depths, over an area of about 50 sq mi (130 sq km).

Coals "of the New River type" were reported in 1915 as far north as the town of Danville and as far west as the hamlet of Mud, Boone County, West Virginia. Examination of drillers' logs of wells drilled in the study area since that time shows that New River coals were reported in a significant number of the logs examined.

New River Formation coals in the study area are thought to correlate with the Sewell and Beckley coals, farther south and east in West Virginia. Log signatures indicate that the Sewell is a single bench coal about 3 ft (1 m) thick. The coal is overlain by a shale unit about 5 ft (1.5 m) thick which is in turn overlain by a sandstone unit interbedded with thin shales; the unit ranges in thickness from 40 to 100 ft (12 to 30 m). The Sewell is underlain by a shale unit about 50 ft (15 m) thick.

The Beckley coal is about 70 ft (21 m) below the Sewell and is also overlain by a thin shale unit which is in turn overlain by a 25-ft (7.5 m) thick sandstone unit. The sandstone is also interbedded with thin shales. The Beckley coal lies directly on the Pocahontas Formation in the southern part of the study area; the coal is about 70 ft (21 m) above the top of the Pocahontas in the northern part of the area.

These New River Formation coals lie at depths as shallow as 300 ft (90 m) along the Warfield anticline, near Madison, West Virginia. The combination of shallow depth and indicated minable thickness may make the coals amenable to future shaft mining. Their location along the anticlinal axis makes them prospective targets for shallow, low-yield gas wells.

HENNINGTON, W. M., Mitchell Energy Corp., Houston, Tex.

Unconventional Evaluation of Cottageville Field, Devonian Shale

Recent compilation and publication of data by the U.S. Department of Energy and West Virginia University on the Devonian shale production in the Cottageville field of West Virginia have made this a good shale-study area.

A preliminary study utilizing a new unconventional exploration technique has been made based on the available data. The technique is an attempt to reconstruct depositional structural conditions which are thought to control development of the natural-compaction-fracture reservoir.

The depositional highs should have the coarser, less compactible material deposited whereas the depositional lows should have received the finer, more compactible materials. Minimum compaction on the depositional highs and maximum compaction in the depositional lows should result in maximum compaction fractures on the flanks of the depositional highs.

Production from the shale occurs on present-day structural noses with about 250 ft (75 m) of regional dip across the field. There does not appear to be any direct relation between good producers and present-day shale structure.

Most of the producers, approximately 75%, fall within a 50-ft (15 m) depositional structure interval and 100% of the producers with initial flows of over 500 MCFGD fall within the 50-ft interval. Only 11% of the Cottageville field wells had initial flows of over 500 MCFGD. This indicates the possibility of being more selective in selecting locations and substantially increasing the chances of making a good well. The high natural open flows and largest accumulated production seem to be associated with the flanks of the depositional structure.

The preliminary study indicates the utilization of the unconventional technique can substantially improve Devonian shale natural-fracture-reservoir prediction, improve definition of productive limits, and demonstrate the possibility of selectively drilling tests with current economic potential.

HOHN, MICHAEL E., and DONALD W. NEAL, West Virginia Geol. and Econ. Survey, Morgantown, W.Va.

Elemental Analyses of Devonian Shales in Southern West Virginia

Elemental compositions were determined on 690 samples of well cuttings from 19 wells in the Devonian shales of southern West Virginia; each well was sampled at roughly 50-ft (15 m) intervals. Sampling included all major stratigraphic intervals with special emphasis on five stratigraphic units: Chagrin Shale, Huron Member of the Ohio Shale, White Slate (correlates with Java Formation and Angola Shale Member of the West Falls Formation), Rhinestreet Shale Member of the West Falls Formation, and the Marcellus Shale. After calculating mean percentages within each unit, hand contouring maps, making trend-surface analyses, and diagramming vertical variations, individual elements showed regional and stratigraphic trends. Silica increases upsection, whereas potassium and MgO decrease. The Marcellus Shale exhibits very high values for calcium and phosphate. Sulfur, strontium, and zinc appear to reflect the quantities of organic matter, which are higher in the black shale of the Huron Member and the Rhinestreet Member relative to the gray shales of the White Slate and the Chagrin Shale. The amounts of titanium, iron, and phosphate are low in black shales.

Regionally, sulfur is higher in the westernmost parts of the study area and appears to be related to the presence of a platform where conditions were conducive to its concentration. Silica is low in the central part of the area. Manganese is highest in the gray shales and areas of black shales interpreted to have been deposited in deeper water; manganese correlates inversely with sulfur, suggesting the influence of redox conditions on manganese deposition.

The results confirm the recent work on stratigraphic correlation of the Devonian shales in West Virginia. They also conform to the picture of the Devonian sea in this area as a platform with a deeper area and sediment source in the east, and possibly a second source in the west.

JAWOREK, W. GIBSON, Consultant, Washington, D.C.

New Economics of Natural Gas Production in Appalachian States

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.

KING, HOBART M., and JOHN J. RENTON, West Virginia Univ. and West Virginia Geol. and Econ. Survey, Morgantown, W.Va.

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.

KLANDERMAN, DAVID S., and MICHAEL E. HOHN, West Virginia Geol. Survey, Morgantown, W.Va.

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.

KUCUK, FIKRI, and WALTER ROSE, Science Ap-