



# Kentucky Cross Section

## Earth Resources—Our Common Wealth

Fall 2011

## Celebration of Kentucky mapping planned for December 1

The publication of all 25 maps in the KGS 30 x 60 minute geologic map series will be celebrated on December 1 with a ceremonial unveiling of a giant-sized replica of the “Geology of Kentucky” map compiled from the 25 smaller maps, followed by a symposium on mapping.

The geologic maps were produced by KGS and the U.S. Geological Survey National Cooperative Geologic Mapping Program. A mapping partnership between the two organizations between 1960 and 1980 produced

the original 7.5-minute geologic quadrangle maps that laid the framework for this series. The new map series demonstrated the level of geologic mapping that can be accomplished through federal-state-university partnerships. No other state has completed such statewide mapping.

Surface and subsurface rock types, formations, and structures such as faults are depicted on these maps. They are considered a major contribution to Kentucky, because the information they provide can be used for resource exploration and production, environmental protection, stability of building foundations and

infrastructure, and identification of hazards. Because the maps are available on the Web, they are always accessible to the public at no cost. Printed versions of the maps can be purchased from the KGS Publication Sales Office.

The large geologic map replica, 10 feet high x 23 feet wide, will be unveiled at a December 1 ceremony and news conference in the first-floor atrium of the Mining and Mineral Resources Building at the University of Kentucky. It will remain on permanent display for visitors to see. That afternoon, the symposium on geologic mapping, “Celebrating Geologic Mapping for

Science and Society,” will be held at the nearby University of Kentucky Hilary J. Boone Center. Participants will include experts from the University of Kentucky, the Kentucky Geological Survey, the U.S. Geological Survey, state geological surveys, industry, and academic institutions. The history of Kentucky mapping and the economic, environmental, and energy-production value of geologic mapping will be discussed at the symposium. Some of the original mappers who worked on the 7.5-minute project from 1960-78 as well as the 1996-2004 Digital Mapping Program are being invited to the day’s events.

## Research assesses carbon storage potential at five Kentucky power plants

KGS has been actively involved in carbon sequestration research since 2003, when the U.S. Department of Energy funded seven regional partnerships to characterize subsurface geologic reservoirs with potential to store carbon dioxide, and to assess the storage volumes available. In 2007, Kentucky House Bill 1 and industry partners funded other sequestration research by KGS, including several demonstration wells into which small quantities of CO<sub>2</sub> were injected into deep reservoirs.

As CO<sub>2</sub> sequestration research matures, larger-scale research projects have begun

to focus on testing commercial viability of geologic storage. Although large-scale injection projects are under way in other Midwestern states (Illinois and Michigan), Kentucky has not been able to secure a large-scale injection test, despite the state’s large carbon footprint. The absence of a low-cost source of CO<sub>2</sub> for injection and the lack of a legal and regulatory framework for CO<sub>2</sub> storage have often been cited as reasons. Significant progress was made in the 2011 Kentucky legislative session with passage of House Bill 259 sponsored by Rep. Brent Yonts. The legislation established the ownership of subsurface pore space for

future CO<sub>2</sub> storage demonstration projects, created a process for pooling of pore space to create storage reservoirs where there are multiple owners, and provided long-term liability protection for companies storing CO<sub>2</sub> underground.

Progress toward identifying a site for a large-scale CO<sub>2</sub> capture and storage demonstration project has also been made. Dave Harris and John Hickman of the KGS Energy and Minerals Section have completed work with Louisville Gas and Electric and Kentucky Utilities (LG&E-KU, a subsidiary of PPL Corp.) to evaluate the

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## Director's Desk

A September 27 Associated Press story by Dylan Lovan about the anticipated decline of central Appalachian coal production painted a bleak picture for the future of coal in that region. According to Lovan, coal production is expected to plummet in the near future, primarily because mineable reserves are being depleted. Lovan cited a 2010 report by Rory McIlmoil and Evan Hansen of Morgantown, W.Va., environmental consulting firm Downstream Strategies (*The Decline of Central Appalachian Coal and the Need for Economic Diversification, 2010*, Downstream Strategies White Paper #1, [www.downstreamstrategies.com/documents/reports\\_publication/DownstreamStrategies-DeclineOfCentralAppalachian-Coal-FINAL-1-19-10.pdf](http://www.downstreamstrategies.com/documents/reports_publication/DownstreamStrategies-DeclineOfCentralAppalachian-Coal-FINAL-1-19-10.pdf)), as well as other sources. As a geologist who is familiar with coal resources in eastern Kentucky, I wanted to find out more about how McIlmoil and Hansen arrived at their conclusions.

Downstream Strategies primarily used public data compiled by the Energy Information Administration about coal production, coal prices, employment, and mine productivity. They cited three reasons for the downward trend in central Appalachian coal production: competition, reserve depletion, and effects of regulation. The AP article would lead us to believe that reserve depletion is overshadowing the other factors. The central argument of the Downstream paper revolves around the relationship between mine productivity and coal prices. Mine productivity (tons per worker hour) increased steadily throughout the 20th century but has been declining since 2000. This reversal coincided with a dramatic increase in coal prices in the last decade that had previously been declining up to that same year. The report implies that this association is because additional employees are needed to mine the thinner seams now available in central Appalachia and uses this as evidence for depletion. There is a serious problem with this argument. The decline in mine productivity is a national trend, not one unique to Appalachia. This suggests to

me that there are other, more important factors affecting mine productivity. The more likely reason is the additional employees needed for complying with new safety and environmental regulations, because this would affect mines irrespective of their location. There is no doubt that significant reserve depletion has resulted in mining of thinner seams, leading to higher mining and processing costs in central Appalachia. But I think it is inaccurate to suggest that this implies an accelerated collapse in production. Technological advancements and market conditions could change the current trend in production.

The inference was also made that declining productivity (caused by mining more difficult seams) has driven up coal prices in central Appalachia, making its coals less competitive with those in other basins. Although the cost of producing coal does have some underlying effect on coal prices, the principal control is supply and demand in the marketplace. Demand for low-sulfur, central Appalachian coal in the domestic electric utility market is clearly in decline for the reasons stated in the report. More than 50 percent of U.S. coal-fired capacity has been retrofitted with pollution-control technology, enabling the purchase of lower-cost, medium-sulfur coal from other areas of the country. At the same time, though, the metallurgical market (low volume, high price), especially internationally, is strengthening and there are indications that international demand for high-quality steam coal may also be on the rise. Although these developing markets are not likely to completely replace lost production in the domestic steam market, they should have a mitigating effect because of the higher market prices for these products.

Downstream Strategies discussed the potential impacts of regulating mountaintop surface mining on future coal production, but did not acknowledge the extent to which current production is affected by such regulations. The Kentucky Coal Association estimates that 19 Kentucky permits that the EPA has objected to have a potential of about 125 million tons of production over their life. Assessing how much this contributes to recent produc-



*Jerry Weisenfluh*

tion losses is difficult, but it is certainly sizable.

The report correctly pointed out that increased production of unconventional natural gas (shale gas), resulting in lower and more stable gas prices, is causing a shift in U.S. electric generating capacity away from coal. Coupled with increasing operating costs of coal plants, primarily related to higher fuel costs, this development is expected to reduce coal's share of the electric utility market slightly over the next two decades. At the same time, though, additional anticipated electricity demand of up to 30 percent (EIA projections) would still result in an increased demand for coal compared to current production levels.

There is no question that the central Appalachian coal fields are experiencing challenges that relate to depletion of thicker and more accessible coal. But I think it is misleading to suggest that this is the principal reason for declines in production, because it implies a near-term and dramatic decline for the region. Resource estimates made by the Kentucky Geological Survey indicate that there are at least 10 billion tons of remaining resources associated with just the top 12 producing seams. The impacts of environmental regulation are having a greater influence on the markets for central Appalachian coal than depletion of resources. This does not mean that the situation does not need serious attention from policy makers and planners, but it is premature to write off a sector of the coal market based on such speculative arguments. ❖

## Three new employees join Mapping, Geoscience Information sections

KGS added three new employees to its roster during the summer months.

Liz Adams joined the Geoscience Information Management Section as a full-time employee in May. She had worked in the section as a student since November 2007, helping to enter oil and gas well completion data, scanning well records, and other related tasks. Now classified as a geological technician senior, Adams maintains the oil and gas records and checks drilling-permit applications for well-spacing requirements and accurate location data.

When asked what she likes about working at KGS, she quickly replied, "The people! Everybody's been extremely nice and truly friendly. And the relaxed atmosphere; it's not stuffy at all here." She completed her bachelor's degree in integrated strategic communications at the University of Kentucky in December 2010 and is now taking geology classes.

Adams moved from her hometown of Memphis, Tenn., to Lexington to attend UK. Her interests include the outdoors and horseback riding.



*Liz Adams*

In July, Antonia Hansen joined the Geologic Mapping Section. The Louisville native's first task with KGS has been mapping the surficial geology of the Lily 7.5-minute quadrangle near London, Ky. She has a bachelor's degree in geology from UK, and has previously microscopically examined coal samples at the Center for Applied Energy Research.

"I like the very fact that I can go out in the field at KGS," Hansen says, "and that I get to see what I've been reading about on paper while I was in school. And this is my first job that I get to just work with nature."

Cooking, gardening, and dogs interest Hansen, along with whatever interests her young son, Lazarus. She also speaks fluent Russian, after taking four years of the language in college. Rather than taking one of the more popular language options, she "wanted to diversify into something not a whole lot of people really want to study, and came up with Russian," she says.



*Antonia Hansen and son Lazarus*

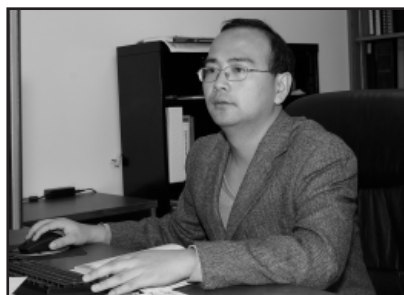
Max Hammond, a recent Morehead State University graduate, has begun his professional career in the Geologic Mapping Section. After joining KGS in July, he has also spent much of his time in the field, examining soils and glacial deposits as he does surficial mapping of the Alexandria and Independence 7.5-minute quadrangles of northern Kentucky. Hammond also coaches soccer at West Carter High School in Olive Hill, where he lives. He had dual majors in geology and geography at Morehead and earned a certificate in geographic information systems.

"I love being out in the field a lot," says Hammond, who is a hunter and fisherman. "We have great people to work with here and a really good atmosphere. Being outdoors a lot has helped me see the physical landscapes more than others might see them." ♦



*Max Hammond*

## Seismic researcher visits KGS for 6 months



*Caibo Hu*

Caibo Hu, a researcher with the Department of Geophysics at Peking University in Beijing, has become the eighth visiting scholar to come to KGS as part of the earthquake exchange between KGS and the People's Republic of China. He arrived in early September and will work at KGS until February 2012.

He received his Ph.D. from Peking University in 2009 and focuses his research on the mechanisms that trigger earthquakes. "I focus on the study of earthquake triggering and stress field evolution using numerical methods," he says. "I have some programs on earthquake triggering, and I have studied many examples, such as the 1976 Tangshan earthquake, the 2008 Wenchuan earthquake, and the 1992 Landers, Calif., earthquake sequence."

He says data collected by the Kentucky Seismic and Strong-Motion Network will be useful for his research. He noted the similarities between the seismic environment of the Central United States and the region in which the 7.9-magnitude Wenchuan earthquake occurred. —Continued on p. 6

## Carbon storage and enhanced gas recovery project starting up

A new KGS project to test carbon dioxide storage and enhanced natural gas recovery in the Devonian Ohio Shale of eastern Kentucky has begun with funding provided by the Kentucky legislature and several partners. The project well, owned and operated by Crossrock Inc., is near Paintsville in Johnson County. KGS has entered into a research memorandum of agreement with Crossrock to allow access to the well for the project.

The site has been prepared, initial background samples of natural gas were acquired, and a baseline logging program designed. The baseline well logs were acquired in October and are being processed.

"We're going to inject 100 to 300 tons of CO<sub>2</sub> into the well and monitor several surrounding producing wells to determine if there is any increase in gas production," says Brandon Nuttall, the principal investigator on the project. "After the injection phase, we'll allow the CO<sub>2</sub> to flow back out through the test well, and we'll determine the difference between the amounts injected and the amount flowed back. That would be the amount sequestered." The injection will target an interval between 1,200 and 1,700 feet deep. The injection and testing phase of the project should last about 6 weeks.

This research is being conducted as a result of House Bill 1, the Incentives for Energy Development and Independence Act of 2007, with funding granted to KGS by the Kentucky General Assembly. About \$250,000 in matching funds has come from the U.S. Department of Energy's Advanced Resources International shale research project, Schlumberger Carbon Services, the Battelle Memorial Institute, and the Midwest Regional Carbon Sequestration Consortium. Some of those funds were expended on site characterization and project development efforts at the original Pike County site that became unavailable, but data and findings developed at the original site will also apply to the Johnson County well.



*This Johnson County gas well, owned by Crossrock Inc., will be used for the Devonian shale project.*

Although some of the injected carbon dioxide may remain permanently stored in the shale, Nuttall says enhanced gas production is the main focus. "We can't inject carbon dioxide into shale here as rapidly as in the Mount Simon or Knox Formations that were targeted in the Western Kentucky Coal Field project," Nuttall explains. "So the real incentive for this to work is the economics of greater gas recovery from existing wells." He notes that some gas wells are currently stimulated with nitrogen for additional production, but experiments have shown that CO<sub>2</sub> stimulation results in greater gas production. ❖

### **Carbon storage research—continued from p. 1**

geology in the vicinity of five of their coal-fired electricity-generating stations in Kentucky. The goal was to determine which station has the best potential for geologic CO<sub>2</sub> storage in order to select, design, and seek funding for an integrated carbon capture and storage demonstration project. LG&E-KU also conducted an engineering study to determine which plant

was best suited for retrofitting capture equipment that separates CO<sub>2</sub> from flue gas. Both studies were funded by a grant from the Kentucky Energy and Environment Cabinet, Department for Energy Development and Independence.

The sites evaluated were the E.W. Brown Station (Mercer County), Ghent

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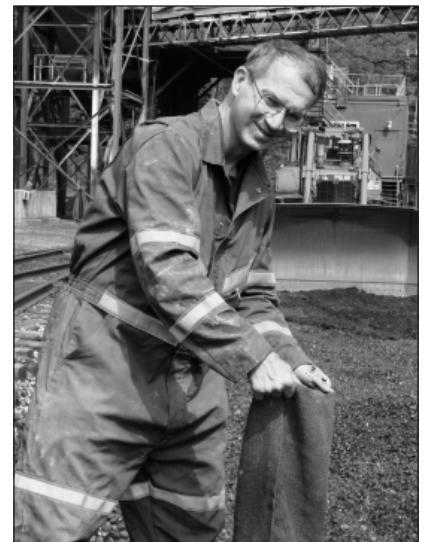
## Cortland Eble receives the Gordon H. Wood Jr. Memorial Award

Cortland Eble of the Energy and Minerals Section received the Gordon H. Wood Jr. Memorial Award from the Eastern Section of the American Association of Petroleum Geologists in September during its 41st annual meeting in Cleveland. The award recognizes outstanding contributions to the geology of coal and other energy minerals and the goals of the Association's Energy Minerals Division in the Eastern Section.

In his citation of Eble for the award, KGS Director Jim Cobb wrote that Eble is "all about coal and has devoted his career to the study of coal geology. Not many of us have the distinction of analyzing coal from near and far, let alone coal from the Titanic and other shipwrecks."

After completing his doctoral dissertation on the Fire Clay coal of the central Appalachian Basin at West Virginia University, Eble joined the U.S. Geological Survey in Reston, Va., as a National Research Council post-doctoral fellow. He has been with KGS since 1990, researching the composition and geochemistry of coal, coalbed methane, and other coal-related issues.

Cortland attributes his success to his wife, Leslie, and son, Francis, who have provided him support throughout his career. ❖



*Cortland Eble at a Pike County coal facility gathering samples for metallurgical analysis.*

## Large crowd of students, parents, and teachers visit KGS open house

The annual Earth Science Week open house at KGS brought more than 250 people to KGS on the University of Kentucky campus. The October 5 evening event showcased 18 displays and demonstrations on earth science topics ranging from rocks and minerals to snakes and iguanas. A number of teachers asked for information on the exhibits ahead of time so they could send students prepared to ask questions on particular topics for extra class credit.

The displays were set up by KGS staff, the Kentucky Paleontological Society, the University of Kentucky Mining Engineering Department, and Kentucky Emergency Management. Tammi Johnson brought her amber collection, and Roland McIntosh showed visitors a variety of geodes and other rocks he has collected. Sharon Carter brought snakes and iguanas for what has become one of the most popular exhibits each year at the open house. ❖



## Second CDC grant will make more groundwater data publicly available

In fiscal year 2010-11, KGS participated in the Centers for Disease Control Unregulated Drinking Water Initiative with a project to find groundwater data stored by government agencies and to estimate the cost of digitizing them for the Kentucky Groundwater Data Repository, which is managed by KGS. The project identified groundwater-quality data sets related to unregulated drinking-water sources compiled by federal, State, and local agencies. They had been generated from sampling private water wells and springs used for drinking water.

KGS has now been awarded a second UDWI grant for 2011-12, through the Kentucky Division of Water, to scan, digitize, and enter four sets of groundwater-quality data into the repository. The data, discovered during last year's pilot project, are from the Kentucky Division of Mine Reclamation and Enforcement, the U.S. Geological Survey's Kentucky Water Science Center, the Kentucky Division of Conservation, and from academic theses, dissertations, and scientific publications.

The end result of the \$71,000 project will be to greatly enhance the amount of easily accessible groundwater-quality data for the promotion and protection of public health and associated research activities. ❖

### *Carbon storage research—continued from p. 4*

Station (Carroll County), Green River Station (Muhlenberg County), Mill Creek Station (Jefferson County), and Trimble County Station. Detailed geologic studies, including interpretation of seismic-reflection data, were completed to estimate CO<sub>2</sub> storage options and capacity for a 15-mile radius around each station. 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 affect containment of injected CO<sub>2</sub>.

The evaluation concluded that all of the sites have potential for injection and storage of CO<sub>2</sub> in the study area, but storage volumes vary significantly between sites. LG&E-KU will use the studies to determine which generating station may be best suited for geologic storage and CO<sub>2</sub> capture facilities, should a future demonstration project be initiated.

An additional step toward an integrated CO<sub>2</sub> capture and storage demonstration was realized in August, when UK's Center for Applied Energy Research was awarded a \$14.5 million grant

from the U.S. Department of Energy to design and build a CO<sub>2</sub> capture facility at the E.W. Brown Station in Mercer County. This pilot facility will process a small amount of the flue gas from the Brown Station, but CAER hopes to capture at least 90 percent of the CO<sub>2</sub> and to improve the energy efficiency of the capture process. There are no immediate plans to inject the CO<sub>2</sub> captured at the Brown Station into a geologic reservoir, but the technology developed in the CAER pilot could be used in a larger integrated capture-storage project in the future. ❖



*Sixty-four people took part in a professional development seminar sponsored by the Kentucky Section of the American Institute of Professional Geologists Oct. 19-20. The program on karst hydrology was led by Ralph Ewers of Eastern Kentucky University and Pete Idstein of the University of Kentucky. The first day of the program was held at the KGS Well Sample and Core Library. The second day was a field trip to Sinking Valley in Pulaski County to see karst geology and demonstrations of tracer methods. Above, Idstein holds the microphone as Ewers describes the geology on one of the field trip stops. This was the second professional development program sponsored by KY-AIPG this year.*

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### ***Seismic researcher—continued from p. 3***

curred in China's Sichuan Province in May 2008.

Hu became aware of the seismic exchange through a mutual connection at Peking University with Geologic Hazards Section Head Zhenming Wang. "My Ph.D. advisor was a teacher of Zhenming Wang at Peking University ... so we are schoolmates!" he quipped. He recently attended a seismic conference in Arkansas with Wang and presented a poster about the similarities between the central United States and Sichuan Province.

His other interests include Taiji (Tai chi), badminton, swimming, and climbing.

The seismic exchange began in 2005 and has brought visiting scholars from Peking University and the Lanzhou Institute of Seismology as well as government officials of Gansu Province to the University of Kentucky and KGS. Researchers from KGS and the UK Department of Earth and Environmental Sciences have made several trips to China to give seminars and participate in earthquake hazard studies, particularly in Gansu Province. ♦

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