that is, alteration products of crude oil. This interpretation is further supported by microscopic examination revealing fracture-infilling by bituminous material. Finally, uranium was provided by ground waters rather than by concentration due to the oil-pyrobitumen transition.

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Clastic Lacustrine Sedimentation in Triassic of Southwestern Colorado

Very fine sandstone and mudstone facies of the Upper Triassic Dolores Formation of southwestern Colorado provide evidence for shallow lacustrine deposition coeval with clastic lacustrine systems of the Dockum Group in Texas. Dolores and Dockum lakes had frequent water-level fluctuations; however, Dolores lakes were filled primarily by shoreline sequences, in contrast to the delta-filled Dockum lakes.

Typical Dolores shoreline sequences fine upward, are laterally continuous over 3 km, are 5 to 15 m thick, have sharp nonerosional planar bases, and grade upward from very fine sandstones into mudstones. The very fine sandstones contain wavy, 1-cm thick bedding; low-angle trough and planar tabular cross-bedding; and isolated symmetrical channels. The overlying silty mudstones are commonly intensely bioturbated. These fine-grained shoreline deposits suggest that weak longshore currents distributed sand away from distributary mouths, and/or that sediment was transported by flow across the low-gradient, lake-margin plain.

Frequent subaerial exposure of these shoreline sequences is documented by abundant desiccation-cracked and rain-textured mudstone drapes, and by well-developed caliche profiles. During low stages of Dolores lakes, distributary channels locally prograded across and sometimes incised into the shoreline sequences. These symmetrical channels, 8 to over 50 m wide, commonly contain basal mudstone-clast/caliche-pebble conglomerates and were abandoned episodically as indicated by alternating beds of very fine sandstone and mudstone. Lake-edge distributary channels contain fillings of wave-reworked, wavy-bedded to rippled very fine sandstone.

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Cenozoic Radiolarian Paleogeography of Eastern Pacific

Along the east Pacific margin two dominant factors influence the distribution of planktonic radiolarians: east boundary ocean currents and the physiography of the southern California borderland. The east boundary current system is mainly wind driven on the surface and geostrophically controlled at depth. It is stratified into distinct water masses owing to differences in salinity, temperature, and current direction. The California borderland is a unique geomorphic province of successive basins and ridges with local circulation patterns. These factors influence present-day radiolarian assemblages but have also influenced such assemblages during the Cenozoic.

Nassellarian and spumellarian radiolarians reflect the temperature and depth of the water masses at the time of deposition. The California borderland serves as an environment similar to, yet distinct from, the boundary currents. Thus, this area seemingly has isolated species and increased their chance for allopatric speciation. These borderland species would eventually have been dispersed into the equatorial region.

Samples studies are from the DSDP Sites 33, 77, 173, 289, 468, and 469, where deposition was influenced by east boundary currents, and from the U.S. Geological Survey dart-core samples from the southern California borderland, to trace the development of the water masses through time. Once the dynamics of the water masses is determined, speciation and extinction events may be more easily postulated. Whereas previous investigations have dealt with present-day circulation, this study is the first attempt to map the influence of the dynamic current systems through time.

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Shelf Break on Modern Passive Margins: Structure, Sedimentation, and Progradation

The time-integrated structural-stratigraphic configuration of the shelf-to-slope break of many modern margins records the interplay of tectonics, submarine erosion and/or depositional processes. A simple process-response model may be used to help interpret the variations of shelf-break configuration and progradational patterns of passive continental shelves. The key factors are (a) the amount and nature of the sedimentary flux (F) provided to and across the shelf, and (b) the depth at which particles come to rest (H), which is largely a function of the local hydrodynamic and boundary layer conditions and of the grain size and density of the particles being transported. By maintaining factors F and H as constants, we can evaluate the role of structural displacement and importance of the relative position of the shelf surface to sea level in the development of the shelf-to-slope configuration.

In places where a shelf subsides, or when there is a demonstrable eustatic rise while an ample sediment supply is provided, a sediment layer may accumulate over much of the shelf; excess seaward-transported sediment will accumulate at and beyond the shelf break. If a shelf remains relatively stable or if there is an appreciable eustatic drop in sea level, much of the sediment can bypass the shelf and will accumulate beyond the shelf break, on the slope, rise, and abyssal plain. As equilibrium is attained, we can expect that D (shelf depth) $\leq$ H on a continental shelf, and D $>$ H on a continental slope. Thus, in this example, H becomes coincident with the depth at the shelf break.

The model is tested at shelf-slope interfaces on the Tuscany and Ligurian margins in the western Mediterranean, and on the Iberian margin in the eastern Atlantic. Seismic profiles indicate that the structural-stratigraphic configuration and progradational patterns at shelf breaks observed on subbottom profiles are variable. We correlate this variability with age and tectonic development of a margin, and thus with the successive structural stages through which a passive margin evolves.

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Past and Potential Mass Movement on Continental Slope Off Northeastern United States

Although evidence of mass movement is common on continental slopes, the importance of mass movement as a geologic process in most slope areas remains unknown, and questions concerning the likelihood of future events are still largely unanswered. Accordingly, the U.S. Geological Survey

and Bureau of Land Management are investigating mass movement on segments of the slope off Georges Bank and in the Baltimore Canyon area off New Jersey.

Preliminary results show that considerable variation in extent and magnitude of previous mass movements exists between the study areas. Off Georges Bank, the slope is typified by many scars, allochthonous blocks, and other mass-movement deposits. Geotechnical analyses of cores taken on two scars indicated that approximately 10 m and 35 m of overburden may have been removed from two sites. Slumps or slides a few tens of meters thick are apparently common. Core data also suggest that most surficial sediments on the Georges Bank continental slope are normally consolidated or slightly overconsolidated and, thus, relatively stable at present.

In contrast, the slope area off New Jersey between Lindenkohl and South Toms Canyons shows little evidence of previous mass movement. Identified features are predominantly on canyon heads and walls. Most events in this region were small, rarely exceeding 10 m in thickness. Despite the general absence of past mass movement, geotechnical data indicate that the surficial sediments is underconsolidated at many sites. This underconsolidation, which implies relative weakness, coupled with the presence of steep gradients and gas in some areas, suggests that these surficial sediments may be marginally stable.

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Gulf of Mexico Types of Intraslope Basins as Determined by Seismic Reflection Patterns

Most of the topographic highs on the hummocky Gulf of Mexico continental slope off Texas and Louisiana are underlain by diapirs. The continuous upward growth of the diapirs can cause local blockage of canyons to such an extent that positions of thalwegs may be in error if based solely on currently available bathymetry. Seismic facies studies can help identify the different types of intraslope basins from which the courses of submarine canyons can be unraveled.

Three types of intraslope basins have been recognized in the Texas-Louisiana slope area: blocked canyon, interdomal, and collapse basins. As sea level rises and bottom transport decreases, the topographic effect of diapiric growth in canyons may be unchecked by erosion and infilling; thus canyon blockage can form an intraslope basin. The interdomal-type basin results where adjacent diapirs move upward, and an intervening section of sea floor is left at about its original depth. Collapse basins are formed from tensional collapse of the crest of domal and anticlinal diapirs. During a relative fall in sea level only the blocked canyon basins can receive sandy terrigenous material, shown in the seismic reflector facies pattern as onlapping onto diapiric flanks. The seismic facies pattern that results from a relative rise in sea level consists of parallel reflectors owing to the deposits of fine-grained sediments that drape the sea floor. The interdomal and collapse types of intraslope basins are characterized by parallel reflector patterns only.

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Geochemical Prospecting and its Value to Oil Finder

The application of surface geochemistry to a basal Cretaceous clastic pool on the Alberta-Montana border has shown that geochemical anomalies can be distinguished in and around areas overlying oil pools. The type of work included helium, calcium, and various hydrocarbon ratios. In addition, gravity, magnetic, electrical, and seismic work was also done over the survey area. The results of this work suggest that seismic is by far the most accurate tool in delineating hydrocarbon traps. Some current geochemical techniques available to the industry are evaluated to perhaps supply the uninitiated with an idea of the use and potential of these methods.

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Upper Cretaceous Shelf Sandstones, Northwestern Colorado: Migrating Sand-Ridge Model

An N45E shoreline trend and five major shelf facies were interpreted from surface and subsurface data in the upper Mancos (Campanian) shelf sands in northwestern Colorado. The *central bar,* up to 20 m thick, coarsens upward from fine to medium-grained sandstone containing large-scale landward-dipping accretion surfaces. Smaller cross-beds have reactivation surfaces and indicate two transport directions (west and southwest). Hummocky surfaces are also present. The *ramp* unconformably overlies the seaward edge of the central bar. Large-scale seaward-dipping ramp units have cross-strata indicating only westward transport. Up to 15 m of bioturbated *back bar* occurs landward and below the central bar. Overall, the back bar coarsens upward but contains (1) fining-upward sequences (<2 m thick); (2) coarsening-upward sequences (<2 m thick); and (3) bioturbated isolated sand waves. Paleocurrents were to the west. *Shelf* bioturbated clayey siltstones gradationally underlie the back bar and overlie the *reworked bar top.*

These facies represent large-scale migrating sand ridges with axes parallel to the shoreline. The dominant processes were: (1) major storms that eroded the seaward edge and crest of the sand ridges and transported sediment landward (westward paleocurrents). Back-bar deposits include storm washovers and graded beds. Channels, hummocky cross-strata, and hummocky erosion surfaces were formed on the bar crest. (2) Between storms, contour currents (southwesterly) transported sand onto and along the bar crest. The ramp facies represents sand waves climbing onto the eroded seaward face of the bar.

The sand-ridge migrated over the back-bar deposits causing that facies to thicken landward.

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Stable Isotope Diagenesis of Multicomponent Carbonate System

The isotopic data of the fossil and matrix/cement components of the Mississippian Burlington Limestone (Iowa and Missouri) and Silurian Read Bay Formation (Arctic Canada) can be reconciled with textural and trace-metal observations of the components only if the ^{18}O content of ancient oceans differed from that of the present. Examination of the ^{18}O content of the least altered low $-Mg$ calcite components of the two formations suggests that the ^{18}O content of Mississippian seawater was, on average, about 1 ppt lighter and that of Silurian seawater was, on average, about 5 ppt lighter than the ^{18}O content of present-day seawater.

The average diagenetic shift in $\delta^{18}O$ of the Read Bay Formation components, which stabilized in a partly closed