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Devonian Gas Shales and Related Tight Reservoir Rocks of Appalachian Basin

Devonian gas shales, a sequence of brown to black, low-permeability laminated rocks that contain 2 to 16% by volume of organic matter, underlie more than 170,000 mi^2 (440,000 km^2) of the Appalachian basin, mainly under the Appalachian plateaus. Their volume exceeds 12,600 mi^3 (52,500 km^3), and they contain more than 3.3 trillion tons of gas-producing organic matter. Their permeability ranges from 0.1 to 10 microdarcys and their porosity from 1 to 4%. Although their total gas production has been only about 3 tcf during the past 160 yr (since 1821), mainly from the Big Sandy area of eastern Kentucky, their gas-in-place resource has been estimated in the range from 200 to 1,860 tcf. Shale gas is of low thermal maturity near the western outcrops, whereas dry gas deep in the basin to the east is of high thermal maturity. Because most of the shale-generated gas has been adsorbed by the organic components in the rock, gas shales must be broken by an extensive natural fracture system before they will yield gas in commercially exploitable volume. In the western part of the basin, gas shales are both source and reservoir for gas. To the east, dark gas shales interfinger with an eastward thickening sequence of low-permeability siltstone and sandstone turbidites. Where fractured, these more brittle beds are also reservoirs for gas migrating from adjacent gas shales. Successful exploitation of shale gas requires careful evaluation of geologic and engineering factors.

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Regional Source Rock Mapping Using Source Potential Rating Index

A method has been developed to combine sediment thickness, organic carbon content, and thermal maturity data from potential source rock units into a single mappable parameter which can be used to indicate areas of potential hydrocarbon generation. This is accomplished by taking the product of the average percent organic carbon and the effective source rock thickness of a formation to give a richness factor. The richness factor is then multiplied by maturity scaling factors to give source potential ratings for oil and/or gas generation. The rating values can be combined with kerogen-type data, if available, to refine these assessments of generating potential. The resulting ratings provide semiquantitative measures by which the source potential of a single formation can be compared within an area or the source potential of 2 or more formations can be compared in the same basin or different basins. By using burial history curves and thermal maturity modeling, the rating index can also be used to estimate source potential through geologic time.

Source potential rating index maps in conjunction with structural analysis of a basin can help the explorer explain the occurrence of already discovered hydrocarbon accumulations and point toward new areas for exploration. Examples are given of applications of rating index mapping to exploration problems in the Williston and Illinois basins.

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Thrust Faults that Violate Classic Thrust Belt Rules: Marathon Basin, Texas

One generally accepted rule of thrust belt geometry is that folding does not occur before thrust faulting; thrust faults do not cut across folds in cross-section view. Original mapping in the Marathon basin documents that the Hell's Half Acre thrust sheet was emplaced after an episode of large-scale folding.

The Hell's Half Acre thrust fault is a shallow, low-angle fault which separates the northeasterly trending, broad (4-km or 2.5-mi wavelength), open folds on the north from the imbricately thrust faulted and overturned, tightly folded (1-km or 0.6-mi wavelength) Paleozoic rocks of the thrust sheet. The thrust fault trends east and truncates the structures on the north. Within the thrust sheet, folds plunge into and are truncated by thrust faults. The Tesnus Formation (Mississippian) is the principal formation of the sheet, but large blocks of younger Dimple Limestone (Morrowan) and Haymond Formation (Atokan) are lodged within fault planes bounded by Tesnus, thereby documenting folding before thrust faulting.

This nonclassic geometry is due to lithology. Classic thrust belt style was developed for a miogeoclinal sequence. The Ouachita stratigraphy is a eugeoclinal sequence composed of lower and middle Paleozoic, thin limestones and cherts with numerous shale interbeds and an upper Paleozoic flysch sequence with a low sand/shale ratio and numerous thick shale horizons. The many thick, incompetent horizons allowed the thrust fault to cut across preexisting structures.

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Expected Paleozoic Stratigraphy Beneath Western Part of Metamorphic Overthrust in Southern Appalachians

A stratigraphic cross section from Roanoke, Virginia, to Alabama shows the formations and facies of the easternmost Valley and Ridge outcrops. This cross section, coupled with 3-dimensional insights on facies changes, siliciclastic sources, and regional unconformity patterns, delimits stratigraphic expectations directly beneath the metamorphic overthrust of the Blue Ridge–Great Smoky–Piedmont terrain as far east as the Brevard zone. These strata are in the Saltville structural block south of central Tennessee and in the Pulaski block to the north.

The stratigraphic column in the block directly beneath the metamorphic overthrust is up to 5,100 m (17,000 ft) thick and contains Upper Precambrian (Chilhowee Group) to middle Mississippian beds. The Chilhowee in the block beneath the metamorphic overthrust is probably less shaly and thinner than equivalent Chilhowee exposed along the leading edge of the metamorphic overthrust block. The Shady Formation becomes less dolomitic eastward, passing into dark, shaly limestone east of the carbonate bank edge. Rome-Conasauga siliciclastics change to carbonates eastward and northeastward. The Knox Group changes to limestone beneath the overthrust, and the post-Sauk unconformity probably disappears. Middle Ordovician siliciclastics coarsen eastward toward the Blount delta. The Wallbridge discontinuity expands eastward, so that Silurian and Lower Devonian strata probably do not occur beneath the metamorphic overthrust. The pre-Upper Devonian unconformity truncates more section eastward, so that Chattanooga Shale locally rests on Middle Ordovician Bays Formation in southeastern Tennessee. In Tennessee, Georgia, and possibly North Carolina, Mississippian strata include sandstone, dark shale, limestone, and bedded chert passing beneath the Great Smoky–Cartersville fault.

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Jurassic-Cretaceous Nonmarine Foreland Basin Sedimentation in Western United States

Synorogenic foreland basin deposition during deformation in the Wyoming Overthrust belt occurred along the active western margin, along the axis of the subsiding trough, and along the eastern cratonic margin. Debris derived from rising thrusts comprise a nonmarine sequence which is underlain and overlain by preorogenic and synorogenic marine formations. In northwestern Wyoming, basal shallow marine units include, in ascending order, the Twin Creek, Preuss, and Stump formations, which pass eastward into the generally coeval Sundance Formation of central Wyoming. Synorogenic nonmarine units of the Gannett Group in northwestern Wyoming pass cratonward into the generally coeval Morrison and Cloverly Formations. Synorogenic marine units consist of basal transgressive clastics overlain by black marine shales. These comprise the marginal marine "Rusty Beds" overlain by the Thermopolis Shale. These grade westward into the lower part of the Wayan group which overlies the Gannett.

Whereas exposures in the Overthrust belt proper have produced extensive documentation of sedimentation patterns along the active basin margin, excellent exposures along the Gros Ventre River in Teton County, Wyoming, allow examination of nonmarine depositional systems across the basin axis during initial subsidence. The preorogenic Stump formation consists of fine-grained glauconitic sandstone and limestone with abundant tabular and trough cross bedding. Flow directions are strik-