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A STUDY OF COAL FORMATION

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ABSTRACT

Coal is a solid, brittle, more or less distinctly stratified, combustible, carbonaceous rock. It is being rediscovered as a reliable energy source, which, historically provided the resource base for the industrialization of the United States' economy.

A firm understanding of growth in coal development is important to the national energy scene so that the implications of factors influencing coal growth upon the industry's ability to realize national energy objectives may be determined. As a result, the future of coal development will be facilitated by compiling basic facts on coal reserves, production, and utilization. In view of this, a review and assessment of facts pertaining to the nature and origin of coal is presented. The various properties and uses of coal are then described, followed by a discussion of the process of coal formation.

INTRODUCTION

Coal is America's "most abundant domestic fossil fuel resource and reserve." As the nation seeks solutions to its energy dilemma, coal deposits in the United States are receiving much attention. The magnitude of the coal resources and reserves in the United States is enormous, measured in billions of tons.

Coal is formed by geometrical, mechanical, thermal, and chemical processes. Once coal has been extracted, it can be utilized as a raw solid, processed to improve its quality as a solid fuel, or converted into either gas or oil. Regardless of the technology employed in coal utilization, the fact remains that coal production is the essential first step in deriving energy or chemical products from coal. Any influences upon coal production, therefore, exert considerable effect on the amounts of coal which can be available for subsequent processing or use.

ORIGIN OF COAL

Coal is a solid, brittle, carbonaceous rock. The heterogeneous nature of coal constituents and their variable chemical composition identify coal as a rock rather than a mineral.

The microscopic constituents of coal are known as *macerals* which occur in three groups, recognized according to their properties. These groups are:

(1) vitrinite, representing plant matter remains

(2) exinite, representing waxy-resinous components

(3) inertinite, representing a group of several organic remains

The coal deposits occur as "seams" interbedded with inorganic sedimentary rocks and represent the accumulation of organic materials through normal sedimentary processes. It is interpreted from the presence in coal seams of plants and trees remains that the coal is "formed from plant substances preserved from complete decay in a normal environment and later altered by various chemical and physical agencies.

The starting material for coal formation is commonly considered to be peat. The accumulation of peat is attributed to the normal life cycle of plants existing in extremely swampy areas and the accumulation of the remains of plants completing that cycle. As it appears, the origin of coal in a given locality is influenced by the complex interaction of environmental conditions.

CLASSIFICATION OF COALS

Coal is classified and grouped in various ways. These include rank, type, grade, volatiles, and their caking qualities. Despite the vastness of varieties of coals, there are two basic methods: one set by the American Society for Testing Materials (ASTM), and the other by the International System.

Looking at the ASTM methodology, coals are broken down into Anthracitic, Bituminous, sub-bituminous, and Lignitic. The first classification, Anthracitic, is characterized by being non agglomerate with between semi- to meta-anthracite containing between 86% to 98% dry fixed carbon. Bituminous on the other hand, comprises agglomerate and or non-weathering coals. Bituminous coals are separated into low, medium, and high A - C volatiles.

The percentage of dry fixed carbon ranges from 85% to less than 69% in the case of high volatiles A-C. Sub-bituminous coal comprises both weathering and non-agglomerating coals, possessing certain moisture characteristics. These are characterized as such:

(1) Group A has a moist British thermal unit (Btu) of 11,000 to 12,999

(2) Group B has a moist (Btu) of 9,500 to 10,999

(3)Group C has a moist Btu of between 8,300 and 9,499.

The last two classes of coal are lignite and brown coal. These two differ in the fact that lignite is consolidated with moist Btu less than 8,300 and brown coal is unconsolidated with moist Btu less than 8,300.

PHYSICAL PROPERTIES

Numerous physical properties of coal have been studied by large numbers of investigators. Density, physical constitution, and heating value are among the principle properties important to processing.

Density. The density of coal measures its weight per unit volume. Because coal is a porous substance, it is difficult to determine its volume accurately. Accordingly, most measurements of coal density are apparent rather than true densities. The apparent density curve passes through a minimum at about 85% carbon; thus bituminous coals are the least dense of any of the other members of the coal series.

Physical Constituents. The several ranks of coal are characterized by variation in a number of physical properties: color, luster, constituent changes, porosity, strength, and reflectance. Each of these properties of coal is employed in classifying coals and in guiding the conduct of specific tests to determine its behavior under conditions of utilization.

Heating Value. The heating value of coals is typically expressed in Btu. Heating value increases progressively with rank (expressed as carbon content) from peat through bituminous coals; a slight decrease in heating value occurs with anthracite.

RANKING OF COALS

The rank of a coal is determined by the time in which the coal was exposed to extreme temperatures. As rank increases, certain properties change. Appearance wise, the color darkens and the vitrinic reflectance and opacity increases. In higher ranking bituminous, moisture rank, and solubility decrease. Anthracites are totally opposite, being that their moisture rank and solubility increase. Obviously, the oxygen content decreases while the carbon content increases. Volatile content varying from lignitic to anthracitic decrease also.

Hilt's law suggests that the depth of burial plays an important role in the fixed carbon and volatile content. This law holds true, excluding abnormal mechanical, chemical and thermal conditions. This law supports the generalized idea that horizontal pressure in certain conditions will increase the rank of coal.

PROCESS OF COAL FORMATION

The series of deposits of organic material experience progressive changes in physical and chemical properties subsequent to burial in the sedimentary environment. These changes are known as the process of coalification, defined as a gradual increase in carbon content of fossil organic material in the course of a natural process. Because of known transitions from peat into lignite and from lignite into coal, and because peat beds have never been found to occur beneath lignite deposits nor lignite beneath coal, it is hypothesized that the beginning of coal occurred in the sequence peat to lignite to coal. The transformation of accumulated organic material into coal is a complex chemical and physical process that varies at different times. Two main phases in coal formation are recognized, the biochemical phase or the geochemical phase which are described below.

Biochemical phase. The biochemical phase of coal formation includes the chemical changes in organic material that occur following accumulation and/or burial of organic material in the sedimentary environment. The original organic material loses oxygen and hydrogen, resulting in an increase in carbon content. During degradation of plant material, cellulose and proteins are decomposed much more rapidly than lignin and the action of microorganisms on plant remains is a significant factor in decomposition; particularly important bacteria and other low organisms. T. Koyawa found that the organic matter in sediments in which microorganisms are active generally will decompose according to

Solid state => colloidal state => soluble, gaseous

The degree to which the decomposition process proceeds will be determined by the original starting material and environment conditions, i.e. temperature, time, solutions, and competing reactions.

Three paths of subsequent coal development are believed to be initiated in the biochemical phase:

(1) the formation of fusain - coal material having the appearance and structure of charcoal; progresses very rapidly in biochemical phase

(2) the formation of vitrain - coal material derived from the lignic and cellulosic substances in plant remains; progresses much more slowly in the biochemical phase

(3) the waxy and resinous remains - undergo very small change during the biochemical stage

Geochemical phase. The processes that act upon plant remains following completion of the biochemical stage to continue the alteration and produce different ranks of coal are less understood. Dependent upon the starting organic material and upon the nature of changes experienced during the biochemical stage, the operation of geochemical processes can result in markedly different coals. As indicated earlier, the geochemical stage is characterized as the period when chemical changes are caused mainly by temperature increases, and to a lesser extent, by the time that the higher temperature persists.

Earlier it was postulated that a short period of accumulation for vegetal matter is not consistent with observed phenomena, with a more lengthy period time during which such material was transformed into what we now recognize as coal. However, it was noted that an extremely short time could account for production of high-carbon-content coals under appropriate temperature conditions.

For example, anthracite could be produced in half a million years at temperatures between 120 and 150 C. As a result, it was concluded that "both the temperatures and times necessary to convert peat into high rank coals are much smaller than have generally been in the past." It appears that time alone may be sufficient to produce the changes observed in coals, although moderate heat and pressure may accelerate such changes.

The hypothesized low-temperature, low pressure environment of coalification suggests that the exposure time of biologically altered organic remains to these conditions may determine the ultimate character of resulting coals. "These findings may explain why coals of Tertiary age [30 million years] are still mainly in the brown-coal stage, whereas coals of the Carboniferous [300 million years] have commonly reached the stage of bituminous coals or anthracites, even it the degree of subsidence was the same in each use."

CONCLUSION

While the apparent body of knowledge about coal is great, there is much to learn about why the formation of coal behaves as it does in specific conditions. The future of coal development will be much like its past, and the process of information exchange will be facilitated by compiling basic facts on coal reserves, production, and utilization.

REFERENCES

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CONCLUSIONS

During this first quarter of research, efforts were made to understand the research objectives by surveying the literature. We plan to perform the following tasks during the next quarter

Task 1 - Procurement and processing Test Samples, Proximate and Ultimate analysis

Task 2 - Preparation of the Coal-Water Slurry, Particle Size Distribution and Viscosity Evaluation

Task 3 - Feed Line/Furnace/Burner Characterization.