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Petrographical properties and unusual features of Kangal coals, Sivas–Turkey

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ABSTRACT

In Turkey, low-rank coal is used in three sectors: power generation industry, and household and commercial heating. Due to poor quality, coal is suitable for thermal power generation only. Kangal coal is of low-rank being mostly used in a thermal power station.

Kangal coal basin, located in Eastern-central Turkey, formed in a Pliocene aged fresh-water lacustrine depositional environment and includes Kalburcayiri, Hamal and Etyemez Fields. Approximately 202.6 Mt of coal reserve, with calorific values between 1010 and 3420 kcal/kg are hosted in the area. Kalburcayiri Field is the only open pit production site in the basin.

Fifty two channel samples were collected from different sites. The composite profile samples of the seams were taken into considerations. The content and depositional properties as well as some chemical and physical properties of the main coal seams are compared. Detailed organic petrographic and chemical analyses were applied for this study. All coal samples tend to have similar coal petrographic properties and were deposited in a lacustrine basin. Later, they were affected by faulting. As a result, there are variations in the properties and rank of the coal samples.

The most abundant maceral group is huminite and the most abundant maceral is gelinite. Liptinite and inertinite contents of the coal are low and the maceral assemblage of the coals show extremely unusual. Broken and deformed maceral contents tend to be more abundant, considering the other Turkish coals. The maceral contents, textures and the unusual appearances imply that the coals were formed as in a hypautochtonous way. The reflectance measurements indicate the rank of the coals to be mostly as sub bituminous, although some chemical analyses exhibit inefficient results.

1. Introduction

With more than 14 Gt of coal reserves and over 100 Mt of annual coal consumption, Turkey has to use its indigenous energy resources, since the country's energy raw materials are limited. Kangal coal basin is an important region located in the Eastern-central Anatolia, the Asian part of Turkey (Fig. 1). The coal produced is consumed for power generation in a powder coal combustion plant. The generated electricity is interconnected to the nation's electricity utilization net, directly.

Kangal Basin formed in a Pliocene aged fresh-water lacustrine depositional environment (Narin and Kavuşan, 1993), and includes Kalburcayiri, Hamal and Etyemez Fields (Fig. 1). Approximately 202.6 Mt coal reserves, with lower calorific values between 1010 and 3420 kcal/kg are present in the area (Altas et al., 2000; Narin and Kavuşan, 1993; Tercan and Karayiğit, 2001; Tuncali et al., 2003). At the Kalburcayiri Field, production continues at present, whereas at the Hamal and Etyemez coal Fields where mining was performed underground, production has been ceased some 10 years ago due to their poor quality and other factors such as finding fund to operate the coal. Turkish Lignite Authority supplies 79% of coal provided to the power stations. Of the whole low-rank coal reserves, 6% only display calorific values ≥3000 kcal/kg.

The purpose of the study was to determine petrographical properties and depositional environment of the basin. While conducting the study, Kangal Basin was noticed to comprise unusual ingredients and an unexpected state of art for natural coal structure. The dense faulty structure and unaccustomed detrital ingredients of coals exhibit relatively rare features for Turkish coals (see Turkish coals in Palmer et al., 2004; Toprak, 2009; Tuncali et al., 2003).

2. Geological setting

The study area is situated at the eastern end of the Anatolides in the southern part of the NE–SW-oriented, Tertiary Sivas Basin – which narrows and closes towards the east – one of the most important sedimentary basins of central Anatolia (Fig. 1). The basin developed beginning in the Early Tertiary at the onset of closure of the northern branch of Neo-Tethys. A typical collision-related foreland basin, the Sivas Basin began to develop in the Late Paleocene and completed its evolution in the Middle Miocene. In the Middle-Late Miocene,

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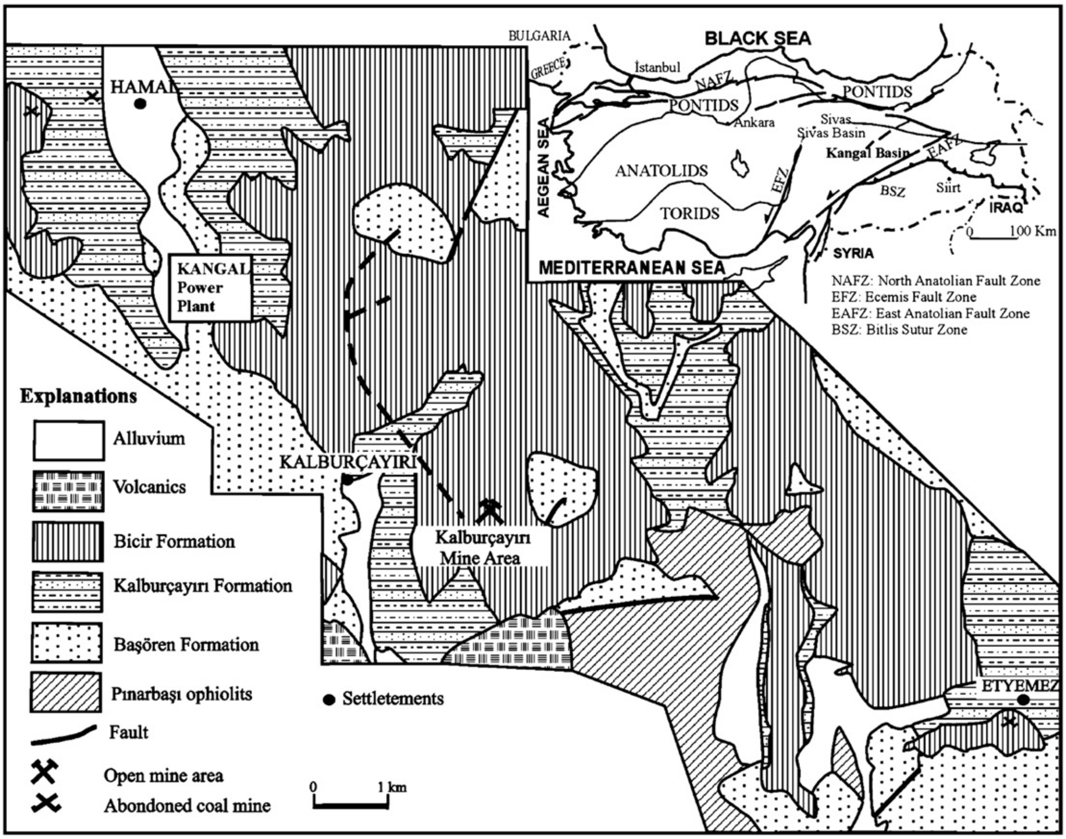

Fig. 1. Geologic map of Kangal coal basin and the location map of the area (modified from Narin and Kavuşan, 1993).

intracratonic basins developed (Görür et al., 1998) under the influence of a neotectonic "plain" regime, and this regime continued until the Late Pliocene. The Kangal Basin was one of the basins that formed in this period, and it comprises Middle Miocene–Late Pliocene fluvial, lake and/or playa deposits.

Basement rocks in the study area are Mesozoic (Jurassic–Cretaceous) and Cenozoic (Neogene–Eocene) in age. Massive basement limestones showing traces of low-grade metamorphism are followed upward by conglomerate and sandstone, which in turn are overlain by intercalating marl and limestone. The Eocene Başören Formation contains alternations of conglomerate and sandstone at the bottom, and alternations of marl and limestone at the top. Neogene (Late Miocene–Early Pliocene) units have been subdivided into the Kalburcayiri and Bicir Formations.

The Kalburcayiri Formation comprises an alternation of siltstone, clay stone, tuff and marl containing two lignite seams, whereas the Bicir Formation comprises marl and limestone (Fig. 2). Abundant gastropod shells occur within rocks of the Kangal Basin. The gastropod shells are concentrated in thin fossil-rich bands at different levels within the exploited coal seams. Pliocene–Quaternary volcanic rocks and Quaternary alluvium are the youngest exposed units (Narin and Kavuşan, 1993) (Figs. 1 and 2). Basaltic lava flows and talus are widespread beyond the study area. In general, the Pliocene units are nearly horizontal (dips of beds vary from 2° to 5° in outcrop), and the most important structural feature is the N–S-oriented Kalburcayiri fault, with a length of about 4 km and a throw of 14–64 m (Fig. 1).

The Kalburcayiri (Kangal) coal is generally dull, brown colored, mineral-rich and own desiccation cracks as well as fractures.

3. Sampling and methods

For this study, 52 samples were collected from the tops to the bases of the seams in the various coal Fields (Kalburcayiri Field; Hamal Field; Etyemez Field) for organic–petrographic and chemical analyses. These samples were taken from along ~1 m lines using the channel-sampling technique, especially from the open-cast mine in the Kalburcayiri Field. As the coal mining facilities there have been abandoned, coal samples from the Hamal and Etyemez area were collected from outcrops. The sampling resolution for coal layers thicker than 20 cm was 10 cm; otherwise, it was equal to the thickness of the lithologically different layers.

The Kangal coal samples were prepared for organic–petrographic analysis using ICCP standards (1993, 2001) and ISO 11760 (2005). To study the maceral and mineral compositions, 30 coal samples were examined under the microscope applying reflected and transmitted white-light and as well as blue-light excitation. The coals and intercalations, samples were crushed to a maximum size of 1 mm and the crushed material was embedded in epoxy; sample preparation and reflectance determinations were performed at the Mineral Research and Exploration General Directorate (MTA), Department of Mineral Analysis and Technology Laboratory (Ankara, Turkey). The chemical analyses such as calorific value, ash, sulphur content, were performed with conventional methods and with Leco instruments in the MTA's laboratories. Huminite reflectance was measured on the prepared polished blocks and the maceral distributions were determined by point counting (at least 500 points for each sample). Reflectance is measured on texto-ulminites and eu-ulminites. The maceral nomenclature applied in this study was adopted by the International Committee for Coal Petrology for low-rank coal (International Committee for Coal and Organic Petrology, ICCP Handbook, 1993; Sykorova et al., 2005). The reflectance measurements and coal petrographic determinations were performed by using a Leitz MPV microscope and MPV-Geor software program with reflected white light. Maximum huminite-reflectance values were measured at 546 nm using a Leitz MPV-Spectra microscope, a glass standard (Leitz R_{oil} 1.24%), and sapphire standard (R_{oil} 0.534%), a