contains some anomalously thick sandstones and siltstones, which are generally limited to the north and have been tentatively assigned to the "Mohawk"(?) unit. These sandstones are mostly medium to coarse-grained, calcite-cemented quartzarenites. Upper Jurassic "Abenaki" limestone as much as 2,210 ft (675 m) thick was penetrated by most of the eastern wells. The limestone is mostly wackestone to grainstone, with varying amounts of oolites and fossils. Thick-bedded sandstones characterize the Lower Cretaceous "Mississauga" unit. These sandstones are mostly fine to medium-grained, calcite-cemented quartzarenites. The overlying "Naskapi" unit consists of calcareous shale. Thick sandstone beds dominate the uppermost "Logan Canyon" unit, which consists mostly of fine to coarse-grained, calcite-cemented quartz arenite.

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Regional Depositional and Tectonic Model for Lower Mississippian Pocono Formation Sandstones, Hydrocarbon Entrapment, and Play Generation—Southern Appalachian Plateau of West Virginia and Virginia

Local and basin analyses were integrated into a regional depositional and tectonic model for hydrocarbon migration and entrapment for the Lower Mississippian Pocono Formation sandstones for a study area located in the Appalachian Plateau of West Virginia and Virginia.

Subsurface mapping on a local scale led to the recognition of a suite of depositional facies corresponding to the Pocono Formation sandstones and the tectonic effects exerted on them. The Pocono depositional sequence consists of sediments deposited in wave-dominated linear clastic shorelines. These features include the corresponding facies of barrier islands and strand plains. Structural elements observed from local mapping on Pocono horizons include northeast-southwest strike, northwest dip, high-angle reverse faults, low-relief folds, and northwest-southeast cross-strike structural discontinuities (tear faults).

Basin analysis generated a basin history model, which was described using the following parameters: basin-forming tectonics, depositional sequences, and basin-modifying tectonics.

Placing the local Pocono Formation study area within the framework of the generated basin history model yielded a tracing for the movement of the study area through time relative to basin evolution. This permitted identification of the genetic relationships among the observed local depositional and tectonic features and the mechanisms responsible for their generation, thus providing a basis for exploration and field extension.

For the study area, we place the Pocono Formation sandstones at the wedge top of a Middle Silurian through Lower Mississippian depositional sequence deposited within an interior sag basin situated immediately west of a westward-converging mobilized fold belt.

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Paleoenvironmental Control of Accumulation and Quality of Upper Freeport Coal Bed (Allegheny Formation, Middle Pennsylvanian), Castleman Coalfield, Maryland

The upper Freeport is generally a thick, widespread coal bed in the north-central Appalachian basin. It is a principal bed mined in the Castleman coalfield, Garrett County, Maryland, as delineated on a new geologic map of the coalfield. In the northern part of the coalfield, the upper Freeport is 21-48 in. (53-122 cm) thick and thickens toward the northwest, where the ash and sulfur contents are generally 7-10 wt. % and less than 1.5 wt. %, respectively. This coal bed thins southward and eastward and is absent from a large area in the central part of the coalfield, where its position is occupied by a carbonaceous claystone or flint clay. Toward the south and east, the upper Freeport coal bed generally contains 12-15 wt. % ash and 1.5-6.2 wt. % sulfur.

Lithofacies analysis of the floor rocks and their lateral equivalents indicates deposition of the upper Freeport coal bed in floodplain swamps. Limestone and limy claystone floor rocks in the northwest represent distal floodplain lake deposits. Where the coal is unminable or absent to the south, proximal overbank floodplain shale, siltstone, and silty claystone grade laterally into channel sandstone. The gradation of thin coal into carbonaceous claystone to the south indicates increased oxidation and shoaling in a well-drained swamp. There, the coal has the highest ash and sulfur contents, which probably reflect the influx of detritus and iron-rich clays. Thus, the upper Freeport is thickest and has the lowest ash and sulfur contents where the paleoenvironment was a poorly drained, distal floodplain swamp.

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Bioclastic Turbidites in Trenton Limestone: Significance and Criteria for Recognition

Bioclastic turbidites are identified and described from the Denley Limestone (Trenton Group) in the Mohawk Valley, New York. These turbidites are recognized by the repetitive Bouma sequences within limestone beds separated by shale interbeds interpreted as interturbidite deposits. The general characteristics of bioclastic turbidites includes internal structures identifiable as Bouma sequences Ta through Te. Bioclastic turbidites differ from the clastic turbidites described by A. Bouma in that they include an additional subdivision termed Td'. This unit, composed of unfossiliferous, bioturbated, but otherwise structureless carbonate mud, is similar to the ungraded, unlaminated mud described by others as representing the finest grained sediment emplaced by turbidity currents. The Trenton bioclastic turbidites are associated with slump-fold zones and syndepositional block faults and have been used by other workers to redefine the Trenton limestones as foreland basin or trench slope deposits. The Trenton Group sediments have been interpreted previously as deposits formed in situ on a subsiding shelf, rather than storm-generated shelf sediments from turbidites. It is suggested that the internal structures of the limestone beds are similar to those that would be produced by storm-surge ebb-flow currents, but differ in that they are associated with other indicators of the slope setting, are consistently associated with vertical burrows descending into the sediment rather than escape burrows, consistently exhibit Bouma sequences, and show a statistical relationship between grain size and bed thickness.

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Comparison of Foreland Basin Sequences: Trenton Group in Southern Quebec and Central New York

Numerous high-angle faults are recognizable within the autochthonous Middle Ordovician (Trenton Group) shelf sequence in southern Quebec. These faults were active during deposition of the Trenton limestones, as evidenced by rapid thickness changes over short distances on the shelf, abrupt facies changes between fault blocks, and associated slump-fold zones. Syndepositional block faults have been described recently from the Trenton Group of central New York. The times of movement were documented by use of the numerous interbedded bentonite beds. Bentonites, although present in the Trenton Group in southern Quebec, are not abundant enough to correlate fault blocks. Instead, the syndepositional nature of the fault blocks can be seen by examining the facies distribution of the Deschambault Limestone. The Deschambault Limestone represents a skeletal buildup on the Trenton shelf, similar to those described from the southern Appalachians. The core facies of the buildups is exposed in the Pont Rouge region. Flank facies are present to the west, near Joliette. The buildup facies are absent both downshelf and upshelf. Using the buildup facies as marker beds, at least one period of movement can be recognized. Fault blocks were primarily active after the Deschambault deposition.

The Trenton in southern Quebec can be compared to that in New York and southern Ontario. The facies changes among these areas can be shown to be controlled by proximity to or position within the Taconic foreland basin.

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Consideration of Possible Productive Zones Within Gatesburg and Postsdam Formations, Northwest Pennsylvania

A recently drilled Cambrian test well in Waterford Township, Pennsylvania, penetrated Precambrian basement at a total depth of 7,342 ft (2,238 m). The well site was determined on the basis of structural contour mapping of the top of the Queenston Shale. This work has lead to the definition of a conspicuous structural high (anticline, horst-block?) characterized by about 250 ft (76 m) of relief. The steeply inclined southeast limb of the structure may control gas production within the younger Paleozoic formations and ultimately in older formations (e.g., Cambrian Gatesburg and Potsdam). Interpretation of structure, lithologic characteristics, and log analysis reveals two target formations—the Gatesburg Sandstone and the Potsdam Sandstone. The upper sandy section of the Gatesburg Sandstone, a clean, yellowish-white quartzarenite of Late Cambrian age was penetrated at a depth of 6,280 ft (1,914 m) and was found to be water saturated between 6,340 and 6,370 ft (1,932 and 1,942 m). The productive zone is targeted between 6,415 and 6,447 ft (1,955 and 1,965 m) and contains approximately 13 ft (4 m) of pay that averages 8% porosity. Silica is the dominant cementing agent. The Potsdam Sandstone was encountered at a depth of 7,143 ft (2,177 m), just below a dolomitic interval of the lower Gatesburg. The productive zone ranges from 7,250 to 7,294 ft (2,210 to 2,223 m) and is characterized by 10 ft (3 m) of sand that averages 7% porosity. Calcite is the dominant cementing agent within the target zone.

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Stratigraphic Relation of Silurian Sandstone in Part of Summit and Portage Counties, Ohio

The Silurian sandstones of northeastern Ohio, informally termed white "Clinton," red "Clinton," and stray "Clinton," in ascending order, have been described by various investigators as belonging to a major Silurian delta complex sourced from an easterly direction. Detailed study of geophysical logs of a limited area in Summit and Portage Counties supports this interpretation. Isopach maps, sand thickness maps, and sandstone-shale ratio maps show a pattern of probable deltaic distributary streams flowing generally from east to west, bifurcating at places to probable crevasse splays, and terminating westerly in nearshore beach and marine bar sands. The units are probably marine regressive. In ascending order, the white Clinton represents partial bars, beaches, and delta front; the red Clinton represents poorly drained swamp and/or upper delta or fluvial environments; and the stray Clinton may be marine transgressive representing environments similar to the white Clinton.

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Upper Devonian First Bradford Formation of Southwestern Pennsylvania: Environment of Deposition and Factors Affecting Gas Production

Core descriptions and thin-section analyses from five wells in southwestern Pennsylvania, in addition to regional cross sections and subsurface maps, provide the basis for subdividing the Upper Devonian First Bradford formation into three distinct members. These include upper, middle, and lower sandstones. Although individual members vary in geometry and areal distribution, similar characteristics in sedimentation persisted over a distance of 125 km (78 mi) along strike and 25 km (16 mi) along dip. The sandstones are generally very fine to fine grained, exhibit upward coarsening, and are calcite cemented. Depositional structures range from planar bedding to cross-laminations, which include flaser, wavy, and lenticular stratification. Bioturbation and disseminated organic debris are common.

Isopach maps show the sandstones to be strike-oriented linear ridges and/or pods 1-3 km (0.6-1.9 mi) wide and 3-20 km (1.9-12.4 mi) long. Thicknesses rarely exceed 10 m (33 ft). Regionally, sand percentage for the overall interval (approximately 46 m or 151 ft) decreases west and southwest of Clearfield County where only the lower sandstone is preserved in parts of Armstrong and Westmoreland Counties. The postulated depositional environment is a shallow marine, inner to mid-shelf bar facies. The sediments accumulated as a result of current reworking; in places, deposition was controlled by shelf topography. Sediments were probably derived from a deltaic complex in the vicinity of Clearfield County.

Gas production is confined to the stratigraphic limits of the clean sandstones and is locally enhanced by a high structural position. This "combination trapping" permits the segregation of gas and water and is evidenced by production in Westmoreland and Fayette Counties. Core porosities average 6.7%; permeabilities, with an effective overburden pressure of 1,000 psi (6,895 kPa), average 0.04 md. Production capabilities are ultimately affected by various diagenetic influences, which include compaction, cementation, authigenesis, replacement, and leaching.

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Basin Analysis and Petroleum Potential of Michigan Basin: Deposition and Subsidence History from Middle Ordovician (Trenton Formation) to Early Devonian

The history of the Michigan basin (Early Ordovician to Early Devonian) is that of a nonuniformly subsiding basin, with the Michigan basin, at times, nearly disappearing as either a topographic feature or a depositional center. This history is interpreted from the analysis of lithostratigraphic units, time stratigraphic features, and log formats (term by J. Forgotson). These units are defined for wells throughout the Michigan basin, and they extended eastward into the Appalachian basin. The definition and thickness mapping of these lithostratigraphic units and formats are accomplished using well cuttings, cores, and wire-line geophysical well logs. Furthermore, these units are correlated to both outcrops and stratigraphic type sections for areas adjacent to the Michigan basin. From these data, it is possible to interpret the major aspects of both the subsidence and depositional history of the basin. During deposition of both the Trenton limestones and Early Silurian carbonates and shales, the Michigan basin behaved as if it were part of the greater Appalachian basin, whereas prior to the deposition of the Trenton (Middle Ordovician) and during Middle and Late Silurian, the Michigan basin was an entity separate from, and with an apparent structural independence of, the greater Appalachian basin. However, even during times of Michigan basin structural independence, the stratigraphic and sedimentologic characteristics of these two basins were closely related.

The structure and topography of the Trenton prior to the deposition of the Utica Shale was mapped throughout Michigan to provide insight into the nature of petroleum entrapment in the Trenton formation. The structural entrapment of petroleum in southeast Michigan contrasts with the combination diagenetic to structural Albio-Scipio trend of south-central Michigan. Evidence is available that more of these two types of traps occur in unproducing areas of the Michigan basin.

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Lineament Analysis near French Creek, Northwestern Pennsylvania

We are attempting to characterize the nature of linear topographic features in the vicinity of French Creek, northwestern Pennsylvania. Straight valleys that trend north to northwest and that are partially filled with glaciofluvial deposits distinguish prominent lineaments in Crawford, Venango, and Mercer Counties. The traces of these linear valleys are 1-15 mi (1.6-24 km) long and 10-4,000 ft (3-1,220 m) wide. The vertical extents of the lineaments are assumed to be proportional to their lengths. We assume that the topographic lineaments mark easily eroded zones coincident with fractures.

The French Creek lineaments have been plotted on a Landsat photo, glacial map, regional map, and topographic maps. Subsurface structural and isopach maps may show facies changes or anomalous thickness across the lineaments. Geochemical surveys determine if there is any enhanced vertical migration of hydrocarbons along a lineament, and very low-frequency magnetic surveys would indicate any increase in groundwater concentration associated with the fracture zones. Well log data on initial production and breakdown pressures have been compared to lineament positions for possible correlations.