that it lacks large-scale radial dispersal patterns as well as canyon and channeled inner-fan facies. Rather than radial progradation, characteristic of a large, stable submarine fan, uniform progradation from multiple point sources built a clastic ramp composed of a coalescing series of small, short-lived submarine fans. This uniform progradation is indicated by the disposition of lithofacies and consistent westerly paleocurrent trends.

We envision a prodeltaic setting for the formation of this clastic ramp. In spite of a paucity of modern analogs for such a depositional system, the Brallier Formation and other ancient examples attest to the significance of turbidite sedimentation in deltaic settings.

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Pseudostalactites from Submarine Cave Near Columbus Cay, Belize Barrier-Reef Complex—Evidence of Extensive Submarine Lithification

Numerous inclined projections resembling stalactites but indicating a marine origin occur on the ceiling of a submarine cave in the Belize barrier-reef platform near Columbus Cay (3 km from the outer edge of the barrier reef and 21 km from the mainland). The accreting "pseudostalactites" consist largely of *Vermiliopsis* serpulid tubes and varying amounts of magnesium calcite cement, which is present either as a matrix or as a coating on the upper surfaces of the inclined projections. The opening of the cave is 10 m long and less than 3 m wide; it breaches the roof at a depth of 17 m. A short distance inside and up to at least 40 m from the opening (the limit of our observations), the ceiling is covered by a field of closely packed pseudostalactites more than 30 cm thick. A distinct transition was observed from large club-shaped forms (30 cm wide at the point of maximum development), present about 10 m from the cave opening, to pencil-thin projections at the 40-m limit. Characteristically, the pseudostalactites incline toward the cave opening at about 40 to 60° near the opening and are almost horizontal at the limit of observation. The magnesium calcite cement (15 mole% $MgCO_3$), which commonly constitutes more than half of a pseudostalactite, exhibits the dentate crystals, peloidal textures, and knobby surface relief recognized in submarine cements from other reef areas. These traits and the results of oxygen and carbon-isotope analyses discount any influence of fresh water. Marine planktobacteria associated with the undisturbed surfaces of cement accumulation suggest that bacteria are an active factor in the precipitation of this submarine cement.

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Piper Oil Field

The Piper field lies in UK block 15/17 near the eastern part of the Moray Firth Basin, 125 mi northeast of Aberdeen, Scotland. The field was discovered in December 1972. Five appraisal wells and one exploratory well were drilled in 1973. A steel platform with 36 well slots and space for two drilling rigs was centrally located over the field in 474 ft of water in June 1975, and readied for production drilling by October 1976. Production is from the Upper Jurassic Piper Sandstone, a high-energy, marine sandstone with gross thickness, 177 to 453 ft (56 to 138 m); net sand, 132 to 378 ft (40 to 115 m); net oil sand, 132 to 296 ft (40 to 90 m); average net oil sand, 160 ft (49 m); average porosity 26%; permeabilities 200 to 1,200 md in lower energy bioturbated sands, 2,000 to 10,000 md in higher energy sands. The reservoir is sealed by Kimmeridge shale over most of the field and by Upper Cretaceous marlstones along some fault scarps. The main area of the field, a gently folded fault block dipping 5° northeast and a downthrown northwest-southeast fault block, covers 6,300 acres (2,550 ha.), has a common oil-water contact at 8,512 ft (2,594 m) subsea, and a gross reservoir column 1,300 ft (396 m), which is 7,200 ft (2,195 m) subsea to the oil-water contact. A small accumulation on a parallel fault block on the southwest has a separate oil-water contact at 9,199 ft (2,804 m) subsea. The P1 production well spudded October 10, 1976, established commercial production December 7, 1976 at more than 30,000 B/D, restricted by 5½-in. tubing. The P7 well completed in April 1977 produced more than 50,000 BOPD, restricted by 7-in. tubing. Twenty-four wells have been drilled, four as water injectors to support an active water drive. Production is 300,000 BOPD and recoverable reserves are estimated to be 700 million bbl. Extensive use of seismic data and excellent cooperation by partners in the consortium and the United Kingdom regulatory bodies allowed maximum use of production and new well data to improve subsequent development.

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Environmental and Diagenetic Controls of Carbonate and Evaporite Source Rocks

The organic geochemistry of shale source rocks has been a subject for extensive research during the past 2 decades. Many useful interpretive techniques have been developed for the assessment of hydrocarbon potential of sedimentary basins in which shales are the principal and logical source for petroleum generation. Nevertheless, the present understanding of carbonate and evaporite source rocks remains superficial. The criteria generally employed to assess shale source rocks are inadequate and misleading when applied to carbonate and evaporite basins.

Most misconceptions regarding the hydrocarbon potential of carbonate and evaporite rocks stem from a simplistic notion that organic matter associated with the sediments on well-aerated carbonate shelves and in evaporite-depositing environments is not likely to be preserved. Recent data on organic geochemistry of Holocene carbonate sediments from shallow shelves suggest that (1) organic matter can be preserved in certain environments, and (2) the kerogens produced from degradation of organic matter in carbonate sediments are predominantly sapropelic and therefore much more efficient sources for hydrocarbons than the mixed humic-sapropelic kerogens of shales.

The preservation of organic matter in carbonate and evaporite units is controlled primarily by environments of deposition and the diagenetic overprints. Sabkha, lagoonal, and basinal environments, for example, are excellent for organic-matter preservation. Vadose and freshwater phreatic diagenetic environments are not favorable for organic preservation. The marine-phreatic diagenetic environment, however, is favorable for preservation of organic matter.

The upward-shoaling cycles, which are the buildup blocks of the carbonate-evaporite sequences, provide for source-reservoir couplets. The base of a cycle generally includes the potential source rocks. The top of a cycle contains the leached and/or primary porosities which provide the reservoir potential.

Synchronous and post-sedimentary tectonic events also seem to have a positive influence on the source-rock potential of carbonate and evaporite rocks. Rapidly subsiding shelves would place the organic-bearing carbonate units below the destructive influence of the freshwater phreatic zone. Late structural movements could produce the microfracture systems which would form the avenues for petroleum migration from source to reservoir rocks.

Geochemical data on ancient rocks strongly suggest that sabkha evaporites should be seriously considered as possible source rocks for petroleum.

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Models for Interpretation of Micromorph Faunas in Washita Group

Micromorph faunas typically are found in limonitic, pyritic, or phosphatic black shales. They consist of individuals that are smaller than those in normal faunas. These faunas are primarily the consequence of stunting, transportation, juvenility, and paedomorphosis. Probable specific factors that might lead to stunting are abnormal salinities, low food supply, and low oxygen. The winnowing out and concentration of smaller individuals of an assemblage can produce a transported fauna. Juvenility is the result of large-scale fluctuations in immature ecosystems. Evolution resulting in paedomorphosis is a response of populations to environmental factors such as instability or substrate fluidity. Faunal and sedimentologic characteristics which are potentially diagnostic of these mechanisms can be recognized. Models defined by expected conditions of the criteria were established for each mechanism.

To test the usefulness of the models for distinguishing micromorph faunas in the Washita Group, a fauna described as micromorph was studied. The small size of fossils in the Grayson Formation of Texas, Oklahoma, and Mexico has been attributed to excessive iron concentrations, anaerobic conditions, and seasonal fluctuations. Comparison of the faunal and sedimentologic characteristics of the Grayson fauna with those of the established models indicates that the small shell size of some of the Grayson oysters and ammonoids is probably an adaptive strategy evolved by these organisms for survival in a soft-substrate environment. The small size may be a consequence of paedomorphosis. Pyritized Grayson specimens are probably a result of microreducing environments that developed within individual shells in the soft mud.

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Possible Biogenic Origin for Some Sedimentary Dolomite

A rather simple biochemical system comprising seawater, algae, and urease-producing bacteria could form microenvironments favoring the formation of sedimentary dolomite. Calcium and magnesium ions are supplied by seawater. Algae, like most plants, produce urea in the ornithine cycle; the urea [$(NH_2)_2CO$] is, in turn, hydrolyzed, producing abundant CO_2 and NH_3. This hydrolysis of urea is catalyzed at ambient temperatures by the enzyme urease, which is produced by several bacterial species as well as by certain plants. Urease-producing bacteria have been found in the world's oceans and in bottom sediments.

Although other biochemical reactions may also favor dolomite formation, the hydrolysis of urea appears to be preeminently important. This is because hydrolysis ultimately produces 1 mole of H_2CO_3 and 2 moles of NH_4OH per mole of urea. Consequently, the solution becomes increasingly basic as CO_2 continues to be produced, which means that the alkalinity also increases. Because of the increased basicity and carbonate content, as HCO_3^- or $CO_3^=$ depending on pH, carbonate minerals, especially dolomite, may form. Experiments by Gebelein and Hoffman illustrated the importance of NH_3 and CO_2, and experiments by Medlin at elevated temperatures and pressures demonstrated the importance of urea hydrolysis.

Thus, the burial of dead, proteinaceous marine organisms, especially algae, and associated urease-producing bacteria may produce conditions favoring the formation of dolomite or at least promoting dolomitization. Stromatolites are a case in point; their organic-rich laminae commonly contain dolomite, and the inorganic interlayers commonly contain calcite. Furthermore, the feasibility of this, or a similar, system was recently demonstrated (unintentionally) by a male dalmatian who produced uroliths of ordered dolomite in his urinary bladder.

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Shallow-Water Upper Jurassic Rocks Dredged from Bering Sea Continental Margin

Rocks recently dredged along the Bering Sea continental slope include fossiliferous, gray-green arkosic sandstone of Late Jurassic age. The sandstone was recovered from acoustic basement at water depths ranging from 1,500 to 2,800 m. These arkosic rocks were sampled at nine sites along a segment of the Beringian margin that extends about 550 km northwest of the Pribilof Islands toward eastern Siberia. Preliminary lithologic and petrographic examination of the feldspathic sandstone and lesser amounts of siltstone indicates that these rocks are equivalent to units in the Naknek For-