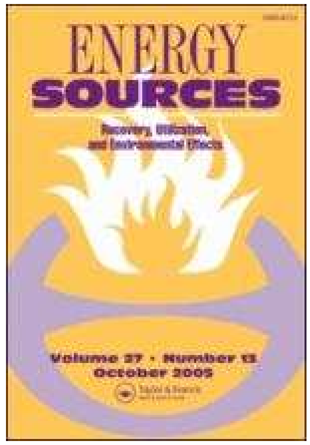

Organic maturity and hydrocarbon potential of Liassic coals from the eastern Pontides, NE-Turkey

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Organic maturity and hydrocarbon potential of Liassic coals from the eastern Pontides, NE-Turkey

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Abstract

Organic matter content, type of organic material and thermal maturity of Lias-aged coals of the Gumushane and Bayburt areas were investigated.

The total organic carbon (TOC) contents of coals in the Gumushane area range from 0.39-35.46 % wt, and in the Bayburt area range from 0.02-50.64 % wt. The Gumushane (except Güvercinlik field) and Bayburt areas coals have low Hydrogen Index (HI) values. The coal samples contain a mixture of Type II and Type III kerogens. Based on average T_{max} values Liassic coals in the Gumushane and Bayburt (except Cerci field) areas are mature, and potential yield (PY) are low.

Key words: Northeastern Turkey, Liassic coal, pyrolysis, TOC, kerogen type, maturity

1. Introduction

Although Upper Paleozoic and Cenozoic coals are very common, Mesozoic and particularly Jurassic coals are rare (Tatsch 1980). In Turkey, Jurassic coals are limited, and some of them were found in the eastern Pontides and in the eastern Taurus (Korkmaz & Kara Gülbay 2007). Jurassic coals in the eastern Pontides were first recognized and studied by Wedding (1963). Organic geochemical characteristics of Jurassic coals in the Norşun (Şiran-Gumushane), Gödül and Alansa (Kelkit-Gumushane) fields were studied by Mann et al. (1998). In addition, Hos Çebi et al. (2009) studied trace element geochemistry of the coals from same fields.

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Studies of Jurassic (Liassic) coals exposed in the eastern Pontides are very limited. The aim of this study is to investigate the organic geochemical characteristics of the Liassic coals in the Edire, Yukarı Edire, Güvercinlik (Gumushane), Balkaynak and Cerci (Bayburt) fields (Figure 1).

2. Geological background

The Eastern Pontides belt in the Black Sea region of Turkey is the part of the Alpine metallogenic belt that has been subdivided into Northern, Southern, and Axial zones; distinguished from North to South by different lithological units, facies changes, and tectonic characteristics (Bektaş et al. 1995; Eyuboglu et al. 2006; Eyuboglu et al. 2011). The Northern zone includes Mesozoic-Cenozoic volcanic sequences, associated with massive sulfide deposits, calderas, and granitic intrusions. The Southern zone is composed of Mesozoic and Eocene sedimentary rocks, pre-Liassic ultramafic-mafic cumulates, and metamorphic-granitic rocks. Upper mantle peridotites and middle to upper Cretaceous olistostromal melange occupy much of the Axial zone (Eyuboglu et al. 2010a).

The basement rocks of the eastern Pontides consist of metamorphic rock and granitoids. Liassic volcanics, volcaniclastic, and clastic deposits lie unconformably on the basement rocks. The basal part of Liassic sequence is composed of intercalations of coal, coaly shale, shale, claystone, and sandstone. These are in turn conformably overlain by widely exposed volcani-clastic and volcanic rocks, covered in the upper-most part of the sequence by shale, coal, coaly shale, claystone, and sandstone (Korkmaz at al. 1995; Hos Çebi et al. 2009). This unit is overlain by pelagic and neritic carbonates of the Malm–Lower Cretaceous age. The Upper Cretaceous, largely represented by volcanics in the north, has developed into turbiditic facies in the south. Miocene and Pliocene deposits occur in restricted areas and are characterized by clastic material (Saydam & Korkmaz 2008; Figure 1).

During the Lias, the eastern Pontides were rifted in the NW, E-W, and NE direction. Subsidance of the Liassic basins occurred in three stages in the Gumushane area : (1) First tectonic subsidence gave rise to tilting of the block and formation of the asymmetric basins (Eyuboglu et al. 2006). As the basal coal-bearing sandstones accumulated in the southern depositional environment of short-lived swamp area (Ravnas & Steel 1998). Volcano-sedimentary rocks are deposited in the northern narrow deep troughs on the northward-tilted block in the Gumushane area. (2) The subsequent phase is gradual thermal subsidance, during which the depositional basins expanded to bury the earlier border faults (Eyuboglu et al. 2006). (3) Failed Liassic rifting ended during the late Jurassic, rift-related sediments were overlain by the upper Jurassic-lower Cretaceous neritic carbonates during long-lived thermal subsidance (Eyuboglu et al. 2006).

3. Samples and Methods

Systematic coal samples were collected from the Edire, Yukarı Edire, Güvercinlik (Gumushane), Balkaynak and Cerci (Bayburt) fields. Total organic carbon and pyrolysis analyses were conducted on 15 coal samples from the Gumushane and Bayburt areas (Figure 2) at TPAO (Turkish Petroleum Corp.) Organic Geochemistry Laboratories. Pyrolysis and TOC analysis were performed using the Rock Eval-6 (RE6) device, with the calibration standard set to IFB 160.000.

4. Results and Discussion

4.1. TOC/Rock-Eval Pyrolysis

Total Organic Carbon (TOC) analysis was made to determine the amount of organic matter. Average TOC values of coal samples from the Edire (Gumushane) are 15.11 %, Yukarı Edire (Gumushane) are 0.4 %, Güvercinlik (Gumushane) are 2.68 %, Balkaynak (Bayburt) are 22.87 % and Cerci (Bayburt) are 0.03 % (Table 1). These values indicate that coal samples from Balkaynak field has the highest average TOC values and Cerci field has the lowest average TOC values. TOC values of the Edire and Balkaynak coal fields change in a wide range, whereas those of Yukarı Edire, Güvercinlik and Cerci coals vary in a narrow range.

In the pyrolysis analyses, free hydrocarbons (S_1) in the rock and the amount of hydrocarbon (S_2) expelled from pyrolysis of kerogen are measured. In addition, T_{max} value which represents the temperature at the point where S_2 peak is the maximum is also determined (Espitalie et al. 1977; Korkmaz & Kara Gülbay 2007).

Average Potential Yield (PY) values of coal samples from the Edire, Yukarı Edire, Güvercinlik, Balkaynak and Cerci fields are 10.6, 0.13, 7.9, 14.3 and 0.14, respectively. S_2 values for the Edire (except DK-4 and DK-5), Balkaynak (except BK-3) and Güvercinlik coal samples are higher than others. Coal samples from the Güvercinlik field has the highest HI values (average 272 mgHC/gTOC), and Yukarı Edire field has the lowest HI values (average 9 mgHC/gTOC). Average T_{max} values of coal samples from Edire, Yukarı Edire, Güvercinlik, Balkaynak and Cerci fields are 459, 459, 446, 435 and 318 ^{o}C, respectively.

4.2. Type of organic matter

Coal samples collected from Edire, Yukarı Edire, Güvercinlik, Balkaynak and Cerci fields were plotted in the S_2-TOC diagram (Langford & Blanc-Valleron 1990). All coal samples from the Cerci and Yukarı Edire fields are in the Type III and one sample from the Edire field, two samples each from the Güvercinlik and Balkaynak fields are in the Type II area while another sample from the same field plots in the Type III area (Figure 3).

HI-Tmax diagrams (Mukhopadyay et al. 1995) are used for determination the kerogen type (Figure 4) in the HI-T_{max} diagram, and it was determined that samples generally plot in Type II and Type III kerogen areas (Figure 4). One sample from the Edire, two of samples each from the Güvercinlik and Balkaynak fields plot in the Type II kerogen area, and other samples from the study area plot in the Type III area. HI-T_{max} diagram also provides information on maturity of samples. As indicated from Figure 4 Cerci coal samples are immature, while most of the other coal samples are mature and one sample each from the Edire and Yukarı Edire fields is extramature.

4.3. Maturity of organic matter

Thermal evolution and maturity of the organic matter can be used for determination of maturity of the organic matter (Tissot & Welte 1984; Hunt 1995).

The average value of T_{max} indicates that samples from the Cerci field are immature. The average values of T_{max} from Edire, Yukarı Edire, Güvercinlik and Balkaynak fields are mature (Tissot & Welte 1984; Merril 1991).

4.4. Potential of hydrocarbon generation

Humic coals that contain Type III kerogen can generate gas. However, sapropelic coals with hydrogen HI of greater than 300 mgHC/gTOC that contain much more Type II organic matter can generate oil if they are subjected to sufficient burial and heating (Bordenave et al. 1993; Korkmaz a& Kara Gülbay 2007).

Potential yield (PY) values of the investigated coal samples from both the Gumushane and Bayburt areas are low (Table 1). Only coal samples of the Güvercinlik field have high HI values (265-279), while the others have less than 200 mgHC/gTOC. Moreover, one coal sample from Edire field, two coal samples from Güvercinlik and Balkaynak fields contained Type II kerogen; and the other coal samples contanined Type III kerogen. Based on these data, Liassic coals of the Edire, Yuka Edire, Güvercinlik (Gumushane) and, Balkaynak and Cerci (Bayburt) fields did not have the potential to generate hydrocarbon.

5. Conclusions

Average TOC contents of the Liassic coals in the Edire, Yukarı Edire, Güvercinlik (Gumushane), Balkaynak and Cerci (Bayburt) fields are 15.11 %, 0.4 %, 2.68 %, 22.87 % and 0.03 % wt, respectively. It was determined that the Liassic coals in the Gumushane and Bayburt areas contain dominantly Type III and lesser amount of Type II kerogen. Overall evaluation of the maturity data implies that the Edire, Yukarı Edire, Güvercinlik and Balkaynak coals are mature and the Cerci coals are immature. PY values of the investigated coal samples from both Gumushane and Bayburt areas are low.

On the basis of all available data, coals exposed in the Edire, Yukarı Edire, Güvercinlik (Gumushane), Balkaynak and Cerci (Bayburt) fields exhibit that they do not have hydrocarbon generation potential.

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TABLE CAPTIONS

Table 1. Results of Rock-Eval/TOC analysis and calculated parameters

FIGURES CAPTIONS

Figure 1. Simplified geological map of the eastern Pontides (after Güven et al. 1993) and location map of the study area. 1- Paleozoic metamorphic basement, 2- Paleozoic granites, 3- Jurassic–Lower Cretaceous volcano-sedimentary sequences and platform carbonates, 4- Upper Cretaceous volcanics 5- Upper Cretaceous sedimentary rocks, 6- Paleocene volcano-sedimentary sequences, 7- Paleocene granites, 8- Eocene volcanic, volcanoclastic rocks, 9- Eocene sedimentary rocks, 10- thrust fault, 11- study area (**1** Edire, **2** Yukarı Edire, **3** Güvercinlik, **4** Balkaynak, **5** Cerci fields).

Figure 2. Stratigraphy of the Liassic coals and position of Liassic coals in the Edire, Yukari Edire, Güvercinlik, Balkaynak and Cerci fields.

Figure 3. Distribution of the coal samples into S_2 vs total organic carbon (TOC) plot

Figure 4. Distribution of the coal samples into HI vs. T_{max} plot.

Table 1.

Sample No	TOC %Wt	S_1 mg HC/g rock	S_2 mg HC/g rock	S_3 mg CO_2/g rock	PY (S_1+S_2) mg CO_2/g rock	T_{max} ^{o}C	HI (S_2/TOC) mgHC/g TOC	OI (S_3/TOC) mgCO_2/g TOC	PI (S_1/S_1+S_2)	Residual carbon
Edire (Gumushane)										
ED-1	22.05	1.52	33.82	0.23	35.34	454	153	1	0.04	19.01
ED-2	5.86	0.21	1.15	2.16	1.36	447	20	37	0.15	5.59
ED-3	35.46	1.55	12.88	12.32	14.43	443	36	35	0.11	33.33
ED-4	5.39	0.24	0.83	2.78	1.07	448	15	52	0.23	5.13
ED-5	6.78	0.11	0.85	5.38	0.96	505	13	79	0.11	6.47
Yukarı Edire (Gumushane)										
YED-1	0.39	0.09	0.05	0.07	0.14	444	13	18	0.65	0.37
YED-2	0.41	0.1	0.02	0.12	0.12	474	5	29	0.82	0.4
Güvercinlik (Gumushane)										
G-1	2.34	0.55	6.19	0.71	6.74	446	265	30	0.08	1.73
G-2	2.94	0.57	7.98	1.17	8.55	445	271	40	0.07	2.17
G-3	2.75	0.74	7.66	0.71	8.4	446	279	26	0.09	1.99
Balkaynak (Bayburt)										
BK-1	13.91	0.2	8.61	9.77	8.81	433	62	70	0.02	12.63
BK-2	50.64	0.4	33.04	24.72	3.44	434	65	49	0.01	46.39
BK-3	4.05	0.1	0.62	3.48	0.72	439	15	86	0.14	3.85
Cerci (Bayburt)										
CE-1	0.03	0.09	0.05	0.12	0.14	316	167	400	0.67	0.01
CE-2	0.02	0.11	0.03	0.05	0.14	319	150	250	0.8	0

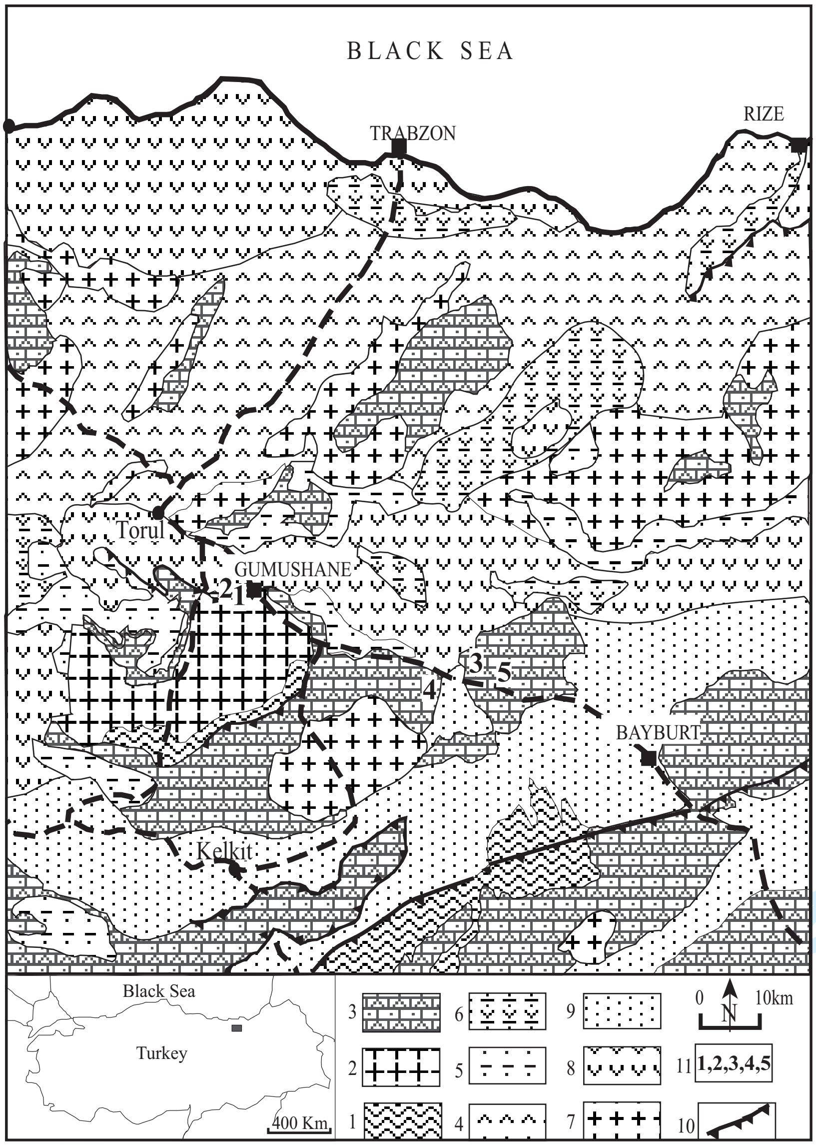
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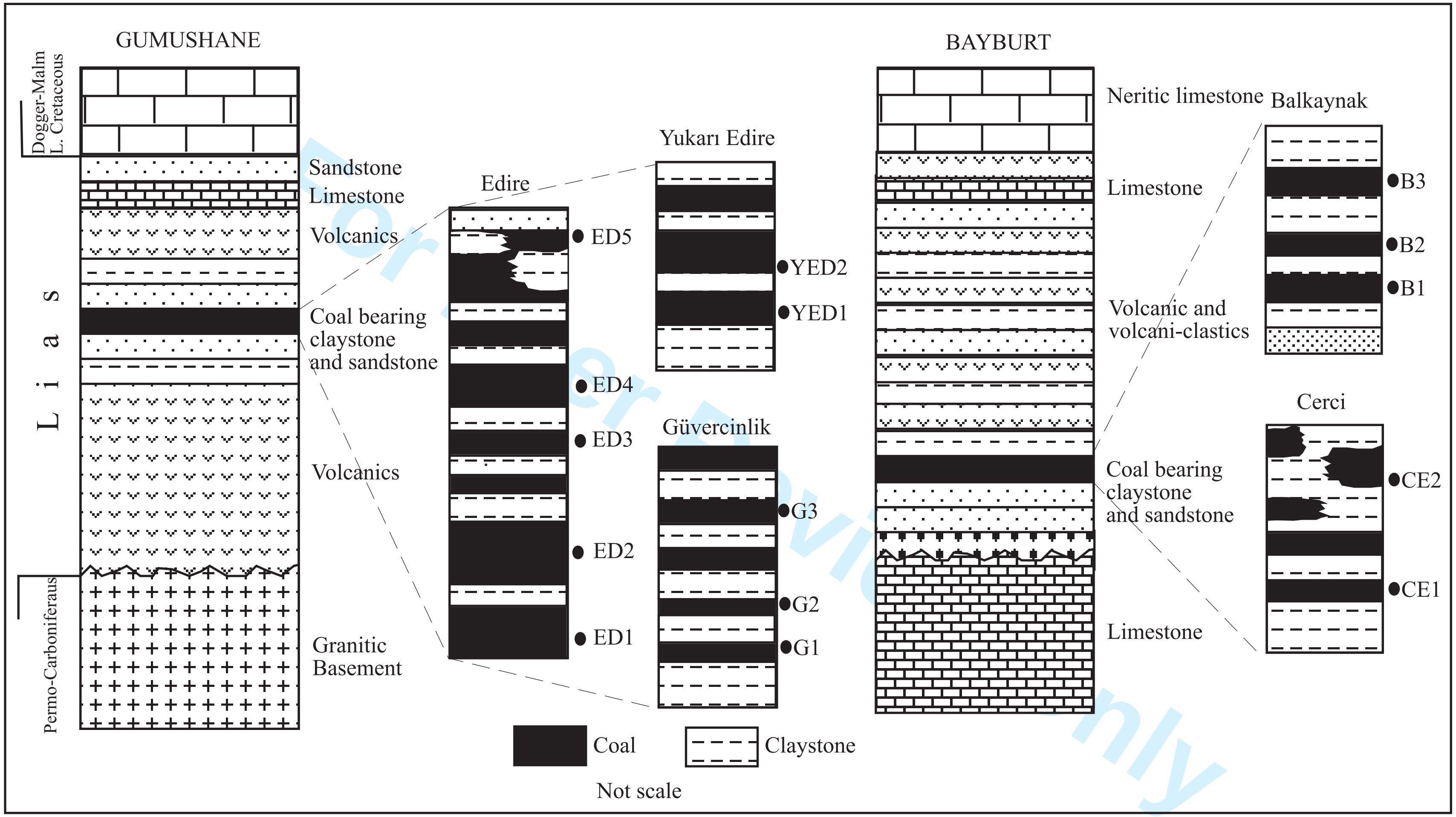
Figure 1.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ED3
ED2
ED1
Yukarı Edire
YED2
YED1
Güvercinlik
G3
G2
G1
BAYBURT
Neritic limestone
Limestone
Volcanic and
volcani-clastics
Coal bearing
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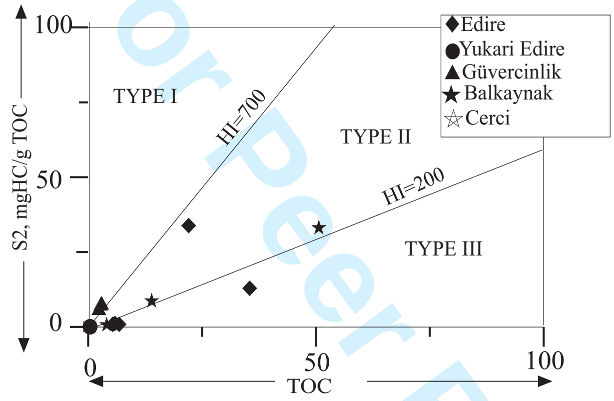
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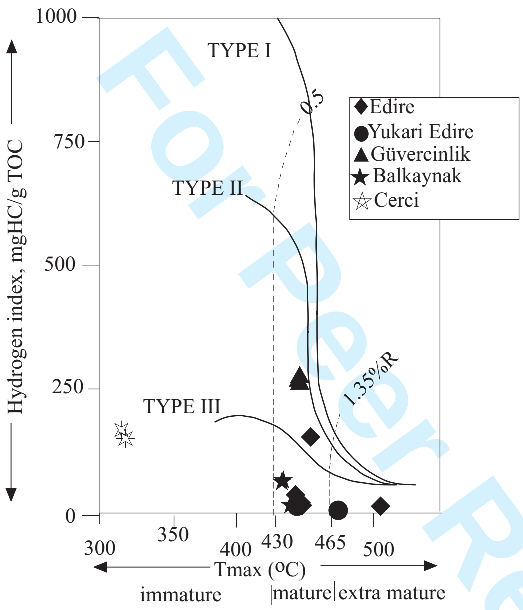
Figure 3.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Cerci
300
350
400
430
465
500
Tmax (oC)
immature
mature
extra mature

Figure 4.