Kentucky Geological Survey Annual Report 2000–01

Kentucky Geological Survey
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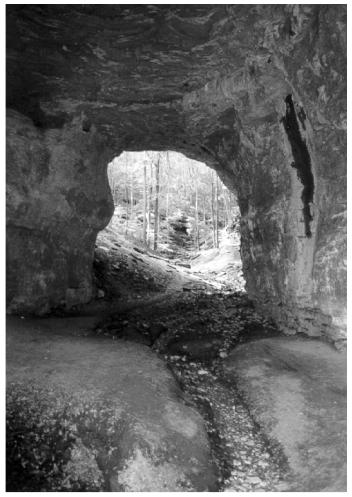
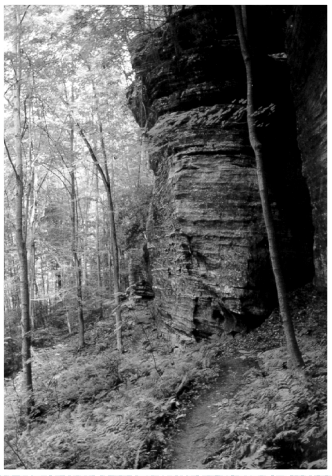
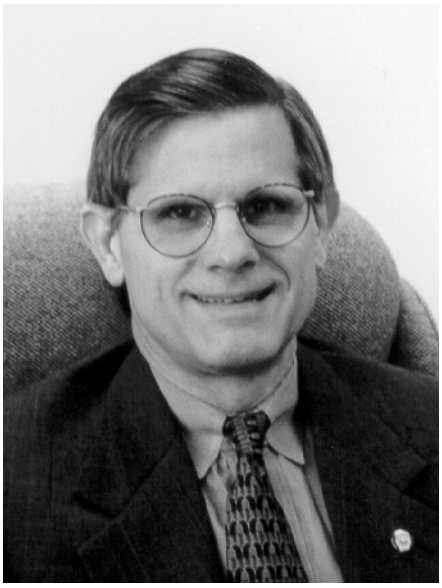
Our mission is to increase knowledge and understanding of the mineral, energy, and water resources, geologic hazards, and geology of Kentucky for the benefit of the Commonwealth and Nation.





In this report



Director's Letter

This annual report summarizes the achievements of the second fiscal year of the Twelfth Kentucky Geological Survey, which began in 1999 with my appointment as State Geologist and Director. We are building on the accomplishments of my predecessors and blazing trails in digital geologic mapping, as well as online delivery of publications and geologic data. We are continuing the tradition of excellence in geologic research and public service that began 147 years ago when the first Survey was created in 1854. The goal of the Twelfth Survey is continued excellence in geologic research for environmental protection, energy production, planning, and hazard mitigation. We are also expanding online access to hundreds of maps available at KGS, and data in the enormous databases archived at the Survey.

In 2000–01, 33 new publications on oil and natural gas, coal, groundwater, general geology, minerals, and fuels were released. The geologic map of the Harrodsburg 30 x 60 minute quadrangle was published in 2001, ushering in an era of digital geologic mapping in Kentucky. This was the first in a new series of 30 x 60 minute geologic maps that will be completed during the next several years. The maps are digitally compiled from 32 previously published 7.5-minute geologic quadrangle maps. What distinguishes these maps from previous ones is that they are published at a 1:100,000 scale. This intermediate scale provides a regional perspective that is ideal for county-level planning. These maps are also different because they are available both as traditional paper maps and as digital files for computer applications that can be used by diverse users. This launches an exciting era in the compilation, distribution, and use of geologic maps.

An invitation to "visit our Web site" has become familiar to all of us and has almost become cliché. What makes the KGS Web site different from others is our commitment to make data, maps, and publications available to as many people as possible, in order to assist them in their research, business, or teaching. A complete list of KGS publications is available in a searchable database at **www.uky.edu/KGS/pubs/lop.htm,** and most of our recent publications can be downloaded in portable document format (PDF) from this location. Many other capabilities were added to our Web site this fiscal year to make it the focal point of our public service, educational outreach, and distribution of publications, geologic maps, and data. This wealth of information can now be accessed by anyone with a computer and Internet access, 24 hours a day, seven days a week, in the home, workplace, business, local library, or in the field. I urge everyone to visit our Web site and discover what we have to offer in meeting your needs.

James C. Cobb

State Geologist and Director

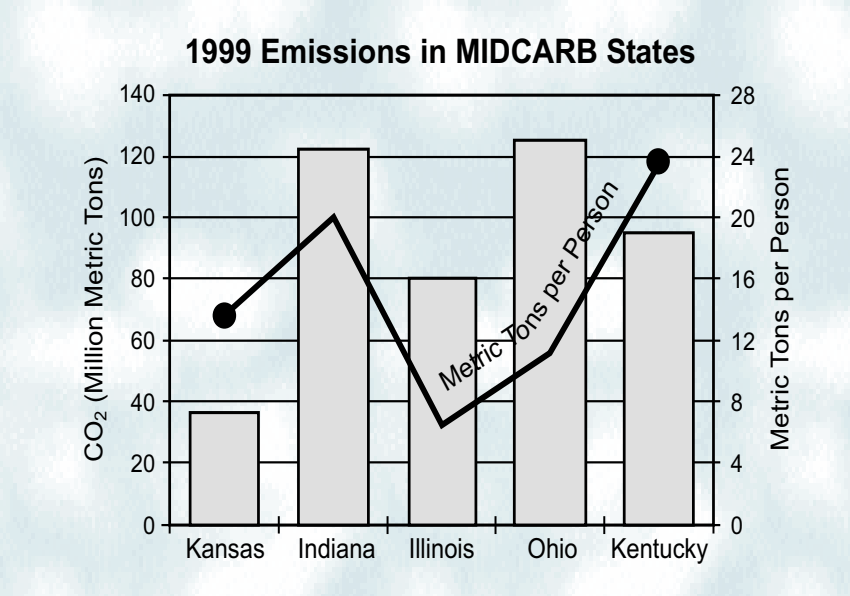
Geology for Environmental Protection

Geologic "sinks" for storing atmospheric carbon dioxide

Carbon dioxide (CO_2), a greenhouse gas, is a by-product of the combustion of fossil fuels in coal-fired electric power plants, industrial activities, and vehicles. An increase in atmospheric CO_2 has been linked by some scientists to global warming and is of concern to environmentalists, government agencies, and industry. A team of KGS geologists led by **Jim Drahovzal** is collaborating with geologists at the geological surveys of Kansas, Indiana, Illinois, and Ohio to study the feasibility of underground storage of CO_2, in order to remove it from industrial emissions. The long-term storage of CO_2 is referred to as "carbon sequestration." Potential sites for carbon sequestration in Kentucky include deep, thin, unmineable coals found in eastern and western Kentucky; some producing oil fields; deep saltwater aquifers; and Devonian black shales.

Geologic "sinks," or sites for the long-term underground storage of CO_2, are being investigated in five states so that a strategy to reduce atmospheric emissions of the greenhouse gas in the highly industrialized Midcontinent region may be developed.

This interstate team of geologists is building a computer database, a geographic information system (GIS), and maps to enable others to identify the amount of CO_2 available for sequestration in relation to power plants and other large CO_2 sources. They are also providing information about the safety of a sequestration site, the effects of injecting CO_2 into a petroleum reservoir, and the cost to compress and transport CO_2 from an industrial site to a geologic "sink" for long-term storage. Because there is no other project like this in the United States, it may provide a prototype for the rest of the country. More information can be found at the project Web site at **www.midcarb.org.**



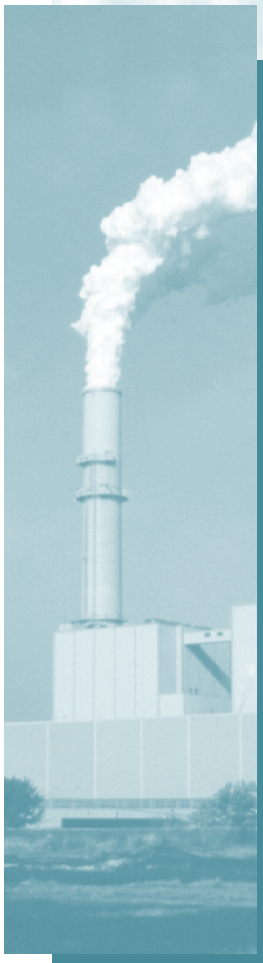
Source: U.S. Census Bureau and U.S. Department of Energy/Energy Information Administration

Potential for carbon dioxide sequestration and methane production

Kentucky has a significant amount of coal that is unlikely to be mined with conventional underground methods, either because the coal is too thin or too deeply buried below the earth's surface. This opens them to the possibility of serving both as a reservoir for carbon dioxide (CO_2) sequestration, and as a coalbed methane (CH_4) resource. Evaluating this potential by characterizing the coal beds and the coal-bearing intervals is the goal of proposed KGS research in cooperation with the U.S. Department of Energy.

Increasing emissions of CO_2 from the combustion of fossil fuels is of considerable global concern. The suggested links to global climate change, human health hazards, and economic disruption are driving the quest for feasible carbon-management options. One strategy is to sequester CO_2 in unmineable coal beds. This is theoretically possible, because coal has been demonstrated to trap CO_2 by adsorption (for example, in the San Juan Basin in New Mexico).

Using coal beds to sequester CO_2 has an added benefit in that the adsorbed CO_2 preferentially displaces methane, which can be recovered as an energy resource. Methane from coal beds is presently produced from several areas of the eastern United States (for example, the Southwestern Coal Field in Virginia, the Warrior Coal Field in Alabama), yet Kentucky has received little, if any, attention in the area of coalbed-methane exploration. Only a limited number of methane analyses have been performed on Kentucky coals, yet preliminary assessments point toward a considerable untapped energy resource.

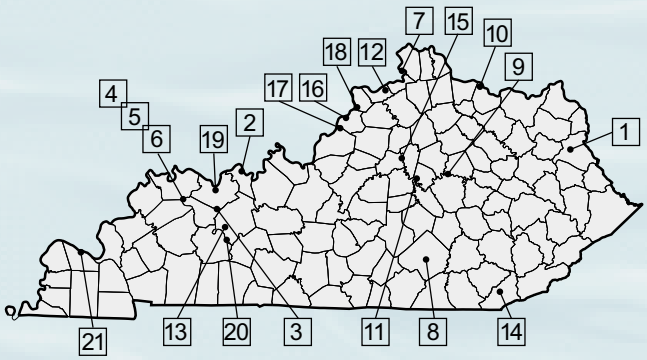


Analysis of KGS coal-quality data indicates that more than 50 percent of Kentucky's coal resource has good or excellent methane potential. This may be extremely important for the future energy needs of Kentucky, since additional generating capacity will largely come from small (less than 250 megawatt), gas-driven "peaking" plants, rather than from additional coal-fired capacity. Conceivably, a future electricity-generating plant, located in one of the coal fields, could be fueled by coalbed methane, with the carbon dioxide exhaust being injected back into the ground; this would not only trap carbon dioxide, but also stimulate additional methane production. Such a process would use a natural resource (thin, deeply buried, or high-sulfur coal) that most likely would not be otherwise exploited, and would use it in an environmentally friendly manner.

Characterizing the quality of Kentucky coal

Recent and proposed regulations have posed new challenges and opportunities for Kentucky coal. In order to respond to environmental regulations, electric utilities and coal companies need to understand the chemical composition of coal. The Federal Clean Air Act Amendments of 1990 placed strict limitations on the amount of sulfur in coal that can be burned in power plants. They also placed limitations on the amount of nitrogen oxides (NO_x) that can be emitted. The U.S. Environmental Protection Agency (EPA) may regulate mercury, and perhaps chlorine, emissions in the future. Utilities are also required to report to the EPA the amount of 17 chemical compounds and elements that are released to air, land, and water. These issues are the focus of cooperative studies with the U.S. Geological Survey (USGS) to give us a better understanding of the quality characteristics of Kentucky coal.

Coal-fired utilities in the Ohio River Valley have recently been required to further reduce nitrogen oxide emissions. To achieve these new emission levels, several coal-fired power plants in Kentucky are in the process of installing selective catalytic reduction (SCR) technology. In the SCR process, ammonia is injected into the flue gas stream, which then passes over a special catalyst, reducing the NO_x in the flue gas to elemental nitrogen and water. Although SCR is effective in controlling NO_x emissions, the catalysts can be easily damaged, or even incapacitated, by high levels of arsenic in the flue gas stream. Therefore, the amount of arsenic and selenium in utility feed coal is of great concern. In response, **Cortland Eble** is cooperating with geologists at the USGS to study the origin and distribution of these elements in Appalachian coal beds.



Location of the 21 coal-fired power plants in Kentucky. (Adapted from Kentucky Coal Council's Coal Education Web site, www.coaleducation.org.)

New combustion and gasification technologies can use coal that is high in ash and sulfur, a resource that was once considered unusable with conventional combustion technology. These technologies can also use waste by-product coal from preparation facilities, a material that formerly was not considered a resource. To take advantage of these opportunities and comply with Federal environmental regulations, the chemistry of the different coal beds must be understood, because the amount of sulfur, ash, nitrogen oxide, and arsenic varies from one coal bed to another. Eble analyzes the chemistry of hundreds of coal samples a year, and records the results in a comprehensive, computerized database about the quality of different coals and measurements of trace elements present in the coal.

In his report, "Overview of Environmental Regulations that Affect Coal Combustion," **Eble** outlined pertinent Federal regulations on air emissions, discussed options available to electric utilities for complying with regulations, and examined the implications for the deregulation of the electric-power industry. This publication is available online at **www.uky.edu/KGS/pubs/coalregs.pdf.**

Protecting water quality in central Kentucky

Karst terrane (limestone characterized by caves, sinkholes, and sinking streams) is found in much of central Kentucky. The presence of karst is an environmental concern, because pollutants from agricultural crops and animal feedlots, urban runoff, and chemical spills can readily drain into underground supplies of groundwater. One-quarter of Kentucky residents depend on groundwater for their water supply. The protection of groundwater and the ability to respond to chemical spills requires an understanding of how pollutants are transported in underground passages (or flow paths).

KGS has published two maps that show karst groundwater basins in central Kentucky. These maps are available as traditional paper maps, as well as digital files that can be used in a GIS. Many groundwater basins and flow paths have not yet been mapped, however, so **Jim Currens** and **Randy Paylor** are conducting dye traces to map the locations of swallow holes and springs, estimated boundaries of groundwater basins, and flow paths; this information will be added to the existing maps.

Helping to protect Kentucky's karst aquifers

Although karst aquifers are vulnerable to pollution, they are an important source of water for agriculture and drinking water in Kentucky. To promote greater awareness of the need for environmental protection of this valuable resource, KGS has published a color poster, "Protect Kentucky's Karst Aquifers from Nonpoint-Source Pollution," by **James Currens.** The poster defines karst aquifers and nonpoint-source pollution, explains how karst aquifers become polluted, and outlines suggestions for protecting karst aquifers. This information will be of interest to environmentalists, naturalists, teachers and students, and the general public.

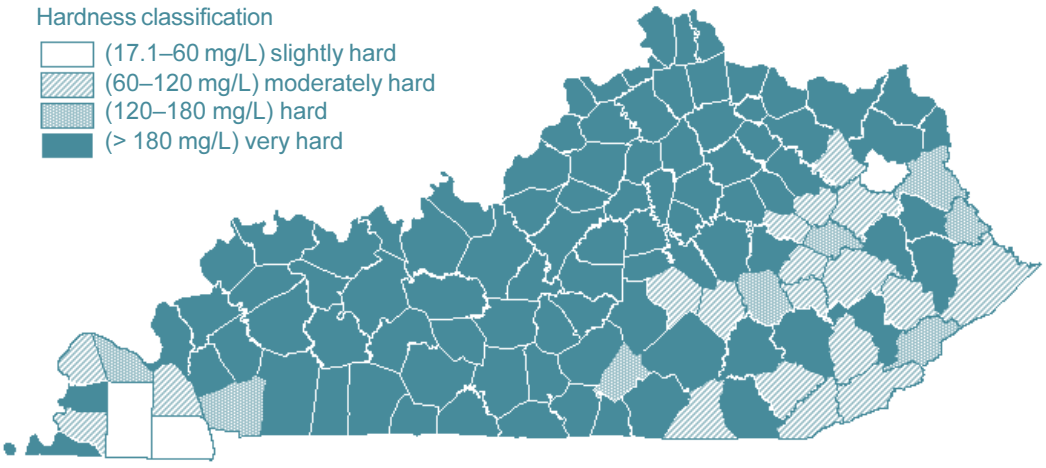
Monitoring the chemistry of groundwater for environmental protection

Groundwater, a resource essential to the economy of Kentucky and the health of its citizens, is also vulnerable to pollution. To protect groundwater from pollution, the quality of groundwater throughout the Commonwealth must be understood, so that informed decisions can be made about where to focus efforts on environmental protection. Despite groundwater's extensive use, until recently little systematic effort had been made to describe its quality and to make that information widely available. To fulfill this need, the **Kentucky Interagency Groundwater Monitoring Network** was established in 1998 to collect, evaluate, and report on groundwater quality.

Steve Fisher is analyzing data from the **Kentucky Groundwater Data Repository** to determine how the concentrations of inorganic and organic chemicals in groundwater vary across the state. Maps of water hardness and pH of sampled wells and springs were published in the spring 2001 issue of the KGS newsletter, *Kentucky Geology,* and are available at **www.uky.edu/KGS/announce/newsletters.htm.** (Water hardness is a measure of the amount of dissolved calcium and magnesium, and pH is a measure of the acidity of water.)

Previous maps have been published showing concentrations of fluoride and nitrate. Fluoride is an ion of the element fluorine, and is a natural component in most water resources. Although fluoride at low concentrations has proven

This map, showing the hardness values for water across Kentucky, is an example of the kind of data available from the Kentucky Groundwater Data Repository.



valuable in maintaining healthy teeth and bones, at higher concentrations it may cause fluorosis (indicated in more severe cases by brown staining or mottling of teeth). Nitrate is composed of the elements oxygen and nitrogen, and is an important source of nitrogen for plant and animal life; but too much nitrate in drinking water can be harmful to human health. For example, excess nitrate in drinking water has been found to cause methemoglobinemia, or Blue Baby Syndrome, in infants less than 6 months old.

A map of the occurrence of arsenic in wells will be published in the near future. Arsenic occurs naturally in water supplies, although it can also come from industrial sources. High levels of arsenic in drinking water are a health concern because long-term exposure of humans to arsenic has been linked to a variety of cancers.

To date, the network has produced the following publications on water quality in the Commonwealth, all of which are available at **www.uky.edu/KGS/water/gnet/gnet.htm:**

- **Ground-water quality in Kentucky: Fluoride,** by Philip G. Conrad, Daniel I. Carey, James S. Webb, R. Stephen Fisher, and Matthew J. McCourt, KGS Information Circular 1 (ser. 12)
- **Ground-water quality in Kentucky: Nitrate-nitrogen,** by Philip G. Conrad, Daniel I. Carey, James S. Webb, James S. Dinger, and Matthew J. McCourt, KGS Information Circular 60 (ser. 11)
- **Annual report, 1999–2000**
- **Annual report, 2000–2001**

To protect groundwater from pollution, researchers at KGS monitor the quality of groundwater throughout the Commonwealth and make the research results widely available to the public.

Assessing water quality

The presence of metals and herbicides that affect the quality of water is studied in the KGS laboratory. Water samples are analyzed for the Kentucky Division of Water and Division of Abandoned Mine Lands, the Kentucky Watershed Watch Program, and the U.S. Geological Survey. The analytical results of water samples provided by the Kentucky Division of Water are archived in the **Kentucky Groundwater Data Repository.** The analytical results of water samples provided by the Watershed Watch Program are used to monitor water-pollution problems and violation of environmental regulations.

The Kentucky Division of Abandoned Mine Lands, in cooperation with the Rock Creek Task Force, has formulated and instituted a program designed to reduce the amount of acid-mine drainage from abandoned mines in the Rock Creek watershed. The lower part of Rock Creek and its tributaries are monitored monthly as part of this program. Data collected from 19 monitoring sites are being used to determine the amounts of acid and metal entering the stream, so that treatment facilities to neutralize the effects of acid-mine drainage can be designed. The U.S. Geological Survey is conducting the monitoring, and KGS is analyzing the collected samples.

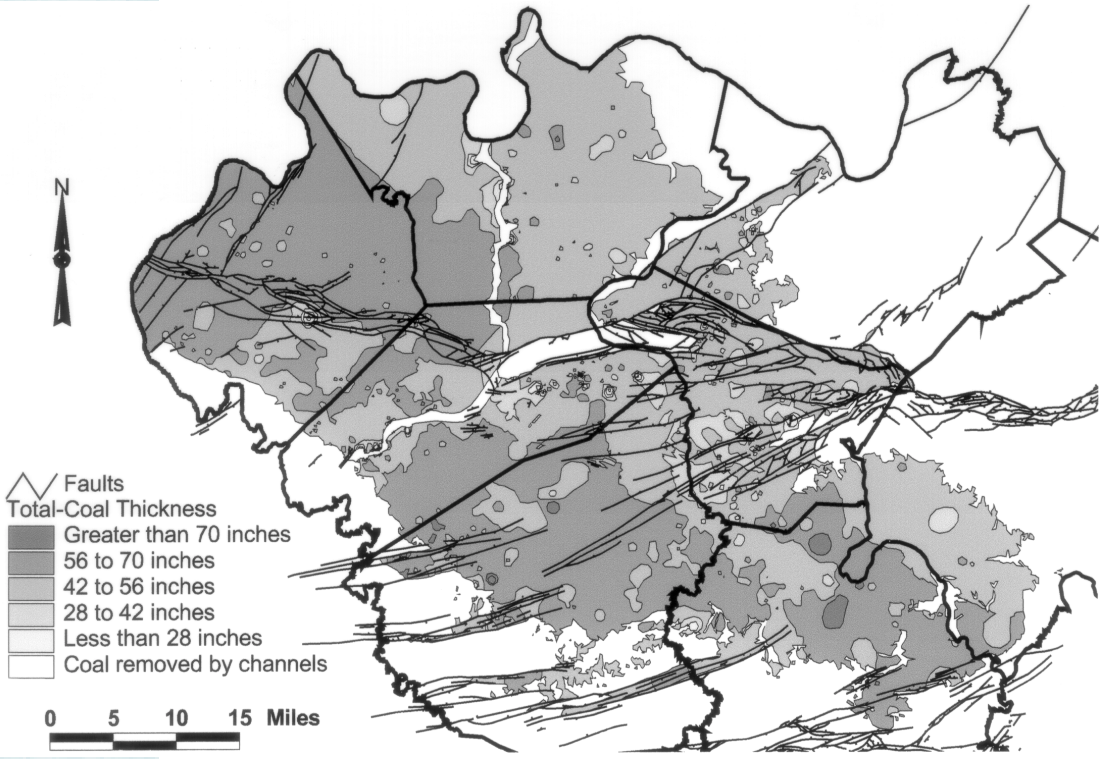
Geology for Energy Production

Digital coal atlas aids energy policy makers, coal companies, and planners

Kentucky is one of the first states to complete a comprehensive digital coal atlas.

KGS, a national leader in the assessment of coal resources and creation of digital geologic maps, has published a digital coal atlas consisting of 12 maps and charts showing original and remaining resources for six historically important coals in eastern and western Kentucky. Nine of the maps and charts pertain to resources in eastern Kentucky and three pertain to western Kentucky. Additional maps for western Kentucky will be published in the future. The atlas is available as traditional paper maps, or in digital files on CD-ROM for use in a GIS.

The atlas shows the degree of depletion of resources, the extent of the remaining coal available for future mining, and thickness and elevation of the coal; this information is useful to the coal industry as it produces coal from remaining reserves. Other charts have information about mining characteristics and coal quality, which is useful for mine safety and environmental planning. The maps permit transportation planners to make preliminary assessments of the impact of abandoned mines and the cost of acquiring minerals in rights-of-way on construction projects. Information on the extent and depth of coal mines in specific areas can be used to study the impacts of underground mining on land use.



Example of data and a map included in the Kentucky digital coal atlas – total coal thickness of the Springfield coal in western Kentucky. This illustration is a gray-scale rendition of the original color version in the digital coal atlas.

Natural gas potential in Appalachia

Natural gas discoveries in the Homer Field in **Elliott County,** Ky., stimulated interest in the potential for natural gas in similar reservoirs in Kentucky, West Virginia, and Ohio. With funding from the private sector and the U.S. Department of Energy, the Rome Trough Consortium, made up of geologists from the Kentucky, West Virginia, and Ohio geological surveys, compiled a database with information from regional cross sections and stratigraphic correlations. The database provided the foundation for an exploration model that should stimulate natural gas exploration in Appalachia. More information is available at **www.uky.edu/KGS/emsweb/rome/rome.html.**

Exploring deep natural gas targets

Successful natural gas discoveries in Roane County, W.Va., Ashtabula County, Ohio, and central New York state have renewed interest in exploring the Ordovician Trenton and Black River carbonate rocks. The target is natural gas in deep reservoirs that have been insufficiently explored by previous drilling. Geologists believe that natural gas and petroleum reservoirs with similar production may be found in both eastern and western Kentucky. **Dave Harris** is cooperating in a research investigation with the New York State Geological Survey and an energy company to study this gas play. Although these reservoirs are difficult to find, they have the potential to be very productive. The results will be applicable for large areas of the Appalachian Basin in Ohio, New York, West Virginia, and Kentucky. More information is available at **www.uky.edu/KGS/emsweb/trenton/trnt.html.**

Examination of outcrops such as this is providing insight into natural gas potential in Kentucky and other states. In nearby outcrops, petroleum can be seen seeping out of the rock on hot days. (Photo by Brandon Nuttall)

Identifying mineral and fuel resources

A new color map, "Mineral and Fuel Resources Map of Kentucky," by **Warren Anderson** and **Garland Dever,** shows areas producing coal, oil, natural gas, ore minerals, limestone, dolomite, sand and gravel, clay, and shale. Quarries, highways, cities and towns, county boundaries, and major rivers are also shown. A discussion of resources, including graphs showing production histories for the principal commodities, is provided. A list of selected references is also included to guide users to detailed information about the geology, minerals, and fossil fuels of Kentucky. This map will be of interest to industry planners, particularly those involved with mineral and fuel production; power-generating utilities; mineral and fuel service industries; transportation planners; government environmental and regulatory agencies; state, county, and municipal planners; educators; and the general public.

Geology in Planning

Blazing a trail with digital geologic maps

Kentucky is the only state of significant size to be completely mapped geologically at a detailed scale (1:24,000). These maps, referred to as geologic quadrangle maps, have been used for decades to address problems associated with landslides, flooding, subsidence, groundwater supply and protection, waste-disposal sites, septic systems, and other issues. There is now a great need for these maps to be in digital format so they can be used in a GIS to prepare custom-designed maps that meet company or project requirements. During the past 5 years, KGS has been converting geologic quadrangle maps into digital data sets. More than 500 of the 707 geologic quadrangle maps for Kentucky have been digitized. The current status of the digital mapping program is found at **www.uky.edu/KGS/statusmap.**

The creation of digital geologic map data sets is a major step forward in KGS's quest to build a statewide GIS of geologic data for Kentucky.

The digital data sets, referred to as digitally vectorized geologic quadrangles, or DVGQ's, allow geologic information from the DVGQ's to be used together with other kinds of information—agricultural, archeological, biological, engineering, geographical, and medical—in GIS and other software. Using a GIS, people can visualize and measure relationships among the different data. The DVGQ's are ideal for regional and county-level planning for:

- land use and development
- construction of roads and highways
- management of watersheds
- restoration of wetlands
- mitigation of geologic hazards
- development of oil, natural gas, coal, and mineral resources.

A free sample data set is available to download at **www.uky.edu/KGS/sampledvgq.**

Once the 1:24,000-scale, 7.5-minute geologic quadrangle maps are digitized, they are digitally compiled to create new 1:100,000-scale, 30 x 60 minute geologic maps. The first map in the new 1:100,000-scale series was published in 2001, the "Geologic Map of the Harrodsburg 30 x 60 Minute Quadrangle, Central Kentucky," by **Thomas Sparks, Garland Dever,** and **Warren Anderson.** This map of a 1,885-square-mile area encompasses all or parts of 15 counties that together have more than half a million people. Priority is being placed on preparing the 1:100,000-scale maps for the major population centers in the state. The Lexington 30 x 60 minute quadrangle map will be published in the near future.

Assisting water-management planning

In order to receive State funding for water and sewage projects, the State of Kentucky requires Area Development Districts (ADD's) to prepare annual water-management plans. With funding from the Kentucky Infrastructure Authority, **Dan Carey** is assisting ADD staff by providing

guidance on the development of the plans and water-demand projections. This technical assistance is provided to ADD water coordinators, who work with local Water Management Councils. The councils identify underserved and unserved areas in their planning region, and develop water and sewer projects to serve those areas. Carey's assistance is helping them meet the governor's goal of ensuring that all residents of the Commonwealth have drinkable water by the year 2020.

Sharing GIS expertise and data

Dan Carey, an ESRI-certified instructor, teaches classes to train researchers, students, local and county government officials, police officers, firefighters, and others in the use of ESRI's GIS software packages. This software can be used for planning land use; managing water, sewer, and highway infrastructure; tracking the location of crimes or incidences of fires; and providing directions for emergency-response personnel. Further assistance is provided in a library of GIS map coverages that is available at **www.uky.edu/KGS/gis/kgs_gis.html.** This site has digital map data about water supplies, water usage, water quality, soils, transportation infrastructure, oil and natural gas wells, topography, demographics, and political subdivisions.

Digital atlas of Kentucky's groundwater

Reports on the groundwater resources of each of Kentucky's 120 counties are available in a digital atlas published by KGS. The reports, prepared for the Water Resource Development Commission, complement other county planning reports of the commission, including strategic water-development plans and strategic wastewater-treatment plans, as well as the county water-supply plans of the Kentucky Division of Water. Each county report has information on hydrology, geology, topography, water supply, and water quality and are based on maps, investigations, and data collected from 1940 to 2000. The reports can be accessed at **www.uky.edu/KGS/water/library/webintro.html.**

Tapping water supplies from underground coal mines in eastern Kentucky

With funding from the Kentucky River Authority, **Dennis Cumbie** is assessing the potential to develop abandoned underground coal mines in the headwaters region of the Kentucky River as municipal water supplies. Detailed analysis has been completed at three sites near Whitesburg in **Letcher County,** one site near Manchester in **Clay County,** and two sites in **Perry County.** Since January 2001, the project has been expanded to include all of the Eastern Kentucky Coal Field, with current projects in **Harlan County.** Long-term monitoring of mines in Letcher and Perry Counties is in progress, and results from Letcher County show that deep-

The development of water supplies from abandoned underground coal mines has the potential to provide an inexpensive, reliable source of water to unserved or underserved communities in eastern Kentucky.

Geologic and remote-sensing technologies are being used to identify sites that could yield large amounts of groundwater in areas of eastern Kentucky where municipal sources of water are limited.

mine water levels and, thus, storage capacity vary seasonally. The water quality varies little over time within an individual mine, but water quality can differ substantially between mines, even for mines in the same coal seam.

Water from deep abandoned coal mines is beneficial because it is not vulnerable to contaminants from the surface, such as crude and refined oils, pesticides, industrial solvents, and human pathogens (for example, *E. coli* bacteria). Municipal water systems currently using underground mines as primary water supplies have had few problems with water quantity, and use conventional treatment methods. More information is available at **www.uky.edu/KGS/water/research/bwmines.html.**

Locating wells with high water yields in eastern Kentucky

Wells in eastern Kentucky producing significant amounts of water (more than 30 gallons per minute) are usually near fractures or faults, which may be expressed as linear features on aerial photographs, satellite imagery, and topographic maps. **Robert Andrews** is using satellite imagery and low-altitude radar to locate linear features in order to identify sites for water wells with potential for high water yields.

Wells have been drilled at eight sites (four in **Breathitt County,** and one each in **Carter, Clay, Knott,** and **Letcher Counties).** Five sites have wells that yield more than 95 percent of the wells drilled in their respective counties. Four of the sites have wells that yield more than 95 percent of the wells in the entire Eastern Kentucky Coal Field. The wells in this project were located by drilling at an angle so that more fractures could be accessed than would be possible with traditional vertical drilling.

On October 13, 2000, a technology-transfer workshop was held to inform government officials and consultants about the project's research methods, results, and drilling techniques. More information is available at **www.uky.edu/KGS/water/research/bwhyield.html.**

Assessing the impact of nitrate and pesticides on water quality in western Kentucky

Glynn Beck is collaborating with researchers in the UK Department of Agronomy and Department of Biosystems and Agricultural Engineering to evaluate the movement and fate of pesticides and nitrate at an agricultural site in **Henderson County.** Monitoring wells and domestic wells are sampled on a schedule consistent with local agricultural practices, and soil cores are analyzed for nitrate-nitrogen and organic matter (for example, livestock manure). The occurrence and movement of nitrate from a dairy barnyard,

abandoned 25 years ago, to a shallow sandstone aquifer is being studied. Future plans are to remediate the abandoned feedlot by removing the organic matter on the surface, and then to monitor wells over time to determine if nitrate concentrations decrease in the aquifer. Soil water and groundwater are also being monitored in an alfalfa field; this is the only known water-quality study of this crop in Kentucky.

This research will determine if present agricultural practices have affected the quality of water in the local groundwater system. Results of the study will be used to construct a conceptual model of groundwater flow and relate it to information on potential transport of agricultural chemicals in similar agricultural and hydrogeologic settings. Agricultural specialists will use this information to help determine best management practices in western Kentucky. More information is available at **www.uky.edu/KGS/water/research/agnitrate.html.**

Protecting well water from nitrate contamination

Groundwater is used by more than 75 percent of the residents in the **Jackson Purchase Region,** and approximately 60 public water utilities provide water from wells or well fields to residents, businesses, schools, and industry. A greater proportion of private wells in the Jackson Purchase Region yield water with nitrate concentrations over the U.S. Environmental Protection Agency's maximum contaminant level (MCL) than wells in other parts of Kentucky. To respond to this problem, **Glynn Beck,** together with researchers from the UK Department of Agronomy, and Department of Biosystems and Agricultural Engineering, is developing methods to protect water wells from nitrate contamination.

Domestic water wells in **Hickman County** are being sampled for nitrate-nitrogen to better delineate the sources of elevated nitrate. To determine the possible sources of these elevated nitrate concentrations, detailed land-use and well-construction surveys were completed, bromide tracer tests were performed on domestic wells (to determine the well construction integrity), and samples were analyzed for caffeine, nitrogen, and oxygen isotopes. The results indicate that possible sources of nitrate are chemical fertilizers, leaky septic tanks, and active and abandoned animal feedlots, in possible combination with leaky wells. More information is available at **www.uky.edu/KGS/water/research/agprotect.html.**

Herbicides, pesticides, fertilizers, and animal wastes can drain into passageways below the surface and pose a risk in polluting groundwater, which is an important source for drinking water in Kentucky.

Geology in Hazards Mitigation

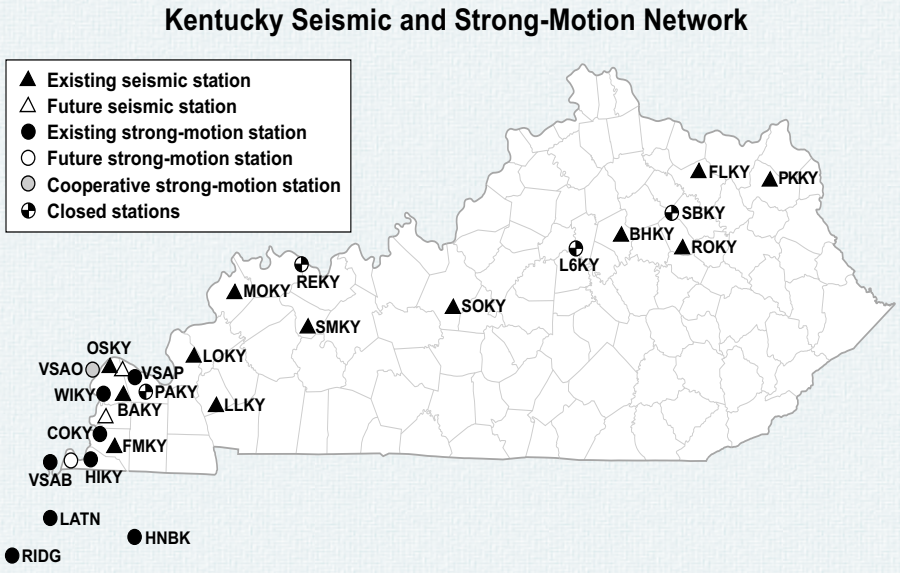
Strengthening research on earthquakes and geologic hazards

Geologists at KGS have addressed geologic hazard issues for more than a century. The need for expertise in geologic hazards and environmental geology has steadily increased. In response, KGS secured additional funding for seismic hazards research and hired geophysicist **Zhenming Wang.** Wang joined **Ed Woolery** in a new Geologic Hazards Section. They are collaborating with Assistant State Geologist **John Kiefer,** who has conducted research on geologic hazards in Kentucky for more than 20 years. Emphasis is being placed on public education and awareness, research to minimize the loss of property and life that may result from geologic hazards across the Commonwealth, near-surface geophysics, and mapping areas with high potential for geologic hazards. Long-term goals will focus on landslides, subsidence, and other hazard issues important to safety and economic development in Kentucky.

Expanding the Kentucky Seismic and Strong-Motion Network

The Survey has continued to expand and upgrade the **Kentucky Seismic and Strong-Motion Network,** which is an essential research tool for understanding the spatial and temporal relationships of earthquakes affecting Kentucky. The network has 20 stations—12 weak-motion stations and six strong-motion stations—which monitor seismic activity throughout the state and surrounding region. KGS established a cooperative agreement with the U.S. Army Corps of Engineers to operate a vertical strong-motion seismic array at the Olmsted Locks and Dam on the lower Ohio River. Data from this seismic array are used to verify the accuracy of a model of ground motion at the dam site. The station also provides valuable data for understanding seismic hazards in the Southern Illinois and Wabash Valley Seismic Zones, which are of concern in western Kentucky.

Since it began operation in late 1980, the Kentucky Seismic and Strong-Motion Network has recorded data for more than 1,000 earthquakes. The Kentucky Geological Survey and the UK Department of Geological Sciences jointly operate the network.



Assessing earthquake risk in western Kentucky

For economic reasons, many Kentucky communities were established in river or stream valleys in geologic environments that are vulnerable to earthquake damage. **Ed Woolery** and **Zhenming Wang** are studying how thick sediment deposits in the **Jackson Purchase Region** and other parts of the northern Mississippi Embayment respond to earthquakes. Research on earthquakes in Japan, Mexico, and California have shown that soil and rock in areas similar to the Mississippi Embayment amplify ground motions, often with catastrophic effects. Proper characterization and modeling of these materials provide information that can be used by engineers to design buildings and infrastructure, and by planners to reduce the risk of seismic hazards. This is especially important for communities in western Kentucky.

Seismic loads and hazardous-waste landfill

The northern boundary of the New Madrid Seismic Zone, the most active seismic zone east of the Rockies, is not well defined. **Ed Woolery** and **Zhenming Wang** are trying to determine whether the seismic zone extends as far north as **Paducah.** This will have important economic implications for Kentucky in general, and for Paducah in particular in defining building codes. Wang and Woolery are also working with the U.S. Department of Energy, the U.S. Environmental Protection Agency, and State government officials to determine what seismic load a hazardous-waste landfill at the Paducah Gaseous Diffusion Plant in western Kentucky must be designed to withstand (a seismic load is analogous to a snow load on a roof or a hurricane force on the side of a building).

Geology and highway engineering

Assistant State Geologist **John Kiefer** is a member of the Appalachian States Coalition for Geological Hazards and Transportation, created in the spring of 2001. The coalition has representatives from state geological surveys and transportation departments in Kentucky, West Virginia, Ohio, and Pennsylvania; the U.S. Army Corps of Engineers; the Federal Highway Administration; the U.S. Geological Survey; and railroads in the Appalachian states. The members are cooperating in research and technology-transfer initiatives related to geotechnical issues that affect highway engineering (for example, rockfalls, landslides, karst hazards, and mine subsidence).

Kiefer has also been active in a transportation task force created by the Central United States Earthquake Consortium. In cooperation with officials from state transportation departments, the task force is sponsoring workshops to explain the importance of taking into consideration local geology when planning highway routes.

Public Service and Educational Outreach

Meeting the public's need for geologic data

Addressing such diverse issues as safe drinking water, air and water pollution, electricity and fuel supply, and locations for landfill sites requires access to data and geologic records available at the Kentucky Geological Survey. Geologic data are provided to assist the public and fulfill legislative mandates that KGS has for managing data repositories and a groundwater monitoring network. Data are made available as copies of paper records, digital files distributed by CD-ROM or electronic mail, and on the KGS Web site. In the near future, digital images of oil and gas well records and water well records will be available online.

In fiscal year 2000–01, KGS geologists responded to more than 12,600 inquiries for data or technical information.

Drillers' logs, wireline logs, well-location survey plats, plugging affidavits, stratigraphic tops, and completion reports for approximately 175,000 oil and gas well tests are available in the **Kentucky Oil and Gas Data Repository.** Data for approximately 114,000 oil and gas wells can be downloaded for free at **www.uky.edu/KGS/gis/geology.html.** The **Well Sample and Core Library,** the fifth largest such facility in the United States, has more than 20 million feet or rock samples from 25,000 locations across the state.

Data on coal thickness measurements; coal-quality analyses; and descriptions from natural outcrops, roadcuts, and mine exposures are available in the **Kentucky Coal Resources Information System.** Borehole records of continuous core and rotary holes drilled for coal exploration and development in eastern and western Kentucky are available online in a searchable database at **www.uky.edu/KGS/pubs/lop.htm.** The borehole records can be searched by geographic or stratigraphic criteria.

Fiscal year 2000–01 in snapshot

Number of active projects: 27

Number of publications: 33

Amount of external funding: $1,807,900

Responses to technical inquiries or requests for information: 12,662

Drilling records for groundwater wells, data on groundwater dye traces, and water-quality analyses are available in approximately 56,000 water well records in the **Kentucky Groundwater Data Repository.** In cooperation with the Interagency Technical Advisory Committee on Groundwater, KGS maintains the **Kentucky Interagency Groundwater Monitoring Network.**

KGS publications catalog goes online

You can now find out what publications KGS has to offer about the geology of Kentucky with just a few clicks of your mouse, because the KGS publications catalog is available in a searchable database at **www.uky.edu/KGS/pubs/lop.htm.** It is possible to search by author, title, or keyword. Or publications can be searched by KGS series (for example, bulletins, maps and charts, reports of investigations, etc.). Many recent publications are also available online: a PDF file can be downloaded and viewed using Acrobat Reader (available free online from Adobe). Additional information about the publications is available in abstracts or executive summaries, which are available online for most recent publications.

Summer intern program at KGS

In the spring and summer of 2000, Bethany Overfield, Hannah Harbin, Matt Crawford, and Sarah Hawkins participated in an internship program initiated at KGS, and earned credit in an independent studies course at the University of Kentucky. The interns were introduced to digital geologic mapping, Global Positioning System (GPS) measurement, seismic research for oil and natural gas exploration, palynology and coal-quality studies, geologic sequestration of carbon dioxide gas, hydrogeology, minerals and geologic mapping, curation of mineral and fossil collections, professional registration for geologists, and earth-science education and public outreach. In weekly mentoring sessions, KGS staff members explained their expertise and current research interests. The interns conducted field work and research for the county geology project featured on the KGS Web site. The field trips included a tour of two underground quarries, a coal-fired power plant, and the Star Fire Mine. Summer students employed at KGS also participated in the mentoring sessions and field trips.

The interns and summer student workers (left to right): Matt Crawford, Jeff Crevier, Sarah Hawkins, Kristin Toth, Hannah Harbin, and Bethany Overfield.

Volunteer GIS instructors at Federal prison

Steve Cordiviola and **Dan Carey** are volunteer instructors in a GIS training program at the Federal Bureau of Prisons–Atwood Camp in **Lexington,** Ky. The program is a cooperative effort between KGS, the U.S. Bureau of Prisons, and the University of Kentucky; a grant of software and books was provided by Environmental Systems Research Institute Inc. (ESRI). Training is provided to prepare persons who are within 18 months of their release for a career as a GIS technician. Participants receive certificates of achievement in geographic information systems from the University of Kentucky, and certificates of achievement in digital cartography from KGS for their contribution to GIS projects. In addition to learning GIS concepts and participating in real-life exercises, students earn certificates for completion of three ESRI courses. The first class of students graduated on September 15, 2000, and the second class on July 1, 2001. The response to the program has been enthusiastic, and enrollments continue to increase.

Throughout the year, KGS geologists visited classrooms across the state to give presentations on earth science.

2001 graduates of the GIS training program. Dan Carey is at left in back row.

Educational outreach—sharing the excitement of earth science

Local schoolchildren joined KGS geologists during Earth Science Week, October 8–14, 2000, to learn about hydrogeology while touring **McConnell Springs,** an environmental park in Lexington. To assist other schoolchildren, earth science education materials were donated to every elementary and middle school in **Fayette County.** To heighten public interest and awareness of local geology, the Survey exhibited a rock, mineral, and fossil display at the Lexington Public Library.

The hallways of the Survey's research building at the University of Kentucky were buzzing with excitement as numerous schoolchildren visited for guided tours of the rock, mineral, fossil, and meteorite exhibits and to hear discussions of the geology of their state.

Kentucky Geological Survey

"Earth Resources – Our Common Wealth"

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Web Site
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Earth Science Education Network
www.uky.edu/KGS/education/education.html

KGS Online List of Publications
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