Excerpts from RockTalk Volume 8, Number 2, 2005

Go to the Coal Minining Glossary

***What is Coal?*** Coal is a solid but brittle, carbonaceous black sedimentary rock that burns. It is made up of carbon, hydrogen, oxygen, nitrogen, and lesser amounts of sulfur and other trace elements. Coal is divided into four classes: lignite, subbituminous, bituminous, and anthracite. Of the commonly minable coals, anthracite is the hardest and has the most carbon, giving it a higher heat value. Lignite is the softest coal and has the least amount of carbon. By definition, coal is a combustible rock containing more than 50 percent by weight carbonaceous material formed from compaction of variously altered plant remains originally derived from peat.

***Subbituminous coal from the Laramie Formation near Morrison, Colorado.***

***Coal Quality*** Not all coal is composed of the same compounds. Different types of coal are characterized by their unique properties, which produce different results when burned. These properties are empirically determined by coal quality tests. The most basic test is the Proximate Analysis, or chemical analysis that determines the amount of moisture, volatile matter, fixed carbon, and ash that are in coal. Ash consists of the impurities in coal such as silica, iron, alumina, and other incombustible matter. Fixed carbon is the nonvolatile part of the coal minus the ash. Volatile matter is the gas in the coal, and moisture is the water in coal. A typical Cretaceous coal in Colorado might have values ranging from 5.4–8.1 percent ash, 37–41 percent volatile matter, 52–56 percent fixed carbon, 19–21 percent moisture. Another coal quality test is the Ultimate Analysis, which indicates the major elements in any sample of coal. Coal is composed of many elemental compounds, mostly carbon and oxygen. Ultimate Analysis indicates that elements such as silica and iron are also present in coal. Many times, sulfur and heat value are added to the test, with results like 0.4–0.7 percent sulfur and 9,940 Btu/lb.

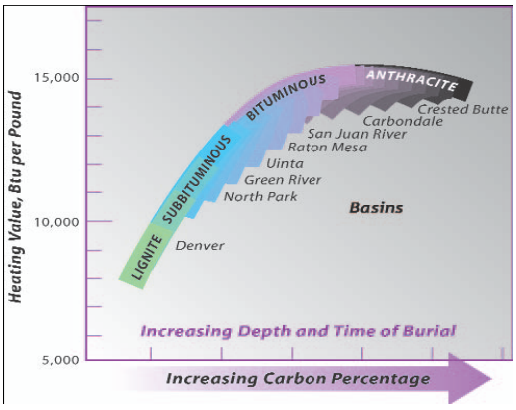
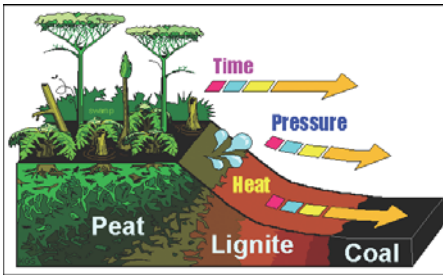



***Diagram of coal rank in terms of carbon content (or depth and time of burial )and heating value.***

***How and when was coal formed?*** Coal is a hydrocarbon-rich, fossil-fuel resource, and like other fossil fuels it was formed millions of years ago. Much of the coal in the eastern U.S. comes from swamps that existed during the Carboniferous Period, 355 to 295 million years ago. However, in the western U.S. coal swamps formed between 100 and 55 million years ago, in the Middle to Late Cretaceous Period and the Paleocene Epoch of the Tertiary Period. During this time, Colorado was situated along the shoreline of a large, shallow seaway that extended from Canada to Mexico throughout the central U.S. This shoreline moved back and forth during the course of time. Fresh-water swamps formed along the coastal plains adjacent to the shoreline of this seaway. The climate was very warm and humid, with abundant vegetation on the coastal plain. During that period Colorado's environment looked similar to modern day South Carolina's coastal plains and swamps, but with dinosaurs. As the vegetation died and sank to the bottom of the fresh-water swamps, it built up large deposits of decomposed, spongy organic matter called "peat." This saturated peat built up to form bogs that were a few feet to over hundreds of feet thick. Over geologic time, sand and clay sediments covered this peat. More and more sediment was deposited on top of the peat weighing it down and squeezing the water out of the peat. Burial compacted the peat and eventually turned the sediments into rock. High temperatures and pressures over millions of years converted the peat into different types of coal. Generally, the greater the pressure, the harder the type of coal that is formed. This entire process is called "coalification." Mountain-building processes also affect coalification. Thermal processes within the coal beds can be initiated by igneous intrusive activity and deep-seated uplift. Tertiary-age uplifts and intrusions into the coal-bearing rocks affected the coal beds. Generally, these coal beds were thermally cooked, which upgrades the "rank" of the coal. Bituminous coals can be upgraded to anthracite rank when thermally cooked by igneous intrusions.

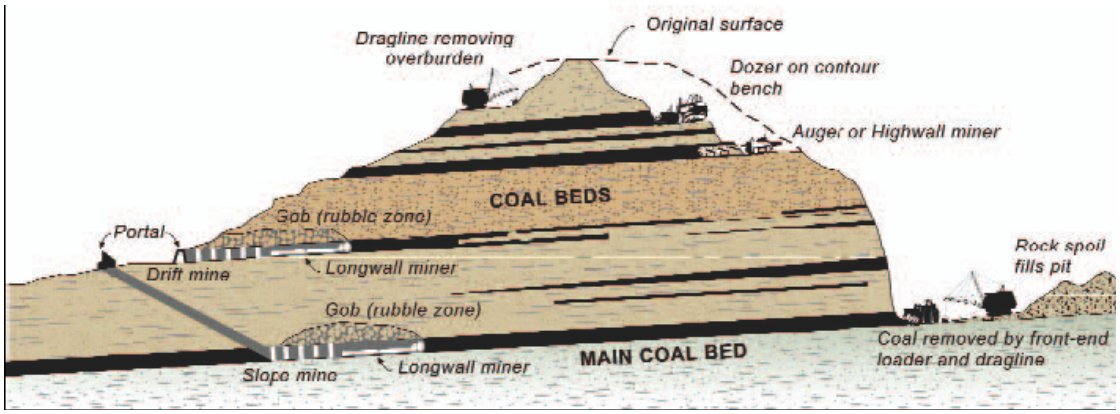



***The coalification process from swamp to coal. Note how a thick section of peat is compressed by heat and pressure into a thin section of coal.*** **Modified from the Kentucky Geological Survey.**

***How much energy is in coal?*** The amount of energy given off by coal is defined by the heat value measured in British thermal units, or Btu's. A single Btu is the amount of heat energy it takes to raise the temperature of one pound of water by one degree Fahrenheit at sea level. One Btu is about equivalent to the amount of energy in a single match. It takes about 2,000 Btu's to make a pot of coffee. One pound of Colorado coal has about 10,000 Btu's, or the equivalent of making five pots of coffee. Igneous dikes and sills also crosscut and alter coal rank. Igneous sills even replace coal beds by injecting themselves preferentially along weak horizontal coal bed layers and altering the surrounding rocks. This process bakes coal into natural "coke."

***Why are trace elements in coal important?*** Trace elements such as arsenic, mercury, cadmium and zinc have an affinity for sulfur and attach themselves to coal. Coal acts

like a sponge in groundwater and adsorbs like a charcoal filter. Much of the world's coal contains hazardous concentrations of mercury and sulfur. Coal-fired power plants are the largest source of mercury emissions in the U.S. For this reason, the Environmental Protection Agency (EPA) is working on new rules to protect the environment from air pollution stemming from coalfired power plants. In particular, mercury emissions from coal-fired power plants are to be regulated. The new rules, adopted March 15, 2005, cap and reduce mercury emissions from coalfired power plants. With enforcement by April 2008, the EPA goal is to reduce mercury emissions by nearly 70 percent.



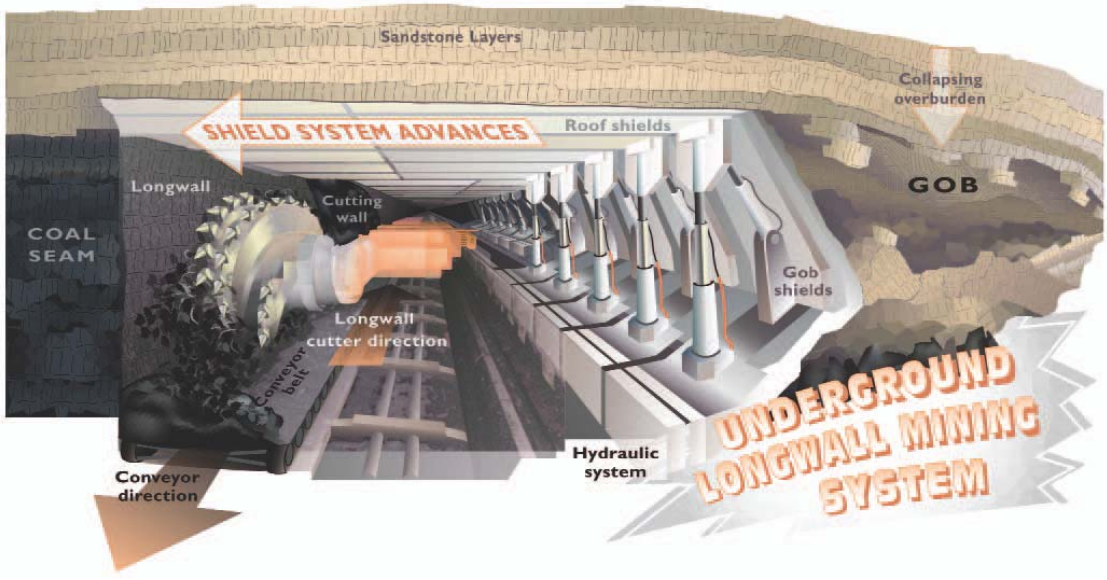

***Surface mining vs. underground mining methods.***

***Mining Methods*** Coal is either mined from the surface or underground. The particular mining method chosen depends on surface terrain conditions, coal layering, access, and/or reclamation laws. Surface mining is regulated by a set of rules governing the recovery and revegetation of original topography, while underground mining is mostly regulated by safety concerns. If the coal seams are shallow and close together, then surface mining is considered. However, if the seams are thick (greater than five feet thick), and deeper (between 200 and 2,500 feet deep), then underground mining is considered.

***Underground Mining*** A deep coal seam is accessed by an opening to the surface called a portal. The portal openings are called drift, slope, or shaft mines. Drift mines cut down the coal bed from the outcrop, slope mines cut through overburden rock at an angle to get to the coal, and shaft mines access the coal through a vertical shaft. Mining begins with a cutting machine called a "continuous miner" creating a box work called room and pillar mining. As the rooms are cut, the coal is loaded onto a shuttle car and carried to a conveyor belt that carries it to the surface. As the mining advances, the pillars remain to support the openings. Roof bolts are placed in the ceiling to stabilize the roof. The larger underground mines use a large coal-cutting machine called a "longwall" miner. This automated machine is 1,000 feet long and has moveable three-foot-wide cutting teeth that cut away at the face of the wall of coal. This 36-inch diameter rotating shearer cuts the coal, where it drops onto a conveyor which hauls to the surface. Because this machine cuts a continuous 1,000-foot-long swath into the coal seam, there are no pillars left to

support the roof. So moveable metallic roof shields are installed all along the 1,000 foot zone that will be cut. This keeps the roof from collapsing near the cutting machine. After each 1,000-foot-long cut (each three feet deep), the metal shields are moved forward allowing the roof to collapse behind.

***Surface Mining*** If the coal beds are relatively close together and less than 200 feet from the surface, then surface mining is considered. The types of surface mining include area, mountaintop removal, and contour mining. Huge dragline shovels (12–27 cubic yard buckets) first remove rock overburden to get to the coal. These machines stockpile the overburden until it is time to reclaim the pit. The coal is excavated from the pit floor with truck shovels and front-end loaders and then hauled to the loading area with large trucks. As the pit widens and deepens, the walls become steeper. The wall in the pit where the coal is mined is called the highwall. The back side of the pit is filled with waste rock. The highwall is benched to mine the upper coal beds, and then the underlying rock is blasted with explosives for easier removal. When the pit walls are too high and steep, surface miners try to remove coal remaining in the highwall without further excavation. Two methods of mining can achieve this feat, auger and highwall mining. Auger mining employs a 6-foot diameter horizontal auger to drill out the remaining coal. This methods works well on flat-lying coal beds. When the coal beds dip or roll, the highwall miner is used. This new technology machine excavates a rectangular hole into the coal outcrop with a rotating continuous miner head. As the laser-guided machine extracts coal from the hole, conveyor belts transport the coal back to the surface while the mining machine advances. The remote-control machine can extract coal up to 1,200 feet into the highwall. This method can safely remove coal without using miners underground.




***Diagrammatic representation of an underground longwall miner.***

*Cretaceous coal strata exposed in a bench cut of the Williams Fork Formation atthe Kennecott Corp. Colowyo surface coal mine in Moffat County, Colorado. Note how the coal beds split and roll.*


*Block diagram of a highwall miner operating in cross-sectional viewin a surface mine operation.*

***What is coal rank?*** The degree of heat value is a measure to which the peat has undergone thermal alteration to form coal. This rank, as it is called, is based on the carbon content in the coal measured as the heat value per pound (or Btu). Rank is categorized by varying coal rock types from peat to anthracite (Fig. 5). Anthracite is the hardest coal and gives off the most amount of heat when it burns. The reserves for anthracite are small. Because it is hard to crush and burn, anthracite is not used much as steam coal.

***What are macerals?*** When coal is observed under a microscope, various forms or parts of plants can be seen. Since trees are the primary vegetation in swamps much of the macroscopic fossil material looks similar. But under the microscope, there are smaller ancient plant and tree parts that make up coal on the microscopic level called macerals, which are considered the basic building blocks of coal. Macerals are characterized in three major groupings:

- **Vitrinite**, the most common maceral, is the decomposition product of plant cell walls like cellulose and lignin.
- **Exinite** is composed of spores, cuticles, resins and waxes like the outer surfaces of leaves.
- **Inertinite** is charcoal from fires that occurred in the peat bogs during early deposition.