



# Kentucky Cross Section

## Earth Resources—Our Common Wealth

Winter 2010

## Report shows Hancock County CO<sub>2</sub> injection project succeeded

Findings of the deep carbon storage test project in Hancock County show that, as expected, the target formation was able to readily store injected carbon dioxide, and that other formations above the target are capable of sealing the stored CO<sub>2</sub> in the injection formation. The 8,126-foot-deep well was drilled beginning April 9, 2009, after a year and a half of planning, site preparation, and regulatory compliance. The injection program for brine and CO<sub>2</sub> lasted from July 25 until August 22; over 18,000 barrels of brine and 1,765 fluid barrels (the equivalent of 323 tons) was injected. Under the depth, pressure, and temperature conditions of the test well, CO<sub>2</sub> storage capacity is estimated to be

about 50 tons per acre-foot of reservoir, using an industry-standard efficiency factor of 5 percent.

The study concluded that an industrial CO<sub>2</sub> storage well drilled into those subsurface conditions would require approximately 120 acres to store 1 million tons of CO<sub>2</sub>, or approximately 3,500 acres of reservoir to store 30 million tons of CO<sub>2</sub>. Depending on well spacing, seven to 10 wells would be required to store 30 million tons of CO<sub>2</sub> in a supercritical state. (When injected deep underground, carbon dioxide goes into a supercritical state and behaves as both a gas and a liquid. It occupies a fraction of the area it would under normal pressure and temperatures.)

The Hancock County well was drilled only as a test well, and there are no plans for permanent storage of large

amounts of CO<sub>2</sub> in it. When all phases of testing are completed, the well will be permanently plugged and abandoned. The findings indicate that because thousands of acres of reservoir will be required to store large quantities of carbon dioxide, issues of ownership and control of subsurface pore space will need to be resolved.

Two samples taken from the Black River Group carbonates and 11 core samples from the Maquoketa Shale demonstrated that those two overlying formations provide effective seals for the Knox CO<sub>2</sub> storage reservoir beneath them. The samples were tested for porosity, permeability, and rock strength. Initial evaluation of the well and other wells drilled into the Knox suggests that large areas of western Kentucky may have CO<sub>2</sub> storage potential. Results of this test will help calibrate CO<sub>2</sub>

storage reservoir models and further evaluate the storage capacity of the Knox Group in Kentucky.

The project was originally mandated and partially funded by the 2007 special session of the Kentucky General Assembly. The legislation also encouraged KGS to find private partners to participate in the project. Industry funding for the project was provided by Peabody Energy, ConocoPhillips, and E.ON U.S. through the Western Kentucky Carbon Storage Foundation. The Tennessee Valley Authority, Illinois Office of Coal Development, and the U.S. Department of Energy–National Energy Technology Laboratory also funded the project.

A second phase of the research, scheduled to get under way this spring, has

—Continued on p. 4

### Kentucky Geological Survey

228 Mining & Mineral Resources Bldg.  
University of Kentucky  
Lexington, KY  
40506-0107  
859.257.5500  
fax 859.257.1147  
www.uky.edu/KGS

Jim Cobb, State Geologist and Director  
Jerry Weisenfluh, Associate State Geologist  
Mike Lynch, Editor,  
*Kentucky Cross Section*, mike.lynch@uky.edu  
Meg Smath, Copy Editor

## Carbon storage legal issues work group develops recommendations

During a session of the Governor's Conference on the Environment in September 2008, an informal work group began discussing the legal issues relating to the geologic storage of carbon dioxide in Kentucky. The issues include the ownership of the pore spaces in which CO<sub>2</sub> would be permanently stored, gaining access to the surface over storage sites, and liability, regulatory issues,

and responsibility for the costs of long-term monitoring and maintenance of such sites. The work group, which included KGS staff, met four times during 2008 and 2009 and submitted a report and recommendations to Kentucky Energy and Environment Cabinet Secretary Len Peters this January. Some of the recommendations in the report were also incorporated into a bill introduced in the

2010 Kentucky General Assembly session.

The report says the economic effects on Kentucky from possible restraints on the emission of carbon dioxide into the atmosphere "may be severe." That conclusion is related to Kentucky's large coal mining industry, the state's dependence on coal for 93 percent of its electricity, and its relatively low electric-

—Continued on p. 2

## Director's Desk

It seems that questions about Kentucky's remaining coal resources rise up like 17-year cicadas. This is usually in response to cyclical energy crises that we have experienced over the last century. Energy issues, like the post-World War II economic boom and the mid-1970's Arab oil embargo, have often resulted in national programs to reassess quantities of our most abundant energy resource: coal. Current questions about the sustainability of mining in Kentucky (and the nation) are now being driven by a host of issues, including development of coal to liquids and gas for energy independence and concerns about the impacts of coal mining and combustion on climate, the environment, and public health. It's unlikely that new programs will be undertaken to improve our resource estimates because there is a shortage of funds and the timeframe for making policy decisions about coal seems to be very short. Policy-makers are likely not going to wait for a lengthy resource review process. So we'll need to use existing data to provide the best picture of what the future holds for coal mining in Kentucky. The question is, what resource data are the best to use for this purpose.

The last comprehensive resource estimate for Kentucky was compiled by Russ Brant and others in the early 1980's and showed an original resource of 104 billion tons. Considering that 9.2 BT of coal have been mined to date (16 BT including mining losses), this would suggest a plentiful remaining resource. This is misleading, though, because about 35 BT of this original coal is probably too thin to mine using current technology. The maximum amount of coal that meets minimum thickness requirements

is closer to 50 BT, but not all of this coal is thought to be available for mining and have desirable quality characteristics. Quantifying the percentage of the 50 BT that is likely to be mined is a challenging problem, and the Brant study lacks all the necessary parameters to solve that problem.

Some suggest that a preferred estimate is that published by the DOE Energy Information Administration as the Demonstrated Reserve Base, currently 32 BT. The use of the term "reserve" rather than "resource" connotes a more accurate or reliable estimate, but this is far from the truth. The DRB uses the same base data as Brant's resource estimate, but excludes coal less than 28 inches thick and all coal more than  $\frac{3}{4}$  mile from a measured point, known as inferred resources. The first assumption is reasonable, but the second eliminates about 14 BT of known resource. If the area of DRB coal is compared to recent mining activity, we see that almost all production is coming from areas outside the DRB. Consequently, although the DRB is probably closer to the correct number, it is probably for the wrong reasons. I don't believe the DRB improves our understanding of the geography of the remaining resource.

The best data KGS currently has about coal resources comes from the National Coal Resource Assessment work that was done in cooperation with the USGS in the late 1990's. This assessment used GIS technology to prepare digital resource maps for some of the most productive coals in the nation. In Kentucky, we assessed 12 coal beds in eastern and western Kentucky. Although this was not a comprehensive assessment, it did include most of the principal beds from which mining is likely to occur in the future. The sum of that work shows about

25 BT of remaining coal greater than 28 inches thick, 60 percent of which is in western Kentucky.



Associate Director Jerry Weisenfluh

Using conservative estimates of availability and recovery, about 10 BT of that resource could be recovered. I consider this a minimum estimate that can be used to evaluate the sustainability of current production.

My opinion is that, considering Kentucky's entire resource base, we have not yet reached a time where resource depletion is the principal factor affecting production. That is not to say that depletion is not in the mix. In the last newsletter, I pointed out that surface-mineable coal in western Kentucky is fundamentally exhausted, and much of the thicker underground resource in eastern Kentucky is also gone. But the primary factor currently affecting annual coal production is market demand for specific qualities of coal at the most competitive price. Market conditions and utilization trends favor western U.S. low-sulfur, low-cost coal and also high-sulfur Illinois Basin coal over high-cost Appalachian coal. Given the abundant high-sulfur resource in western Kentucky, this suggests production will increase in that region while eastern Kentucky will continue to face challenges because of the higher costs of mining, processing, and transporting that coal. ❖

---

*"Carbon Storage"—continued from p. 1*

ity rates, which help attract industry to the state. Flue gas from coal-fired power plants is 10 to 12 percent carbon dioxide by volume, making these plants major emitters of carbon dioxide.

The report adds that a draft study "indicated that retrofitting an existing pulverized coal-fired power plant with scrubbing capability would double the cost of electricity from that plant and require 25 percent more coal in order to

power the scrubbing process." The report also cites several studies that conclude that thousands of coal mining, aluminum, steel, and auto-making jobs could be lost in Kentucky if some existing carbon management proposals became law. But the report's recommendations contend that Kentucky can be a favorable location for business by proactively addressing the issues that may arise in a carbon-managed environment.

Among the conclusions of the report: the Kentucky Division of Oil and Gas should be responsible for regulating carbon transportation and storage, because that agency "has the most experience with the physical aspects of the process." The work group called for appropriate funding and staffing of the division to allow it to attain "primacy" over the underground injection program. The

—Continued on p. 5

# KGS loses two former employees, Jim McElhone and Norm Hester, to death

Jim McElhone, who joined KGS in 1994 and managed information technology services, died late in 2009 at the Hospice Care Center of St. Joseph Hospital in Lexington. McElhone, known by his KGS co-workers as a quiet and gentle man, graduated from Eastern Kentucky University with a bachelor's degree in computer science and earned an associate's degree in electrical science from Lexington Community College. Before joining the University of Kentucky and KGS, Jim worked with IBM in Lexington, providing technical training. He was a consultant to the manufacturing firm of James River Corp. Jim then went on to the University of Kentucky Computing Center, and was a part-time faculty member of Lexington Community College.

Because of medical issues, he left KGS in the spring of last year with a disability retirement before his December 18 death. KGS staff gathered with McElhone's family and friends for his interment at Calvary Cemetery in Lexington on December 22. He is survived by three sisters and a large number of nieces and nephews.

Norman Hester, who served as Kentucky's assistant state geologist under Don Haney from 1979 until 1982, died in December in Bloomington, Ind. A native of Jeffersonton, Ky., Hester had previously been a geology professor at Eastern Kentucky University and a geologist with the Illinois State Geological Survey. He received his Ph.D. from the University of Cincinnati, specialized in sedimentary geology, and worked in industrial minerals, coastal and marine sediments, coal, oil and gas, and earthquake geology. He was known for his keen powers of observation and great field skills. "He was one of the best field geologists I ever knew," said KGS Director Jim Cobb. "He was the first boss I ever had in geology and because of his exceptional abilities and enthusiasm for geology, he attracted me to a career in geology. He was a great friend to many at KGS."

After leaving KGS, he worked as an independent oil man in western Kentucky before being selected as the 13th state geologist and director of the Indiana Geological Survey in 1992. In that position, he promoted the importance of geology to State, federal, and local officials as a vital component to the decision-making process. He also fostered improved communications and cooperation among the geological surveys of Indiana, Kentucky, Illinois, and Ohio. The creation of the Illinois Basin Consortium was the most notable example of these efforts. He left that position 6 years later, remaining in the Bloomington area. Hester later worked for the U.S. Geological Survey in the central U.S. earthquake preparedness program. He had been a key promoter of establishing the Central United States Earthquake Consortium State Geologists organization, a cooperative group involved in the development of seismic-hazard maps for the Midwest.

Cobb added that Hester enjoyed attending field trips and other geology-related activities in Kentucky. He is survived by his wife, Ruth, two daughters, and grandchildren. ❖



*Jim McElhone*



*Norm Hester (courtesy IGS)*

## Potential oil and gas revenues from public lands assessed by KGS

A KGS analysis shows that the State could derive between \$6 million and \$15.4 million in additional revenue each year if the oil and natural gas resources of State- and university-owned lands were developed. Brandon Nuttall, of the Energy and Minerals Section, led the study, which was mandated with the passage of the 2009 Kentucky General Assembly's Senate Joint Resolution 67. SJR 67 called for the Department of Energy Development and Independence in the Energy and Environment Cabinet to contract with KGS "to study the value of potential oil and gas operations on State-owned and university-owned lands and to identify factors that may limit development of such a program." The legislation noted that oil and gas production on public

lands occurs in other states and could bring additional revenue to Kentucky.

Nuttall, along with Tom Sparks and Sarah Briland of KGS, gathered and assessed data from State agencies and public universities. They determined that 178 tracts of public land, covering just over 181,000 acres, have potential oil or gas resources. Actual development of those resources depends largely on surface-access restrictions. The range of likely revenue from drilling activity is large because changing market conditions, price volatility, and unforeseeable circumstances at each site make such estimates speculative. Nuttall says the estimates are based on a range of revenue projections for single wells using public

data describing production trends and commodity prices.

"Further complications for the assessment could arise from errors in the data and sensitive environmental issues at the sites," Nuttall says. "Surface access for drilling will be prohibited at many sites, but the State or universities could enter into agreements where horizontal drilling technology can be used to develop the resource in those cases."

The study was completed relatively quickly because the General Assembly requested the assessment before the start of the 2010 General Assembly. Nuttall presented the findings at a December 11

*—Continued on p. 5*



## New Hampshire geologist to give Haney Lecture



A former program coordinator with the Kentucky Geological Survey who now serves as the state geologist of New Hampshire will give the

annual Donald C. Haney Distinguished Lecture at KGS on April 7. David Wunsch served as the coordinator for the Coalfield Hydrology Program in the Water Resources Section at KGS from 1985 until 2000, when he took the position of state geologist and director of the New Hampshire Geological Survey.

Wunsch plans to discuss water-policy issues in his April 7 lecture, tentatively titled "The Making of a National Groundwater Monitoring Network." The next day he will make a presentation on the fall of New Hampshire's "Old Man of the Mountain," a granite outcrop on Cannon Mountain in New Hampshire that had the appearance of a human profile when viewed from a particular angle. The outcrop collapsed on May 3, 2003.

Wunsch earned a doctorate in hydrogeology at the University of Kentucky. He has also taught geology at Central Michigan University and served as a congressional science fellow at the American Geological Institute. In 1999, he received the Outstanding Kentucky Geologist Award from the Kentucky chapter of the American Institute of Professional Geologists.

The annual lecture is named for former Kentucky State Geologist Don Haney, who served in the position for 21 years before retiring in 1999. ❖

## Another visiting scholar from China working at KGS

The third visiting scholar from China to visit KGS since the start of an international exchange program has taken up temporary residence at the Survey. Zhongxia Yuan, an associate professor at the Lanzhou Institute of Seismology in China, arrived at KGS in December. The exchange, which began in 2005, has encouraged the sharing of earthquake hazards information and researchers between the Institute, KGS, and the UK Department of Earth and Environmental Sciences.

Yuan works in the Department of Loess Earthquake Engineering at Lanzhou and has focused his research on soil mechanics and soil dynamics relating to loess, a porous silt deposited over long periods by wind action. "There are a lot of loess deposits in the Lanzhou area, and because of the loose structure of these deposits, when an earthquake occurs there can be a lot of ground settlement, which can be disastrous," says Yuan. "So we have been studying the soil dynamics of loess, and we hope we can find economical ways to treat the situation so buildings will perform better."

Loess deposits can be found in the Mississippi Valley as well. Yuan and his colleagues in China have already done some cooperative research with scientists at the University of Memphis on the issue of loess performance in earthquakes. But he says the deposits found in the Mississippi Valley differ from those in Lanzhou. "We found that loess in the central United States has higher clay content, combined with water in the soil, acting as a kind of cement to make soil structure more stable. So the loess here is expected to perform better than the loess we have in the Lanzhou region," he says.

The loess in Lanzhou can be as much as 40 to 50 meters deep, Yuan adds, and the deformation of the landscape can potentially be huge in larger earthquakes, causing major damage to buildings and infrastructure.

He will be at KGS until late May, and hopes to continue working with KGS on seismic-hazard mapping of Tianshui in Gansu Province, China. During their fourth visit to China in the summer of 2009, KGS and UK researchers worked in Tianshui with researchers from the Lanzhou Institute. Another trip to China by KGS and UK researchers is tentatively planned for summer of 2010. A master's degree student at UK's Department of Earth and Environmental Sciences, David Butler, plans to go on that trip as part of his work toward his thesis. In collaboration with the Lanzhou Institute, the Baton Rouge, La., native hopes to assess the ground-motion hazards as well as site effects in Tianshui's urban area. He plans to produce ground-motion hazard maps on bedrock from historical earthquake records and geologic information, as well as ground-motion hazard maps of the soil surface by incorporating site-amplification information.

Two other staff members of the Institute, Yuxia Lu and Zhijian Wu, have previously spent time as visiting scholars at KGS. ❖



### Annual seminar May 14

The KGS annual seminar is scheduled for Friday, May 14, at the Well Sample and Core Library on Research Park Drive in Lexington. The theme for the seminar this year is "KGS: Applying New Technologies." Organizers are developing a list of topics and speakers, who will focus on new methods and tools being used for research in a variety of fields. ❖

*"Hancock County"—continued from p. 1*  
been funded by the American Recovery and Reinvestment Act. It will involve additional analyses of rock samples, injection of more brine and CO<sub>2</sub> to monitor

movement of the material after injection, collection of data for modeling the permeability and porosity of the storage formation, and analysis of fractures and

faults to determine their effect on porosity and permeability. ❖

*“Carbon Storage”—continued from p. 2*

participants determined that ownership of the pore space in which CO<sub>2</sub> is stored will depend on the existing ownership of the property. If, for instance, the mineral rights have been severed from the surface ownership, pore-space ownership could belong to the lessee or owner of the mineral rights. Legal access to the pore space, according to the report, could be provided in several ways: using existing practices and laws relating to utilities, natural gas exploration, and pipeline development; by the State exercising eminent domain; or by creating a new State-regulated utility to provide carbon dioxide storage.

The panel believes that liability for carbon storage should begin with the operator of the storage facility “during storage and the initial period after storage” and then transfer to the state or federal government. The cost of long-term management of storage sites would be paid through a fee assessed for each ton stored, and a quasi-governmental entity would be created for this purpose.

House Bill 491, including a number of the recommendations from the report, was introduced by Rep. Brent Yonts of Greenville in late February. It declares CO<sub>2</sub> management to be an important goal for the state and directs the Division of Oil and Gas to develop a regulatory framework for CO<sub>2</sub> storage, permitting, assessments, and long-term maintenance.

Participants in the work group included representatives of State agencies, law firms, utilities, energy-related companies, and public-advocacy groups. Sara Smith of Smith Management Group served as chair of the group and compiled the final report. The report has been posted on the Web site of the Kentucky Department for Energy Development and Independence. ❖

## Bill proposes changes to geologist registration in Kentucky

Legislation introduced in the Kentucky General Assembly that would change the registration process for professional geologists in the state has been approved by the House of Representatives. One of the most significant changes would be in the area of continuing education requirements. House Bill 286 would allow the Kentucky Board of Registration for Professional Geologists to “require that a person applying for renewal or reinstatement of a certificate show evidence of completion of continuing education requirements as prescribed by administrative regulations promulgated by the board.”

Another provision in the bill would end the current exemption from mandatory registration for geologists employed by State and local governments. Fines up to \$1,000 would also be added to the board’s current power to suspend, revoke, or refuse to renew a registrant’s license for actions such as fraud, negligence, or ethics violations.

Registration for each professional geologist would also expire every 2 years rather than annually under the provisions of the bill, and the state geologist could designate another person to take his position on the Board of Registration.

The bill was introduced by Reps. Tommy Thompson of Owensboro, Dennis Horlander of Shively, and Steve Riggs of Louisville. After passing the House on an 83-13 vote, it was sent to the Senate, where it has been posted in the Licensing, Occupations & Administrative Regulations Committee. ❖



*Kentucky Educational Television broadcast a segment on its “Kentucky Life” program in February about Jephtha Knob along Interstate 64 in Shelby County. The segment included interviews with Warren Anderson of the Energy and Minerals Section. Jephtha Knob is believed to be the geologic remnant of an ancient meteorite impact. “Kentucky Life” host Dave Shuffett prepares to interview Anderson in the KGS lobby, above, for a segment of the program. Anderson also accompanied Shuffett to the site for additional taping. KET plans to produce later segments on other impact sites in Kentucky—Middlesboro, in southeastern Kentucky, and Woodford County, in the Bluegrass Region.*

*“Public Lands”—continued from p. 3*

meeting of the Interim Joint Committee on Natural Resources and the Environment. He adds that the report includes suggestions for refining the estimates.

SJR 67 also called on the Kentucky Department of Energy Development and Independence to develop regulations for permitting oil and gas operations on public lands and protecting public safety and the environment. The Finance Cabinet will also develop lease and oversight guidelines relating to possible oil and gas operations on these properties.

The full report, “Senate Joint Resolution 67: Assessing Oil and Gas Potential of State- and University-Owned Lands in Kentucky,” is available on the KGS Web site through the KGS Publications & Map Catalog at [kgs.uky.edu/kgsweb/findpubsmain.asp](http://kgs.uky.edu/kgsweb/findpubsmain.asp). ❖



**Retired KGS employee donates to Henderson hospital**—A retired KGS employee, Juanita Smith, and her husband Edward recently made a major donation to Methodist Hospital in Henderson, which is being replaced with a new building. Their \$25,000 donation will purchase a baby grand player piano for the lobby of the new hospital's South Tower and help with the construction of that part of the new hospital. Juanita indicated to State Geologist Jim Cobb that she considers the gift to the hospital to be from KGS as well. The donation was made in memory of the Smiths' son, Randall, who was born at the hospital in 1952 and died in 1996. A plaque on the piano will memorialize him and the donation. Juanita worked as an office assistant in the KGS office in Henderson from February 1960 until her retirement 43 years later in 2003.

University of Kentucky  
Kentucky Geological Survey  
228 Mining & Mineral Resources Bldg.  
Lexington, KY 40506-0107

*Address service requested*



**Water sampling continues at Sugar Creek EOR project**—Kathy Takacs and Glynn Beck take quarterly water samples at the Sugar Creek enhanced oil recovery project site in Hopkins County in February. More than 4,500 tons of carbon dioxide had been injected 1,850 feet deep into the oil field by early January, and a slight increase in oil production had occurred. A total of 8,000 tons of carbon dioxide will be injected into the oil field. KGS, the Illinois State Geological Survey, and Gallagher Drilling Inc. are jointly administering the project, which is funded by the state of Kentucky and the U.S. Department of Energy through the Midwest Geological Sequestration Consortium. About \$111,000 in additional funding has come from the MGSC to support monitoring, verification, and accounting activities for the project.

Nonprofit Organization U.S. Postage PAID Lexington, KY Permit No. 51
--