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# 1998–99 Annual Report

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Lexington, Kentucky

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Data Repository**

**Kentucky Coal  
Resources Information  
System**

## Our Mission ...

**T**he Kentucky Geological Survey at the University of Kentucky is a State-mandated organization whose mission is the collection, preservation, and dissemination of information about mineral and water resources and the geology of the Commonwealth. KGS has conducted research on the geology and mineral resources of Kentucky for more than 150 years, and has developed extensive public databases for oil and natural gas, coal, water, and industrial minerals that are used by thousands of citizens each year. The Survey's efforts have resulted in topographic and geologic map coverage for Kentucky that has not been matched by any other state in the Nation.

One of the major goals of the Kentucky Geological Survey is to make the results of basic and applied research easily accessible to the public. This is accomplished through the publication of both technical and nontechnical reports and maps, as well as providing information through open-file reports and public databases.

# Director's Report



The past year, July 1, 1998–June 30, 1999, has been characterized by continued success in research achievements, increased funding, expansion of our professional staff, and receipt of numerous awards. The Survey's expertise in digital geologic mapping, water-supply development and water-quality studies, geologic hazards, coal-resource assessment and coal-quality analysis, and petroleum exploration provided the foundation for attracting more than \$1.1 million in new research funding from Federal and State government agencies, the University of Kentucky, research consortia, and industry. Our facilities were also greatly improved with the addition of a new 48,000-square-foot Well Sample and Core Library. The facility, which houses the fifth largest collection of its kind in the Nation, was officially opened to the public on April 29, 1999.

The Survey has a proud tradition of 160 years of research focused on serving the needs of the Commonwealth. This tradition continues to be upheld. In response to an Executive Order from Governor Patton that every Kentucky household have access to drinkable water by the

year 2020, we are developing a strategic water-resources plan for the State. We are also developing a digital hydrologic atlas for Kentucky to update existing hard-copy hydrologic atlases and help determine the role that ground water may play in meeting water-supply demands in areas of critical need. In an effort to find sources of clean water for households, farms, and businesses in eastern Kentucky, we are studying the availability and quality of water supplies from abandoned underground coal mines, and using satellite imagery to locate fractures or faults that are associated with high-capacity water wells. Our research to develop water supplies is timely and crucial as Kentucky is confronted with severe drought conditions, and the impact on eastern Kentucky has been particularly harsh.

In recent years, there has been heightened research interest in geologic hazards as our physical infrastructure of buildings, roads, bridges, and highways age, and an expanding economy and population growth necessitate construction in less desirable locations that are more prone to geologic hazards. In response, the Survey has initiated a geologic hazards program that will emphasize public education and awareness, and research to minimize the loss of property and life that may result from geologic hazards, particularly landslides and earthquakes. Collaborative initiatives are under way with the National Earthquake Hazards Reduction Program of the U.S. Geological Survey, U.S. Army Corps of Engineers, NASA, several research consortia and universities across the Nation, academic departments at the University of Kentucky, other state geological surveys, and private foundations. Funding has been received to extend and upgrade the Kentucky Seismic and Strong-Motion Network, and to operate a vertical strong-motion seismic array at the Olmsted Locks and Dam on the lower Ohio River. The Survey also played a key role in the development of an award-winning educational videotape on geologic hazards titled, "All Kentucky Is at Risk."

Research investigations and mapping initiatives continued in support of mineral and fuel resource development. The Survey is continuing to contribute to the U.S. Geological Survey's National Coal Resource Assessment program and is being funded to conduct coal-quality analyses as part of a project funded jointly by the U.S. Geological Survey and the Electric Power Research Institute. The Department of Energy and four private-sector investors are funding the Rome Trough Consortium that is investigating deep natural gas resources in eastern Kentucky.

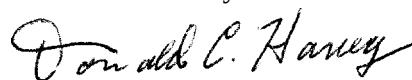
Our Digital Geologic Mapping program continues to expand. Funding was received from the Kentucky Transportation Cabinet to provide a digital geologic map and database for a proposed Interstate corridor in south-central Kentucky. The U.S. Geological Survey also provided funding for generating digital map coverage for the Kentucky River Basin.

Public service also continues to be an integral part of our mission. Our expertise was provided to decision makers at all levels of government—our geoscientists provided techni-

cal support to more than 100 committees, boards, and advisory groups at the international, national, regional, state, and local level, and at the University of Kentucky. We assisted the public by responding to more than 7,800 requests for information or technical exchange. More than 4,300 people were assisted by staff in the Publication Sales office and the Well Sample and Core Library. Valuable professional experience was provided to 26 student assistants who were involved in our research program. The results of our research were published in KGS and external publications. Our geoscientists presented 117 talks to professional and civic groups, and 57 papers were published in external publications.

Although the tools we employ in conducting our research are markedly different than those used by our predecessors, our mission of research and public service for the benefit of the Commonwealth and the public remains unchanged. As we look to the future, it is evident that the Survey is well positioned to continue to find solutions to the resource problems in our state and provide expertise to guide private- and public-sector decisions for the prudent management of our natural resources and environment.

Donald C. Haney



State Geologist and Director

# Coal and Minerals

Coal and industrial rocks and minerals are important to Kentucky's growth and development. In 1996 (the latest year for which figures are available), the coal industry employed more than 19,000 miners, and tax revenues generated from all economic activity related to the industry provided more than \$494 million to the General Fund in Kentucky<sup>1</sup>. Today, more than 50 percent of the Nation's electricity is generated in coal-fired power plants, and 95 percent of the electricity generated in Kentucky comes from coal.

The Clean Air Act Amendments of 1990 have had significant impacts on the Kentucky coal industry in the past, but additional challenges have surfaced during the past year. The first is a mandate by the U.S. Environmental Protection Agency (EPA) for an additional reduction of nitric oxide (NO<sub>x</sub>) emissions, above and beyond the limits set for Title IV of the Clean Air Act Amendments, from coal-fired power plants in the Ohio Valley. Utilities will have to adopt NO<sub>x</sub> reduction strategies such as low-NO<sub>x</sub> burners, selective catalytic reduction, air-staging (two-stage combustion), fuel staging (reburning), and flue-gas recirculation, all of which may necessitate costly retrofitting of existing infrastructure. Another challenge is EPA's requirement that all coal-fired utilities in the United States test for mercury in the coal they burn. Unlike most elements in coal, which adhere to the ash fraction of coal and are thus removed from the flue-gas stream, mercury remains largely volatile and escapes into the atmosphere. In fact, the EPA has determined that mercury emissions from coal-fired electricity-generating plants are the largest

source of mercury emissions in the United States, accounting for one-third of man-made mercury emissions to the air. Initially, this mandate will mean increased coal-testing costs, because determining mercury in coal is much more costly than more conventional analyses, such as those for sulfur content and calorific value.

The proposal to reduce greenhouse gases produced by the combustion of fossil fuels, which was introduced at a summit meeting in Kyoto, Japan, may ultimately be the biggest challenge to the Kentucky coal industry. If the proposal is implemented, the use of coal for electricity generation may be severely curtailed, which would be detrimental not only to Kentucky's coal industry, but to the Nation's coal industry. In addition, residents in Kentucky would almost certainly feel the impact in the form of higher electric rates.

To help meet these challenges, the Kentucky Geological Survey collects and analyzes hundreds of coal samples each year. The accumulated data, which are publicly accessible, help identify which coal beds contain the most desirable properties (for example, low ash, low sulfur, high calorific value, low element concentrations). This information can then be used to help direct future exploration and mining. In addition, many of our data are now being organized and graphically displayed using geographic information system (GIS) software, which greatly expands our capabilities.



*Mountaintop-removal mining.*



*Auger mining.*



*Surface mining.*

<sup>1</sup>Kentucky coal facts [5th ed.], 1997: Kentucky Coal Marketing and Export Council and Kentucky Coal Association, 49 p.

Industrial and metallic rocks and minerals furnish society with raw materials for agricultural, ceramic, chemical, construction, energy, metallurgical, and manufacturing industries. The value of industrial minerals to the economy is often underestimated, but extremely important for the future growth and development of the state. The principal industrial rocks in Kentucky (limestone, dolostone, sand, gravel, clay, and shale) are used in construction, ceramics, lime manufacture, cement manufacture, agriculture, and in reducing sulfur dioxide emissions from coal-burning plants. Kentucky's rock and mineral industry, including the manufacture of cement and lime, had a value of \$489 million in 1998<sup>2</sup> (the latest year for which figures are available). Crushed stone (limestone and dolostone) is the leading industrial rock produced in the state. It had a value of \$282 million in 1998<sup>3</sup>. Kentucky ranks eleventh in the United States<sup>3</sup> in the production of crushed stone. It

ranks fourth in the production of limestone; the third largest limestone quarry in the United States is in Kentucky<sup>3</sup>.

Staff in the Coal and Minerals Section are involved with research projects on coal-resource assessment, coal-mining geology, coal quality, and industrial rocks and minerals. Information generated by the coal projects is made available through the Kentucky Coal Resources Information System (KCRIS), one of the largest publicly available coal databases in the United States. KCRIS contains coalbed descriptions, coal-thickness measurements, coal-quality analyses, and borehole descriptions. Most of this information is in electronic form and is continually updated. A similar rock and mineral database is being developed to provide information to the public on these commodities. In addition to the databases, the Coal and Minerals research staff promotes technology transfer through workshops, seminars, and publications.

## Coal-Resource Assessment

### Available Coal Resources in the Eastern and Western Kentucky Coal Fields

*Jerry Weisenfluh*

In 1983, coal-resource estimates completed for Kentucky's two coal fields indicated that an estimated 57 billion short tons of resource remain in eastern Kentucky, and 38 billion short tons remain in western Kentucky. This suggests long-term potential for mining, but land-use and technological limitations reduce this potential. Coal Availability for Economic Development is an ongoing national research program

*Technological restrictions to mining may restrict as much as 50 percent of Kentucky's coal resources.*

administered by the U.S. Geological Survey to quantify the impact of these mining limitations. The results will be valuable for planning the development of energy resources. Under this program, KGS has prepared coal-availability estimates for nine 7.5-minute quadrangles in eastern Kentucky. For western Kentucky, 12 quadrangle studies have been completed.

The results of these 7.5-minute studies have shown that land-use restrictions (for example, cemeteries, roads,

railroads, and pipelines) have a negligible impact on mining in Kentucky because of their small area relative to the coal resource. Technological restrictions to mining, such as thin coal and underground mine barriers, may restrict as much as 50 percent of Kentucky's coal resource. Resource depletion is also a significant coal-availability factor for a number of important coal beds. Therefore, methods are being developed to measure these factors on a regional scale in order to

<sup>2</sup>U.S. Geological Survey, 1998, Kentucky annual estimate: U.S. Geological Survey Mineral Industry Surveys, 4 p.

<sup>3</sup>U.S. Geological Survey, 1999, Crushed stone and sand and gravel in the first quarter of 1999: U.S. Geological Survey Mineral Industry Surveys, 9 p.

extend the results of the 7.5-minute studies.

### **Deep Coal and Energy Resources of the Western Kentucky Coal Field**

*Dave Williams*

Western Kentucky coal production is increasingly dependent on underground mining. Information obtained from operating mines, as well as from mines not currently operating, can aid in our understanding of local underground resources and lead to an accurate assessment of future coal and energy resources. Data from recent mining operations are being compared with data from boreholes drilled in other parts of the coal field so that coalbed depth, thickness, and quality can be better understood. A database has been compiled containing more than 3,000 descriptions.

Coal horizons in the subsurface beyond the limit of

mining and coring are being correlated. This requires analysis of hundreds of geophysical logs drilled for oil and gas exploration. Subtle geophysical signatures of coals and other strata can be used to project the positions of possible coal-bearing strata in the deep subsurface. Results of these analyses can be used for future coal and coalbed-methane exploration.

### **Geologic Analysis of the Coal-Bearing Rocks of the Western Kentucky Coal Field for the Development of Coal Resources**

*Steve Greb*

The Federal Clean Air Act requires that no more than 1.2 pounds of sulfur dioxide per million Btu should be released when coal is burned without the use of scrubbers. The Kentucky Geological Survey is sampling low- to moderate-sulfur coals to determine how geologic factors affect coal

quality. If a model can be developed, it could help identify areas with the potential for similar-quality coal. This research will assist coal companies in interpreting controls on sulfur variation within western Kentucky coals.

Low- to moderate-sulfur coals such as the Western Kentucky No. 4 are mined, but are not widespread. Sampling of the Western Kentucky No. 4 coal on the southwestern edge of the Western Kentucky Coal Field has shown that sulfur content increases near some faults, possibly indicating that fluid moved toward the faults when the coal was being formed. In contrast, sulfur contents in the Elm Lick coal may have been controlled by fluid movement along post-depositional topographic surfaces. Sulfur contents of coals in the Tradewater Formation are sometimes lower than those in the Carbondale Formation because of changes in paleoclimate during deposition.

### **Geologic Analysis of the Coal-Bearing Rocks of the Eastern Kentucky Coal Field for the Development of Coal Resources**

*Steve Greb*

More than 70 percent of Kentucky's annual coal production is from the Eastern Kentucky Coal Field. Although generally lower in sulfur content and ash yield than coal from western Kentucky, coal from eastern Kentucky is highly variable in thickness and quality.



*Surface mine in the Western Kentucky No. 4 coal showing dip above local structure. Photo by Steve Greb.*

Many eastern Kentucky coals are composed of distinct benches of coal separated from each other by thin but wide-spread partings. Often these benches have different quality and thickness characteristics. Because generally much more thickness data than quality data are available, methods for projecting quality based on thickness can greatly improve the accuracy of resource estimates. Regional analysis of the Fire Clay and Pond Creek coals indicates that a substantial amount of regional thickness and quality variation can be explained through analysis of bench architecture. This research will assist coal companies in identifying high-quality coal and improve the economics of coal recovery.

### **Coalbed Methane and Deep Coal Resources of the Eastern Kentucky Coal Field**

**Steve Greb**

Past mining in the Eastern Kentucky Coal Field has concentrated on areas where the coal is most accessible, resulting in the easily recovered resources being depleted. Deeper, harder-to-recover coal deposits will become increasingly important in the future. The Kentucky Geological Survey maintains a database of descriptions of exploratory cores obtained from coal companies. The publicly available database currently contains more than 8,400 borehole records and is continually

updated. Research indicates that methane gas contained in deep coal resources in the Eastern Kentucky Coal Field may also be recoverable. If there is sufficient commercial interest, development of coalbed-methane gas could provide a future source of energy for markets in Kentucky and surrounding states.

A cross section has been constructed from Tennessee to West Virginia, traversing the area just north of Pine Mountain, in order to investigate deep coal in this area. Forty oil and gas geophysical logs were digitized and interpreted for this section. The cross section showed that coal-bearing rocks extend to well over 2,000 feet below the surface in some parts of the coal field and that many coal beds occur within these strata. This cross section, the first in a series, will help identify subsurface coal beds for future exploration.

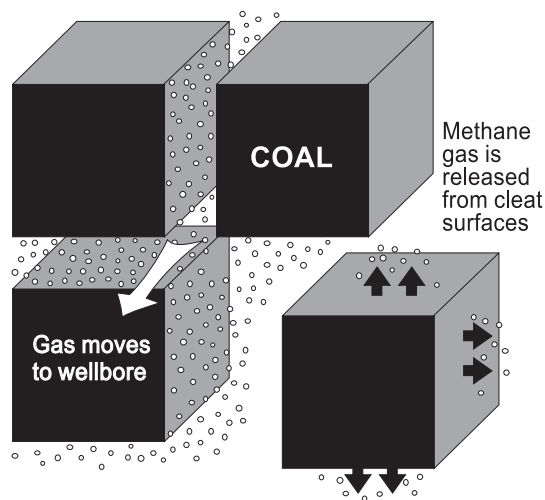
### **Coal Atlas for Kentucky**

**Jerry Weisenfluh**

Previous research at the Kentucky Geological Survey has identified several factors,

such as outcrop area, mined-out areas, thickness, structure, and quality, that affect the potential for mining Kentucky's coal. As part of the U.S. Geological Survey's National Coal Assessment Program, data on these factors are being compiled for the most important coal beds in the state. The data will eventually be included in a national coal assessment. Data are being compiled for the Pond Creek, Fire Clay, Upper Elkhorn Nos. 1, 2, and 3, and Amburgy coals in eastern Kentucky, and the Springfield, Herrin, and Baker coals in western Kentucky. This information will be included in the Central Appalachian and Eastern Interior Basin portions of the national coal assessment and will be valuable for guiding future mining of coal resources in Kentucky.

Products for Kentucky's part of the national coal assessment are of two kinds. First, paper plots of the maps at scales between 1:250,000 and 1:750,000 will be produced as part of the Kentucky Geological Survey Map and Chart Series. These maps will be printed on demand and will be periodically updated in the future. Second, a digital version of the maps and their associated databases will also be produced that will permit a user to view the data at different scales in relation to common geographic and infrastructure overlays.



## Coal-Mining Geology

### Mineability of Kentucky Coals

**Steve Greb**

The thickness and quality of coals, and the types of rocks that occur in roofs and floors, are being examined at mine sites in both the Eastern and Western Kentucky Coal Fields. If geologic features such as faults and roof falls in one mine are understood, then that knowledge can be used to assess similar problems in other mines. Information is collected from mines with known problems, and from the results of other Kentucky Geological Survey research projects. Mine operators who encounter geologic obstacles can also ask KGS geologists to visit their mine and help them understand problems. Results of this program are published in reports and articles about the mineability of Kentucky coals and will also be incorporated in the coal atlas (see above).

In the past year, investigations have helped us understand how coal-thickness and roof trends in Lower Elkhorn mines are related to ancient topography and regional stress fields; how the position of a rider coal and fireclay in the roofs of mines in the Hazard No. 8 coal are related; and how fractures and faulting are related to the occurrence of the Baker (Western Kentucky No. 13) coal. Several newly discovered faults, exposed by surface mining near Middlesboro, have been interpreted to have formed in the distant past

when a meteor or comet hit the area that is now Middlesboro. This is the only place in the world where coal is mined within such a structure, and further mining will provide more data for interpreting the origin of the ring-like faults and determining more accurate positions of faults.

### Application of Geographic Information Systems to Coal-Field Geology

**Steve Greb**

Geographic information systems (GIS) store geographically referenced data in a computer and are designed to manipulate, analyze, and display those data. With GIS, multiple coverages (layers of data and databases about the features on a map) can be combined and analyzed for a wide variety of applications.

KGS recently finished a cooperative project with the Tennessee Valley Authority to develop a GIS database containing information on active and inactive coal preparation plants, loading facilities, and transportation

networks in Kentucky. The project used data from the U.S. Geological Survey, the Kentucky Coal Marketing and Export Council, the Governor's Office of Coal Marketing and Export, the Kentucky Energy Cabinet, the Kentucky Transportation Cabinet, and other agencies. GIS coverages of the coal transportation infrastructure in Kentucky (road, rail, and river), and load-out facilities are being prepared for release in the fall of 1999.



*Fall in stackrock roof in an underground mine in eastern Kentucky. Photo by Steve Greb.*

### Coal Quality and Petrology

#### Coal-Quality Characteristics of Major Mineable Coal Beds in Kentucky

*Cortland Eble*

The effects of Federal regulations that limit the amount of sulfur dioxide that can be emitted during coal combustion have already been felt throughout the Commonwealth. In fact, almost half of Kentucky's coal-fired generators are now equipped with pollution-control devices, which is well above the national average of 22 percent. In part, this has allowed much of the coal in western Kentucky, which has a moderate to high sulfur content, to remain a viable economic source of coal for utilities. Although eastern Kentucky remains a valuable source of low-sulfur compliance coal (emits less than 1.2 pounds of SO<sub>2</sub> per million Btu), the amount of coal that is mineable using existing technology remains a topic of debate.

To help meet these challenges, the Kentucky Geological Survey collects and analyzes hundreds of coal samples each year. The accumulated data, which are publicly accessible, help identify which coal beds contain the most desirable properties (for example, low ash, low sulfur, high calorific value, low element concentrations). This information can then be used to help direct future exploration and mining. In addition, many of our data

are now being organized and graphically displayed using GIS software, which greatly expands our capabilities for analysis.

#### Public Access to Coal Information and Coal-Data Management

Data in the Kentucky Coal Resources Information System have been collected by the Kentucky Geological Survey for the last two decades. Data in KCRIS include coal-thickness measurements and descriptions of coal at natural outcrops, roadcuts, and mine exposures in eastern Kentucky; analyses of coal quality in samples from mines, natural outcrops, and cores from both eastern and western Kentucky; and records of holes drilled for coal exploration and development, obtained from industry and government sources in both coal fields. The database also contains estimates of coal resources for all coal-bearing 7.5-minute quadrangles, estimates of the amount of coal available for mining in selected 7.5-minute quadrangles, and stratigraphic correlations. Data from KCRIS are valuable to the coal industry, consultants, government agencies, researchers, and students.

The database contains more than 30,000 coal-thickness measurements, 3,500 coal-quality analyses, 1,200 petrographic analyses, and 8,500 drill-hole descriptions. These data are continually updated to improve location information and coal-bed correlation. In areas with sparse data, oil

and gas geophysical logs are being interpreted to obtain depth and approximate thickness data for important coal beds. The KCRIS data can be provided on request as paper printouts or in electronic format.

### Minerals

#### Industrial Limestone and Dolostone Resources in Kentucky

*Garland Dever*

Determining the chemical quality of limestone and dolostone is important for assessing their use as industrial raw materials. Limestone and dolostone deposits across the state have been sampled by KGS geologists to determine their chemical composition. KGS is preparing regional and county resource reports that will present chemical and lithologic data for the sampled sites, and will outline the geographic and stratigraphic distribution of potential sources of industrial-grade stone.

Limestone samples from the High Bridge Group (Ordovician) in cores from north-central Kentucky are currently being processed and analyzed at KGS facilities. In the central part of the state, the High Bridge Group is a major source of industrial and construction stone. Mines in the High Bridge produce feedstock for lime plants along the Ohio River and construction aggregate for the metropolitan Lexington market. In Gallatin and Jefferson Counties, new

slope mines are being driven down to the High Bridge.

Reports on limestone resources in southeastern and east-central Kentucky are being prepared, as well as descriptions of samples and compilations of measured sections.

### **Nonfuel-Mineral Statistics** **Garland Dever**

The Kentucky Geological Survey monitors the state's nonfuel-mineral industries and compiles information on industry activities and mineral-related government actions. This information is used to answer public-service inquiries, and to prepare

reviews of state activities and mineral-resource reports.

Summaries of 1998 Kentucky activities were prepared for publication in *Mining Engineering* and the U.S. Geological Survey's *Mineral Industry Surveys* and *Minerals Yearbook*. Information is being updated to compile a directory of nonfuel-mineral producers in Kentucky.



*High-calcium oolitic limestone, Ste. Genevieve Limestone. Hopkinsville Aggregate Company quarry, Christian County.  
Photo by Garland Dever.*

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# Geologic Hazards

The Kentucky Geological Survey has been addressing geologic hazards issues for more than a century and a half, but on an ad hoc basis, because of lack of funding. In recent years the workload in geologic hazards and environmental geology has increased at a higher rate than in the traditional areas of geology. This is not surprising, because as our existing infrastructure begins to age, and the expanding economy and population continue to force new construction in more undesirable locations, geologic hazards are becoming more problematic for structural and geological engineers. As a consequence, with new funding for seismic hazards, KGS has initiated a geologic hazards program that will emphasize public education and awareness, as well as pursue the technical research required to minimize the loss of property and life that may result from geologic hazards.

KGS has directed much of its efforts during this first year toward projects that assess the Commonwealth's seismic hazards. Projects included the rehabilitation and expansion of the Kentucky Seismic and Strong-Motion Network. The seismicity of the Midcontinent is very complex, and in some aspects it is more complex than the seismotectonics of California; therefore, the seismic network is an essential research tool for establishing and understanding the spatial and temporal relationships of earthquakes affecting Kentucky.

Complementing the seismic network initiative were investigations of the seismic response of thick sediment deposits in the Jackson Purchase Region and other parts of the northern Mississippi Embayment. Earthquakes in Japan, Mexico, and California have shown that these types of materials in areas such as the Mississippi Embayment amplify ground motions, often with catastrophic effects. For example, of the \$59 billion in damage sustained during the recent Northridge, Calif., earthquake, almost 98 percent was directly related to ground-

motion amplification. For economic reasons, many Kentucky cities and communities were established in river or stream valleys characteristic of these geologic environments. Proper characterization and modeling of these materials are necessary for seismic-hazard mitigation and engineering design. This is especially true for communities in the western part of the state.

Long-term goals, in addition to continued seismic research, incorporate and focus more resources toward landslide, subsidence, and other hazards issues important to the safety and economic development of Kentucky. The most efficient and only meaningful approach to these

*KGS has initiated a geologic hazards program that will emphasize public education and awareness, as well as pursue the technical research required to minimize the loss of property and life that may result from geologic hazards.*

problems is through multidisciplinary intra- and interagency cooperation. Toward that end, KGS has worked with State, county, and city governments; state geological surveys from across the Nation; the U.S. Geological Survey; the U.S. Army Corps of Engineers; the Central United States Earthquake Consortium; and the Natural Resources Conservation Service. We are also partners with UK's Departments of Geological Sciences and Civil Engineering, as well as the Kentucky Transportation Center, on several new initiatives that will alert and educate the public about potential geologic hazards. KGS has been invited by the U.S. Geological Survey to participate in the development of a National Landslide Mitigation Initiative, a cooperative effort to be funded by the USGS. KGS geologists have been working with the Natural Resources Conservation Service on a program of landslide prevention in eastern Kentucky, and have developed a pamphlet and sponsored a workshop for that program. KGS has also worked with the Kentucky Division of Disaster and Emergency Services, the UK Martin School of Public Policy

and Administration, the State Hazard Mitigation Adoption Program, and UK Media Design and Production to produce a video on natural hazards, "All Kentucky Is at Risk," which won the annual Kentucky Award of Excellence from the Kentucky Association of Government Communicators.

In addition, KGS geologists also team-teach a course for the University's Environmental

Systems Program (ES-610), in which geologic hazards and environmental issues are emphasized. The course discusses landslides, earthquakes, sinkhole and mine collapse, flooding caused by filled sinkholes, dam construction and seepage, and numerous issues involving water supply and ground-water contamination. A special problem is construction on land that has been previously strip mined, of which Kentucky has a great abundance.

### **State-of-the-Art Instrumentation for High-Resolution Shear-Wave Investigations**

*Ed Woolery*

This new equipment, acquired in cooperation with Ron Street of the UK Department of Geological Sciences, can be used to (1) image deformed unconsolidated sediment associated with neotectonic activity in the vicinity of the New Madrid Seismic Zone, (2) define the thickness and elastic properties of unconsolidated sediments for understanding the dynamic response to seismic loads, and (3) target potential fractured Devonian shale reservoirs, particularly in western Kentucky. The equipment includes a 24-bit, IFP, 48-channel seismograph and a

trailer-mounted Vibroseis unit with shear-wave option. It is unique in the central and eastern United States, and places the University among the Nation's leaders in the direct measurement of deep sediment properties, which is necessary for seismic-hazards mitigation and designing earthquake-resistant structures.

We are currently documenting and defining the thicknesses and shear-wave velocities of the 975-meter-thick sediment column in the southern New Madrid Seismic Zone. This semiconsolidated sediment is vulnerable to ground-motion amplification and other damaging effects during moderate to large earthquakes. Approximately 50 sites in the area are being

evaluated to characterize the three-dimensional subsurface conditions.

These data, along with existing near-surface data, will be used to develop a large-scale seismic-hazards map. This research is funded by the U.S. Geological Survey's National Earthquake Hazards Reduction Program.

### **The Kentucky Seismic and Strong-Motion Network**

*Ed Woolery*

Kentucky is at risk for major damage to life and infrastructure from earthquakes, as evidenced by the widespread damage in western Kentucky from the earthquakes of 1811–1812. They occurred in what is now called the New Madrid Seismic Zone, the most active seismic zone east of the Rockies. The University began operating the Kentucky Seismic and Strong-Motion Network in late 1980. The network, which ranges from Grayson in the east to Clinton in the west, monitors seismicity throughout Kentucky and the surrounding region. Operated in conjunction with Ron Street of the UK Department of Geological Sciences, it has recorded data for approximately 1,100 earthquakes.

Data from the network's seven strong-motion stations



*The trailer-mounted Vibroseis unit with shear-wave option.  
Photo by Ed Woolery.*

along the Mississippi River are used to investigate how thick sequences of unconsolidated sediments affect the propagation of seismic waves. The network provides engineers high-quality data with which to design and build safer structures.

We are expanding and upgrading the network with a grant from the Kentucky Division of Disaster and Emergency Services. Four new intermediate-period seismometers will be deployed, and two aging strong-motion stations will be replaced with state-of-the-art accelerometers. The new seismometers will

monitor deep crustal features, which could lead to a redefinition of the northern boundary of the New Madrid Seismic Zone. This could enhance economic development in several western Kentucky communities, because the seismic-hazard risk would be lessened.

A vertical strong-motion station at Olmsted Locks and Dam, on the lower Ohio River, will be operated cooperatively with the U.S. Army Corps of Engineers. KGS will collect, process, interpret, and archive the data, and the Corps will maintain the instruments. Besides verifying ground-motion modeling for the dam site, this station will provide data to help us understand seismic hazards from the Southern Illinois and Wabash Valley Seismic Zones.

### Central United States Earthquake Consortium State Geologists

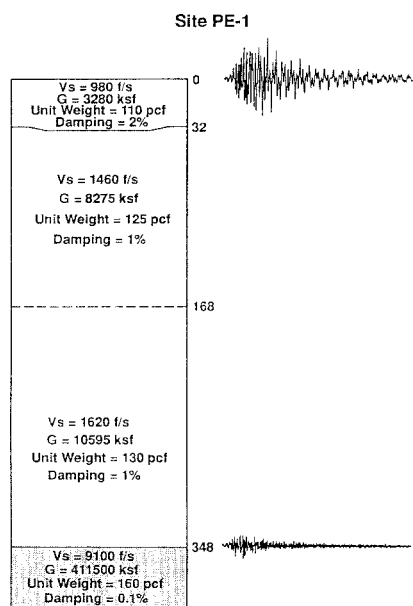
**John Kiefer**

The Kentucky Geological Survey is a member of a multi-state research consortium, affiliated with the Central United States Earthquake Consortium (CUSEC). Referred to as the CUSEC State Geologists, the core group consists of representatives from the state geological surveys of Kentucky, Indiana, Illinois, Ohio, Missouri, Tennessee, Arkansas, and Missis-

sippi. They are developing earthquake-hazard maps for the central United States, funded through a grant from the U.S. Geological Survey's National Earthquake Hazards Reduction Program. A series of 1:250,000-scale maps will be published, based on an assessment of amplification of shaking and potential for liquefaction.

Ground motions generated by earthquakes can be amplified by nonlithified geologic materials resting on the bedrock. The degree of amplification is directly related to variations in the geotechnical properties and thickness of the nonlithified materials. The classification of map units follows a procedure developed for the Federal Emergency Management Agency, which will be incorporated into the new National Building Code. This classification correlates measured amplifications, shear-wave velocity characteristics, and the physical characteristics of the soils, including standard penetration test values.

In the future, the CUSEC State Geologists will refine the classification parameters, obtain additional shear-wave information, and develop more detailed hazard maps at a scale of 1:24,000 for specific communities in the New Madrid and Wabash Valley Seismic Zones.



*Information gathered by the Vibroseis unit shown on page 15 can be used to model the amplification effects at a particular site. This simulation for a site near Paducah shows that waves from a relatively small earthquake occurring at a depth of 348 feet would be greatly amplified by the time they reach the surface. Data from an actual earthquake closely match this model.*

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*Landslides at Hickman, Fulton County, have been a continuous problem since the founding of the town in 1819.*

# Geologic Mapping and Hydrocarbon Resources

In 1978, through the joint efforts of the Kentucky Geological Survey and the U.S. Geological Survey, Kentucky became the first state of large area to be mapped geologically at a scale of 1:24,000. The 707 maps generated during the project resulted in data of immense value in the subsequent development of mineral resources in the state. The Digital Geologic Mapping Program, instituted 4 years ago, is making significant strides in digitizing the geology of the entire state based on the same 1:24,000-scale geologic maps developed earlier. At the current rate of progress, the digital mapping will be completed during the first half of the 21st century, but already these products are having an impact on the Commonwealth. These digital products will be of great importance to planning and managed-growth decisions in Kentucky during the 21st century. The data will allow the maps to be used in sophisticated geographic information systems. The resulting digital products are more than geologic maps: they constitute a graphic spatial database that can be quickly and effi-

ciently manipulated to provide planners, engineers, and scientists with the tools they need to answer specific questions. The digital geologic information can be linked to other digital data sets, allowing modeling and analytical work to be carried out in ways never before possible. For example, this approach to problem solving is already being applied to link tectonic faulting in a particular rock unit with rock-fall information supplied by the Kentucky Transportation Cabinet. In a GIS, the geologic information can be linked and correlated with engineering data, so that decisions can be made about problem mitigation, design corrections, or highway route changes. Integrating diverse data sets from various agencies can improve future planning and design in a variety of applications that are influenced by geology. This approach will become increasingly important as we strive to manage our urban and rural growth in a sustainable manner. The methods will not only save time and money, but they will provide us with the ability to make more informed decisions.

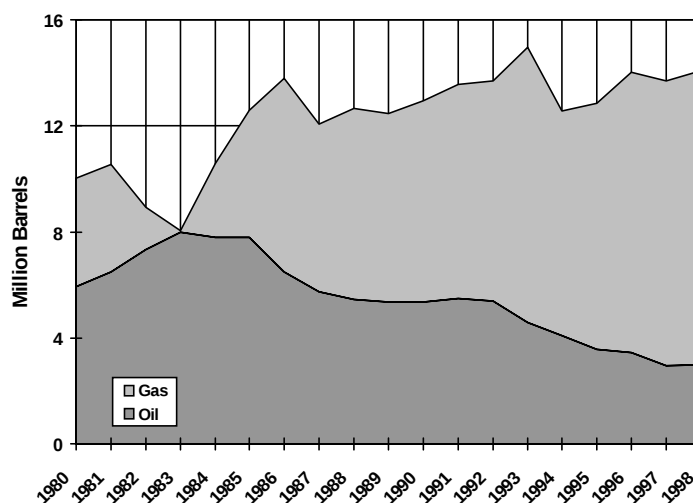


*The Digital Geologic Mapping team examines tar sands in Edmonson County in west-central Kentucky. Photo by Steve Martin.*

Once we have captured the information from the maps, a two-dimensional product, we will begin using similar technology to develop the third dimension—that is, we will begin integrating well and geophysical information to show the nature and distribution of subsurface rock units as they relate to specific problems. Some of this work has already begun and will grow in the future as we become more concerned with deep disposal and storage, earthquake mechanisms, and the location of additional mineral resources.

In addition to these surface mapping projects, regional geologic framework studies are also being conducted. Much of this work takes advantage of the approximately 175,000 oil and gas well records archived in the Office of Geologic Information and geophysical data in KGS files. Regional geologic research is vital in developing a sound subsurface stratigraphic and structural framework for the state. Such knowledge is critical in understanding the character and distribution of energy and mineral resources, as well as the geologic aspects of environmental and hazard issues. These activities directly support the exploration and development of natural gas and oil resources in the Commonwealth. One example of this type of study is the Rome Trough Consortium (page 21), where basic stratigraphic research being funded by industry and the Federal government is leading to a better understanding of the distribution of natural gas in this deep Cambrian basin in eastern Kentucky and southwestern West Virginia. Although this basin lies across state boundaries, the consortium is considering the basin as a whole, and KGS is working in concert with the Ohio and West Virginia geological surveys to complete the research.

Oil and natural gas continue to be important commodities for the Kentucky economy. The Geologic Mapping and Hydrocarbon Resources Section provides research and service related to the oil and gas resources of the state. In 1998, the value of oil and natural gas production was more than \$233 million, bringing \$10 million in severance tax revenue to the State<sup>1</sup>.



*Kentucky production of oil and natural gas (on an oil-equivalent basis).*

Nationally, the industry remains in a slump that extends back to 1986, although natural gas production has been rising during the last several years. Natural gas production held essentially steady in 1998, rising 3 percent to 81.9 billion cubic feet (Bcf). Oil production increased, for the first time since 1991, by 2 percent to 3 million barrels in 1998.

The Appalachian Basin of eastern Kentucky produced 98 percent of the state's natural gas and 35 percent of the oil. Leslie County, the third most prolific oil-producing county, produced 380.4 thousand barrels of oil and Pike County produced the most natural gas (30 Bcf). In the Illinois Basin, Union County continued as the top oil-producing county in Kentucky, although production fell 12 percent from the previous year to 425,435 barrels.

The value of natural gas production in Kentucky continues to outstrip the value of oil production by a margin of more than two to one. The state has large untapped natural gas resources that include coalbed methane. Despite falling oil production, hydrocarbons still represent an important state and national resource. Hydrocarbons will be important bridging fuels well into the 21st century, until renewable energy resources become more cost-effective to produce and consume.

<sup>1</sup>Revenue and production calculations from data supplied by the Kentucky Revenue Cabinet.

### Geologic Mapping

#### Digital Geologic Mapping in Kentucky

**Warren Anderson**

This program is the result of a cooperative effort between the Kentucky Geological Survey and the U.S. Geological Survey. It is part of the National Geologic Mapping Program (STATEMAP), which will result in the entire United States being mapped geologically. Kentucky's part in this program is producing 7.5-minute digital geologic quadrangle maps at a scale of 1:24,000.

In the first 3 years of the STATEMAP project, 96 of the 7.5-minute quadrangles in the Hazard, Irvine, and Harrodsburg 30 x 60 minute quadrangles were completed. In the fourth year of this project, thirty-two 7.5-minute quadrangle maps from the Lexington 30 x 60 minute quadrangle will be digitized. The Kentucky River Basin has been the focus of most of the digital mapping, but recently mapping has begun for the Jackson Purchase Region of western Kentucky. In future years mapping will be concentrated in other parts of the state, as priorities dictate. The goal is to have complete digital coverage for the state by the year 2005.

Kentucky is also cooperating with the Kentucky Transportation Center and the Transportation Cabinet to provide digital geologic maps for the proposed I-66 highway corridor between Somerset and London, Ky. The project

will evaluate the use of digital geologic and engineering information in planning, design, construction, and maintenance of highways.

The most important use of digital geologic information is for economic-development planning. These digital maps are valuable for assessing coal, mineral, and petroleum resources; construction and urban development; engineering, planning, and reclamation; and water-supply and waste-disposal studies.

#### Scanning and Preservation of Geologic Quadrangle Maps

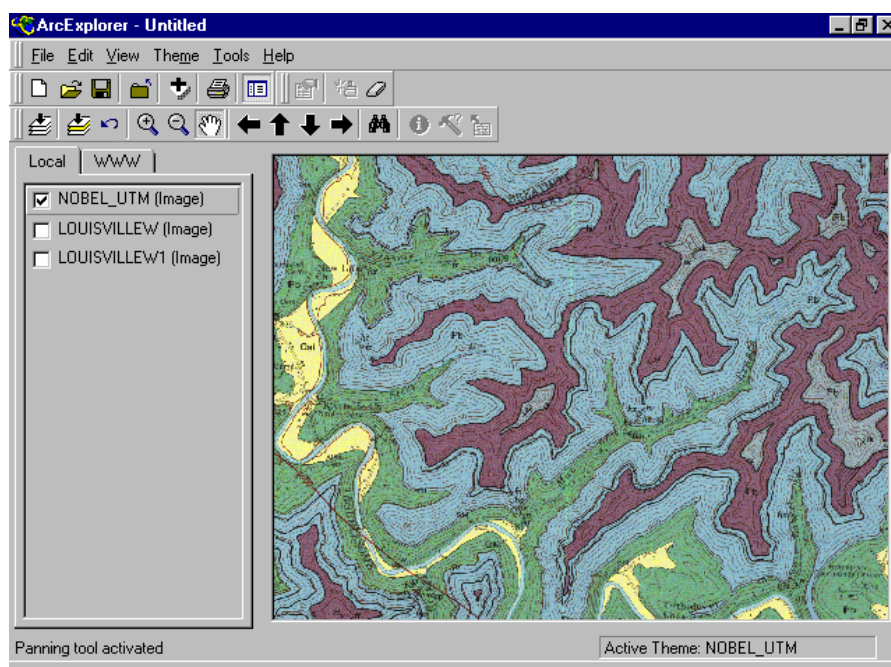
**Steve Cordiviola**

KGS, in cooperation with the University of Kentucky libraries, purchased a color scanning system that can scan images up to 66 inches wide. The initial use of this system will be to preserve the more than 700 geologic quadrangle

maps (GQ's) for Kentucky. Preserving the GQ's is critical, because the U.S. Geological Survey, who originally published them, has no plans to reprint them. Eventually, our archive will be the only source of the original maps. KGS will be able to print color copies of the maps for the public. The libraries will use the system to scan large manuscripts.

The planning and inventory phase was completed in 1997. Characteristics of each map, such as size, number of colors on the map, physical condition, and special features, were entered in a relational database. These data will eventually be linked to the main KGS database for use by researchers and the public.

The scanning phase was completed in March 1999. The scanned images will be preserved on 4-millimeter magnetic tape, CD-ROM, and



*One of the layers of the Noble 7.5-minute digital geologic quadrangle map, viewed in a GIS.*

possibly DVD. Archivists working for UK and the State are being consulted to determine the best format and media for final archiving. They're studying how other agencies, including the Library of Congress, are archiving these types of media.

The third phase will begin in mid-1999. The scanned images will be reduced to the map only, without the supplementary information (such as stratigraphic

*Information from the Rome Trough Consortium project will benefit the oil and gas industry by improving exploration success for deep natural gas.*

columns, scales, and text), and the image will be georeferenced so it can be used with various GIS applications.

## Natural Gas Resources

### Rome Trough Consortium

**Dave Harris**

A 1994 natural gas discovery in the deep part of the Rome Trough in Elliott County led to renewed exploration interest in Cambrian rocks (deposited 510 to 570 million years ago) in eastern Kentucky. To assist in the development of this deep gas potential, a research consortium has been formed with industry and the U.S. Department of Energy to provide the geologic data and interpretations needed to increase exploration

success. The study area includes eastern Kentucky, southern Ohio, and northern West Virginia. Colleagues from the Ohio and West Virginia geological surveys will collaborate on parts of the project.

The consortium was formed in late 1998, after several meetings with interested industry representatives. Industry needs were considered at these meetings, and project goals were modified to

better reflect industry concerns. The project began in January 1999, and will last for 2 years. A new staff geologist was hired early in 1999 to work on the project. Major

objectives in 1999 are stratigraphic correlation and collection of formation tops for approximately 700 wells. Stratigraphy in the Conasauga Group and Rome Formation is being refined with detailed correlation using a sequence-stratigraphic approach. Locations of regional cross sections have been determined, and sections are being constructed with digital well-log data using computer software. Collection of formation tops has begun. This research will result in an interpretation of the depositional history of the basin, source-rock quality, and hydrocarbon-reservoir quality. It will benefit the oil and gas industry in Kentucky by improving exploration success for deep natural gas.

### East Continent Rift Basin Study

**Jim Drahovzal**

Recently acquired well and seismic data indicate that Middle Proterozoic rocks (deposited 950 to 1,500 million years ago) of the East Continent Rift Basin extend to western Kentucky. Previous research by a consortium of the Kentucky, Indiana, and Ohio geological surveys had defined the basin as extending from northwestern Ohio to central Kentucky, and a short distance westward across southern Indiana. In addition to the extension in Kentucky, a rock type previously unknown in these rocks has been discovered in a recent well. The new lithology is a quartzose sandstone. The sandstone may be a reservoir rock for natural gas. An overlying Late Proterozoic sequence (deposited 600 to 700 million years ago) is also present in western Kentucky, but is probably eroded or was never deposited in the central part of the state. These two Precambrian rift sequences have implications for oil and natural gas and mineral-resource exploration, as well as for aiding our understanding of mechanisms that cause earthquakes in the western part of the state.

### Gas Reservoir Character of Devonian Shales of Kentucky

**Dave Harris**

Fractured Devonian shales act both as source rock and as a reservoir for most of the gas reserves of Kentucky, most notably the Ohio Shale of eastern Kentucky, but also the

New Albany Shale of western Kentucky. Despite decades of investigation, these unusual reservoirs are not well understood; therefore, shale-gas development is often only marginally commercial outside traditional shale-gas-producing areas. Development of this resource is expected to grow rapidly, especially in the Illinois Basin, within the next several years. This growth could be hampered in the short term by low natural gas prices, but in the long term this resource is likely to be strongly developed. A small project on the New Albany Shale was completed this year in conjunction with the Illinois Basin Consortium and the Gas Research Institute. Natural gas production from the New Albany Shale in western Kentucky dates back to the late 1800's, but little drilling had been done in this Devonian formation (deposited 360 to 410 million years ago) until recently. This year a stratigraphic database on the New Albany Shale in western Kentucky, which was originally completed in 1992, was updated. Stratigraphic tops and thicknesses for the New Albany Shale in more than 800 wells drilled since 1991 were interpreted and added to the database. A bibliography for the New Albany Shale was also compiled as part of this project. The project resulted in an updated edition of "Gas Potential of the New Albany Shale (Devonian and Mississippian) in the Illinois Basin," published by the Illinois Basin

Consortium as Illinois Basin Studies 2.

### **Coalbed-Methane Resources Investigation: Subsurface Stratigraphy of the Pennsylvanian Coals in Kentucky**

***Brandon Nuttall***

Coalbed methane in Kentucky is a potential energy resource that is increasing in importance in both the Western and Eastern Kentucky Coal Fields. The results of a reconnaissance survey conducted from 1996 to 1997 summarized indicators of coalbed-methane potential in Kentucky. Cleated coals of sufficient rank and depth are known to contain methane, as indicated by limited desorption data, mine-ventilation data, and occurrences of mine explosions. A study area in eastern Kentucky will be

selected, based on current oil and gas drilling activity and an assessment of available data. Net coal thickness and depth information will be gathered from electric logs on file in the Office of Geologic Information and from data available in the Kentucky Coal Resources Information System database. Additional funding is being sought, and if it is obtained a type geophysical log, a representative structural cross section, a structure-contour map, a net-coal isopach map, and an electronic database of stratigraphic tops and location information will be published. These materials will provide oil and gas operators with basic data to facilitate future exploration and development of coalbed-methane resources in the Commonwealth.



*Active oil well in eastern Kentucky.*

## Oil Resources

### Tertiary Oil Recovery Information System (TORIS) Database Enhancement in Kentucky

**Brandon Nuttall**

TORIS is a national database of reservoir and geologic data used by the U.S. Department of Energy to characterize the Nation's oil resources and develop national energy strategies. In the original study, no data were included for reservoirs in the Appalachian Basin region of eastern Kentucky, and data from only five reservoirs were included for the Illinois Basin region of western Kentucky. The Kentucky Geological Survey conducted studies and collected data to provide more accurate estimates of the reserves in Kentucky. The study indicated that the original oil in place in Kentucky was more than 1.7 billion barrels; the remaining oil in place is estimated to be more than 1.3 billion barrels. The Lower Mississippian Weir sandstone of eastern Kentucky accounts for approximately 41 percent of the total remaining oil in place. These data have been placed in a database and will be posted at the Kentucky Virtual Regional Resource Center Web site ([www.uky.edu/KGS/PTTC/home.htm](http://www.uky.edu/KGS/PTTC/home.htm)) that is currently being developed.

### Stratigraphy and Reservoir Sedimentology of Mississippian Carbonates in Kentucky

**Dave Harris**

Mississippian carbonates are one of the largest classes of hydrocarbon reservoirs in Kentucky. The Ft. Payne, Warsaw, St. Louis, Ste. Genevieve, and Newman/Slade ("Big Lime" in drillers' terminology) formations make up this interval in the Illinois and Appalachian Basins of Kentucky. An understanding of the depositional and diagenetic controls on hydrocarbon reservoir development and the prediction of reservoir quality in these rocks is vital to the oil and gas industry as it develops exploration concepts and enhanced-oil-recovery programs. This project began in 1994 in the Appalachian Basin with the collection of stratigraphic data for the Mississippian Newman Limestone (Big Lime) and adjacent units from more than 7,700 wells.

KGS is now interpreting the geologic data collected in the first phase of this study. The data are available to the public on diskette as KGS Open-File Report OF-97-03. Regional cross sections illustrating the stratigraphy of the rocks will be published as part of the Map and Chart Series in 1999. A regional structure map on the top of the Big Lime is being prepared for publication later in 1999.

### Tar Sands of Western Kentucky

**Brandon Nuttall**

Tar sands of western Kentucky comprise a major hydrocarbon resource of more than 3 billion barrels of heavy oil and tar in place in the shallow subsurface. This resource has been developed periodically for more than 100 years, depending on price and

*Original oil in place in Kentucky was more than 1.7 billion barrels; the remaining oil in place is estimated to be more than 1.3 billion barrels.*

market considerations. With the declining availability and rising price of conventional oil, the tar sands will probably be commercial again in the future. In addition to their commercial potential, the western Kentucky tar sands provide a record of oil migration in the Illinois Basin, and are therefore of significance to petroleum geology research. A database on tar sands continues to be maintained, and M.C. Noger's "Tar-Sand Resources of Western Kentucky" has been reprinted as KGS Reprint 45.

## Regional Subsurface Geology

### Regional Subsurface Maps in Kentucky

**Dave Harris**

The Kentucky Geological Survey is producing regional maps, all published at the same scale, showing the structure and thickness of

important geologic horizons and intervals in Kentucky. This information is critical for energy and mineral industries, and for environmental issues. Furthermore, it will serve as a framework for future research by industry, government, and academia. Geophysical data are also being collected to aid in the mapping of several horizons. Data from a study on the Slade Formation (Big Lime) of eastern Kentucky are being interpreted, and a map of the structure on the top of the Slade Formation is being completed. An isopach map of part of the Slade Formation is planned. The top of the Mississippian Borden Group will be the next unit to be mapped. Data collected as part of the new project on the “Corniferous” (see next project description) will also be used to prepare structure and isopach maps as part of this series.

Mapping of the Precambrian continued in west-central Kentucky during the year and will continue next year. The work was aided by the recent acquisition of seismic data and information from three newly drilled wells that penetrated the Precambrian surface. The new data are important for depth migration calculations made by geologists who, as a result, are changing some of the previous interpretations. In addition, a new map of the basement of the western part of the Rough Creek Graben is being developed; it will be based on a map published by the U.S. Geological Survey in cooperation with

the Illinois Basin Consortium in 1998 (U.S. Geological Survey Geologic Investigations Series I-2583-D). The part of that map illustrating the Precambrian unconformity is being developed as a separate, print-on-demand, color contour map that will be published by the Illinois Basin Consortium. This new product will be of considerable use to exploration geologists, as well as to those concerned with earthquakes in western Kentucky.

### **Subsurface Stratigraphy and Digital Geologic Mapping of the Silurian–Devonian “Corniferous” of Western Kentucky**

**Dave Harris**

Rocks of Silurian–Devonian age, known by drillers as the “Corniferous” zone, comprise an important hydrocarbon-producing interval in central and western Kentucky. The stratigraphy of this interval in the deeper parts of the Illinois Basin in western

Kentucky is not well documented, however. This new project, begun in early 1999, will result in regional stratigraphic correlations to enhance our understanding of Corniferous geology. In recent years, additional well data have become available that should be interpreted so we can develop successful hydrocarbon exploration models for the area. In cooperation with the ongoing digital geologic mapping project (see page 20), this project will assume responsibility for digitizing 10 of the 7.5-minute geologic quadrangle maps that cover Corniferous outcrops in west-central Kentucky. The research will combine these digital surface geologic maps with subsurface correlations to produce an integrated three-dimensional model of Corniferous geology.

A grid of cross sections has been defined for the study area, and correlation of Silurian and Devonian formations has begun. Stratigraphic-



*Digital Geologic Mapping team examining a geologic map at a clay mine in Graves County. Photo by Steve Martin.*

tops data were collected for entry in the KGS tops database.

**Illinois Basin Consortium  
Cross Section C-1 in Central  
and Western Kentucky**  
*M.C. Noger*

A cross section from Lincoln County in central Kentucky to Crittenden County in western Kentucky will be useful to those interested in the stratigraphy and structure of the Rough Creek Graben (a basin in western Kentucky) and its relationship to the Cincinnati Arch (a gentle upwarping of rocks extending northward from central Kentucky into Ohio). The cross section will also be useful to those drilling for natural gas and oil in the area. The upper part of the section has been completed using available geologic mapping and well data. The lower part of the section will be supplemented with seismic data. This is part of a grid of cross sections being produced by the Illinois Basin Consortium (composed of the Kentucky, Indiana, and Illinois geological surveys).

## **Oil and Gas Data**

### **Oil and Gas Maps**

*Brandon Nuttall*

Kentucky is covered by thirty-two 30 x 60 minute quadrangles. The Kentucky Geological Survey is preparing a series of maps of these quadrangles showing oil and gas drilling activity and results. The maps are printed at a scale of 1:100,000, using GIS software, and are periodically updated. To date, maps have been released for the Tompkinsville, Evansville, Hazard, and Corbin quadrangles. The Beaver Dam, Bowling Green, and Campbellsville quadrangle maps will be completed shortly. The Pikeville and Williamson quadrangle maps were previously released and were prepared by conventional drafting techniques. These maps are useful for oil and gas exploration and development and are becoming increasingly important in assessing environmental issues.

Summary maps at a scale of 1:1,000,000 are also being compiled and will include a map of Cambrian and deeper well tests of Kentucky. The statewide oil and gas well-location map published on demand as Map and Chart Series 9 has been updated and reformatted.

### **Development of a Virtual Regional Resource Center Using the Resources of the Internet and the World Wide Web**

*Brandon Nuttall*

The Petroleum Technology Transfer Council has called for regional and satellite resource centers where oil and gas operators and producers can find information on technologies for efficient and economic exploration and development of petroleum. These resource centers will provide information for drilling and completion, reservoir characterization, environmental regulatory compliance, and exploration issues. The KGS resource center is an electronic gateway to information on the petroleum-related resources and services available at the Kentucky Geological Survey and the Midwest Region of the Petroleum Technology Transfer Council. Information will include lists of publications, fact sheets, summaries of current KGS research, oil and gas well-location maps, oil and gas well-location and completion data, production data, reservoir-specific information, sample data files, and links to other petroleum resource and technology sites. This site can be found on the Internet at [www.uky.edu/KGS/PTTC/home.htm](http://www.uky.edu/KGS/PTTC/home.htm).

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# Water Resources

For Kentucky to maximize its economic potential, large quantities of usable water are necessary. Kentucky must plan for increasing use of its water resources, including both ground- and surface-water supplies, for the expansion of industry and urban areas and to further develop its mineral and agricultural resources. In 1999, Governor Patton created the Water Resources Development Commission, whose goal is to develop plans to provide drinkable water and acceptable sewage disposal to every household in Kentucky by the year 2020. KGS is taking a lead role in writing the statewide plan to meet this goal, and to update and put the hydrologic atlases for Kentucky into a GIS format.

Over the past 20 years, 10 Federal acts have been enacted to protect water. With guidance from these acts, State regulatory agencies have developed programs dealing with mining and mine reclamation, solid and liquid waste disposal, sewage disposal, water supply, oil and natural gas recovery, and agricultural practices. The State has developed ground-water regulations to protect this vital resource. An understanding of the varied hydrogeologic conditions in Kentucky is essential for appropriate regulations and the optimum development, use, and management of these water resources. The Water Resources Section has directed much of its efforts over the past few years to designing and

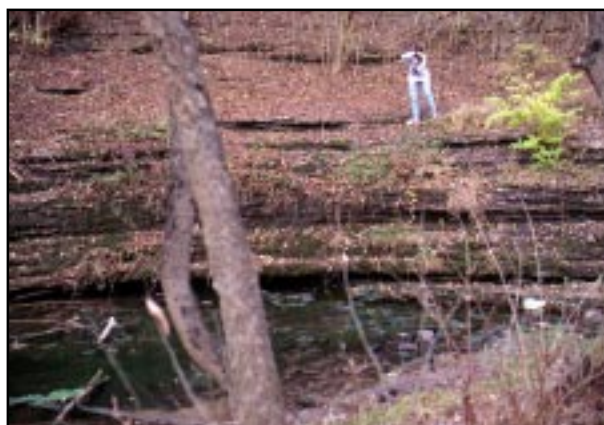
implementing projects to characterize these conditions. These efforts include drilling monitoring wells, sampling wells and springs, and monitoring surface waters. In addition, KGS maintains the Kentucky Ground-Water Data Repository for all ground-water data collected by State agencies.

During the 1998 legislative session, House Bill 172 was passed, which created a new section in KRS Chapter 151. This statute mandates that KGS establish a long-term ground-water monitoring network to characterize the quality, quantity, and distribution of Kentucky's ground-water resources. This network is in cooperation with an interagency technical advisory board composed of 14 agencies and is chaired by the director of the Kentucky Water Resources Research Institute at the University of Kentucky.

The effect of land use on water quality and quantity is also an important factor in economic development. Therefore, research on basin hydrology is essential for future economic development in the Commonwealth. To facilitate this type of research, KGS has instituted a geographic information system for storage and use of statewide data on land use, topography, geology, ground-water levels and water quality, and water-supply systems. Several research programs deal with large basins, up to the size of the Kentucky River watershed, where the effects of land use and hydrogeology are being studied.



*Kentucky River Palisades in central Kentucky.*



*McConnell Springs in Lexington.*

## Hydrogeology of Agricultural Lands

### Assessment of Nitrate and Pesticide Impacts on Bedrock Aquifers in the Western Kentucky Coal Field

**Glynn Beck**

The Kentucky Geological Survey is evaluating the movement and fate of pesticides and nitrate at an agricultural site in Henderson County, in the Western Kentucky Coal Field. The study will determine if pesticides and nitrate applied by farmers have infiltrated the groundwater system. Results of the study will be used to provide a conceptual model for groundwater flow in the coal field and relate it to information on potential transport and fate of agricultural chemicals in similar agricultural and hydrogeologic settings. Agricultural specialists will use this information to help determine best management practices (BMP's) for this region.

Focus during the past year has been on the occurrence and movement of nitrate from a dairy barnyard, abandoned 20 years ago, to a sandstone aquifer approximately 70 feet below land surface. Nitrate-nitrogen concentrations are above 40 mg/L in groundwater monitoring wells. More than 100 soil samples to a depth of 5 feet have been taken and are being analyzed for nitrate-nitrogen concentration. Soil water and ground water are also being monitored in an alfalfa field; this is the only known water-quality study of this crop in Kentucky.

This project is a cooperative effort between the Kentucky Geological Survey, the UK Department of Biosystems and Agricultural Engineering, and the UK Department of Agronomy. Funding is provided by Kentucky Senate Bill SB-271.

### Protection of Well-Water Supplies from Nitrate Contamination

**Glynn Beck**

Approximately 6 percent of private wells in the Jackson Purchase Region of western Kentucky yield water that exceeds the U.S. Environmental Protection Agency's maximum contaminant level for nitrate. The Kentucky Geological Survey is determining if some of the private water wells are being contaminated by nitrate moving from the land surface along the well bore to the well pump. The research will focus on poor well seals that might allow leakage. If poor well seals are

responsible for some of the elevated nitrate in water supplies, then this knowledge will be publicized through outreach education programs for citizens. Local officials and well owners are being contacted to identify suitable wells for the study.

Funding for this project is provided by Kentucky Senate Bill SB-271. It is a cooperative effort between the Kentucky Geological Survey, the UK Department of Biosystems and Agricultural Engineering, and the UK Department of Agronomy.

## Hydrogeology of Karst Terranes

### Monitoring the Impacts of the Animal Research Center on Surface- and Ground-Water Quality

**Alex Fogle**

The UK College of Agriculture is constructing the UK Animal Research Center on



*Livestock enclosures close to water wells are commonly a contamination problem. Photo by Phil Conrad.*

karst terrain in Woodford County. Karst is terrain on which sinkholes and caves form, and ground water in karst areas can be polluted by contaminants from the surface. The Agricultural Water Quality Authority requires every farm in Kentucky to have a water-quality protection plan. To comply with this requirement, the Kentucky Geological Survey and the UK College of Agriculture are monitoring water quality at streams, springs, and wells on the property. Collected data are readily available for teaching, research, planning, and construction purposes. Studies are under way to determine movement and storage of water in the soil and karst aquifers for hydrologic modeling purposes.

Since October 1996, nearly 700 water samples have been collected, resulting in more than 10,000 constituent analyses. Weather data from the center's weather station and stage and flow data from six streams have been collected and archived, dating back to November 1994. Nitrate-nitrogen, pH, electrical conductivity, temperature, dissolved oxygen content, and turbidity have been continuously monitored at the center's principal pour point since January 1997.

The center's activity is having a definite impact on surface-water quality, but it appears to be seasonal. For some constituents, such as fecal coliform, water quality is degraded throughout most of

the year. Pollution from sources outside of the center has also been detected. Elevated triazine concentrations were detected in April 1997.

A project report was written and submitted to the College of Agriculture's 271 Committee in April 1998. The project is funded through the Kentucky Senate Bill SB-271 Water Quality Program and the U.S. Department of Agriculture. It is a cooperative effort between the Kentucky Geological Survey and the Department of Biosystems and Agricultural Engineering of the University of Kentucky.

#### **Characterization and Quantification of Nonpoint-Source Pollutant Loads in the Pleasant Grove Spring Basin, Logan County, Kentucky**

*Jim Currens*

The goal of this study is to demonstrate the effectiveness of the U.S. Department of Agriculture's (USDA) Water Quality Incentive Program in protecting ground-water quality. The USDA Natural Resources Conservation Service received funding in April 1995 to implement a variety of best management practices in the Pleasant Grove Spring Basin, a predominantly agricultural region in Logan



*Instruments to sample water quality in the mouth of Pleasant Grove Spring. Photo by Jim Currens.*

County. Ground-water quality was monitored before, during, and after BMP implementation to determine if water quality changed after BMP implementation. Field work was completed in fall 1998, and extensive statistical analysis of the resulting data is under way.

If improvement in the ground-water quality cannot be demonstrated on a basinwide scale, in a real-world setting, then the effectiveness of the BMP's and the program's success in obtaining farmers' cooperation will need to be reevaluated.

A KGS Report of Investigations on the first 3 years of the project is in editorial review, and a report on the last 3 years is in the early draft stage.

#### **Inventory of Karst Springs in Fayette County**

*Jim Currens*

A database of information on springs in Fayette County has been compiled, and a small-scale map showing karst springs has been completed.

This work is largely the result of efforts by Ken Pidgeon, of the Kentucky Division of Water. He recorded location, elevation, flow volume, and a general description of each site. The inventory will also include existing data in the Kentucky Ground-Water Data Repository.

### **Bibliography of Karst Geology in Kentucky**

**Jim Currens**

A comprehensive bibliography of karst-related literature for Kentucky was published by KGS in 1978. Because of the extensive publication on this topic since then, an update is needed. The new bibliography covers the last 20 years and will add more than 800 new references. Thus far, extensive bibliographic searches have been conducted, and a computer database has been established. Before a report can be completed, the database must be reviewed to ensure that most of the important references have been cited. Having this literature easily accessible will make evaluation of water resources and pollution problems much faster and more comprehensive.

### **Atlas of Karst Ground-Water Basins in Kentucky**

**Jim Currens**

A series of ground-water basin maps showing swallow holes, springs, hypothetical flow routes, and estimated ground-water basin boundaries of karst springs is being developed in cooperation with Joe Ray of the Kentucky

Division of Water. Each map will cover a 30 x 60 minute area at a scale of 1:100,000. The ground-water basin boundary will be shown for each basin for which there are sufficient data to delineate the boundary. Less well-defined basins will be represented by lines connecting ground-water dye-trace input points and recovery points. In addition, some basins will be mapped at a large scale if they will serve as examples of basin types or if more detail is available and of special value. The project goal is to assemble the maps into an atlas. These maps will provide the first statewide delineation of karst basins in Kentucky. The value of such maps and data for water supply, ground-water protection, and general economic development is significant.

Five maps are now available: the Lexington, Campbellsville, Harrodsburg, Beaver Dam, and Somerset quadrangles. The Bowling Green quadrangle has recently been submitted for drafting. Revision of the Lexington quadrangle map is also planned.

### **Hydrogeology of Coal Fields**

#### **Hydrology of Large Spoil Areas**

**Dave Wunsch**

Surface coal mining often transforms rugged topography into potentially usable, gently

rolling land in areas where flat land is at a premium. This newly available flat land can lead to economic development and diversification. The Kentucky Geological Survey is evaluating water resources and spoil settlement at the Star Fire Mine in eastern Kentucky, which will be vital for the site's successful postmining development. The suitability of ponds and springs at the site for agricultural, urban, industrial, and recreational uses is being determined. The water in the ponds and springs is derived from ground water stored in the mine spoil. The effects of spoil thickness, age, and premining topography on the degree and

*Ground-water basin maps are valuable for water-supply studies, ground-water protection, and general economic development.*

rate of vertical movement of spoil are also being studied. Areas underlain by recent spoil have settlement rates approaching a foot per year. Data collected by KGS will also be applicable to other areas of Appalachia.

Ongoing monitoring of the springs issuing from the mine spoil is giving us a better understanding of the overall water quality at the site, and of the evolution of the water and its dissolved mineral load. Electronic water-quality loggers are gathering flow and chemical data at the Long Fork Trout Pond, the lowest-eleva-

tion sediment pond on Long Fork, and flow data from the spring at the mouth of the former Chestnut Gap Branch. Samples of solids have been taken at one outlet, and they are being analyzed for isotopes and elements.

This project is funded by A.E.I. Resources and the E.O. Robinson Trust of the University of Kentucky.

**Ground-Water Geochemistry and Its Relationship to Ground-Water Flow in the Eastern Kentucky Coal Field**  
*Dave Wunsch*

The flow and chemical characteristics of ground water in eastern Kentucky are being monitored to study the ground-water systems in coal-bearing rocks. This research is characterizing the occurrence, movement, and quality of ground water, and examines trace elements present in ground water. Information from this study will help people making decisions on the use of ground water, and with the implementation of Kentucky's ground-water protection regulations. Data from the study will aid in the development of statewide ground-water monitoring strategies. Industries that operate in eastern Kentucky, including mining, oil and natural gas, and landfill operations, need this information for both permitting and compliance activities.

The bedrock wells at the Star Fire site were sampled, and water levels are being tracked as part of long-term

monitoring of the background water quality in the region. The water levels and water quality are also being monitored in wells adjacent to recent mining, to determine the impact of mining.

This project is funded by A.E.I. Resources, the E.O. Robinson Trust of the University of Kentucky, and KGS.

**Hydrologic Investigations in Robinson Forest**  
*Dave Wunsch*

The University of Kentucky's Robinson Forest contains some of the largest undisturbed tracts of land in eastern Kentucky. This setting provides a unique opportunity to monitor ground water and investigate the water system of a forested watershed, including the interaction between ground water and surface water. Data indicate that a model proposed by the Kentucky Geological Survey accurately explains why ground water in eastern

Kentucky is divided into chemical zones. This knowledge will allow drillers to devise strategies that will minimize the entry of salt water into wells used for water supplies in valley bottoms.

Wells in Robinson Forest are monitored for water-level changes. Collaborative work is planned with faculty of the UK Department of Forestry to compare base-flow characteristics in unaffected watersheds in the forest and the artificial aquifer at the Star Fire Mine.

This project is funded by A.E.I. Resources, the E.O. Robinson Trust of the University of Kentucky, and KGS.

**Characterization of Hydraulic Conductivity in the Eastern Kentucky Coal Field**  
*Dave Wunsch*

The amount of water that can flow through a rock unit (hydraulic conductivity) varies dramatically in eastern Ken-



*Drilling a monitoring well in eastern Kentucky.*

tucky, making the prediction of ground-water occurrence and movement difficult. This hinders efforts to remove water from mines, prevent landslides caused by leaking coal barriers, predict or track how contaminants are transported, and locate water-supply wells. The Kentucky Geological Survey has assembled a database of hydraulic-conductivity information, which indicates that fractured rock and coal seams are an average of 10 to 100 times more conductive than other rock types, and have apparently captured and diverted fresh water from recharging aquifers (ground-water reservoirs). The quantification of this information will be important to engineers and scientists who deal with water-quality and supply issues in the Eastern Kentucky Coal Field. A publication based on this data is in preparation.

## Hydrogeology and Waste Management of Urban and Industrial Areas

### Maximum Daily and Annual Nutrient and Pesticide Loads from Turfgrass Management Areas

*Mike Williams*

The quality of effluent exiting a turf management area was evaluated in two subwatersheds in Jessamine County with distinctive land uses. The smaller watershed has an intermittent stream and contains a golf course surrounded by residential devel-

opment. This watershed drains into a larger watershed with a perennial stream (Sinking Creek). Sinking Creek watershed contains both residential and agricultural land uses.

Water-quality and pesticide-use studies in the large watershed determined how much lawn-care products were used and how they affected water quality in Sinking Creek. Approximately 33 percent of the homeowners surveyed used lawn-care services, 17 percent applied lawn-care products themselves, and the remainder used no lawn care other than mowing. The most common products used by homeowners and professionals other than fertilizer were herbicides to control broadleaf weeds and crabgrass. The most commonly used herbicides were 2,4-D, mecoprop, and Dicamba for broadleaf weeds, and Pendimethaline for crabgrass. Application rates did not exceed manufacturers' recommendations.

Water-quality analyses in 1997–98 revealed few instances of pesticide concentrations in Sinking Creek that exceeded minimum detection limits. Following spring pesticide application, 2,4-D was detected twice at less than 4 micrograms per liter ( $\mu\text{g/L}$ ), well below the maximum contaminant level (MCL) set by the U.S. Environmental Protection Agency (EPA) of 70  $\mu\text{g/L}$ . No pesticides were detected for the remainder of the sampling period.

Diazinon and 2,4-d were detected at levels up to 2.5  $\mu\text{g/L}$  and 1.4  $\mu\text{g/L}$ , respectively, at the intermittent stream exiting the golf course during monitoring from April through November 1994. No MCL has been established for diazinon, but the EPA's life-time health advisory level is 0.6  $\mu\text{g/L}$ . The diazinon source is most likely the residential neighborhood surrounding the golf course, because diazinon is disapproved for golf courses. Diazinon was found consistently in samples taken from August 30 to October 5, 1994, although at much lower levels than the peak reported above.

A manual and brochure on best management practices for turfgrass have been completed with the assistance of an advisory committee of representatives of State government, academia, the turfgrass industry, and private citizens.

This project was funded by section 319 funds from the EPA, administered through the Kentucky Division of Water, in cooperation with the UK Department of Biosystems and Agricultural Engineering and the Department of Agronomy.

### Hydrogeologic Investigations at the Paducah Gaseous Diffusion Plant, McCracken County, Kentucky

*Steve Fisher*

The Paducah Gaseous Diffusion Plant in McCracken County is a uranium-processing facility where the concen-

tration of uranium-235 is enriched to produce material that can be used as nuclear-reactor fuel. In 1988, the U.S. Department of Energy discovered that ground water north of the plant was contaminated with trichloroethylene, which is commonly used as a solvent, and technetium-99, a radioactive isotope produced in nuclear reactors. In addition, plant facilities include waste-disposal trenches and burial grounds that contain radioactive waste and volatile and semivolatile organic compounds. These trenches and burial grounds may be leaking radioactive and organic contaminants to the ground water.

Kentucky Geological Survey researchers are assessing environmental investigations and remediation activities at the plant. We review and make comments on reports and plans for site investigations, investigate the chemical species and mobility of aqueous uranium in local ground water, investigate release rates of uranium from waste trenches, and are developing a computer model that can be used to predict the transport and fate of uranium leached from waste-disposal facilities.

The Paducah investigations are funded by the U.S. Department of Energy through the Kentucky Water Resources Research Institute at the University of Kentucky.

### **Hydrogeologic Investigations at the Maxey Flats Disposal Site, Fleming County, Kentucky**

**Steve Fisher**

The Maxey Flats disposal site is located on a plateau in Fleming County, in northeastern Kentucky. Low-level radioactive waste was buried in shallow trenches at Maxey Flats from 1963 to 1972, when it was discovered that tritium and other radioisotopes were leaking from the disposal trenches.

Kentucky Geological Survey researchers are investigating the hydrogeology of the Maxey Flats plateau to evaluate the performance of existing monitoring wells and recommend future sampling strategies, select locations for new monitoring wells both around the restricted area and at the property boundary, review results of computer models designed to evaluate effects of various trench-cap designs, and locate fractures that could transport contaminants beyond the restricted area. Because most ground-water flow at Maxey Flats is controlled by fractures, defining potential contaminant transport paths requires more detailed investigations than have been conducted previously. Current activities are focused on evaluating the usefulness of geophysical methods to locate fractures that function as preferential flow paths.

This project is funded by the Kentucky Cabinet for Health Services through the



*Sampling a spring in western Kentucky. Photo by Phil Conrad.*



*Historical entrance to Mammoth Cave, Edmonson County. Mammoth Cave was formed by karst processes.*



*Vaughn Creek, Burkesville, Ky.*



*Eagle Falls, eastern Kentucky.*

Kentucky Water Resources Research Institute of the University of Kentucky.

### Basin Hydrology and Water Supply

#### Statewide Water Resources Development Plan

**Dan Carey**

Governor Paul Patton has issued an Executive Order to ensure that every Kentucky household has access to drinkable water and modern sewer service by the year 2020. The Kentucky Water Resources Development Commission (WRDC) was formed in response to this Executive Order, and the commission contracted with the Kentucky Geological Survey to prepare a strategic water-resources plan that will inventory all water and sewer systems in the state, both public and private; characterize the strengths and weaknesses of those systems; and recommend strategies to build on the strengths and eliminate the weaknesses.

KGS is gathering data from Federal, State, regional, and local agencies. The plan will consider infrastructure and financial and managerial factors as it evaluates water and sewer systems, and will estimate costs to make needed improvements. The commission will also suggest areas where systems could expand, and make recommendations on quality and quantity assurance for private systems. It will discuss how regions could coordinate their resources, and will consider regulatory,

funding, management, and privatization issues.

The plan will be completed by October 1999, and is being funded by the WRDC through the Kentucky Department of Local Government. Both these organizations have been extremely helpful in identifying and bringing the knowledge and expertise of key agencies and organizations into the planning process.

#### Digital Atlas of Kentucky's Ground Water

**Dan Carey**

The Kentucky Geological Survey is creating a ground-water atlas of Kentucky to support the water-resources planning activities of the Kentucky Water Resources Development Commission. The atlas will be used to evaluate ground-water quantity and quality throughout the state, particularly for those areas in which public water may not be available. The atlas will be compatible with the geographic information system under development by the WRDC and will provide the thematic layers of ground-water zones and water-well data. Hydrogeologists from KGS will also help the WRDC in its ground-water resource planning.

The U.S. Geological Survey hydrologic atlases (HA's) for Kentucky will be converted to digital format and placed in a geographic information system. The geology of the HA's will be updated, and water-well data and ground-water research

*The Kentucky Geological Survey is preparing a strategic water-resources plan for the State in response to an Executive Order by Governor Paul Patton that every Kentucky household have access to drinkable water and modern sewer service by 2020.*

obtained in the 40 years since the first HA's were created will be incorporated into the GIS. The new digital atlas will thus combine all the information in the original, paper versions with the knowledge gained since their publication.

#### Water Supplies from Underground Coal Mines in Letcher and Knott Counties

**Dennis Cumble**

Steep terrain and highly dissected topography in the Eastern Kentucky Coal Field limit the ability of surface water to provide adequate municipal supplies. Naturally occurring ground-water systems are sporadic, difficult to locate, and limited by water-quality problems. To alleviate these problems, KGS is evaluating the potential of abandoned underground coal mines to serve as alternative sources for municipal water supplies. This study will (1) identify and characterize

abandoned underground mines that may provide adequate water supplies, (2) evaluate the quantity and quality of the water in those mines, (3) identify and address issues of water quality, safety, and property ownership that may inhibit the use of underground-mine water, and (4) develop a model for evaluating the quantity of underground-mine water that can be used at untested abandoned mines.

This study is being funded by the Kentucky River Authority, and research is focusing on underground mines near population centers in Knott and Letcher Counties, in the region of the headwaters of the North Fork of the Kentucky River. Sixteen abandoned deep mines have been identified as potential water sources, and have estimated storage volumes ranging from 114 to 550 million gallons per mine. High-volume pumping tests on selected mines indicate natural recharge rates ranging from 150,000 to 450,000 gallons per day. Water levels are being monitored to determine seasonal variations in water storage.

Detailed analysis during pumping tests has shown that water quality varies little over time for a particular mine, but does vary substantially from mine to mine. This indicates that the water quality should be determined for each mine, and the limitations of current water-treatment technologies should be considered before a

mine is developed as a water-supply source.

### **Hydrogeologic Evaluation of High-Yield Well Potential in the Eastern Kentucky Coal Field**

**Dave Wunsch**

In much of eastern Kentucky, municipal sources of water are limited and there are no underground mines to supply water. In these areas, KGS is using geologic and remote-sensing technologies to identify

areas that could yield large amounts of ground water. Wells in eastern Kentucky that produce 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. KGS is examining satellite imagery such as Landsat TM and SLAR (side-looking airborne radar) to locate these linear features. Exploratory boreholes and wells are being drilled at sites identified from this imagery.

This year, KGS reviewed satellite imagery of the Kentucky River Basin to identify potential study sites. Exploratory boreholes and wells were drilled at two sites in Breathitt County and one in Letcher County. The Letcher

County well produces enough water (65 gallons per minute) to supply 180 homes, and its yield is greater than 95 percent of all wells drilled in Letcher County, according to data found in the Kentucky Ground-Water Data Repository. One site in Breathitt

*A well sited in Letcher County using remote-sensing techniques produces enough water to supply 180 homes, and its yield is greater than 95 percent of all wells drilled in Letcher County. Another site in Breathitt County produces enough water to support 200 homes, and its yield is greater than 99 percent of all wells drilled in the county.*

County produces enough water to support 200 homes (100 gallons per minute), and its yield is greater than 99 percent of all wells drilled in the county. The second site in Breathitt County did not produce a significant amount of ground water. Additional sites for exploratory drilling are being selected for next year.

The project is funded by the Kentucky River Authority, and the Kentucky Division of Water is assisting in evaluating the presence and density of fractures in the wells through the use of their downhole video camera.

### Geographic Information System for Water-Resources Planning and Management

**Dan Carey**

Broad-based support for water-resources planning requires the distribution of information on issues, alternative solutions to problems, and an understanding of the consequences of policy decisions. In general, this information must be gathered from a variety of sources and clearly summarized. As part of its research activities, the Kentucky Geological Survey has begun assembling a spatial database to be used for water-resources planning and management.

ARC/INFO and ArcView GIS software packages are used to create and maintain spatial data at a statewide and basin level on water supplies, water usage, soils, ground water, water quality, demographics, transportation, infrastructure, oil and natural gas activities, topography, and political subdivisions. These data and the GIS are used to support water, coal, and petroleum resource studies.

### Kentucky Interagency Groundwater Monitoring Network

**Phil Conrad**

New legislation (KRS 151.625) signed into law in March 1998 created the Kentucky Interagency Groundwater Monitoring Network (GNet). The Kentucky Geological Survey was mandated to establish this long-term program in coordination with a new Interagency Technical Advisory Committee on Groundwater (KRS 151.629), which is composed of 14 agencies. KGS coordinates the network program, and various agencies are involved in sampling programs and other activities. The network is beginning to characterize the quality, quantity, and distribution of Kentucky's groundwater resources. This information will be used to "develop community water supplies; address resource allocation concerns; set boundaries on wellhead protection areas; recognize groundwater degradation if it occurs; and evaluate and improve the quality and quantity of data collected through all programs" (KRS 151.620). Some of the needed ground-water sampling has begun. A report on nitrate in

ground water in Kentucky has been published as a network product, and a similar publication on fluoride is nearly finished. The Kentucky Geological Survey published these reports, which were written jointly by KGS and Kentucky Division of Water personnel.

Agencies that have provided sampling for GNet include the Kentucky Division of Water, Kentucky Geological Survey, and Kentucky Division of Pesticides. The Division of Water is using State and Federal funds through the section 319 program to support sampling in south-central Kentucky (1997–98) and the Kentucky River Basin (1998–99). In 1999–2000 the Division of Water will sample 30 new sites in the Salt and Licking River Basins using section 319 funds.

The Kentucky Geological Survey is developing a database on network sampling sites. Financial support was provided by the Kentucky Water Resources Research Institute at the University of Kentucky, through December 1999.

### Surface-Water Database

**Dan Carey**

The surface-water database for Kentucky continues to



*Ground-water well nest.*



*Drilling a monitoring well.*



*Sampling a water well.*

be expanded for use in research and to provide data to respond to public inquiries. With the addition of surface-water data to the KGS relational database, citizens can obtain geologic, topographic, and surface- and ground-water data from a centralized location. Providing easily accessible data in a centralized location will encourage greater efficiency and use of data by consultants, agencies, local governments, and citizens.

Currently, the surface-water database contains flow and water-quality data. Low-flow and flood statistics will be incorporated on a priority basis. The database greatly enhances the Survey's ability to respond to public requests and can be used with the Survey's geographic information system database (see above) to facilitate planning and research for water resources.

### **Water-Quality Survey for Kentucky Army National Guard Training Sites**

**Carlos Galcerán**

The Kentucky Department of Military Affairs has contracted with the Kentucky Geological Survey to assess the quality of surface-water resources of the Wendell H. Ford, Artemus, and Clay City training sites operated by the Kentucky Army National Guard.

The goals of this project are to assess the impact of current activities on surface water at the sites and exiting from the sites, and to develop a long-term plan to monitor surface-water quality. Water-quality measurements and analysis of the data collected will provide a baseline and the framework to allow the National Guard to determine how well it is protecting the land and water resources at these sites. This assessment will indicate what precautions must be instituted to minimize deterioration of the water

resources, and provide the scientific basis to help guide future use of these sites. It will provide the data critical to developing an efficient, long-term, water-quality monitoring plan.

*KGS is providing a baseline and the framework to allow the Kentucky Army National Guard to determine how well it is protecting the land and water resources at its training sites.*

Particular emphasis is being placed on heavily used areas. Physical, chemical, and biological parameters are being monitored and analyzed for each land use, under wet and dry conditions, in order to develop a protocol for long-term monitoring. Monitoring is in progress; two wet seasons and one dry season have been completed. The monitoring plan will be used to meet State requirements and to assess the long-term impact of various land uses on the surface-water resources of the sites.

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- Beck, E.G., Geology and hydrogeology of western Kentucky: Henderson Lion's Club, Henderson, Ky., February 3, 1998.
- Carey, D.I., Digital atlas of ground water in Kentucky: Kentucky Interagency Groundwater Monitoring Network, Technical Advisory Committee, Lexington, Ky., May 18, 1999.
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# Public Service

**M**aking the results of research available to the public is the cornerstone of the Survey's mission. We accomplish this by publishing technical reports; providing information through open-file reports, public databases, and our World Wide Web site at [www.uky.edu/KGS](http://www.uky.edu/KGS); speaking to professional and civic groups; and attending meetings and conferences.

By collaborating with other departments at the University of Kentucky, as well as local, State, and Federal agencies, we can complement each others' strengths, and not duplicate each others' efforts.

## University of Kentucky

Several KGS projects are in collaboration with other departments at UK, including the Department of Geological Sciences, UK libraries, Department of Biosystems and Agricultural Engineering, Department of Agronomy, Kentucky Water Resources Research Institute, and the Center for Applied Energy Research. We have shared our expertise with other departments, such as the Kentucky Transportation Center and the Department of Geography. In addition, Don Haney, John Kiefer, Jim Cobb, Dave Wunsch, Steve Greb, Don Chesnut, Jim Dinger, Jim

Drahovzal, and Cortland Eble are adjunct professors in the Department of Geological Sciences. Cobb and Kiefer teach Environmental Systems 610, an interdisciplinary course in the Graduate School that integrates earth science and engineering for environmental problem-solving. KGS researchers also serve on numerous thesis committees, and have taught courses such as "Field Work in Regional Geology" and "Low-Temperature Geochemistry."

In addition, John Kiefer represented the University at a summit in Washington, D.C., December 8–10, 1998, to

## Public Service Activities

### Requests for information or technical exchanges

Coal and minerals—1,154  
Oil and gas—3,776  
Water—1,987  
Earth Science Information Center—688  
Digital mapping—240\*

### Publication Sales Office

Visitors or requests for information—3,218  
Oil and gas permit applications processed—801  
Oil and gas completions, terminations, drilling affidavits, and changes processed—1,362

### Well Sample and Core Library

Visitors or requests for information—1,091

### Oil and gas well record products sold

Well records copied—21,554  
Electronic-data disks and well lists—50  
Computer-generated overlays to topographic maps—271

### Copies of electric logs and miscellaneous maps (number of feet)—22,238

### Data entry or new records received for oil and gas well records (number of wells)—2,226

### Samples analyzed by Laboratory Services—1,212

### Kentucky Geological Survey publications completed—11

### Publication and map sales

Publications—6,863  
Topographic maps—9,269  
Geologic quadrangle maps—3,195

### Talks to civic and professional groups—117

### Papers by staff members in outside publications—57

### Committees, boards, and societies

International—4  
National—21  
Regional—13  
State—39  
Local—12  
University of Kentucky—20

### Grants and contracts in effect—25

\*For 1999 only

announce the cities selected to participate in Project Impact, a program designed to mitigate natural hazards, rather than merely react to them after the fact. Lexington and Louisville were among the cities chosen for the project, which is sponsored by FEMA (Federal Emergency Management Agency).

### Cooperation with Government Agencies

The Kentucky Geological Survey cooperates with many government agencies at the local, State, regional, and national level. This cooperation takes many forms, from serving on committees and advisory boards, to offering advice, to collaborative research. KGS geologists serve on more than 100 committees or boards (see page 61). They have helped the Kentucky Division of Water find a monitoring location from which they could sample for nonpoint-source pollution in the Royal Spring groundwater basin near Georgetown; provided illustrations for geologic displays to McConnell Springs Park in Lexington and Fishpond Lake, near Jenkins in Letcher County; offered advice to the city of Versailles about ways to mitigate flooding problems associated with sinkholes; and sampled the water quality at Raven Run Nature Sanctuary, near Lexington.

**Lexington-Fayette Urban County Government.** John Kiefer has been serving on committees studying two of

the most important and contentious issues for Fayette County's future: water supply and rural development. For the past several years, he has served on the Lexington-Fayette County Greenspace Commission, which has been helping develop a long-term plan for the rural areas of Fayette County. He has also served on the Water Supply Planning Council, which has been developing a plan for a long-term water supply for Fayette County.



### Educational Outreach

**Earth Science Week.** The Kentucky Geological Survey celebrated Earth Science Week as part of a national initiative undertaken by the American Geological Institute. Kentucky was one of 26 states that proclaimed October 11–17, 1998, as Earth Science Week. As part of the celebration, geologists at KGS presented a week-long series of lunchtime seminars, including a video tour of the Bright Angel Trail in the Grand Canyon, and slide presentations on mineral quarries in Kentucky, geographic information systems, the geology of Kentucky, the geology of the Gulf of Corinth, discovering ice ages, and the volcanic eruption of Mount St. Helens. KGS geologists also gave an earth science talk at an elementary school; hosted a group of middle-school students for a presentation on earth science and a tour of the

Survey's rock, mineral, and fossil collections; held an open house for the public to discuss rocks, minerals, and fossils; and identified rock and mineral samples.

The Survey is now planning for Earth Science Week 1999, and will host activities that introduce the public to the earth sciences, explain how knowledge of the earth sciences is crucial for addressing many challenging problems in society, and allow geologists to share their knowledge and enthusiasm about the earth and its processes.

**Media Interaction.** John Kiefer helped write and produce an educational videotape on natural hazards, "All Kentucky Is at Risk." Shown on public television in December 1998, it was produced in cooperation with the Kentucky Division of Disaster and Emergency Services, the Martin School of Public Policy and Administration at the University of Kentucky, Pat Trotter of the State Hazard Mitigation Adoption Program, and Esther Tattershall of Media Design and Production at UK. It discusses strategies to mitigate the personal loss and cost to individuals, as well as the overall cost to taxpayers, as a result of damage from natural disasters. This videotape won the annual Kentucky Award of Excellence from the Kentucky Association of Government Communicators.

### Talks to School Groups.

KGS has hosted numerous school groups during the year. The children listened to talks on a variety of geological topics, and toured the KGS facilities. The atrium of the Mining and Mineral Resources Building has enough rock and mineral specimens displayed in it to qualify as a small museum. Particularly popular are the new displays of meteorites and fluorescent minerals. The meteorites were donated by William Ehmann, a UK professor emeritus in chemistry; Dr. Ehmann studied moon rocks for NASA in the 1970's, and has also been collecting meteorites for many years. The fluorescent minerals were donated by Harold Watkins of Ewing, Ky., a retired fluorite miner. Staff members also visited schools throughout the state to deliver educational talks, and spoke to

a number of civic organizations as well.

KGS had booths at conferences for various educational groups, such as the Kentucky Earth Science Teachers Association. In addition, KGS geologists are helping the Kentucky Department of Education determine the core content for earth science curriculum (see also "Earth Science Education Network," page 46), and held workshops for teachers throughout the year. They also participated in environmental field days, and judged science fairs and state fair exhibits.

**KGS Kids Day.** KGS sponsored the first KGS Kids Day on June 30, 1999, at the Survey offices in Lexington. Primarily attended by children of KGS staff, the event was designed to introduce geology to elementary- and middle-school children, and show

them that learning can be fun. They looked at amber containing insects under the microscope, learned about dinosaurs, watched an earth science slide show and video, and broke open their own geodes.

**Kentucky History Center.** The Kentucky Geological Survey contributed rock and mineral samples and historical photographs of Kentucky geologists in the field for an exhibit on Kentucky geology at the new Kentucky History Center in Frankfort. The current exhibit is modeled after an exhibit of Kentucky rocks and minerals that was displayed at an exhibition in Louisville from 1883 to 1886, and is being partially recreated in the main exhibit hall of the History Center. The original case used in the 1883-86 exhibition will be used for the display.



*KGS Kids Day. Photos by Collie Rulo.*

## World Wide Web Site

The KGS World Wide Web site ([www.uky.edu/KGS](http://www.uky.edu/KGS)) continues to be popular. The site has received several awards (see page 58), and has extensive information on coal, oil and gas, water resources, rocks and minerals, fossils, and the geology of Kentucky. A virtual regional resource center has an online inventory of oil and gas data organized by region and county, drilling statistics, general information about oil and gas data, and responses to frequently asked questions. A geospatial data library has electronic maps (showing county and state boundaries, area development districts, census block tracts, major river basins, geologic features, hydrology and watersheds, state roads and highways, and a base map of the United States). The site also has the Earth Science Education Network, with extensive resources for kindergarten through grade 1 teachers.

## Earth Science Education Network

In recent years, earth science education has been mandated for different grade levels than previously. This has required teachers with little or no experience in earth science to teach unfamiliar topics. To assist teachers and attract the interest of students in Kentucky, geologically significant locales from across the state are used to explain earth science concepts. To broaden the scope of the

network, links to the best sites on the Internet are selected by geologists at KGS, based on the accuracy of the information, appropriateness for kindergarten through grade 12 audiences, quality of graphics, and availability of free classroom activities and handouts. This information is assembled at a single location, and annotations for each link are provided to enable teachers to find needed information without having to search myriad sites. The network includes hundreds of color photos and images, fact sheets, lesson plans and classroom exercises, e-mail addresses and phone numbers of people involved in earth science outreach, and a listserv to allow teachers and resource persons to exchange ideas and information. Input and materials from educators and students are being incorporated to enhance the site as a learning environment.

A new feature of the network will be summaries of the geology of each of Kentucky's 120 counties, written by high-school students. This is made possible by a grant from the Geological Society of America.

## Workshops and Short Courses

In addition to workshops for teachers, KGS geologists have taught or participated in workshops for coal-industry

*A new feature of the Earth Science Education Network will be summaries of the geology of each of Kentucky's 120 counties, written by high-school students.*

personnel; oil and gas operators; faculty, staff, and students at UK, Berea College, and Centre College; members of the Kentucky Society of Professional Geologists; and personnel from State and local agencies. Topics have been as diverse as roof control in underground mines, geographic information systems, software productivity tools, ground-water networks, watershed protection, growth management, and environmental geology. Sponsors include the Kentucky River Coal Corporation, Petroleum Technology Transfer Council, Kentucky Society of Professional Geologists, Appalachian Rural Systemic Initiative, Kentucky Department for Natural Resources, American Geological Institute, American Association of Petroleum Geologists, Environmental Council of States, and Falls of the Ohio River State Park.

## Field Trips

**KSPG Annual Field Conference.** KGS geologists were active in organizing and leading the Kentucky Society of Professional Geologists (KSPG) annual field conference, at Pound Gap on Pine Mountain near Jenkins in southeastern Kentucky.

State Geologist Don Haney gave the mayor of Jenkins, Robert Shubert, a plaque designating the new roadcut at Pound Gap as Kentucky's first Distinguished Geologic Site. Approximately 2,000 feet of Mississippian and Lower Pennsylvanian strata (rocks between 300 and 345 million years old) are exposed in the roadcut at Pound Gap. This is one of the most extraordinary geologic sections in the eastern United States. Fifteen specialists examined the site during the spring and summer of 1998 and discussed their findings during the field trip.

**Other Field Trips.** KGS geologists led several other

field trips throughout the year, including one in eastern Kentucky for international coal exploration managers, one for members of the Cincinnati Nature Conservancy to Natural Bridge State Park, and one for UK extension agents to kimberlite dikes in Elliott County.

## Conference

Don Haney organized and chaired the Symposium on the History of Geology in New Harmony, Ind., on July 25, 1998. For several decades

*State Geologist Don Haney designated the new roadcut at Pound Gap as Kentucky's first Distinguished Geologic Site. This is one of the most extraordinary geologic sections in the eastern United States.*

in the 1800's, New Harmony attracted leading scientists from across America and abroad, and was a major center for geologic and other scientific investigations. The research conducted at New Harmony had a lasting impact on the advancement of scientific knowledge in America.

## KGS Publication

Kentucky Geological Survey, 1998, Annual report, 1997-98: 57 p.

## Contributions to KSPG Guidebook

Eble, C.F., Greb, S.F., and Dever, G.R., Jr., eds., 1998, Geology of the Pound Gap roadcut, Letcher County, Kentucky: Kentucky Society of Professional Geologists, 166 p.

## Abstract

Kiefer, J.D., 1999, Geology and public policy—A state geological survey perspective: Geological Society of America

Abstracts with Programs, v. 31, no. 2, p. 25.

## Publications

Dever, G.R., Jr., 1999, Memorial to Preston McGrain, 1917-1996: Geological Society of America Memorials, v. 29, p. 93-95.

Noger, M.C., Cobb, J.C., and Hall, E.W., 1998, Memorial to Wallace Woodrow Hagan, 1913-1997: Geological Society of America Memorials, v. 29, p. 113-115.

Ruthven, C.L., and Hall, E.W., 1998, Memorial for Wallace Woodrow Hagan: American Association of Petroleum

Geologists Bulletin, v. 82, no. 11, p. 2148.

## Presentations

Davidson, B., Careers in geology: Madison Middle School, Richmond, Ky., May 7, 1999.

Davidson, B., The geology of Kentucky: Earth Science Week, Kentucky Geological Survey, Lexington, Ky., October 14, 1998.

Davidson, B., The Kentucky Geological Survey's Office of Geologic Information: Illinois Basin Consortium, Lexington, Ky., May 25, 1999.

Davidson, B., OGI: One-stop shopping at KGS: Kentucky Geological Survey

- 39th annual seminar, Lexington, Ky., May 14, 1999.
- Davidson, B., Rocks, minerals, and geology: Nicholasville Elementary School, Nicholasville, Ky., August 10, 1998; Leestown Middle School, Lexington, Ky., September 22, 1999; Stonewall Elementary School, Lexington, Ky., January 26, 1999; Mayfield Elementary School, Richmond, Ky., March 24, 1999; Bridgeport Elementary School, Frankfort, Ky., May 19, 1999.
- Drahovzal, J.A., Honorary membership citation for William Charles MacQuown Jr.: American Association of Petroleum Geologists—Eastern Section annual meeting, Columbus, Ohio, October 7, 1998.
- Gooding, P.J., Geology—How it affects and impacts on our everyday life: Blue Grass Comprehensive Care Center, Well Sample and Core Library, Lexington, Ky., July 17, 1998.
- Gooding, P.J., An introduction to geology: Berea College Educational Talent Search Program, Well Sample and Core Library, July 16, 1998.
- Greb, S.F., Build it and they will come—Creating an earth science education network: Geological Society of America annual meeting, Toronto, Canada, October 28, 1998.
- Greb, S.F., Conglomerates and ancient big rivers: Bluegrass Rock and Mineral Club, Lexington, Ky., November 15, 1998.
- Greb, S.F., Dinosaur art: Kentucky Paleontological Society, Lexington, Ky., July 24, 1998.
- Harris, D.C., Mississippian Newman lithologic core: Kentucky Geological Survey Well Sample and Core Library grand opening, Lexington, Ky., April 29, 1999.
- Kiefer, J.D., Geology and public policy—A state geological survey perspective: Geological Society of America—Southeastern Section annual meeting, Athens, Ga., March 26, 1999.
- Ruthven, C.L., Earth Science Education Network: 32nd annual meeting of the Association of Earth Science Editors, Washington, D.C., September 12, 1998.
- Ruthven, C.L., and Greb, S.F., An earth science education network—Build it and they will come: Geological Society of America—North-Central Section annual meeting, Champaign, Ill., April 22, 1998.
- Smath, R.A., Dinosaurs and Kentucky fossils: Buckley Wildlife Sanctuary, Versailles, Ky., September 28–29, 1998.
- Smath, R.A., Geology of Kentucky: Lancaster High School Science Club, Lancaster, Ky., November 11, 1998.
- Smath, R.A., Kentucky agate and other geological processes: Lexington Rock Club, Lexington, Ky., April 15, 1999.
- Smath, R.A., Public service offerings at the Kentucky Geological Survey: State ESIC Conference, Rolla, Mo., September 2, 1998.
- Smath, R.A., Rocks and minerals: Leestown Magnet School, Lexington, Ky., September 22, 1998; University of Kentucky Ambassador Program, Lexington, Ky., October 6, 1998; Clays Mill Elementary School, Lexington, Ky., October 21, 1998; University of Kentucky Ambassador Program, Lexington, Ky., January 21, 1999; Berea High School, Berea, Ky., January 29, 1999; Deming School, Lexington, Ky., March 3, 1999; Mayfield School, Richmond, Ky., March 24, 1999; Christ the King School, Lexington, Ky., March 30, 1999; Providence Montessori School, Lexington, Ky., April 15, May 5, 1999.
- Smath, R.A., Video tour of the Bright Angel Trail in the Grand Canyon National Park: Earth Science Week, Lexington, Ky., October 12, 1998.
- Smath, R.A., and Davidson, B., Rocks and minerals of Kentucky: Earth Science

Week, Lexington, Ky.,  
October 17, 1998.

Wente, K.J., Fossils of Kentucky: Buckley Wildlife Sanctuary, Versailles, Ky., July 1998; Robertson County Elementary School, Lexington, Ky., March 10, 1999; Christ the King Elementary School, Lexington, Ky., March 30, 1999.

Wente, K.J., Geology of Kentucky: Winburn Elemen-

tary School, Lexington, Ky., March 22, 1999; Winburn Elementary School, Lexington, Ky., April 29, 1999; Cincinnati Nature Center, Natural Bridge State Park, April 23, 1999; Appalachian Explorers Program, Lexington, Ky., June 15, 1999.

Wente, K.J., Landforms: A lesson in structural geology: Living Arts and

Science Center, Lexington, Ky., October 23, 1998.

Wente, K.J., Rocks and minerals—An introduction to earth science: Garden Springs Elementary School, Lexington, Ky., October 20, 1998.

Wente, K.J., What's a geologist? A lesson in earth science: Southern Elementary School, Lexington, Ky., May 17, 1999; Foster Heights Elementary School, Bardstown, Ky., May 24, 1999.

# Office of Geologic Information

Public service is one of the most important functions of the Kentucky Geological Survey. By consolidating geologic data in a single office, KGS geologists are able to make information available to the public in a timely and effective manner. The Office of Geologic Information includes the Kentucky Ground-Water Data Repository, Kentucky Oil and Gas Data Repository, Kentucky Coal Resources Information System, Earth Science Information Center, and Publication Sales office.

Geologic data in electronic and hard-copy formats are archived in the Office of Geologic Information. The office has access to all the major databases of the Survey, enabling staff members to respond to many inquiries from the public. Requests that require more detailed assistance or further explanation are forwarded to the appropriate research staff at the Survey.

A detailed summary of public requests answered by Office of Geologic Information personnel is found on page 43. Requests from the Henderson field office are also included in these statistics.

## Kentucky Ground-Water Data Repository

The Kentucky Ground-Water Data Repository was created in 1990 by the Kentucky Geological Survey under mandate from the Kentucky

General Assembly (KRS 151:035). The purpose of the repository is to archive and distribute ground-water data collected by State agencies, other organizations, and independent researchers and make them publicly available at a centralized location in a manner that meets the needs of the public.

Data in the repository have been provided by more than 15 different agencies. The largest contributor of data on a regular basis is the Kentucky Division of Water, Groundwater Branch. The branch processes drillers' logs from the Certified Water Well Drillers Program, initiated in 1985.

Data are provided to the public on various media, including hard-copy printouts, diskettes, and CD-ROM's. Data may also be transferred electronically by e-mail or ftp (file transfer protocol).

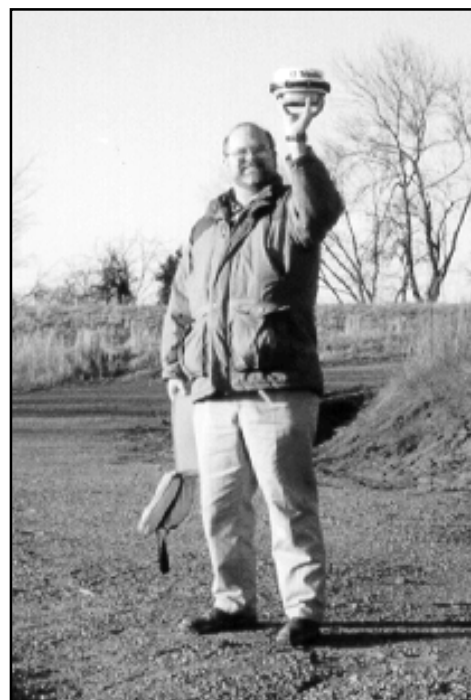
Also included in the repository are hard-copy maps, field notes, publications, and other related information. Efforts to compile ground-water data from State agencies and other sources in the industrial, academic, public-health, and research sectors are continuing as new data are generated.

Repository personnel responded to more than 1,100 inquiries from the public during the fiscal year.

Most of these inquiries were from environmental consulting firms. The remaining inquiries were from the public and private sectors and concerned ground-water occurrence, supply, and quality.

## Kentucky Oil and Gas Data Repository

KGS is the official repository for records of all oil and natural gas wells drilled in the state, and the Geologic Mapping and Hydrocarbon Resources Section is responsible for these records on file in the Office of Geologic Information. Records such as drillers' logs, wireline logs, well-location survey plats, plugging



*Bart Davidson displays the equipment used to take GPS measurements. Photo by Richard Smath.*

affidavits, and completion reports are on file for approximately 175,000 wells. In addition, files for western Kentucky wells are available at the Henderson field office.

Custom printouts based on user specifications are made on request. Well-location base maps are available as overlays for the U.S. Geological Survey 1:24,000-scale, 7.5-minute, topographic quadrangle maps. Data are also available in machine-readable form on floppy disks or by ftp.

Kentucky Geological Survey staff review and enter into the computerized database as many of the older well records as time permits. The project to archive well records

*KGS distributed more than 19,300 maps and publications in fiscal year 1998–99, an average of 78 items per business day.*

in digital format continues. As of June 30, 1999, data for 153,000 wells are available through the database.

### **Electronic Data**

Most KGS data can be provided to the public in electronic format. Tabular reports of oil and gas, water, and coal data are available on diskette, CD-ROM, and by e-mail or ftp, making it easy to enter the information into personal databases or spreadsheets. Digital topographic maps are available on CD-ROM for the entire state. These digital raster images, georeferenced to the universal

transverse Mercator or state plane projection, were created by the U.S. Geological Survey at scales of 1:24,000, 1:100,000, and 1:250,000. Digital elevation models containing topographic information and digital orthophoto quarter quads (aerial photography) at a scale of 1:24,000 are also available on CD-ROM. Other GIS maps are available either on diskette, CD-ROM, or by ftp.

### **Earth Science Information Center**

The Earth Science Information Center (ESIC) has information on the availability of current and historic maps, aerial photography, satellite imagery, and geodetic control and digital cartographic data. Close coordination between the ESIC coordinator and other

KGS scientists makes it possible for customers to obtain desired materials or information with a single inquiry or visit to the Kentucky Geological Survey.

Resources available to the ESIC office for answering requests include a file of more than 5,700 microfiche indexes to aerial photography (available also on CD-ROM), satellite data (with an up-to-date, microimage index), and historic maps (a microfilm file containing 37,400 historical topographic maps of the United States). Access to the USGS electronic database of

geographic names for Kentucky, which contains more than 30,000 place names used on Kentucky topographic maps, is available.

### **Publication Sales Office**

The Publication Sales office makes available published information about Kentucky's mineral and water resources to thousands of customers each year. Maps and reports published by the Kentucky Geological Survey and U.S. Geological Survey account for most of the materials sold. Publications from other sources, as well as open-file reports dealing with Kentucky geology, are also available.

Open-file maps showing landslide susceptibility and related features are available for approximately 250 quadrangles in eastern and south-central Kentucky; copies of these maps are available at a nominal cost.

Kentucky has complete 7.5-minute, 1:24,000-scale topographic and geologic map coverage. The Publication Sales office stocks all 779 topographic maps and most of the 707 geologic quadrangle maps that are still in print. All available 1:250,000- and 1:100,000-scale topographic maps of Kentucky, and complete coverage of hydrologic atlases published by the U.S. Geological Survey, are also kept in stock. Numerous other geologic, geophysical, structure, hydrologic, and mineral-resource maps are also available.

# Well Sample and Core Library

Samples of rock cuttings from selected oil and gas test wells drilled in Kentucky are required by the Oil and Gas Conservation Act of 1960 (KRS chapter 353) to be archived by the Kentucky Geological Survey. The Well Sample and Core Library contains more than 20,000 sets of well cuttings from 120 counties, 2,500 cores from 95 counties, and 95 sets of auger samples from 11 counties. The cost of replacement for the contents of the library is conservatively estimated at \$585 million.

Rock samples are requested from drillers of selected oil and gas wells; cores are also donated, primarily by private companies. Certain cores are sometimes kept confidential for 1 year at the request of the company that drilled them. The Survey's goal is to obtain a representative set of well samples for each Carter coordinate section

(about 1 square mile) of the state. The library also provides storage for samples obtained from research projects. Facilities are provided for researchers, students, government employees, industry personnel, and the public to study the library's materials.

The new Well Sample and Core Library totals 48,000 square feet. All cores and well samples are organized to allow easy identification by farm name, county, operator, location, and permit number.

After the grand opening ceremonies, on April 29, 1999, public tours of the facility were offered, core drilling and well logging were demonstrated, cores were described, and dye-tracing techniques were demonstrated. The grand

opening was held in conjunction with the Kentucky Society of Professional Geologists' annual geosciences symposium, and was well attended.

*On April 29, 1999, the Kentucky Geological Survey's new Well Sample and Core Library was officially opened to the public. The Survey's collection is the fifth largest in the Nation.*

The library recently received a large donation of scientifically important cores of Cambrian and Precambrian rocks from central Kentucky. These cores, several of which were thought to be lost, are from deep exploration wells drilled by Texaco in the late 1960's. They will greatly aid current research at KGS aimed at improving deep gas exploration in eastern Kentucky.



*Grand opening of the Well Sample and Core Library, April 29, 1999. Photos by Collie Rulo.*

# Computer and Laboratory Services

The Computer and Laboratory Services Section operates state-of-the-art laboratory equipment and acquires up-to-date computer software and hardware to provide KGS researchers tools to analyze geologic and hydrogeologic data and collect, store, and manipulate data for reports, maps, charts, and other products for the public. KGS laboratory facilities analyze the chemical and physical characteristics of water, rock, coal, oil and natural gas, and other natural resources.

## Laboratory Services

During the fiscal year, water samples were analyzed for the Kentucky Division of Water. The data from these samples were used by the Kentucky Interagency Groundwater Monitoring Network and for the Section 319 Nonpoint-Source work

plan for fiscal year 1998. The laboratory contracted with the Kentucky Water Watch Program to analyze herbicide and pesticide samples. The laboratory also participated in the fourth International Proficiency Testing Trial of Analytical Geochemistry Laboratories, organized by the International Working Group of the Association Nationale de la Recherche Technique, Paris. A summary of analyses performed by the laboratory is found on page 43.

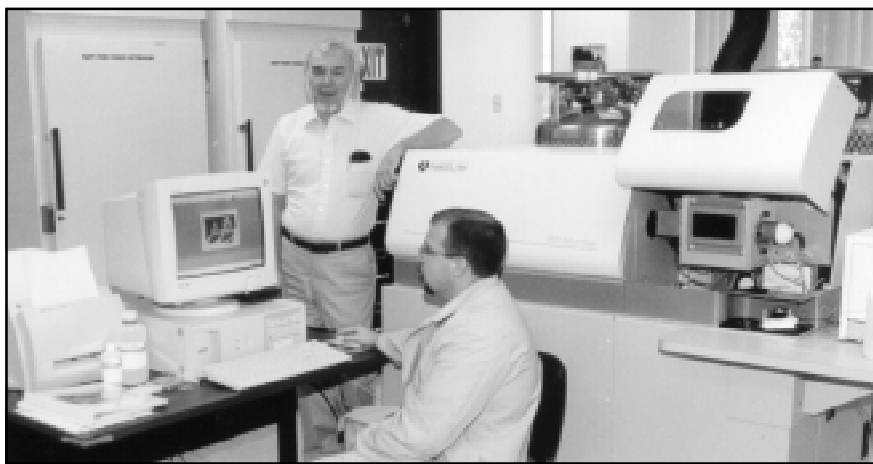
## Computer Services

KGS has begun migrating its users and applications to Intel-based servers running Microsoft's Windows NT operating system. This was done to give KGS more flexibility for future growth, conform with the University of Kentucky's computing and network strategies, lessen the administrative load for main-

taining computing systems, and address Year 2000 issues.

KGS maintains a relational database for geologic and hydrologic information that is the most comprehensive publicly available collection of nonproprietary petroleum, coal, water, and limestone data for Kentucky. Currently, the system is accessed using a variety of interface products such as SQL (structured query language), Datatrieve, and Microsoft Access. KGS researchers access the database to respond to thousands of public inquiries each year and compile data for ongoing research. Future plans are to provide direct public access (with limits) to the database through workstations in the Office of Geologic Information and remote access through the Internet.

KGS has moved the relational database to a Microsoft SQL Server 7 running under the Windows NT operating system. This will allow KGS to integrate its growing spatial database with the relational database. This new database has built-in tools that make possible such things as constructing World Wide Web pages, so that outside users can access the database.



*Ron Gearles demonstrates the ICAP (inductive coupled argon plasma spectrophotometer) for Henry Francis. The ICAP is used for metal analysis of water samples.*

# Office of Communications and Technology Transfer

Geoscientists at the Survey have taken great strides forward in the geospatial organization of data on maps, which will assist the public in understanding important issues such as the quality of ground water, location of karst ground-water basins, thickness of coal seams, distribution of oil and gas wells, and location of mineral and fuel resources. To assist geoscientists in presenting this information in a format that is easy to understand and useful for research, our cartographic staff is achieving continuous improvements in the quality of our maps. We produce high-quality, low-cost maps. By publishing our maps on a print-on-demand basis, we are able to release our maps more quickly to the public, reduce our costs and lower the price, and provide an option for readily updating the maps as more data are available.

The publication of the mineral and fuel resources map of Kentucky (1:500,000 scale) represents the culmination of more than 5 years of research. This wall-size, multicolor map showing the distribution of the state's resources will be an essential tool for producers and users of coal, oil, natural gas, metals, construction raw materials, and industrial rocks and minerals. The map was initially released as a print-on-demand product, and we are now in the process of preparing the map for printing on the press.

The release of four maps showing karst ground-water basin boundaries has been welcomed by researchers in the karst community, as well as officials in State agencies. This map series is the first of its kind in Kentucky and may be the first in the Nation. These maps will be valuable to persons interested in identifying areas subject to geologic hazards such as sink-hole collapse and ground-water pollution as a result of the presence of karst terrane.

As concern about the quality of ground water continues to attract public attention, a series of maps on the occurrence of chemicals in ground water will provide an important tool for

research and analysis. The first map in this series is a map showing the geographic distribution of nitrate-nitrogen concentrations and the general trend of concentrations according to depth below the ground surface. Environmental scientists, engineers, and other professionals will be able to use this information to study general trends in water quality.

As competition in the domestic coal market and electric-power generation industry continues to increase, coal producers and utilities purchasing Kentucky coal will benefit from improved understanding of the thickness and quality of coal in Kentucky. A new series of maps is being generated to summarize the characteristics of Kentucky's most important coal beds. The first in this series is a map of the total thickness of the Lower Elkhorn coal in eastern Kentucky. The results of a study of variations in the geochemistry, petrography, palynology, and paleoecology of the Fire Clay coal bed of eastern Kentucky provides insight to assist mine operators in selectively mining superior coal.

Petroleum industry officials will benefit from the latest addition to our series of oil and gas well-location maps. Data compiled from the Kentucky Oil and Gas Data Repository is used to show the location of oil and gas pools and fields, organized by producing zone. Interest continues among petroleum producers in the resource potential of the tar sands of western Kentucky. In response, the Survey has reprinted a popular study of the tar-sand resources and evaluation of the resource potential.

The expertise of geologists continues to be critical for the wise management of our resources and environment, and the public depends on reliable, professional services of geologists. Since July 1992, there has been formal registration of professional geologists practicing in Kentucky. The Kentucky Board of Registration for Professional Geologists provided funds

to the Survey to hire a professional geologist to serve as a communication liaison between the Board and the public. Doug Reynolds was hired as the communication liaison and began working at the Survey in January 1999.

In the future, we anticipate continued emphasis on adopting state-of-the art cartographic technology to generate traditional geologic maps, as well as a wide array of derivative geologic maps, as geoscientists at the Sur-

vey increasingly use GIS to integrate data from comprehensive databases with digital maps. We also anticipate expanded outreach efforts as we strive to increase the public's understanding of the value of our research and explain why knowledge of the geosciences is essential for addressing crucial issues of resource development, water-supply development and water-quality studies, and geologic hazards.

### **Communications Coordinator for the Kentucky Board of Registration for Professional Geologists**

***Carol Ruthven***

A new position was created to establish a liaison between the Kentucky Board of Registration for Professional Geologists, professional geologists registered in Kentucky, and other persons and organizations concerned with licensing of geologists in the state. Doug Reynolds began as the communications coordina-

tor for the Board in January 1999.

Since the position was created, communication activities have centered on creating a quarterly report distributed to registered professional geologists and other interested persons, revising and enhancing the World Wide Web site of the Board, and responding to public inquiries about licensing of geologists in Kentucky. The project is funded by the Kentucky Board of Registration for Professional Geologists.

### **Information Circular**

◆ **IC 60. Ground-Water Quality in Kentucky: Nitrate-Nitrogen**, by Philip G. Conrad, Daniel I. Carey, James S. Webb, James S. Dinger, and Matthew J. McCourt, 4 p.

A map of the state shows the geographic distribution of nitrate-nitrogen concentrations, and a table shows the general trends of concentrations according to depth below the ground surface. Environmental scientists,

engineers, and other professionals can use this information to gain an understanding of general trends in water quality that may be relevant on a regional or site-specific basis.

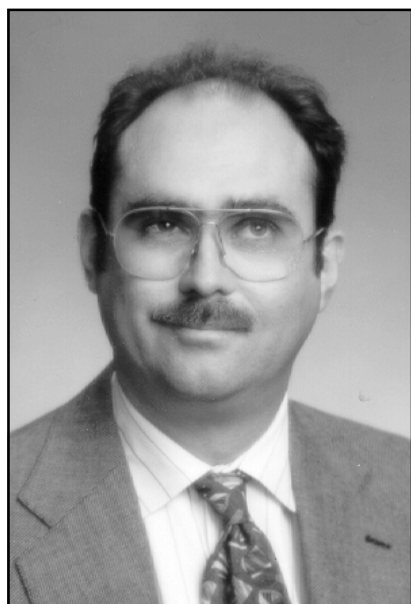
### **Map and Chart Series**

◆ **MCS 16, Mapped Karst Ground-Water Basins in the Harrodsburg 30 x 60 Minute Quadrangle**, by James C. Currans and Joseph A. Ray, scale 1:100,000.

◆ **MCS 17, Mapped Karst Ground-Water Basins in the Campbellsville 30 x 60 Minute Quadrangle**, by Joseph A. Ray and James C. Currans, scale 1:100,000.

◆ **MCS 18, Mapped Karst Ground-Water Basins in the Somerset 30 x 60 Minute Quadrangle**, by James C. Currans and Joseph A. Ray, scale 1:100,000.

◆ **MCS 19, Mapped Karst Ground-Water Basins in the Beaver Dam 30 x 60 Minute Quadrangle**, by Joseph A. Ray and James C. Currans, scale 1:100,000.



*Doug Reynolds*

These four maps are part of a series showing karst ground-water basin boundaries of 30 x 60 minute quadrangles in central Kentucky. The maps also show the locations of dye traces, springs, and swallow holes. They are critical to the regional understanding of ground-water flow in karst aquifers and are powerful tools for accessing literature about site-specific problems.

✂ **MCS 20. Total Coal Thickness of the Lower Elkhorn Coal in Eastern Kentucky**, by Ernest E. Thacker, Gerald A. Weisenfluh, and William M. Andrews Jr., various scales.

This map is the first in a series that will summarize characteristics of Kentucky's most important coal beds. The maps will be particularly beneficial for professionals in the coal industry and those involved in planning.

✂ **MCS 21. Mineral and Fuel Resources Map of Kentucky**, by Warren H. Anderson and Garland R. Dever Jr., scale 1:500,000.

This wall-size, multicolored map shows the distribution of the state's resources and will be an essential tool for both producers and users of coal, oil, natural gas, metals, construction raw materials, and industrial rocks and minerals. The map will also provide valuable information that

will be useful to government agencies, engineering firms, consultants, researchers, and students for a multitude of purposes.

⚙ **MCS 22. Oil and Gas Map of the Corbin 30 x 60 Minute Quadrangle**, by Brandon C. Nuttall, scale 1:100,000.

Data compiled from the Kentucky Oil and Gas Data Repository show the locations of oil and gas pools and fields, organized by producing zone. This map will provide the public, government agencies, and the petroleum industry with a vital tool for planning, exploration, and development of oil and gas resources in Kentucky.

## Report of Investigations

✂ **RI 14. Compositional Variations in the Fire Clay Coal Bed of Eastern Kentucky: Geochemistry, Petrography, Palynology, and Paleocology**, by Cortland F. Eble, James C. Hower, and William M. Andrews Jr., 18 p.

Bench samples of the Fire Clay coal from eastern Kentucky were analyzed geochemically, petrographically, and palynologically to determine spatial or temporal trends. Bench sampling provided more detailed information than full-channel sampling would have, and is recommended to allow mine

operators to selectively mine superior coal and isolate inferior coal. The Fire Clay coal in the study area is split into an upper and lower bench by a flint-clay parting. The results of this study indicate that mining in this area should be confined to the upper bench.

## Reprint

⚙ **R 45. Tar-Sand Resources of Western Kentucky**, by Martin C. Noger, 27 p.

Tar-sand deposits in western Kentucky have been recognized as a potentially significant mineral resource since the middle of the 19th century. Deposits of bitumen-bearing Late Mississippian and Early Pennsylvanian sandstones have been reported both at the surface and in the subsurface for a distance of approximately 100 miles along the southeastern rim of the Eastern Interior Basin. This reprint summarizes the results of a project to inventory and evaluate the oil-resource potential of the asphaltic sandstones in the subsurface of western Kentucky. In-place resources are calculated to be in excess of 3 billion barrels.

## Miscellaneous

❖ **KGS Annual Report, 1997-98**, 57 p.

# Awards and Appointments

## Awards

### **William E. Lyons Award.**

On May 14, 1999, Don Haney was presented the William E. Lyons Award, given each year by the Martin School of Public Policy and Administration at the University of Kentucky to the person associated with the University who has made the most outstanding contributions in the area of public policy. Haney was recognized for expanding the scope of the geological survey in numerous areas, including environmental protection, resource assessment, and water supply since 1978, when he became the director of the Survey. Haney's contributions include his work to encourage passage of ground-water monitoring legislation in Kentucky; securing funds for constructing the Mining and Mineral Resources Building at UK; assisting the Lexington-Fayette Urban County Government in planning a water-management strategy for the Kentucky River, leading to the creation of the Kentucky River Authority, which he chaired in 1994–95; and organizing support for legislation establishing the Kentucky Ground-Water Data Repository in 1992.

**Geological Society of America.** Cortland Eble was named a Fellow by the society. Fellowship is awarded to members who have actively promoted the science of geology through their own



*State Geologist Donald C. Haney receives the William E. Lyons Award from Edward Jennings, director of the Martin School. Photo by Jim Cobb.*

professional endeavors, and who have promoted GSA through involvement in various activities such as divisional functions, symposia, and field trips. Eble is one of only 27 geologists under the age of 40 to be named a Fellow.

**American Institute of Professional Geologists.** Dave Wunsch was named the recipient of the 1999 Outstanding Kentucky Geologist Award from the Kentucky chapter of the American Institute of Professional Geologists during a ceremony on May 8, 1999, in Morehead, Ky. The award is presented to the professional geologist in Kentucky who has made significant contributions to the advancement of geological sciences and the practice of geology at both the state and national level. Wunsch is currently on leave from the University of Kentucky to serve as a Congressional Science Fellow in the U.S.

House of Representatives, where he is an advisor on scientific and technical issues.

**International Pittsburgh Coal Conference.** Jerry Weisenfluh and Ernie Thacker won honorable mention for the poster they presented at the Fifteenth Annual International Pittsburgh Coal Conference, September 14–18, 1998. The title of the award-winning poster was “Implications of Coal-Bed Splitting for National Coal Assessment.”

**American Association of Petroleum Geologists.** Steve Greb and Jerry Weisenfluh won the Ralph E. Miller Energy Minerals Division Award for the best paper presented at the Eastern Section meeting of the American Association of Petroleum Geologists, October 9, 1998. The title of their paper was “Mining Geology of the Hazard No. 8 Coal, Four Corners Formation, Middle Pennsylvanian, Eastern Kentucky Coal Field.”

**Geological Society of America.** Steve Greb, Don Chesnut, and Cortland Eble won the Geological Society of America Coal Geology Division's Best Paper Award. The award, which was presented at GSA's annual meeting on October 26, 1999, was for the paper "Changing Influences of Tectonics, Eustasy, and Climate on Pennsylvanian Coals in the Illinois and Appalachian Basins."

**Kentucky Geological Survey Web site.** On July 22, 1998, the Kentucky Geological Survey's Web site received two different awards. First, the KGS Web site was featured by the Learning Kingdom as a "Cool Site of the Day." Each day the Learning Kingdom presents a new "cool fact" that is intended to be both educational and entertaining. The KGS Web site was selected for its educational value in describing the giant centipede *Arthropleura*, which lived during the Pennsylvanian Period (about 300 million years ago), and was about 6 feet (2 meters) long. The fossils of this ancient centipede can be found in shales and coal beds across the central United States. Approximately 27,000 readers view the Learning Kingdom site daily. The second award was a Links2Go Key Resource award under the topic heading for "Surveys."

## Appointments

**Governor's Geographic Information Advisory Council.** Dan Carey was elected to the Executive Committee of this council.

**Kentucky Interagency Technical Advisory Committee on Groundwater.** Phil Conrad was appointed chair of the Network Design Subcommittee of the advisory committee. The advisory committee considers issues involving the Kentucky Interagency Groundwater Monitoring Network, which was mandated through legislation in the spring of 1998. That network is being implemented by the Kentucky Geological Survey with the involvement of other agencies. The Network Design Subcommittee considers issues that concern network sampling and related parts of the network program.

The advisory committee also created a Data Subcommittee, which will be chaired by Bart Davidson. This subcommittee will consider issues of electronic data transfer and data storage.

**International Journal of Coal Geology.** In February 1999, Cortland Eble agreed to serve on the editorial board of this prestigious journal, published by Elsevier, in the Netherlands.

**Kentucky Society of Professional Geologists.** In June, Carlos Galcerán was appointed seminar chairman.

**Central United States Earthquake Consortium.** John Kiefer was named chairman of the Central United States Earthquake Consortium State Geologists for 1999–2000 at their meeting in Alaska in June 1999.

**Kentucky Department for Public Health.** The department is sponsoring a conference on public health, to be held in August 1999. Bart Davidson is a member of the planning committee for the conference.

**Kentucky Women's Leadership Network.** In May 1999, Carol Ruthven was elected secretary of the network.

**UKadvance Leadership Development Institute.** Meg Smath was a graduate of the 1998 class of the institute at the University of Kentucky. The program, which selects 40 participants every 2 years, provides opportunities for personal and professional growth for University of Kentucky staff, in support of the University's mission of teaching, research, and service. Smath also serves on the UKadvance Application Committee.

# New Staff

## Coal and Minerals

**Dara Grider** and **Matt Gregory**, both undergraduates in the Department of Geological Sciences at UK, interpret and enter coal data into the KGS database.

**Kristin Palmgreen**, a student in the Natural Resources Conservation Program at the University of Kentucky, compiles coal information, along with **Rob Blair**, a master's candidate in the Department of Geological Sciences; Rob received his bachelor's degree in geology from UK.

## Communications and Technology Transfer

**Doug Reynolds**, the communications coordinator for the Kentucky Board of Registration for Professional Geologists, graduated with a bachelor's degree from Murray State University in 1979 and a master's degree in geology from Indiana University in

1987. He has presented papers at professional meetings and taught geology part-time at Owensboro Community College and Brescia University.

## Computer and Laboratory Services

**Jason Backus**, Research Analyst in the water parameters laboratory, has more than 4 years of analytical laboratory experience with Galbraith Labs and Altech Biotechnology. His experience includes various sample preparation techniques and the use of both flame and graphite furnace atomic absorption spectroscopy.

**Ron Gearles**, Research Analyst in the metals and inorganic anions section of the laboratory, was previously employed with McCoy and McCoy Environmental Consultants as the quality assurance director and head of the

metals division of the Pikeville office.

## Geologic Hazards

**Ed Woolery**, Geologist IV, Geologic Hazards program, has a bachelor's degree in geology from Eastern Kentucky University, a bachelor's in civil engineering from UK, and master's and Ph.D. degrees in geology from UK. Ed was previously employed by the U.S. Army Corps of Engineers and the Defense Mapping Agency.

## Geologic Mapping and Hydrocarbon Resources

The staff of the Digital Geologic Mapping project was increased to help meet our goal of digitizing all 707 of the 7.5-minute geologic quadrangle maps that cover Kentucky by the year 2005. Doug Curl, Steve Martin, and Jason Patton were hired as Geologist



*New staff, fiscal year 1998–99. Front row, l–r: Jack Stickney, Jason Backus, Jason Patton, Doug Curl, Rob Blair, Kristin Palmgreen, Steve Martin, Doug Reynolds, John Hickman. Back row, l–r: Ron Gearles, Shawn Duncan, Ed Woolery, Michael Stidham, Chris Hettinger, Michael Solis, Xin-Yue Yang.*

II's; Shawn Duncan, Chris Hettinger, Michael Solis, and Elise Venard as Geologic Technicians; Xin-Yue Yang as a Post-Doctoral Scholar; Qinhua Zhang as a Visiting Scholar; and Ed Melton, Michael Stidham, and Carrie Wirth as student assistants. **Doug Curl** has a bachelor's degree in geology from Guilford College, and completed his master's degree in geology at the University of Tennessee. He has an extensive computer background in addition to his geologic mapping experience in the Appalachian Piedmont. **Steve Martin** has a bachelor's degree in business from the University of Tennessee–Chattanooga, another bachelor's degree in geology from the University of Tennessee–Knoxville, and a master's degree in geology from the University of Tennessee–Knoxville, where he mapped part of the Blue Ridge in Tennessee. Previously, Steve worked for the Arkansas Geological Commission, where he used GIS in preparing several digital 7.5-minute geologic quadrangle maps for parts of the Arkansas Coastal Plain. **Jason Patton** has a bachelor's degree in geology from Arkansas Tech University and a master's degree in geography from Murray State University. Jason's thesis was on the tar sands of south-central Kentucky. He has had extensive course work and experience as a research assistant in geographic information systems, global positioning systems, and remote

sensing. He also has skills in programming languages. **Shawn Duncan** has a bachelor's degree in environmental science with an emphasis on geology and geography from Morehead State University, where he graduated with honors in 1997. Previously, he worked with the Morehead Wastewater Treatment Plant. **Chris Hettinger** received his bachelor's degree in geology from the University of Kentucky. Chris previously worked on the project as a student assistant. **Michael Solis** has a bachelor's degree in geology from the University of Alabama–Birmingham, and previously worked with Quest Engineering in Lexington. He has geologic mapping experience in the Coosa Synclinorium near Cooksprings, Ala. **Elise Venard** completed her bachelor's degree in geology at the University of Kentucky. **Xin-Yue Yang** has bachelor's and master's degrees from universities in China, and received his Ph.D. from the University of Kentucky in August 1998. He has a strong background in geology, especially in tectonics, mineral deposits, and fluid-rock interactions of orogenic belts. He is also knowledgeable in several computer languages and has experience with ARC/INFO. **Qinhua Zhang** received his Ph.D. from Changsha Institute of Geotectonics, Chinese Academy of Sciences. **Ed Melton** is a mining engineering student and working toward a B.S. degree. **Michael Stidham**

received his bachelor's degree in biology at the University of Kentucky, and is working on a master's degree in geology.

**Kari Wirth** is a master's candidate in hydrology at the University of Kentucky.

**John Hickman**, Geologist II on the Rome Trough Consortium project, completed his master's degree in geology at Texas A&M University, where he studied the structural geology of Taiwan. He has a bachelor's degree in geology from the University of Michigan. **Tina White**, student assistant on the same project, is a junior in geology at the UK Department of Geological Sciences. She has a bachelor's degree in history from Berea College, where she received awards in both history and geology.

## Water Resources

**Jack Stickney**, Hydrogeologist IV on the Statewide Water Resources Development Plan and the Digital Atlas of Kentucky's Ground Water, received his master's degree in geology from Eastern Kentucky University, and is a registered professional geologist with 20 years experience in geology and hydrogeology.

**Mike Williams**, Hydrogeologist IV, received his Ph.D. in biosystems and agricultural engineering from the University of Kentucky. He is a licensed professional engineer and has done research in environmental-risk assessment, site audits, pollution prevention, nonpoint-source pollution, hydrology, and animal waste.

# Committees, Boards, and Advisory Activities

## International

- American Association of Petroleum Geologists
- Association of Earth Science Editors
- Geological Society of America
- The Society for Organic Petrology

## National

- American Geological Institute
- American Society for Testing and Materials
- Association of American State Geologists
- Association of Engineering Geologists
- Data Model Committee for the National Geologic Mapping Program
- Geological Society of America National Committee on Geology and Public Policy
- Geology Alumni Advisory Board for the Department of Geology, University of Iowa
- Interstate Oil and Gas Compact Commission
- Mineral Resources Committee of the National Association of State Universities and Land-Grant Colleges
- National Academy of Science / National Research Council
- National Association of State Universities and

- Land-Grant Colleges
- National Coal Quality Inventory Advisory Committee
- National Water Resources Policy Committee
- Natural Resources Conservation Service
- Sandia National Laboratory
- Seismological Society of America
- U.S. Army Corps of Engineers
- U.S. Department of Energy
- U.S. Department of the Interior
- U.S. Geological Survey
- U.S. Geological Survey Energy Program Council

## Regional

- Advisory Committee for the Rapp Granary–Owen Foundation, New Harmony, Ind.
- A.E.I. Resources Wildlife Management Area Education Committee
- Appalachian Basin Coal Consortium
- Appalachian Oil and Natural Gas Research Consortium
- Appalachian Region of the Petroleum Technology Transfer Council
- Central United States Earthquake Consortium State Geologists
- Cincinnati Arch Consortium

- Eastern Section, American Association of Petroleum Geologists
- Southeastern Section of the Geological Society of America
- Illinois Basin Consortium
- Ohio River Basin Consortium for Research and Education
- Rome Trough Consortium
- Technical Guidance Committee for the Pittsburgh Office of the Federal Office of Surface Mining

## State

- Clement Mineral Museum
- Governor's Earthquake Hazards and Safety Technical Advisory Panel
- Governor's Geographic Information Advisory Council
- Interagency Technical Advisory Committee on Groundwater
- Kentucky Agricultural Water Quality Authority
- Kentucky Board of Registration for Professional Geologists
- Kentucky Department for Environmental Protection
- Kentucky Department for Local Government
- Kentucky Department for Local Health
- Kentucky Department of Education
- Kentucky Department of Natural Resources

- Kentucky Division of Conservation
- Kentucky Division of Disaster and Emergency Services
- Kentucky Division of Water
- Kentucky Engineering Earthquake Response Team
- Kentucky Geographic Information Advisory Council
- Kentucky Hazard Mitigation Adoption Program
- Kentucky History Center
- Kentucky Human Resources Cabinet
- Kentucky Interagency Technical Advisory Committee on Groundwater
- Kentucky Museum of Natural History
- Kentucky Oil and Gas Association
- Kentucky On-Site Sewage Disposal Advisory Committee
- Kentucky Paleontological Society
- Kentucky River Basin Team
- Kentucky River Authority
- Kentucky Section of the American Institute of Professional Geologists
- Kentucky Society of Professional Geologists
- Kentucky Transportation Cabinet
- Kentucky Water Availability Advisory Council
- Kentucky Water Interagency Coordination Committee
- Kentucky Water Resources Development Commission
- Kentucky Watershed

### Monitoring and Assessment Committee

- Kentucky Watershed Prioritization Committee
- Kentucky Watershed Steering Committee
- Kentucky Water-Well Drillers' Certification Board
- Kentucky Women's Leadership Network, Board of Directors
- Legislative Research Commission
- Mammoth Cave Karst Area Water-Quality Oversight Committee

### Local

- City of Georgetown
- City of Versailles
- Evansville-Henderson Disaster Resistant Community Committee
- Fayette County Board of Education
- Lexington Living Arts and Science Center
- Lexington-Fayette Urban County Council Storm Water Management Committee
- Lexington-Fayette Urban County Government McConnell Springs Restoration Committee
- Lexington-Fayette Urban County Government Storm Water Advisory Committee
- Lexington-Fayette Urban County Government Greenspace Commission
- Lexington-Fayette Urban County Government Water Supply Planning Committee
- National Speleological Society, Blue Grass Grotto

- Raven Run Nature Sanctuary

### University of Kentucky

- Appalachian Rural Systemic Initiative
- Capital Campaign Committee
- Center for Applied Energy Research Advisory Board
- College of Agriculture
- Cost Accounting System Appeal Committee
- Department of Biosystems and Agricultural Engineering
- Department of Geological Sciences
- Environmental Initiative Committee
- Environmental Systems Program
- Kentucky Senate Bill (SB-271) Program
- Kentucky Transportation Center
- Kentucky Water Resources Research Institute, Research and Policy Committee
- Lexington Campus Research Subcommittee
- Martin School of Public Policy and Administration
- Media Design and Production
- Natural and Engineering Sciences Promotion and Tenure Committee
- Research Advisory Committee
- Research and Graduate Studies Web Steering Committee
- UKadvance Application Committee
- Wellness Advocates

# Research Funding Sources

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## A.E.I. Resources

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 Cyprus-Cumberland Coal  
 Electric Power Research Institute  
 Equitable Resources Energy Company  
 Gas Research Institute  
 Geological Society of America  
 Kentucky Board of Registration for Professional Geologists  
 Kentucky Cabinet for Health Services  
 Kentucky Department for Local Government  
 Kentucky Department of Military Affairs  
 Kentucky Division of Communications  
 Kentucky Division of Disaster and Emergency Services  
 Kentucky Division of Water  
 Kentucky Natural Resources and Environmental Protection Cabinet  
 Kentucky River Authority  
 Kentucky Senate Bill SB-271  
 Kentucky Transportation Cabinet  
 National Earthquake Hazards Reduction Program of the U.S. Geological Survey  
 Peak Energy  
 Petroleum Technology Transfer Council  
 UK Kentucky Water Resources Research Institute  
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