subsurface sedimentary layers.

Seismic mapping indicates much greater variation of near-surface horizons than mapping with well data. Axial planes of Acadian folds appear to be vertical. Fold amplitude diminishes between the Tully formation and the Lockport Group in some areas, while in other areas amplitude remains constant through the Devonian and Silurian section. In Chautauqua County, an anomalously thick Onondaga to Lockport interval parallel to regional fold axes has been interpreted as an anticline with a salt core, suggesting decollement tectonics.

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An Exploration Model for Medina Group Sandstones of Western New York and Northern Pennsylvania

Hydrocarbon accumulations in the Medina Group of western New York and northern Pennsylvania are controlled by stratigraphic traps. The discontinuous productive sand lenses were previously considered to be unmappable due to the erratic fluviatile deposition and marine reworking of the deltaic sediments. Wells were subsequently drilled only on the basis of pipeline availability, government spacing regulations, and general geology. Many of the completed wells proved to be marginal or noncommercial. Using core analysis, log data, and well production histories on several thousand wells, an exploration model has been developed to improve Medina well success ratios and performance. Specific sedimentary structures can be identified using characteristic gamma-ray patterns and they can be mapped in the subsurface. Highly productive coarsening-upward channel and bar-sand sequences can be projected into undrilled acreage, thereby reducing the percentage of non-economic wells drilled into the Medina sands.

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Oil and Gas Exploration in Appalachian Overthrust Belt of Southwestern Virginia

Hydrocarbon exploration is on the upswing in the southwestern Virginia portion of the "Eastern Overthrust belt." Several potential reservoir horizons have been identified on surface exposures, but remain untested. Major faults, including the Saltville and Pulaski thrusts, have as much as 16,000 ft (4,877 m) of displacement, suggesting potential structural traps in the largely allochthonous belt. Excluding the Early Grove gas field and the oil fields of Lee County, only a small number of wells have tested the strongly folded and faulted 20,000-ft-thick (6,100 m) sequence of Paleozoic sediments in the Valley and Ridge province. Seismic and leasing activities indicate several significant tests in the near future.

The Early Grove gas field was developed on an anticlinal flexure within the Greendale syncline. The field produced gas from porous anhydrite beds in the Lower Mississippian Little Valley Formation until shut-in in 1957. Five new wells since March 1980 have encountered near-virgin pressures in the old Little Valley pay zone and have discovered significant gas in the sandstones of the Price Formation.

Detailed field mapping near Rose Hill, Lee County, identified several fensters through the folded Pine Mountain overthrust block, and most oil exploration efforts have been concentrated in those windows. Recently, fensters near Ben Hur have also proved successful targets. Production is from shallow fractured carbonates of the Ordovician Trenton formation. An 8,020-ft (2,444 m) test by Shell Oil discovered a deeper major thrust, proving the allochthonous structure of the area, and indicating potential deep targets. An ARCO test now being drilled will help to evaluate the deeper possibilities.

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Stratigraphy and Facies Relationships of Silurian (Wenlockian) Rochester Shale: Layer Cake Geology Reinterpreted

Along its east-west trending outcrop belt in western New York and Ontario, the Silurian Rochester Shale displays classic "layer cake" stratigraphy. Lower and upper members and their component beds are traceable for distances exceeding 62 mi (100 km) east-to-west, without substantial change in lithology, fossil content, or relative thickness. In contrast, abrupt facies changes occur within the Rochester along short, 3 to 6 mi (5 to 10 km) north-south oriented sections (e.g., Niagara Gorge). Fossil-rich calcareous mudstones and thin limestones tongue out southward and are replaced by sparsely fossiliferous shales. Similarly, the frequency of storm-generated coquinites and calcisiltites decreases to the south. These observations indicate that facies belts are elongate east-west, perpendicular to a gently south-dipping paleoslope, and subparallel to the modern outcrop belt.

Vertical facies changes in the Rochester Shale at local sections reflect lateral (north or south) shifting of environmental tracts, due to migration of the northern paleoshoreline. The entire formation appears to comprise two transgressive-regressive sequences; the lower (Lewiston) member represents a symmetrical deepening-shallowing cycle, while the upper units (Burleigh Hill-Stoney Creek members) record a shallowing-upward hemicycle. Facies tongues in the north-south sections confirm these interpretations.

Layer-cake stratigraphy in the Rochester Shale is thus an artifact of parallelism between the outcrop belt and depositional strike. As such, the Rochester provides a useful paradigm for understanding numerous similar stratigraphic units in the northern Appalachian basin.

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Glacio-Eustatic Sedimentary Cycles in Trenton Limestone (Middle Ordovician) of Southern Ontario

The fully-developed ideal cycle consists of the following, from base to top, always with calcareous clay seams throughout.

(a) Coarse, poorly sorted intrabiosparite or biosparite grainstones, in crosscutting (often cross-stratified) lenses, or channelized. In places, grain flow is shown by lobate, steep-sided edges, often smoothed by well-sorted biosparite grainstones.

(b) Fine to medium-grained well-sorted biosparite grainstones, parallel or cross-laminated, usually in several thin beds.

(c) Very fine-grained, well-sorted, commonly graded biosparite and biomicrosparite packstones and grainstones, with coarser shell fragments concentrated at their bases.

(d) Nodular bioturbated biomicrite mudstones and wackestones, alternating with bioturbated calcareous clays. This unit may also contain lenses of poorly sorted biosparite.

Units (a) to (c) show abundant evidence of rapid deposition of individual beds, followed by extensive periods of non-deposition, erosion, or both, when the bed surfaces were burrowed by omission-type trace fossil-forming organisms, cemented, and colonized by attached organisms. The abundant and diverse hardgrounds of the Ordovician sequence are concentrated at these horizons. In the more argillaceous sections, subdued cyclicity occurs.

The difficulty of explaining these cycles by normal facies changes has led to a glacio-eustatic explanation. Actualistic comparison can be made with the recent Arabian shelf of the Persian Gulf.

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Preliminary Investigations for Underground Coal Mines

Coal exploration and development drilling techniques for underground coal mines have significantly advanced during the past two decades. This has been the result of mining under more difficult conditions such as depth, geologic disturbances, vicinity of mined-out areas or gas and oil wells, methane emission, and higher ground pressures. Furthermore, capital requirements and operating costs for mining projects have been increasing. The mine operators find it advantageous to know more about the geological environment of the reserves to minimize the risks of development. Pre-mining investigations can provide useful information for mine planning and design (equipment selection, layout of mine workings, estimation of mine productivity, and analysis of ground control problems).

Some data obtained can be utilized to improve feasibility studies and financial analysis. The writers have been actively engaged in pre-mining investigations for coal reserves in the Illinois basin for about seven years. This paper describes geological, geotechnical, and hydrological investigations which can be conducted during the exploration drilling phase to obtain meaningful data for mine planning and design. The emphasis of the paper is on room-and-pillar coal mining.

COPLEY, DAVID L., ARTHUR E. OWEN, and BRADLEY R. GILL, Berea Oil & Gas Corp., Buffalo, NY

Akron Dolomite Oil and Gas Production, Chautauqua County, New York

The Upper Silurian Akron Dolomite in western New York has become the focus of exploratory drilling, with the recent discovery of significant volumes of both gas and oil. Depth through the productive zone is commonly less than 3,000 ft (900 m) ad unofficial reports indicate natural production over 10 mmcfgd and at least 500 barrels of high-gravity crude oil per day per well.

Productive wells have been erratic, but at least eight and as many as twelve discoveries have been drilled to date, all located within a narrow northeast-southwest trend spanning the county. Low-angle reserve faulting appears to be the trapping mechanism, with concomitant fracture enhancement of permeability. The haphazard distribution of productive wells within the trend suggests the need for both faulting and intense fracturing in order to create a viable reservoir. The fairway may extend northeastward into Cattaraugus and Erie Counties, New York. Detailed geological and geophysical work is necessary to pinpoint specific prospects. It is predicted that the play will have substantial impact on proven oil and gas reserves in New York State.

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Provenance Study of Upper Freeport (Pennsylvanian: Allegheny Group) and Mahoning (Pennsylvanian: Conemaugh Group) Sandstones in Eastern Ohio

Deposition of the complex sedimentary facies in the Allegheny basin exhibits a change in the dominant source of sediment influx from north to southeast through Pennsylvanian time. Lobate deltas entered eastern Ohio from both the rising Appalachian Mountains to the east and southeast and from the Canadian shield to the north. Confusion exists regarding the limits of the respective deltas. The present study is an attempt to define the limits of these sedimentary domains for a small portion of the basin in space and time. Samples of the upper Freeport (Upper Desmoinesian) and Mahoning (Lower Missourian) sandstones were collected along their western outcrop through eastern Ohio from Summit to Gallia Counties along a north-south transect. Thin sections were point-counted and analyses of the data made to determine whether the individual samples had their source in the high-grade metamorphic and igneous crystalline basement of the Canadian shield, or among the sedimentary and low-grade metamorphic rocks of the Appalachians. Determination of the source of the samples allows delineation of the boundary between respective delta lobes.

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Variability in Btu, Ash, and Sulfur Content of Northeastern Ohio Peat Deposits

Northeastern Ohio contains over 24,460 acres (9,898 ha.) of peatlands, some of which combine relatively low ash and sulfur with Btu values comparable to those of Ohio coal. This combination of properties makes these deposits a potential local fuel source.

Eighteen bogs developed in nine different substrate units were sampled to determine the range of within-bog and between-bog variability with respect to Btu, ash, and sulfur content. The substrate units are based on glacial and soil maps of the area. Two bogs were sampled from within each substrate unit. For each unit, one bog was sampled laterally at two localities at a depth of 6.5 ft (2 m), and a second bog was sampled vertically at one locality at depths of 6.5 and 20 ft (2 and 6 m). A total of 36 samples was collected and analyzed for Btu, ash, and sulfur.

The data show a strong negative correlation between ash and Btu. Ash content can explain 99.2% of the Btu values in the peat samples and can be used to predict Btu values to within $\pm$200 Btus. There are statistically significant differences in Btu, ash, and sulfur content in samples from different substrate units. Bogs in the substrate units, which included the Kent-Lavery Drift end moraine and kame facies, are generally high in Btu and low in ash and sulfur. An attempt was made to identify the combination of variables present locally in the nine substrate units which best explained their Btu content. Stepwise multilinear regression analysis of these variables shows that mean annual precipitation and drainage area explain 72% of the variation in the peat Btu values.

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Geologic Prediction of Shale Roof Rashing

Summertime rashing of coal mine roof shales can be deleterious to mine operation by restricting ventilation, impeding access, and posing other safety hazards. A two-year field monitoring program, coupled with laboratory investigations of shale behavior under various humidities, was aimed at defining causes and methods of prediction of shale roof deterioration.

Both strong and weak shales may exhibit deterioration in mines. It appears, on the basis of both laboratory and field investigations, that some weak shales, such as the "soapstone" above the Pittsburgh seam, may undergo very large swelling strains under high humidities. Some of this is recovered during wintertime drying, but the result is general loosening and disaggregation of the rock mass, which falls in small or medium-size chunks. By contrast, a more competent shale that exhibits less swelling strain (such as the roof of the Harrisburg [No. 5] seam in the Illinois basin) may still develop high compressive stresses and fail, by buckling or shear, into medium or large slabs. Further monitoring, both in the lab and underground, is needed to enable confident predictions of roof deterioration for all shales.