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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.