International Journal of Coal Geology 144–145 (2015) 111–129

Contents lists available at ScienceDirect

International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/ijcoalgeo

Mineral matter, major and trace element content of the Afşin–Elbistan coals, Kahramanmaraş, Turkey

Emine Cicioglu Sutcu [a,*], Ali Ihsan Karayigit [b]

[a] General Directorate of Mineral Research and Exploration, 06800 Ankara, Turkey
[b] Department of Geological Engineering, Hacettepe University, Beytepe, Ankara, Turkey

ARTICLE INFO

Article history:
Received 23 February 2015
Received in revised form 16 April 2015
Accepted 16 April 2015
Available online 24 April 2015

Keywords:
Trace elements
Major elements
Mineral matter
Elbistan coal basin
Turkey

ABSTRACT

The Afşin–Elbistan coal basin is one of the most important coal deposits of Turkey. The mineral matter, major and trace element concentrations of the Afşin–Elbistan coals and their modes of occurrence are discussed in this study. The coal seam is located within the Upper Miocene–Pliocene aged Ahmetcik Formation which is represented by fluvial–lacustrine facies. Thickness of the coal zone is 80 m, but it reaches 105 m in the Kışlaköy sector. A total of 86 samples were taken from the Kışlaköy open-pit mine and from the 14 boreholes drilled by the General Directorate of Mineral Research and Exploration (MTA) for coal exploration. The proximate, XRD, SEM-EDS, major and trace element analyses were conducted on the samples. The studied coals are characterized by relatively high moisture, ash, total sulfur, volatile matter contents and low gross calorific values. The mineral matters of the Afşin–Elbistan coal are represented by calcite, quartz, pyrite, feldspar, aragonite, opal-CT, gypsum, jarosite and clay minerals. Strontium, Rb, Sm, Zr, Hf, Nb, Mo, U, Zn, Pb, As, Mn, Co, Cr and Ni concentrations detected by EDP-XRF are higher than the world brown coal values. Many of the trace elements showing positive correlations with ash content imply inorganic affinity. The element concentrations of the coals are mainly related to the carbonate, silicate, sulfide, phosphate, ore minerals and fossil shells. However, some elements have also organic affinities.

1. Introduction

Trace elements can be associated with organic or inorganic matters in coals. They can be derived from detritic materials, coal forming plants and syngenetic or epigenetic minerals. Many authors (e.g. Alastuey et al., 2001; Dai et al., 2012; Eskenazy, 2009; Finkelman, 1982, 1994; Gluskoter et al., 1977; Spears and Zheng, 1999; Swaine, 1990; Vassilev et al., 2010; and Ward et al., 1999) have indicated links between the minerals in coal and the concentration of particular trace elements (Ward, 2002). Mineral formations in coal are complex and are controlled primarily by source rocks, lithology, degree of weathering, nature of the coal-forming environment, hydrology, conditions of burial and degree of coalification. However, there are predictable end products of a definite set of biological, chemical, and physical conditions that provided an environment in which the minerals could be deposited or in which they could form. Therefore, the occurrence, abundance, and distribution of minerals could be strong indicators of the processes resulting in the geological progress of a coal seam or deposit (Vassilev et al., 2010).

Environmental impact of trace elements is generally related to concentration, toxicity and mobility (modes of occurrence) of these elements in coals (Dai et al., 2005; Finkelman, 1995). Coal-fired power plants are traditionally considered as one of the main sources of environmental pollution. Along with the emissions of carbon dioxide, nitrogen and sulfur oxides, coal combustion at power plants causes the release of great amounts of potentially toxic and radioactive elements into the biosphere (Arbuzov et al., 2011).

Many publications have reported the concentration, distribution and origin of hazardous elements in Turkish coals from different coal basins (Cakir et al., 2003; Cicioğlu, 2001; Gürdal, 2011; Karayigit and Celik, 2003; Karayigit and Gayer, 2000; Karayigit et al., 2000a,b; Karayigit et al., 2001; Palmer et al., 2004; Querol et al., 1997; Vassilev et al., 2005).

Previously, in the Afşin–Elbistan coal basin, Karayigit and Gayer (2000) have studied the trace element content of the coal samples collected from the BA-103 borehole drilled in Kıslakoy sector. However, the studied samples represent only the 25 m top part of the coal seam. In this study, the mineral matter, major and trace element concentrations and their modes of occurrence in the Afşin–Elbistan coal are discussed. The coal samples were taken along the whole coal seam at different locations of the basin.

The coal exploration studies were started by the General Directorate of Mineral Research and Exploration (MTA) and the Ottogold Firm in 1966 and approximately 3.357 billion tons of proven recoverable coal reserve was determined in the basin. As a result of the drilling studies carried out by MTA, the coal reserve of the basin increased to

* Corresponding author. Tel: +90 3122012690; fax: +90 3122875409.
E-mail address: sutcuemine@gmail.com (E.C. Sutcu).

http://dx.doi.org/10.1016/j.coal.2015.04.007
0166-5162/

4.5 billion tons in recent years. The coal basin approximately covers 126 km^2 and it is divided into twelve sectors called as Kışlaköy, Çöllolar (C), Afşin, Kuşkayası (D), A, B, D1, E, F, G, H and J sectors (Fig. 1). The coal production was started in the Kışlaköy sector as an open-pit mine in 1973. The coal extracted from Çöllolar and Kışlaköy sectors is used in the Afşin-A and Afşin-B power plants. New power plants (Afşin-C power plant in the Afşin sector and Afşin-D power plant in the Kuşkayası (D) sector) were scheduled to be held in the near future. Knowledge about the concentrations, distribution, and modes of occurrence of trace elements and minerals in the Afşin–Elbistan lignite, is important in coal beneficiation, utilization, disposal of coal ashes, and environmental protection.

2. Geological setting

The study area experienced two geologic phases during Pre-Maastrichtian and Maastrichtian–recent times. The Pre Upper-Maastrichtian tectonic units divided into two groups, show east–west general direction and different depositional characteristics in the region. The units are called as the Gürün Parautochthon and the allochthonous units. In the study area, the basement rocks are represented by allochthonous units which are divided into three groups (Fig. 2 and Fig. 3). The first group is called Keban-Malatya Metamorphics which consist of Yoncayolu Schists and Çayderesi Marble. The second group contains Andırın Limestone, Kırmızıkandil Formation, Binboga Formation, Kemaliye Formation and Dağlıca Complex. Their ages vary between Triassic and Upper Cretaceous. Göksun Ophiolites are the third group of the allochthonous units (Yılmaz et al., 1997). The allochthonous units are covered by Middle Maastrichtian–recent aged units called Harami Formation, Seske Formation, Ahmetcik Formation and Quaternary deposits.

The Miocene–Pliocene aged coal bearing Ahmetcik Formation overlies unconformably the older units and is covered uncorformably by Quaternary deposits. The formation is represented by limnic and fluvial deposits. The limnic deposits were developed in the center of the basin and are transitioned to the fluvial deposits towards the basin margin. The limnic deposits start with bluish-gray colored marl/claystone layers and they continue with coal and claystone intercalations at the lower parts. Towards the upper part of the coal zone, the coal and gyttja intercalations are observed and thick claystone layers with coal lenses are

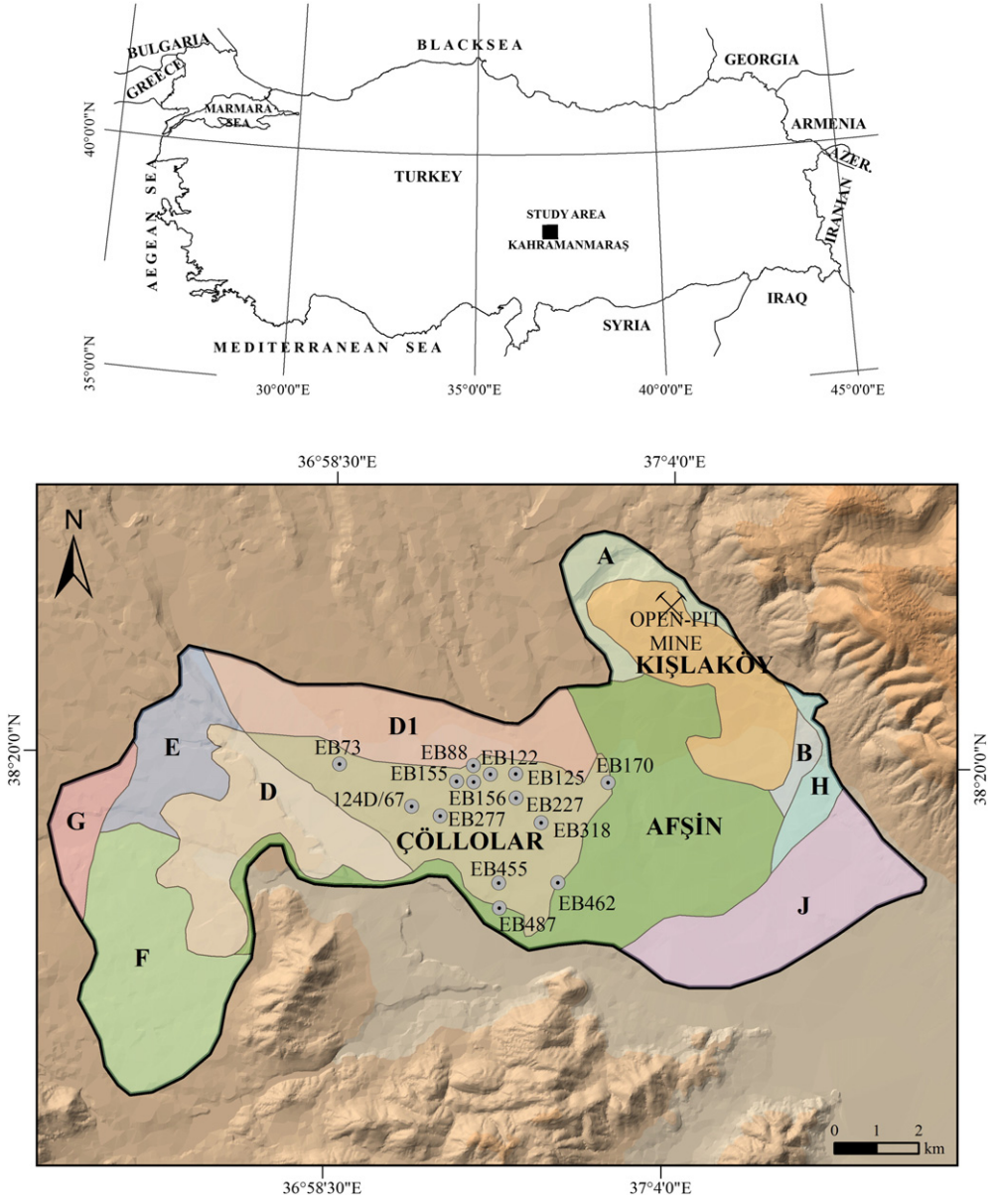

Fig. 1. The location maps of the study area and the distribution map of the boreholes and the coal sectors of the Afşin–Elbistan coalfield.