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PETROGRAPHIC AND MINERALOGICAL PRECONDITIONS FOR SPONTANEOUS COMBUSTION OF COAL FROM KYUSTENDIL BASIN

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Introduction

The present study is important, because the former "Bistritsa" mine near the town of Kyustendil would be interesting as a site for waste disposal. The underground and surface fires are result from human carelessness or from spontaneous coal combustion. The ecological balance of huge territories can be destroyed. A lot of energy and mineral resources can be lost, the underground and Earth surface damaged, and many biological types and the human health may be in danger. Because the coal is a combustible material, this study concerns the question: are the coal seams suitable for waste depots? Even the "innocent" domestic waste is dangerous for disposal in coal seams, because of the high amounts of gases, separated during their decomposition – mainly methane. The power of such potential bomb will increase from such combustible material and gas collector like coal.

The Kyustendil coal basin is located in Southwest Bulgaria about 100 km from the city of Sofia, in the northern part of Kyustendil Field. The coal mine is closed since 1997 and the mining works are stopped. The coal is lignite and the coal seam is from 3 to 12 m thick. It has different thickness and ash content (Kamenov, 1954). The age of the coal-bearing sediments is determined from P. Bakalov (Nikolov, 1974) as Upper Miocene on the basis of tooth remains from *Dinotherium giganteum (race minor)*.

Material and methods

The objective of the present study is to determine the petrographic and mineralogocal preconditions of the coal for their tendency to spontaneous combustion.

For this purpose 20 coal samples were collected at 20 cm intervals from the former 42nd gallery of the mine. The optical studies were done under a microscope Carl Zeiss Jena with no immersion and with magnifications 64, 160 and 400 times. The macerals from the Liptinite group were studied without fluorescence light and their content is approximate. X-ray diffractometry and differential-thermal analyses were used for identifying the clay and carbonate minerals. Debye-Scherer analysis was used for identifying pyrite and marcasite.

Results and discussion

Maceral content of the coal:

Textinite is observed in all samples. Its content is from 1% to 20% of the total matter. It is frequently filled with clay minerals and resinite.

Ulminite is the most commonly observed maceral - from 50% to 90%. It is presented by the maceral type texto- and eu-ulminite.

Attrinite varies between 1 and 55% in the studied samples.

Densinite also varies between 1 and 55%. It associates with attrinite and eu-ulminite and is represented by destroyed gelified plant relicts.

Gelinite is rarely observed with amount between 0 and 10%.

Corpohuminite is mainly phlobaphinite with percentage from 0 to 10%.

Resinite is between 0 and 10% from the total matter.

Sporinite is established in amount from 1 to 5%. Only well shaped spores are counted as sporinite.

Suberinite varies from 0 to 10% as the typical cell chains are frequently destroyed.

Cutinite is rarely observed (<1%) and its walls are thin, consequently the conditions of the peat bog were appropriate for plant growth.

Alginite forms colonies (0-10%). It was not determined with certainty.

Liprodetrinite (~1%). It is an unidentified maceral from the Liptinite group.

Fusinite is a rarely observed maceral. It associates with clay minerals and attrinite. Its amount varies between 0 to 10% from the total matter.

Sclerotinite (~1%) occurs as single bodies or colonies with 2-3 bodies. It is usually one-chamber sclerotinite.

Inertodetrinite varies between 2 and 3 % as it is situated between the attrinite and densinite.

Mineral content of the coal:

The following minerals were diagnosed:

Pyrite is established as: framboidal pyrite, euhedral pyrite and massive pyrite.

Marcasite is established by X-ray analysis.

Quartz – rarely observed as oval grains with strong relief.

Calcite – mainly epigenetic, but there is syngenetic as well.

Kaolinite and *illite* are determined by X-ray analysis.

Indices of the coal facies:

The random percentages of the macerals from all samples were used, calculated on the basis of total matter. Using the indices of coal facies, the type and origin of the ancient peat bog were determined:

Ground Water Index by Calder et al. (1991):

$$GWI = \frac{\text{gelinite} + \text{corpohuminite} + \text{minerals}}{\text{textinite} + \text{ulmonite} + \text{densinite}} = 0{,}42$$

Tissue Preservation Index by Diessel (1986):

$$TPI = \frac{\text{textinite} + \text{ulminite} + \text{fusinite}}{\text{densinite} + \text{macrinite} + \text{inertodetrinite}} = 2{,}80$$

Gelification Index by Diessel (1986):

$$GI = \frac{\text{huminite} + \text{macrinite}}{\text{fusinite} + \text{inertodetrinite}} = 19{,}53$$

Vegetation Index by Calder et al. (1991):

$$VI = \frac{\text{textinite} + \text{ulminite} + \text{fusinite} + \text{suberinite} + \text{resinite}}{\text{densinite} + \text{inertodetrinite} + \text{alginite} + \text{liptodetrinite} + \text{sporinite} + \text{cutinite}} = 2{,}42$$

According to the calculated indices of the coal facies GWI=0.42 and VI=2.42, the type of the peat bog was determined as "Ombrotrophic swamp" (Calder et al. 1991) or the peat bog was mainly rain fed. According to the TPI=2.80 and GI=19.53, the peat bog originated in an intermediate dry forested swamp, when the ash content was high (the studied coal comprises 32.40% ash content). Mild humification and gelification of the plant tissue (Diessel, 1992).

Distribution of the macerals and minerals in the seam profile:

There is some uniform regularity in the maceral and mineral distribution. In the lower part of the seam, mainly macerals from the Huminite and Liptinite groups occur (Fig. 1). In the middle part of the seam, mainly clay minerals in association with Inertinite group appear. The amount of macerals from the Liptinite group decreases in the middle of the seam and the amount of the Inertinite group increases there. The upper part of the seam is poor in Liptinite macerals. The macerals from the Huminite group are prevailing in the upper part of the seam. Therefore the Eh of the environment of the peat bog was about +400 mV and pH was between 3 and 9.

Tendency to spontaneous combustion of coal, according to petrographic composition:

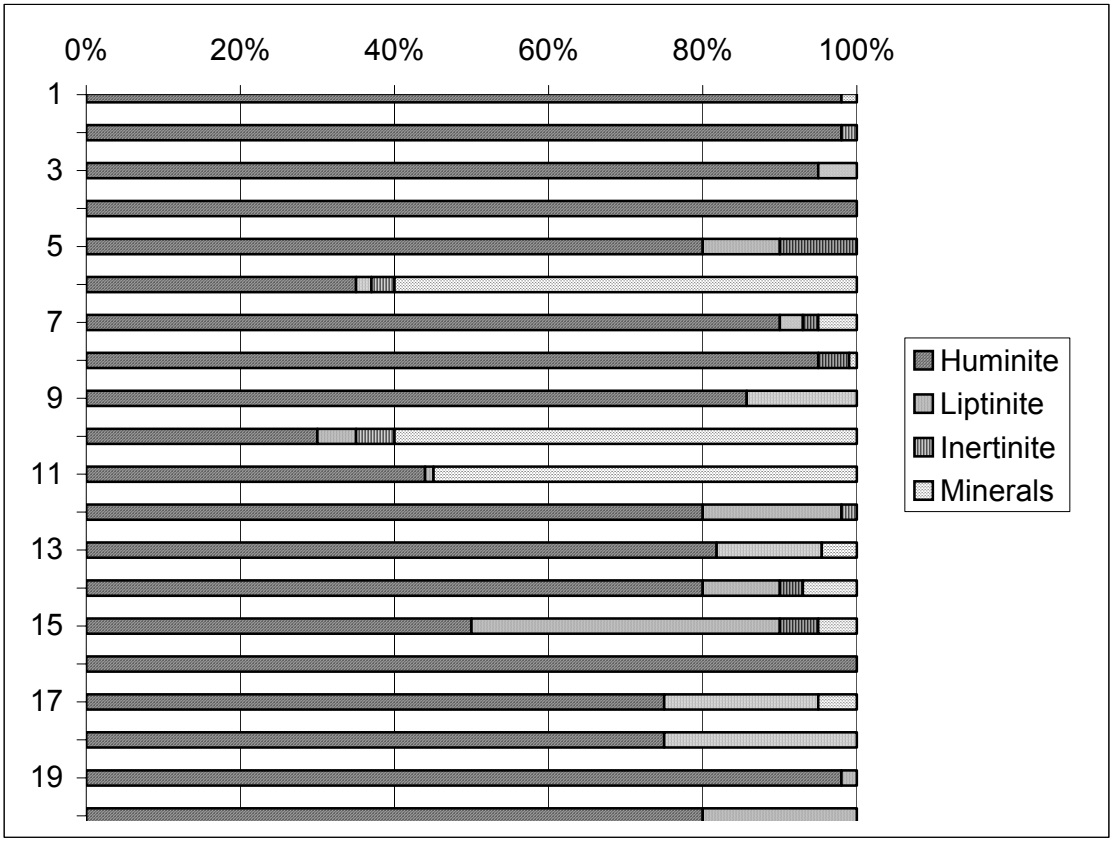

Fig. 1. Distribution of maceral groups and mineral content in the seam profile. Axis X – percentage content of the maceral groups and mineral content. Axis Y – number of samples (20), sampled at 20 cm in the seam profile.

The petrgraphic and mineralcomposition of coal was used to predict their tendency to spontaneous coal combustion. The most important petrographic preconditions for spontaneous combustion after Stach et al. (1978) are:

1. Presence of high amount of macerals from the Inertinite group. These macerals are porous and they are good gas collectors, including oxygen, which oxidizes the coal.

Macerals from the Inertinite group are absent in the studied coal or they are in low amount in the lower part of the coal seam. In the middle part of the seam they are in low amount too, but they are observed in the layers with high ash content (Fig. 1).

2. Presence of fine-grained pyrite with amount from 9 to 16%. The oxidation of pyrite is a heating process, which can provoke spontaneous combustion.

The amount of pyrite in Kyustendil lignite is below 5-7%, which is less than the percentage according to Stach et al. (1978). Only one layer in the middle of the seem contains higher amount of pyrite and marvasite (Fig. 1).

3. Presence of layers with high content of clay minerals in the coal seam. They play the role of heat non-conductor and provoke heat accumulation in the coal layers between them.

Several layers with high content of clay minerals in the studied coal seam have been established. They are almost uniformly distributed within the seam at 40-80 cm (Fig. 1).

The spontaneous combustion of coal from the studied former 42nd mining gallery of Kyustendil basin is not very probable, according to petrographic and mineral composition of the coal, except for the middle part of the seam profile.

Conclusion

According to the calculated indices of coal facies, the type of the peat bog was determined as "Ombrotrophic swamp" or the peat bog was mainly rain fed. The peat bog originated in a medium-dry forested swamp, at high ash content. Mild humification and gelification of the plant tissue.

According to the three petrographic preconditions of Stach et al. (1978), the spontaneous combustion of coal from the 42nd gallery is not very probable. The possibility is higher in the middle part of the seam.

It is important to note that the spontaneous combustion of the Kyustendil coal is not an unknown phenomenon. They can be fired from human carelessness or spontaneous combustion. For this reason, the use of old mining galleries of former coal mines for waste disposal is not appropriate.

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