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Highlights of Energy Research at the Kentucky Geological Survey

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The Energy and Minerals Section at the Kentucky Geological Survey (KGS) is engaged in research and service that is traditional in many ways, but that is taking advantage of new technologies and concepts to meet the challenges of the increasing importance of environmental issues and regulations. Energy research and service is divided into two major program areas: coal resources and oil and natural gas resources. In addition, the group maintains databases related to these resources.

COAL RESOURCES

The coal resources program has two main goals: to assess the occurrence and thickness of the remaining coal resource and to assess the quality of the various coals that make up that resource. KGS has been involved in various types of coal-resource assessment. Much of this work has been with the cooperation and funding of the U.S. Geological Survey. The results of recent coal availability studies of selected test areas on detailed base maps have shown that land-use restrictions have a negligible regional impact on mining in Kentucky. Technological and economic restrictions, such as thin coal and the depth of the coal, are more significant; in some test areas, they restrict up to 50 percent of the resource. Resource depletion is also a significant factor for a number of the important coal beds. To that end, the major mineable coal seams of the state are being digitally mapped and assessed as part of the National Coal Resource Assessment, a program funded by the U.S. Geological Survey.

An understanding of coal quality is important not only in determining its uses, but increasingly in assessing its compliance with existing and pending environmental regulations. Title III Federal Clean Air Act Amendments of 1990 limit the emission of 189 substances that are considered hazardous air pollutants (HAPs). Fifteen of these occur in coal naturally as trace elements. Research is being carried out to determine how geologic factors affect coal quality relative to these specific trace elements. Such geologic models help identify areas and coals with lower amounts of specific HAPs. In addition, regulations requiring further reduction of NO_x emissions have resulted in selective catalytic reduction (SCR) units and retrofits being installed in Ohio Valley power plants. Coals with elevated levels of arsenic and selenium can negatively affect these units; therefore understanding the geologic controls on these elements can be critical. The restrictions on sulfur dioxide mandated by Title IV of the Clean Air Act Amendments of 1990 have led some utilities to selectively purchase and burn coals substantially below the regulatory limits in order to exceed the act's requirements, and thereby accumulate credits for sulfur dioxide emissions in the future. This practice could affect the long-term availability of low-sulfur, high-value coal for other uses, such as feedstock for metallurgical coke. Some of KGS's coal-quality work is being funded by the U.S. Geological Survey.

Knowledge of the availability and quality of coal will continue to be

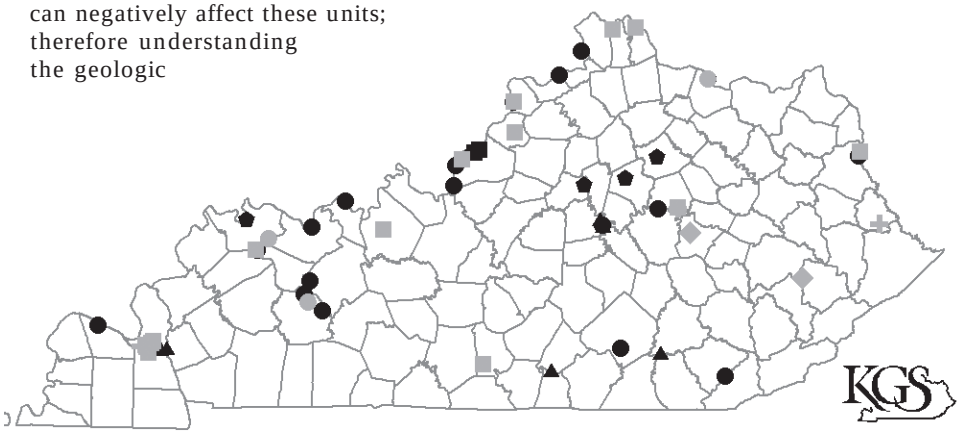

Figure 1. Existing (black) and proposed (gray) power plants in Kentucky. Key to fuel type symbols: circles = coal, squares = natural gas, pentagons = fuel oil, triangles = hydro, diamonds = waste coal, and cross = gasified coal and municipal garbage. Currently there are 34 power plants operating in Kentucky that collectively produce approximately 18,000 megawatts of power. Twenty-six of these are baseload facilities, four are peaking plants and four are a combination of the two.

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vital to Kentucky, as the state requires more resources for current and future power generating plants (Figure 1). New coal utilization technologies have the potential to drastically change the Kentucky resource picture. Five of the new facilities that will use these new technologies are currently in the permitting stage. Four will burn waste or low-grade coal in combination with other fuel types and one will use a combination of coal and municipal garbage for gasification feedstock.

Traditional geologic studies of coal-bearing rocks are still important. Investigations of geologic obstacles in Kentucky's underground mines will give mining engineers a better understanding of specific types of obstacles and geologic hazards for future mining. The results of these studies are also extrapolated to other coal fields where data are not so readily available. The state's spectacular outcrops of coal-bearing rocks allow detailed studies of geologic relationships not easily seen in other coal fields. Some of the rock associations visible in the Eastern Kentucky Coal Field are also being used to predict the nature and occurrence of hydrocarbon reservoirs and traps in oil fields around the world, including the Hibernia Field in offshore Newfoundland.

Coalbed methane, currently being produced in Alabama, New Mexico, and several other states, may also play a future role as an important energy resource in Kentucky. Several studies are pending to better assess its potential in Kentucky (Figure 2). The collection of high quality methane desorption data will be critical if companies are to look to Kentucky as a potential coalbed methane producing region.

OIL AND NATURAL GAS RESOURCES

KGS provides basic studies that will aid in the exploration and production of oil and gas within the Commonwealth and provide means that will assist in mitigating the environmental impact of consuming hydrocarbons.

Although most of the oil and gas in Kentucky is being produced from relatively shallow reservoirs, some deeper oil and gas reservoirs may be important for future exploration efforts. Several of our studies have focused on this deep hydrocarbon potential.

One such study is funded by the Rome Trough Consortium, made up of oil and gas industry representatives and the U.S. Department of Energy. The study will provide basic stratigraphic and geochemical information to be used in the exploration of oil and gas reservoirs in the Rome Trough of eastern Kentucky and West Virginia. The data generated by the project will be made public in two years. This research has identified Cambrian shales in Kentucky and West Virginia as hydrocarbon source rocks, the first source rocks of this age and depth to be identified in the Appalachians. This suggests that the source of Cambrian gas and oil is from within the basin itself. In addition, a graduate student at the University of Kentucky, sponsored by the KGS is using seismic reflection data to explain the structural development of the trough. Current results suggest that this Cambrian rift basin was affected by later contraction, which formed anticlines that may be important hydrocarbon traps (Figure 3).

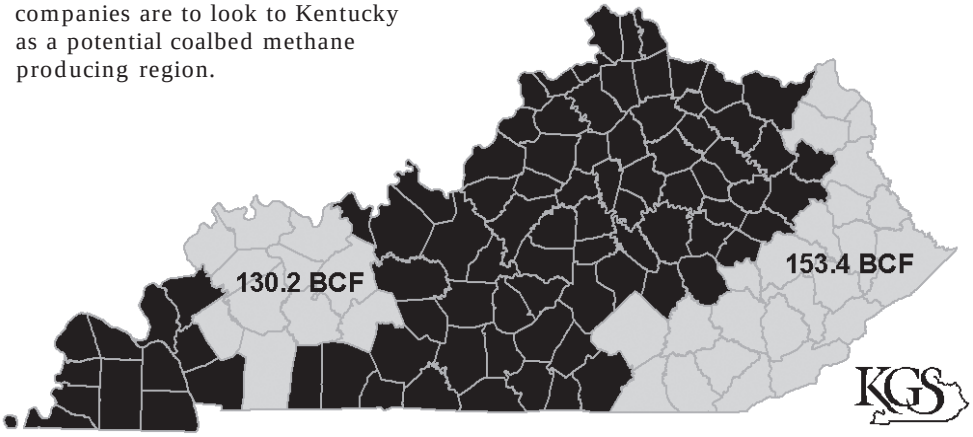

Figure 2. Estimated coalbed methane resources in Kentucky in billions of cubic feet (BCF) based on USGS 1995 National Assessment. Light areas represent the counties with potential coalbed methane.

Another study was recently initiated as the result of important gas discoveries in Ordovician Trenton-Black River Formations of New York and West Virginia. Trenton-Black River (Lexington Limestone-High Bridge Group) rocks exposed in the Bluegrass Region of central Kentucky are being investigated to give us a better understanding of the nature of hydrothermal dolomites that are similar to those in oil and gas fields in other parts of the Appalachians. In fact, some of the dolomites exposed in the Bluegrass contain mineralized vugs (small chambers or openings in the rock) filled with oil. The study of the stratigraphic, structural, geochemical, and seismic characteristics of these exposed rocks will aid exploration efforts, not only in Kentucky, but also throughout eastern North America. The New York State Energy Research and Development Authority, the U.S. Department of Energy, and industry are funding the study.

For the past 13 years, KGS has been studying the Proterozoic rocks of Kentucky. Drilling below the base of the Paleozoic section in Kentucky and adjacent Indiana and Ohio has revealed that sedimentary rocks are commonly present in the Proterozoic. Seismic reflection data available to KGS have shown that layered reflectors characterize the drilled sedimentary intervals as well as the section beneath them. This suggests that oil and gas accumulations are possible many kilometers below the base of the Paleozoic. Already, one well has encountered a porous quartzarenite at about 8,100 feet in the Proterozoic that has reportedly blown "gas." Such possible deep potential needs to be examined, especially in light of projected increased demand for the United States of up to 30 trillion cubic feet of gas per year in the next decade or two.

In addition to exploration research, we are conducting research on the environmental impact of burning fossil fuels. KGS was instrumental in forging a consortium of state geological surveys to develop a database for assessing the regional potential for carbon dioxide sequestration. The consortium is made up of the geological surveys of Illinois, Indiana, Kansas, Kentucky, and Ohio, and the project is the Midcontinent Interactive Digital Carbon Atlas and Relational DataBase (MIDCARB). Increasing concern about greenhouse gases and their possible

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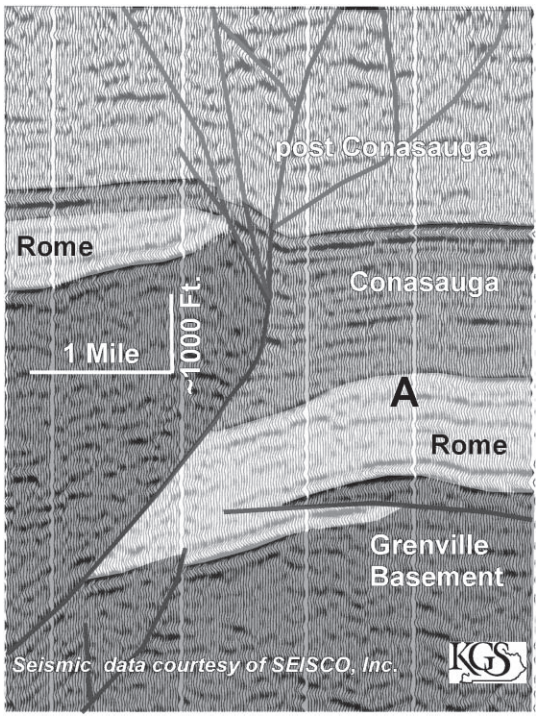

Figure 3. The Rockcastle Uplift (left) thrust over the Rome Trough (right). The Rome Trough formed by Cambrian extension. Thrust faulting created the uplift and the faulted anticline (A) in the trough. The faulted anticline may be an undrilled oil and gas target. Deep structures like this will need to be explored if the U.S. is to adequately supply future increasing natural gas consumption.

effect on global climate change has prompted the U.S. Department of Energy to sponsor this project, which will result in a database of the characteristics and volumes of anthropomorphic CO_2 sources, possible geologic sinks, and transportation facilities between the sources and the sinks. Former oil and gas fields, unmineable coal beds, organic-rich shales, and saline aquifers may be candidates as geologic sinks for CO_2.

An associated benefit of this work may be the enhanced recovery of oil and gas from some of these potential carbon sinks. The study will use geographic information system (GIS) technology, and the resulting atlas and database will be critical to planners of future CO_2 disposal efforts. The MIDCARB study may serve as a prototype for future national programs.

The similarity in reservoir characteristics of coal and organic-rich, black gas shales has led KGS to begin a study of the Devonian black shales as a potential important CO_2 sink (Figure 4). The effort, sponsored by the U.S. Department of Energy, represents basic research in this field and has not been previously attempted. It may be possible for CO_2 to displace methane in the shale so that the methane may be produced as an energy resource, thereby achieving a double benefit. Theoretical calculations suggest that more than 1,270 billion tons of CO_2 could be stored in Kentucky Devonian shales, or about 12,000 times the 1999 Kentucky CO_2 emissions. If this concept is valid, large areas of North America could use this method of carbon sequestration and natural-gas enhanced production. Similar funding for studies of Kentucky coals as potential CO_2 sinks and sources of natural gas is also being sought.

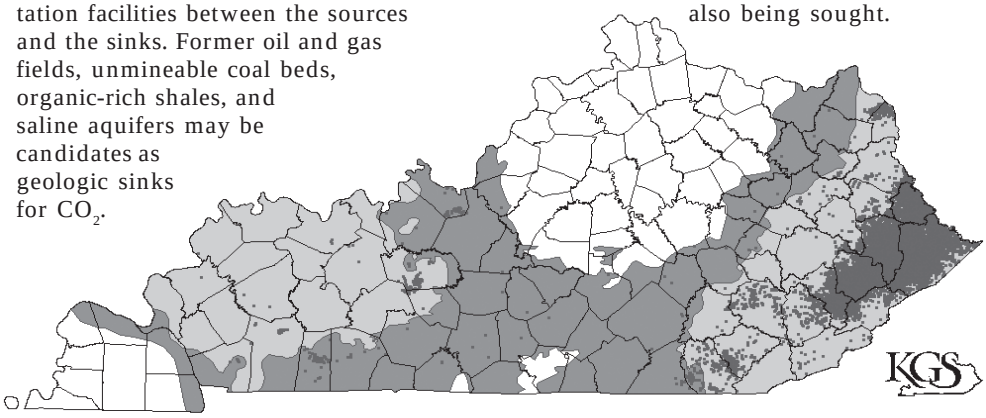

Figure 4. Devonian shales underlie the colored areas on this map of Kentucky. The medium gray area represents areas where the shales are relatively thin and shallow. The light gray represents those areas where the shales are greater than 100 feet thick and more than 1000 feet deep—potentially the best areas for carbon dioxide sequestration. The dark gray areas represent gas fields in the Devonian shales (the large dark gray area on the east is the Big Sandy field, a giant gas field).

DATABASES

The Energy and Minerals Section maintains several databases, including the Kentucky Coal Resources Information System, the Coal Borehole Database, the Oil and Gas Database, and the Kentucky Industrial Minerals Data System. The Oil and Gas Database and the locations for the Coal Borehole Database are available online at www.uky.edu/kgs. These databases are critical to ongoing energy research, and our efforts to serve the Commonwealth of Kentucky.

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