planktonic and larger foraminiferal zones are correlated, and datum planes are designated. These zones are correlated to Blow (1969) and van der Vlerk (1927) Letter Stage Classification for interregional correlation.

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Could Middle Ordovician Carbonate Shelf Depositional Patterns in Appalachian Orogene Indicate Collision Along an Irregular Continental Margin?

Analysis of Lower to Middle Ordovician carbonate successions and the conodonts they contain from Tennessee to New York show that (1) in the northern Great Valley, strike-parallel disconformable contacts occur between Lower and Middle Ordovician and within Middle Ordovician carbonate units, (2) apparent maximum extent of unconformities along tectonic promontories, and (3) relatively rapid subsidence and transgression at promontories. Diachronous early Paleozoic collisional events at an irregular continental margin might explain these observations. Initial Taconic collisions may have occurred at the Virginia promontory resulting in uplift and erosion of the Knox/Beekmantown shelf in Whiterockian time followed by rapid subsidence and transgression. Uplift and erosion, possibly related to continued convergence migrated southwest and at least as far northeast as Lexington, Virginia; beyond Lexington, shelf deposition continued relatively uninterrupted on the east side of the Great Valley. Collision at the New York Promontory could have produced the two pre-Blackriverian and pre-Rocklandian Middle Ordovician intervals of uplift and erosion on the Beekmantown shelf. These unconformities are greatest near Newburgh, New York, and decrease in magnitude northeastward and southwestward. West of Reading, Pennsylvania, in the Great Valley, carbonate shelf deposition remained virtually continuous. Thus between Reading and Lexington, in the Pennsylvania reentrant, continuous deposition during early Paleozoic collisions suggests that an irregular outline of the continental margin may have controlled patterns of sedimentation during collision tectonics.

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Sedimentation on a Passive Continental Margin (Late Cambrian-Early Ordovician), Central Appalachians

Environmental reconstruction of rocks of the Richmond slice, the tectonically highest slice at the eastern end of the Hamburg klippe in Pennsylvania, indicates that these rocks were deposited on a northwest-facing passive continental margin in Late Cambrian to Early Ordovician time. Detailed sedimentologic studies suggest that they can be divided into four main lithologic types, each bearing the imprint of one or more processes involved in its deposition. These include: (1) thin to thick-bedded, massive to graded, parallel and cross-laminated grainstone or calcarenite (high density turbidity currents; fluidized flows); (2) thin to medium-bedded, massive to structureless, graded and cross-laminated black lime mudstone and wackestone rhythmically interbedded with very thin to thin-bedded black limy mudstone and shale (low density turbidity currents and suspension); (3) thinly laminated graphitic black shale interlayered with irregular (lag) concentrations of fine sand and silt (redistribution of sediment by bottom currents); and (4) very thick-bedded, sand-matrix carbonate-clast conglomerate (gravelly high density turbidity currents and cohesive debris flows). The proposed depositional processes form a continuum of mechanisms that were in operation in the slope environment.

Regional stratigraphic studies suggest that the carbonate rocks of the Richmond slice were deposited on a depositional margin or ramp characterized by a gentle slope (1 to 2°) that decreased in gradient basinward. Only the lower slope portion of the continental margin has been preserved.

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Diagenesis and Secondary Porosity in Medina Reservoir Sandstones, Athens and Geneva Fields, Crawford County, Pennsylvania

Lower Silurian Medina Group reservoir rocks at Athens and Geneva fields in Crawford County, Pennsylvania, consist of very fine-, fine-, and medium-grained red and gray sandstones. The sandstones were deposited as bars and tidal deltas in a transitional marine setting. The sandstones produce gas from depths of 4,650 to 5,000 ft (1,395 to 1,500 m). The productive intervals are characterized by low average porosity and permeability (4.0% and <0.1 md) and low reserves.

Petrographic analyses show that primary porosity was extensively reduced during burial diagenesis by the precipitation of quartz and feldspar overgrowths. This stage of chemical compaction resulted in the reduction of intergranular porosity to irreducible lamellar porosity in the very fine to fine-grained intervals. These intervals also functioned as an extra stratal source of dissolved silica which precipitated as pore-filling cement in adjacent medium-grained intervals. Silica cementation was followed by the formation of authigenic clays, which diminished any remaining effective intergranular porosity.

Secondary porosity developed after deep burial. A variety of secondary sandstone pore textures are present in the Medina reservoirs at Athens and Geneva fields. Fracturing and grain shrinkage, coupled with remaining lamellar porosity, provided adequate passage for leaching brines formed during the generation of hydrocarbons in the adjacent shales. Additional secondary porosity formed through dissolution of sedimentary material and authigenic cement. Dissolution is evidenced by oversized and elongate pores, corroded grain margins, inhomogeneous packing, and microporosity within individual grains and cement. Some secondary porosity was subsequently reduced by the precipitation of carbonate and anhydrite cements concomitant with the entrapment of hydrocarbons. Secondary porosity was further reduced by grain alteration in the feldspathic intervals, as evidenced by a well-developed replacement fabric in these zones.

Adequate porosity for commercial production is found where the sandstones have the highest secondary porosities as determined by petrographic examination. Optimum reservoir development occurs where late-stage cementation by carbonate, anhydrite, and alteration product clays has not been extensive.

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Minnehaha Member of Upper Devonian Brallier and Scherr Formations of Central Appalachians

The Minnehaha member of the Upper Devonian Brallier and Scherr formations has been informally named, and its use as a time band within the marine strata of the Devonian Catskill delta complex of the central Appalachians is suggested. The coarse clastic bundle of the Minnehaha member can be identified in both outcrop and subsurface for approximately 150 mi (235 km) along the Allegheney Front from Bedford County, Pennsylvania, to Greenbrier County, West Virginia. The Minnehaha member is 20.9 to 98.4 ft (6.37 to 30.0 m) thick, consisting of interbedded very thinly to thickly bedded medium-gray siltstones and olive gray shales, with some grayish-red siltstones and shales.

The Minnehaha member was deposited by turbidity currents in generally unchanneled suprafan environments during the earliest Cohocton Stage. Three major, time persistent, depositional systems are recognized as having contributed to the Minnehaha member.

They are in order, from northeast to southwest, the Fulton, Mouth of Seneca, and Augusta depositional systems. The relatively brief time interval of Minnehaha deposition by three separate depositional systems strongly suggests a sea-level drop in the Appalachian basin as a causal factor. The overlapping of submarine fan deposits from three depositional systems could enhance the hydrocarbon reservoir potential of the Minnehaha member. The Minnehaha member may be the shoreward correlative of the gas productive Sycamore siltstone of north-central West Virginia.

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Exploration: Key to America's Energy and Mineral Policies

The current goals and objectives of the Department of the Interior have been formulated to support and assist the Reagan administration's overall program and to return balance to the management of the public lands.

The federal government's proper role is to insure that private enterprise has access to energy and mineral resources within the context of its responsibilities for protection of the environment. The Department of the Interior is formulating policies designed to: encourage exploration as a guarantee of adequate, accurate geologic data of the mineral resources of the nation; reduce excessive and unnecessary regulations, thereby encouraging increased responsibility and competition on the part of private enterprise; implement wise multiple use of the public lands; reduce this nation's reliance on foreign sources of strategic minerals.

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Predictive Geological Mapping of Mining Conditions in Appalachian Coal Fields

Recent case histories in the Appalachian region incorporating active mining operations with detailed geological hazards mapping prior to mining have confirmed the importance of certain geological techniques and applications. Applying these techniques to active operations in Pennsylvania, Maryland, West Virginia, southwest Virginia, and eastern Kentucky demonstrates that certain of these geological factors can be related to mining on a regional basis. Some of the applications involve the identification of weak, fractured rock zones underground through use of high-altitude satellite imagery. The simple procedure of intensity or the magnitude rating of the linear features appears to be the real key in identifying hazardous roof areas prior to mining. Composite and overlay mapping of significant, anticipated geological factors is the most important application to identifying safe, high-production mining areas as opposed to hazardous, low production mining. Again, it is necessary to apply rating factors to each potential problem and to design a presentation technique that can achieve simplicity and workability from a multitude of complex geological factors.

Although local or on-site physical and geological conditions largely dictate mining conditions, understanding and identification of regional geology and paleodepositional environments greatly enhance the more important ability to predict hazards prior to mining. Additional benefits derived from applying geologic hazards mapping are (1) identification of significant hydrologic factors which must be considered in meeting state and federal requirements for ground-water monitoring, and (2) establishment of confidence levels for coal reserve classifications.

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Lithofacies of Subsurface "Packer Shell" (Brassfield Limestone-Rochester Shale) Interval in Eastern Ohio

The interval between the subsurface "Clinton" (Medina) sandstone in Ohio and the base of the Niagaran dolomite was mapped using geophysical logs and samples over an area of 37 counties in eastern Ohio. The density of control approximated 1 well per 5 mi^2 (13 km^2) over the 23,640 mi^2 (61,228 km^2) studied. Between the "Clinton" sandstone and the Niagaran dolomite, the limestones and dolomites of the "Packer Shell," "Casing Shell," and other carbonate rock units are interbedded with shales called the Rochester in Ohio. On logs, the differentiation between the limestone or dolomite and shale was based on greater than 50% gamma-ray deflection and the density log readings.

Lithologically, the "Packer Shell" is a gray to dark gray, dense crystalline bioclastic limestone and/or dolomite. The Brassfield Limestone on the outcrop includes glauconitic oolitic grainstones, glauconitic molluscan crinoidal packstones with chert, and glauconitic bioturbated mudstones to wackestones. The "Casing Shell" and other carbonate units in the Rochester are gray to dark gray and contain bioclasts. At the base of the "Packer Shell" is a distinctive red, hematitic shale which is present over 65% of the area.

Regional cross sections show the three to four main carbonate units interbedded with shale in eastern Ohio. These carbonate rocks maintain their approximate individual thicknesses as the interbedded shales thin west and southwestward until the "Casing Shell" merges with the "Packer Shell" to form the unbroken stratigraphic unit recognizable on the outcrop as the Brassfield Limestone in southwestern Ohio.

The shale interbeds are thickest in east-central and southeast Ohio where they average 110 and 170 ft (33 and 52 m) thick, respectively, indicating the possible source direction for the shale influx from the east and southeast.

Correlations indicate a transgression of the Brassfield-"Packer Shell"-"Casing Shell" units so that the carbonate rocks appear to climb eastward in the section with respect to a datum at the base of the "Packer Shell." In Ohio, on the outcrop, the Brassfield Limestone is dated as Silurian, Albion, although part of its lithostratigraphic equivalents—the "Casing Shell" and other Rochester Shale carbonate beds—are Niagaran.

The "Packer Shell" is a useful unit on which to base a structural map, if care is taken at the critical locations of facies changes. The "Packer Shell" is porous locally and is reported to produce gas from some wells in Ohio. The production appears to be related to the occurrence of small structural noses, possibly associated with fracturing above the "Clinton" sandstone reservoir.

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Effect of Discontinuities on a Room-and-Pillar Coal Mine Plan

The highest safe extraction ratio is the goal of coal mine planning. This may be affected substantially by the interaction of regional in-situ stress with coal-measure discontinuities such as faults, interbedded weak and strong strata, rolls, and sandstone channels. The effect of discontinuities is to interrupt or concentrate the mechanics of stress transfer and cave development during coal extraction, often resulting in a costly change in mining plan. Heavy ground conditions were encountered when extracting pillars during retreat in a room-and-pillar panel at a mine in central Utah, resulting in the decision to bypass about 25% of the coal within the panel.

Conditions which led to abandonment of the central portion of the