Since at least 1920, production of natural gas in the Appalachian states has fluctuated between 400 and 500 Bcf per year. Among the factors limiting expansion in drilling, recompletion of old wells, and introduction of new technology, such as that applicable to Devonian shale, has been the adverse wellhead prices paid to producers by purchases under regulations applied by the federal government under the Natural Gas Act of 1938.

After long debate and apparent deadlock, Congress passed the Natural Gas Policy Act of 1978. The provisions of the act include incentive pricing for stripper wells and for deep drilling, and the deregulation of all sales of gas from Devonian shale beginning November 9, 1979. Other aspects of the legislation, when fully implemented, should allow greater freedom to producers to bargain fairly with purchases of natural gas in most circumstances.

An analysis of the Act indicates its potential impact in spurring research efforts to commercialize natural gas production from Devonian shale and other unconventional sources, as well as accelerating exploration and development from conventional reservoir targets in the Appalachian region.

From projections comparing future prices and costs of Appalachian gas with costs of supplies from the Southwest, the Arctic, and foreign LNG, together with synthetic fuels, it is concluded that the "new economics" of Appalachian natural gas can revitalize the industry within the next decade, and can provide a regional solution to the predicted national energy supply deficit in the 1980s.

KALYONCU, R. S., J. P. BOYER, and M. J. SNYDER

Devonian Shales—In-Depth Analysis of Well EGSP NY 1 with Respect to Shale Characterization, Hydrocarbon Gas Content, and Wire-Log Data

The objective of the Battelle portion of the Eastern Gas Shale Program has been to determine the relations among shale characteristics, hydrocarbon gas content, and wire-log information to establish a sound basis for defining the productive capacity of the reserve and to provide guidance for continuing research, development, and demonstration projects designed to enhance the recovery of gas from these deposits. Because the strategy for stimulation technology development and application is strongly tied to the way the gas is held and transported within the parent formation, a thorough understanding of the resource is required.

Historically, efforts to determine these interrelations have been hampered by the fact that many of the test wells are small and do not provide sufficiently large data bases for meaningful statistical interpretations. However, during the coring of the EGSP NY 1 well, more than 400 core samples were taken and over 12 wire-log runs were made. This data base has provided an outstanding foundation from which to develop correlations and draw significant conclusions using variance analysis techniques developed at Battelle.

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Geologic Age Versus Major, Minor, and Trace-Element Compositions of West Virginia Coals

The abundances of 36 elements in the ashes of 29 column samples representing 15 different West Virginia coals indicate several systematic relations between the geologic age of these coals and the abundance of certain elements within their ashes. Li, Si, Al, Be, Bi, Co, Cu, La, Ni, Ph, Sn, and Va show a definite increase in abundance with increasing geologic age; Bo and Fe show a definite decrease in abundance with increasing geologic age.

In addition to the systematic relations, some local variations are evident, such as high concentrations of boron in ashes of Monongahela coals and high concentrations of tungsten in coal ashes from the Allegeheny through Monongahela Groups. This information opens speculation as to the geologic factors responsible for these relations and may be significant in coal utilization.

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Compositional Variations in Fabric-Element-Based Lithotype Classification for Devonian Shales

The use of fabric elements to classify specific shale lithotypes tentatively permits rapid qualitative evaluation of productive potential and interpretation of general depositional environments without recourse to detailed chemical and mineralogic characterization.

To evaluate the usefulness of subjective lithotype classification, 169 samples from the Lincoln 1637 cored well, classified into the four shale lithotypes of E. B. Nuhfer and R. J. Vinopal, were examined through parametric and nonparametric statistical tests performed on petrophysical and compositional data derived from the same samples. The lithotypes consisted of: (1) sharply-banded shale, (2) thinly laminated shale, (3) lenticularly laminated shale, and (4) nonbanded shale. Analytic parameters considered were: bulk density, matrix density, porosity, log density, sonic travel time, resistivity, gamma-ray log response, silt (by thin-section point counts), quartz, illite, pyrite, and 14 angstrom clays quantified relatively by X-ray diffraction, total sulfur by rapid LECO method, organic matter by loss-on-ignition between 100 and 550°C, and an additional loss-on-ignition between 550 and 1,000°C. The data were first tested for normality by means of Kolmogorov-Smirnov and Shapiro-Wilkes tests and then for significant differences between lithotypes by means of both the analysis of variance and the nonparametric analog, the Kruskal-Wallis test.

The test results show that significant differences do exist between the specific lithotypes, and therefore, that classification by fabric elements does reflect real differences in rock properties. Fabric-element classification must precede more destructive physical and analytic tests so that this valuable information is not lost and so that later test results can be related back to specific rock types.

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Modeling of Devonian Shale Gas-Reservoir Performance

A recent trend in developing new natural gas reserves has been the intensified efforts to exploit Devonian shale gas reservoirs in the Appalachian basin. Thus, the Department of Energy is now engaged in the support of the Eastern Gas Shale Project, which is aimed at accelerating the development of this resource.

To make an engineering and economic evaluation of Devonian shale gas-reservoir development, it is necessary to be able to predict future reservoir performance. A review of the Devonian shale modeling experience to date reveals that such a demonstration of predictive capability has not been achieved.

Most Devonian shale reservoirs are expected to consist of very tight porous shale formations which may be rather highly fractured in certain tectonic terranes. Under these conditions, the fractures may provide most of the permeability to gas flow, but contribute very little to the overall storage capacity. By comparison, the matrix of the shale may provide most of the storage capacity, but contribute very little to flow because of the low permeability. The gas-release and sorption-isotherm data from Devonian shale samples indicate that gas is present in the matrix of the shale both as a free-gas phase and as a sorbed-gas phase.

Gas transport in Devonian shale reservoirs, according to the assumption adopted here, occurs only in the permeable fractured medium, into which matrix blocks of contracting physical properties deliver their gas contents, that is, the matrix acts as a uniformly distributed gas source in a fractured medium. Furthermore, desorption from pore walls is treated in the modeling as a uniformly distributed source within the matrix blocks.

A mathematical model to simulate well and field-wide performance of Devonian shale gas reservoirs has practical applications for gas reservoir studies such as well-test and history-matching problems.

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Submarine Slumping in Reef-Flank Deposits (Middle Silurian) of Indiana

Flank beds adjacent to the Rich Valley bioherm, Wabash County, Indiana, display unusual structures suggesting catastrophic slumping during and shortly after deposition. Lithotopes representative of reef core, reef flank, and interreef environments are mixed randomly within the deformed sedimentary rocks. Deformation appears to have involved processes of both brittle and semiplastic materials.

Displaced boulders, 1 to 2 m in diameter, are imbedded in laminated calcilutite. Uniformly inclined stratification typical of reef flanks is here locally reversed in dip, faulted, and contorted into minor folds within the sequence. A dike of fine-grained limestone, about 0.5 m thick, perpendicularly transects an inclined sequence of flank beds. Masses of mature quartz sandstone also are present, apparently as isolated blocks, displaced from some formerly higher location.

Observed features tentatively are attributed to multiple failures resulting from unstable oversteepening of normal flank sediments, storm ripping of semilithified core materials, and plastic flowage of poorly lithified flank-margin materials. Individual events could have been triggered by storms, earth shocks, or other catastrophic events.

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Bishop–Bradshaw Creek Fault

The Bishop–Bradshaw Creek fault extends 22 mi (35.2 km) across McDowell County, West Virginia. Initially identified on side-looking airborne radar (SLAR) in 1974, the fault trace has since been confirmed as a distinct linear feature trending N60°W on Landsat, black and white and color infrared photography, and topographic maps. Located astride the northwestern end of the fault trace is a semi-circular "donut," 5 mi (8 km) in diameter and truncated by a N25°E-trending linear fault. Displacement along the Bishop-Bradshaw Creek fault has been reported as .75 mi (1.2 km) right-lateral strike slip.

Considerable geologic information exists that contradicts the reported strike-slip displacement along this linear feature. Structural contours of the top of the Berea and the base of the Big Lime show a 150 ft/mi (28 m/km) westward dip, but neither map indicates any displacement. Further, a Berea isopach map does not show any indication of movement. After fracturing parallel and across the fault trace, a Berea gas field extending across the fault at Berwind shows elongations of contours of both natural open flow and flow without apparent displacement. Structural contour maps of the top of the Pocahontas 3, Sewell, and Douglas coal seams also show no measurable displacement. The same conclusion can be reached from examinations of geologic maps, the state aeromagnetic map, and elevations of salt water.

However, the use of the word "fault" has been retained. Coal mining at the southeastern end is presently taking place on both sides of the fault. At this location, the Pocahontas 3 seam is displaced 40 ft (12 m) vertically with the southern side downthrown. That is the only known place where fault displacement can be observed. The fault can be observed at Canebrake as a razor-sharp vertical fracture with slickensides oriented horizontally; however, displacement cannot be detected.

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Meteoritic Impact—Reservoir-Forming Process

Known impact sites caused by meteoritic bodies falling to earth's surface, together with frequency distributions for observed rates of material infall and those inferred from lunar, martian, and mercurian data for the Phanerozoic, indicate that meteoritic-impact features have been sufficiently common and large to justify their recognition by petroleum geologists. The rock-shattering and dome-forming process of impact cratering can and does result in unconventional petroleum reservoirs.