that the Tx-La basin was periodically isolated from normal seawater during Louann deposition; radiogenic fluids, derived either from local red beds or from meteoric waters, equilibrated with seawater prior to anhydrite precipitation.

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Seismic Structure and Stratigraphy of Eastern New York–Western Vermont

A reconnaissance grid of 550 mi of Vibroseis data extending from northernmost Vermont to slightly north of Albany, New York, provides a framework for analyzing subsurface structure and stratigraphy of eastern New York and western Vermont.

Regional stratigraphic analysis based on outcrop sections indicates northward and eastward thickening of the Cambrian-Ordovician shelf sequence. Synthetic seismograms from wells in Quebec and southwestern Washington County, New York, document this change in the subsurface and correlate the seismic stratigraphy. Seismic data indicate thickening occurs north of the "Whitehall culmination," an approximately 40-mi long buttress area of Adirondack Grenville basement. Changes in thickness appear to be gradual and not fault controlled.

Foreland thrust systems of New York and Vermont relate via a displacement transfer or lateral ramp zone associated with the "Whitehall culmination." Both thrust systems accomplish final emplacement of metamorphic sheets, deform them, and transport shelf material, which is predominantly shale in New York with increased percentage of carbonates in Vermont. Deflection of several major structural elements illustrates the culmination's buttress effect.

Subsurface structural elements in New York include western graben, central horst block, and eastern fault-zone trends. No analogous trends have been identified in Vermont where predominant faulting is down-to-the-east. Significantly, in southwestern Washington County, New York, preexisting horst blocks do not serve as ramps to deflect thrusts upward. Instead, the Snake Hill–Smiths basin and Schuylerville thrusts shear off the upper sedimentary sequence of the horst and transport it westward.

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Powder River Basin, Wyoming: Structural Development, Hydrocarbon Migration, and Accumulation

The geographical location of oil accumulations in the Powder River basin, Wyoming, is closely related to present basement structure. About 70% of the basin's cumulative oil production has been obtained from only 12 fields or 23% of the total fields. Each major oil field lies in an area of a pronounced positive Bouguer gravity anomaly and in the path of preferred regional hydrocarbon migration. Powder River basin Bouguer gravity anomalies most likely are caused by a combination of present basement structure and density changes in post-Paleozoic sediments; the latter are the result of synsedimentary basement structure and/or related topographic features influencing post-Paleozoic sedimentation. Stratigraphic and structural traps occur in close interrelationships across the basin. Published geochemical data in connection with available regional subsurface data permit mapping the preferred migration paths for oil and gas across the basin. Future discoveries of major hydrocarbon fields will be made in these hydrocarbon migration paths and areas in and around regional positive Bouguer gravity anomalies. Powder River oil field distribution follows general rules known from practically all producing basins but rarely used for lack of sufficient integration of geological and geophysical data. Gas field distribution is expected to be similar to oil field distribution.

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Examples, Causes, and Consequences of Vitrinite Reflectance Suppression in Hydrogen-Rich Organic Matter—a Major Unrecognized Problem

Vitrinite reflectance (R_0) is regarded as one of the most powerful tools available to petroleum organic geochemistry. A major limitation of this method is the severe suppression of R_0 by significant exinite maceral concentrations (hydrogen-rich types I and II kerogen) in association with vitrinite macerals. This effect is not subtle, as R_0 in hydrogen-rich organic matter (OM) is suppressed at least 3-5 times from what the value would be in oxygen-rich OM (type III kerogen), and the effect extends to at least $R_0 = 4.0$. The effect has been attributed to the migration of early generated bitumen from hydrogen-rich OM into the associated vitrinite macerals with the bitumen retarding maturation of vitrinite macerals. However, this explanation for R_0 suppression is inadequate in many cases.

Suppression of R_0 is due more likely to 2 factors: (1) anaerobic conditions at deposition and diagenesis when much greater amounts of hydrogen than "normal" are incorporated into the vitrinite macerals, and (2) hydrogen-rich OM requiring significantly higher burial temperatures to attain the same maturation rank as oxygen-rich OM. Thus, all maturation indices, including R_0 and the threshold of intense hydrocarbon generation (TIHG), are suppressed in hydrogen-rich OM compared to oxygen-rich OM buried under the same conditions.

R_0 values are primarily derived from exinite-rich sediments, leading to the establishment of the R_0 value of 0.6 (± 0.1) for the TIHG in hydrogen-rich OM. Far higher R_0 values are read in oxygen-rich OM at the same regional rank for the TIHG in hydrogen-rich OM. The "oil deadline" has been defined as occurring at $R_0 = 1.35$. There is a sharp decrease in the maximal values of the hydrocarbon coefficient (mg HC/g OC) at $R_0 = 0.9$ to the very low values at $R_0 = 1.35$ in type III OM. This decrease of the hydrocarbon coefficient, previously assumed to result from the thermal destruction of C_{15+} hydrocarbons by carbon-carbon bond breakage, is actually due to a loss of C_{15+} hydrocarbons by intense primary petroleum migration by gaseous solution. This general lack of recognition of R_0 suppression and the necessity of higher burial temperatures to attain the same maturation rank in hydrogen-rich OM compared to oxygen-rich OM has led to a miscalibration of the regional ranks necessary for significant petroleum generation from hydrogen-rich OM and the oil deadline. Examples from the Los Angeles and Williston basins as well as other areas demonstrate these problems.

The consequences have staggering implications to petroleum exploration and to basinal and worldwide petroleum resource estimates.

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Controls on Pennsylvanian Algal-Mound Distribution in Mid-Continent North America

Middle (Desmoinesian) and Upper (Missourian) Pennsylvanian phylloid algal-mound distribution in Missouri, Kansas, and Oklahoma is largely controlled by subtle sea-floor topography. Topographic highs served as loci favoring initiation and continued growth of complexes. Topographic highs controlling mound distribution are the "shelf-edge rise" in northeastern Oklahoma, the "Bourbon arch" in southeastern Kansas, and the " Mine Creek prodeltaic shale buildup" in west-central Missouri.

Outcrop studies document controls on development of these mounds and reveal the potential for development of stacked mounds. This will help exploration for these features in the subsurface to the west.

The shelf-edge rise and Mine Creek prodeltaic shale buildup control the location of the Oologah algal-mound complex and an isolated algal mound in the Pawnee Limestone, respectively. These apparently were positive features only during Middle Pennsylvanian time. In contrast, the Bourbon arch apparently was controlled by basement faulting and remained high for a more-extended period of time. Both Middle and Upper Pennsylvanian algal mounds coincide with the geographic position of the Bourbon arch and result in a stacked-mound complex. Evidence suggesting that the Bourbon arch was a positive feature are (1) thinning of clastics over the feature and (2) change from anoxic, black, fissile, and phosphatic basinal shales to oxygenated, diversely fossiliferous gray shales over the arch.

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Petrology of Middle Jurassic Twin Creek Limestone, Lincoln and Sublette Counties, Southwestern Wyoming

Cluster analysis was used to delineate lithofacies in the Twin Creek Limestone of Middle Jurassic age in the Tunp, Salt River, and Wyoming Ranges in southwestern Wyoming. Subjective appraisal of the petrographic data produced lithofacies similar to that created by cluster analysis. Modern carbonate environments and their ancient analogs were compared with information obtained from field study and petrographic analysis of samples of the Twin Creek Limestone to delineate environments of deposition, paleogeography, and diagenetic history.

Six major lithofacies were recognized: (1) carbonate mudstone, (2) packstone-grainstone, (3) fossiliferous wackestone, (4) terrigenous mudstone, (5) sandstone, and (6) carbonate mudstone breccia. These lithofacies were deposited in a variety of environments, including outer shelf platforms (carbonate mudstone and fossiliferous wackestone), oolitic sand belts (packstone-grainstone), open to restricted lagoons (carbonate mudstone, fossiliferous wackestone, and terrigenous mudstone), tidal flats, and supratidal environments (terrigenous mudstone, sandstone, and carbonate mudstone breccia). The Twin Creek epeiric seaway experienced two major transgressions (early Bajocian and late Bathonian–early Callovian) and two regressions (early Bathonian and middle Callovian). Lateral migration of the adjacent facies occurred in response to these changes in sea level.

Eogenetic diagenetic features include minor compaction, micritization, coarse fibrous rim cementation, granular cementation, syntaxial rim cementation, and silicification of carbonates. These features were produced in environments ranging from freshwater phreatic to marine phreatic. Mesogenetic diagenesis was characterized by pressure-solution features and neomorphism. Telogenetic features are limited to calcite vein fillings and oxidation coating on carbonate and detrital grains.

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Subsurface Geology and Paleodepositional Environments of Pleistocene Trend; South High Island and South Galveston Area—a Regional Evaluation

The Pliocene-Pleistocene producing trend of South Galveston and South High Island areas represents a matured province with excellent data control. Four biostratigraphic working units (upper Pleistocene-*Trimosina A*, middle Pleistocene-*Angulogerina B*, lower Pleistocene-*Lenticulina I*, and upper Pliocene-*Valvularia H*) were regionally established and interpreted using all nonconfidential electric well logs. These correlations were verified with seismic data. Geophysical verification was possible in the upper and middle Pleistocene, but limited to local areas in the lower Pleistocene. Three major growth-fault systems, which become larger southward and attain as much as 4,000-5,000 ft of growth, were recognized. Salt piercement structures are sparse north of Federal Block HI-495 but increase in number southward. Paleoecological data and lithological information obtained from SP logs indicate that sedimentary sequences steadily prograded south from the Pliocene through Pleistocene, reaching the most southward position during the time of *Trimosina A*. Deposition of Pliocene-Pleistocene sand sequences occurred primarily in low-energy deltaic and associated environments. Occasional intraslope basinal and deep-water submarine fan type sand bodies were also recognized. The morphology and occurrence of deltas were significantly influenced by paleotopography and salt tectonics.

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Structural Control on Molasse Sedimentation: Example of Siwalik Group of Northern Pakistan

Molasse sediments accumulate in elongate foredeeps during orogenic episodes induced by plate collision. These sediments are typically fluvial, but may grade distally into marine sediments. Molasse lithofacies exhibit a variety of syndepositional structural controls. Structural controls can be subdivided conveniently into 3 scale-dependent categories: (a) regional (basin-wide) control in which the fundamental asymmetric basin architecture is established by the collision process, (b) subregional in which structural control on the location of river systems influences facies distribution and preservation, and (c) local control in which developing folds and faults influence the character of the rock record. New data derived from paleomagnetic stratigraphy and fission-track dating has permitted refinement of lithofacies correlation in the Siwalik molasse sediments of northern Pakistan. A suite of 8 dated sections illustrates the structural controls on molasse facies distribution in the Himalayan foredeep between 3.4 and 1.6 m.y. Subregional and local structural controls are critical factors defining the facies of the proximal molasse sequence. Variable rates of sediment accumulation, differing efficiency of sediment preservation, structurally controlled unconformities, and abrupt time-transgressive lithofacies transitions are documented. Facies patterns preserved in the rock record are compared to analogous modern environments in India. The observed patterns indicate profound structural control on the distribution and interconnectedness of reservoir facies in fluvial-dominated foredeep settings.

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Evolution of Cambrian-Ordovician Carbonate Shelf, United States Appalachians

Cross sections and isopach maps (palinspastic) of the Cambrian-Ordovician continental shelf, United States Appalachians, show that thickness and facies trends are controlled by the Adirondack, New Jersey, and Virginia highs and depocenters in Tennessee, Pennsylvania, and by the Rome trough. Carbonate sedimentation was initiated with drowning of Early Cambrian clastics, deposition of carbonate ramp and rimmed shelf facies followed by drowning, then regional regression and deposition of Early to Middle Cambrian red beds and platform margin rimmed shelf facies. During subsequent regional transgression, the Conasauga intrashelf shale basin formed, bounded toward the shelf edge and along depositional strike by Middle to Upper Cambrian oolitic ramp facies and cyclic peritidal carbonates. Intrashelf basin filling and regional regression caused progradation of Late Cambrian cyclic carbonates and clastics across the shelf. By this time, the margin had a relief of 2.5 km. During the Early Ordovician, incipient drowning of the shelf formed subtidal carbonates and bioherms that passed up into cyclic carbonate as sea level oscillations decreased in magnitude. Numerous unconformities interrupt this sequence in the northern Appalachians. The earlier high relief rimmed shelf was converted into a ramp, owing to uplift in the basin, heralding approaching collision. Subsidence rates on the margin were low (4 cm/1,000 yr) and typical of a mature passive margin. Shelf sedimentation in the southern Appalachians ceased with arc-continent collision and development of the Knox unconformity, which dies out into the Pennsylvania depocenter. Major exploration targets are in the Late Cambrian-Early Ordovician Knox Group.

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Igneous Intrusions in Porous Sandstone Sequences—Widespread Thermal Effects Measured by Fission Track Annealing and Vitrinite Reflectance

Current literature suggests that igneous bodies have only minor thermal effects on intruded sedimentary rocks, increasing the maturity of a thickness of adjacent strata approximately twice the width of the intrusion. This study shows that this is not always true. In the Canning basin of Western Australia, Permian dikes, sills, and laccoliths have intruded porous and permeable Carboniferous and Permian sandstones. Efficient vertical and lateral heat transfer has occurred by movement of hot waters through the sedimentary rocks over large distances away from the igneous bodies. This heat transfer is recorded by the resetting of fission tracks in detrital Precambrian apatites, which now have apparent ages similar to those of the igneous intrusions. In some instances, a significant increase in vitrinite reflectance within the sediments is also evident, but vitrinite appears to be less sensitive to heat pulses of short duration, even though temperatures greater than 110°C have developed. Fission-track studies suggest that temperatures of at least 110°C to 130°C have occurred up to 3 km from thin doleritic dikes and sills in porous sandstones where pre-intrusion temperatures were around 40°C. Some evidence of increased temperature is also apparent 26 km from the nearest mapped intrusion, although this has not been sufficient to totally anneal fission tracks.