Iowa Science Teachers Journal

Volume 12 | Number 2 Article 3

1975

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Recommended Citation

(1975) "Coal? What's That?," *Iowa Science Teachers Journal*: Vol. 12: No. 2, Article 3.
Available at: https://scholarworks.uni.edu/istj/vol12/iss2/3

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COAL? WHAT'S THAT?

Reprinted from the August, 1973, issue of Energy Perspectives, a newsletter published by the Batelle Energy Program, an instrumentality of the Batelle Memorial Institute in Columbus, Ohio, with permission of the editor, Richard J. Anderson.

In any analysis of the energy resources now available to the United States of America, coal occupies a dominant if not a preeminent position. The very fact that, within the borders of the U.S., there is more energy in the form of coal (more than three trillion tons) than in all of the other combined resources of fossil fuel—petroleum, natural gas, oil shale, and bituminous sandstone—makes coal loom as our most important source of energy for the remaining years of this century, and perhaps for centuries to come.

But back to the title. For those over 40 years of age, this title may not appear to apply. We certainly know what coal is! But a considerable share of our population cannot look back with fond memories of the coal bin in the basement, shoveling coal into a hungry furnace, "banking the fire," frigid, early-morning trips to shake down the coals, or prying out clinkers, or hauling out ashes. Nor can they look back at the awe and wonder of the sight and sound of two of those coal-fired, steam-driven iron horses "double-heading" a one-hundred-car freight load up a mountain grade.

But enough of nostalgia. What is coal? To begin with, *coal* is a family name and as such is a broad generalization. The term alone simply designates a family of rocks. What modern technology can do with coal depends, to a large extent, on which "rank" of coal we are talking about since all coals are *not* alike.

To understand the differences between various types of coal is to appreciate the history of this unique material. The beginnings of coal were plants—trees, bushes, grasses, and the like, including roots, trunks, bark, leaves, and even pollen and spores. The accumulation of this material in a swamp or a bog, under proper weather conditions, gradually becomes a soggy mass of plant debris which we call peat. The first step in a long chain of events had now taken place—plants become peat.

The great peat swamps of North America 300 million years ago (Pennsylvanian age in geological time) extended over enormous areas along a wide coastal plain. From time to time, changes in sea level took place, and on occasion, the sea invaded the swamps. Salt water killed the plants and the peat accumulations were buried beneath clay and sand. The weight of the overlying sediment compressed the peat, compacted it, and changed its color and appearance. The second step had been taken; peat became *lignite* (the lowermost in rank of the coal family).

Successive invasions of the sea and the piling on of layer upon layer of sedimentary material resulted in the deep burial of the lignite deposits. With the passage of time, new changes occurred. Deep burial often results in a rise in temperature, and some of the original "swamp" gas contained in the peat, and still retained through the change to lignite, was expelled. Much of the trapped moisture was also squeezed out, and the third stage in the metamorphosis of plant debris was completed. The lignite became bituminous coal.

In some geographic areas and under special circumstances, still another step occurred. The layers of coal, together with the underlying and overlying strata, were subjected to awesome compressive forces, as great slabs of the earth's crust moved and pushed against each other. The layers wrinkled into great folds. This wrinkling of the rocks produced high temperatures, and the coal, thus heated and compressed, changed once again; this time the resulting product was anthracite, sometimes called "hard coal."

The material we call coal, therefore, is sometimes a lignite, sometimes a bituminous coal, and sometimes an anthracite or an intermediate stage, for example, part way between lignite and bituminous coal, a material called "sub-bituminous" coal. These classifications of coal by rank are based upon such properties as the percentage of fixed carbon calculated on a dry, mineral-matter-free basis, or upon calorific value on a moist mineral-free basis.

Most lignites are rather young, geologically speaking, while bituminous coal is usually quite older, but age does not necessarily dictate the rank of coal. There are very old lignites in the U.S.S.R., while there are some very young anthracites in western Washington. The principal differences between coals can be traced to different plant assemblages in the original forest, and to the history of the coal layer since it was first formed. The deeper it has been buried, the greater the compression and the more heat it has experienced. Heat and compression combine to drive off the more volatile constitutents and to raise the ratio of carbon content.

The original peat bogs and coastal swamps were occasionally subjected to flooding by streams from the adjacent hills. When this happened, clay and silt were carried by the flood water into the swamp. This clay and silt became mixed with the plant debris and now is responsible for the ash content of the coal. Clay and silt are not consumed in the coal-burning process; thus ash is that part of coal which remains after coal is burned. The muddier the original bog, the higher the ash content of the coal.

The classification of coal by rank and quality helps in the marketplace by letting consumers know generally what they are buying, but it does little to describe the fantastic complexities in the chemical and physical composition of different coals. Proximate analyses only describe how a coal behaves when exposed to carefully specified laboratory procedures, and ultimate analyses tell only what chemical elements are present and in what proportion. Neither indicates *how* the elements are combined nor what compounds are present. And it is because of this chemical complexity that coal is evaluated for combustion or for making coke by so very many physical tests, such as the calorific value or the free swelling index.

The chemical composition of coal varies widely because coal is not a mineral of fixed composition. It is not homogeneous; its chemical composition depends largely on its origin and on changes caused by temperature and pressure as coalification proceeded from the original accumulated plant debris. Coal chemists long ago examined coal petrographically, describing the various fractions in a given coal by such names as "vitrain," a coherent, glossy, vitreous fraction; "clarain," material with a banded surface luster when broken at right angles to the bedding plane; "durain," granular in appearance, with a matte surface; and "fusain," powdery dull sections, resembling charcoal. Such descriptions as this, originating in England a half century ago, are supplemented by many others. For instance, coal "macerals," which are largely homogeneous microscopic constituents, may be called "vitrinite," "fusinite," or "semi-fusinite" if definitely derived from woody tissues, or "exinite," "resinite," or "sclerotinite," if derived from plant material other than woody tissues. Again, these are names for complex chemical mixtures found in coal. They tell us essentially nothing about the true chemical compounds in coal.

Coalification was a gradual process, and what we observe now in the different ranks of coal are various stages in that process. Carbon and hydrogen are the main constituents, with small but important quantities of oxygen, nitrogen, and sulfur. Many investigators have demonstrated the presence of various chemical groupings, such as methoxyl and carboxyl groups, carbonyl groups, hydroxyl and non-reactive oxygen, and others. But the apparently most direct measurement of all, the molecular weight of coal, has eluded all investigators. Molecular weights varying from 400 to 2,500 have been determined, but these are evidently minimum values. Since coal is a polymer, the true size of the coal molecule may be very large indeed.

Little emphasis has been given in recent years to further basic studies of coal. Whereas chemists found this a fascinating field fifty years ago, more emphasis is given today to the engineering problems in utilizing coal. Structurally, the fact that coal consists of a large number of chemical constituents, identical in type, but different in molecular structure, seems less important now than determining how to best utilize the tremendous reserves of energy stored in this huge mineral resource.

The present coal deposits are only remnants of the great peat bogs of yesterday. Like other rocks on the continents, they have been subjected to the wearing away process that is constantly going on. But, what is left is still very large—3,224 billion tons in the United States alone. These remnants or "fields" are identified by their geographic location, such as the Appalachian area, the Central Coal Basins of Illinois, Indiana, Kentucky, and Michigan, the lignite deposits of the Dakotas, or the bituminous coal and lignites of the Rocky Mountain Province. In some cases the coal fields are near centers of population and transportation problems are minimized. As a matter of fact, the availability of coal nearby has been a factor in the growth of local industry, as has been the case with Pittsburgh and Birmingham. In other instances, the coal is remotely situated, far from major cities. Here, little mining has been conducted, and here lie the huge reserves of the future.

Something like 90 percent of the world's reserves of bituminous coal is shared by only three countries: China, the U.S.S.R., and the United States. Three nations—Australia, the U.S.S.R., and the United States—possess 90 percent of the world's reserves of lignite (brown coal). A stroke of geographical and historical good fortune has placed the United States in an enviable position with respect to coal resources. It remains for us to employ these enormous resources of "stored sunlight" to supplement, and ultimately replace, our dwindling reserves of petroleum and natural gas.

This substance, categorized, but not completely defined, was so important to the industrial and economic growth of our country that it earned the title of King Coal. Now, after years of "semi-retirement," it appears that the monarchy will rise again. However, there will be little resemblance to the pollution belching reign of the past. The pipeline gas and liquid hydrocarbons that we convert to btu's in the future will be increasingly coal derived, and much of our electricity will be generated in pollution free coal-fired systems. The new King Coal may well have a new image—the "White Knight," who will provide the energy for a still-growing America.

WEATHER CHANGES AND CROP YIELDS

Some scientists, believing that the earth is getting colder, are now predicting the future of world crop production, based on projected temperature changes. Dr. Iben Browning of the Thomas Bede Foundation in Albuquerque, New Mexico, suggests the climate in North America will change as follows: areas to the south of Mexico City and to the north of Minneapolis will become cooler by 1° or 2° F and suffer drought; areas in between (and that takes in most of the U.S.) will also cool off, but at the same time they will enjoy more effective rainfall. There will be fewer hard, short rains and more long, soft drizzles. Because growing crops make better use of the slow, soaking rains, the "drizzle factor" should override the colder temperatures, and most of the U.S. should have increased crop yields. The Charles F. Kettering Foundation is supporting some work in this area; additional information is available from them at 5335 Far Hills Avenue, Dayton, Ohio 45429.