gradients range from 1 to 2°F and most are between 1.2 and 1.3°F per 100 ft of depth. At a depth of 10,000 ft the temperature ranges between 190 and 230°F. The most prominent features of the temperature distribution at 10,000 ft is a belt of high temperature about 30 mi wide close to the present coastline. The location of this "hot belt" is puzzling because it is located approximately where the greatest thickness of Cenozoic sediments is believed to occur. Extrapolating the temperature and pressure downward, it seems possible that conditions necessary for regional metamorphism are present in the lower part of the sedimentary column at depths below 40,000 ft. Possibly the recrystallization of the sediments accounts for the high temperature values.

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SUPRATIDAL ACCUMULATION OF REEF DETRITUS AT BONAIRE, NETHERLANDS ANTILLES

In many areas of the Carribbean with suitable environmental conditions and a gently sloping shelf, four coralline ecologic zones may be identified: a deep, quiet-water *Dendrogyra* zone, an intermediate moderately agitated *Acropora cervicornis* zone, a shallower agitated *Acropora palmata* zone, and a shallow quiet lagoonal zone. Patch reefs grow and trap distinctive coralline debris in the *A. cervicornis* zone, and barrier reefs grow and trap distinctive coralline debris in the *A. palmata* zone.

At Bonaire, with a steeply sloping island shelf and increased water agitation, the same ecologic zones are found. However, the shallower ecologic zones are not everywhere present, and the extent to which they are absent is proportional to the increased agitation of the water. Patch reefs and barrier reefs are not found. Instead coralline detritus is deposited as beach ridges. On the windward side of the island these ridges are composed mainly of corals and coral fragments from the *Dendrogyra* zone, whereas the beach ridges on the leeward side of the island are composed almost exclusively of corals and coral fragments from the *A. cervicornis* zone. The detrital content and geometry of these beach ridges are similar to those of subaqueous patch reefs, except that they are larger and better developed. Modern beach ridges are being built on lithified Pleistocene beach ridges, developing a pinnaclelike complex. Evaporite pans formed behind the beach ridges. Thus, a lagoon to coral mount to shelf sequence is formed that might, if preserved in the geologic column, be misinterpreted as a patch or pinnacle reef development.

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HYDROLOGY OF DEEP SEDIMENTARY BASINS[1]

Continental blocks of the earth's crust are mainly deep basin sediments, generally lithified and commonly metamorphosed. Observed rock transformations required input of heat in an environment of pressure ranging from hydrostatic to geostatic, and most occurred in the presence of water.

The role of hydrology in diagenesis and lithification of deep basin sediments, and in the leaching, transport, and reprecipitation of mineral constituents is now in a period of intensive reevaluation. New techniques of study, vastly improved methods of data collection and processing, and an enormous store of information on widespread conditions through a great depth range provide effective means for such reevaluation.

The hydrologic evolution of deep basin sediments prior to metamorphism occurs in two distinct phases. Discharge of connate water upward and toward the basin margin is the first phase; intake and throughflow of meteoric water comprise the second. The first phase may be considered near completion only when clay-mineral dehydration has entered its final stage. Each phase may span scores to hundreds of millions of years, and different parts of a basin may be in different phases at a specified time.

The hydrologic evolution of a sedimentary basin is related to its configuration and dimensions, its depositional and structural history, the relative thickness and areal distribution of sediments (by type) within it, and changes in its regional geomorphic setting. Evolutionary progress is evidenced by changes in formation-water composition and salinity as functions of depth and areal distribution, changes in the geothermal and interstitial fluid pressure regimes, and reduction of the water content of the rocks. Conditions in basin deposits ranging in age from early Paleozoic to Neogene illustrate these evolutionary processes.

[1] Publication authorized by the Director, U.S. Geol. Survey.

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ENIGMA OF COLORADO PLATEAU EOLIAN SANDSTONE

Precise environmental interpretation of Colorado Plateau eolian sandstone bodies remains difficult despite advances in sedimentology. The early interpretation of all sediments of great textural and compositional maturity, and high grain roundness and frosting, that display large-scale cross-lamination as desert deposits has hindered environmental reconstruction. Great sandstone wedges that thicken away from the cratonic margin, such as the vast Navajo-Nugget complex, are particularly enigmatic.

Colorado Plateau eolian sediments represent combinations of four environmental models: mainly eolian, mainly marine, mixed alluvial-eolian, and mixed littoral-eolian. Mainly eolian units (Coconino, Cow Springs) are recognized by limited areal extent, irregular deposit geometry, intricate cross-bedding, lack of prominent planar features, and by scarce paleontologic evidence. Mainly marine units formerly considered to be eolian (Cedar Mesa, White Rim, Glorieta) are characterized by horizontal bedding, lower angle and less intricate cross-bedding, certain stratigraphic relations, and a few marine fossils. Mixed alluvial-eolian sediments (Wingate, lower parts of Navajo) have complex lateral and vertical facies relations with adjacent alluvial units and show evidence of fluvial modification.

Mixed littoral-eolian deposits (De Chelly, Navajo, Entrada) are areally extensive, bear multiple parallel-truncation planes as prominent features, and generally are well cross-bedded (but contain some horizontal or aqueous ripple bedding). Contorted slump structures and thin discontinuous carbonate lentils are conspicuous in some units. Partial intertonguing with marine units, although generally obscure, is characteristic. Parallel truncation planes are produced by repeated widespread marine planation of coastal dune fields by temporary transgressive oscillations, followed by varying degrees of deflation removal of water-laid beds after subsequent reexposure. Mixed littoral-eolian deposits require a tectonic-climatic-environmental model which has no definite modern analog; this causes difficult interpretational problems.

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NEOCURRENT TRENDS AND STRUCTURAL CONTROL OF SEDIMENTATION IN WILMINGTON SUBMARINE CANYON, EASTERN UNITED STATES

Neocurrent trends, patterns of sediment transport in the geologically recent past inferred from preserved vectorial properties, indicate that sediment is moving predominantly toward the west-southwest on the outer shelf off the U.S. east coast. Sediment is being trapped by the north-south-trending head of the Wilmington submarine canyon. Seismic-reflection profiles, direct observation of the bottom with camera and underwater television, and sampling reveal that (1) a greater thickness of the unconsolidated sediment wedge drapes the eastern canyon wall and (2) the percentage of pebbles, coarse sand, and shell exceeds that on the west flank. Coarse sediment, largely of relict origin, consists of Pleistocene and Tertiary materials some of which have been reworked recently from the canyon walls.

Cognizance of the structural framework is essential in interpreting the morphologic and sedimentary patterns of the canyon. The sharp northward bend of the canyon head and its shelfward migration is controlled largely by faulting (probably pre-Quaternary) and Pleistocene drainage as shown in subbottom profiles. Draping of deeper, probably pre-Pleistocene, subbottom reflectors into the outer part of the canyon head suggests that this canyon formed before the Pleistocene. A morphologic high (Nyckel ridge) forming the southern margin of the canyon on the slope and upper rise is recognized as a compound flexure of structural origin. This feature is not a simple depositional levee as has been suggested. It serves as a locus for bottom current activity on the lower slope and rise and controls the textural distribution in the area. Intrabasinal slumping off this ridge is important.

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NORTH SEA EXPLORATION PROGRESS

In the British North Sea five confirmed major gas discoveries have been made. Gas is being produced from two fields, and two other discoveries are being linked to land. The basal Permian (Rotliegende) sandstone is the main reservoir; the Triassic Bunter is of secondary importance. Oil shows have been reported but no economic discovery of liquid hydrocarbon has been made, despite the drilling of about 100 exploration wells.

In the Norwegian and Danish sectors oil shows have been found in more westerly wells, but no economic discoveries have been reported. In Dutch offshore waters the first tests have been drilled on attractive structures, but, in contrast to the adjoining land areas, poor reservoir conditions are reported.

Interest is being extended to more westerly parts of the European continental shelf, particularly the Irish Sea area, where major thicknesses of Mesozoic and Tertiary sediments are likely to be present in narrow basins between Paleozoic high-standing areas.

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MIDDLE AND EARLY LATE CAMBRIAN ALGAL BIOSTROMES AND REGIONAL DOLOMITIZATION IN GREAT BASIN

Middle and early Late Cambrian stratigraphic sections from southeastern California, across eastern Nevada, to northern Utah are characterized by the rhythmic repetition of dolomitic algal biostromes and dolomitized pelletiferous calcisiltite. Stratigraphic and petrographic criteria indicate deposition on a very wide, shallow, low-gradient shelf on which extensive calcareous algal mats formed. Penesaline conditions, resulting in part from the combination of the width and shallowness of the shelf, led to production of brines and syndiagenetic dolomitization of the algal mats.

Syndiagenesis is suggested by associated intraformational breccias composed chiefly of dolomitized algal debris in a matrix of calcisiltite and by a few erosion pits cut to depths of several inches. Subaqueously formed cracks across wrinkled mats, probably caused by the drag of passing waves, appear to represent an incipient stage in the formation of the breccias.

The pelletiferous calcisiltite is a more seaward deposit and is believed to be composed largely of detritus washed from the algal-mat environment. Seaward refluxion of the brines led to the dolomitization of these rocks.

Rhythmic repetition of these environmentally controlled lithic types reflects a set of conditions which alternately inhibit and enhance algal growth.

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ALGAL-BEARING CARBONATE RESERVOIRS OF PENNSYLVANIAN AGE, WEST TEXAS AND NEW MEXICO

Leafy, platy, or phylloidal algae have been observed in many well cores from hydrocarbon reservoirs at various localities in the Permian basin of west Texas and southeastern New Mexico. These algae have a significant bearing on the quality, and in some cases the existence, of the reservoir. Three examples have been chosen to illustrate these relations.

Nena Lucia field, Nolan County, Texas, produces from massive limestone of Desmoinesian (Strawn) age on the east side of the Midland basin. Inferences of eolian depositional environment published previously are not supported, for the dominant reservoir lithofacies is algal calcareous wackestone. Saunders field, Lea County, New Mexico, produces from both massive and well-bedded limestone of Permo-Pennsylvanian age on a well-defined structure just north of the Delaware basin. Although diverse elements contribute to the different porous zones, platy or phylloidal algae are a dominant factor in some of the zones. Conley field, Hardeman County, Texas, produces from three separate formations, including a limestone reservoir in the early Missourian (Canyon) Palo Pinto Formation. This unit is particularly noteworthy for the profusion of algae and the nearly complete dependence of reservoir development on the organisms. Though much smaller in volume, this reservoir is petrologically very similar to that described from the Aneth field complex of the Paradox basin.

Phylloid algal reservoirs commonly are surrounded by nonporous mudstone and wackestone and thus fall in the class of reservoirs wherein sediment genesis is an important factor in pore origin. An initial pore net-