocarbons, and a C_{15+} fraction containing abundant NSO compounds. The mature facies exhibits a complete spectrum of hydrocarbons; its start marks the onset of oil generation. The metamorphic facies, characterized by abundant methane, only traces of heavier hydrocarbons, and practically no NSO material in the C_{15+} fraction, signifies the thermal destruction of preexisting oil pools. These facies, which can be mapped very early in the exploration of new-venture areas, can be recognized by combined cuttings-gas and organic-matter study. Chemical changes are paralleled by measurable physical changes in the solid-organic components. A correlation of coal rank, vitrinite reflectance, and thermal alteration numbers, based on color of organic debris, is presented.

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PLIOCENE TO HOLOCENE SEDIMENTS IN MEDITERRANEAN AREA AND THEIR TECTONIC SETTING

Today's plate-tectonic boundaries in the Mediterranean area are delineated on the basis of earthquake hypocenters, faults, ophiolites, intermediate volcanic rocks, paleomagnetic data, linear gravity anomalies, and magnetic anomalies. These plate boundaries are subdivided into subduction zones, zones of oceanic crust formation, and transform or strike-slip faults.

The thickness and facies of Pliocene to Holocene sediments, both onshore and offshore, have been compiled from many sources, which include measured surface sections, well data, offshore sparker and other seismic surveys, and cores from JOIDES Leg XIII drilling sites. A prominent, subbottom, acoustic reflector is present on almost all marine-seismic sections. This reflector was proved to be the top of an upper Miocene evaporite sequence in cores from JOIDES site 134, where late Miocene Foraminifera are present in marine shales intercalated with halite. Evaporites from the same reflecting horizon were cored at 5 other JOIDES sites. On this evidence the prominent acoustic reflector has been identified as marking the Miocene-Pliocene boundary. The subsea Pliocene to Holocene sediments correlate with post-Messinian onshore sediments.

A comparison of the postulated Mediterranean geometry with the Pliocene to Holocene sediment distribution shows the following correlations.

1. Thick, linear accumulations may occur along subduction zones, as in Italy, the eastern Carpathians, and the southern Caspian Sea-Caucasus area, but may also be thin or virtually absent, as offshore south of Crete and north of Algeria.
2. Sediment fans occur at the mouths of larger rivers as the Nile, Rhone, and Ebro; and where sea currents emerge from a constriction as south of the Strait of Messina. Some fans are related to plate-rift margins.
3. Thin sediment sheets or patches characterize the interior areas of both continental and oceanic plates.

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MECHANISM FOR LARGE-SCALE DEFORMATION IN EOLIAN DUNES

Large-scale deformation of laminae in ancient sandstone of supposed eolian origin has perplexed geologists for many years. Other workers have described several types of deformation related to lee-side avalanching, but none at the scale observed in some ancient eolian sandstone. Our observations on the surface and in trenches of a transverse dune in the Killpecker dune field in southwestern Wyoming suggest that incorporation of snow into dunes may provide such a mechanism.

During periods of snowfall, large snow cornices form on the crests of dunes. In the spring the cornices are covered by blown dry sand which is remobilized after most other snow has melted. Subsequent warming causes the sand-covered cornices to melt, become unstable, and slide at least part way down the slipface. Both folding and brecciation take place in the sand covering the snow during melting and sliding. Folding of laminae in sand under the snow also occurs. Further burial of this deformed mass of snow and sand results in its incorporation into the internal structure of the dune. Collapse breccia is formed where climatic conditions and depth of burial permit the continued melting of incorporated snow. In some cases, however, the covering sand provides sufficient insulation to prevent further melting and the snow becomes a permanent or semipermanent part of the dune.

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PALEOGEOGRAPHY, PALEOBATHYMETRY, AND PALEOTECTONISM OF MID-TERTIARY JAMAICA

Two biologically and lithologically distinct realms of carbonate deposition characterized mid-Tertiary Jamaica. After a latest Cretaceous to Paleocene orogenic episode, complete submergence of insular paleo-Jamaica accompanied the strike-slip or extensional faulting associated with the formation of the Cayman Trench on the north. Differential subsidence along a series of peripheral subsea escarpments (Duanvale-Wagwater escarpment) produced relief of more than 2,000 m by the middle Eocene. The slowly subsiding Cornwall-Middlesex platform was covered by shoal-water limestones which ended the supply of clastics to sea-bottoms north and east of the escarpment,