mapped in the Salina and overlying groups, whereas the top of the underlying Lockport Group has been mapped as a relatively smooth homocline dipping south. An appropriate method was selected that is dependent on the simplicity of the structural configuration at depth rather than the complexity of near-surface reflectors. The interface between the Vernon Shale (basal Salina) and the underlying Lockport carbonates is an easily identified reflector on seismic sections. By using the map of the Lockport surface as a reference, reflectors immediately above and below can be mapped using the travel times between reflectors and velocity analyses to calculate isopach information between reflectors. Additional reflectors can be mapped by adding or subtracting isopach information in an upward or downward continuation manner.

This velocity correction involves digitizing the seismic reflectors and shotpoint map, making or obtaining subsurface regional maps of a reference horizon, and performing simple mathematical calculations on a microcomputer. Independent operators can use this inexpensive and straightforward method to rescue some analog seismic data that might otherwise be regarded as useless. Subtle zones of structural closure have been mapped where initial observations suggest the presence of chaotic deformation.

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Control of Lineament in Fluid Migration and Ore-Mineral Localization in Rifts and Rift-Faulted Basins

Many paleorifts and rift-faulted basins are characterized by high gravity, magnetic, and thermal anomalies, and high-density mantle cushions in the crust. Base metals are among the many important ore minerals and hydrocarbon accumulations occurring in the sedimentary formations and fracture zones of such rifts, and basins are commonly related to thermal processes and fluid migration through fractures, faults, and other micro or macro passages. Experimental and theoretical studies show that thermomechanical stresses owing to diapirism result in (1) development of fractures or faults and their patterns, (2) rejuvenation and opening of preexisting fractures, faults, or lineaments providing passages for migration of fluids or hydrothermal solutions, and (3) orientation of fracture pattern of preexisting anisotropy in rocks. Experiments show that changing property from brittle to brittle-ductile to ductile influences the volume percentage of dilation of the preexisting fractures and exerts control on the orientation, patterns, and opening of fractures in the overlying rocks. Rock mechanics experiments also show that extensive en echelon fractures or faults that develop under high fluid pressure by brittle to brittle-ductile extensional fracturing provide additional passage for the migration of fluid during active thermal uplift or rift formation, but they close during subsidence or basin formation. However, marginal fractures or thrust faults formed during doming and uplift open during subsidence and rift-basin formation, and facilitate fluid migration and late hydrothermal ore-mineral localization.

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Micro-Platform Carbonate Development and Facies in Mauch Chunk Formation (Chesterian) of Southwestern Pennsylvania

Through much of southwestern Pennsylvania, adjacent Maryland, and West Virginia, Upper Mississippian (Chesterian) strata are represented by intertonguing of red clastics of the Mauch Chunk Formation and carbonates of the Loyalhanna and Wymps Gap Limestones.

The lower clastic wedge of the Mauch Chunk represents an episodic shoreline progradational event that buried the underlying Loyalhanna carbonates. The sea level rise concurrent with the Wymps Gap transgression resulted in nearly continuous deposition of clastics in nearshore areas while carbonates were being deposited on more offshore areas. This resulted in the development of a lobe of clastics (forming a small platform) that created significant topography to be transgressed by the deepening Wymps Gap sea. Facies development of the Wymps Gap carbonates was markedly influenced by this inherited topography. In areas where clastics are thin, the Wymps Gap is represented by a medium-bedded, dark-gray, petroliferous, clay-rich carbonate mudstone to wackestone. These sediments are representative of open shelf deposition, in moderate water depths below storm wave base. Along the margin of the thick clastic lobe, the Wymps Gap is represented by a light-gray, locally cross-bedded carbonate grainstone to packstone. These accumulations appear to represent a slope-break platform-edge shoal environment. Over the top of the thick lobe of clastics, highly argillaceous, nodular-bedded, variegated, bioturbated carbonate mudstone to packstone formed. These facies represent platform deposition landward of the shoal environment in an open-circulation shallow lagoon.

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Undiscovered Recoverable Natural Gas in Pennsylvania—Estimates and Projections

The total of probable, possible, and speculative resources of undiscovered recoverable natural gas from conventional reservoirs in Pennsylvania is estimated to be approximately 8.5 tcf. The total undiscovered and potentially recoverable gas resource in unconventional reservoirs may be about 11.1 tcf.

Conventional natural gas resources were estimated in five general stratigraphic "packages," using differing approaches made necessary by the variable character and density of the data available, conditioned by time considerations. These packages and their total of probable, possible, and speculative resources are: Mississippian and Upper Devonian sands, 3.6 tcf; Onondaga/Oriskany and related reservoirs, 1.5 tcf; Lower Silurian Medina Sandstones, 1.8 tcf; Silurian Tuscarora and Cambrian-Ordovician formations, 0.7 tcf; Eastern Overthrust belt, 0.9 tcf.

Unconventional resources are: natural gas in coal beds, 2.7 tcf; Devonian shale gas, 8.4 tcf.

General subdivisions of the estimated conventional resources are 31% probable, 40% possible, and 29% speculative. In contrast, subdivisions of estimated unconventional resources are 11, 24, and 65%, respectively.

Short-term projections demonstrate that production of natural gas in Pennsylvania can be doubled without stress and maintained at that level for several years. Much beyond 10 yr, however, projections become speculations. One can say only that significant quantities of natural gas will be produced in Pennsylvania for many more decades. Whether gas production 50 yr hence will be in greater, equal, or lesser quantities than current production is beyond meaningful prediction.

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Hydrocarbon Production in Appalachian Basin: a Glance at the Forest

The Appalachian basin covers approximately 175,000 mi^2 (450,000 km^2) and contains about 0.5 million mi^3 (2 million km^3) of sediments. In the century and a quarter since Drake's first well, more than 500,000 wells have been drilled, producing 3.2 billion bbl of oil and 41 tcf of gas, mostly from shallow depths. Basin oil and gas production largely peaked by World War I. The stratigraphic nomenclature of the basin has arisen from that largely developed by early cable-tool drillers.

Hydrocarbon production has been established in all of the Appalachian's Paleozoic systems. Devonian rocks have been the most productive, and the Mississippian and Devonian combined account for more than three-fourths of all Appalachian oil and gas production. Stratigraphic traps are by far the dominant feature of Appalachian oil and gas fields.

Although the Appalachian basin is a generally mature oil and gas province from a developmental standpoint, this is only true above a depth of much less than 10,000 ft (3,000 m). New shallow discoveries will doubtless continue to be made. In addition, using the improved exploration technologies now available to the petroleum industry, it is reasonable to expect deeper discoveries, particularly in association with the deeper unconformities known to exist in the basin.

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Ohio Paleozoic Source-Reservoir Combinations: Source Rock Quality and Source-Oil Correlation Studies