

In 2020, Virginia produced approximately 9.9 million short tons of coal, worth an estimated \$2.1 billion dollars. Although this number represents a significant decline from the 1990 peak of 47 million tons, Virginia ranks 19th in U.S. Coal production.

NATURE OF COAL

Coal is a combustible organic rock composed principally of consolidated and chemically altered vegetal remains. Geologic processes, working over vast spans of time, compressed and altered decaying plant material which resulted in an increase of the percentage of carbon. With increasing heat and pressure, different ranks of coal can occur: lignite (the softest), subbituminous, bituminous, and anthracite (the hardest). Upon close examination, some coals have bright, shiny bands of varying thickness that alternate with duller bands, whereas other coals show no banding. This horizontal layering reflects the initial accumulation of the organic rich materials. Bright layers (vitrinite) consist primarily of woody cellwall materials, while the dull layers (exinite) consist primarily of the most resistant plant remains, such as spores and cuticles of leaves and rootlets. These organic portions of coal are categorized as macerals, the various types of coalified plant material. Banded coals are referred to as attrital or splint coal types, whereas the non-banded coals are cannel and/or boghead coal types. Each has its own characteristics and appearance that reflect the environmental conditions responsible for its formation.

ORIGIN OF COAL

Coal originated from ancient plants that flourished in swamp-like environments millions of years ago. In Virginia, coal was formed mainly during the Carboniferous Period of the Earth's history, 299 to 359 million years ago. There are also coal beds in Virginia that were formed during the Triassic Period, 201 to 250 million years ago. By comparison, most of the coals in the western United States were formed during the Cretaceous Period, 66 to 145 million years ago, and the Tertiary Period, 2.6 to 66 million years ago.



Figure 1. Bituminous coal.

At the time in Earth's history when the Appalachian coals were accumulating, the Atlantic Ocean had not yet formed. What was to become the North American continent was situated near the equator, slowly drifting northward. This large mountainous landmass was east of our present-day East Coast and a vast, shallow sea stretched to the west, submerging what is now the Great Plains. The influence of the sea decreased and the water became brackish as freshwater influence from the eastern highlands increased because of extensive deltaic plains developing from the erosion of these highlands. Extensive swamps covered much of the coastal lowlands that lay along the western margin of these highlands. The perennially wet, tropical climate at that time was particularly conducive to coal formation (Cecil, 1990).

Leaves, stems, spores, tree trunks, branches, roots, resins, charred wood from swamp fires, other organic material, and mineral (inorganic) matter were deposited within the swampy basins. Thick deposits of

partially decomposed vegetal debris (peat) accumulated under the cover of stagnant water in these basins. Over time this peat was buried by layers of sediment from deltaic and coastal processes or by an occasional rising of sea level. Continued burial and the influence of the Earth's thermal gradient subjected the peat to pressure and heat. Eventually, various chemical and physical changes transformed the peat into coal, a process called coalification. A significant volume reduction occurs in the transformation of peat to coal. Although coal can range in thickness from less than 1 inch to more than 100 feet, it has been estimated that 3 to 10 feet of compacted vegetal matter are necessary to form each foot of coal. The extensive accumulation of thick coals involves slow rates of basin subsidence, implying a minimal change of sea level (or a "stand-still") and an equable tropical climate. The final composition of the coal depends upon the original ratio of organic to inorganic matter found in the parent peat.

A modern-day depositional analogue for the formation of extensive, commercial Appalachian coal beds are the swampy coastal regions of Sumatra and Borneo. For additional information refer to Cobb (1988).

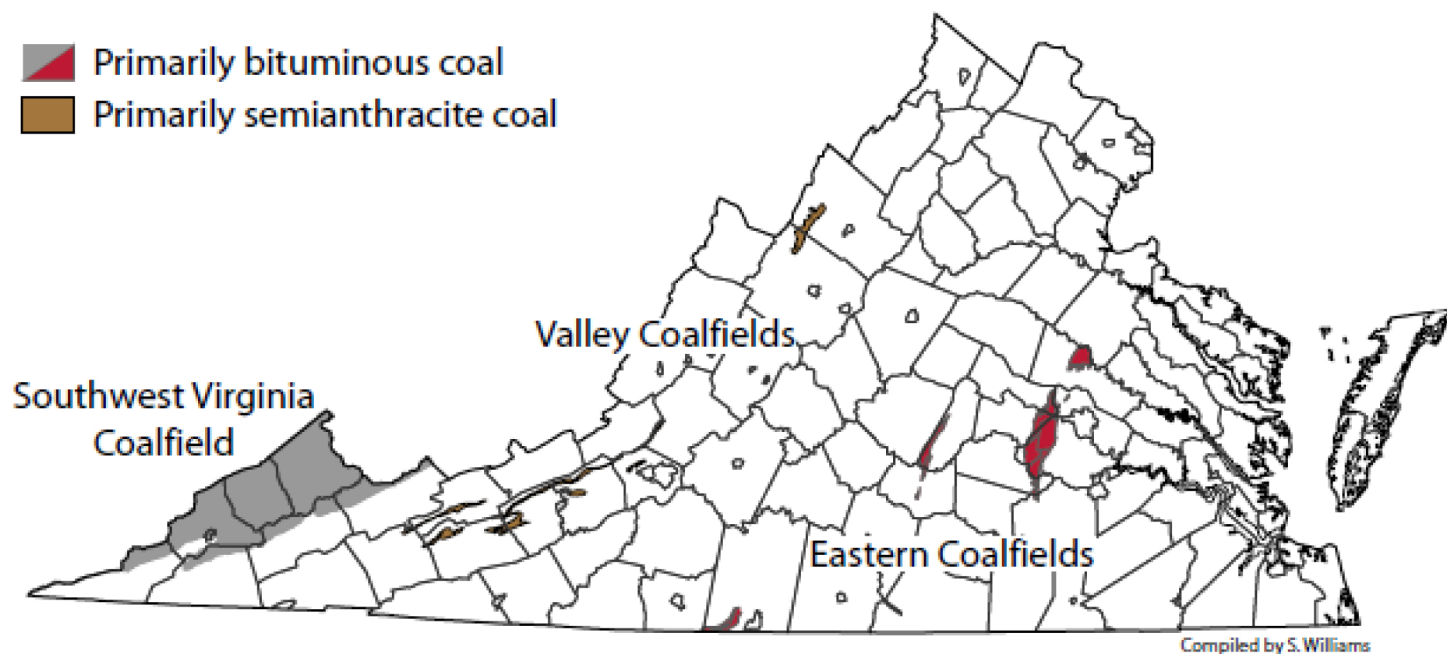
DISTRIBUTION OF COAL BEDS

Coal occurs in Virginia in three widely separated areas, encompassing approximately 2,000 square miles of surface area: the Eastern Coalfields (Mesozoic basin fields such as the Richmond and



Figure 2. Coal bed in southwestern Virginia.

Farmville basins), the Valley Coalfields (narrow coal-bearing areas in the west-central mountainous part of the State), and the Southwest Virginia Coalfield (part of the extensive Appalachian coal basin). The Southwest Virginia coalfield occupies an area of approximately 1,550 square miles, contains nearly all of Virginia's bituminous coal reserves, and is currently the source of all the State's coal production. Virginia's coal is produced from seven counties: Wise, Dickenson, Lee, Buchanan, Russell, Scott, and Tazewell. However, 85 percent of the coal produced comes from the counties of Buchanan, Dickenson, and Wise.



Seventy-six discrete coal beds occur within five major geologic formations across the Southwest Virginia Coalfield. Coal is currently mined from nearly 45 coal beds, which are from 3 to 5 feet thick. The four principal commercial coal beds are the Pocahontas No. 3, Jawbone, Splash Dam, and Dorchester. The Pocahontas No. 3 is an important source of metallurgical grade coal and ranks as one of the major economic coal beds in the United States. Other important Virginia commercial coal beds are the Low Splint, Taggart, Imboden, Clintwood, Upper Banner, Lower Banner, Kennedy, Raven, and Tiller.

COAL QUALITY

The types of plant-derived materials and the depth and chemistry of the water varied from place to place within the ancient coal-swamp environments. These variations determined the composition and properties of the peat which further produced varied quality within the resultant coal during the coalification process. Coals can be subdivided into organic and inorganic portions. Techniques used to describe the organic portion of coal determine the amount of moisture, volatiles (amount of gases and tars), ash, fixed carbon, and other elements. Inorganic determinations generally involve microscopic petrographic analysis and X-ray diffraction of a low-temperature ash sample of the coal.

Three components that determine coal quality and resultant use are the ash, nitrogen, and sulphur contents. Nitrogen and sulphur can occur in both organic and inorganic constituents of coal. Ash is more directly related (but not equivalent) to the inorganic content within coal. Ash, sulphur, and nitrogen emissions from burning coal are regulated through the Clean Air Act. Therefore, their concentrations in the coal is of great concern to the industrial user. The amounts of these components present in coal have a direct relationship to facility maintenance and atmospheric pollution.

Most of Virginia's coal is among the highest quality produced. It is generally low in sulphur, nitrogen, volatiles, and ash. An average coal analysis of Virginia coal would show less than one percent sulphur, less than ten percent ash, less than thirty-one percent volatiles, and an energy content (heating value) of nearly 13,000 British Thermal Units (BTU) per pound. Individual analyses of Virginia coal beds can be found in Wilkes and others, 1992. As far as energy content is concerned, using an average of 11,000 BTU per pound, a ton of coal contains the same energy as 22,000 cubic feet of natural gas, 158 gallons of distillate fuel oil, or one cord of seasoned hardwood.

TYPES OF COAL

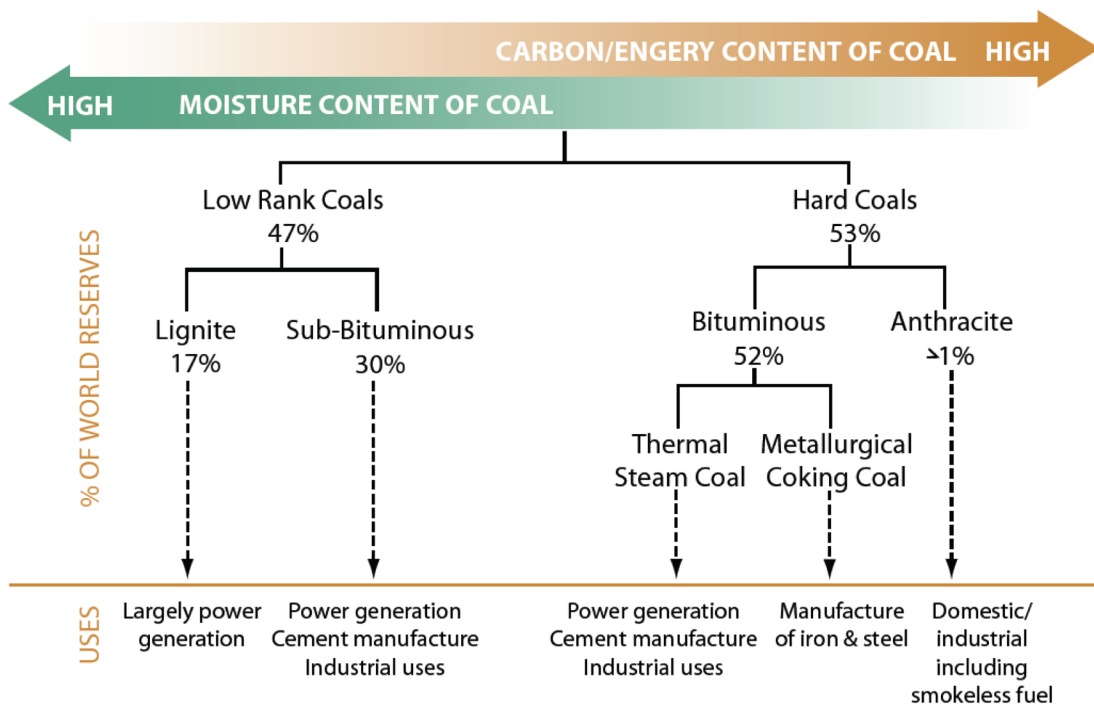


Image modified after World Coal Institute: <http://www.worldcoal.org/pages/content/index.asp?PageID=91>

COAL, AN ECONOMIC RESOURCE

The first documented Virginia coal production was in 1748 from mining in the Richmond basin (Wilkes, 1988). Since then, Virginia's coal production has been as high as 47 million tons a year from more than 400 surface and underground mines within the Southwest Virginia coalfield. Surface-minable coal is limited by the amount of overburden which can be economically removed to uncover the coal bed. Underground mining of coal deeper than 4,000 feet is generally not considered to be economic at the present time. In Virginia, an additional method of coal extraction is augering. Augering uses large (about 3 feet diameter), circular augers which are drilled horizontally into a coal bed. This method of mining generally occurs, after surface mining, to a distance greater than 100 feet into the coal bed.

As America's most abundant energy source, coal is currently used to generate approximately 40 percent of our electricity. Coal-generated power is among the lowest cost sources of electricity in the U.S. today and will likely remain so well into the 21st Century. Another primary use of coal is coke production. Coke is very important as a reducing agent in steel manufacture and is produced by heating coal, in the absence of air to drive off the volatiles. It is interesting to note that naturally occurring coke was mined in the 19th Century in the Triassic Richmond Basin Coalfield. This coke is directly related to igneous intrusions into the rock section that "cooked" some coal beds. New techniques such as gasification and pressurized fluid-bed combustion have been developed for conversion of coal into other fuel forms. These techniques bypass the conventional combustion process and avoid the resultant environmental problems. Such new developments continue to assure this fossil fuel to be a viable future energy source.

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