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## ON THE COVER

Longwall (continuous) mining of coal in Greene County, Pa. Longwall mining accounts for about 50 percent of total U.S. underground coal production each year (see article on page 2). Photograph by Albert D. Glover.

## PENNSYLVANIA GEOLOGY

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Editor: Anne B. Lutz.

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### VOL. 35, NO. 2 SUMMER 2005

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The years 2004 and 2005 were remarkable for the number of natural catastrophes, including tsunamis, hurricanes, and earthquakes, that caused great loss of life and property. Whereas geologists cannot prevent such large disasters, we do have the ability to predict where some might occur, and in the case of smaller potential disasters (such as sinkhole formation or landslides), we can do an even better job of pinpointing trouble spots. Some of the Bureau's products, the karst density maps (Maps 68 and 70), for example, can help planners predict where there might be trouble spots.

Prediction is a key component of any scientific theory. A theory is used as long as it does a good job of predicting. If a new theory is presented that does a better job of prediction, scientists drop the old one (usually with great reluctance) and embrace the new one. An example is the idea of plate tectonics. When I was in college, geosynclinal theory was taught alongside the theory of continental drift. However, the two theories were in the process of switching predominance; continental drift was on the rise of acceptance, and geosynclines were sinking. Today we readily accept that the continents are moving, but a few decades ago that was an absurd idea.

Being geologists means that we must have flexible minds, open to multiple working hypotheses. We also have to use the scientific method for discovering truth. Our interpretations may be wrong, but our observations should be accurate and long lasting. Accordingly, the Bureau has embarked on a slow but steady attack on our masses of information on paper. We are putting the contents into a digital database, which ultimately will store all of our data. Bureau geologists of the future will be able to access the data collected by generations of employees, making it possible to do a better job of prediction.

Jay B. Parrish
State Geologist
Energy Bills Getting You Down? Maybe Coal and Unconventional Energy Sources Can Help

by Antonette K. Markowski
Bureau of Topographic and Geologic Survey

DOWN AND OUT IN THE USA. Are erratic and high energy costs the new norm? We all felt the pinch in our wallets in September when gasoline prices reached all-time highs, and oil hovered around $65 a barrel (Energy Economist, 2005). Although less visible, natural gas prices also spiked to the point where consumers may expect to pay about 25 percent more this winter to heat their homes (ABC News, December 7, 2005) and in some parts of the country, up to 67 percent more (U.S. Department of Energy, Energy Information Administration, 2005a). Is there a way to escape this quicksand, or can this situation at least be ameliorated? Can old king coal and unconventional energy sources be a way out?

IN RETROSPECT. An article in a previous issue of Pennsylvania Geology (Markowski, 2004) focused on coal-bed methane (CBM) as a realistic addition to the domestic energy mix. In fact, unconventional and marginal resources now constitute about one third of United States production (Tinker, 2003). Having these resources strengthens the economy and national security, and using them benefits the environment because the amount of methane vented to the atmosphere is reduced. CBM (also called coal-seam natural gas) is one of the fastest-growing energy sources in North America and Pennsylvania today. Additionally, 15 other countries are developing coal-mine methane (CMM, which has a lower heating value than CBM) with the help of the CBM Outreach Program of the U.S. Environmental Protection Agency. For more information on this topic, refer to Bruner and others (1995), Markowski (1993, 2000, and 2001), and Rice (1997), and/or contact the author at amarkowski@state.pa.us.

THE PHOENIX TAKES FLIGHT. In this article, we will examine the future of oil and natural gas, and we will consider the important role that coal, unconventional energy resources, and conservation can play. This is important to address as we begin the gradual ascent from the ashes of fossil fuels to carbon-free fuel technologies. Over the next 50 years, we will either tap our outer limits of innovation or be tenu-
ously energy dependent in a competitive global market. It will be an interesting ride, filled with new technology applied to existing resources and perhaps lifestyle changes in response to a changing energy economy. Are we ready to take this flight?

**HURRICANE KATRINA’S FURY AND THE OUTLOOK FOR OIL AND NATURAL GAS.** According to Ammer (2005) of the Department of Energy (DOE), oil and natural gas provides about two thirds of U.S. energy consumed, and the demand for energy will continue to rise. Over the past 30 years, we have seen a decline in our oil production and an increase in its consumption (Figure 1). The Gulf of Mexico accounts for about 30 percent of domestic oil production, 20 percent of domestic natural gas production, and nearly half of the nation’s refining capacity (U.S. Department of Energy, Energy Information Administration, 2005b). However, Hurricane Katrina forced about 40 percent of that region’s natural gas production to be shut in (stopped), and seven processing facilities were damaged. Other damage was caused by oil spills (Figure 2). These problems translated into unprecedented price jumps at the gasoline pump. The storm, however, did not affect CBM and CMM fields; this underscores the importance of supply diversification.

Natural gas prices also spiked this fall, and consumers may bear the brunt of higher prices this winter. Trapmann (2005) predicted that natural gas markets will stay tight (in limited supply) and natural gas prices will remain high as winter arrives because of supply disruptions and high crude oil prices, and because current storage inventories are three percent less than last year.

![Figure 1. U.S. oil production has been on the decline for 30 years as daily consumption grows. Modified from graph by Randy Yeip, The Patriot-News, Harrisburg, Pa. (Field, 2005); black line, U.S. consumption of oil; colored line, U.S. production of oil.](image)
Green (2005) similarly commented on why oil prices will remain high. He included the following reasons: (1) the Middle East war has bred uncertainty and speculation, consequently affecting oil markets; (2) the U.S. dollar is declining relative to other benchmark currencies; (3) the deliverability of crude oil is at or near capacity; (4) no new giant oil fields have been found in 20 years; (5) drilling and operating costs have increased; (6) crude oil and gasoline are taxed at many levels; (7) domestic refining costs have spiked to comply with environmental mandates; (8) demand outside the U.S. is rising; (9) the oil service sector has suffered due to sustained poor prices; and (10) economically feasible energy alternatives to gasoline do not yet exist.

During the last half of the twentieth century, fossil fuels (oil, natural gas, and coal) provided 85 to 95 percent of the total world energy consumption (Salvador, 2005). At present, natural gas is used to heat 50 percent of U.S. homes and fuel 95 percent of new power plants; 51 percent of Pennsylvania households are heated with it (Figure 3) (Pinsker, 2002). The demand for natural gas is forecast to increase by 53 percent by the year 2020 (Holberg and others, 2000). A large domestic shortfall in the 1990s was met by Canadian natural gas imports.
In effect, we are being pushed toward unconventional forms of energy such as synthetic hydrocarbons, biomass, and methane hydrates (crystalline solids found in marine sediments that release methane when melted).

Pennsylvanians currently get about 64 percent of their electricity from coal, oil, and natural gas, and 34 percent from nuclear power (Citizens for Pennsylvania’s Future [PennFuture], 2005). The remainder includes clean, renewable sources of energy such as wind, small-scale hydroelectric, solar, and biomass.

**COAL: MAKING THE MOST OF WHAT WE HAVE NOW.** In addition to contributing nearly 10 percent of natural gas (CMM and CBM) to the nation’s energy mix, coal (see front cover) is the most abundant, lowest cost fuel source for the nation’s electrical-generation industry, providing more than 50 percent of the energy requirements and more than a 250-year supply at the present rate of use, according to the U.S. Department of Energy (2005a). In Pennsylvania, about 77 percent of our coal (mostly bituminous) is burned for electric power generation (Edmunds, 2002). The latest reserve estimates of 32 billion tons, 78 percent of which is bituminous coal and 22 percent of which is anthracite coal, provide assurance to Pennsylvanians of reliable, low-cost energy for many decades (Pennsylvania Coal Association, 2000). Salvador (2005) echoed Green (2005) in saying that no radical discovery for energy generation and use is expected; he predicted important advances in existing technologies, such as clean coal use, gas-to-liquid conversion, more efficient transport engines and electrical-generation plants, and development of hydrogen-powered fuel cells for transportation and electrical generation. Coal may very well be the strategic antidote to America’s domestic energy woes until time, resources, or technology prove otherwise.

**THE ENERGY POLICY ACT OF 2005 HOLDS BIG OPPORTUNITIES FOR COAL.** After five years without a national energy policy, President Bush signed into law the $12.3 billion measure on August 8, 2005. The act covers the spectrum from energy efficiency and all fuel sources (renewables, oil and gas, nuclear, coal, and so on), to vehi-
cles, to associated fuels such as hydrogen for fuel cells and ethanol (Coal Age, 2005). Four highlights of the act are the following: (1) It provides $1.8 billion over nine years for the Clean Coal Power Initiative. About 70 percent of those funds must be used for coal gasification demonstration technologies, and the remainder will be used for advanced coal pulverizing technologies. Coal gasification combines coal with oxygen to break coal down into its chemical constituents, converting the energy content of coal into electricity, hydrogen, and other energy forms in a clean, versatile way. Pulverized coal can be combined with pulverized limestone to capture sulfur dioxide emissions when coal is burned. Nitrogen oxide emissions can also be reduced through this clean coal technology process. (2) The act specifies $1.14 billion for basic coal research and development, including a 10-year program to develop carbon-sequestration technologies for new and existing coal-fired power plants. Carbon sequestration is the term used to describe a broad class of technologies for capturing and permanently sequestering, or storing, carbon dioxide to help stabilize atmospheric levels of greenhouse gases. (3) The act grants $3 billion for a new Clean Air Coal Program, which consists of two parts. The first part is a five-year plan to help existing coal-fired power plants install advanced pollution-control technologies; the second part is a seven-year plan to help electrical-generating plants install advanced clean coal technologies to replace existing capacity or for new capacity. Tax incentives are offered to help jump-start many of these technologies. (4) Changes to the Mineral Leasing Act allow for the increase in the amount of coal acreage a company can lease from federal lands. More information on the Energy Policy Act of 2005 can be found by searching for bill number HR 6 at http://thomas.loc.gov.

INCENTIVES FOR DOMESTIC POWER. Pennsylvania is in the vanguard of innovative environmental and energy solutions, as indicated by the state’s involvement in the following four programs.

The Alternative Fuels Incentive Grant Program was created by Act 166 in 1992 (Pennsylvania Department of Environmental Protection, 2005a). Its goals are to reduce dependence on imported oil, improve environmental quality, and foster economic development by encouraging the transfer and commercialization of alternative and cutting-edge energy technologies and the use of Commonwealth fuels. Act 178, passed in 2004, expanded upon these goals and provided for project funding at higher percentages.

The FutureGen initiative, announced by President Bush on February 27, 2003, is a $1 billion cost-shared partnership between the DOE and an alliance of nine coal utilities and producers to build a world prototype integrated carbon sequestration, electrical, and hy-
drogen production research power plant (U.S. Department of Energy, 2005b). The goal of this 10-year project is to validate the feasibility and economics of emission-free energy from coal and demonstrate this concept as a groundbreaking solution for future energy and environmental security. When operational, it will be the first near-zero-emissions fossil fuel plant. FutureGen seeks to turn coal into a gas for hydrogen fuel cells and explore technologies to remove more than 90 percent of carbon dioxide from coal gas and store the carbon dioxide in geological formations. Pennsylvania is one of the states competing for the location of the plant (Fuel Cell Today, 2005).

Since 2003, the Pennsylvania Department of Environmental Protection (DEP) has helped the future of hydrogen and fuel cell economy through the Pennsylvania Energy Harvest grant program, awarding $5 million per year for clean, advanced energy projects. According to DEP Secretary Kathleen A. McGinty (Pennsylvania Department of Environmental Protection, 2005b), investments in biodigesters, solar, micro hydro (energy from flowing water on a small scale), wind, and other renewable sources, and cleaner ways to use traditional energy sources such as coal, will help build incentive, markets, and jobs for these technologies.

On November 30, 2004, the Alternative Energy Portfolio Standards Act (Act 213) was signed into law by Governor Rendell (Citizens for Pennsylvania’s Future [PennFuture], 2004). This act requires 18 percent of the electricity sold in Pennsylvania to come from renewable and advanced energy sources within 15 years. It established two tiers for power generation. Tier I includes more traditional renewable resources, and Tier II includes alternative sources, such as waste coal, that provide some additional environmental benefit (GreenYes, 2004).

IMPROVING THE LANDSCAPE WITH DOMESTIC POWER. The Anthracite Region Independent Power Producers Association (ARIPPA) provides an example of environmentally friendly power generation. ARIPPA is a nonprofit trade association of 13 independent power producers in Pennsylvania that generates approximately 11 million megawatt-hours of electricity per year by using environmentally responsible technology to burn old, abandoned anthracite coal-mining waste (culm). These culm banks have dangerous, unstable, and highly eroded slopes and can occasionally ignite; after ignition, the fire can burn for many years. They are also a primary source of acid mine drainage. Cogeneration plants convert the coal waste from ugly refuse piles into electricity by treating it with limestone before burning it at low operating temperatures to neutralize the acid, bind heavy metals, and minimize nitrogen oxide emissions. As a bonus, the byproduct ash of coal waste combustion is used to restore abandoned
mine lands to productive use. The state now has 14 small and one large coal-waste-fueled plants that generate electricity (GreenYes, 2004).

**FUTUREWORLD: POSITIVE OUTLOOK FOR UNCONVENTIONAL GAS, INNOVATIVE TECHNOLOGY, AND COAL.** There may be ups and downs regarding oil supply and controversy over “peak oil” due to a variety of speculative and geopolitical reasons, but the United States is not running out of natural gas, only natural gas from conventional shallow reservoirs that are relatively easy to develop and produce (Stott, 2005). The energy deficit can be met in the near term by conservation, by fully developing known domestic reservoir basins (tight gas sands, gas shales, CMM, and CBM) and increasing liquefied natural gas imports, and also by converting existing technical resources (synthetic technology), exploring for deeper, untapped sources of natural gas onshore and offshore, and developing aggressive, clean coal technologies. For example, research will soon begin on the potential of methane hydrates.

These tasks require many disciplines and a partnership approach because new supplies may be difficult and costly to develop. Critical needs are more efficient exploration, production, and improved reservoir access (Ammer, 2005).

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Educational Series 13, Reading and Using Maps, is a new type of publication for the Pennsylvania Geological Survey. It is being provided as an interactive product on the Bureau’s web site (www.dcnr.state.pa.us/topogeo/pub/educational.aspx#ES13). It is intended for beginners as well as those who are generally familiar with maps but who would like a better understanding of geologic maps or other specialized maps. Students are especially encouraged to read ES 13, and several web-site locations for kids are referenced.

This Educational Series publication was written by three staff members in the Pittsburgh office of the Bureau, Kristin M. Carter, Jaime Kostelnik, and Karen A. McCoy. Hilton McKnight and Marshall Osborne, artist-illustrators at the Pennsylvania Department of Environmental Protection, developed it for the web.

Compass Rose, a friendly character who is a combination of compass and field geologist, guides the reader of ES 13 throughout this electronic booklet. Tracy Stack of the Bureau of Recreation and Conservation gave Compass Rose her voice.

Maps are more important in today’s world than ever before because they provide information about location, direction, and distance. We use them as navigation tools, whether we are making our way through the mall or backpacking through Europe. We can use maps to represent the distribution of annual snowfall amounts or average family income. But because maps are so versatile, they can also be complicated. It is hoped that ES 13 will help in understanding how and why maps are made, as well as the purposes of the components of a map.

Because the earth is almost spherical, representing any part
of it on a two-dimensional piece of paper requires using one of many different types of map projections. Some of these are described in this publication. Grids that are drawn on maps, such as latitude and longitude, help us to locate areas of interest.

There are many different types of maps, including topographic maps (see back cover), road maps, geologic maps, and meteorological maps, among others. All of these types have some features in common, but each has unique components as well. Many of these features are presented in ES 13, including those that are common to all maps, such as scale and location and direction information. A handy scale comparison chart gives the reader an idea of the distances on the ground represented by different map scales.

The concept of contour lines (lines connecting points of equal value) is important for understanding topographic, isopach, and some meteorological maps. Compass Rose helps the reader with this concept by drawing lines around a hill with white paint. In addition, some of the symbols and colors that are used on topographic maps are described. Further, the technique of drawing a topographic profile is explained.

Geologic maps include information about the third and fourth dimensions, namely depth (by showing the positions and thicknesses of different rock units) and time (by showing the ages of rocks represented on the map). They may also be accompanied by cross sections that illustrate the author’s interpretation of the structure of the rocks in a vertical slice of the earth’s crust. A geologic map example and its associated cross section are provided in this publication, along with an explanation of strike and dip and the formation of folds.

ES 13 provides a discussion of map creation over the years, from the early days of mapping on horseback to today’s digital mapmaking techniques, as well as a glimpse of what is to come in terms of future digital map products.

Rounding out Reading and Using Maps are suggestions for where to obtain maps, a glossary, and lists of recommended books and web-site addresses.
ANNOUNCEMENT

Northeastern Section of Geological Society of America to Meet in Camp Hill

The 2006 annual meeting of the Northeastern Section of the Geological Society of America (GSA) will be held March 19–22, 2006, at the Radisson Penn Harris Hotel and Convention Center in Camp Hill, Pa., just across the Susquehanna River from Harrisburg.

The meeting will take place in the heart of the classic Appalachian Ridge and Valley province, in close proximity to the Mesozoic basins and Piedmont of Pennsylvania. A special hot topic lecture will feature the latest on the Mars Exploration Rovers. There will be general sessions, theme sessions, short courses, and field trips.

Theme sessions will feature presentations on many aspects of geology, including hydrogeology, oil and gas geology, geologic hazards such as landslides, forensic geology, and current research in the Appalachians and Allegheny Plateau. Geoscience education is the focus of one of the sessions.

Geoscience education will also be emphasized in a series of short courses. Topics include innovative course design, making digital movies for classes, and academic job searches. A special K–12 teachers’ program will include an introduction to geospatial technology, and web-based laboratory exercises. For geologists interested in hands-on training to understand, anticipate, and measure geologically dependent indoor radon and waterborne radon, a course pertaining to this topic is on the schedule.

Field trips will provide the opportunity to explore various facets of geology in the vicinity of Harrisburg. These include Cambrian microbial reefs, stream evolution, tectonic patterns, karst subsidence problems, a mineral aggregates quarry, conodont-bearing strata, and acid-drainage problems at Skytop.

Undergraduate and graduate students who are giving presentations may apply for travel grants.

The preregistration deadline is February 13, 2006. For more information about the meeting, and to register, go to GSA’s website at www.geosociety.org/secdiv/northe/06nemtg.htm.
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(Modified from Carter, Kostelnik, and McCoy, 2005)
(See article on page 10.)

Part of the U.S. Geological Survey Canonsburg 7.5-minute quadrangle map (Washington County, Pa.)