





*Cover photo:* by Bethany Overfield, KGS geologist.

A steel and concrete bridge faced with native sandstone from a McCreary County quarry carries KY 90 over the scenic Cumberland River at the McCreary / Whitley County line. The 460-foot long bridge was completed in 1954.

The state geologist has reported on the progress of the Kentucky Geological Survey to policy-makers and citizens for over 153 years, and this is my eighth year writing this summary. The mission of the Survey, to serve the citizens of the commonwealth through research and public service on geology, mineral and fuel resources, geologic hazards, water, mapping, and information dissemination, is relatively unchanged, but the details, methods, and focus have undergone great changes.

Energy and global climate change were the most discussed earth-science issues of 2006-07, and were the subject of major news stories on record oil prices, peak oil supply, earthquakes, severe droughts, and global warming. The Nobel Peace Prize for 2007 was awarded to the United Nations Intergovernmental Panel on Climate Change and former Vice President Al Gore for their stance on global warming. Gore's Academy Award-winning documentary, "An Inconvenient Truth," dramatized man's role in global warming. It was embraced as visionary by some and vilified as trumped up by others. This demonstrates how geology-related issues can become highly politicized.

Important measures of progress and effectiveness at KGS are numbers and amounts of grant funding, publications completed, and amount of data disseminated. KGS had 22 funded projects totaling \$1,457,000 in multiyear funding, and 49 new publications. Internet searches and downloads averaged 1,000 per day.

KGS completed phase I of the Central U.S. Seismic Observatory, which is a 2,000-foot-deep well for seismic monitoring equipment in the New Madrid Seismic Zone. It is an observatory for research on earthquake-resistant engineering to collect information on soils and rock behavior in response to earthquakes. CUSSO was made possible by funding from the Kentucky Research Consortium for Energy and the Environment and contributions from the U.S. Geological Survey.

Drought in Kentucky once again raised awareness of the fragility of our water resources. KGS conducted research on many water issues and produced reports on the quality and availability of groundwater in

the commonwealth. In an interesting combination of groundwater hydrology and geologic engineering, KGS researchers unraveled questions about erosion of aggregate beneath the Cumberland Gap tunnel highway. Results of this work will help engineers stabilize the tunnel highway.

KGS, with the UK Department of Earth and Environmental Sciences, has a scientific exchange with the Lanzhou Institute of Seismology in Gansu Province, China. Four KGS researchers visited the province and conducted seismic reflection studies on active faults. The group was treated to a ride on the new Qinghai-Tibet Railway linking central China and Tibet. KGS hosted Vice Governor Li Ying and a delegation from Gansu Province for a visit to Kentucky and meeting with Gov. Ernie Fletcher. This program is highly regarded by both parties as a significant scientific endeavor.

I served on a committee for the National Academy of Science/National Research Council to study federal funding for coal. Coal is the largest domestic energy reserve in the United States but has many environmental, social, and technical problems that must be addressed. Currently, not enough federal resources are being provided to ensure increasing coal production can be done in the safest and most efficient manner. The study verified a sufficient domestic resources for at least 100 years and set the needs for federal funding for research in all areas of the coal fuel cycle.

KGS staff testified for a number of legislative committees and consulted with State officials to help plan research programs to manage CO<sub>2</sub> emissions. Future annual reports will have much more information about carbon sequestration research, but at the end of the fiscal year, KGS received the largest State grant in its history to investigate CO<sub>2</sub> for enhanced oil and gas recovery and permanent sequestration in deep geologic formations. This \$5-million grant will allow KGS to drill deep test holes and cooperate with industry partners in developing technologies to enhance oil and gas production.

This is an exciting and tremendously active time for researchers and staff at KGS.



*James Cobb*  
James Cobb  
State Geologist and Director



The mission of the Kentucky Geological Survey is to serve the people of Kentucky with information about resources, groundwater, and geologic hazards. Never in history has geologic information been so available, and never before has such a diversity of new information been put before the public.



# Energy Research

**National energy issues are reflected in KGS research.**

Interest in the development of regional energy resources and the reduction of man-made greenhouse gases guided the work of the Energy and Minerals Section during the fiscal year. The section continued its working relationship with the Governor's Office of Energy Policy on several projects as well as its participation in three regional Department of Energy carbon sequestration partnerships. Section staff provided geologic assessments of a number of locations for the state's "site bank" for possible projects to convert coal to liquid or gas fuels. The assessments focused on the potential for carbon sequestration at the 18 sites.

## **Drahovzal Retires; Harris Becomes Section Head**

On September 30, **Jim Drahovzal** retired as the head of the Energy and Minerals Section after serving in the position for nearly 18 years.



Jim Drahovzal

During his time as section head, he focused on cooperative work with other state surveys, which resulted in the creation of groups such as the Illinois Basin Consortium and the Cincinnati Arch Consortium. He guided the Energy and Minerals Section as it made research proposals to state and federal agencies and developed a research relationship with the Governor's Office of Energy Policy.

**Dave Harris**, who had served as interim section head after Drahovzal's retirement, was permanently appointed section head on February 1. He is a native of Roanoke, Va., with experience in the petroleum industry and 17 years with KGS. His KGS career has included research on the Big Lime formation in eastern Kentucky and regional studies of the Rome Trough and Trenton/Black River hydrothermal dolomite formation, among other research projects.

## **Rough Creek Graben Consortium**

The Energy and Minerals Section enlisted the help of 11 energy exploration companies to form the Rough Creek Graben Consortium, a public/private partnership studying the oil and gas production potential of the graben in western Kentucky. The Governor's Office of Energy Policy is also participating in the 2-year \$349,370



Rough Creek Graben Consortium project manager John Hickman speaks to potential project partners during a meeting with industry representatives.

project, managed by **John Hickman**. Each energy company has agreed to contribute at least \$10,000 for each year of the project, and GOEP has pledged a 39 percent share. This fiscal year marked the second phase of the project.

Hickman began gathering and interpreting available energy-related data about the Rough Creek Graben for the project. The U.S. Geological Survey, which is assessing the energy potential throughout the Illinois Basin, has also agreed to do bio-marker testing of oil samples gathered for the project.

Energy exploration companies participating in the project are based in Kentucky, Ohio, West Virginia, Michigan, and Colorado.

## **Carbon Sequestration**

KGS geologist **Brandon Nuttall** completed a study that determined that deeper and thicker parts of the Devonian shales under two-thirds of Kentucky could provide a large geologic storage reservoir for captured carbon dioxide (CO<sub>2</sub>). His 3-year study was funded by the U.S. Department of Energy. The geologic storage of CO<sub>2</sub>, known as carbon sequestration, is one method for reducing CO<sub>2</sub> in the atmosphere.

Nuttall's project, which involved analysis of shale samples from Appalachian Basin and Illinois Basin wells, showed that Devonian black shales in Kentucky could store up to 28 billion tons of injected CO<sub>2</sub> through a bonding process known as adsorption. The shale may also release



natural gas when carbon dioxide is present, possibly adding an economic incentive to the process.

**Marty Parris** completed the first phase of his work on surface and shallow monitoring of the movement of CO<sub>2</sub> and methane gas between the air and soil at four major sites in the eastern part of Kentucky. He took over 1,000 samples from the surface to a meter deep to characterize how CO<sub>2</sub> moves from the soil to the atmosphere and how methane diffuses into the soil during summer and winter seasons. Knowing how much of this background activity already exists will be important for carbon sequestration projects, in order to differentiate between existing activity and actual leakage of stored carbon dioxide.

Work continued on three regional carbon sequestration partnerships that KGS is participating in: the Midwest Regional Carbon Sequestration Partnership (eastern Kentucky; **Steve Greb**, principal investigator), the Midwest Geologic Sequestration Consortium (western Kentucky; **Brandon Nuttall**, principal investigator), and the Southeast Regional Carbon Sequestration Partnership (eastern Kentucky coals; **Steve Greb**, principal investigator). The section did

Energy and Minerals Section Head **Dave Harris** examines core samples as part of escalating research at KGS on carbon sequestration in Kentucky.



A soil gas sampler and temperature monitor set up in the Big Andy Oil Field in Wolfe County as part of Marty Parris's project to monitor the movement of gases between the air and soil at potential carbon sequestration sites.

preliminary planning for a pilot carbon sequestration project at Duke Energy Company's East Bend electricity generating station in Boone County. **Jim Drahovzal** and **John Hickman** interpreted seismic-reflection data on the site for this project, in preparation for a deep CO<sub>2</sub> injection well to be drilled there in late 2007 by the Midwest Regional Carbon Sequestration Partnership.

**Kathy Takacs** completed the field work for a study of the Euterpe Oil Field in Henderson County. Miller Energy, which has ongoing oil drilling on the 3-square-mile site, is interested in possible enhanced oil recovery and CO<sub>2</sub> sequestration in this field. Takacs did X-ray diffraction and petrographic analysis of the Cypress Sandstone to determine its potential for such activity.

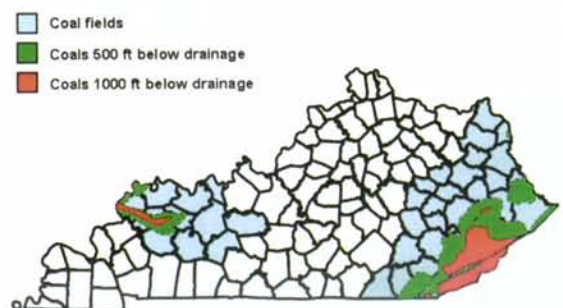
### Coalbed Methane in Eastern Kentucky

As the demand for natural gas continues to increase across the nation, exploration for new gas resources is at an all-time high. One area that hasn't received much attention is the Eastern Kentucky Coal Field. Although better known as a producer of low-sulfur coal for electricity generation, the field is being studied by **Cortland Eble**, **Steve Greb**, and **Kathy Takacs** as a potential resource for economic coalbed methane. The Survey believes this resource could be very important to the energy and economic future of eastern Kentucky, stimulating industry to begin exploration activities for coalbed methane.

The first year of the project, which is funded by the Kentucky Governor's Office of Energy Policy, involved a detailed geologic evaluation of eastern Kentucky to identify the most promising areas to drill test wells. The areas that were deemed most promising had deeply buried coal (greater than 500 feet) with thick, multiple-bed coal thickness. With the assistance of industry partners, drilling and subsequent testing for gas contents will occur in the second year of the project. \*

### Deep coals in Kentucky

Locations of deeply buried coal beds in eastern and western Kentucky that could be sources of coalbed methane.





# Water Resources

Water Resources staff receive calls each month asking for assistance on local karst and water issues.

## Community Projects

Water Resources staff completed the final report for a hydrogeology study of karst-related flooding in a section of the city of Radcliff, funded by the U.S. Army Corps of Engineers. Under the direction of **Jim Currens** and **Randy Paylor**, dye traces and measurements of water flow and water-level changes were used to determine the sources and amount of water flowing through the karst terrain, and to measure the intake capacity of a swallow hole draining the study area. The city then contracted with the section to map all the karst groundwater basins in Radcliff through dye tracing, to help the local government comply with EPA water-quality standards. The field work for this study was completed during the fiscal year.

Section members were also involved in developing public water supplies from groundwater resources for the communities of Evarts and Wallins (Harlan County), Campton (Wolfe County), and Hindman (Knott County) in the Eastern Kentucky Coal Field. **Jim Dinger**, **Steve Webb**, and **Bart Davidson**, with funding from the Kentucky Infrastructure Authority, sited new well locations, conducted pumping tests, and sampled and evaluated groundwater quality in cooperation with the Kentucky Rural Water Association.



Student worker Trish Coakley pours dye into a swallow hole as a part of the project to map the groundwater basins in Radcliff.



Tim Nolan, a student worker for the Water Resources Section, changes a dye receptor at Halli Spring in the Radcliff basin-mapping project.



## Selenium in Surface Waters in the Eastern Kentucky Coal Field

KGS is assisting the Kentucky Division of Water in a study of selenium in surface water draining from surface coal mines and other construction that disrupts the land surface in the Eastern Kentucky Coal Field. The EPA has determined that elevated concentrations of selenium in water can be detrimental to aquatic life and terrestrial animals consuming contaminated aquatic life. With the help of **Lifeng Guo**, the Division of Water will sample both water and aquatic life in streams that drain certain stratigraphic intervals in the coal field. Approximately 15 sites will be sampled in the coming year and analyzed by the Kentucky Division of Technical Services and laboratories capable of determining the species of selenium in stream water and aquatic life.

## Regional Groundwater Report Published

Records of thousands of well- and spring-water samples taken during the past century were used to develop a report on groundwater quality that was completed by **Steve Fisher** and **Bart Davidson** and published on the KGS Web site. The report, *Regional Groundwater Quality in Watersheds of the Upper Cumberland, Lower Cumberland, and Lower Tennessee Rivers, and the Jackson Purchase Region*, concluded that the overall water quality is good, though there are some wells and springs in the study area with constituent concentrations approaching or above federal standards. Water analyses used in the study are archived in the Kentucky Groundwater Data Repository.

This regional study focused on nonpoint sources, which involve potential contaminants from land-use practices. Regional and community planners, environmental quality



Randy Paylor takes advantage of low water levels at Lake Cumberland to do dye-tracing work in a stream at Sloans Valley in Pulaski County.

regulators, and ordinary citizens who need to know about the quality of groundwater can find much valuable information in the study.

The Kentucky Division of Water estimates that 1.8 million Kentuckians rely on groundwater from wells or springs for at least part of their drinking supply.

## Groundwater Quality Reports

Water Resources Section staff also produced information circulars on iron and barium in Kentucky groundwater. These reports contain information about natural and contaminant sources of these metals, potential health effects if they occur in drinking water, a summary of their occurrence in groundwater throughout the state, and a map showing concentration ranges. These information circulars are available on the KGS Web site and in printed form.



Bart Davidson estimates the amount of groundwater being pumped from a public water supply well at the Campton Water Plant in Wolfe County. The aquifer is being tested to determine whether it has water of sufficient quantity and quality to serve as a back-up water supply for the city.

A map-based search capability was also made available online, giving users the ability to display the same groundwater-quality data that are found in the tabular groundwater-quality data searches on a variety of base maps. This search type is particularly useful to those wishing to view groundwater quality as it relates to various hydrologic, geologic, or cultural features. \*



# Geologic Mapping

Modern maps  
serve a variety  
of needs.

The Kentucky Geological Survey and a variety of other State and local agencies are in constant need of new and refined mapping of the state, and the KGS Geologic Mapping Group works to meet those needs with a variety of products.

On August 30, 2006, the group hosted a special meeting of the KGS Advisory Board and State Mapping Advisory Committee to review the priorities for the KGS field mapping program. Other participating agencies included the Kentucky Transportation Cabinet, the University of Louisville Center for Hazards Research and Policy Development, the Groundwater Branch of the Kentucky Division of Water, Central U.S. Earthquake Consortium–State Geologists, and the U.S. Geological Survey. Written feedback was also received from several other agencies. The attendees discussed topical needs and applications of geologic mapping and how geologic maps and data were used for different activities in the commonwealth. The result of the meeting was a revised long-range plan for geologic mapping in Kentucky.

Members of the mapping team discuss their priorities in a planning session early in the fiscal year.



The Geologic Mapping Group has embarked on several new projects designed to address the high-priority needs identified during the meeting. A pilot grant from the USGS Landslide Hazards Program supported development of a prototype



William Andrews, who heads the Geologic Mapping Group, speaks to a special meeting of the State Mapping Advisory Committee in Henderson. The committee gathers comments from interested agencies on the mapping needs of the state.

landslide hazards map of the Hazard North quadrangle for nontechnical users. This map brought together available data on natural ground conditions to determine which areas are more or less susceptible to different landslide processes. The long-range plan is to use the pilot map to attract funding, so that mapping can be done for all of eastern Kentucky.

The STATEMAP Program of the U.S. Geological Survey continues to be the primary funding source for KGS geologic mapping projects. During FY 2006-07, KGS received \$197,000 from STATEMAP to support new Quaternary geologic mapping in western

Kentucky. KGS field mappers **Ron Counts, Mike Murphy, Steve Martin, Matt Crawford,** and **William Andrews** completed mapping in eight 7.5-minute quadrangles from the Green River near Curdsville to the Ohio River at Uniontown.



The Mapping Group anticipates a busy future, as the STATEMAP Program announced funding of \$234,000 during fiscal year 2007-

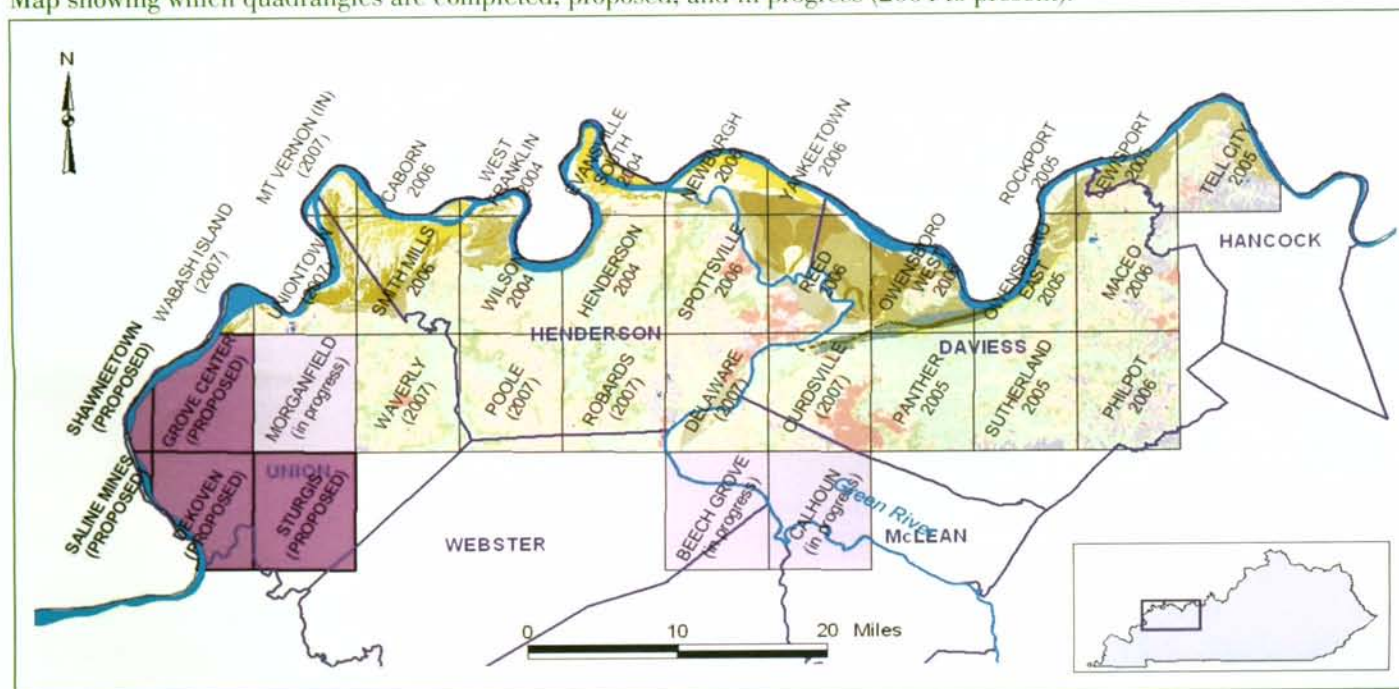
Webster, and Union Counties, as well as new surficial geologic

Members of the Mapping Group look over one of their draft maps to check their accuracy during a trip to western Kentucky.

Mapping Group members made several field trips to conduct quality control on their mapping products. During this trip in January 2007, they field-check their surficial mapping in western Kentucky.

Kentucky for landslide assessment. The Kentucky Transportation Cabinet also approved a fracture mapping program. During the next 18 months, US geologist **Steve Martin** will begin the orientation, trending, and spacing of major fractures in selected areas of central Kentucky. The information will be useful for a wide range of applications, from slope design for road projects to water resource exploration. \*

Map showing which quadrangles are completed, proposed, and in progress (2004 to present).





# Geohazards Research

**KGS**  
investigates  
seismic risk  
with national  
and inter-  
national  
partners.



A rig is set up to drill the 1,900-foot-deep hole for the Central U.S. Seismic Observatory.

## Deep Hole Drilled

The deepest borehole for seismic instruments in the eastern United States was drilled at Sassafras Ridge in Fulton County in a partnership of KGS, the USGS, and other university and federal entities. **Jonathan McIntyre** of the Geologic Hazards Section, managed the construction phase of the project, in which a 4 inch-diameter hole for the Central U.S. Seismic Observatory, drilled by Layne Christensen Company, reached bedrock at a depth of 1,948 feet.

The location is near the most active part of the New Madrid Seismic Zone, which will allow instruments placed in the hole to gather the maximum amount of data from earthquakes in the region for evaluation of their effects on bedrock and soil.

The partners in the project, including the University of Kentucky Department of Earth and Environmental Sciences, the Kentucky Resource Consortium for Energy and the Environment, and the U.S. Department of Energy, will eventually choose the instruments to place at various depths in the shaft and will seek grants to purchase them.

The Department of Energy has an interest in the region's earthquakes because of uranium-enrichment operations at the Paducah Gaseous Diffusion Plant. **Ed Woolery** of Department of Earth and Environmental Sciences and KGS Section Head **Zhenming Wang** led the effort to plan and secure funding for the project.

When instrumentation is completed, the observatory will be added to the Kentucky Seismic and Strong-Motion Network

## Seismic Hazard in McCracken County

**Zhenming Wang** and **Ed Woolery** completed a peer-reviewed study on the seismic hazard posed by the New Madrid Seismic Zone in the vicinity of the Paducah Gaseous Diffusion Plant in McCracken County. The Department of Energy-funded study was the result of a proposal to build a contained landfill for low-level radioactive waste at the site. The study objectives were to "gain a better understanding of the seismic hazard assessment at the Paducah Gaseous Diffusion Plant and its surrounding area, and to communicate the hazard information more effectively to the users and policy-makers." The report notes that doing such a seismic hazard

assessment is complicated by a number of factors, ranging from the different assessment methodologies to the lack of frequent damaging earthquakes in the region.

The report discusses the two major methodologies of determining seismic hazard and concludes that the ground-motion hazards with a 2,500-year return period estimated by the U.S. Geological Survey are too conservative to be used in making such policy decisions. It concludes that the peak ground acceleration level, expressed as a percentage of the acceleration of gravity, of 0.25 to 0.3g would be appropriate for engineering design of ordinary buildings and facilities at the site and surrounding areas. That is a ground motion with an estimated 1,000-year return period.

## Seismic Network

Strong-motion instruments in the Kentucky Seismic and Strong-Motion Network recorded six earthquakes within Kentucky's borders with a magnitude of 2.0 or greater during the fiscal year. Sixteen other earthquakes of 2.0 magnitude or greater were recorded in the region outside the state. Several hundred earthquakes of smaller magnitudes were recorded by the weak-motion instruments. The public can view recordings of a dozen of the instruments in near-real time on the KGS Web site.

## Visiting Scholar from China

A second visiting scholar from China's Lanzhou Institute of Seismology came to KGS in the ongoing exchange between the Institute, KGS, and the University of Kentucky. **Yuxia Lu**, a researcher at Lanzhou, arrived in February for a year of work on earthquake seismic issues with the KGS Geologic Hazards Section and UK's Department of Earth and Environmental Sciences.

Lu, who specializes in seismic hazards and near-surface geophysics, will spend time processing seismic data gathered in China during two visits by KGS and UK staff in the past 2 years as well as data gathered by instruments in the central United States. \*



Yuxia Lu





KGS staff work in the Cumberland Gap Tunnel.

### Cumberland Gap Tunnel

The Cumberland Gap Tunnel Authority contracted with KGS to have Water Resources Section staff conduct testing and analyses to help determine the cause of subsidence in sections of the roadbed. The tunnel is a 4,600-foot section of U.S. 25E passing under the Cumberland Gap National Historic Park just south of Middlesboro, Ky., at the southeastern border of Kentucky with Virginia and Tennessee. A series of investigations, mostly conducted at night so the tunnel could be closed to traffic, were completed by a team composed of **Jim Dinger, Jim Currens, Randy Paylor, and Steve Webb**. Tests included dye tracing, groundwater velocity measurements, downhole packer tests, analyses of water samples collected from the groundwater system, and physical observations of the bedrock and the limestone gravel forming the roadbase material beneath the pavement. Results from these investigations indicate that groundwater is dissolving the limestone-gravel roadbase. KGS continues to participate on a team, along with the Kentucky Transportation Center at the University of Kentucky and State and federal highway administrations, that is advising the Tunnel Authority on developing solutions for the problem. The solutions include replacing the limestone gravel with granite aggregate, and installing a new groundwater handling system under parts of the roadway.

### Core Description Manual

A new project, funded by the State Transportation Cabinet, was begun by **Bethany Overfield** to develop a prototype core description manual that will relate rock properties to geotechnical behavior. The project complements another transportation research project to develop

## Transportation Issues

a computerized system for collecting and storing geotechnical drilling information (see below).

During the project, Overfield will look for representative samples from dozens of core boxes delivered by the Transportation Cabinet. The cores came from transportation projects in more than 30 counties in central and northern Kentucky. Overfield is categorizing the samples by their visual and tactile properties and grouping them into classes with similar geologic characteristics and geotechnical properties. She will create a reference collection of the types of rock found in central and northern Kentucky and classify them by these properties. A guide will be produced to allow easier comparison of information collected by different agencies and to serve as a training tool for new Transportation staff involved in materials description. Selected samples from the collection will be tested for sonic velocity, and these measurements will be compared to traditional strength tests in order to better predict geotechnical behaviors of the rock materials.

### Tracking Transportation Studies

A project that began in the previous year as an effort to help the Kentucky Transportation Cabinet Geotechnical Branch provide Web access to its project reports was expanded to the design of an enterprise system for tracking and managing all information related to geotechnical engineering studies. The Web-based system allows Cabinet managers to efficiently monitor the progress of 500 current projects and to quickly gather geologic background data to support engineering assessments. Geospatial Analysis Section Head **Jerry Weisenfluh** oversees this project. Another software system is being developed to store the results of drilling, sampling, and testing of rock and soil materials used in road construction.

Managers of the Transportation Cabinet's Geotechnical Branch report the system is saving much time and other resources. \*

The knowledge and experience of KGS staff has proven to be valuable for Kentucky's Transportation Cabinet and for transportation projects.



Bethany Overfield categorizes core samples for a transportation-related project.



# China Exchange

**KGS**  
continues the  
exchange of  
experts and  
information  
with China.

The exchange of seismic experts and information between KGS and China's Lanzhou Institute of Seismology continued during the fiscal year as State Geologist **Jim Cobb** and staff from the Geologic Hazards Section traveled to China during June and July. It was the second such trip in 3 years.

Geologic Hazards Section Head **Zhenming Wang** and **Ed Woolery** of the UK Department of Earth and Environmental Sciences conducted a workshop on near-surface exploration seismology at the Institute and conducted field seismic investigations in Lanzhou and in the Kunlun Mountains, where an 8.1-magnitude earthquake occurred in 2001. They also helped their Chinese hosts with the use of seismic equipment and interpretation of seismic profiles in the region.

The KGS researchers were also among the first foreigners to take a trip on the recently opened final section of a high-elevation railway linking Beijing with Lhasa, Tibet. The section from Qinghai, China, to Lhasa has a peak elevation of over 16,000 feet. Work on the railway began in 2001, and service began on July 1, 2006. The railway crosses 451 bridges and goes through 10 tunnels; long stretches of permafrost must be protected from thawing to prevent the rail bed from failing. Thirty-three underpasses were also installed along the route to allow animals to safely cross the railway.



Kentucky Gov. Ernie Fletcher and Vice Governor Li Ying of Gansu Province exchange gifts representative of their cultures during the October visit by a Chinese delegation to KGS.

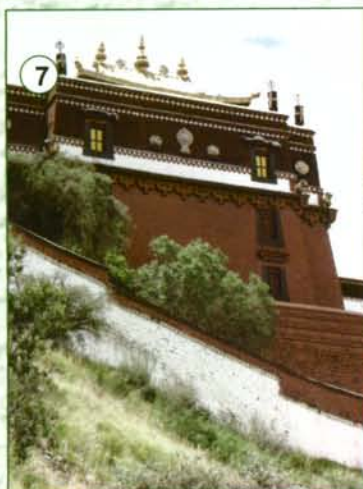




Cobb and others wrote a story about the railroad and their trip, entitled "Rails across the Roof of the World," which was the cover story for the February edition of *Geotimes* magazine, published by the American Geological Institute.

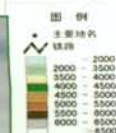
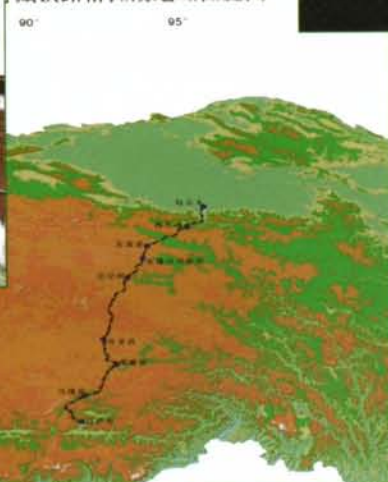
In October, a delegation headed by the Gansu Province Vice Governor for Science and Education visited Kentucky to meet with University and State officials. After an evening dinner in Lexington, the delegation met Gov. **Ernie Fletcher** in his office at the Capitol, where the governor praised the exchange effort and its mutual value to Kentucky and to China. He and the vice governor also exchanged gifts representative of their cultures.

Assistant State Geologist **John Kiefer** also traveled to Beijing to teach a 2-week course at the Graduate Academy of Sciences. Fifty-six students took the course, entitled "How Geology Affects Public Policy," focusing on water, geologic hazards, and resources. \*



See inside of back cover for photo captions.

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# Outreach and Education

KGS  
sponsored  
events tailored  
for a variety  
of audiences  
during the  
year.

## Earth Science Week Open House

Nearly 200 people came to the University of Kentucky campus October 11 for the annual KGS open house during Earth Science Week 2006. KGS staff and members of the Kentucky Paleontological Society, the Kentucky Water Resources Research Institute, and other organizations set up displays, demonstrations, and experiments relating to earth-science issues on two floors of the Mining and Mineral Resources Building. The American Geological Institute, along with a group of federal agencies and others, sponsors the week each year, and Gov. **Ernie Fletcher** declared the week of October 8–14 Earth Science Week in Kentucky, with a theme of “Be a Citizen Scientist!”



## Distinguished Lecture

Texas State Geologist **Scott W. Tinker** was invited to speak April 19 at the Survey for the fifth Donald C. Haney Distinguished Lecture. A standing-room-only crowd heard his talk on “The Global Energy Scene: An Energy, Economy, Environmental Waltz.” Tinker, the 2007 president of the Association of American State Geologists, discussed historic energy trends and projected future needs for coal, natural gas, nuclear, and other energy sources.





## Annual Seminar

State government, KGS, and private-sector speakers gave their views on the topic of *Geology and Public Policy* April 20 at KGS's 47th Annual Seminar at the Well Sample and Core Library. Speakers included House Majority Leader **Rocky Adkins**; **John Byrnes**, a consultant with Castlebar Petroleum; the director of the Governor's Office of Energy Policy, **Talina Matthews**; KGS section heads **Dave Harris** and **Jim Dinger**; and KGS Director **Jim Cobb**. About 130 people attended the seminar.



Rep. Rocky Adkins addresses the 47th Annual Seminar (above).



Paul Potter (left) is recognized by KGS Director Jim Cobb as "Best Unpaid Employee" at the Annual Seminar.

## Landslide Seminar

KGS again partnered with the Boone, Campbell, and Kenton County Conservation Districts to sponsor a landslide workshop on July 25 as a follow-up to one held in 2005. About 75 people, mostly from the Greater Cincinnati area, attended the workshop. KGS staff geologists **William Andrews** and **Jerry Weisenfluh** provided guidance on finding geotechnical data relating to landslides and also provided a "decision matrix" to help local officials make landslide-related decisions.

Cincinnati private-practice geologist and realtor **Tim Agnello** talked about the local landslide geology and history. Landslide prevention strategies were presented by **Rich**

**Pohana** of the Cincinnati Transportation and Engineering Department and **Chris Slone** of the Kentucky Department of Highways. **Camille Crain**, of Kentucky Emergency Management, discussed a program she oversees for acquiring landslide-damaged homes and restricting future use of the land.

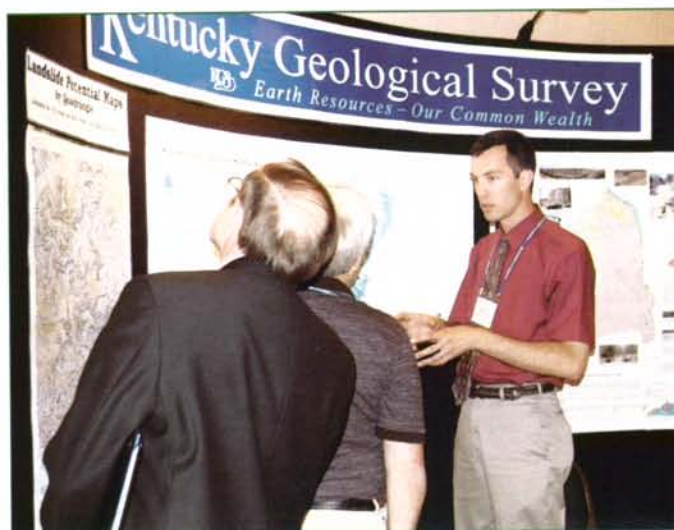


About 75 people attended the landslide seminar in July.

## Transportation Hazards Seminar

KGS co-hosted the Sixth Annual Technical Forum on Geohazards in Transportation in the Appalachian Region, held in Lexington August 2–3. About 85 people attended from throughout the Appalachian states.

KGS researchers **Zhenming Wang**, **Jim Currens**, **Randy Paylor**, and **Matt Crawford** were among the speakers who dealt with topics from seismic issues to karst terrain and the aging of transportation infrastructure in the region. \*



William Andrews talks with visitors to the KGS display during the Forum on Geohazards in Transportation in the Appalachian Region.



# Henderson Office

**KGS  
Henderson  
staff serve  
the needs of  
western  
Kentucky.**

Staff members at the KGS office in Henderson, headed by **Dave Williams**, do research, water sampling, and mapping work in the western part of the state. During the fiscal year, they continued work on long-term projects such as domestic water-well sampling in the Jackson Purchase Region and groundwater sampling at selected project locations.

## Liquefaction Feature Found

In September 2006, **Ron Counts** and **Scott Waninger** found an ancient liquefaction feature in a bank of the Green River in Daviess County, about 21 river miles upstream from its confluence with the Ohio River. The feature, a clastic dike 4 to 7 centimeters wide and at least 3.3 meters high, was visible because the water level was relatively low at the time. It is the first such documented earthquake-induced feature found in the Ohio River Valley east of the Wabash River.

Results from radiocarbon dating of wood from a clay bed that the dike was injected into indicate that the maximum age of the earthquake that produced the feature is 9,400 years. Counts has collected additional samples for luminescence

dating and hopes to better estimate the timing of the earthquake. He emphasizes that it is probably not related to the New Madrid earthquakes of 1811-12. KGS is working with other researchers to determine if the earthquake responsible for the feature was generated by the New Madrid Seismic Zone, the Wabash Valley Zone, or some other previously unidentified seismic hazard.

Such features can occur when saturated, sandy sediments are shaken during an

earthquake. The shaking pressurizes the sediment, and under the right conditions, the liquefied slurry of wet sand and gravel can be injected upward through overlying sediments toward the surface. If the slurry breaks through the surface, it is commonly referred to as a sand blow or sand boil.

An ancient liquefaction feature found by Ron Counts in a bank of the Green River in Daviess County is the first documented earthquake-induced feature found in the Ohio River Valley east of the Wabash River.



## EPSCoR Coordination

**Glynn Beck** served as field coordinator for a National Science Foundation EPSCoR (Environmental Program to Stimulate Competitive Research) grant administered by UK's Civil Engineering Department. He worked with faculty and students to develop viable research proposals on environmental issues in western Kentucky by helping them find potential field sites, determine appropriate budgets, and linking researchers with staff at the Environmental Research and Training Laboratory at UK. Funding was secured for 12 projects proposed by researchers from Murray State University, Western Kentucky University, and UK.

## Well-Camera Training

Beck also traveled to Texas A&M University in the fall to help conduct a well-camera training course for Texas A&M staff. He is Kentucky's lead member for the Southern Region Well Camera Team, which is funded by the U.S. Department of Agriculture to promote proper domestic well maintenance. KGS has two well cameras, used for well inspections and research. \*

The Henderson staff joined staff from Natural Resources Conservation Service offices in western Kentucky and Tennessee for a 3-day field trip in spring 2007 to view exposures of unconsolidated materials in the region. KGS staff gathered valuable information for the ongoing mapping program in western Kentucky, while the NRCS heard the geologic point of view about the sites the group visited. Dan Kotter and Ron Counts, below, examine an exposure during the field trip.





# Well Sample and Core Library

The increase in the price of oil on the world market has had a direct impact on the amount of activity at the KGS Well Sample and Core Library. Higher oil prices have made increased exploration economically feasible. Investors and the energy industry are once again looking at deeper plays in sparsely drilled areas, Devonian



Ray Daniel (right) of the Well Sample and Core Library talks to University of Kentucky petroleum geology students about the use of well samples in exploration and research.

black shales, and tar-sand deposits in Kentucky. Exploration geologists are examining cores and cuttings available at the library from wells drilled in the 1960's, 1970's, and 1980's as they again gather information, interpret geology, and identify potential hydrocarbon prospects. Given the high

costs of drilling, it is much more cost-efficient to examine samples and cores already on file at the library than to drill again in order to acquire these data.

Although many tools are available to assist in the exploration for oil, gas, coal, lead, zinc, and other minerals, the examination of rock samples and cores provides the greatest single source of information. Samples and cores are also the best sources of information about the nature and occurrence of rocks beneath the earth's surface.

Such samples and cores are of great value to industries and researchers as new methods, technologies, and instruments for examination and analysis are developed. The preservation of data in such sample and core facilities helps to avoid duplicate exploration work. \*



Patrick Gooding, manager of the Well Sample and Core Library, shows examples of cores and well cuttings available at the library to the KGS Advisory Board.



Members of the KGS Advisory Board tour the rows of sample and core boxes at the core library.

## Fiscal year 2006-7:

- ✓ Over 760 telephone requests for information were received
- ✓ More than 300 researchers, geologists, consultants, and students visited the library
- ✓ More than 250,000 feet of core and well cuttings were examined
- ✓ More than 430,000 feet of core and well cuttings from 133 oil wells were added to the collection



# KGS Laboratory

A total of  
3,082  
samples  
were  
analyzed  
during the  
fiscal year.

Kentucky government agencies, students and faculty of the University of Kentucky, and Survey researchers depend on the KGS laboratory for analysis of field samples taken for research projects. Several projects being run by KGS staff and other University researchers analyze samples of water from wells around Kentucky to determine levels of chemicals, including nitrates, chlorides, and herbicides. For 10 years, hundreds of water samples from western Kentucky's Jackson Purchase Region have been analyzed by the laboratory each year in an ongoing effort to detect possible sources of pollution for rural users of domestic water wells in the region.

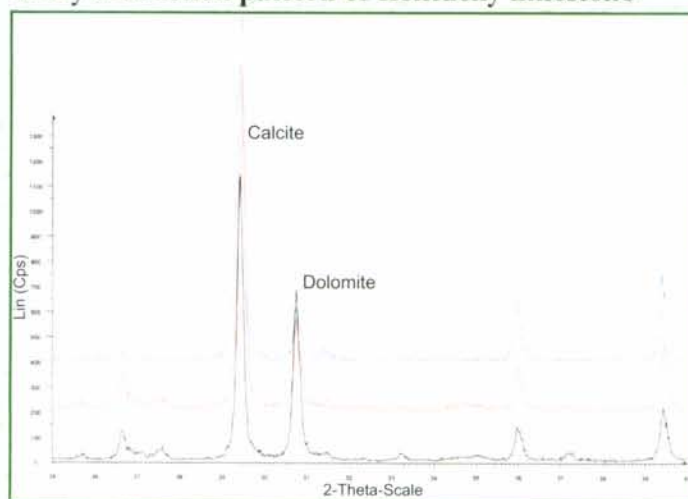
The Kentucky Division of Water collects samples from selected streams twice a year through its Water Watch Program, and these samples are analyzed in the KGS laboratory. Coal is also sampled for its quality, and rock samples are analyzed for their mineral content in the coal and minerals section of the lab.

The lab also serves the needs of other departments of the University by providing analyses for them or making laboratory instruments available for their educational needs. KGS and the UK Department of Earth and Environmental Sciences use the X-ray fluorescence and X-ray diffraction instruments for identification and analysis of geologic samples. Students from other colleges conduct activities such as texture or thin-film analysis.



Nick Cprek of the Consortium for Fossil Fuel Science at the University of Kentucky analyzes coal samples on the X-ray diffraction instrument in the KGS Laboratory.

**X-ray diffraction pattern of Kentucky limestone**



Limestone samples taken from the High Bridge Group indicating different amounts of calcite and dolomite at three different depths.



# Awards, Appointments, and Recognition

**Glynn Beck** of the Henderson office joined the Board of Directors of the Southwest Indiana Disaster Resistant Community Corporation. The organization works to promote the reduction of damage and economic loss related to natural and human-caused disasters.



**Jim Drahovzal** of the Energy and Minerals Section received a Distinguished Service Award from the Division of Professional Affairs of the American Association of Petroleum Geologists in April. The award, recognizing Drahovzal "for many years of dedicated service," was presented at the annual AAPG meeting in Long Beach, Ca.



**Dan Carey** of the Geospatial Analysis Section received the Outstanding Kentucky Geologist Award from the American Institute of Professional Geologists, Kentucky Section, 2007.

**Jim Cobb**, state geologist and KGS director, served as treasurer of the American Geological Institute and as a member of the AGI Executive and Finance Committees; he was a member of the National Research Council Committee on Coal Research and Development to Support National Energy Policy. He is also historian of the Association of American State Geologists and served on the USGS Eastern Energy Review Committee.



**Steve Fisher** of the Water Resources Section is a member of the Advisory Committee on Water Information for the National Water Quality Monitoring Council and the Kentucky Agricultural Water Quality Commission.

**Patrick Gooding**, who manages the Well Sample and Core Library, was reappointed by the chairman of the AAPG House of Delegates to serve another 1-year term as the chairman of the Credentials Committee. He was appointed by the president of the society to chair the AAPG Committee on Preservation of Geoscience Data for a 3-year term.



**Ron Counts** of the Henderson office served as co-chair of the field trip committee for the GSA North-Central Section meeting.



**Jerry Weisenfluh**, head of the Geospatial Analysis Section, was reappointed to the Governor's Kentucky Geospatial Board during the fiscal year.



# Summary of Grants and Contracts in Effect Fiscal Year 2006-07

## A. Grants and Contracts Funded by State, Federal, and Private Sources

1. Computerized Coal Resources Data for the National Coal Resources Data System. Budget period 7/1/06- 6/30/07. Award \$51,825. This is funding for an additional year of multi-year projects on Coal Resources Data. Total award to date \$1,334,614. Funding agency - U.S. Geological Survey.
2. Chemical Analysis of Groundwater Samples Taken from the Kentucky Groundwater Network. Budget period 7/1/06- 6/30/08. This is a continuation of a project started 2/1/95. Current year pro-rated award \$15,700. Total award \$31,400 for current project. Total award to date \$899,912. Funding agency - Kentucky Natural Resources and Environmental Protection Cabinet.
3. Generation of 1:100,000 Geologic Maps from Digital 1:24,000 Geologic Quadrangle Maps in the Kentucky River Basin, Kentucky. Award of \$197,373 for budget period 4/15/06-4/14/07. This is the 11th year funding of the project. Total award to date \$2,017,369. Funding agency - U.S. Geological Survey.
4. Communications Specialist for the Kentucky Board of Registration for Professional Geologists. Budget period 7/1/06- 6/30/07. Award \$15,000. Funding agency - Kentucky Board of Registration for Professional Geologists.
5. Groundwater Education, Training, and Technology Transfer. Budget period 7/1/03-6/30/10. Current year pro-rated \$106,989. Total award \$450,000. Funding agency - Kentucky Natural Resources and Environmental Protection Cabinet.
6. Midwest Geological Sequestration Consortium. Budget period 10/1/05-9/30/07. Current year pro-rated \$100,000. Total award \$199,509 with additional funding of \$123,000 pending for current year. Funding agency - U.S. Department of Energy through the Illinois State Geological Survey.
7. Mid-America Integrated Seismic Network - UK. Budget period 1/1/04-1/31/07. Current year award pro-rated \$35,000. Total award \$107,921. Budget period 2/1/07-1/31/08. Current year prorated \$14,596 with total award of \$35,031. Funding agency - U.S. Geological Survey.
8. Groundwater Quality Monitoring for Nonpoint Source Chemicals in the Jackson Purchase Region of Kentucky. Budget period 11/1/04-6/30/08. Current year no cost extension only. Total award \$85,000. Funding agency - Kentucky Natural Resources Environmental Protection Cabinet.
9. Development of Community Water Supplies. Budget period 7/1/06-6/30/07. Total award \$50,000. Funding agency - Kentucky Infrastructure Authority.
10. A Systems Approach to Identifying Exploration and Development Opportunities in the Illinois Basin: Digital Portfolio Plays in Under-Explored Lower Paleozoic Rock. Budget period 9/24/05-9/27/07 with \$103,433 current year funding. Total award \$144,498 with additional \$53,410 third year funding possible. Funding agency - U.S. Department of Energy through University of Illinois.
11. Geochemical Analysis of Surface and Shallow Gas Flux and Composition Over a Proposed Carbon Sequestration Site in Eastern Kentucky. Budget period 7/15/06-1/14/08 with current year award of \$153,101. Project period 7/15/05-1/14/08 with total award of \$277,989. Funding agency - U.S. Department of Energy.
12. Hydrogeology of Karst Related Flooding, Happy Valley Karst Valley (Quiggens' Sinkhole), Radcliffe, Ky. Budget period 8/1/05-7/31/06. Current year pro-rated \$6,466. Total award \$77,588. Funding agency - U.S. Army Corps of Engineers.
13. Southeast Ky: Coals as CO2 Sequestration Reservoirs (part of Southeast Regional Carbon Sequestration Partnership Phase 2 Project). No cost extension for current year. Project period 10/1/05-9/30/07. Total award of \$66,000. Funding agency - Virginia Polytechnic Institute and State University.

14. Seed Grant - Consortium Development for Western Kentucky Deep Gas Exploration. Budget period 1/1/06-3/31/07. Current year pro-rated \$30,159. Total award \$46,914. Funding agency - Kentucky Office of Energy Policy.
15. Seed Grant - Exploring for Economic Coal Bed Methane in Eastern Kentucky. Budget period 2/15/06-12/31/07. Current year prorated \$43,125. Total award \$86,250. Funding agency - Kentucky Office of Energy Policy.
16. Kentucky Part of Phase 2 of the Midwest Regional Carbon Sequestration Partnership. Budget period 10/1/06-9/30/07 with current year award \$72,754. Project period 10/1/05-9/30/09. Total award \$285,732. Funding agency - Battelle Memorial Institute.
17. Investigation of the Hydrogeochemical Issues Leading to Roadbed Subsidence in the Cumberland Gap Tunnel. Budget period 4/15/06-12/31/06. Current year pro-rated 38,658. Total award \$77,316. Funding agency - Tunnel Management, Inc.
18. Integrating Geotechnical Drill Hole Data with Geologic Information. Budget period 7/1/06-6/30/07. Total award \$125,000. Funding agency - Kentucky Transportation Cabinet.
19. Geotechnical Guide to Cored Rock in Kentucky. Budget period 7/1/06-6/30/07. Total award \$50,000. Funding agency - Kentucky Transportation Cabinet.
20. Developing a Prototype Map for Slope Stability Characterization in the Hazard North 7.5-Minute Quadrangle, Eastern Kentucky. Budget period 7/16/06-12/15/06. Total award \$10,457. Funding agency - U.S. Geological Survey.
21. Quarternary and Surficial Mapping for Multiple Applications in Kentucky. Budget period 5/15/07-5/14/08. Current year prorated \$19,519. Total award \$234,228. Funding agency - U.S. Geological Survey.
22. Mapping Karst Groundwater Basins for Radcliffe as a Groundwater Quality Management Tool. Budget period 10/1/06-9/30/07. Total award \$62,525. Funding agency - City of Radcliffe, Kentucky.
23. Selenium Occurrence and Bioaccumulations in the Eastern Kentucky Coal Fields. Budget period 2/16/07-6/30/08. Current year prorated \$17,461. Total award \$69,845. Funding agency - Kentucky Department of Environmental Protection.
24. Rough Creek Graben Consortium. Budget period 3/1/07-2/28/08. Current year prorated \$21,390. Total award \$64,169. Funding agency - Kentucky Office of Energy Policy.
25. Rough Creek Graben Consortium. Budget period 3/1/07-2/28/08. Current year prorated \$37,500. Total award \$225,000. Funding companies - Chesapeake Energy, Forest Oil Corporation, Greensburg Oil LLC, Highway Resources, Marathon Oil Company, MegaWest Inc, MSD Energy Inc, North Coast Energy, Onyx International Exploration, Triana Energy, and Viking Energy LLC.

## B. Participation in Grants Administered by Other Units of the University of Kentucky

1. Nonpoint-Source Assessment of Groundwater. Funding agency - Commonwealth of Kentucky. Cooperative study with University of Kentucky College of Agriculture.
  - A.) Animal Research Center - Woodford County. Budget period 7/1/06- 6/30/07. Award \$52,599.
  - B.) High Nitrate Wells. Budget period 7/1/06- 6/30/07. Award \$64,565.
2. Paducah Gaseous Diffusion. Budget period 5/1/06-8/30/2006. No cost extension to 9/30/06 with no additional funding. Total award \$200,000. Funding agency - Department of Energy through Kentucky Water Resources Research Institute.

**Total Amount of Grants and Contracts Awarded:**  
**\$1,457,695**



# KGS Staff

## State Geologist's Office

Cobb, Jim *State Geologist/Director*  
 Kiefer, John *Assistant State Geologist*  
 Haney, Don *State Geologist Emeritus*  
 Lynch, Mike *Technology Transfer Officer*  
 Hower, Judy *Temporary Technician*

## Administrative Section

Silvers, Jackie *Administrative Staff Officer II*  
 Long, Mandy *Administrative Support Associate I*  
 Phillips, Gwen *Staff Support Associate II*  
 Nolan, Tim *Student Worker*

## Energy and Minerals Section

Harris, Dave *Section Head*  
 Barth, Leah *Geological Technician*  
 Daugherty, Shannon *Student Worker*  
 Drahovzal, Jim *Temporary Professional*  
 Eble, Cortland *Geologist V*  
 Greb, Steve *Geologist V*  
 Hickman, John *Geologist III*  
 Nuttall, Brandon *Geologist IV*  
 Parris, Marty *Geologist IV*  
 Solis, Mike *Geologist I*  
 Takacs, Kathy *Geologist I*

## Geologic Hazards Section

Wang, Zhenming *Section Head*  
 Lu, Yuxia *Temporary Researcher*  
 McIntyre, Jonathan *Geologist III*  
 Richards, Travis *Student Worker*  
 Vance, Dave *Student Worker*  
 Woolery, Ed *Temporary Professional*  
 Wu, Zhijian *Temporary Researcher*

## Geoscience Information Section

Cordivola, Steve *Section Head*  
 Banks, Roger *Account Clerk I*  
 Coleman, Matt *Student Worker*  
 Davis, Luanne *Geological Technician*  
 Evans, Theola *Stores Supervisor*  
 Farwell, Mike *Student Worker*  
 Hounshell, Terry *Chief Cartographic Illustrator*  
 McElhone, Jim *Information Technology Manager I*  
 Pulliam, Carrie *Geologist II*  
 Rulo, Collie *Senior Graphic Design Technician*  
 Smath, Meg *Geologist III*  
 Smath, Richard *Geologist III*  
 Thompson, Mark C. *Information Technology Manager I*  
 Troutman, Justin *Student Worker*  
 Watson, Anna *Geologist II*  
 Williams, Sidney *Student Worker*

## Geospatial Analysis Section

Weisenfluh, Jerry *Section Head*  
 Anderson, Warren *Geologist V*  
 Andrews, William *Geologist IV*  
 Carey, Dan *Geologist V*  
 Crawford, Matt *Geologist II*  
 Curl, Doug *Geologist III*  
 Fedorchuk, Nick *Student Worker*  
 Heck, Jason *Student Worker*  
 Lambert, Jason *Student Worker*  
 Loudon, Bryan *Student Worker*  
 Lutz, David *Student Worker*  
 Martin, Steve *Geologist III*  
 Murphy, Mike *Geologist I*  
 Overfield, Bethany *Geologist II*  
 Reynolds, Joshua *Student Worker*  
 Rivers, Monte *Student Worker*  
 Sergeant, Rick *Geologist IV*  
 Sparks, Tom *Geologist III*  
 Thompson, Mark F. *Geologist II*  
 Wang, Rebecca *Information Systems Technology Support Specialist III*

## Laboratory Services

Francis, Henry *Scientist II/Laboratory Manager*  
 Backus, Jason *Scientist II*  
 Mitchell, Andrea *Scientist I*  
 Mock, Steve *Scientist I*

## Water Resources Section

Dinger, Jim *Section Head*  
 Currens, Jim *Geologist V*  
 Davidson, Bart *Geologist IV*  
 Fisher, Steve *Geologist V*  
 Fogle, Alex *Geologist III*  
 Gadbois, Clifton *Temporary Technician*  
 Guo, Lifeng *Geologist IV*  
 Paylor, Randy *Geologist II*  
 Spears, Anita *Temporary Technician*  
 Webb, Steve *Geologist I*

## Well Sample and Core Library

Gooding, Patrick *Geologist IV/Manager*  
 Daniel, Ray *Principal Research Analyst*  
 Pinkston, Ryan *Senior Lab Technician*

## Western Kentucky Office at Henderson

Williams, Dave *Section Head*  
 Beck, Glynn *Geologist IV*  
 Counts, Ron *Geologist II*  
 Kotter, Dan *Temporary Technician*  
 Waninger, Scott *Temporary Technician*



## IN MEMORY



**Theola Evans**

October 4, 1963–June 12, 2007

Theola had been employed since 1991 at KGS and was stores supervisor for the Public Information Center.



**Luanne Davis**

July 28, 1957–June 20, 2007

Luanne, a KGS employee since 1988, was a geological technician in the Geoscience Information Section; she oversaw the scanning of drilling records for the online oil and gas database.



### **Captions for the photos on pages 10-11**

1. Seven-meter-tall statue of a cephalopod in a municipal square in Golmud, Qinghai Province.
2. The Qinghai-Tibet Railway construction medal to the Kentucky group is awarded by Professor L. Zhang (center) to Jim Cobb, John Cobb, Lanming Wang, Zhenming Wang, and Ed Woolery.
3. Potala Palace, the traditional home of the Dalai Lama, in Lhasa, Tibet.
4. The White Pagoda Temple in Lanzhou, Gansu Province. This museum preserves ancient forms of Chinese calligraphy.
5. Street vendors in Lhasa, Tibet.
6. Buddhist shrine in Lhasa Tibet.
7. Another view of the Potala Palace, Lhasa, Tibet.
8. Route of the Qinghai-Tibet Railway from Golmud to Lhasa.
9. Tibetan yak herders in their summer encampment.
10. Picnic at Lake Namtso near Lhasa, Tibet, at an elevation of 15,270 feet.
11. KGS group with TV reporters from China Central News at Kunlun Pass on the Tibet Plateau. Elevation: 15,500 feet.
12. New passenger car on the Qinghai-Tibet Railway, pressurized and equipped with oxygen for the very high-elevation conditions.
13. New train engine for the Qinghai-Tibet Railway.
14. Qinghai-Tibet train passing the Kunlun Fault near the Kunlun Pass.



**Kentucky Geological Survey**

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