Coalification degree of organic matter in Oligocene sediments from the footwall of the North Rhodopian Thrust

Степен на въглефикация на органичното вещество в олигоценски седименти от лежащото крило на Севернородопския навлак

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Introduction

As a coherent part of the Rhodope Metamorphic Complex (RMC), Rila Mountain shows common tectono-metamorphic evolution with the other parts of the complex. Despite different interpretations on the pre-Late Eocene evolution of RMC, most of the scientists share common opinion that since Late Eocene the Rhodope area underwent a regional scale extension that caused exhumation of high-grade metamorpfic rocks in the foodwalls of low-angle detachment faults. The brittle tectonics in the hanging walls of the latter and horizontal rotation of large rigid blocks caused formation of half-grabens where continental sedimentation started about the same time. Some authors interpret the Paleogene extension in RMC as linked to the opening of the Aegeans, what brings the onset of Aegean extension back in the Eocene (Burchfiel et al., 2003). However, it is well known fact (Ivanov, 1988) that in the northern slopes of Rila and Rhodope mountains high-grade metamorphic rocks and granitoids of Sredna Gora basement were thrusted southward onto continental Oligocene sediments along North Rhodopian Thrust (NRT). Consequently in the Neogene and Quaternary, the area was again affected by extensional tectonics, normal faulting and related formation of a number of basins. Concerning the significance of the NRT, this structure was either interpreted as a structurally shallow failure (Ivanov, 1988) or as a system of dextral strike-slip and reverse-slip faults that were related to the activity of Maritsa Shear Zone (Naydenov et al., 2008). However, there are no data on the horizontal offset along NRT and the rate of related tectonic burial related.

The aims of this study are to describe organic and inorganic matter of coal fragments found in Oligocene sediments from the footwall of NRT, and to elucidate the thermal conditions of their generation. The establishing of some main classification parameters concerning reflectance of vitrinite and other petrographic characteristics of coal-bearing strata will give us evidences for better understanding of paleoenvironmental conditions during Oligocene sediments deposition and general tectonic development of this region. Further in the discussion and conclusions part we are trying to set this data in a structural frame and to show how the evolution of the organic matter in the Oligocene sediments is related to the tectonics along the northern slopes of Rila Mountain.

Geological settings

The crystalline basement of north Rila Mountain consists of amphibolite facies metamorphic rocks intruded by the granitoids of the Rila-Rhodopian Batholith (RRB). In the area south of Kostenetc village these rocks are covered by the Oligocene sediments of Kostenets Basin (Naydenov et al., 2008). To the north Kostenetc Basin is bounded by NRT. NRT represents a moderately to gently dipping (15–30°) to north fault along which high-grade metamorphic rocks from the basement units north of Rila Mountain were emplaced towards south onto the Oligocene sediments of Kostenetc Basin (Ivanov, 1988). The studied organic matter was found as small layers and lenses dispersed within the sandstones for some tens of meters above the lower contact of the Oligocene sediments with the underlying granites of RRB. The size of the coal fragments vary from 3–5 to 15–20 cm for layers and about 5–6 cm for lenses.

Sampling and methods

The study was performed on two coal samples taken from Oligocene sediments from the footwall of the NRT. The petrographic studies cover proximate anal-

Table 1. Main characteristics and petrographic composition of the coal fragments dispersed among the Oligocene sediments from the North Rhodopian Thrust

Samples	Type of samples	Proximate analysis wt%			Sulfur forms wt%				Maceral composition vol%			Reflectance Rr, %	Rock Eval T max (°C)
		W^a	A^d	V^{daf}	total	pyrite	sulfate	organic	V	L	I		
1	coal	4.97	6.93	40.84	1.1	0.4	0.2	0.5	89	3	8	0.96	463
2	coal rich in vitrain	10.68	4.20	35.79	0.8	0.6	0.2	–	95	1	4	0.99	481

W^a, moisture; A^d, ash content; V^{daf}, volatile matter; V, vitrinite; L, liptinite; I, inertinite

yses including moisture, ash content, volatile matter and sulfur forms determination, maceral analysis and measurement of vitrinite reflectance. Additionally, Rock Eval analysis of both samples was also performed in order to assess the temperature of the environment during coalification. Mineralogical study of inorganic coal matter was performed by using XRD and SEM-EDS analyses. The reflectance measurements of vitrinite and Rock Eval analyses were made in the Leoben University by using microscope Leica DM 2500 RX and Rock Eval 6 analyzer.

Results and discussions

The data concerning the main characteristics, chemical parameters and petrographic composition of the coal fragments are given in Table 1. The samples are described as low ash and low to very low sulfur content. The reflectance was determined on the collotelinite maceral from telovitrinite subgroup by measuring in 50 points. Therefore, the coal fragments from Oligocene sediments can be classified as medium rank – bituminous coal and especially meso-bituminous coal with Rr between 0.6 to 1.0% (Alpern, Lemos de Sousa, 2002). Rock Eval analyses show very similar Tmax data for both studied samples (463 °C for sample 1 and 481 °C for sample 2). Taking into consideration the data from vitrinite reflectance measurement and Rock Eval analyses it can be concluded that the temperature during geochemical coalification of the organic matter is in the range between 80–90 °C.

The micropetrographic composition of the organic matter is represented by macerals from all maceral groups, but those of vitrinite group are totally dominating followed by inertinite and liptinite macerals. The structural maceral collotelinite from the telovitrinite subgroup, collodetrinite from the detrovitrinite subgroup and gelinite from gelovitrinite subgroup compose 92 vol% of the studied organic matter. The amount of the inertinite macerals varies from 4% to 8 vol% and includes especially fusinite and inertodetrinite. The macerals from liptinite group are rather rare and present in low concentrations (1–3 vol%). The mineral matter of coals is compose mainly of quartz, illite and montmorillonite, but feldshpar, pyrite and other rare minerals like Fe-oxides, chalcophanite, cristobalite and calomel were also detected.

Conclusions

The studied coals can be determined as medium rank – bituminous coal, with mean reflectance Rr > 0.4, with low yield of ash and with high content of vitrinite. Considering that the average values of the geothermal gradient are ~25 °C per km of depth, the temperatures between 80 and 90 °C should correspond to a depth of 3.2–3.6 km. Since in the study area the thicknesses of the Oligocene sedimentary successions do not exceed the 1000 m, such a maturity of the organic detritus can be explained with the tectonic burial caused by the North Rhodopian Thrust. If we assume the angle of the thrust contact between 10 and 20°, then the total offset must have been between 10 and 20 km.

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