micritized skeletal debris are the dominant particles. Peloids are abundant in the middle of the formation. The Alsen represents slightly deeper water and less current activity than the equivalent upper Becraft.

Port Ewen lithologies include irregular and nodular, silty, skeletal wackestones and packstones, silty, peloidal packstones, and interbedded shale. Ostracodes, bryozoans, brachiopods, and micritized skeletal grains represent the sparse fauna. Bioturbation is ubiquitous; *Chondrites*, *Planolites*, and *Zoophycos* lebensspuren are common. The Port Ewen formation records the deepest, least-oxygenated environment in the Helderberg Group.

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Cost of Adverse Geologic Conditions on Coal Production

This paper explores the cost attributed to mining of coal under adverse geologic conditions, in order to derive the costs that the geologic conditions generate. Both surface and underground models will be developed for ideal mining conditions. The two models will represent a reference point to which all costs are related. The underground model will consider such factors as roof and floor conditions, the effect of faults, and split coal. The surface model will include the effects of total overburden, hydrogeology, total thickness, and structure. These items of geologic information will be compared with geology of ideal mining conditions to determine the cost differential resulting from adverse conditions.

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Aspects of Porosity Development in a Tight Sandstone, "Clinton" of Eastern Ohio

The Silurian "Clinton" sandstone of the Appalachian basin has long been a favored target for oil and gas exploration. Though most wells are of modest production, success ratios have been excellent. Porosities generally range from nil to as much as 10%, and permeabilities commonly range from less than 0.1 md to 1.0 md and more.

Detailed study of three cores from northeast Ohio by visual, petrographic, X-ray diffraction, cathodoluminescence, scanning electron microscopy, and electron microprobe analysis, shows that present porosity is essentially secondary in nature, and intergranular porosity shows significant modification and reduction by authigenic minerals. Pressure solution is suggested as moderate and fracture porosity is limited and, where present, is commonly healed by quartz and calcite overgrowths. Porosity appears to have developed and modified through successive stages. It appears to have progressed initially from dissolution of early calcite cement and local detrital clay matrix. Authigenic potassium feldspar rims formed on detrital potassium feldspar cores. Subsequently, ubiquitous quartz overgrowths, authigenic iron chlorite, and illite reduced porosity. Dissolution of the authigenic rims and detrital potassium feldspar cores also occurred. Some late-stage(?) calcite and phyllosilicate cements, and differential patches of anhydrite cement, further reduced porosity.

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Geologic Information Requirements of Surface Mining Control and Reclamation Act of 1977 (PL 95-87)

The geologic information requirements of the Surface Mining Control and Reclamation Act of 1977 (PL 95-87) and the promulgating regulations are summarized. The basis and purpose of these requirements and their relationship to the protection of water resources are explored. Specifically, with the geologic and related information acquired, mining and reclamation operations can be designed to preclude or mitigate the generation of acid mine drainage, and to maintain, restore, or perhaps even improve groundwater resources in proximity to and at the mine site. A hypothetical case study illustrates the substance of these requirements.

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Distribution of Layer-Parallel Shortening Fabrics in Appalachian Foreland of New York and Pennsylvania: Evidence for Two Non-Coaxial Phases of Alleghany Orogeny

A structural interpretation of a part of the central and northern Appalachian foreland, uses the correlation of mechanical twinning, solution cleavage, crenulation cleavage, pencils, joints, and deformed fossils. Such a correlation suggests that within the central Appalachians, the Alleghanian orogeny consists of two major phases: a deformation possibly as old as Pennsylvanian, herein called the Lackawanna phase, and a second deformation, termed the Main phase, which is Permian or younger in age.

The Lackawanna phase affects mainly the eastern parts of the foreland, such as the Hudson River Valley and Pocono Plateau, while the Main phase affects most of the Valley and Ridge and Alleghany Plateau. The Lackawanna phase is interpreted as the product of strike-slip motion possibly between the Avalon microcontinent and North America. The Main phase may record the final convergence of Africa against North America and its accredited microcontinents.

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Natural Gas Reserves as a Function of Reservoir Quality in Medina Group, Chautauqua County, New York

The Lower Silurian Medina Group is a deltaic sequence composed of interbedded sandstones, siltstones, and shales, and is the primary target for natural gas in western New York. Chautauqua is the westernmost county in the state, and the most actively drilled for Medina gas. While the Medina Group underlies all of the county and is generally considered productive of natural gas, there is a wide disparity in the production results that cannot be attributed to structural control.

A sufficient number of wells have been drilled to allow comparison of production history and reservoir quality as determined from geophysical logs. Contouring of these data shows a preferential accumulation of natural gas along linear trends that correspond to zones of enhanced reservoir quality. These trends may have a primary origin related to deposition within a complex deltaic sequence or a secondary origin of diagenetic or tectonic nature. The apparent presence of definable productive trends in the Medina suggests their extension into undeveloped areas, where they would constitute a viable exploration objective.

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Use of Digital Potential Field, Geologic, and Remote Sensing Data in Studies of Structure of the Mid-Continent

A great deal of digital potential field, geologic, and remote sensing data exists for the Mid-Continent region of the United States. These data sets are fundamental to the understanding of the

structure of the crust. As the data are geographically oriented and in digital format, standard image-processing and analysis techniques can be applied. For instance, we have used a spatial filtering technique to interpolate between station locations of gravity and magnetic data to produce gray or color-coded images with continuous coverage throughout the Mid-Continent. The images contain more information than found in standard contour maps, because they can have many more contour intervals, and because they preserve local details of anomaly patterns.

As an example of applicability of these techniques, gravity images registered and overlayed with magnetic, geologic, and remote sensing data lead to the identification of a Precambrian rift structure that begins at a break in the Mid-Continent gravity high in southeast Nebraska, extends across Missouri in a northwest-southeast direction, and intersects the Mississippi Valley graben. The rift structure is about 435 mi (700 km) long and 75 to 100 mi (120 to 160 km) wide. It is expressed in gravity images as a low with a Bouguer amplitude of about -34 milligals below regional values. Some of the discrete positive magnetic anomalies in Missouri are located along the borders of the gravity low. The gravity feature cuts across a major age boundary within the Precambrian basement.

Finally, digitally enhanced thermal infrared images show a distinct alignment of linear structures with the gravity feature. The linears in some places correspond to mapped high-angle normal faults, to drape folds over relief within the Precambrian basement, and in some places, to extensions of mapped structures.

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Possible Hydrocarbon Resources Beneath Blue Ridge-Piedmont Thrust Sheet

An integration of surface geologic data and subsurface seismic reflection data across the southern and central parts of the Appalachian orogene has emphasized that the fundamental structure of the orogene is a low-angle mega-thrust fault system. Documentation of this basic model began in the southern Appalachians, where seismic reflection data indicated that crystalline rocks of the Blue Ridge and Piedmont had been thrust westward burying a 50 mi (80 km) segment of Paleozoic sedimentary rocks. Recently, in a continuing effort to further define and document the regional distribution of the buried Paleozoic section, our seismic reflection studies were shifted from the southern to the central Appalachians in Virginia. Approximately 174 mi (280 km) of seismic data was acquired in a continuous profile along Interstate I-64 from the Valley and Ridge near Staunton, Virginia, eastward across the Blue Ridge, the Piedmont, and most of the coastal plain to Hampton, Virginia.

Our latest data verify the basic mega-thrust framework model by demonstrating that crystalline rocks of the Blue Ridge and Piedmont have been thrust westward burying about 30 mi (50 km) of Paleozoic sedimentary rock. Regional thermal patterns within the Appalachian orogene were disrupted by thrusting, consequently the same patterns must have existed prior to thrusting. Because thermal levels have a direct bearing on organic maturity, palinspastic restoration of these thermal patterns can be used as a general tool to assess the regional hydrocarbon potential of the area.

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Boron, Gallium, Rubidium, and Vanadium as Geochemical Indicators of Marine and Freshwater Depositional Environments: Hamilton Group (Middle Devonian), Southeastern New York

Thirty-two shale-mudstone samples collected from the Hamilton Group and previously classified on the basis of paleoenvironmental studies using geologic criteria as being of marine, brackish, or freshwater origin were analyzed for the environmental-discriminant trace elements B, Cr, Ga, Li, Ni, Rb, and V by atomic absorption spectrophotometry. The most efficient trace element discriminator used to differentiate geochemical partition of Hamilton marine from freshwater argillaceous samples was based on B vs. V, but use of other trace-element partition variables produced nearly similar results.

Considering marine and freshwater samples together, 69% of those designated on the basis of geologic criteria as either freshwater or marine were correctly classified according to the three best geochemical partition methods (B vs. V, B vs. Ga, and B vs. Ga vs. Rb). For those designated by geologic criteria as marine, partition plots of B vs. V, and B vs. Ga correctly classified 90%, and B vs. Ga vs. Rb correctly classified 95% of the samples. Only 14% of those samples geologically defined as being of freshwater origin were correctly classified based on these geochemical partition methods. The overall paleosalinity signature for the Hamilton based on geochemical partition methods is marine. The source area mountains (Acadian) at that time thus were still probably of low relief. The Hamilton probably represents a degradational delta in part with many reentrant transgressive bays, and in part a sluggishly prograding mud-dominated shoreline.

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Clearville Siltstone of Middle Devonian Mahantango Formation in Parts of Pennsylvania, Maryland, West Virginia, and Virginia

The Clearville siltstone of the Middle Devonian Mahantango Formation is an eastward-thickening and coarsening detrital clastic wedge which crops out in the Valley and Ridge province of south-central Pennsylvania, western Maryland, eastern West Virginia, and northwestern Virginia. Its west limit defines the west limit of the Mahantango Formation and can be traced in the subsurface of Cambria and Somerset Counties in Pennsylvania and in outcrop in Hardy and Mineral Counties in West Virginia.

The Clearville siltstone in the western half of its surface occurrence consists predominantly of a sequence of interbedded siltstone and mudstone which is usually directly overlain by the Pokejoy Member of the Mahantango Formation, which exists as either a calcareous, fossiliferous siltstone or an argillaceous, fossiliferous limestone. To the east, the Clearville siltstone changes to a more complex sequence of several upward-coarsening cycles, the first of which is directly overlain by a "*Spirifer*" *tullius* zone that correlates with the Pokejoy Member to the west.

The upward-coarsening cycles are interpreted as delta cycles, grading from prodelta mudstones and claystones near the base to medium to very thick-bedded delta front sandstones near the top of the cycles. The Pokejoy Member probably originated as an indirect result of either delta lobe abandonment or a eustatic sea-level rise following the first major phase of sedimentation of the Clearville siltstone.

The sedimentation pattern of the Clearville siltstone is marked by two lobate regions of thickening: a more northern region long referred to as the Fulton lobe, and a more southern region referred to as the Frederick lobe. In both lobes, primary sedimentation appears to have been the result of westwardly flowing turbitity currents on a gently sloping shelf with later resedimentation and physical reworking from a combination of sublittoral processes such as tidal and storm surge currents. This physical reworking, as well as biogenic reworking, is particularly evident in the Fulton lobe, where two distinct sheet sandstone facies are recognized. This and other facies comparisons suggest lower rates of sedimentation in perhaps shallower water for the Fulton lobe than the Frederick lobe during Clearville deposition.

Although very low porosity values are characteristic of the Clear-