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DETERMINATION OF THE INDICES OF THE COAL FACIES IN THE SVOGE ANTHRACITE BASIN, BULGARIA

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ABSTRACT

Thirty samples from V and VII coal seam were studied. The maceral, mineral and chemical composition of the coal ash were established. The indices of the coal facies were determined. Groundwater Influence Index (GWI) was 0.02 and Vegetation Index (VI) was 92.46. This had been determined the ancient peat bog as "ombrotrophic bog forest". According Tissue Preservation Index (TPI) (92.46) and Gelification Index (GI) (97.97) the coal seams of the Svoge anthracite basin had been originated in a forested peatland. The SAL factor (68.7) was deternined the bog also as fen with forest vegetation. The environmental acidity was determined on the diagram of the acidity. The pH value was from 3.5 to 6.2 (average 4.8). The Supply Index (SI) was determined. The supply of the peat bog was prevailing clastic according SI=3.7 and peatdeposit was realized in the limnic bog. Only three macerals from the Vitrinite group and two macerals from the Inertinite group were established in the coal. On the basis of the Vitrinite reflectance, the coal was determined as "Anthracite and Meta-Anthracite".
Key words: anthracite, indices, macerals, chemical composition, type of the peat bog, environment conditions, Svoge basin.

INTRODUCTION

The Svoge basin is situated about 30 km North from the city of Sofia. The basement of the coal-bearing sediments is composed of Ordovician, Silurian, Devonian and Lower Carboniferous rocks. Triassic and Quaternary sediments cover the coal-bearing deposits. Six lithostratigraphic formations in the Carboniferous sediments was separated by Тенчов (1962, 1966). The Tsarichinska Formation (Namurian A, B) is composed of conglomerate, sandstone, siltstone, mudstone and thin coal seams (thickness 150-200 m). The Svidnenska Formation (Namurian C) includes alternation of brecia-conglomerate, sandstone, siltstone, mudstone and coal layers, with summary thickness about 260m. The Dramshanska formation (Lower Westphalian A) is composed of sandstone, siltstone and mudtstone (thickness about 200 m). The Svoge formation (Westphalian A) (conglomerate, sandstone, siltstone, mudtstone and coal) is thick 510 m. The Berovdolska formation (Westphalian AB) is composed of sandstone, siltstone, mudtstone, coal shale and coal. Its thickness is 220 m. The Chibaovska formation (unspecified Westphalian) contains conglomerate, sandstone, siltstone, mudtstone and coal seam with summary thickness 250m. Русанов, Попов (1987), Русанов и др. (1997) determine the same boundaries of the Tsarichinska and Chibaovska formations. These authors are defined the Dramshanska formation as a second formation in the low Namurian A sediments. Русанов, Попов (1987) are separated a new formation (Drenovska formation with Namurian C–Westphalian B age), which includes the sediments from the second to the fifth formations determined by Тенчов (1966). Русанов и др. (1997) are separated three members in the Drenovska formation and one more (Radoglavski Member) into the Chibaovska formation. The Svoge basin is located in the Svoge synclinorium with East-West orientation. A number anticlines and synclines with south spreading are established. After Тенчов (1966), Tenchov (1977) and Русанов и др. (1997) are established two systems of faults in the Svoge basin: Northeast-Southwest and Northwest-Southeast. Petrographic investigations of the Svoge anthracite are reported from Константинова (1962), Пешева (1971) and Майхерчик (1975). The main purpose of the study is to be determined on the basis of the petrographic and chemical composition of the coal, the type of the peat bog, the type of supplying and the environment acidity during the peat genesis.

MATERIAL AND METHODS

The present study is based on 20 samples from V and VII coal seam of the Svoger basin. As a first step, the samples were crushed to a maximum grain size of 3 mm. For petrographical investigations, a representative part of the sample was mounted in epoxy resin, ground and polished. At least 400 points were counted on a Leitz microscope using reflected white (λ=546 nm) and fluorescent light to provide data for maceral analyses. The oil immersion objectives 50x/0.85 and 100x/0.25 and the automatic counter "Prior-G" were used also. For each sample the relative amounts of maceral groups and their subgroups were calculated. The vitrinite reflectance were measured in fifty points in each sample. Yttrium-alluminium-granat with reflectance 0.899% was used as standard. The chemical composition of the ash is determined through ICP analysis.

RESULTS AND DISCUSSION

Average Vitrinite reflectance was measured Ro=4.89%, (Rmin= 4.50% and Rmax=5.64%) with standard deviation ±0.2756. According to the Vitrinite reflectance the coal was determined as "Anthracite" and "Meta-Anthracite A".

Petrographic composition

Vitrinite group. The submaceral telinite 1 have amount 10.14% (10.30% from the organic matter). The submaceral telocollinite predominate (81.32% from the organic matter). The third observed maceral is Vitrodetrinite with amount 5.51% (7.68% from the organic matter).

Inertinite group. Fusinite and inertodetrinite were established in some samples with amount below 1%.

The macerals from the *Liptinite group* were not established because of the very high rank of the coal.

Minerals. Euhedral pyrite, framboidal pyrite and massive pyrite (~1%), clay minerals (1.74%) and calcite (0.29%) were observed in the samples.

Indices of coal facies.

On the basis of the macerals content, the indices of the coal facies were calculated. For that purpose the maceral contents on the basis of all matter were used.

Groundwater Influence Index by Calder et al. (1991):
GWI = gelocollinite+corpocollinite+mineral matter / tellinite+telocollinite+desmocollinite = 0.02

Vegetation Index by Calder et al. (1991):
VI = tellinite+telocollinite+fusinite+semipyrofusinite+suberinite+resinite / desmocollinite+inertodetrinite+alginite+liptodetrinite+sporinite+cutinite = 92.46

According to above-mentioned indices the peat bog was determined as "limnic ombrotrophic forest swamp". Calder et al. (1991) determined the conditions in the peat bog, which are characterized with low ground supplying, low values of the pH, higher degree of tissue preservation (tellinite/telocollinite), lower value of the ratio biological matter/time, lower amount of the sulphur.

Tissue Preservation Index by Diessel (1992):
TPI = tellinite+telocollinite+semipyrofusinite+fusinite+rootletvitrinite+phylovitrinite / desmocollinite+macrinite+inertodetrinite = 92.46

Gelification Index by Diessel (1992):
GI = vitrinite+macrinite / semifusinite+fusinite+ inertodetrinite = 97.97

According to the TPI and GI, the peat bog is originated in a "forested peatland". Two types of origin, according to the conditions are possible: 1) in forested peatland (telmatic swamps), when the coal ash is high and/or there are epiclastic bounds. 2) in forested, wet raised bog, when low in ash. The humification is mild and gelification of plant tissues is strong. In present study the peat bog have the second type of origin, because of the low ash and inertinite content. This type of origin corresponds with the determined type (limnic) of the peat bog by Calder et al. (1991).

Silica-aluminum (SAL) factor after Diessel (1992):
SAL=SiO_2x100/SiO_2+Al_2O_3

The SAL factor was calculated with value 68.7, which supposes that the peat bog was "fen" with limited forest plants (Diessel, 1992).

Acidity of the environment (pH).

The environmental acidity in the ancient peat bog is determined through the chemical composition of the coal ash on the diagram of the acidity after Kortenski (1986). It was established that the samples are located in the interval of acidity from 3.5 to 6.2. Most of the samples are located in the interval from 4 to 6. The average value of pH is 4.8. The established pH corresponds very well with the already established TPI as suggests well-preserved plant tissue and the data of Calder et al. (1991) for low values of pH.

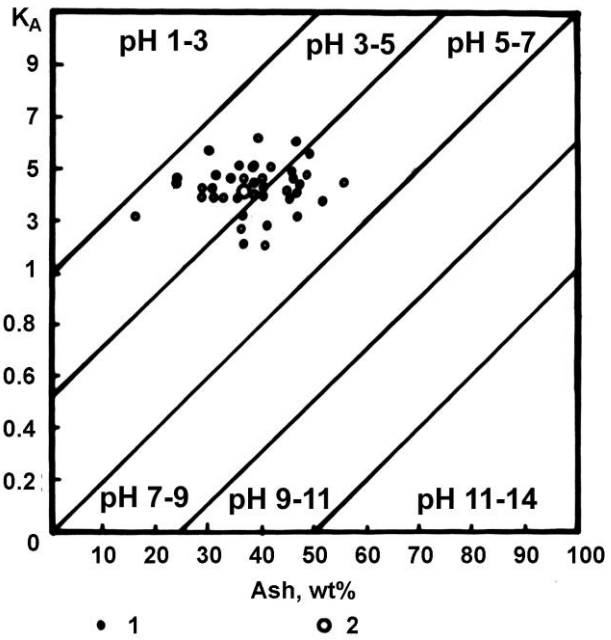

Figure 1. Diagram of environment acidity in the ancient peat bog (after Кортенски, 1985).
KA – coefficient of acidity;
KA = (SiO_2+Al_2O_3+SO_3+P_2O_5)/ (CaO+MgO+Fe_2O_3+K_2O+Na_2O+MnO+TiO_2);
1 – sample from the coal seam; 2 – average sample

Supplying Index (SI)

This index is determined on the basis of the chemical composition of the coal ash:
SI = SiO_2+Al_2O_3+TiO_2 / CaO+MgO+Fe_2O_3+SO_3+MnO+K_2O+Na_2O+P_2O_5=3.7

Six type of supplying may be divided, according to the supplying index:

- **SI below 0.1** shows marine facies. The rocks from the coastal zone are mainly carbonates. The ground water supplying is predominated. The surface water supplying with clastic matter from the carbonate rocks is very slight. SiO_2+Al_2O_3+TiO_2 is up to 10%. The presence of

SiO_2 is a result of the slight surface water supplying, when the epigenetic quartz is not established in the coal.

- **SI from 0.1 to 0.25.** The marine or calcium-rich facies are typical. The groundwater supplying is prevailing with participation of surface water supplying with clastic matter. $SiO_2+Al_2O_3+TiO_2$ is from 10 to 20%. The coastal zone is composed of different rocks. It is possible the marine transgression bring one part of the clastic matter. Possible the surface water supplying is very slight if the epigenetic quartz (a part from SiO_2) present. The presence of epigenetic carbonate and pyrite show, that the clastic matter amount is relatively big, because a part from CaO, MgO, Fe_2O_3 and SO_3 is connected with this mineralization.

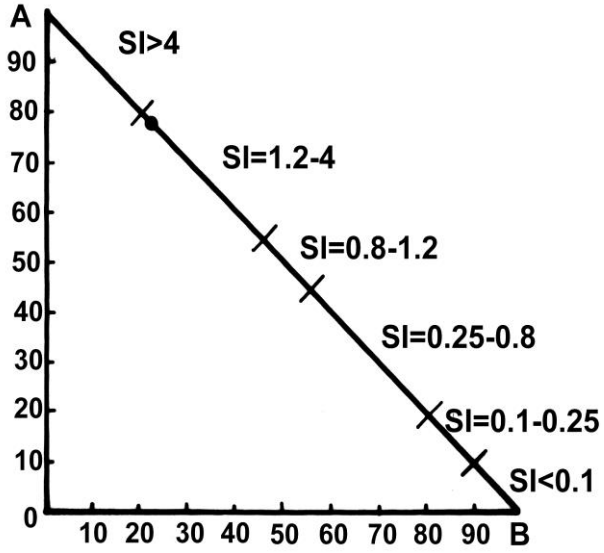

Figure 2. Diagram of the Supplying Index (SI) of the peat bog. The point of the diagram is the SI value in the studied coal.
A=$SiO_2+Al_2O_3+TiO_2$, %;
B=$CaO+MgO+Fe_2O_3+SO_3+K_2O+Na_2O+MnO+P_2O_5$, %.

- **SI from 0.25 to 0.8** is a sigh for mixed supplying, but the groundwater is prevailing. $SiO_2+Al_2O_3+TiO_2$ is from 20 to 45% and it is a result of clastic supplying through surface water. The coastal zone is composed of different types of rocks. Very high ground water supplying (low ash content) or marine transgression (high ash content) is possible when the carbonate rocks absence. The surface supplying is low when the high SiO_2 content as a result from epigenetic quartz mineralization. If the presence of carbonate or/and sulphide epigenetic mineralization in the coal is a reason of the high CaO, MgO, Fe_2O_3, SO_3 and MnO content, ground water supplying is not very high. The peat bog is telmatic, limnic-telmatic, or with Ca-reach facies.
- **SI from 0.8 to 1.2.** The surface supplying is equal to the groundwater supplying. The coastal zone is composed of different type rocks. Very high ground water supplying (low ash content) or marine transgression (high ash content) is possible when the carbonate rocks absence. The presence in the coal of epigenetic quartz mineralization indicate higher fround water supplying and the presence in the coal of epigetic carbonates and/or sulphides indicate higher surface water supplying. The peat bog is limnic-telmatic or limnic or with Ca-reach facies.
- **SI from 1.2 to 4.** The surface water supplying is prevailing and the groundwater supplying is low and insignificant. CaO+MgO+Fe2O3+SO3+MnO+K2O+Na2O+P2O5 is from 20 to 45% and it is a result mainly of groundwater supplying and one part of the elements is transported with the clastic material. Probably some rocks from the coastal zone are carbonates. It is possible marine transgression if the carbonate rocks absence. The presence of the epigenetic quartz mineralization show than the ground water supplying is not so low. The increasing of the CaO, MgO, Fe_2O_3 and SO_3 content is a result of the presence of epigenetic carbotes and/or sulphides and testify to the ground water supplying is lower. The peat bog is limnic, possible telmatic-limnic.
- **SI more than 4.** The supplying is mainly surface water, which transport clastic material. In the coastal zone CaO+MgO+Fe2O3+SO3+MnO+K2O+Na2O+P2O5 is up to 20%, but it is a result of participation of these element in the igneous rocks from the coastal zone of the peat bog. The very low ground water supplying (low ash coal) is possible if the carbonate rocks (limestone, dolomite, marble etc.) in the coastal zone absence or the epigenetic quartz present in the coal. The peat bog is limnic.

The calculated index of supplying with value 3.7 determine prevailing supplying of the peat bog with clastic material as the carbonate rocks from the coastal zone are almost absent. The peat bog is limnic. That conclusion correlates with the determined above acidity of the environment. The value of the pH from 4.8 supposes limited groundwater supplying and relatively well preserved plant tissues. Everything corresponds well with the results for GWI and GI after Calder et al. (1991). The received values for the SI corresponds well with the data of Diessel (1991) for low gelification.

CONCLUSION

As a result of the present investigations was established that the prevailing maceral is telocollinite, followed by telnet and vitrodetrinite. The coal ash is reach of SiO_2 and Al_2O_3. The acidity of the environment is from 3.5 to 6.2 (average 4.8), SAL factor = 68.7, GWI = 0.02, VI = 12.06, TPI = 92.46 and GI = 97.97. The chemical data was used for the calculations of the supplying index (SI), which determines the type of supplying and the facies. The value of the SI=3.7.

Summary data of indices, petrography and chemical composition of the coal determine type of the peat bog, where the plant tissues created the coal seams number V and VII of the Svoge basin, as limnic with prevailing forest plants and prevailing ombrotrophic character. The environment at the time of pet-genesis is characterize by wetness of the peat bog (probably low values of the Eh), pH of the environment from 3.5 to 6.2, relatively low humification, high penetrating of the clastic material, limited groundwater supplying with limited presentation of carbonate rocks in the ancient coastal zone. The plant tissues are well preserved, but the Vitrinite macerals are prevailing and the Inertinite macerals are insignificant.

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