Cambrian Rogersville Shale in the Rome Trough, Kentucky and West Virginia: A Potential Unconventional Oil and Gas Reservoir in the Appalachian Basin

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Abstract

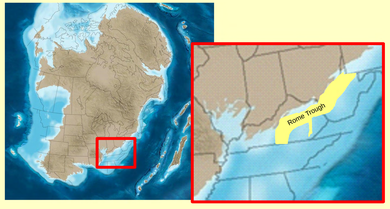
Research by the Kentucky, Ohio, and West Virginia Geological Surveys has refined the stratigraphic framework of a Cambrian extensional basin underlying the Appalachian Basin. This graben, called the Rome Trough, is filled with up to 9,000 ft of pre-Knox Group sedimentary rocks. Well log correlations extended the Cambrian Conasauga Group north from outcrops along the Eastern Tennessee Overthrust, across parts of eastern Kentucky, and into the Rome Trough. Regional distribution of these formations and the underlying Rome Formation is controlled by extensional faults that were active during and after Conasauga deposition. Stratigraphic correlation of these units reveals the presence of a westward-prograding carbonate ramp and distal intrashelf shale basin in the Rome Trough.

To identify the source of hydrocarbons produced from various Cambrian completions in eastern Kentucky and southern West Virginia, numerous Cambrian shale samples were analyzed from across the Rome Trough. Total organic carbon content of these shales was less than 1 percent for all samples, exception for a core of Rogersville Shale from the Exxon #1 Smith well in Wayne County, W.Va. TOC for the Rogersville Shale in this core ranges from 1.2 to 4.4 percent, with Tmax values of 460 to 469ºC. Six additional Rock-Eval analyses from the Smith core confirmed the original data, with TOC of 1.2 to 4.75 percent, and Tmax of 446 to 460ºC. Low hydrogen indices and Tmax data indicate a thermal maturity in the wet gas-condensate window. The Rogersville Shale is a dark gray fissile shale, interbedded with thin laminated and bioturbated siltstone. Hydrocarbon extracts from the No. 1 Smith core are geochemically very similar to produced condensate from Elliott and Boyd County, Ky., and suggest the Rogersville was the source of gas and condensate in the Homer Field.

The Rogersville Shale has suitable thickness, mineralogy, and organic content to potentially produce gas or liquids if fractured to improve permeability. Challenges in developing a Rogersville Shale play include interpreting structure and stratigraphy in the deeper fault-segmented parts of the Rome Trough and predicting the distribution of organic-rich intervals. The Rogersville Shale ranges in thickness from under 100 to over 1,100 ft, and in depth from approximately 5,000 to 18,000 ft below surface. Interest in the unconventional resource potential of the Rogersville is increasing. Seven deep tests have been permitted in the last year.

Introduction

Research by the Rome Trough Consortium (RTC) at the Kentucky, Ohio, and West Virginia Geological Surveys from 1999-2002 refined the stratigraphic framework of a Cambrian-age extensional basin underlying the Appalachian Basin. This fault-bounded graben, called the Rome Trough, is filled with up to 10,000 ft of Cambrian sedimentary rocks. The Rome Trough formed during opening of the lapetan ocean, on the southeastern margin of the North American craton. Faults were active during deposition, with significant thickening of Middle and Upper Cambrian sediments downthrown of bounding faults.

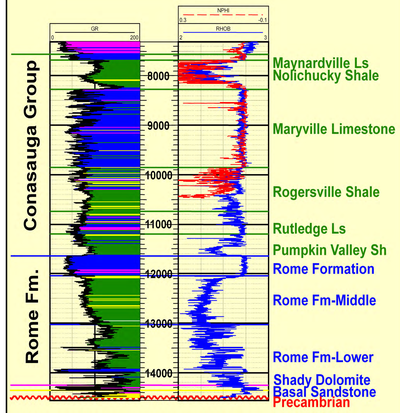


Middle Cambrian paleogeography with Rome Trough superimposed (modified from Blakey, cpgeosystems.com)

Stratigraphic Framework

Stratigraphic correlation of these units reveals the presence of a westward prograding carbonate ramp and distal intrashelf shale basin in the Rome Trough in eastern Kentucky. The Conasauga formations record several cycles of progradation and transgression from east to west into this basin.

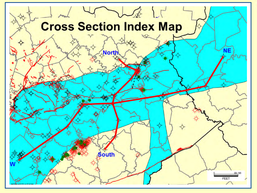
Type Log, US Signal #1 Elkhorn well Johnson County, Kentucky

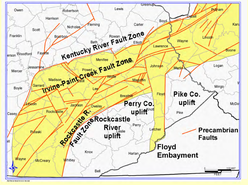


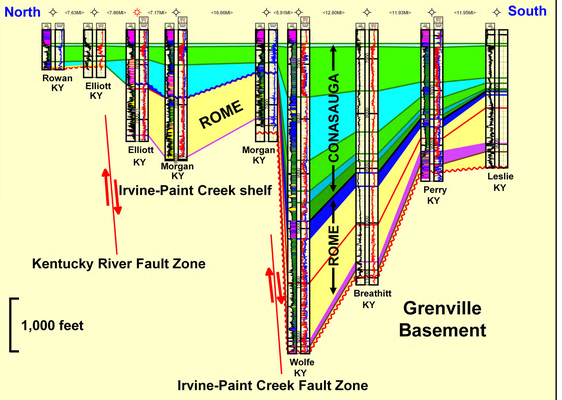
Well log correlations indicate formations comprising the Cambrian Conasauga Group extend across parts of eastern Kentucky, and include in ascending order the Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone.

Most fault movement had ceased, and the trough was filled by the end of Conasauga time. The trough is overlain by the Cambrian-Ordovician Knox Group, a thick regional carbonate platform sequence. Regional distribution of these formations and the underlying Rome Formation is controlled by extensional faults that were active during Conasauga deposition.

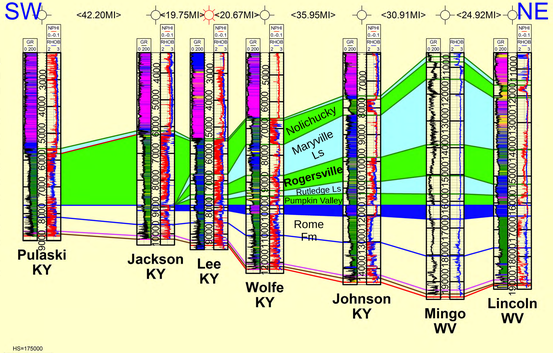
Rome Trough structural features



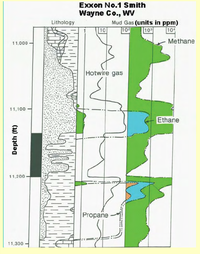




The full sequence of Conasauga formations is restricted to areas south of the Irvine-Paint Creek Fault. North of this fault the Pumpkin Valley Shale, Rutledge Limestone and Rogersville Shale are missing, and the Maryville Limestone overlies the Rome Formation. The Rome Formation is restricted to areas south of the Kentucky River Fault, but the Maryville and Nolichucky extend father north. Maryville and Rutledge carbonate units thin and pinchout to the west into an intrashelf basin in central Kentucky. The Rogersville Shale cannot be recognized in this area.

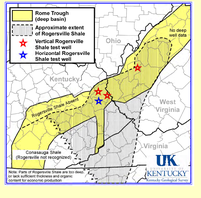


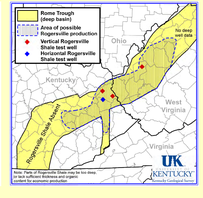
Unconventional Reservoir Potential



The Rogersville Shale has sufficient organic carbon, is thermally mature, and has generated gas and condensate. The mud log from the Exxon Smith well indicates shows of gas were encountered during drilling of the Rogersville interval. This suggests the shale contains hydrocarbons, in nanoscale pores and adsorbed to organic matter. (Cored interval indicate by black bar)

X-ray diffraction analyses of Rogersville Shale samples show mineralogy that is lower in clay, and higher in brittle minerals, such as carbonate and quartz. This indicates the Rogersville will be more susceptible to fracture stimulation than the Nolichucky Shale, which is higher in ductile clays and lower in carbonate.





These maps show the approximate extent of the Rogersville Shale (left) and a speculative map of the potential productive area in the Rome Trough (right). The Rogersville extends into southwest Virginia and northeast Tennessee but is likely too thin, or lacks organic content outside the trough. Newly permitted well locations targeting the Rogersville Shale are also shown.