



Kentucky Geological Survey 2010-11

OUR MISSION

is to increase knowledge
and understanding of the mineral,
energy, water resources, geologic hazards,
and geology of Kentucky for the benefit
of the commonwealth and nation.

COVER PHOTO

Blakeman's well, by Elliot Stahl
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Blakeman's well is a 161-foot-deep vertical shaft
on the Kentucky River, developed in the Highbridge Group
along a major joint that breached the bentonite beds
at the top of the Highbridge. No known cave passage leads
from the shaft. A climber can be seen descending into the
shaft by rope near the opening at the top.



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The Kentucky Geological Survey

Annual Report

Fiscal Year 2010-11

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University of Kentucky President Eli Capilouto and KGS Director Jim Cobb discuss the maps on display at a KGS mapping celebration and symposium in December 2011.

Letter from the Director

The Kentucky Geological Survey at the University of Kentucky publishes this annual report to inform the public about its activities for each fiscal year, as required under Kentucky statute 151.01. This is the 12th year of the 12th survey (numbered consecutively from the first permanent survey established in 1854) and so is a time to reflect not only on the past year's accomplishments but also on the accomplishments of the past 12 years. There have been many such accomplishments in energy, hazards, water, and data distribution.

The mission of the Kentucky Geological Survey is to investigate the commonwealth's geology, mineral and fuel resources, groundwater, and hazards, and report on these important topics to society. These investigations were aided in 2010-11 by 18 projects funded by \$1.9 million in grants; approximately \$0.72 million was from federal sources and \$1.3 million from State sources. Much of the resulting information was distributed via the KGS Web site, which continues to be a valuable tool used by many people in private businesses, industries, and government agencies, as well as citizens. During the fiscal year more than 110,000 database searches were made online for oil and gas, coal, and water data, resulting in more than 1,400 data downloads. Users viewed KGS data on interactive Web maps, especially our signature interactive geologic maps. An average of 500 users each day accesses our data at www.uky.edu/kgs. The KGS Web site is one of the University's most active information providers. In addition, through its Well Sample and Core Library, KGS provides data to staff, professional geologists, and students, and acquired 47 sets of new well samples in 2010-11.

KGS produced 17 new publications in 2010-11, including six new maps in the 30 x 60 minute geologic map series. The maps in this series are based on 1:24,000-scale data, making them extremely high-fidelity products. When the series is completed during the next fiscal year, it will be an important milestone in the history of geologic mapping in both Kentucky and the United States.

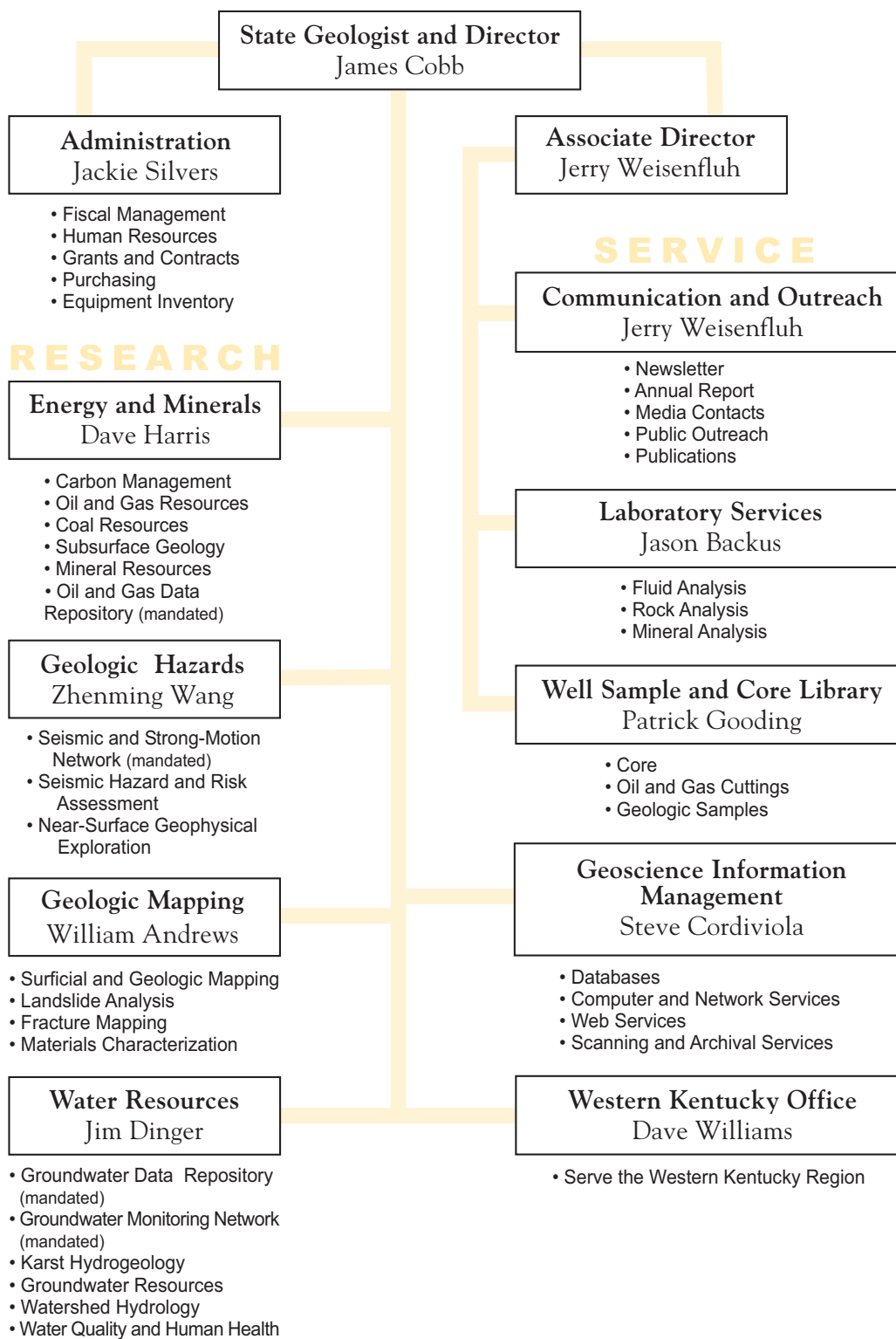
A new publication was released during the year that assessed the potential ground motion from the maximum credible earthquake in or near Kentucky. It provides advice to government officials, policy makers, and developers about the level of earthquake hazard anticipated from this magnitude earthquake.

Two new maps showing the remaining resources of the Springfield and Herrin coals in the Illinois Basin were published in response to an increased demand for western Kentucky coal.

On the national level, the year can be characterized as political gridlock in Congress. There is an apparent standoff between those who want higher taxes and those who want lower spending. As a result, no new programs are being initiated and some important programs are at risk of being cut or even eliminated. Since KGS relies on both State and federal programs to fund its work, we are very concerned. Geological surveys provide society a great return on the investment of tax dollars through mapping, characterizing resources, identifying hazards, and distributing data to thousands of users each year. KGS costs less than \$1 per year for each Kentuckian. Kentucky's mineral and fuel industries rely upon information provided by KGS to avoid hazards, meaning that this information adds up to billions of dollars for the public good.

We hope this annual report will inform you about our research and service activities during the year. Please let us know if you have any questions or suggestions about anything you have read in these pages. I am interested in comments and suggestions from our readers and partners, so email your comments to me at cobb@uky.edu. ||

Kentucky Geological Survey Organizational Chart 2010-11



Energy

Research by the KGS Energy and Minerals Section contributes to our understanding of Kentucky's energy resources and carbon storage capacity.

Kentucky House Bill 1 Carbon Storage Demonstrations

CO₂ Enhanced Oil Recovery and Sequestration

Two types of enhanced oil recovery sequestration projects continued to move toward completion. At Sugar Creek Field in Hopkins County, 7,268 tons of CO₂ was injected into the Mississippian Jackson Sandstone reservoir in 2009 and 2010. CO₂ was continuously injected through a central well surrounded by six to eight production wells, followed by water injection. The final round of monitoring and sampling occurred June 8, 2011. Geochemical monitoring of reservoir fluids and gases conducted by **Marty Parris**, **Kathryn Takacs**, and **Glynn Beck** documented changes in fluid chemistry as a result of CO₂ migration in the reservoir.

The Sugar Creek project is part of the Midwest Geological Sequestration Consortium pilot program administered by the Illinois State Geological Survey and supported with U.S. Department of Energy funding. According to MGSC Deputy Program Coordinator **Scott Frailey** of the Illinois Survey, the project produced approximately 1,000 barrels of incremental oil. The final report of findings is currently being drafted.

The Euterpe Field in Henderson County was the site of another enhanced oil recovery CO₂ injection project, which began with geochemical characterization in 2010. CO₂ was injected and fluids subsequently produced from the same well after an appropriate shut-in period. The initial injection of 20 tons of CO₂ in late October 2010 produced a favorable response, with 119 barrels of incremental oil produced. That

prompted a second injection of 60 tons in the same well in late January 2011. Pump failure, possibly related to CO₂ corrosion, however, shut the well in and has precluded a full assessment of the reservoir response to injection. Reservoir pressure and temperature at Euterpe and Sugar Creek are low enough that CO₂ resides as a gas in the oil reservoir; consequently, the oil-CO₂ interactions are immiscible.

Marty Parris is the principal investigator for the projects, and researchers **Glynn Beck** and **Kathryn Takacs** have conducted most of the fluid and gas monitoring. The KGS laboratory is measuring fluid chemistry.

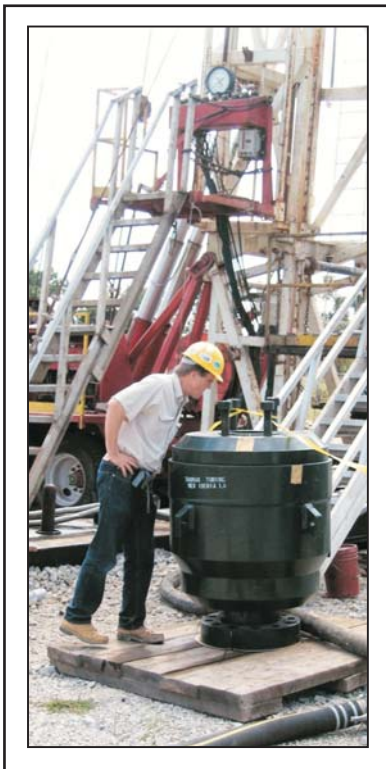
Devonian Shale CO₂ Enhanced Gas Recovery Demonstration

A project headed by **Brandon Nuttall** is under way to test the hypothesis that Devonian black shales beneath about two-thirds of Kentucky may serve for long-term CO₂ storage and play a role in enhanced natural gas recovery.

A site in Johnson County was selected, and a memorandum of agreement for access and research has been completed. In addition to the House Bill 1 (2007) funding, support for this project has been secured from the U.S. Department of Energy.

Eastern Kentucky Coal Field Deep Saline Injection Well

With completion of phase 2 of the western Kentucky deep injection well in Hancock County, KGS has shifted focus to locating a deep saline injection test well in the Eastern Kentucky Coal Field. **Steve Greb**, **Dave Harris**, and **Warren Anderson** evaluated several areas, and northeastern Kentucky was selected as the primary target because



Energy and Minerals Section Head Dave Harris inspects equipment at the Hancock County site during the second phase of deep carbon sequestration testing.

of the presence of multiple reservoir zones at reasonable drilling depths and proximity to the Ohio and Big Sandy River industrial corridor. A final site decision was expected by the end of 2011, with drilling planned for early 2012.



This vibrator truck was used to create the time-lapse three-dimensional vertical seismic profiles during the second phase of the Hancock County deep-sequestration test.

Evaluating Deep CO₂ Storage in the Illinois and Michigan Basins

Begun in 2010, this 3-year project is a collaborative effort of four research groups: state geological surveys in Illinois, Kentucky, and Indiana, and geologists at Western Michigan University funded by the U.S. Department of Energy. The project will characterize the carbon sequestration potential of the Cambrian-Ordovician Knox Group and Ordovician St. Peter Sandstone in the Midwest. KGS is characterizing the Knox Group in western Kentucky, a potentially important subsurface formation for storage of CO₂. Progress this year was:

- Completion of a second phase of CO₂ injection in the Knox Group in the Hancock County well to evaluate a discrete reservoir zone, and imaging the CO₂ plume with time-lapse three-dimensional vertical seismic profiles (**Rick Bowersox** and **John Hickman**).

A total of 367 tons of CO₂ was injected into the test interval over a period of about 8 hours, followed by 12 hours of monitoring of the post-injection pressure decline. A differential temperature log was then recorded across the injection interval to verify CO₂ placement before the well was abandoned. Two vertical seismic profiles were recorded by SeisRes2020 Inc. of Brea, Calif. These profiles used data recorded by 80 geophones in the well from approximately 1,300 source locations in the Blan property. One

profile was recorded before injection testing, and the second recording was performed 5 days later, immediately following the injection of CO₂ into the Gunter Sandstone. By occupying the same source and receiver points for both profiles, a two-point, time-lapse, three-dimensional, depth-migrated seismic volume (1,000 feet x 1,000 feet x 8,500 feet deep) was produced to image the injected CO₂ plume and its effects on the surrounding geology.

- In addition to the three-dimensional vertical seismic profiles at the Blan well, advanced seismic analysis began in late 2010 using preexisting two-dimensional seismic profiles. This research, led by **John Hickman**, is intended to investigate possible techniques for enhancing the ability to image discrete porosity zones in the dolostones of the Cambrian-Ordovician Knox Group in the Illinois Basin. Although this work is still ongoing, initial efforts using frequency filtering, continuous phase analysis, and stochastic inversion techniques have produced encouraging results.
- Knox cores from several wells, including the KGS Marvin Blan No. 2 well drilled for CO₂ research, in western and central Kentucky were described in detail, and sampled for geochemical analysis and petrography. Porosity development in the Knox is highly variable, and controlled by burial diagenesis. Results of the petrographic and geochemical work in progress will help us better understand porosity distribution in the Knox. (**Dave Harris** and **Marty Parris**)
- Developing geochemical models to predict interactions among supercritical carbon dioxide, brines, and the minerals making up the Knox carbonate reservoir and seal rocks (**Marty Parris** and **Junfeng Zhu**).

Speciation models, which describe the equilibrium state between reservoir fluids and minerals, have been developed for the Knox using fluid chemistry, mineralogy, and temperature and pressure conditions documented at the Marvin Blan No. 1 well in Hancock County. The speciation models were developed using Geochemists Workbench and ToughReact software. The models are the first step in characterizing the geochemical system before simulating injection of CO₂. In addition, a reactive-transport study is being undertaken with Sienna Geodynamics Inc. in which the effect of hydrogen diffusion on geochemical interactions in confining intervals is being investigated. The modeling suggests that most geochemical interactions, such as

dolomitization, occur in the lowermost part of the confining interval near the contact with the Knox, which in an active injection project would have high CO₂ concentrations and low pH. These reactions appear to have little effect on porosity or permeability, however.

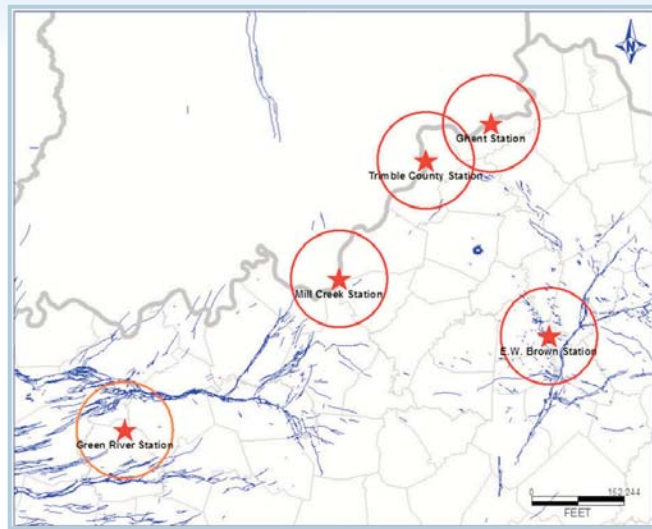
Regional Carbon Storage Partnerships

The section continued research in phase 3 of the U.S. Department of Energy–funded Midwest Regional Sequestration Partnership (**Steve Greb**). A new multi-state U.S. Department of Energy project, called the Simulation Framework for Regional Geologic CO₂ Storage Infrastructure along the Arches Province of the Midwest United States, was also begun (**Greb**). Research in Kentucky included continued characterization of regional CO₂ sequestration potential in saline reservoirs, and analyses of oil and gas fields for potential enhanced oil and gas recovery with CO₂. Large data sets of stratigraphic tops and petrophysical information are being collected from subsurface geophysical logs by **Tom Sparks, Kathryn Takacs, Mike Solis, Brandon Nuttall, and Marty Parris**; the data will be combined into regional data sets for a better characterization of the region’s sequestration potential.

The simulation project is an effort managed by the Battelle Memorial Institute to model multiple injections of CO₂ at different sites along the Ohio River Valley and adjoining regions in order to better understand the potential and implications of future industrial-scale CO₂ storage. Work for this project included detailed analyses of seismic data and a new map of the Mount Simon Sandstone in Kentucky. **Mike Solis, John Hickman, Tom Sparks, and Rick Bowersox** helped with this project.



Brandon Nuttall leads a training session on PETRA software for Energy and Minerals Section staff and students. PETRA is used for mapping, reservoir analysis, and other geologic applications.



The locations of the five power plant sites studied for geologic carbon sequestration potential.

LG&E-KU Power Plant Carbon Storage Evaluations

As part of a larger State-funded carbon-capture feasibility study, **Dave Harris** and **John Hickman** evaluated five Kentucky coal-burning power-generating stations owned and operated by Louisville Gas and Electric–Kentucky Utilities, a subsidiary of PPL Corp. This work was undertaken to determine which station had the best potential for geologic CO₂ storage in order to select, design, and seek funding for an integrated carbon capture and storage demonstration project.

Detailed geologic studies, including interpretation of seismic-reflection data, were completed to estimate CO₂ storage options and capacity. Various subsurface geologic maps and cross sections were made for each site. Additional reflection-seismic data from around the Green River Station were purchased by LG&E-KU to improve mapping of faults near the site that could have an impact on containment of injected CO₂. These new data were interpreted and incorporated into the Green River evaluation. The rest of the data used for the study consisted of geophysical well logs, seismic data, and core data from databases maintained by KGS. The evaluation concluded that all of the sites, with the exception of the E.W. Brown Station in Mercer County, have potential to inject and store CO₂ onsite to some degree.

*W*hat they're telling us
From an oil and gas operator:

"Thanks for your prompt attention and the update. I appreciate all that you folks at the Survey have done and continue to do regarding availability of data. It really is superb!"

Examination of Pennsylvanian Marine Shale Beds for Gas Resources

Pennsylvanian shale beds of at least partially marine origin occur throughout Pennsylvanian strata in both the Appalachian and Illinois Basins. Some of these beds are thick (more than 5 meters), laterally extensive, and occur below regional stream drainage level across much of their geographical extent. These beds, though recognized and used extensively as marker beds for correlation, are poorly understood as a potential gas and oil resource. **Cortland Eble** and **Steve Greb** are examining and documenting the organic composition of these beds in an effort to better evaluate their potential as a petroleum resource.

Desorption tests of the shale above the Springfield coal indicate an average gas content of 34.3 standard cubic feet per ton (as-received basis), which is very similar to desorption test results obtained from a Devonian shale well in eastern Kentucky. For comparison, the Springfield coal itself was found to have an average gas content of 88.4 scf/ton (as-received basis). Though not presently economic to recover, the gas in the Springfield coal and shale in western Kentucky nonetheless represents an untapped resource that may have future significance.

Rare Earth Element Research

Federal agencies consider rare earth elements to be strategic and critical minerals. These elements are used in a variety of electronics and military applications from cell phones to guided missiles to magnets and lasers. The United States has only one operating mine with limited reserves that produces these elements. Therefore, the United States typically imports most of these metals from China, which recently announced restrictions on the export of these minerals to the United States, citing China's own domestic need.

Warren Anderson has initiated a project to examine ultramafic igneous rocks in the Western Kentucky Fluorspar District and in Elliott County for their potential to produce rare earth elements. KGS will sample, analyze, and interpret the geochemical data to determine quantitative values for rare earth elements.

Nonfuel Minerals Database

Warren Anderson, **Tom Sparks**, and **Richard Smath** are in the process of establishing a database of all the noncoal mineral deposits in Kentucky to allow access to hundreds of files with information on the mineral

resources of the state. This project was started several years ago and is only worked on as funds become available to hire students for scanning thousands of records of mineral, ore deposit, and mine information to be linked to a GIS system for implementation of this database. ||

State Geothermal Data Project—Kentucky's Participation

The KGS Geoscience Information Management Section began working during the fiscal year with the National Geothermal Data project, administered by the Association of American State Geologists with funding from the U.S. Department of Energy. The purpose of the project is to collect and digitize scientific data on geothermal exploration and development from across the country.

KGS received a 3-year, \$586,000 subcontract in July 2010 and spent the first year cataloging 14,800 images of oil and gas borehole geophysical logs, 11,200 borehole bottom-hole temperatures, and 1,500 digital traces of geophysical logs.

KGS was selected as one of four regional technical hubs, primarily responsible for the southeastern states and the Virgin Islands. The geothermal and related data will be made available through a national network, whose purpose will be to focus geothermal exploration activities and minimize investment risks.

Water Resources

Important issues, from drinking-water supplies to sinkhole development, keep Water Resources staff busy with projects around Kentucky.

Cane Run Watershed

Water Resources Section staff and faculty in the University of Kentucky Department of Earth and Environmental Sciences continued to spend a significant amount of time developing shallow seismic and electrical-resistivity techniques to aid in drilling monitoring wells into the underground conduit that carries Cane Run from Lexington to Royal Springs, the major water supply for the city of Georgetown. The Cane Run watershed is the focus of a U.S. Environmental Protection Agency consent decree and grant to mitigate poor water quality. Equipment has been installed to monitor discharge and water quality through the subsurface conduit, and some initial samples have been taken at the Kentucky Horse Park. Another upgradient site is being studied for future well installation.



Junfeng Zhu of the Water Resources Section sets up electrical-resistivity equipment to detect groundwater in Burnside, Ky., where ground movement may be damaging nearby houses. He has used this equipment in other projects, including the Cane Run watershed project.

Groundwater Contaminant Modeling at the Paducah Gaseous Diffusion Plant

Historical operations at the Paducah Gaseous Diffusion Plant have released hazardous, nonhazardous, and radioactive wastes to the environment, including PCB's (polychlorinated biphenyl), TCE (trichloroethene), multiple isotopes of uranium, and technetium-99. TCE and technetium-99 contamination is widespread at the plant. The site is an EPA National Priority List Superfund site. **Junfeng Zhu** conducted an independent review of the most recent version of a groundwater flow and contaminant transport model designed to help with remediation at the site. KGS will continue to develop and operate the model to simulate potential groundwater and source-area remedial scenarios for the plant. In the future, the model will incorporate newly collected hydrostratigraphic data.

Karst Activities

In cooperation with the Kentucky Division of Water, **Jim Currens** completed and released the karst groundwater basin map for the Tell City 30 x 60 minute quadrangle. A major revision of the karst map of the Somerset 30 x 60 minute quadrangle has



Alex Fogle, Junfeng Zhu, and Bart Davidson set up at one of the exploratory wells drilled for the Cane Run Watershed project in Lexington.

recently been completed and is undergoing final review. Currens is also using statistical analysis to link geologic strata to the occurrence of past sinkholes and the probability of future sinkholes as part of a continuing effort to develop sinkhole maps.

Cumberland Gap Tunnel

Roadway pavement subsidence at the tunnel continues to be of great concern. **Jim Dinger** and **Steve Webb**, with the help of the Kentucky Transportation Center at the University of Kentucky, sampled at sites beneath the pavement to monitor the dissolution rate of roadbase aggregate. Information collected has helped to develop remediation plans and costs for the 6-year highway plan formulated by the Kentucky Transportation Cabinet.



Baskets of limestone were installed by the Water Resources Section in Cumberland Gap Tunnel monitoring wells to monitor dissolution of the rock.

Analysis of Formation Water Chemistry in the Appalachian and Illinois Basins

Marty Parris, Glynn Beck, and Kathryn Takacs continue to evaluate archived formation-water chemistry data, gathered primarily during drilling for oil from deeper reservoirs in the Appalachian and Illinois Basins of Kentucky. More than 1,200 measurements from 107 counties have been examined and entered into a database, along with well location, sampled depth, and stratigraphic interval. Most of the analyzed waters are nonpotable brines with salinities up to 300,000 milligrams per liter of total dissolved solids. Samples were collected from Pennsylvanian through Precambrian reservoirs spanning a depth range of 2,000 to 8,000 feet below sea level. Most of the archived measurements are of major cations (sodium, calcium, magnesium, potassium), major anions (chlorine, sulfate, bicarbonate), and water properties (pH, conductivity, total dissolved solids). About half of the data have been checked for quality using charge-balance analysis. This information is valuable because

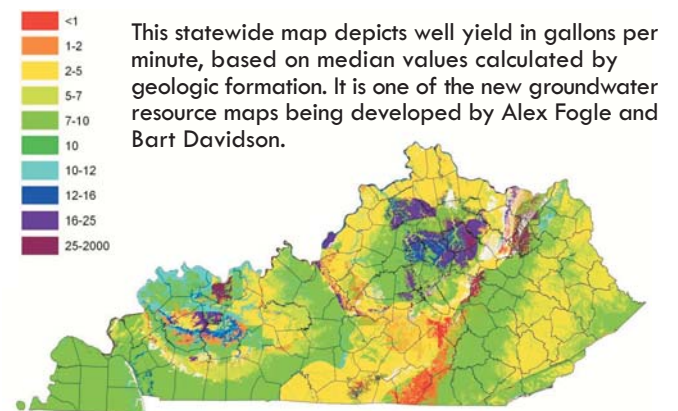
the distribution of solutes in a stratigraphic and depth context is used to analyze basin hydrostratigraphy. The chemistry data are also used as inputs for CO₂ solubility models in carbon sequestration studies.

In addition to the historical data, new formation water samples collected in 2010-11 include Silurian samples from the Laurel Dolomite in Green County, Keifer Sandstone in Lee County, and Lockport Dolomite in Wolfe County. Silurian reservoirs in Kentucky contain sodium chloride brines with the highest salinities in the state. The chemistry of the Silurian brines is being assessed because they can contain high concentrations of lithium.

New Groundwater Resource Maps

Alex Fogle and **Bart Davidson** continued their effort to create a new series of groundwater resource maps for Kentucky using digital 1:24,000-scale geology and current water-well data. These maps build on previous groundwater availability maps from the U.S. Geological Survey's Hydrologic Atlas series of the 1960's. Hydrologic factors such as well yield, depth, static water level, and groundwater quality are now being mapped and analyzed to characterize the quantity and quality of groundwater resources. Median values for each of these factors have been calculated for every major geologic formation and physiographic region in the state. Resulting data are displayed in both map and graphical format. GIS technology allows several of these factors to be analyzed within a single map.

Other maps are also being generated that compare geology, water-well characteristics, and groundwater-quality parameters. These maps will help users determine



the likelihood of obtaining groundwater from any point in the state and provide basic information on the quantity and quality of that groundwater.

Assessment of CO₂ Injection on Local Groundwater Quality

Glynn Beck, Marty Parris, and Kathryn Takacs continued shallow groundwater monitoring for two carbon storage and enhanced oil recovery projects overseen by the Energy and Minerals Section. The shallow groundwater was sampled to characterize the local water quality and assess any changes in quality that may be associated with CO₂ injection. Sampling was completed in June 2011 of formation waters from the Mississippian Jackson Sandstone reservoir and Pennsylvanian aquifers in the vicinity of a Hopkins County enhanced oil recovery project; sampling continued for the Hancock County carbon storage project funded by the State and private partners.

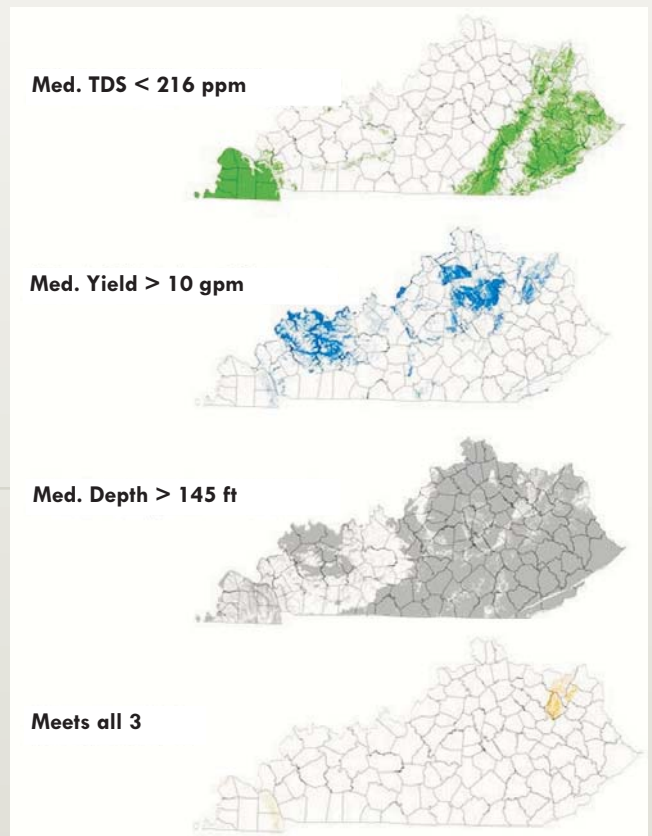
Unregulated Drinking-Water Initiative

Bart Davidson and Jim Dinger completed a joint project with the Centers for Disease Control and Prevention and six other states. The CDC has initiated a nationwide project to identify and characterize unregulated drinking-water sources, primarily wells and springs, not covered by the Safe Drinking Water Act. The Kentucky pilot project found nondigitized groundwater data from government agencies and estimated the cost for digitizing them and entering them into the Kentucky Groundwater Data Repository, where they are accessible to the CDC and project participants. Eight data sets that would be useful for inclusion into the repository were located. The CDC has awarded KGS additional funds to digitize and enter four of these data sets into the repository during the next fiscal year.

Groundwater-Quality Data from Domestic Well Sampling in Western Kentucky

Groundwater-quality data collected from 668 water wells in 12 western Kentucky counties were checked for errors

and formatted for entry into the Kentucky Groundwater Data Repository. Of the 668 wells, 650 are located in the eight counties making up the Jackson Purchase Region. The remaining 18 wells are located in four counties in the Western Kentucky Coal Field. Data for parameters such as electrical conductivity, pH, nutrients, alkalinity, and herbicides were assessed. A total of 23,932 analyses were assessed and submitted for entry into the repository. ||



The new online groundwater resource interactive maps will allow users to specify a group of requirements regarding the amount and type of groundwater needed and get a map showing locations that meet all those criteria. For example, a company requires groundwater that has total dissolved solids less than 216 parts per million, a flow of greater than 10 gallons per minute, and a depth greater than 145 feet. The resulting map shows that only two areas of Kentucky would meet all three criteria for the company: Rowan and Lewis Counties in northeastern Kentucky, and Marshall and Calloway Counties in southwestern Kentucky.

What they're telling us
From a teacher:
"On behalf of our entire Science Department, I want to thank you for the beautiful map of Mason County. It is full of terrific learning opportunities for our kids."

Henderson Office

KGS staff in the Henderson office perform important research and public service in western Kentucky. The office provides support for economic activity, particularly in the vital production of industrial and energy resources, industrial stone, and groundwater. In addition, the staff help the general public and local agencies understand geologic hazards such as mass wasting and earthquakes.

During the past year, **Dave Williams** managed the reclamation of the Hancock County deep well drilled for carbon storage research. **Glynn Beck**, with the Water Resources Section, continued sampling two domestic water wells and two domestic springs near the deep well to monitor for potential geochemical changes in the shallow groundwater system. Williams continued mapping paleochannels in the Western Kentucky Coal Field. He is responsible for adding stratigraphic and completion information to the petroleum records database for new petroleum tests in western Kentucky. He also described coal cores and worked with members of the Illinois State Geological Survey investigating Permian rocks in Kentucky.



Ron Counts and University of Southern Indiana Geology Department Chair Bill Elliott split open a Carbondale siltstone slab containing trace fossils at the Spottsville Bridge over the Green River in Henderson County.

*W*hat they're telling us From a property owner:

"A staff member from the KGS Western Kentucky office provided information to me on what I could read about coal and oil and gas on my Union County farm. His knowledge was impressive and his willingness to help most appreciated."

Beck, Ron Counts, and Scott Waninger completed eight electrical-resistivity surveys over an abandoned fluorspar mine in Marion, Ky., to locate mine water that could supplement the municipal reservoir during drought conditions.

Williams and Waninger met with members of the U.S. Natural Resource Conservation Service in Daviess County to investigate soil piping, a sometimes serious soil erosion issue in the loess-covered areas of western Kentucky and which continue to be a regular source of inquiries. Soil piping is the erosion of soils through a natural subterranean channel and can lead to surface depressions or sinkholes, occasionally causing damage in yards and pastures.

Counts and Waninger drilled shallow tests to characterize seismic behavior of unconsolidated materials in western Kentucky and continued investigating paleoseismic features in the region. Counts also cooperated with researchers from outside institutions on several projects relating to archeology and recent earthquake activity.

Other work by Henderson office staff can be found in the Energy and Minerals Section (page 4) and the Water Resources Section (page 8). ||



University of Southern Indiana Geology Department Chair Bill Elliott and Scott Waninger of the Henderson office inspect an alluvium outcrop and recent slumps along the lower Green River near the confluence with the Ohio River.

From Coal Mine to the Headlines:

It was a big critter—20 to 25 feet long, weighing about 1,000 pounds—and it had large, sharp teeth, the better to tear apart the soft fish upon which it preyed.

From an article in the *Lexington Herald-Leader*, April 11, 2011

When coal miner **Jay Wright** went to his job at Webster County Coal Co.'s underground Dotiki Mine on a February day in 2011, he probably wasn't expecting to find something more significant than a shift's worth of coal. But early in the afternoon, while bolting the roof about 4 miles into the mine, he saw something lodged in the roof about 8 inches above the Springfield coal bed. All he had to do was pry it from the rock.

What he had found turned out to be the jaw of a large specimen of *Edestus*, an ancient shark genus that prowled a shallow sea covering the region 300 million years ago. KGS Associate Director **Jerry Weisenfluh** heard about the find through contacts in the coal industry and traveled to Webster County to meet Wright and borrow the specimen for research and display.

The 18-inch-long specimen includes original bone material encased in shale and serrated triangular teeth measuring up to 2 inches wide at their base. Because the jaw is particularly large, the shark is believed to have been as much as 20 feet in length.

Both mainstream and scientific news media across the country became very interested when KGS and the University of Kentucky published a news release on the find. Lexington area television and radio stations and newspapers interviewed Wright and KGS staff, and stories based on the release

were published by multiple news media. Weisenfluh says a major natural science museum contacted KGS about buying the specimen. A small number of other *Edestus* fossils have been found in

western Kentucky over the last century, but this is definitely the largest.

Because it became clear that this *Edestus* specimen is significant because of its size, KGS asked **Chuck Ciampaglio** and **Mike Taylor** of Wright State University's Earth and Environmental Sciences Department to make several high-quality replicas. The pair spent a couple of days at KGS creating the molds for replicas of both the western Kentucky fossil

and several smaller ones owned by the University of Kentucky Department of Earth and Environmental Sciences. The white elastic mold they created can be used to make dozens of

additional replicas, using a two-part liquid composite material that hardens in a couple of hours. Taylor's careful painting with an airbrush and small art brushes yielded a very faithful rendition of the original.

The new find should help scientists better understand the extinct shark.

Earth Magazine, July 2011

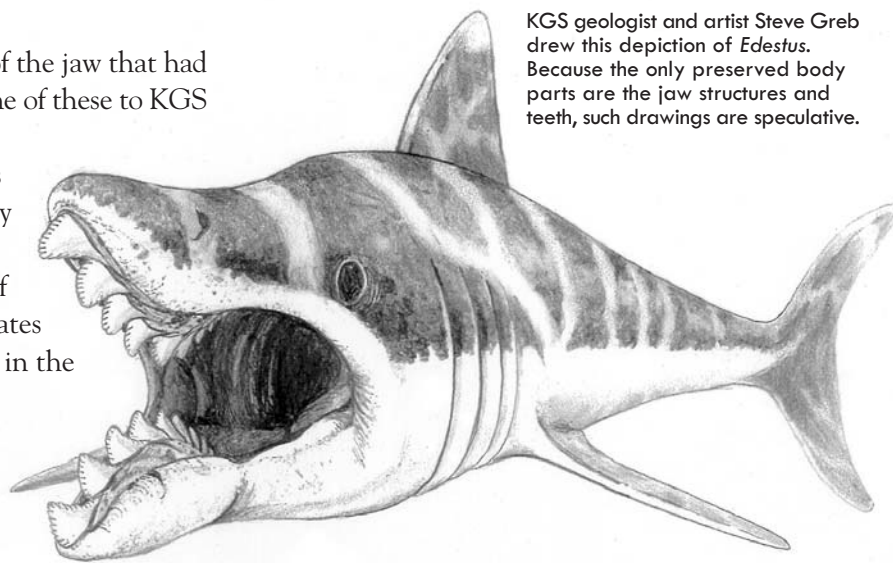


Jay Wright holds the shark-jaw fossil that was displayed at the Kentucky Geological Survey.

Ancient Shark Fossil Makes News

Wright also recovered several smaller pieces of the jaw that had detached from the main specimen. He gave one of these to KGS for detailed study. Geologist **Steve Greb** is coordinating the investigation, which entails making thin sections to study the morphology of the cellular makeup of the structure. One question to be answered is whether the size of this specimen compared to earlier finds indicates a different animal or merely a different point in the life cycle of the same species.

According to the New York Museum of Natural History, this find is one of two known specimens of the species *Edestus giganteus*. The other is in their museum. ||



KGS geologist and artist Steve Greb drew this depiction of *Edestus*. Because the only preserved body parts are the jaw structures and teeth, such drawings are speculative.

Making a Replica



A. KGS geologist Steve Greb discusses making a mold of the original specimen with Mike Taylor and Chuck Ciampaglio of Wright State University.

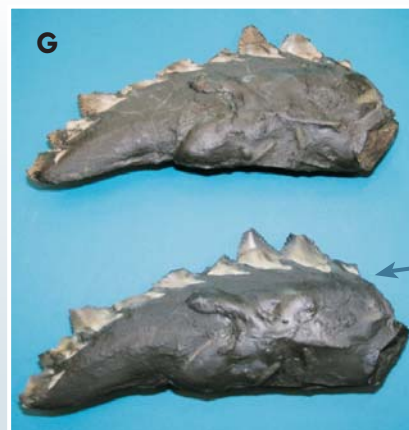
B–C. The *Edestus* jaw specimen is placed in a rubbery molding material until the mold sets up.

D. Taylor and Ciampaglio pour a liquid material into the mold to create the replicas.

E. A finished replica is pulled from the mold after hardening for a couple of hours.

F. Taylor carefully paints the replica to match the original.

G. Can you tell the real from the replica?



Geologic Hazards

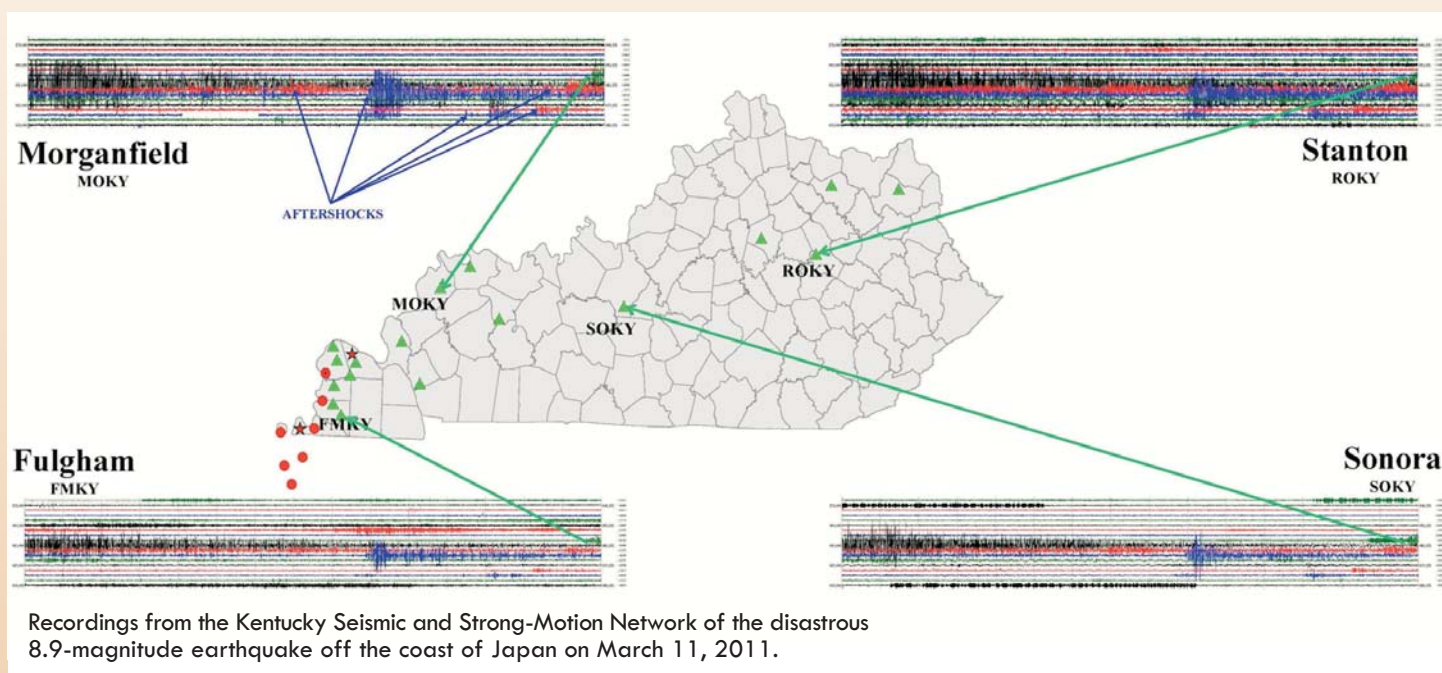
Seismic hazard assessment continues to be the top priority for the Geologic Hazards Section because it is an important issue for the commonwealth. Economic development in western Kentucky has been affected by extremely high ground motion estimated by the U.S. Geological Survey. This fiscal year our main effort was to continue communication of our scientific findings with federal and State agencies as well as professional and international communities. Presentations were made to the Advisory Committee on Earthquake Hazards Reduction, Kentucky Society of Professional Engineers, and Structural Engineers Association of Kentucky; in addition, comments and input were provided to the Independent Expert Panel on New Madrid Seismic Zone Earthquake Hazards.

Seismic issues in Kentucky have been well recognized nationally. In a statement, the Advisory Committee on Earthquake Hazards Reduction acknowledged local community concerns and made addressing the issues of high hazard levels and costs a priority. The committee recommended that the National Earthquake Hazards Reduction Program examine the hazard levels depicted in USGS hazard maps and engage other earthquake professionals by making a

clear statement of current seismic risk and goals for reducing that risk in the New Madrid region. The Independent Expert Panel concluded that “evolution in our knowledge will change the estimated hazard from New Madrid mainshocks in the next round of seismic hazard calculations; we infer that there are several factors that might reduce the estimated hazard.” Furthermore, “it is likely that the estimated ... hazard [for the New Madrid Seismic Zone] may decline moderately in the next hazard assessment due to improved knowledge of past earthquakes and current deformation.” In other words, the panel acknowledged that the current assessments of ground motion hazard for New Madrid are too high.

The Kentucky Seismic and Strong-Motion Network

Operation and maintenance of the Kentucky Seismic and Strong-Motion Network is one of the Geologic Hazards Section’s main tasks. KGS and the University of Kentucky’s Department of Earth and Environmental Sciences jointly operate the network of 26 recording stations located throughout the state. The network monitors earthquakes in the central United States and



records larger earthquakes around the world, as well as mine blasts and other activities. It includes 19 short-period (weak-motion) seismometers and 10 strong-motion accelerometers, including two vertical strong-motion arrays. Continuous near-real-time recordings from 12 of the instruments can be viewed on the KGS Web site at www.uky.edu/KGS/geologichazards/equake3.htm.

During the fiscal year, many earthquakes from around the world were recorded by the network, including the March 11, 2011, earthquake in Japan. But only a few earthquakes occurred in Kentucky. One such quake (magnitude 2.4) was located near Massac in McCracken County, western Kentucky. Progress has also been made on upgrading the seismic station from analog to digital communications as part of the digital upgrade of the Kentucky Emergency Warning System.



Visiting scholar Shunhua Xu couples a shear-wave geophone to the ground for a seismic velocity sounding near the Ohio River in McCracken County in a USGS-funded collaborative project between KGS and the University of Memphis.



Visiting scholars from China, graduate students, and Ed Woolery set up a microseismic-reflection experiment at the Kentucky Horse Park. The work supported the KGS Water Section's monitoring of the Cane Run watershed's underground conduit.

China Scholarly Exchange and Cooperative Research

The scholarly exchange and cooperative research between KGS and the Lanzhou Institute of Seismology entered its seventh year. Based on the field work and data collected from China, UK master's student **David Butler** developed a thesis, "Scenario Seismic Hazard Assessment of Tianshui's Urban Area, Gansu Province, People's Republic of China," and successfully defended it in April 2011. Three visiting scholars from China came to UK to participate in research projects and exchanges. ||

W hat they're telling us
From a geologist:

"I'm a geologist that has used your excellent Web site for some time now. Your Web site is best in the USA."

Geologic Mapping

The primary activity of the Geologic Mapping Section during the fiscal year was surficial mapping in western, northern, and northeastern Kentucky. **Scott Waninger** and **Ron Counts** did surficial mapping in the Livermore area of western Kentucky (McLean County), and Counts worked with the help of a National Earthquake Hazards Reduction Program grant to investigate the site of a possible Quaternary fault he found during earlier mapping in Union County. **Matt Crawford** did surficial mapping in the New Richmond quadrangle of northern Kentucky, **Mike Murphy** mapped in Irvine, and **Monte Rivers** mapped in the Morehead area.

Crawford's mapping was for landslide hazard assessment and other geotechnical applications (see page 17) and in support of the KGS landslide



As part of his landslide inventory, Matt Crawford has visited multiple sites to gather information on slides and damages.

inventory, which contained information on 2,200 sites by the end of the fiscal year. Information and assistance on this project were provided by agencies such as the Kentucky Transportation Cabinet, the Division of Emergency Management, the Northern Kentucky Area Planning Commission, other State and local government agencies, and the



Steve Martin measures an arch in the Red River Gorge.

general public. At the end of the fiscal year, Crawford joined the Geologic Hazards Section, where he will continue his work on landslides and related hazards.

Steve Martin continued to develop his database on natural arches and geologic joints. Since spring of 2007, he has visited 225 locations and measured 2,374 joints. Beginning in the fall of 2009, he visited 172 arches for which he has made 188 measurements. Martin also reviewed and digitized USGS augur data that had been collected during the cooperative mapping program of 1960-78.

Bethany Overfield completed her master's degree work, which involved creating a classification of lower Paleozoic carbonate-bearing rocks for geotechnical applications. She and **Dan Carey** have been analyzing the Kentucky Transportation Cabinet maintenance cost database, focusing on correlating geology with remediation costs of landslides and rockfalls throughout the state.

Carey joined the Geologic Mapping Section during the fiscal year. He has helped the section gather data for a map-unit characterization



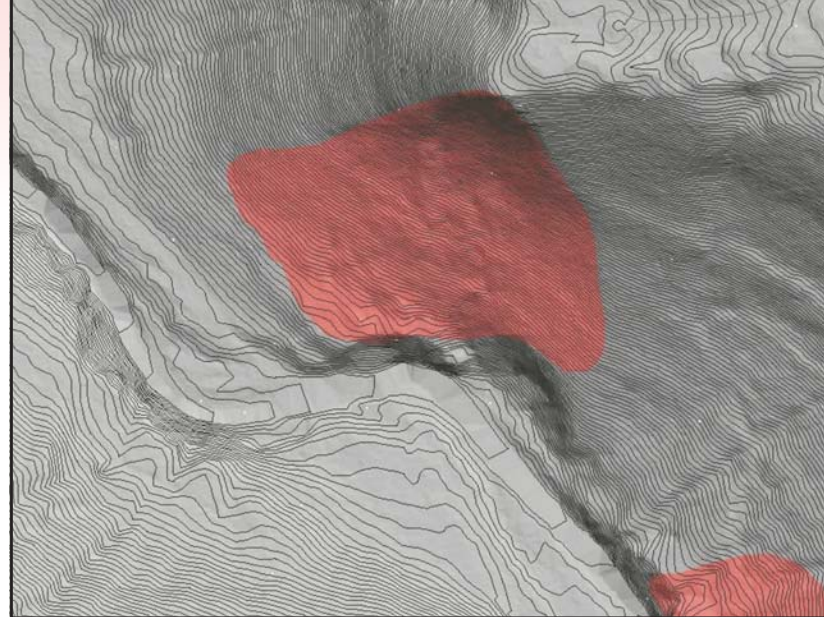
Bethany Overfield visits a site along Ky. 2000 in Clay County in a project to track highway maintenance costs.

database while also working on public interest publications and educational outreach.

Inventory Mapping and Characterization of Landslides Using LiDAR: Kenton and Campbell Counties, Kentucky

The northern Kentucky and Cincinnati region's natural geology and topography make the region susceptible to landslides. Decades of development and slope modification have produced some of the highest costs per capita for landslide damage in the United States. Landslides can damage roads, homes, and other infrastructure, causing financial woes for property owners and struggles for government agencies. The gradual nature of some landslides and incremental damage that can span several decades often leave people unaware of the problem, however. Many landslides go unreported, and citizens do not take advantage of resources to become educated and start to mitigate the problem.

Landslide identification and hazard mapping using LiDAR (light-detection and ranging) has proven successful in other landslide-prone areas of the United States, such as Oregon, Washington, and Pennsylvania. The purpose of this project, funded by the U.S. Geological Survey's Landslide Hazards Program, was to develop a methodology using LiDAR data optimal for the geologic setting of Kenton and Campbell Counties to document landslides as part of an existing landslide inventory. Potential landslides were mapped and data that were previously not visible on existing maps or coarse digital elevation models were digitized. Hillshade digital



An example of the use of LiDAR data and hillshade maps used to detect potential landslides.

elevation maps were the primary data set used for LiDAR visualization and landslide mapping. Locations were also verified in the field, where possible.

A total of 234 potential landslide extents for the two counties were digitized. Using the LiDAR visualization method, 20 landslides were initially classified as confident. The other mapped slides were classified as questionable and very few as moderately confident. LiDAR elevation models, topography, geology, and aerial photography all contributed to the landslide identification and classification. Fifteen percent of these landslides were field checked. Many of the landslides were not associated with roadways and occurred in rural, wooded areas that are private property. Approximately 43 percent of the landslides that were field checked were confirmed, 40 percent were likely or observed but could not be

confirmed, and 17 percent were not accessible. The types of landslides (translational or rotational) could not be determined solely by LiDAR visualization. Further field investigation will be needed.

Continued use of high-resolution LiDAR to identify potential landslides will provide a framework for analyzing landslide data that is crucial to understanding the nature of the landslide-prone areas and reducing long-term losses. ||

Section Head **William Andrews** chairs a strategic planning committee of the Kentucky Geographic Information Advisory Council. The planning group was formed in July 2010 with members from State agencies, local governments, private industry, and consultants. Its purpose is to explore future directions of GIS in Kentucky for a variety of uses, including environmental management, economic development, and public health and safety. The group is discussing digital base-map layers (i.e., road centerlines and addressing), LiDAR, public education and outreach, and cooperation among GIS-related organizations and professional development practitioners.



*W*hat they're telling us

From a software developer:

"I just wanted to write to ask if you could convey my compliments to the author of your online geologic map. I think the KGIS map is probably the best in the nation."

KGS Laboratory

The KGS laboratory analyzes water, coal, mineral, and rock samples in support of geologic and environmental research conducted by the Survey and other University of Kentucky departments, and agencies of State and local governments.

The laboratory continued to analyze water samples for the Hancock County deep carbon storage test well drilled in 2009, as well as water samples taken from the Sugar Creek enhanced oil recovery project in Hopkins County and the Euterpe site in Henderson County. Both of these projects are overseen by the KGS Energy and Minerals Section.

Several projects from University of Kentucky departments were undertaken. One analyzed basalt samples from Mexico for a researcher in the Department of Anthropology.

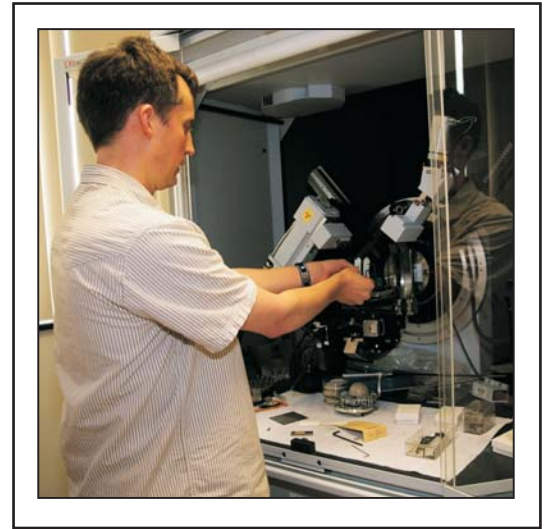
Collaborative projects were undertaken with the University of Texas and other universities. These projects included analyzing shale samples for sulfur content and a soil leaching project examining lead concentrations.

KGS laboratory staff continued to analyze water samples for the Kentucky Water Watch program, which monitors the quality of the state's streams, rivers, lakes, and wetlands.

The laboratory started a yearlong watershed-quality monitoring program for the Lexington-Fayette Urban County Government and Kentucky Division of Water being administered by Third Rock Consultants, LLC.

During the fiscal year, the laboratory analyzed 3,498 samples:

- 621 water samples,
- 2,721 mineral and rock samples, and
- 156 coal samples



Darby Harris, a doctoral student working with University of Kentucky horticulture professor Seth DeBolt on plant cell research, places a sample for testing in the KGS laboratory's X-ray diffractometer.

Several new projects analyzing limestone and dolomite samples from both inside and outside of Kentucky were started during the fiscal year. The analyses were for several private consulting firms using the laboratory's X-ray instruments to classify the chemical qualities of the rock at known depths and locations.

The KGS laboratory continues to house, maintain, and oversee scheduling of the X-ray diffraction instrument for use throughout the University. Students and researchers from many disciplines use the instrument for a wide variety of projects. For instance, the laboratory provides the use of its X-ray diffractometer for horticultural research into the modification of plant cell walls for industrial applications.

A new automated sample fluxer was added to the lab during the fiscal year. This equipment is used to prepare samples for X-ray fluorescence elemental analysis of mineral and rock samples. ||



Steve Mock works with a lab instrument that analyzes metal content in water.

Well Sample and Core Library

The KGS Well Sample and Core Library contains Kentucky's only public collection of well samples and rock cores, storing cuttings from about 19,000 oil and gas wells and core samples from more than 2,850 sites. The library provides a service to individuals, universities, and companies needing direct access to samples for research or investigations.



Core library employee Ray Daniel searches records and updates information in the facility's database.

During the fiscal year, more than 1,500 boxes of cores exceeding 18,200 feet were pulled off the shelves for examination. One hundred sets of well cuttings, representing about 120,000 feet, were examined. Eighty-one college students from nine universities used geoscience data at the facility for dissertations, theses, and projects. New holdings added to the collection during the year were 47 sets of well samples totaling 205,028 feet and two cores surpassing 1,580 feet. Cores from the KGS Marvin Blan No. 1 well, the recent carbon dioxide injection site in Hancock County, are now stored at the facility.

Research projects conducted at the core library were on carbon sequestration, hydrocarbon and coal exploration, groundwater resources, environmental issues, and stratigraphy and sedimentology. For example, when the Energy and Minerals Section began assessing Kentucky's sedimentary basins for their capacity to store CO₂, a key source of data was cores and cuttings

What they're telling us

From the Lexington Legacy Trail Narrative Committee:

"Thank you for your contributions of explanations and materials about geology to place along the Legacy Trail."

drilled decades ago. They provided the porosity, permeability, thickness, and mineralogy data necessary to help determine the storage potential of deep subsurface intervals, and to rank candidate oil fields for CO₂ enhanced oil recovery. These data improved capacity estimates and helped predict injection zones in the deep CO₂ research well drilled in Hancock County.

Another project, which investigated the stratigraphy and distribution of the oil shales of Kentucky, benefitted from the collection. **Frank Etensohn**, a professor of geology in the UK Department of Earth and Environmental Sciences, and Core Library Manager **Patrick Gooding** have been working on correlating black shale horizons across the state, using samples stored at the facility.

Staff answered 488 telephone and e-mail requests for information. In addition, 67 tours, which included demonstrations, presentations, and displays on various geologic topics, were conducted. Other assistance was provided for 331 visitors to the facility. ||



KGS staff study cores stored at the Well Sample and Core Library.

Outreach Activities

As a full-service geological survey, KGS has been proactive in taking its research to the people we serve and providing opportunities for the public to hear about geologic issues. A number of public events, both at KGS and in the field, were held during the fiscal year.

Annual Seminar

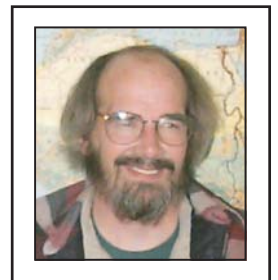
About 120 people filled the Well Sample and Core Library's meeting room on May 13 for the 51st KGS annual seminar. The topic of the day was the future of the geosciences. Speakers included **Linda Rowan** of the American Geological Institute and **Richard Spruill**, president of the Association of State Boards of Geology, as well as KGS staff. A panel of teaching and practicing professional geologists discussed steps to strengthen the geologic profession. The seminar included an official meeting of the Kentucky Board of Registration for Professional Geologists. The board took comments from participants on the issue of "direct professional knowledge," a term found in the Kentucky Geologists Code of Professional Conduct. The code reads, "a registered geologist shall sign and seal

March 16 talk on analyzing faults, seals, structures, and stratigraphy in the exploration and production of hydrocarbons through modeling.

Medwedeff's was another in the AAPG Distinguished Lecture Series. In his discussion of the role of modeling in the search for oil and gas, he cautioned that probabilistic models should not substitute for careful analysis of available data.

Darwin Lecture

The Kentucky Section of the American Institute of Professional Geologists' third annual Darwin Lecture, co-sponsored by KGS, drew nearly 1,000 people on February 10 as **Dr. Jack Horner**, curator of paleontology at the Museum of the Rockies in Bozeman, Mont., spoke on "How to Build a Dinosaur: Extinction Doesn't Have to Be Forever." The talk was based on the book of the same title by Horner and James Gorman (Dutton Adult, 2009, \$12.99). Horner was the real-life inspiration for the paleontologist in the *Jurassic Park* books and movies.



A panel of teaching and practicing professional geologists discussed steps to strengthen the geologic profession at the KGS annual seminar held at the Well Sample and Core Library meeting room.

only professional work, including, but not limited to, maps and reports for which the registrant has direct professional knowledge, and for which the registrant intends to be responsible for its accuracy and adequacy."

Distinguished Lecture

KGS hosted **Donald Medwedeff**, of Chevron Energy Technology Co., for a

Shark Jawbone

Visitors to KGS were able to view a 300-million-year-old jawbone of an ancient shark, *Edestus*, when it went on display in the Publications Sales Office in April. The fossil had been discovered by a Webster County coal miner in

February. His employer allowed him to keep it, and he loaned it to KGS for study and display. The 18-inch-long jaw, with several serrated teeth, received much media attention in Kentucky and around the country when KGS and UK distributed a news release about the find.



Hancock County Well Completion Final Public Meeting

Rick Bowersox, of the KGS Energy and Minerals Section, and other KGS staff made presentations on the closure and reclamation of the site for the Hancock County deep carbon test well during the final public meeting of the project in Hawesville, October 12.

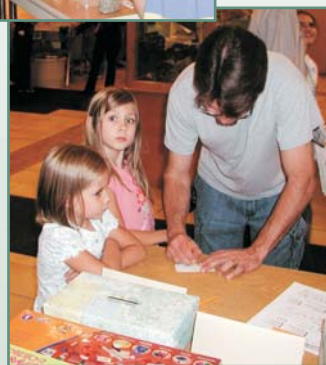
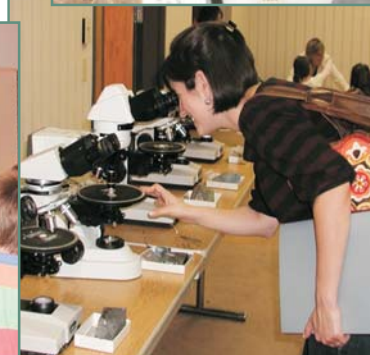
Local officials discussed the importance of carbon capture and storage technologies to local industries, including an aluminum smelting operation. That operation uses a large amount of electricity generated by coal-fired power plants, which are considered a major source of human-caused carbon dioxide.



Rick Bowersox spoke at the final public meeting concerning the Hancock County deep carbon test well.

Open House

Staff of the Survey and other organizations set up exhibits and demonstrations on energy, dinosaurs, caves, karst, minerals, and polished rocks on the evening of October 13 for the annual open house for Earth Science Week. A large crowd of more than 250 students, parents, and teachers came to the Mining and Mineral Resources Building for the event. Other organizations participating were the UK Department of Earth and Environmental Sciences, the UK Geology Club, the UK Mining Engineering Department, and the Kentucky Paleontological Society. II



*W*hat they're telling us
From a teacher:
 "Thank you for a great Earth Science Open House!
 My students really enjoyed it!"

Publications and Web Services

KG S continues to produce new publications and provide Web-based data on a wide range of geologic and related topics. This fiscal year, staff published 17 new reports and maps, including six new maps in the 30 x 60 minute quadrangle series and two maps on the remaining resources of the Springfield and Herrin coals in the Illinois Basin.

In addition, a new series of Special Publications about the geology along major highways of the state began with the release of “Geology Along the Martha Layne Collins Bluegrass Parkway,” by **Dan Carey, Martin C. Noger, and Donald Haney.**

searches were conducted by 124,000 users. Our map services were accessed nearly 110,000 times, with more than 1,400 tabular data downloads. The total number of files downloaded exceeded 4.5 million. Users most frequently downloaded oil and gas records, online publications, coordinate conversion services, and data from the newly redesigned online geologic map site.

As a service to the University of Kentucky community, KGS provided direct online access to Kentucky’s complete GIS catalog of map imagery and boundary data that are compiled by the Kentucky

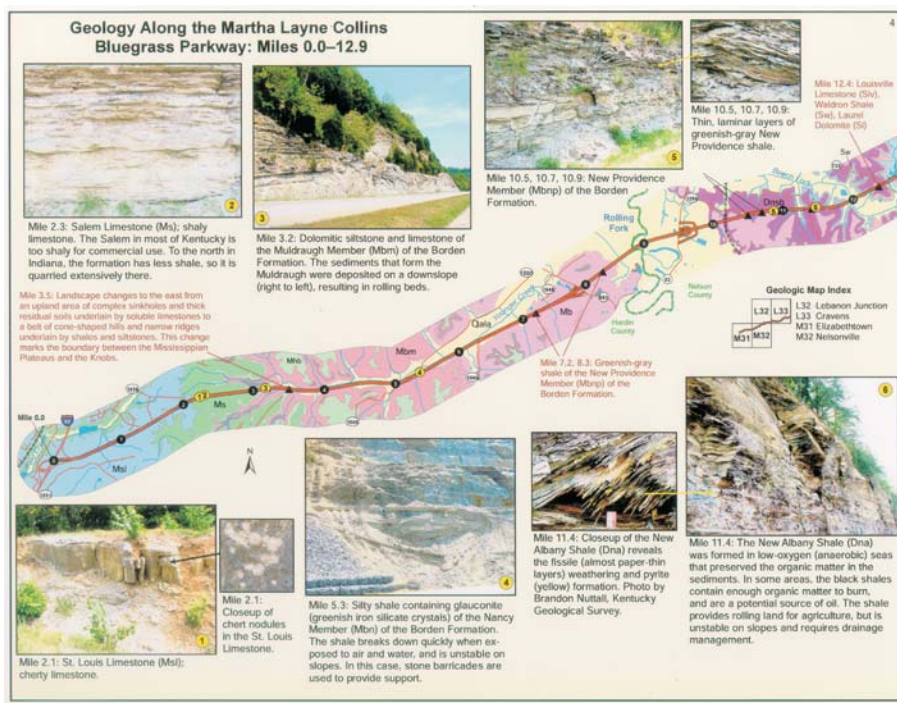
Division of Geographic Information. This gives University researchers on-campus access to a wealth of mapping resources at the click of a mouse.

KGS is mandated to maintain the Kentucky Groundwater Data Repository, and the Survey cooperated with the Kentucky Division of Water to streamline the transfer of water-quality data that the division collects into the online repository hosted by KGS. This process that formerly took months to complete can now be done in a matter of hours, providing end users with up-to-date information on a regular schedule.

The map service that allows users to plot groundwater-quality data on a base map for regional analysis was completely overhauled this year to speed redraw times and provide additional functionality.

A new interactive energy infrastructure map was created that provides information

about the locations of power plants, railroads, active coal mines, and other coal processing, handling, and transportation facilities in Kentucky. Users can zoom in to areas of interest to find energy facilities and query the system for descriptive information about the sites, such as ownership and capacity. The map can be found at kgs.uky.edu/kgsmmap/kycoal/viewer.asp. ||



This sample page from “Geology Along the Martha Layne Collins Bluegrass Parkway” teaches parkway travelers about the geology they drive through.

An assessment of the ground shaking from earthquakes was published in Report of Investigations 22, “Ground Motion for the Maximum Credible Earthquake in Kentucky,” by **Zhenming Wang.**

The KGS Web site continues to serve a diverse audience, receiving a very large number of visits during the fiscal year, as nearly 486,800 database

Staff Awards and Recognitions



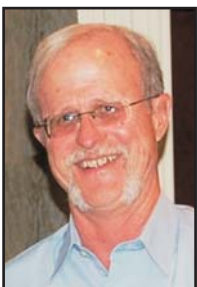
William Andrews chairs the Strategic Planning Committee for the Kentucky Geographic Information Advisory Council.



Jim Cobb completed his term as president of the Association of American State Geologists on June 30. AASG promotes earth sciences and represents state geologists in Washington, D.C.



Matt Crawford continues to serve on the committee that plans the annual Geohazards in Transportation in the Appalachian Region Forum. The 10th forum was held in August 2010 in Columbus, Ohio.



Jim Dinger received the 2011 Bill Barfield Award from the Kentucky Water Resources Research Institute. The award is named for a former director of KWRRRI and recognizes outstanding contributions in water resources research in Kentucky.



Cortland Eble served as the member-at-large of the Coal Geology Division of the Geological Society of America.



Patrick Gooding served as secretary-editor as well as a delegate for the Kentucky Society of Professional Geologists to the House of Delegates of the American Association of Petroleum Geologists. He is also a member of AAPG's Preservation of Geoscience Data and Field Safety Committees. He received the House Recognition of Service Award from the AAPG House of Delegates. In addition, he is secretary-treasurer of the Kentucky Society of Professional Geologists and a member of the Narrative Committee of the Lexington Legacy Trail Project.



Dave Harris serves on the Advisory Council for the American Association of Petroleum Geologists, representing the AAPG's Eastern Section.



Meg Smath served as president of the Association of Earth Science Editors, a position she automatically assumed after her election the previous year as vice president.



Richard Smath received a Presidential Merit Award from the Kentucky Section of the American Institute of Professional

Geologists. The award recognized Smath for a variety of tasks he performs for KY-AIPG, including editing publications, coordinating conferences, and maintaining the group's Web site.



Jerry Weisenfluh received the Gordon H. Wood Jr. Memorial Award from the Eastern Section of the American Association of Petroleum Geologists at the section's September 2010 annual meeting. The award recognizes outstanding contributions to the geology of coal and other energy minerals and the goals of the Energy Minerals Division of the Eastern Section. Weisenfluh is also the associate members' representative to the Association of American State Geologists' Executive Committee and a member of the Standards Committee of the Geographic Information Advisory Council.



Dave Williams serves as a member of the Henderson City-County Planning Commission, which oversees all public and private development in the western Kentucky county.

*What they're telling us
From a student:*
"I wanted to tell you that as a student teacher working on a lesson plan for next year, your page was a great source of information."

KGS Staff 2010-11

State Geologist's Office

Cobb, Jim
Geologist/State Director
Weisenfluh, Jerry
Associate Director
Haney, Don
State Geologist Emeritus
Hower, Judy
Temporary Technician

Administrative Section

Silvers, Jackie
Administrative Staff Officer II
Long, Mandy
Administrative Support
Associate I
Phillips, Gwen
Staff Support Associate II
Ellis, Kati
Student Worker

Energy and Minerals Section

Harris, Dave
Section Head
Anderson, Warren
Geologist V
Bandy, Ralph
Student Worker
Bowersox, Rick
Geologist IV
Eble, Cortland
Geologist V
Greb, Steve
Geologist V
Hickman, John
Geologist IV
Nuttall, Brandon
Geologist V
Parris, Marty
Geologist V
Schumacher, Anne
Student Worker
Solis, Mike
Geologist I
Takacs, Kathryn
Geologist I
Webb, Forrest
Student Worker

Geologic Hazards Section

Wang, Zhenming
Section Head
Altobellis, Eric
Student Worker

Burton, Cate
Student Worker
Chen, Xugeng
Temporary Technician
McIntyre, Jonathan
Geologist IV
Woolery, Ed
Geophysics Faculty Associate
Qi, Yan Yang
Temporary Technician
Xu, Shunhua
Temporary Technician

Geoscience Information Management Section

Cordiviola, Steve
Section Head
Adams, Elizabeth
Geologic Technician
Banks, Roger
Stores Supervisor
Briland, Sarah
Senior Geologic Technician
Conover, Suzanne
Student Worker
Curl, Doug
Geologist III
Ellis, Mike
Computer Support Specialist II
Farwell, Mike
Student Worker
Livingood, Steve
Student Worker
Noakes, Chase
Student Worker
Pulliam, Carrie
Geologist II
Sergeant, Rick
Geologist IV
Smath, Richard
Geologist III
Sparks, Tom
Geologist III
Spaulding, Dan
Student Worker
Thompson, Mark
Information Technology
Manager I
Ulande, Joe
Temporary Technician
Wang, Rebecca
Information Support Specialist
Watson, Anna
Geologist II
Wolfe, Phillip
Student Worker

Communications and Outreach

Weisenfluh, Jerry
Section Head/Associate
Director
Anness, Philip
Student Worker
Carey, Dan
Geologist V
Combs, Megan
Student Worker
Fedorchuk, Nick
Temporary Technician
Fox, Michael
Student Worker
Hounshell, Terry
Chief Cartographic Illustrator
Lynch, Mike
Technology Transfer Officer
Rulo, Collie
Senior Graphic Design
Technician
Smath, Meg
Geologic Editor

Geologic Mapping Section

Andrews, William
Section Head
Crawford, Matt
Geologist III
Eastridge, Emily
Student Worker
Martin, Steve
Geologist III
Murphy, Mike
Geologist II
Overfield, Bethany
Geologist II
Rivers, Monte
Geologist I
Tripathi, Ganesh
Student Worker

Laboratory Services

Backus, Jason
Scientist II/Laboratory Manager
Conner, Andrea
Scientist I
Francis, Henry
Temporary Technician
Mock, Steve
Scientist I

Water Resources Section

Dinger, Jim
Section Head
Currans, Jim
Geologist V
Davidson, Bart
Geologist IV
Fogle, Alex
Geologist III
Johnson, Byron
Student Worker
Webb, Steve
Geologist II
Zhu, Junfeng
Geologist V

Well Sample and Core Library

Gooding, Patrick
Geologist IV/Manager
Daniel, Ray
Principal Research Analyst
Pinkston, Ryan
Research Analyst

Western Kentucky Office at Henderson

Williams, Dave
Section Head
Beck, Glynn
Geologist IV
(Water Resources Section)
Berdine, Jane
Staff Support Associate I
Bleichroth, Amy
Temporary Technician
Counts, Ron
Geologist III
(Geologic Mapping Section)
Fest, Kaitlin
Student Worker
Waninger, Scott
Geologist I
(Geologic Mapping Section)
Wedding, Dan
Temporary Technician
Yoegerl, Ryan
Temporary Technician

Research Projects

Fiscal Year 2010-11

Communications Outreach

Communications Specialist Liaison for the Kentucky Board of Registration for Professional Geologists
Continuing award. FY 2010-11: \$7,700. Total: \$247,700. Funding: Kentucky Board of Registration for Professional Geologists. Ending 6/30/2011.

Energy

Carbon Management

An Evaluation of the Carbon Sequestration Potential of Cambrian-Ordovician Knox Strata
Three-year project. FY 2010-11: \$915,206. Total: \$1,605,624. Funding: U.S. Department of Energy through Illinois State Geological Survey. Ending 12/7/2012.

Assessment of Geologic Carbon Sequestration Options in the Illinois Basin (participation in the Midwest Geological Sequestration Consortium)
Sugar Creek monitoring. FY 2010-11: \$113,694. Total: \$169,627. Funding: U.S. Department of Energy through Illinois State Geological Survey. Ending 9/30/2011.

CO₂ Sequestration and Enhanced Oil and Gas Recovery Using CO₂ (Kentucky House Bill 1)
Carbon storage demonstration projects. FY 2010-11: \$1,250,000. Total: \$5,000,000. Funding: Governor's Office of Energy Policy. Ending 6/30/2012.

Compiling Carbon Storage Data for the USGS National Carbon Dioxide Sequestration Assessment
One-year award. FY 2010-11: \$50,000. Funding: U.S. Geological Survey. Ending 6/30/2011.

Midwest Regional Carbon Sequestration Partnership (Appalachian Basin)
Phase III project to characterize regional reservoir and seal geology. FY 2010-11: \$157,203. Total: \$183,404. Funding: U.S. Department of Energy through Battelle Memorial Institute. Ending 8/31/2011.

Stimulation Framework for Regional Carbon Sequestration Storage Infrastructure Along the Arches Province of the Midwestern United States
Three-year award. FY 2010-11: \$81,818. Total: \$150,000. Funding: U.S. Department of Energy through Battelle Memorial Institute. Ending 9/30/2012.

Geologic Information

Coal Information

Coal Facts Publication
Update of the 2011 *Coal Facts* publication. FY 2010-11: \$14,149. Total: \$14,149. Funding: Kentucky Department for Energy Development and Independence through Kentucky Coal Association. Ending 6/30/2011.

Computerized Coal Resources Data for the National Coal Resources Data System
Five-year project for compiling coal information. FY 2010-11: \$15,000. Total: \$75,000. Funding: U.S. Geological Survey. Ending 6/30/2015.

Data Dissemination

National Geologic and Geophysical Data Preservation Program
Continuing grant. FY 2010-11: \$20,260. Total: \$70,102. Funding: U.S. Geological Survey. Ending 8/31/2011.

National Geothermal Data System Program
Geothermal data inventory and data capture. FY 2010-11: \$187,613. Total: \$585,996. Funding: U.S. Department of Energy through Arizona Geological Survey. Ending 4/30/2013.

Geotechnical Information

Analysis of the Geologic Context of Transportation Maintenance Costs
Three-year project. FY 2010-11: \$50,000. Total: \$150,000. Funding: Kentucky Transportation Cabinet. Ending 6/30/2012.

Geology

Geologic Mapping

Determining the Deformation History of a Newly Discovered Holocene Fault in the Wabash Valley
One-year award. FY 2010-11: \$31,693. Total: \$57,623. Funding: U.S. Geological Survey. Ending 11/30/2011.

Quaternary and Surficial Geologic Mapping for Multiple Applications in Kentucky (STATEMAP)
Quaternary geologic mapping. FY 2010-11: \$200,931. Total: \$1,261,809. Funding: U.S. Geological Survey. Ending 6/30/2011.

Hazards

Seismic Monitoring

Implementation and Operation of Transportable Seismic Array Elements for EarthScope
One-year award. FY 2010-11: \$13,820. Total: \$34,550. Funding: Incorporated Research Institutions for Seismology, sponsored by National Science Foundation. Ending 9/30/2011.

Installation of the Central U.S. Seismic Observatory (CUSO)
Phase II CUSO maintenance. FY 2010-11: \$60,676. Total: \$192,664. Funding: U.S. Department of Energy through Center for Applied Energy Research. Ending 9/30/2010.

Water Resources

Groundwater Information

Feasibility Study for Compiling a National Groundwater Quality Database
One-year award. FY 2010-11: \$41,280. Total: \$41,280. Funding: Center for Disease Control through SciMetrica, LLC. Ending 6/11/2011.

Groundwater Monitoring

Groundwater Modeling at the Paducah Gaseous Diffusion Plant
FY 2010-11: \$46,215. Total: \$61,247. Funding: U.S. Department of Energy through Center for Applied Energy Research. Ending 12/31/2010.

Hydrogeochemistry of Tunnel Roadbed Subsidence (Cumberland Gap Tunnel)
Phase IV. FY 2010-11: \$8,475. Total: \$33,900. Funding: Kentucky Transportation Cabinet. Ending 6/30/2014.

*W*hat they're telling us

From a teacher:

"It is hard to find reliable and informative resources (as well as appropriate for their age group) these days on the Internet, so I was glad they came across this page. Thank you for making such good references available!"



Jonathan McIntyre
1975–2011

Jonathan McIntyre of the Geologic Hazards Section died on June 23, 2011. He had worked for KGS since November 2005, managing the instruments of the Kentucky Seismic and Strong-Motion Network, and earned a reputation for friendly professionalism and dedication to his work and family. Jonathan, who was 36, was a native of Hazard, Ky. He is survived by his parents, Jerry and Karen McIntyre, as well as his wife, Sherri Profitt McIntyre, and their twin 4-year-old sons, Andrew and Austin.

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