mentary, low-grade metamorphic, and volcaniclastic detritus that was shed northwestward in an alluvial and/or fluvial system from an uplift produced during the Taconian orogeny.

Intermediate to felsic volcaniclastic rock fragments comprise approximately 3% of the framework grains. They consist of devitrified shards, partially kaolinized plagioclase laths, and biotite in a cryptocrystalline groundmass. Siltstone, mudstone, chert, radiolarian chert, and recycled grains are indicative of a sedimentary source. Chlorite-quartz, epidote-quartz, and muscovite-chlorite phyllite clasts indicate a low-grade metamorphic provenance. Quartz varieties plotted on a diagram are consistent with a low-grade metamorphic provenance. Metaquartzite, slate, and cataclastic lithic fragments indicate tectonic deformation in the source area.

Provenance criteria support a plate tectonic model involving an eastward-dipping subduction zone in the central Appalachians during the Middle to Late Ordovician. The climax of the Taconian orogeny has been described as a collision of an island arc with the North American continental margin. Petrologic data from the Bald Eagle and Juniata Formations suggest that this collision was accompanied by uplift of accretionary prism and continental margin or forearc basin sediments prior to the Richmondian. The presence of sedimentary, low-grade metamorphic, cataclastic, and volcaniclastic lithic fragments, and the notable absence of higher grade metamorphic and plutonic grain-types, indicate unroofing at relatively shallow levels of the orogene.

LEONARD, KATHERINE E., Univ. Vermont, Burlington, VT

Foreland Fold and Thrust Belt Deformation Chronology, Trenton Group Limestones and Overlying Shales, Northwestern Vermont

Outcrops of Trenton and younger limestones and shales between Plattsburgh, New York, and Malletts Bay, Vermont, show eastwardly increasing progressive deformation fabric in the foreland fold and thrust belt of northwestern Vermont.

The deformation sequence within the calcareous Stony Point and Iberville shales is: (1) bed-parallel slip, marked by grooved calcite-covered surfaces; (2) folding accompanied by pressure solution cleavage; (3) overturned folds with frequent faulting along overturned limbs; fault surfaces, marked by calcite slickensides, at high angles to calcite-filled extension fractures; cleavage frequency increases and is rotated into a lower angle with bedding; (4) late-stage features 2-3 km (1.2-1.9 mi) from the Champlain thrust include high-angle faults and pervasive shearing of early fabric. Less than 1 km (0.6 mi) from the Champlain thrust (Malletts Bay area), fold hinges are sheared out and closely spaced cleavage is folded.

The Cumberland Head Argillite (transitional between the Trenton Glens Falls Limestones and the younger Stony Point Shale) contains medium to thick micrite beams in a calcareous shale matrix. Deformation in the beams occurs by brittle failure and minor thrusting up ramps in the beams. The surrounding shale deforms by bed-plane slip and pressure-solution cleavage.

Glens Falls Limestone in the study area consists of medium to thick beds of fossiliferous micrite. A widely spaced pressure solution cleavage is intensified and rotated in ramp-and-fold zones. The cleavage is crosscut by late high-angle faults.

A progressive increase in deformation fabric from west to east across the Ordovician limestones and shales of the northern Champlain Valley allows the fold and thrust chronology to be determined for the different lithologies.

LEWIS, J. SCOTT, Mobil Exploration and Producing Services, Inc., Dallas, TX

Stratigraphy and Depositional Environments of Catskill Deltaic Sequence, Northern West Virginia

The Catskill deltaic sequence (Upper Devonian–Lower Mississippian) is inadequately mapped and subdivided in the subsurface of northern West Virginia (central Appalachian basin). Stratigraphic interpretations are often hindered by the liberal use of drillers' names for noncontemporaneous gas-bearing sandstones.

Base-line analysis of 275 gamma-ray logs permits the resolution of lithostratigraphic units in this sequence. Five regionally mappable units are recognized, within which the position, geometry, trend, and distribution of reservoir sandstones are interpreted. Three units are within the Upper Devonian Chemung Formation, and two are considered equivalents of the Hampshire (Upper Devonian) and Pocono (Lower Mississippian) Formations. Stratigraphic cross sections graphically display relative thickness variations of reservoir sandstones and document the intertonguing facies of the Catskill deltaic sequence that are attributable to "cyclic" marine transgression and regression, and/or to changing sedimentation or subsidence rates in the basin.

Five lithofacies (A-E) are identified by the study of equivalent strata on outcrop. Facies A consists of gray shales and thin-bedded siltstones, interpreted as interbedded hemipelagic shales and turbidites. Facies B is comprised of thick-bedded and amalgamated siltstones and sandstones containing hummocky cross-stratification, representing composite storm deposits of the shelf and slope. Facies C consists of thick-bedded to massive clean sandstones and interbedded red and gray shales, interpreted as barrier-beach and back-barrier deposits. Facies D is dominated by red beds (silty mudstones and siltstones) with some interbedded sandstones, representing vertical accretion and channel deposits of an alluvial plain. Facies E consists of gray sandstones containing marine fossils and greenish-gray shales (Pocono Formation), interpreted as marine and marginal marine deposits developed during net transgression of the subaerial "Catskill delta."

Contrary to some previous studies, this study indicates these strata are best interpreted within the context of deltaic sedimentation. More specifically, stratigraphic and sedimentologic evidence suggests deposition in a wave- and storm-dominated deltaic complex.

LIBBY-FRENCH, JAN, U.S. Geol. Survey, Denver, CO

Upper Cretaceous and Cenozoic Sedimentary Sequence, Baltimore Canyon Trough, United States Atlantic Margin

The extent and character of Upper Cretaceous and Cenozoic rock units in the Baltimore Canyon Trough are revealed by geologic data from 29 exploratory wells. These data, released to the public in 1982, have been used previously in the description of regional rock-stratigraphic units in the trough. Now, a more detailed interpretation and correlation of electric logs and mud logs from these wells and a petrographic examination of thin sections have revealed the composition and lateral distribution of these units. Four detailed stratigraphic cross sections were constructed to show rock-unit correlations among 19 exploratory wells based on lithology and electric logs. Thin-section photomicrographs of drill cuttings and conventional cores document the mineralogic composition of these units.

The Upper Cretaceous section is composed principally of gray to brown, calcareous mudstone and is 1,555-3,220 ft (475-980 m) thick. One major shaly, glauconitic quartzarenite within the mudstone is present at most of the well sites. An Eocene carbonate unit, 100-1,100 ft (30-335 m) thick, overlies the mudstone. This unit grades from fossiliferous wackestones to calcareous shale. Oligocene to Miocene calcareous mudstone overlies the Eocene carbonate. White to gray, calcareous clay, shale, and siltstone are common constituents, and limestone, dolomite, and sand are minor constituents. Miocene to Pliocene unconsolidated fine to very coarse-grained sand overlies the mudstone. An uppermost unit of predominantly gray clay is present in the eastern part of the basin.

LIBBY-FRENCH, JAN, U.S. Geol. Survey, Denver, CO

Upper Jurassic and Lower Cretaceous Sedimentary Sequence, Baltimore Canyon Trough, United States Atlantic Margin

The extent and character of Upper Jurassic and Lower Cretaceous rock units in the Baltimore Canyon Trough are revealed by geologic data from 29 exploratory wells. These data, released to the public in 1982, have been used previously to define regional rock-stratigraphic units. In this study, four detailed stratigraphic cross sections were constructed to show rock-unit correlations based on lithology and electric logs. Thin-section photomicrographs document the mineralogic composition of these units. The stratigraphic terminology used herein is informally adopted from the nomenclature used on the Scotian Shelf.

Most of the Upper Jurassic section consists primarily of "Mic Mac" gray shale and siltstone with minor amounts of very fine to medium-grained quartzarenite, red-brown shale, and lignite. This interval also 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.

LYNCH, ROY W., JR., and JAMES R. APUTIC, Berea Oil and Gas Corp., Buffalo, NY

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.

LYONS, PAUL C., U.S. Geol. Survey, Reston, VA, EDWIN F. JACOBSEN, Vienna, VA, and ROMEO M. FLORES, U.S. Geol. Survey, Denver, CO

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.

MEHRTENS, CHARLOTTE, Univ. Vermont, Burlington, VT

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.

MEHRTENS, CHARLOTTE, and RONALD PARKER, Univ. Vermont, Burlington, VT

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.

MILLER, MARC A., BRUCE A. BENNETT, and GARY G. LASH, State Univ. College, Fredonia, NY

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