Coal and geophysics in the USA

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When the word hydrocarbon is discussed, most geophysicists in the United States think of oil or natural gas. Neither, though, is the country's most abundant fossil fuel. That distinction belongs to coal, which accounts for about 90 percent of total fossil fuel reserves. Current data from the World Energy Council indicate the USA has the second largest coal reserves of any nation, an amount that is 20 percent of the world's estimated recoverable coal.

Geophysics has never played a prominent role in the coal industry because locations of the major North American basins are known. Coal companies don't need to find more coal, but they do need to improve extraction methodswhich will increase productivity and efficiency, and let them remain competitive in a tight fuels market. The most prominent of the new extraction methods is longwall mining (see TLE, April 1990). Efficient use of these capital intensive systems requires detailed information on seam thickness, quality, and geologic trends. When the face of the longwall machine encounters unexpected geologic anomalies, a serious delay can result that is often very costly. Improvement in the evaluation of reserves is possible when geophysical methods, particularly seismic, complement the normal exploratory drilling program.

Although TLE has published many papers dealing with petroleum reserves, it has said little about coal. This article attempts to point out the important role that coal plays in the energy mix, and the role that geophysics might have in this area.

Reserve base. According to the US Geological Survey, the country has about 1.7 trillion tons of identified coal reserves. But, since some coalbeds cannot be mined cost effectively or quality may not meet current standards, a more realistic estimate of recoverable coal is 476 billion tons. This is known as the "demonstrated reserve base." Recovery rates vary depending upon the extraction method; it could be as high as 90 percent for western surface mines but only about 60 percent for eastern underground mines (because some coal must be left behind to support the mine roof). Thus, the "recoverable reserve base" is estimated at 286 billion tons.

Coal basins are divided into three major groups: the eastern, interior, and western regions. The Northern Appalachia, Central Appalachia, and Black Warrior basins are in the eastern region. Seam thicknesses are generally less than 3 m. The coalbeds are mostly bituminous and extraction is generally by underground methods. The interior region, composed of the Illinois and Arkoma basins, includes numerous bituminous and lignite deposits scattered from Michigan to Texas. Major basins in the western region are the San Juan, Powder River, Piceance, Uinta, Wind River, Greater Green River, and Raton Mesa. Seam thicknesses are generally over 7 m and can be as thick as 30 m. The coalbeds are primarily sub-bituminous and extraction predominantly by surface methods.

Types of coal. Coalification is the process by which fossilized plant materials are turned into coal. Physical and chemical characteristics like heating value, ash, melting temperature, sulfur, mechanical strength, impurities, and other properties must be considered when matching coals to a specific application. There are four general categories of coal, reflecting the progressive states of individual deposits subjected to increasing heat and pressure during the coalification process.

Lignite. A brownish-black coal with the lowest carbon content (25-30 percent), heating value of 4000-8300 BTUs/lb, and moisture content than can be as high as 45 percent. Used mainly for electric power generation.

Sub-bituminous. Carbon content of 35-45 percent, heating value of 8300-13 000 BTUs/lb, and moisture content of 20-30 percent. Although the heating value is lower than bituminous, the generally low sulfur content makes it an attractive energy source because of cleaner burning.

Bituminous. The most plentiful form. Used primarily to generate electricity and make coke for the steel industry. Carbon content of 45-86 percent with heating value of 10 500- 15 500 BTUs/lb. Moisture content usually less than 20 percent.

Anthracite. Considered "hard coal" because it has the highest carbon content (86-98 percent). Heating value nearly 15 000 BTUs/lb, and moisture content less than 15 percent. Very small segment of reserves, found mostly in 11 counties of northeastern Pennsylvania, of about 7.3 billion tons (2 percent of USA total). Most frequently associated with home heating.

Coal deposits in the USA have an average heat content of 22 million BTU/ton. This equals the energy obtained by burning 22 000 ft^3 of natural gas or 160 gallons of distillate fuel oil.

Production and coal markets. Coal was once the primary energy source in North America and the one which fueled its industrial revolution in the late 1900s. Shortly after, though, discoveries of major petroleum reserves caused coal production and consumption to decline. The trend reversed in the 1960s and surged upward during the oil crises of the 1970s. Since that time, coal production has been at record highs in the USA; Nine billion tons were mined in the 1980s, giving that decade the largest coal production in American history. In 1990, production surpassed 1 billion tons for the first time and production in succeeding years has remained close to that figure. Production is well distributed geographically; in 1993, the five states with the highest production were Wyoming (200 million tons), Kentucky

(155), West Virginia (135), Pennsylvania (62), and Texas (54).

About 78 percent of the 996 million tons produced in 1992 was used as fuel in power plants, producing nearly 56 percent of the country's electricity. (This translates into about a fourth of the energy used in the USA today.) The remaining 22 percent was exported to other nations (103 million tons worth about $4.3 billion) and consumed by domestic industries. Note that the USA is a coal exporter -at a time when it imports nearly half of its petroleum demands. It is estimated that, if coal consumption were eliminated, the country would need about 4 billion bbl of oil or 198.8 trillion ft3 of gas to replace it, resulting in even greater reliance on foreign petroleum.

Coalbed methane. This has long been known as a promising source of unconventional gas reserves, but has traditionally been considered a major underground mining safety hazard. However, improved mining and drilling technologies have reduced risks (e.g., degasifying seams before mine development). Tax incentives offered by the government coupled with improved downstream technologies made production of this gas economically viable. As a result, drilling has increased and there has been significant growth in natural gas reserves from the late 1980s to the present.

Commercial production of coalbed methane is currently estimated at 1 bil-. lion ft3/d from some 2000 wells, located mostly in New Mexico, Colorado, Wyoming, and Alabama. The Black Warrior Basin in Alabama is currently the leading area for such production. The Potential Gas Agency estimates that current technology could produce 147.3 trillion ft3 of coalbed methane, and that improved technology could make the figure much higher.

Conclusions. As long as the USA relies on fossil fuel as its primary energy source, coal will play an integral role in meeting the demand. At current rates of production and consumption, domestic coal would last another 250 years-much longer than petroleum reserves. Despite these statistics, there is a disproportionately large anomaly between geophysicists working in the petroleum and coal industries. I estimate only a handful (less than one tenth of one percent) are working in coal geophysics (either full time or part time). Other countries with sizable coal reserves (including some considered third world), are conducting more geophysical work which suggests they have a higher percentage of geophysicists working in the coal industry.

One coal company in the USA recognized the value of geophysics to complement its exploration and development projects and developed its own geophysics program. This program has been successful, so seismic surveys are now routinely conducted before mining in order to improve the evaluation of reserves. Other geophysical tools (like electrical resistivity, magnetometry, ground-probing radar) are also used for engineering and environmental applications.

Based on this company's experience, geophysical activity in the coal industry has no where to go but up.