Kentucky Section-AIPG Professional Development Conference
Unconventional Hydrocarbon (Gas-Shale) Exploration and Production in Kentucky
Kentucky Geological Survey Well Sample and Core Library
2500 Research Park Drive
Lexington, KY 40511
Friday, April 17, 2015

<u>Session Schedule and Presentations</u>

8:45 a.m. - 9:00 a.m. **Registration and Check-in**

9:00 a.m. - 9:10 a.m. **Welcome and Acknowledgements**
Donnie Lumm, Kentucky Section-AIPG, Lexington, KY

9:10 a.m. – 9:45 a.m. **The Role of Kentucky in the Natural Gas Future**
Harry D. Callicotte, H & H Energy Group, Lexington, KY

9:45 a.m. – 10:20 a.m. **Current Kentucky Division of Oil and Gas Permit Regulations and Implementation of Senate Bill 186**
Kim Collings, Kentucky Division of Oil and Gas, Frankfort, KY

10:20 a.m. – 10:40 a.m. ***Break***

10:40 a.m. – 11:15 a.m. **Cambrian Rogersville Shale (Conasauga Group) in the Rome Trough, Kentucky and West Virginia: A Potential New Unconventional Reservoir**
Dave Harris, Kentucky Geological Survey, Lexington, KY

11:15 a.m. – 11:45 a.m. **Core-Sample Analysis of Devonian-Mississippian, Black, Gas-Shales and Related Rocks from Kentucky**
Frank Ettensohn, University of Kentucky, Lexington, KY

11:45 a.m. – 12:45 p.m. ***BBQ Buffet Lunch and Review of Core Samples***

12:45 p.m. – 1:20 p.m. **Keys to Prospecting in Low-Permeability Reservoirs**
Will Gilliam, Terra Nova Exploration, Morehead, KY

1:20 p.m. – 1:55 p.m. **Evidence for Oil Generation in Early-Mature Shale, the Devonian New Albany Shale, Breckenridge County, Kentucky**
Brandon Nuttall, Kentucky Geological Survey, Lexington, KY

1:55 p.m. – 2:15 p.m. ***Break***

2:15 p.m. – 2:50 p.m. **Geosteering: A Brief Discussion on its Development, Application, Benefits, and Future Potential**
Boyd Gray, Rubicon Geological Consulting, Morehead, KY

2:50 p.m. – 3:00 p.m. **Summary Remarks**
Donnie Lumm, Kentucky Section-AIPG, Lexington, KY

The Role of Kentucky in the Natural Gas Future

Callicotte, Harry D., Managing Member, H&H Energy Group, LLC, 1228 Sherborne Pl., Lexington, KY 40509, hcallicotte@engrservices.com

The enormous growth in natural gas production in both the Marcellus Shale of Pennsylvania and West Virginia, and the Utica Shale of Ohio, coupled with the current challenges to the Appalachian coal market, has left Kentuckians wondering whether any opportunities exist for growth in Kentucky gas production. This presentation will discuss the opportunities for natural gas production in Kentucky and the geological and logistical hurdles of increasing production, as well as the political challenges. In addition, the speaker will address a current legislative initiative in which both the industry and state government are involved.

Current Kentucky Division of Oil and Gas Permit Regulations and Implementation of Senate Bill 186

Collings, Kim, Director, Kentucky Division of Oil and Gas, P.O. Box 2244, Frankfort, KY 40602, kim.collings@ky.gov

The Kentucky Division of Oil and Gas is the state regulatory agency that oversees the permitting, drilling, completion and production of oil and gas wells in the Commonwealth. The main duties of the division are fostering conservation of all mineral resources, encouraging exploration of such resources, protecting the correlative rights of land and mineral owners, prohibiting waste and unnecessary surface loss and damage, and encouraging the maximum recovery of oil and gas from all deposits. The division is staffed with geologists, administrative personnel and field inspectors to perform these duties.

In May 2014, Energy and Environment Secretary Dr. Leonard Peters established an oil and gas workgroup comprised of representatives from the cabinet, oil and gas industry and public and environmental organizations. The purpose of the workgroup was to review the current regulations and statutes, suggest appropriate revisions and possible legislative action. During the 2015 General Assembly, Senate Bill 186 was the product of this workgroup and included fluid disclosure requirements, public notice requirements, increased reclamation plans, updated deep well permit processes and a plan to address abandoned storage tanks. The bill received unanimous support and was signed into law at the end of the session.

Cambrian Rogersville Shale (Conasauga Group) in the Rome Trough, Kentucky and West Virginia: A Potential New Unconventional Reservoir

Harris, David C., Hickman, John B., and Eble, Cortland F., Kentucky Geological Survey, University of Kentucky, 228 Mining and Mineral Resources Bldg., Lexington, KY 40506, dcharris@uky.edu

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 graben, known as the Rome Trough, is filled with up to 10,000 ft of pre-Knox Group sedimentary rocks. 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. 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 in eastern Kentucky.

Commercial hydrocarbon production from the Rome Trough includes the Homer Field in Elliott County, KY., and short-lived gas and condensate production from the Exxon No. 1 McCoy well in Jackson County, WV, and the Inland Gas 529 White well in Boyd County, KY. Two wells in Johnson County, KY have produced gas and condensate since the mid-1980's from fractured Nolichucky Shale near the Irvine-Paint Creek Fault. In order to identify the source of these hydrocarbons, the RTC analyzed numerous Cambrian shales from across the Rome Trough. Total organic carbon content (TOC) of these shales was less than 1 percent for all samples, with the exception of a core of the Rogersville Shale from the Exxon No. 1 Smith well in Wayne County, WV TOC for the Rogersville Shale in this core ranges from 1.2 to 4.4 percent. Hydrocarbon extracts from the Rogersville Shale are geochemically very similar to produced condensate from Elliott and Boyd County, KY.

The Rogersville Shale has suitable thickness (200 to > 1,200 ft), mineralogy, organic content, and thermal maturity to potentially produce gas or liquids if fractured to improve permeability. Interest in the unconventional resource potential of the Rogersville is increasing; to date, three vertical and one horizontal exploratory well have been permitted. The Bruin Exploration No. 1 Young well in Lawrence County, KY was permitted to 15,000 ft in the Rome Formation and drilled in late 2013. Results of this well are being held confidential, but it appears to have tested hydrocarbons from a deep zone, and is currently shut-in. A second well, the Cabot Oil and Gas No. 50 Amherst Industries, was permitted to 14,000 ft targeting the Rogersville Shale in Putnam County, WV.

Challenges in developing the 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. Due to the drilling depth of the Rogersville, economic viability of the play will depend on the production rates established and hydrocarbon type (gas vs. oil).

Core-Sample Analysis of Devonian-Mississippian, Black, Gas-Shales and Related Rocks from Kentucky

Ettensohn, Frank R., Professor, Department of Earth and Environmental Sciences, University of Kentucky, 101 Slone Bldg., Lexington, KY 40506, fettensohn@uky.edu

In core samples, one black shale sample looks very much like any other. As such, despite some very real differences in characteristics such as composition and radioactivity that cannot be visually discerned, black shales are difficult to log wholly on visual characteristics. However, in place of black shale lithologic characteristics, other characteristics such as lithologic associations where they occur, stratigraphic or biostratigraphic marker horizons, and radioactivity can be successfully used to log black shale cores. The Devonian-Mississippian black shales in Kentucky occur in a well-established stratigraphic sequence of units, some of which are defined by the co-occurrence of different lithologies including green or gray shales or dolostones with the black shales. Similarly, some units can be defined by the presence of a distinct biostratigraphic zone or lithostratigraphic marker. Although fossils are very rare in the shales, a horizon of the probable planktic alga, *Protosalvinia*, is common in Kentucky shales and immediately identifies the stratigraphic horizon in the otherwise uniform shale cores. Lithostratigraphic markers such as phosphate nodules, lag zones or cone-in-cone limestones can also be very useful in identifying stratigraphic positions in cores. Many of these features are not widely known or easily identified in cores, and so to facilitate identification and use of these features in logging, a black-shale core-logging manual with an alpha-numeric code has been recently developed, not only to help identify these features, but also to more easily record and possibly computerize core descriptions. The author will demonstrate the use of the logging manual as a guide for facilitating black shale core-log description. Finally, even though all the black shales look very similar visually, the Kentucky shales can be correlated into distinct units based on their radioactivity or gamma-ray signatures, which effectively measures organic-matter content and the radioactive elements that are associated with the organic matter. Hence, the most effective black-shale core-log descriptions also involve generating an artificial gamma-ray log for the core, sometimes called a radioactivity profile. To generate such a profile, a hand-held scintillometer is used. The resulting profile is not only used with lithologic and biostratigraphic indicators to identify specific black shale units, but also to correlate with those in the subsurface via gamma-ray logs.

Clearly, the uniform appearance of black shale cores renders visual description difficult, but the use of core-logging manuals and a hand-held scintillometer helps to make maximum use, respectively, of the few sedimentary features that are present and of the radioactivity that is always present, but impossible to see.

Keys to Prospecting in Low-Permeability Reservoirs

Gilliam, William G., President, Terra Nova Exploration, P.O. Box 1205, Morehead, KY, 40351
wgilliam@terranovaexp.com

Recent advances in horizontal drilling technology have allowed operators to achieve economic petroleum production from low-permeability, unconventional reservoirs. The unconventional reservoir classification applies to a wide-range of low-permeability hydrocarbon-bearing formations that include gas, condensate, or oil saturated tight-sandstones/siltstones and shales. The low-permeability reservoir geometry differs from conventional oil and gas accumulations because they lack a definitive oil-water contact and are largely self-sourced (or near sourced) hydrocarbon accumulations that cover a large geographic area. The generation of petroleum in a shale reservoir is controlled by the type and amount of organic material in the system, and the protracted burial and heating of the preserved organics; this increase in thermal maturity will hopefully result in a regionally distributed immature, oil, condensate, and dry gas hydrocarbon generation window. Anoxic waters present in deep marine environments provide the ideal conditions for organic matter preservation due to the reducing conditions of the depositional environment; this has been demonstrated to have a direct correlation to the overall effective porosity and hydrocarbon content of the shale reservoir. Thermal maturity promotes the development of hydrocarbons from the preserved organic material where the destruction of the organic material creates porosity in the shale.

Exploration methods in low-permeability reservoirs break from the conventional exploration paradigm by relying heavily on geochemistry and detailed microscopy to characterize the target reservoir interval and its distribution across the basin. A typical workflow involves determining the key characterization parameters needed to delimit prospective areas in low-permeability rocks, they include: thermal maturity level (Tmax, Ro, Cai), total organic carbon content (TOC), hydrogen index (HI), oxygen index (OI), absorbed gas/canister gas analysis, porosity, permeability, fluid saturation, mineralogy, mechanical properties, and organic material. Sample-based analysis techniques include: TOC, Rock-Eval, pyrolysis, X-ray diffraction, detailed core analysis, electron microscopy, and petrography, these results are coupled with gamma ray, neutron porosity, density porosity, photoelectrical effect, resistivity, and sonic log well log signatures to develop a type log to be used to correlate target formations across the basin.

Determining the mechanical properties of the target interval(s) are important to the horizontal development and completion of a low-permeability reservoir, zones with high Young’s Modulus and low Poisson’s ratio typically correlate to zones with increased brittleness, higher TOC, and higher porosity. Accurate well bore placement through geosteering will ensure the operator is in the target interval and completing the desired interval to achieve the optimized stimulation and hydrocarbon recovery from the shale reservoir.

Evidence for Oil Generation in Early-Mature Shale, the Devonian New Albany Shale, Breckenridge County, Kentucky

Nuttall, Brandon C., Parris, Thomas M., and Beck, Glynn, Kentucky Geological Survey, University of Kentucky, 228 Mining and Mineral Resources Bldg., Lexington, KY 40506, bnuttall@uky.edu

Breckinridge County is located on the eastern margin of the Illinois Basin in western Kentucky. In 2011, Endeavor Energy Resources LP completed four natural gas producers in the Grassy Creek Member of the Devonian New Albany Shale (NAS) Group. These wells were hydraulically fractured with less than 400 barrels of fluid. In 2012, new reports indicated the wells were producing oil. In 2013, Hard Rock Drilling Co. completed another oil producer to the northwest of the Endeavor wells. Through 2013, these wells produced more than 17,000 barrels of oil and 90 MMcf of gas.

The NAS is recognized as the primary source of oil and gas produced across the Illinois Basin, but these wells represent the first documented occurrence of significant amounts of liquid hydrocarbons from the shale. To develop a better understanding of this production, oil, gas, and cuttings samples were collected from several of these wells and from the KGS No. 1 Blan well, Hancock County, Kentucky. Geochemical analyses included Rock-Eval Pyrolysis, isotopic analysis, and biomarkers. The data indicate the light 42° API oil has an unexpected gasoline fraction. The hydrocarbons were thermally generated in place from oil-prone, marine, Type I and II organic matter. The observed wet gas production and gasoline fraction are inconsistent with classic measures of thermal maturity. This suggests an alternative idea is needed to better understand oil generation in lower temperature and pressure source rocks which could influence exploration and completion methods and expand development into additional areas of known continuous resource plays.

Geosteering: A Brief Discussion on its Development, Application, Benefits, and Future Potential

Gray, Boyd A., CEO, Rubicon Geological Consulting, 1690 Sharkey Rd., Morehead, KY 40351, boydgray@rubicongeological.com

With the inception of horizontal drilling, operators have searched for a cost effective method of ensuring well bore placement in the target zone for the maximum possible distance. Starting with cuttings analyses and physical attributes of the formation, the natural progression was to develop new methods and procedures toward that end. With the advent of modern logging techniques and more reliable measurement while drilling (MWD) and logging while drilling (LWD) tools, it was inevitable that software would be developed to improve upon the time in target, and to fine tune the ability of directional drilling to do so. With the proper training and tools, geosteering can be implemented successfully in nearly every horizontal play currently being drilled.

Developed for shale gas plays such as the Marcellus, geosteering software has proven its ability to assist drilling to maintain the well bore in a specific target zone, and has made the transition to other conventional and nonconventional plays alike. With the depressed energy market of today, operators are searching for methods and technologies that will decrease drilling time and cost while increasing the production and profitability of each well, and geosteering is providing one of the most cost effective ways to boost output from horizontal wells by increasing time in target and reducing drilling times.

Future improvements in technologies and software will solidify geosteering as an indispensable tool for horizontal drilling for the foreseeable future. Geosteering improvements in the future will include enhanced predictive technologies, improved field implementation, simultaneous data curve interpretations, increased data outputs and database inclusiveness.