remains, are present on small banks and beaches in Barkley Sound.

Mineralogically, relict and modern sands are similar, consisting mainly of detrital plagioclase and lithic fragments. However, there are marked differences between heavy mineral suites, which led to the establishment of the Barkley Sound and continental shelf provinces. The ultimate sources of the sediments are mainly Mesozoic diorites and intermediate-basic volcanic rocks.

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MORPHOLOGIC EVOLUTION OF CAMBRIAN ALGAL MOUNDS, TEXAS, WITH CHANGING DEPOSITIONAL ENVIRONMENT

Algal mounds within the Morgan Creek Limestone (Upper Cambrian) of central Texas, exhibit an overall change in morphology with height in the section. This "evolutionary" trend is associated with a change in depositional environment. The modification in algal-mound morphology is believed to be a response of the algal communities to change in the level of water turbulence and water depth.

The earliest forms are discrete club-shaped mounds exhibiting a relatively simple, highly arched, non-branching, concentric structure. They are up to 1.5 ft thick and 2 ft in diameter. They are succeeded by larger mounds, 0.75–3 ft thick and 1–5 ft in diameter, with a complex, digitate internal structure. Near the top of the Morgan Creek Limestone are the largest algal mounds, biconvex lenses up to 5 ft thick and 25 ft in diameter. The overlying strata contain some flat, algal-laminated structures.

This evolution in mound form, a decrease in height-to-width ratio and from simple to complex internal structure, is associated with a decrease in water turbulence and a shift from shallow marine to intertidal to supratidal site of deposition. This environmental response demonstrates that changes of mound morphology can be useful in interpreting depositional environments.

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PHOSPHATE DEPOSITS OF CABINDA DISTRICT, ANGOLA, PORTUGUESE WEST AFRICA

Thick high-grade high-quality sedimentary marine phosphate deposits have been delineated in the Cretaceous-Tertiary strata of the Cabinda district of the Province of Angola, Portugal. The phosphate-bearing strata, a 1,500-ft sequence of sands, clays, phosphatic beds, and limestone, are underlain by redbeds and greenish-gray shales and overlain by relatively unconsolidated sands and conglomerates. The phosphate is concentrated in 2 units: an upper phosphate zone ranging in thickness from about 45 ft to 75 ft and containing from 15 to 20% P_2O_5, and a lower phosphate zone ranging in thickness from 80 to 130 ft. These are separated by 65–390 ft of sandstones, shales and conglomerates, with minor phosphate beds. The ore in the lower zone is concentrated in 3 units which are from oldest to youngest, about 10 ft, 40 ft, and 28 ft thick. They contain from about 10 to 20% P_2O_5 and are separated by 2 waste beds which are about 15–30 ft thick.

The phosphate mineral is carbonate-fluorapatite as inorganic phosphates (pellets, oolites, and nodules), and organic phosphates (fragments of fish teeth, bones, and fish scales). The phosphate in the upper ore zone is predominantly inorganic and that in the lower ore zone is about an equal mixture of organic and inorganic. Some phosphate beds (up to 10 ft in thickness) are primarily apatite and contain as much as 38% P_2O_5; however, most are mixtures of apatite with quartz sand and silt. Within any ore zone the phosphatic beds are interbedded with sand and silt beds. High-grade and high-quality phosphate concentrates (36–38% P_2O_5) can be produced by simple sizing and flotation from low-grade ore (10–20% P_2O_5).

The phosphate was deposited as continuous beds in a marine basin which covered much of the Cabinda district. This basin generally shelved gently westward from near the Congo border on the east, so most lithologic units thicken westward. Phosphate deposition was in part controlled by folding developed before and during the period of deposition. The major known fold which strikes southeast through the middle of the area was probably the predominant structural feature controlling distribution and deposition of the phosphates.

After deposition the folding continued and a strong system of southeast-trending faults developed. The fault system has resulted in the formation of several grabens, which presently form topographic highs where the major reserves of phosphate are preserved.

The major factor bearing on the economic potential of the phosphate is the leaching and oxidation of the phosphate beds by the recent downward movement of meteoric water where the beds are near the surface. Leaching extends to a maximum depth of about 300 ft and increases the grade of the beds by as much as 50%, and the grade of the apatite from 32 to 34% P_2O_5 to 38% $\pm$ P_2O_5.

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EVALUATION OF HYDROCARBON POTENTIAL FROM STRATIGRAPHIC ANALYSIS OF MESOZOIC CLASTIC SEQUENCE, SASKATCHEWAN

Jurassic and Cretaceous sediments form a northward-thinning wedge of 5,000 ft maximum thickness that occupies 125,000 sq mi in south Saskatchewan. Significant petroleum production began in the 1940s. New reservoirs were located each year to total, by the end of 1969, 73 main pools in 6 principal producing units, yielding 337,089,144 bbl of crude oil and 435,851,579 Mscf of natural gas from depths of 750 to 4,700 ft.

Middle Jurassic beach and channel-fill, marine sandstones and carbonates, enclosed in less permeable carbonates and fine-grained clastic rocks yield medium-gravity oil in southwestern Saskatchewan and are prospective both west of the oil-field trend and in southeastern Saskatchewan. Medium-gravity oil also is produced in southwestern Saskatchewan from Upper Jurassic marine sandstones forming updip mesas, buttes, and interfluves beneath a basal Cretaceous cover of locally permeable and productive continental deposits. Production of heavy oil and nonassociated natural gas is obtained where deltaic sandstones of the Cretaceous interdigitate with marine shales. The sequence is prospective throughout central Saskatchewan, particularly where sandstone-body trends may be related to major structural features. In west-central Saskatchewan, light oil and nonassociated gas are produced from sandstone bodies of good economic potential. These sandstones are hydraulically isolated within a thick sequence of Lower Cretaceous marine shales and exhibit structural features that closely reflect the texture of the dissected pre-Cretaceous surface. Nearshore marine and continental-fluviomarine sandstone bodies of Late Cretaceous age yield nonassociated natural gas in western Saskatchewan; the best prospects appear to be at the base of this sequence in southwestern Saskatchewan.

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DEPOSITIONAL MODELS FROM A HIGH-ENERGY COAST

The 2 most common depositional systems along the coast of southern Oregon are the nonbarred nearshore and the longshore bar–rip channel systems. Detailed observation of these systems, largely by scuba diving, has led to delineation of facies of sedimentary structures and recognition of their genetic relation to physical processes operating in the high-energy coastal environment. A 3-dimensional analysis of the geometric interrelation of the facies within each system permits construction of progradational depositional models that can be used to identify deposits of similar origin in the stratigraphic record.

In the most simple depositional system, the nonbarred nearshore, the bottom profile extends smoothly seaward into deeper water. Progradation of the facies in this system will produce a distinctive vertical sequence. At the base lies fine sand of the offshore facies, which shows landward-dipping ripple lamination and scour-and-fill structure. The upper part of this facies is likely to contain lenses of crossbedded coarser sand in which foresets dip landward. The facies grades upward into predominantly cross-stratified beds formed by different facies of the surf zone. The upper crossbeds are likely to be gravelly and inclined seaward. They are overlain by planar-bedded swash facies.

Progradation of the longshore bar–rip channel system produces a different sequence. An erosion surface separates the offshore facies from overlying rip channel facies in which crossbedding dips seaward. Above the rip channel facies lies a gradational sequence of longshore trough facies, wave-current complex facies, and, at the top, swash facies. In an actual situation, the bar facies, in which cross-stratification dips onshore, may be preserved locally within the deposit.

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MIOCENE MARINE TO NONMARINE TRANSITION IN SOUTHERN COAST RANGES OF CALIFORNIA

The southeastern Caliente Range, in the southern Coast Ranges of California, contains a remarkably exposed transition between marine and nonmarine rocks. The transitional sequence consists of depositional facies that contain sedimentary structures comparable to those found at present in coastal environments in Oregon and California. The spatial relations of the facies are consistent with their origin as interpreted from depositional structures. Directional structures and lateral trends within the deposit relate to the local middle Miocene paleogeography as deduced from independent evidence.

Fine-grained ripple-bedded and bioturbated shelf sediment constitutes the seaward-most facies. Medium- to coarse-grained sandstone in which crossbedding dips predominantly seaward defines a facies that resembles deposits produced by laterally migrating longshore bar-rip channel systems. Abundant medium-scale (5–30 cm) trough cross-stratification characterizes a facies similar to that formed in the modern high-energy surf zone. Planar sand and gravel layers that dip gently seaward identify another facies, one with a modern counterpart on the lower foreshore. Heavy-mineral layers 1–10 cm thick that dip gently seaward, where they interfinger with quartzose sand, identify ancient upper foreshore deposits. Other facies include oyster-bearing siltstone (probably a lagoonal deposit) and structureless muddy medium-grained sandstone that may represent a vegetated back-beach deposit. Structureless red mudstone, sandstone, and conglomerate of alluvial origin form the most landward facies.

The different facies are repeated cyclically throughout the transitional sequence. Within each cycle the facies lie in an ascending order of increasingly shallow-water deposition. Each cycle represents a progradational episode; the intervening transgressions are indicated by erosional surfaces, in places covered by a thin layer of conglomerate. This cyclic repetition of slow progradation interrupted by rapid submergence may relate to episodic movements on the nearby San Andreas fault.

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JURASSIC LIMESTONE FACIES OF ATLAS MOUNTAINS AND COMPARISON WITH ITS RECENT RED SEA MODEL

The Atlas Mountains of Morocco stretch across the northwest African continent and can be subdivided into the High Atlas on the south and the Middle Atlas on the north, separated by the broad Atlas platform in eastern Morocco. The Lower and Middle Jurassic rocks which form the Atlas Mountains consist of a series of limestones, interbedded dolomites, and cherts. These rocks comprise the following three facies: (1) littoral-lagoon facies; (2) shelf facies characterized by reefs and a shallow-water neritic fauna; and (3) a deeper-water bathyal facies dominated by planktonic forams and radiolarians. The facies of the Middle Atlas are similar to those of the High Atlas and were deposited in a branch of the Atlas sea. Detailed studies of the High Atlas indicate that it grew in response to rifting. Both north and south margins are characterized by reefs and shaly limestone, which were deposited over steep fault scarps. The Atlas ocean, which formed during the Early Jurassic and reached its demise during the Late Jurassic can be compared favorably with the Red Sea from the point of view of facies distribution, faunal associations, and gross size and geographic relations.

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NORTH AMERICAN STRATIGRAPHIC PRINCIPLES AS APPLIED TO DEEP-SEA SEDIMENTS

North American stratigraphic principles as developed by geologists mapping on continents can be applied to deep-sea sediments. The ability of the Deep Sea Drilling Project to obtain long cored intervals over extensive areas of ocean basins makes possible the establishment and lithologic correlation of rock-stratigraphic units (*e.g.*, formations).

Deep-sea sediments should be divided and reported in terms of lithologic units which may be assigned rock-stratigraphic names if these units can be recognized at other sites. This practice is desirable in place of current stratigraphic practices in oceanography of defining rock-stratigraphic intervals by time-stratigraphic terms. The generally accepted North American usage of formation as a lithologic mappable unit devoid of any time connotation is recommended over the