western West Virginia

Regional stratigraphic studies of the Middle and Upper Devonian clastic sequence of West Virginia have been based on gamma-ray-density logs, cores, and sample studies. In northwestern West Virginia, the Upper and Middle Devonian unit is characterized by interbedded gray and black shales, with the darker shales recognized on gamma-ray logs as zones of increased radioactivity. The overall thickness of the section decreases toward the west whereas the proportion of black shale increases toward the west. The proportional increase in black shale occurs in two ways; there is an increased number of black shale beds in the west, and the thickness of the interbedded gray shales decreases.

The study area extends across the western boundary of the Rome trough, with the presence of this tectonic feature manifested in two ways in the sediments accumulated over the trough. First, there is a pronounced thickening of the sediments into the trough, and second, the Rhinestreet Shale Member of the West Falls Formation and the Huron Member of the Ohio Shale undergo a facies change from black shale west of the trough to gray shale in the trough area. Further, cross sections and isopach maps provide additional evidence that the Rome trough controlled basin configuration in the region and thus influenced sedimentation during the deposition of the Upper and Middle Devonian clastic sequence in northwestern West Virginia.

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Past and Current Developments for Drilling New Albany Shale Gas in Western Kentucky

Gas from the New Albany Shale was produced in western Kentucky prior to 1890. Old fields have been abandoned with little record of production history. Current exploration for gas in the New Albany Shale began in 1976. Three fields have been discovered, and development has been progressing steadily spurred by the increase in gas price. Drilling and completion techniques have varied. Sale of natural gas has been limited to availability of local markets, and proximity to existing natural gas pipelines. Leasing of exploration acreage is continuing and plans for future drilling to develop the New Albany Shale as a reservoir and source for natural gas appear to be excellent in western Kentucky.

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Novel Formation-Evaluation Concepts for Shale Reservoirs and Black Shale Formations

Highly radioactive, black and organic-rich shales are present in the United States, in several geologic provinces, and elsewhere. Such organic-rich shales are not only potential source rocks but commonly owe their localized but significant production potential to natural fracture systems in an otherwise impermeable rock. These natural fracture systems are concentrated in the interbedded brittle, calcareous, cherty or silty zones.

Natural gamma-ray spectral information, such as that from the Spectralog, easily locates calcareous or silty zones, as both are characterized by low values of potassium and thorium, but excessively high values of uranium. These interpretive concepts have already assisted in many successful gas and oil well completion and recompletion attempts in the more permeable and/or fractured intervals of such shale formations.

The Spectralog allows a continuous monitoring of the source rock potential (SRP) of shales in open and cased boreholes. Hence, SRP variations can be studied both versus depth and on a lateral basis using appropriate mapping techniques. Gamma-ray spectral data also assist in detailed stratigraphic correlations, for; in addition to total gamma-ray counts, the Spectralog measures the individual gamma rays emitted by potassium (K^{40}), the uranium series nuclide bismuth (Bi^{214}), and the thorium series nuclide thallium (Tl^{208}).

Interpretive experiences with SRP, including SEM pore-system studies, in the Miocene Monterey Formation in California, the Cretaceous Niobrara and Pierre Shales of Colorado, the Lower Mississippian and Upper Devonian Woodford Shale of Oklahoma and West Texas, and the Eagle Ford Shale in the Cretaceous carbonate trend in south Texas indicate application potentials similar to those in the Devonian gas shales of the Appalachian basin.

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Characterization of Production Mechanism in Devonian Shale and Its Sensitivity to Change in Various Reservoir Parameters

The U.S. Department of Energy is supporting cooperative research for enhanced gas recovery in a major effort to help reverse our country's decline in natural gas reserves. A potential major source of natural gas is the Devonian shale of the Appalachian region, estimated to contain hundreds of trillion cubic feet of natural gas. As part of the DOE's Eastern Gas Shales Project, we undertook the task of making a comprehensive analysis of the production of natural gas from the Devonian shales. Two reservoir-stimulation models were validated and used in characterizing the production mechanism of the Devonian shale.

There are two widely held theories on the occurrence of natural gas in the Devonian shales. One theory, the single-porosity theory, is that the gas is present as free gas in a macrofracture system and is produced as Darcy law type flow through these fractures. The second, the dual porosity theory, assumes a macrofracture porosity of smaller magnitude and that, in addition to free gas in the fracture system, there exists a volume of gas present as an adsorbed phase within the shale matrix which diffuses into the fracture system and is produced as pressure drops. The likelihood of one system being present as opposed to the other was studied. Sensitivity analyses were conducted on various reservoir parameters. The validity of conventional transient-pressure-analysis techniques in the Devonian shale was also investigated.

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Petrographic Evaluation of West Virginia Coals for Coal Utilization Schemes

Proper evaluation of coals for utilization, whether it is to be combustion, carbonization, gasification, or liquefaction depends on a knowledge of the petrographic (maceral) composition of the coals in question. This petrographic study of West Virginia coals was designed to provide a basic knowledge of the composition of the state's coals, with specific reference to utilization. Compositional trends and their causal influences were evaluated.

Thirty major seams were quantitatively analyzed, and the data were displayed in histograms for interpretation of the resulting frequency distributions. The frequency distributions of the macerals were generally non-normal with minor macerals showing highly negatively skewed histograms, and major maceral distributions displaying bimodal characteristics.

Both areal and vertical stratigraphic trends were evident in the abundance of some macerals. Q-mode factor analysis related these trends in composition to metamorphism (rank), plant evolution, and sedimentary environments of peat deposition. The knowledge acquired on coal composition, its expected variation, and factors influencing composition can be applied to the evaluation of West Virginia coals for many utilization technologies.

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Theoretical and Experimental Analyses of Hydraulic Fracturing and Sonic Logging in Gas Shales

A joint theoretical/experimental research program on hydraulic fracturing, is being conducted. Newly developed numerical models have been applied to analyze some aspects of fracture propagation near well-bonded material interfaces to determine whether these interfaces can inhibit propagation. Results from these calculations indicate that, for fractures propagating from a lower modulus material toward an interface with a higher modulus material, the stress-intensity factor at the tip near the interface decreases significantly as the tip approaches the interface. However, upon penetration of the interfaces into the higher modulus material, the stress-intensity factor increases abruptly and arrives at a higher value than in the lower modulus material. Conversely, when the fracture is propagating from a higher modulus material toward a lower modulus material, the situation is reversed. The presence of fractures near the interface significantly reduces the effects of these phenomena. Dynamically, where wave-mechanics effects are taken into consideration, the change in material properties also affects fracture propagation across an interface.

Small-scale laboratory experiments are being performed to study the growth of hydraulically driven cracks in the vicinity of unbonded interfaces in rocks. Blocks of the materials being studied are held adjacent to one another under a static load, and a hydraulically driven crack is initiated in one of the blocks. For blocks of the same material, penetration of the crack into the adjacent block is controlled by the normal stress across the interface and the finish of the interface surfaces. Experiments have been performed to measure the frictional properties of the interfaces to understand better the mechanism of crack growth across the interface.

The LLL dry-hole sonic logging tool was applied in Columbia 20569 gas well, Mingo County, West Virginia. Although some problems were encountered in the application of the tool, data were collected and analyzed to locate reflection loci near the well bore at distances up to several meters.

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Eastern Projection of Valley and Ridge Beneath Metamorphic Sequences of Appalachian Orogene

Surface and subsurface data from parts of the Appalachian Plateau, Valley and Ridge, Blue Ridge, Piedmont, and the continental shelf indicate that the Appalachian orogene is a broader feature than heretofore suggested. The orogene appears to form a continuous northeast-trending structural belt from Georgia to Canada, whose east-west dimension includes the area from the continental shelf to the limit of thrusting in the Appalachian Plateau. Seismic reflection data suggest that the entire southern part of the orogene is underlain by an eastward-dipping subhorizontal master decollement zone. Thus, the structural style of the orogene is dominated by subhorizontal thrusts that are characteristic of thin-skinned tectonics. Within the orogene, from Canada to Georgia, displacement on subhorizontal thrusts has moved eugeosynclinal sequences (metamorphic and igneous rocks) tens of kilometers westward, burying thick sequences (4,500 to 10,500 m) of Paleozoic miogeosynclinal rocks. Limited seismic data in North Carolina and Georgia suggest that miogeosynclinal sequences project eastward in the subsurface beneath thrust plates of eugeosynclinal rocks for at least 65 km. If the eastward projection of miogeosynclinal rocks in the subsurface of North Carolina and Georgia is representative of the entire Appalachian orogene, there may be a concealed belt of Paleozoic miogeosynclinal rocks on the order of the present length and width of the Valley and Ridge. Future exploration programs for hydrocarbons within the Appalachian orogene should give careful consideration to this vast untested and unknown area.

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New River Formation Coals in Southern Boone and Northern Logan Counties, West Virginia—Possible New Coal and/or Methane Resource

Porosity logs run in uncased sections of oil and gas wells in Boone and Logan Counties, West Virginia, indicate that several potentially minable coal beds are present in the lower coal measures. Geophysical-log correlations indicate that the New River Formation may contain continuous, minable coals, at developable