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

European usage of formation which often is actually a time-stratigraphic unit correlated across major facies changes.

Leg 9 of the Deep Sea Drilling Project recovered 1,500 m of core in eight sites (sites 77–84), a distance of 5,000 km, along the equatorial Pacific. Each site was cored to basement. Site 77 which was continuously cored 480 m was divided into several lithologic units that served as a standard of reference for Leg 9 sites. The consistent stratigraphic sequence and areal distribution of these lithologic units led to the adoption of four deep-sea formations: Line Islands Formation, Marquesas Formation, Clipperton Formation, and San Blas Formation. These formations are lithologically distinct, Tertiary, diachronous units that can be traced at least 4,000 km. The most useful and objective criteria to define these formations are color differences and to a lesser degree bedding characteristics. Color variations often are accompanied by textural, mineralogic, and biotic changes which further aid in the characterization of these formations.

Description of deep-sea sediments in terms of lithologic units and the establishing, tracing, and dating of oceanic formations can provide an improved basis for understanding the interrelations among rock-stratigraphic and time-stratigraphic units, lithologic and biologic sedimentation patterns, depositional processes, and subaerial dispersal patterns. It can also improve communication between oceanographers and continental stratigraphers.

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STRATIGRAPHY AND PETROLOGY OF TYPE ESCONDIDO FORMATION (UPPER CRETACEOUS), MAVERICK COUNTY, TEXAS, AND ADJACENT COAHUILA, MEXICO

The type Escondido Formation (Rio Grande section) has an aggregate outcrop thickness of about 900 ft and is sandwiched between the underlying coal-bearing Olmos Formation and the basal tabular limestone beds of the Midway Group (Tertiary). The lower three fourths of the outcrop Escondido is calcitic mudstone and shale separated by several fine-grained quartz arenite to lithic subarkose sandstone layers. Lithology, sedimentary structures, and macro-invertebrate faunal assemblages suggest a bay-lagoon-barrier bar depositional system. The upper part of the Escondido (Cuevas Creek Member) is a lithosome of calcitic mudstone, siltstone, very fine sandstone, and muddy to silty, commonly glauconitic limestone. Recurrent molluscan assemblages and abundant burrow structures suggest deposition in an inner-shelf setting of shallow neritic depths.

Sphenodiscid ammonite assemblages in the Escondido historically have been correlated with the lower part of the standard Maestrichtian stage of Europe. The uppermost sphenodiscid zone in the Escondido [zone of *Sphenodiscus pleurisepta* (Conrad)] has not been conclusively defined in other parts of Texas, the eastern Gulf Coast, or northeastern Mexico; it may represent higher Maestrichtian.

The Escondido-Midway contact is sharp, consisting of ledge-forming limestone above and mudstone below. However, the Cretaceous-Tertiary boundary does not coincide exactly with the contact. The boundary lies in a thin transitional interval, showing successions of glauconite concentrations and discontinuous levels of pholad borings.

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NEW COMPONENT OF BRAIDED RIVER MODEL

During the late Wisconsin glacial retreat in southern Ontario, extensive sheets of braided gravelly and sandy outwash were deposited. In the Credit River valley, near Toronto, there are 2 overall fining-upward sequences of braided deposits, with gravels passing upward into sands. The gravels contain large-scale (up to 3 m) crossbedding and abundant channeling, suggesting deposition from migrating mid-channel braid bars. The sands contain some tabular crossbedding (sets up to 1 m), and also a distinctive, newly defined coarsening-upward lithofacies sequence.

The sequence begins with a thin (3–6 cm) layer of clay, which overlies abruptly on rippled sand. The clay grades upward into silty clay with faint wavy laminations, and some cross-lamination with preserved stoss sides. The silty clay grades upward into cross-laminated silt, and then ripple-drift cross-laminated sand with eroded stoss sides. The rippled sand is followed erosionally by trough crossbedded sands (sets up to 40 cm) resting in channels up to 1 m deep and 3 m wide. In places, these channels cut down to the basal clay layer. The uppermost part of the sequence consists of tabular and trough crossbedded coarse sands and gravels.

The coarsening-upward sequence is interpreted as the fill of an abandoned channel. The clay represents fines washed over a levee from an active channel in flood. As more material was washed in, gentle flow began and ripples were formed in silt and fine sand. Levee breaching introduced bed load material into the new channel, forming the crossbedded gravels and sands.

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POSTDEPOSITIONAL REACTIONS INVOLVING BORON, SEDIMENT, AND PORE WATER IN MISSISSIPPI DELTA SYSTEM

The boron concentration in the clay fraction of argillaceous sediments has been used for several years as an index to paleosalinity. Although experimental studies have shown that adsorption is the initial uptake reaction between clay and solution, basic questions have remained concerning the permanent fixation of boron in a clay mineral, and other possible diagenetic effects. The present study considered that question in the light of data obtained from sediment and expressed porewater from shallow cores taken from various parts of the Mississippi Delta system.

Clays entering the Gulf of Mexico from the Mississippi River adsorb boron from seawater while the clays are still in suspension. After burial, this initially adsorbed boron is fixed by the clay, and additional boron is adsorbed from the interstitial pore-water. Very soon after burial, considerable boron may be released from organic matter in the sediment (perhaps due to microbiological decomposition), causing an early enrichment of boron in the porewater. This boron, however, is also adsorbed by the clay minerals in time.

Contrary to the conclusions reached by others, these data indicate that late diagenetic enrichment is not required to explain the boron content of deeply buried Gulf Coast shales.