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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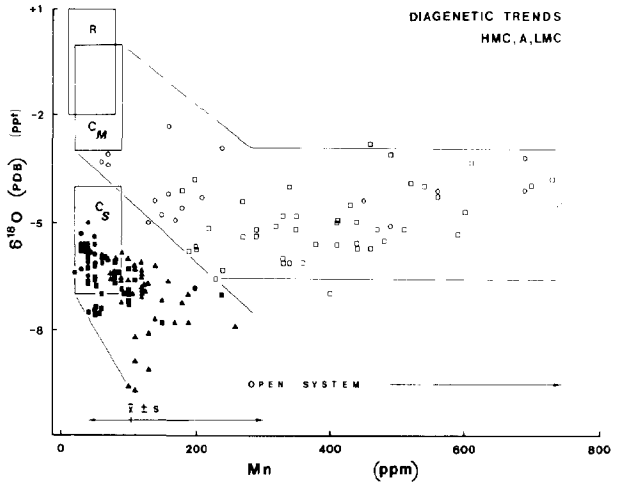
Stable Isotope Diagenesis of Multicomponent Carbonate System

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



diagenetic system, is about −1 ppt for the originally low −Mg calcite components and about −2 ppt for the originally high −Mg calcite and aragonite components. Conversely, for the Burlington Limestone components, which stabilized in an open diagenetic system, the average diagenetic shift in $\delta^{18}O$ is about −3 ppt for the originally low −Mg calcite components and about −4 ppt for the originally high −Mg calcite components.

The $\delta^{13}C$ values of the components are bimodally distributed. This distribution is independent of geologic age, inferred original mineralogy of the component, degree of diagenetic alteration, and the type of diagenetic system, with components from both formations contributing to the light (+0.5 ± 0.4 ppt) and heavy (+3.1 ± 0.7 ppt) ^{13}C groups. Both groups also show a decrease in ^{13}C of about 1 ppt with stabilization of the carbonates in the diagenetic system.

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Thermal History by Fission-Track Dating, Tejon Oil Field Area, California

Data that have been obtained from deep drill holes in several areas where the approximate duration of heating events is known suggest that fission tracks in apatite and zircon are totally annealed when the grains are heated at temperatures of 135 to 105°C and 200 to 175°C, respectively, over periods of 10^6 to 10^8 years. Annealing can pose problems for determining the primary ages of samples, but if offers a powerful method for studies of their thermal and tectonic history. This paper explores the application of this method to determining the thermal history of sedimentary basins using detrital grains separated from drill-hole samples.

Detrital apatite and zircon have been separated from Eocene to Miocene sandstone recovered from deep drill holes in the southern San Joaquin Valley of California (Tejon oil field area). The Tejon area is divided by the seismically active White Wolf fault. Fission-track data show that apatite in the downthrown block immediately northwest of the fault is totally annealed at a maximum paleotemperature (reconstructed from laumontite geothermometry) of 135 to 140°C, suggesting heating of 10^6 years' duration. The higher paleotemperature (> 150°C) indicated for total annealing of apatite in the upthrown block shows that these samples could have been at the suggested maximum paleotemperatures for no more than 10^5 years. The relative short duration of heating over the whole Tejon area is supported by the lack of annealing in zircon, even at paleotemperatures as high as 179°C. These conclusions are consistent with the thermal history suggested by laumontite crystallization viewed with stratigraphic and structural evidence.

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Spatial Variations in Sand-Wave Size and Migration Rate: Implications for Shoal Dynamics

Spatial patterns of sand-wave size and migration rate were carefully monitored using side-scan sonar and narrow-beam echo sounding on Southwest Middle Ground Shoal in Vineyard Sound, Massachusetts, from March 22 to November 16, 1978. Navigation was provided by an acoustic-transponder system with a positioning accuracy of 3 m.

Sand waves migrate obliquely upshoal from depths greater than 19 m to depths less than 11 m. Erosion at depths less than 16 m is caused by a downcurrent increase in the sediment-transport rate, represented by a twofold increase in bed-form height that more than offsets a small decrease in migration rate. Deposition farther downcurrent, above 16 m, is caused by a downcurrent decrease in sediment-transport rate, manifested by downcurrent decreases in both bed-form height and migration rate. These bed-form-size trends are consistent with a kinematic control on bed-form size that causes bed forms to grow or shrink while they acquire or lose sediment owing to erosion or deposition.

The observed pattern of erosion on the shoal's lower flanks, and of deposition on the upper flanks and crest (a constructional phase of shoal dynamics), may be seasonal because the period of our study did not include the more energetic winter months. Alternatively, this constructional pattern may occur during all seasons, and only be balanced by such major storm events as hurricanes, which would transfer sediment from the shoal crest to its lower flanks.

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Statvik Field of Norwegian North Sea—Exploration Study of Unconformity Trap

The Statvik field is situated in block 34/10 in the Norwegian sector of the North Sea approximately 20 km east of the Statfjord field. The main reservoir is the Middle Jurassic Brent sandstone which is truncated by the late Kimmerian unconformity. the unconformity is overlain by Upper Cretaceous shales. The delta structure is one of the biggest structures at the late Kimmerian unconformity level in this part of the North Sea.

In the early exploration phase the crucial question was whether the Jurassic reservoir rocks had been eroded during the late Kimmerian orogenic event. Early generation seismic showed no reflectors below the unconformity. A square km seismic reflection survey was shot in 1974 and interpretation of this data gave indications of a thick Jurassic sequence below the unconformity.

The first well was drilled during the summer of 1978. It showed a 165-m thick hydrocarbon column in sandstones of Middle Jurassic age. The predrilling interpretation was largely correct. An active period with continuous drilling followed; by August 1979, 8 wells had been drilled on the structure. During