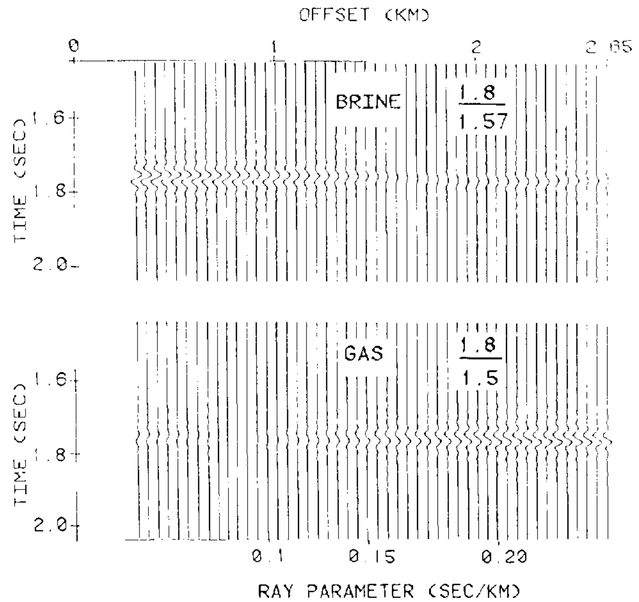

Synthetic seismograms after normal moveout correction for a hypothetical 20-m (66 ft) high impedance sand reservoir in shale. Ratio of compressional velocity to shear velocity in this model is 1.8 for shale, 1.57 for brine sand, and 1.5 for gas sand. Variation in reflectivity with offset in this model is a first order effect over normal recording range.

ture of the effects of compressional and shear velocity variations.

The expected variation in reflectivity with offset in clastic basins suggests that we should seriously question our conventional processing and interpretation assumptions in these areas. It also suggests that conventional seismic reflection data might yield a shear impedance image and an improved compressional impedance image rather than the currently employed hybrid impedance image.

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Lacustrine and Paludine Facies: Cretaceous Baum Limestone, South-Central Oklahoma

The Lower Cretaceous Baum Limestone in the Arbuckle Mountains of south-central Oklahoma was deposited in lacustrine and paludine settings near the Cretaceous shoreline. The unit rests unconformably on folded Pennsylvanian rocks and is overlain by and grades into the Paluxy Formation, a sandstone deposit with numerous *Ophiomorpha* burrows. The lacustrine lithofacies include the following: (1) massive micrite containing charophyte fragments and ostracodes; (2) intraformational conglomerate composed of rounded micrite clasts in a micritic matrix; (3) rounded peloids and coated peloids; (4) laminated micrite; and (5) conglomerate composed of clasts derived from Paleozoic rocks within a micritic matrix. Disintegration of charophytes that grew in the littoral zone of the lake produced the massive micrite. Intraformational conglomerates and peloids represent reworking of massive micrite whereas the other conglomerates represent fluvial influx. The coated peloids and laminated micrite probably formed as a result of algal activity in the shallow margins of the lake.

Features found within the paludine facies include: (1) brecciated micritic limestone that probably formed as a result of shrinking and swelling due to an oscillating phreatic water table; (2) subspherical nodules of micrite (peds) separated by red shale (plasma) that represent pedogenic alteration of exposed lacustrine mud; and (3) subcylindrical columns composed of micritic limestone representing root-casts. These paludine features formed as a result of pedogenic processes in a marsh that rimmed the shallow lake where the lacustrine facies accumulated.

The lacustrine and paludine facies are not grouped into sequences similar to those reported from some modern and ancient lacustrine carbonate deposits, but alternate in an apparently random pattern. Comparison with modern carbonate-dominated lacustrine systems indicates that the facies in the Baum Limestone have no precise counterparts, although they are most similar to facies in temperate-region marl lakes.

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Seismic Expression of Carbonate to Terrigenous Clastic Sediment Facies Transitions of Western Florida Shelf

Transitions from carbonate to terrigenous clastic sedimentary deposits are commonplace in the Mesozoic-Cenozoic section of the northwestern Florida shelf. On a regional scale, these transitions are responsible for a large seismic velocity variation between the areas of the Destin dome and the Middle Ground arch. In the Destin region, clayey shales and sands are more prevalent, interspersed with carbonates and evaporites, with the result that seismic transmission velocities are relatively low. Toward the south on the Middle Ground arch, the increased carbonate-evaporite content of the section results in much higher velocities. An example of this variation is that a reflection two-way travel time of 2 sec corresponds to a depth from 2.5 to 2.8 km (1.5 to 1.7 mi) in the Destin area while this same reflection time corresponds to a depth of 4 km (2.5 mi) in the vicinity of the Texaco 2516 well on the Middle Ground arch. Analyses of stacking velocities indicate that the transition is a gradual one to the north and west of Middle Ground arch.

On a local scale, transitions or terminations related to facies changes, erosion, or sediment body geometries are a potentially important factor in prediction of reservoir rock on the as yet uncondemned, 12 km(7.4 mi) broad, deep structural culmination west of the Destin tests and on the untested, 9 km (5.5 mi) broad, deep structure 20 km (12.4 mi) south of the Destin dome. The deep Exxon test on the Destin dome encountered 20 m (66 ft) of Norphlet quartz sand with porosity ranging from 20 to 30% and permeability of 1 darcy. This potentially excellent reservoir bed at a depth of 5,224 m (17,138 ft) is more than 150 m (492 ft) below the deep structural crest on the Destin dome. The Sun test, 25 km (15.5 mi) east of the Exxon well, penetrated 6 m (19.6 ft) of Smackover oomoldic dolomite with porosities of 13 to 15% and failed to find any Norphlet sand as it bottomed in Louann salt immediately below the Smackover. A study of a combination of velocity analyses, density and velocity logs, and synthetic seismograms allows speculations that the deep Destin dome and the structure on its south flank are still viable exploration prospects.

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Significance of Limestone-Shale, Rock-Stratigraphic Contacts—The Connecting Links Between Areas of Contemporaneous Carbonate and Terrigenous Detritus Sedimentation

In undisturbed depositional sequences one rarely, if ever, observes lateral change directly from mud-supported carbonate into grain-supported siltstones, sandstones, or conglomerates. Shale or claystone always intervene. Such bounding and internal contacts are the most conspicuous and most informative—yet most neglected—aspects of the limestone-shale record. Significant progress in understanding carbonate to terrigenous detritus facies changes can come from closer attention to these contacts.

A majority of Mid-Continent Pennsylvanian limestone-shale contacts are of regional extent and commonly are represented by upward gradations from shale to limestone. Shale units in carbonate sections commonly range from fractions of inches to tens of feet in thickness. Genesis of thin (2 ft ot .6 m or less) shale breaks and argillaceous partings has been neglected. This is a serious oversight since such breaks are the connecting links between contemporaneous-land- and shallow-inland-sea-derived sediment.

The following conclusions result from the study of numerous limestone-shale contacts in outcrops and conventional cores in the period 1957 to 1981. (1) The history of Mid-Continent Pennsylvanian sedimentation, including river mouth shifts and numerous floods, is recorded in limestone-shale contacts. (2) The day-to-day regime was one of minor terrigenous sediment bypassing laterally adjacent embayments in which carbonate sediment accumulated. (3) Day-to-day deltaic progradation was minor with carbonate sedimentation curtailed only along the narrow junction between deltas and adjacent embayments. (4) During and immediately after floods, major deltaic progradation spread relatively thin and widespread deltaic "packages" which stifled carbonate sedimentation over several hundred square-mile (minimum) adjacent areas. (5) Thin shale or claystone breaks to featheredge argillaceous partings in limestone record flood-deposited prodeltaic increments. (6) Shale or claystone interbeds (more than 2 ft or .6 m thick) in limestone as well as shale- or claystone-sandstone units tens to a few hundreds of feet thick and laterally equivalent to largely limestone are predominantly the composite record of many floods and many times of small-scale mass movements. (7) Within the thicker terrigenous detritus units, individual flood or individual mass movement record is extremely difficult to define. (8) The lateral movement of life assemblages was slower than the influx of terrigenous clay in flood-generated plumes and organic communities were buried before they could vacate the area. (9) Terrigenous detritus sedimentation rates exceeded carbonate sedimentation rates. (10) The writer is unaware of a convincing modern analog supportive of all aspects of these conclusions. Possibly, the problem is that day-to-day tides reach most present-day shorelines whereas that may not have been so in the Paleozoic epieric sea setting.

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A Surface Vitrinite Reflectance Anomaly Related to Bell Creek Oil Field, Montana U.S.A.

Vitrinite reflectance measurements from surface samples of mudrock and coal show anomalously high values over the Bell Creek oil field. The average vitrinite reflectance (R_m) increases to a peak of 1.2% over the field against background values of about 0.3%. The R_m anomaly coincides with a geochemical anomaly indicated by $\delta^{13}C$ in carbonate-cemented sandstones. These samples were taken from the Upper Cretaceous Lance and Paleocene Fort Union formations, which form an essentially conformable sequence. The depositional environment is apparently similar in both formations, and we expect little variation in the source and composition of the organic matter. R_m should be rather constant across the field if conditions of diagenesis were uniform. The limited topographic relief ($<$ 1,000 ft or 305 m) over the shallow-dipping homoclinal structure of the field and the poor correlation coefficient of R_m regressed against sample locality elevation ($r = 0.2$) indicate that the R_m anomaly is not due to burial, deformation, and subsequent erosion. Temperature studies over local oil fields with similar geologic conditions suggest the expected thermal anomaly would be less than 10°C (50°F), which is too small to account for the significantly higher rank over the field. Coal clinkers are rare in the vicinity of the Bell Creek and widespread heating by burning of coal seams is unlikely. We suggest that activity by petroleum-metabolizing bacteria is a possible explanation of the R_m anomaly. Microseepages from oil fields support large colonies of these organisms, which could also metabolize aliphatic side-chains on the kerogen molecule. The loss of these side-chains increases the aromaticity of the vitrinite and consequently increases its reflectance.

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Organic Geochemistry—Perspectives and Projections

In the past 15 years organic geochemistry has evolved from an academic discipline into an important and useful tool in exploration. The development of experimental techniques for analyzing complex organic materials (such as kerogen) and multicomponent mixtures (such as crude oils) has played a critical role, and this ability to characterize organic matter in detail has led to a better understanding and documentation of the process of petroleum generation. Although the nature of the organic matter in source rocks exercises initial control over the hydrocarbons generated (oil versus gas), it is processes acting in the reservoir that most influence oil quality. Thermal maturation and bacterial alteration are well-understood and their influence on the details of oil composition is documented by many studies. Pyrolysis techniques have been particularly important in providing a means for analyzing small samples quickly, and their introduction onto drilling rigs has made geochemical data available at the same time as other electric log information.

Despite considerable progress, some areas of geochemistry need further development. Analytical techniques, although still capable of refinement, are in general adequate for the tasks in hand. The biggest conceptual gap is in understanding the process of migration out of source rocks. Progress is being made, but the relative importance of the various possible migration mechanisms is imperfectly understood. This is a critically important area because of its impact in recognizing source rocks, establishing time of migration and distance of migration, and in developing oil-to-source correlation methods. Quantitative models that use time-temperature relationships to establish the time of oil generation are developing rapidly and provide an important tool. Further refinement is needed, and here parallel research on simulating generation in the laboratory will be important. Hydrous pyrolysis (which involves heating samples of immature source rocks at elevated temperatures and pressures in an aqueous medium) seems to duplicate natural generation very well and has enormous potential for investigating generating capacities of different types of organic matter under various conditions.

The biggest challenge in exploration is to extrapolate from limited well data to other locations in the basin. Geochemistry cannot function in this way without a much better understanding of the relationships among organic matter types and environments, and the processes that operate to separate organic matter types (such as different hydraulic behaviors). It is important to establish the geochemical style of each depositional environment and to extend the present concepts of organic facies. We need more "geo" in geochemistry. Also more attention should be paid to mass balance considerations within the geologic framework;