COAL GEOLOGY

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Summary

Coal is a sediment, organoclastic in nature, composed of lithified plant remains, which has the important distinction of being a combustible material. The composition and characters of coal are determined by the nature of the makeup of the original organic and inorganic accumulation, and by the degree of diagenesis it has undergone.

Coals are the result of the accumulation of vegetable debris in a specialized environment of deposition. Such accumulations have been affected by synsedimentary and postsedimentary factors and these factors also determine the coal rank and various degrees of structural complexity.

Coalification includes the alteration of vegetation to peat formation, the transformation of peat to coal and coal metamorphism. The coalification process is essentially an initial biochemical phase followed by a geochemical or metamorphic phase. Coal geology is a basic as well as applied science. Coal geology not only deals with the formation,

distribution, composition and character of the coals, but also deals with the exploration, extraction and utilization of coal resources. It will play an important role in the sustainable development of coal resources in future.

1. Introduction

Coal, as an abundant fossil fuel resource in the world, has provided an important source of energy to human society for its progress and development since early times. Originally, coal was used as a source of heat and power in home and industry. Many economies depend on coal for a significant portion of their energy needs. Coal usage, as with all fuels in an energy-consuming economy, with result in a consumption of resources and impact on the environment. It is clear that coal will continue to find a place in those economies that use fuels responsibly, economically, efficiently and with consideration for the environment.

Coal is the end product of a sequence of biological, geochemical and geologic processes. According to the recent genetic characteristics, coal can be divided into three types, humic coal, sapropelic coal, and liptobiolith (Table 1).

Humic coal	Brown coal
	Bituminous coal
	Anthracite
Sapropelic coal	Cannel coal
	Boghead coal
	Saprocollite
Liptobiolith	Cutinitic liptobiolith
	Bark liptobiolith
	Resinitic liptobiolith
	Sporinitic liptobiolith

Table1 Genetic types of Coal

Coal geology, as an important field in coal science, deals not only with the formation, distribution, composition and character of the coals, but also with the exploration, extraction, and utilization of coal resources. The evolution of coal formation was affected by paleobotanical, paleogeographic, and paleotectonic factors. Therefore, coals in different basins have different characteristics that are closely related to the different coal-forming periods of geologic history. In addition, coal geologists have paid much attention to the relationship between the utilization of coal and the development of the human society.

2. History of Coal Geology Research

It has been a long time since man used coal. In ancient countries, such as Greece, Rome, and China, coal was used for making handicrafts, ornaments, and writing tools. Afterwards coal was used as medicine, for heating, smelting meals, roasting construction materials, and as a fuel for daily life. In China, coal carving articles have been unearthed from ruins of the Neolithic age (more than 6000 years ago) and graves of the Western Zhou dynasty (before 771 B.C.). Coal mining was begun during the Western Han dynasty (206 B.C.-24 A.C.), and the usage of coal for iron smelting was started during the last stage of this dynasty. In the late 18th century, the industrial revolution brought about drastic increase in coal demand. In most industrial countries, coal has historically been a key source of energy and a major contributor to economic growth. Because coal is a main source of energy in economic growth, coal research had been becoming more and more important.

Initially, coal geology research was mainly focused on the formation and evolution of coal. From the viewpoint of the coal-accumulation patterns, two major models were proposed, the autochthonous coal and the allochthonous coal. The evidences showed that both accumulating patterns exist although the autochthonous coal is dominant. In addition, the third pattern, the hypautochthonous coal, was also defined late on in the coal formation.

In the 19th century and the early 20th century, many coal scientists have studied the genesis and the substantial composition of coal, and have proved that coal was formed from the plant material. In 1910, Jeffrey made thin sections from coals to a very high degree of perfection. A landmark in the early years was White and Thiessen monograph: “The Original of Coal"(1913). Coals can be divided into two types, the humic coal and the sapropelic coal. Stopes (1919) proposed a classification of four lithological types (lithotypes) to describe humic coal, vitrain, clarain, durain, and fusain, and which afterwards became the basis of the international nomenclature. In 1873, Hilt observed the change of volatile matter with depth in the coalfields of South Wales and the Ruhr, and had found that the volatile matter in coal decreases proportionally to the depth of the seam from the surface. Such observation has since become known as Hilt's Law.

With the industrial development and the scientific progress in the 1930s, the coal requirement greatly increased and the study of coal geology was intensively made. Some achievements of coal petrology, coal-bearing formations, coal basins, coal depositional environments, coal metamorphism, distributions of minor elements in coal, and the utilization of coal were made, and this greatly enriched the study content of coal geology.

3. Recent Advancements in Coal Geology

3.1 Peat-Accumulating Environments

Present is the key to the past. Study of present peat swamps can help us to understand the coal-accumulating environments in geologic history, the coal composition, and the genesis of the thick and thin coal seams. Generally speaking, the formation of a coal seam often depends on the crustal movements, which not only influence the thickness of coal seams, but also control the splitting and thinning of coal seams. Since coals formed in different accumulating environments contain different substantial compositions, some researchers introduced the concept of coal facies, which was widely applied to the study of coal-accumulating environments. Teichmüler pointed out that the coal facies are the original genetic types and are dependent on the peat-accumulating environments. In recent years, researchers investigated the peat in the United States, Indonesia, Malaysia, and other places.

Coal depositional models were suggested to be predictive tools for coal exploration. Since 1950's, a variety of coal depositional models have been proposed, which include coal deposition in shoreline (Young, 1955), fluvial-deltaic (Coleman and Smith, 1964; Ferm and Horne, 1979), alluvial fan (Heward, 1978), sandy braided fluvial (Haszeldine and Anderson, 1980), lacustrine (Ayers and Kaiser, 1984), and aeolian settings (Richardson, 1985). In China coal is also preserved in fully marine carbonate successions, which suggested that coal can accumulate in carbonate platform settings (Zhang et al., 1983;Shao et al., 1998). Most of these models, except for coal deposition in carbonate platform settings, emphasize the peat, precursor of coal, forms in low-lying mires which are adjacent to active clastic sedimentation. These conventional models have been challenged by many coal geologists in recent years. McCabe (1984) believes that the peat developed in low-lying mires adjacent to clastic sedimentation can only form low-quality coal or carbonaceous mudstones while the peat developed in the raised or floating mires can form thick high quality coal (Figure 1). It is now widely accepted that peat deposition is not contemporaneous with local clastic deposition, in other words, the regional clastic supply is shut off during mire development (McCabe, 1984, Hamilton and Tadros, 1994). More recently, it has been argued that the preservation of thick coals is dependent on a rising water table, which itself is best achieved by base level rise (McCabe and Parrish, 1992; Flint et al,1995).Although coal accumulations are believed to be able to occur in both transgression and regression settings (Teichmüller,1982), majority of coal deposition is believed to occur during base level rise which are associated with sea level rise, as accommodation for peat accumulation has to be maintained by the rising water table.

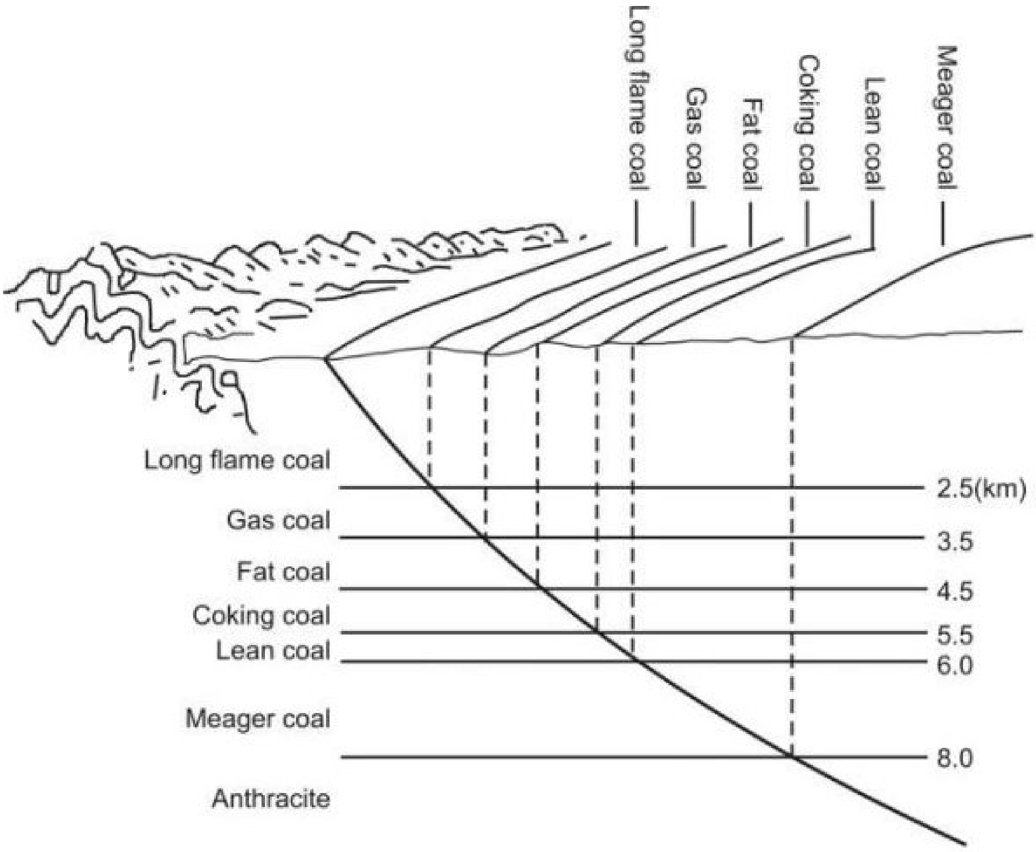

Figure 1 Modern environments of peat formation (from McCabe ,1987) showing the components of a raised mire

The characteristics of coal petrology, especially the contents and distributions of the macerals and microlithotypes in coals, can give detailed information about sedimentary environments of the peat-accumulating, the types of paleobotanies, the paleoclimate, and the conditions of water medium. Rollin and Cohen (1993) found that charcoal-enriched zones from the Snuggedy Swamp in South Carolina. The detailed anthracological analyses of microtome thin sections revealed that three charcoal zones in the peat core were apparently caused by the forest fires. Coal seams formed in the different paleoclimates show remarkably different in anthracological features: seams formed under humid and warm climatic conditions contain lustrous bands which formed from thick trunks, whereas ones formed under mild or slightly cold climatic conditions contain much less bright coal. More recently, researchers have undertaken the studies of the microtextures, the genetic types, the facies features, and minor elements of coals. The scientific utilization of coal will certainly be improved with the further study of coal basins and sedimentary environments and coal quality in the future.

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