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;