



Kentucky Cross Section

Earth Resources—Our Common Wealth

Fall 2013

Work at Carter County research well completed

A test to evaluate the carbon dioxide storage potential of deep geologic formations in the Eastern Kentucky Coal Field has been completed at the AA Limestone Quarry in Carter County, operated by Hanson Aggregates. The well was drilled to a depth of 4,835 feet. Steve Greb, Warren Anderson, and Rick Bowersox of the KGS Energy and Minerals Section led the research on this project with assistance from other KGS geologists.

The well penetrated Paleozoic strata from Mississippian to Cambrian ages, plus 120 feet into Precambrian granite gneiss. Steel casing was cemented in the well from

the surface down to 2,944 feet to protect groundwater from contamination. Eight cores totaling 453 feet in length and 30 sidewall cores were taken during drilling operations. Laboratory analysis of these cores for porosity, permeability, mineralogy, and other parameters is in progress. A suite of geophysical logs, including imaging logs, was run in the well. Three intervals, Mount Simon to Maryville Sandstone, Middle Copper Ridge Dolomite, and Rose Run Sandstone, at depths from 3,257 to 4,709 feet below the surface, were tested.

Testing in the wellbore itself determined properties such as formation rock strength, pressure, porosity and permeability, and formation fluid chemistry. This research demonstrated that

several geologic formations in the deep subsurface in the area investigated may be suitable for future CO₂ storage. Other formations above the potential carbon-storage depths have properties that can help seal stored carbon dioxide in the deep subsurface.

With testing complete, the well was permanently plugged and abandoned as required by Kentucky oil and gas regulations, and the well site was restored to its original condition.

A similar project in Hancock County in western Kentucky was completed in 2010. Both projects were conducted as a result of the Energy Independence and Incentives Act of 2007 passed by the Kentucky General Assembly. The information gained from this

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Blan well cores now available

Core material and data from KGS's first carbon storage test well in western Kentucky are now available to outside researchers. Approximately 400 feet of core from the 2009-10 KGS No. 1 Blan well project in Hancock County is housed at the KGS Well Sample and Core Library in Lexington. Cored intervals include the Upper Devonian New Albany Shale, Upper Ordovician Maquoketa Shale, Middle Ordovician Black River Limestone, Lower Ordovician and Upper Cambrian Knox Group, and Precambrian Middle Run Formation. Sampling is permitted, subject to standard KGS data submission rules. Extensive analysis has already been conducted on these cores, and all resulting data are available to the public. ♦

Kentucky coal resource map website developed by KGS

An interactive website on Kentucky coal resources developed by KGS is now available to the public. The site was developed with a grant from the Kentucky Department for Energy Development and Independence in the Energy and Environment Cabinet.

As Kentucky coal production and employment has declined, and the sustainability of coal mining has been debated, the State agency sought an unbiased source of

data about the current state of this important natural resource. KGS has long been a leader in coal resource analysis and regularly revises estimates of remaining coal for future development.

The Kentucky Coal Resource Information site, located at kgs.uky.edu/kgsmmap/kcrim, was designed for a wide audience ranging from community leaders and State policy makers interested in the future of coal to academic and industry experts needing

site-specific information about coal beds. Assessments of remaining coal resources conducted in 2012 for 16 of Kentucky's most prolific coals are included in the website. These beds represent about 75 percent of the total Kentucky resource. Information on remaining coals of lesser importance may be added in the future.

A map of each coal bed can be viewed to visualize the geographic distribution of

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KGS researchers are nearly finished with several projects to evaluate carbon sequestration potential in Kentucky, which began under the Energy Independence and Incentives Act of 2007. Five projects were conducted: two tests of deep geologic formations, two tests for enhanced oil recovery, and one test for enhanced gas recovery in shale. Twenty-eight scientific papers and abstracts have been written on various aspects of this research, hundreds of cores and samples have been taken for study, and thousands of analyses have been performed. The research determined that CO₂ injection and containment is feasible in the deep subsurface of Kentucky and that enhanced oil recovery is possible under certain conditions. More work is needed to determine how shale gas production would respond to CO₂ injection and whether the CO₂ would remain in the shale. Research such as this is a vital part of KGS's mission.

Public service is also a big part of the KGS mission. Recently we were asked to compile case studies that highlight public service at UK. As a land grant university,

UK places a high priority on service to the commonwealth, but it often does not get the same level of recognition as research projects do. Research projects are funded and their results are published, providing appropriate credit for the investigators and KGS. Generally, public service projects do not result in publications, but nonetheless are significant for the people of Kentucky. Below are two examples.

The drought of 2010-11 forced some Kentucky communities to look for new sources of drinking water because surface supplies were at dangerously low levels. KGS helped these communities find groundwater as an alternate drinking-water source. Although the analysis and reports were vitally important for the communities affected, these kinds of projects do not usually rise to the level of justifying publication. But perhaps they should.

KGS data and maps are accessed online by an average of 500 users each day, and annually there are more than 1 million downloads of KGS information. We know from anecdotal evidence that these



Jim Cobb

downloads help industry find and produce resources; help citizens avoid hazards such as landslides, earthquakes, and sinkholes; help companies and government agencies in planning construction and infrastructure; and evaluate resources and property.

In all, the economic impact of KGS public service is very large, but difficult to assess in terms of actual dollars realized for economic gain. KGS will continue to serve the citizens of the commonwealth by providing this vital service. ❖

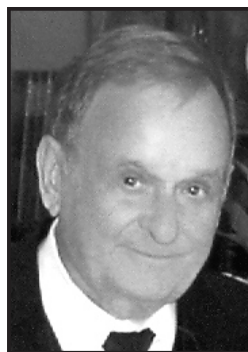
Retired KGS cartographer Potts, former employee Graham die

Roger Potts, who began working at KGS in the early 1950s, died Aug. 2 at the Hospice Care Center in Lexington. He was a World War II Army Air Corps veteran and a fan of Adolph Rupp's UK basketball teams. KGS colleagues said that he still considered himself a member of the Survey after his 1989 retirement and kept in touch with the people and events of KGS.

"When I joined KGS, all of the publications had white covers with black lettering," says Garland Dever, a KGS retiree and colleague of Potts. "Roger suggested adding color to the covers. You would have thought that he was instigating an overthrow of the federal government based on the reaction he received. But, Roger—who really understood the nuances of human nature—in his shrewd and low-key approach eventually won over his critics."

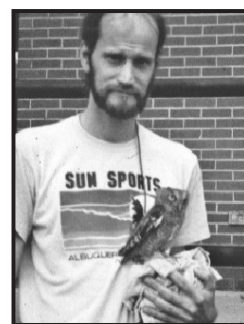
Potts's wife, Yarette, had died earlier this year. They are survived by a daughter, two sons, six grandchildren, and four great grandchildren.

Former KGS hydrogeologist Doug Graham died Oct. 27 of injuries from a fall at his home. The 55-year-old Newark, Ohio, native had worked as a student assistant at KGS during the late 1980's before joining the Water Resources Section in the early '90's. Among his responsibilities were organizing and interpreting data from projects in eastern Kentucky and running a basin management unit project with other KGS geologists.



Roger Potts

"Doug was a naturalist and loved his job here," says Steve Webb of the Water Resources Section. "He loved the fact that he was furthering research and science while being able to work out in nature."



Doug Graham

Graham's master's degree thesis, "Electrical Resistivity Studies of the Inner Bluegrass Karst Region, Kentucky," can be found by searching the online KGS publications catalog. After leaving KGS, Graham worked for the Underground Storage Tank Branch in the Kentucky Division of Waste Management. He is survived by two sisters and several nephews and nieces. ❖

New Berea Sandstone research consortium planned

The Upper Devonian Berea Sandstone has been a major producer of natural gas in eastern Kentucky for decades, but recent horizontal drilling in northeastern Kentucky has generated new interest in this interval. The new Berea horizontal oil play is of significant interest to the energy industry because of shallow drilling depths (less than 1,600 feet vertical depth), good production rates, and the current price advantage of oil versus natural gas.

KGS, in partnership with the U.S. Geological Survey, is forming an industry-funded research consortium to better characterize the Berea horizontal oil play in eastern Kentucky and adjacent parts of Ohio and West Virginia. This research has several objectives to help better define the extent of the play area and controls on hydrocarbon distribution in the Berea:

- Improve the accuracy of thermal maturity maps of the Devonian Ohio Shale source rock, particularly in the shallow, lower-maturity area in northeastern Kentucky
- Characterize Berea oil, gas, and brine chemistry, and geochemically tie Berea hydrocarbons to their source
- Interpret Berea structure and detailed stratigraphy in the producing area, incorporating data from Berea cores and outcrops, to gain a better understanding of the reservoir architecture and distribution of porosity and permeability
- Interpret controls on Berea permeability and fluid distribution (oil, gas, water)

Principal investigators for the 18-month study will be Steve Greb, Marty Parris, and Cortland Eble. Companies interested in participating in the consortium should contact KGS for a full project proposal.

More data on the Berea horizontal play can be found by going to the KGS website, www.uky.edu/kgs, and entering the search term "Berea."❖

KGS delegation visits China; new visiting scholar at the Survey

In July, a delegation from KGS and UK took another trip to China as part of the seismic exchange, now in its 10th year. The delegation visited an earthquake rescue training center in northwest China and several institutes of the China Earthquake Administration, where State Geologist Jim Cobb gave several talks. Others in the delegation were KGS Associate Director Jerry Weisenfluh, Geologic Hazards Section Head Zhenming Wang, and graduate student Alice Orton of the UK Department of Earth and Environmental Sciences.

Orton is working on her thesis, "Science and Public Policy of Earthquake Hazard Mitigation in the New Madrid Seismic Zone." Her research includes an investigation of the science behind the National Seismic Hazard Maps for the central United States, how that science is used to develop public policy, and how public policy affects the local economy in western Kentucky.

"China has a similar intraplate seismic region, which is much more active than ours," Orton explains. "China has 2,000 to 3,000 years of historical records

to pull from when making policy decisions and very detailed public policy about building codes and emergency response to earthquakes in high-hazard areas." Orton is evaluating how the building codes and emergency planning changed following the 2008 Wenchuan earthquake and will compare them to current scenarios for the central United States, and also evaluate the level of expectation for building codes in case of a large seismic event in the New Madrid Seismic Zone.

While the delegation was in China, a 6.6-magnitude earthquake occurred at Minxian in Gansu Province, killing about 90 people. Wang visited the affected area before returning to the United States.

Another Chinese visiting scholar involved in the exchange, Zehua Qiu, arrived at KGS in November for a three-month stay on the UK campus. He is a researcher with the Institute of Crustal Dynamics of the China Earthquake Administration in Beijing. The focus of his work is borehole strain monitoring and theoretical seismology.❖



A group of schoolchildren in Yinchuan, Ningxia Province, central China, practice their English with graduate student Alice Orton.

German researcher uses KGS laboratory for soils research

A soil scientist from the University of Natural Resources and Life Sciences in Vienna, Austria, spent 3 months earlier this year on the University of Kentucky campus doing post-doctoral research with the Department of Plant and Soil Sciences. For his research, Andreas Schwenn and others collected 700 soil samples, which he brought to the KGS laboratory for analysis, with the help of Laboratory Manager Jason Backus.

The research applies tracers to detect how soils used for differing agricultural purposes transport nutrients and pesticides. Macropores, such as wormholes, cracks, and voids left by decayed roots, are typical conduits for these substances. Two agricultural land uses in the Lexington area, grassland and cropland, were tested.

The researchers were trying to map the macropore network in the soils and analyze the leaching behavior of the

tracer in the two soil environments. Dye tracers have been used to map the spatial distribution of macropores, but Schwenn, a native of Germany, believes the relative influence of the macropore network on leaching under field conditions needs study using innovative sampling techniques.

The 700 samples were pressed into 40-millimeter pellets and analyzed in the X-ray fluorescence instrument in the KGS lab. The XRF was able to save time and costs by directly analyzing the soil samples for bromine and silica dioxide concentrations. Analyzing the samples directly meant ion chromatography, an involved process of leaching each sample, did not have to be used.

The practical purpose of the research is to provide information for more precise applications of pesticides and fertilizers.❖



Andreas Schwenn prepares soil pellets for analysis in the KGS laboratory.

Scanned images now available from Kentucky Groundwater Data Repository

Nearly 300,000 scanned images of well and spring records have recently been added to the Kentucky Groundwater Data Repository, which is managed by KGS. The repository was created in 1990 and now contains information about more than 92,000 water wells, 5,100 springs, and 58,000 sets of water-quality analyses. The data are available online at www.uky.edu/kgs; click on the “Data” link and then on the “Groundwater” link.

The information is collected by State agencies, other organizations, and independent researchers. Historically, the water well records have included location, usage, depth, and static water level, among other information. Now, with the permission of the Kentucky Division of Water, scanned images of water-well inspection forms, monitoring-well records, spring inventory forms, plugging records, and various types of water-quality analyses are also available in the repository. These images are generated by the Division of Water as a result of their Certified Well Drillers Program, which requires that every water well in Kentucky be installed by a certified driller.

KGS received the images from the Division of Water in July, and they were processed and placed online on October 1. Well and spring searches in the repository’s database will produce a PDF file for every record for which images are available. “We very much appreciate the Division of Water for providing these scanned images to enhance the repository,” says KGS geologist and repository manager Bart Davidson. “They provide additional information that is not otherwise obtainable, such as drillers’ notes on lithology at the time of drilling. The images will not only assist the general public, but also drillers themselves as they assess possible drilling locations.”

Users of the repository should note that only records coming from the Division of Water (denoted by having AKGWA numbers starting with “0” or

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Students, teachers, and families attend annual KGS open house

More than 170 people crowded into the Mining and Mineral Resources Building Oct. 16 for the annual Earth Science Week open house at KGS. They browsed 20 displays and demonstrations on earth science topics, including several new ones for 2013.

Pete Idstein of the UK Department of Earth and Environmental Sciences drew a crowd each time he set off his volcano demonstration outside the building, using a plastic bottle of liquid nitrogen dropped into a barrel of water. The Blue Grass Gem and Mineral Club displayed their collection for the participants, and the Kentucky Division of Water brought one of its Enviroscape groundwater displays to the open house. Other displays were set up by KGS staff, research offices at UK, and earth science societies in Kentucky.

Many students again came to the event with lists of questions prepared by their teachers so the students would learn from the displays and demonstrations, which were spread through the atrium



Participants in the open house watch as Pete Idstein sets off a volcano demonstration.

and hallways of the first and second floors of the building.

The American Geosciences Institute has organized Earth Science Week since

1998 to help the public gain a better understanding and appreciation for the earth sciences and to encourage stewardship of the earth. ♦

Carter County—continued from p. 1

research will help in planning the state's future with regard to coal usage, controls on CO₂ if required, and other industrial applications that produce CO₂. There are no current plans for commercial CO₂ storage at either project site or anywhere in Kentucky. ♦

Scanned images—continued from p. 4

“8” for well records or “9” for spring records) have these images available. Not every record will have images. The PDF files may contain one or more pages, with each page corresponding to a scanned document associated with that well or spring. ♦

Coal resource website—continued from p. 1

remaining resources for each of them. The maps show the general thickness characteristics of unmined coal and how accessible the areas are to near-surface development. Original and remaining resource tonnages are available by county and presented in tabular and graphical format. For local officials, a county view is provided that quickly summarizes all coal resources for a selected county.

An introductory section and tutorial are included to help first-time users navigate the available search options. The site also lists the source data used in the assessment of the coal beds, including

borehole records, coal thickness measurements, and coal quality data.

According to these estimates, Kentucky has more than 30 billion tons of remaining resources thick enough to be mined with current technology. How much of this resource can be profitably mined and marketed remains an open question. This website illustrates the geographic distribution of the remaining coal, its proximity to active mines, and distinct differences between the Eastern and Western Kentucky Coal Field deposits. ♦

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Cortland Eble and Steve Greb of the Energy and Minerals Section led a coal field trip in May after the conclusion of the annual meeting of the American Association of Petroleum Geologists. Twenty-one participants from several countries, including Great Britain, Norway, China, and Saudi Arabia, took the four-day trip, which looked at several coal outcrops in roadcuts. The trip originated in Pittsburgh and wound through West Virginia and eastern Kentucky, ending at the Greater Cincinnati Airport in northern Kentucky.



Wayne Burd of the Kentucky Division of Emergency Management gives a tour of the new State emergency operations center in Frankfort to Associate Director Jerry Weisenfluh, Seth Carpenter, and Geologic Hazards Section Head Zhenming Wang in November. The new 26,000-square-foot building provides office space for State agencies and others who help in response to emergencies and disasters. The KGS group was there to discuss the Survey's role in the event of a damaging earthquake in the central United States.