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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 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.

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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.

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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.

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New Economics of Natural Gas Production in Appalachian States