wave and tidal frequency, provided bulk densities are less than 1.20 g cm^{-3}. Suspended-sediment concentrations in the nearshore region are typically 1 to 10 × 10^3 mg l^{-1}. Thickness of brown oxidized mud which overlies steel-gray muds beneath provides an indication of the depth to which suspension and redeposition occur.

In addition to serving as a storehouse for littoral sediments and as a buffer to wave attack, tidal-flat muds serve as a source of sediment for longshore transport processes. Because of high suspended-sediment concentrations, sediment transport rates can be enormous, even under relatively weak currents.

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Nearshore Marine and Continental Facies in Eocene of North-Central Pakistan

Stable-shelf carbonate sedimentation along the northwestern edge of the Indian subcontinent preceded the post-mid-Eocene Indian-Asian collision. The early Eocene section in Pakistan displays very rapid facies changes controlled by a cycle of regression and transgression. Beginning with the Paleocene Patala Formation in the Kohat area, quiet-water offshore dark shales grade up-section to include increasingly thick, extensive, and common marly limestones, becoming a foraminiferal limestone sequence. This section then becomes shalier with progressively thinner and more argillaceous micrites and grades upward into the unfossiliferous green Panoba Shale, which then passes into the nearshore, medium-energy, fossiliferous, and bioturbated limestones of the Shekhan Formation. The upper Shekhan beds are mud-cracked, festoon-bedded, channelform dolostones, presumably tidal deposits. The topmost dolostones contain zones of small disruptive anhydrite nodules and pass rapidly into gypsum laminated with varicolored clays. To the west, the Panoba Shale and the Shekhan Formation grade into a massive salt deposit; to the northeast they grade into deeper water limestone. The evaporites are interpreted as sabkha deposits. All are covered by the mostly continental, mammal-bearing Kuldana Formation red beds. Drowning of the coastline then caused rapid development of (1) local lacustrine dolomite and chert units, (2) oyster-rich lagoonal or estuarine limestones, and finally (3) open-bay nummulitic limestones and shales of the mid-Eocene Kohat Formation. The succession is truncated by a regional unconformity that records uplift, erosion, and dolomitization of the underlying carbonate rocks. The unconformity is then buried by continental Himalayan molasse.

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Uranium Mineralization in Hopi Buttes, Arizona

The Hopi Buttes dominate the landscape north of Holbrook, Arizona, rising to heights of ~1,000 ft (305 m) above the surrounding countryside. The buttes, erosional remnants of lava-filled diatremes and associated sediment-filled diatremes, are approximately 5 m.y. in age. The volcanic rocks of the diatremes are limburgite and monchiquite, which are distinguished from normal alkalic basalts of the Colorado Plateau in their extreme silica unsaturation, high water, TiO_2, and P_2O_5. Many trace elements are also unusually abundant, most notably Zr, Ba, Nb, Ce, and U (average value of about 4 ppm U compared to an average of 1 ppm for continental basalts). Many of the diatremes are filled with local maar lake sediments believed to have been deposited in part by rising thermal solutions. Limestone lake beds locally resemble travertine deposits and contain high concentrations of phosphate, sulfate, Ba, Sr, and As, as well as U and Se. Areas of high Se content are recognizable in the Hopi Buttes by the abundance of *Astragalus patersoni* ("loco weed").

Approximately 300 diatremes occur in the Hopi Buttes area. Of 79 studied during the past year, 35 contain lake-bed deposits with radioactivity exceeding background levels. Scintillometer traverses have shown 20 of these diatremes to have radioactivity exceeding 5 times background. An airborne gamma-ray survey shows sharp-peaked anomalies over all 20 of these diatremes. Hydrogeochemical sampling in the area also revealed anomalous concentrations of uranium in spring and well waters from the Hopi Buttes area. Uranium ore was mined during the 1950s from the Morale claim. Production records show the average grade for 186 tons of ore was 0.15% U_3O_8. Extensive drilling in this diatreme in October 1979 revealed intervals within limestone and siltstone maar lake sediments up to 20 ft (6 m) thick and 500 × 300 ft (152 × 91 m) in area containing an average of 0.015% U_3O_8. The potential for uranium in the Hopi Buttes is for low grade deposits within 50 ft (15 m) of the surface, some of which may contain on the order of 100 tens of U_3O_8 per diatreme.

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"Middle" Cretaceous (Albian-Turonian) Depositional Environments Along a Part of Eastern Margin of North American Epicontinental Seaway

In Iowa and bordering states the Dakota Formation, Graneros Shale, Greenhorn Limestone, and Carlile Shale were deposited along the eastern margin of the North American epicontinental seaway during the middle part of the Creteceous (Albian to Turonian). The pre-Cretaceous physiographic surface of northwestern Iowa consisted of ridges and valleys developed upon tilted Paleozoic rock. This surface profoundly affected the deposition of sediment. Detailed studies of surface outcrops, subsurface cores and cuttings, and gamma-ray well logs reveal that this part of the seaway was the scene of fluvial-deltaic deposition followed by an extensive marine transgression. The Dakota Formation commonly consists of a quartzarenite sequence which has a sharp basal contact and grades upward and laterally into clay shales. This sequence is commonly capped with organic-rich mudrocks, or lignite beds. Analyses of textures, sedimentary structures, and lateral relations indicate that these lithologies represent southwestward-flowing fluvial systems which floored topographic valleys. The Dakota Formation grades upward into fluvially dominated deltaic and shallow-marine sands and muds of the Graneros Shale. These deposits completed the filling of pre-Cretaceous valleys and buried the predepositional topography. By early Turonian time, the eastern edge of the seaway had transgressed far to the east, leaving western Iowa far from siliciclastic source areas. The result was the deposition of the carbonate muds of the Greenhorn Limestone. Renewed introduction of siliciclastic muds, probably from the northeast, resulted in deposition of the Carlile Shale.

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Relations Between Stromatolites and Burrowing Organisms

The activity of burrowing organisms seems to be of great importance in limiting the occurrence of stromatolites. Profiles of Callovian and lowermost Oxfordian of the Cracow-Wielun Upland, central and south Poland, are very useful for studies of relations between stromatolites and burrowing organisms. Many burrows, with up to 20 burrow apertures/sq m, of the *Thallasinoides* type occur in sandy crinoid limestones of early Callovian age. They are sublittoral deposits without stromatolites. However, stromatolites occur in stratigraphically condensed limestone sequences of middle and late Callovian age, and indicate deeper-water deposition. The associated fossils are pelagic forms: ammonites, belemnites, and coccoliths. Also present are iron-manganese nodules with a red or brown color. Probably these deposits accumulated on a submarine swell at a depth of several tens of meters. They pass laterally into deeper water marls which do not show any features of stratigraphic condensation. The latter deposits are without stromatolites, but contain numerous *Zoophycos* burrows.

Stromatolites of condensed sequences occur as beds of various thicknesses, up to 40 cm. Interstitia and pockets in stromatolites are filled by highly bioturbated red limestones. The limestones and marls above the stromatolites contain numerous burrow structures of the *Chondrites* type. Such relations suggest competition for space between blue-green algae and burrowing organisms. Probably the instability of the sediments caused by the activity of the burrowing organisms was an important factor limiting the spread of algal mats.

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New and Developing Techniques in Coal Exploration

New techniques in coal exploration develop slowly. Most of the current work being done in this field relies heavily on the techniques and practices in common usage about 20 years ago. Developments in three areas are improving the geologist's ability to better quantify available information and to better predict the position and distribution of coal seams between and beyond drill holes: (1) improved geophysical techniques; (2) modeling of the deposition environments; and (3) manipulating available information with computer programs.

Several new geophysical techniques are proving useful. These include improved resolution of downhole logging probes that more accurately indicate depth and thickness of seams and give coal quality information. High-resolution seismic equipment and techniques are now defining better the discontinuities in seams. Faults can be identified readily, but sedimentary cutouts are more difficult to define. New instrumentation in gravity and magnetic technology show some promise. These new geophysical methods lean heavily on manipulation of data by computers.

Modeling of depositional environments is gradually becoming more accepted as a better means of predicting what happens to the coal seam and adjacent rocks beyond the outcrops and drill holes. Not only does it allow the geologist to extrapolate the presence and thickness of seams, but also to predict the rock type that overlies and underlies the coal. All of this information is important for mine planning.

Increased use of computers and accessories provides rapid handling of large amounts of data. Once the data are entered, the computer will construct a variety of maps, do statistical calculations, and tabulate requested information.

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Potential Petroleum Reservoirs on Deep-Sea Fans Off Central California

A variety of potential petroleum reservoirs are indicated in subbottom siesmic profiles or implied by the depositional history of the deep-sea fans off central California. The size and extent of both the stratigraphic and tectonic traps off California are large compared to terrestrial analogs as seen only through the crude filter of acoustic profiling. Stratigraphic traps such as buried deep-sea channels, sand lobes, and updip pinch-out sands are produced as a normal consequence of the formation of deep-sea fans. Such stratigraphic traps can be expected on any submarine fan if the sand budget and porosity are sufficient. Slumps of sediment from the continental slope cover large areas of the deep-sea fans, and slumped sediment may isolate and bury channel segments and associated sand bodies. Tectonic traps resulting from folding or faulting are rare in deep-water fans. Faulting and folding are more commonly observed in fans from slope basins and from the California borderland and produce both tectonic traps and stratigraphic traps by altering configuration of the basin.

Large deep-sea fans are built over irregular oceanic crustal topography that has as much as 2 km of relief. As a result, many localized basins on the middle and outer fan are substantially thicker than much of the adjacent fan. On Monterey fan, for example, these local basins include valleys between abyssal hills and a large fracture-zone trough.

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Reservoir Rock, Source Rock, and Trapping Mechanism of Permian Basinal Facies, Delaware Basin