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The Miocene coal seams in the Soma Basin (W. Turkey): Insights from coal petrography, mineralogy and geochemistry

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ABSTRACT

The Neogene Soma Basin, western Turkey, hosts three coal seams (kM2, kM3 and kP1) and several altered tuff layers within the Miocene sequences. This study focuses on the evaluation of coal-petrography, mineralogical and elemental compositions, as well as the Rock-Eval pyrolysis of the three coal seams from Eynez, Işıklar and Deniş sectors, and to identify the mineralogy of altered tuff layers within kM2 and kP1 seams. The routine coal quality analyses show that coal samples from the kM2 seam are characterized by lower ash yields and total S contents, and higher gross calorific values than kM3 and kP1 seams. The mineralogical composition of the bulk coal samples varies between all three seams. The statistical treatment implies that major elements in bulk coal samples such as Al, Fe, K, Mg and Na, and the vast majority of minor and trace elements have inorganic affinity. The trace element contents and elemental enrichments in the coal samples are generally changeable from seam to seam, which could be related to differences in ash yield and mineralogy. Altered tuff layers, or tonsteins were identified in kM2 and kP1 seams. The tonsteins are clay rich, and certain trace elements (e.g. As and Zr) are enriched in the coal layers beneath the tuff layers in the kM2 seam. This might be related to penetration of leached pore water into these layers and precipitation of epigenetic minerals.

The coal-petrography composition and the coal-facies diagrams show that the precursor peat of the kM2 seam was accumulating under telmatic, mesotrophic, anoxic conditions, whereas the water level was high and stable. The relatively low ash yields and thicker coal beds suggest a lower clastic input from the basin margins, and water table fluctuations resulted in calcareous intercalations in the kM3 and kP1 seams. These imply the development of limno-telmatic conditions whereas fluvial activity affected during peat accumulation of both seams. Considering the maceral composition along with the coal thickness, coal seams in the Soma Basin might display oil-generation potential; however, the pyrolysis analysis shows that the studied coal seams are mainly gas-prone and only certain coal beds have mixed-hydrocarbon generation capacity. All data presented in this study indicates that lithological features, differences in coal qualities and elemental contents in the Soma Basin were mainly controlled by changes in the depositional conditions and the detrital input during Miocene.

1. Introduction

The regional extensional tectonic regime during late Cenozoic resulted in the development of regional volcanic activity and the formation of several NW–SE and NE–SW trending grabens in the western Turkey (Seyitoğlu and Scott, 1991; Yılmaz et al., 2000). Terrestrial conditions were also predominant during Neogene. The grabens were filled in with alluvial, fluvial and lacustrine sediments, and volcanosedimentary rocks. Suitable climatic conditions along with constant subsidence allowed peat accumulation within these basins during Miocene; therefore, several economic coal deposits are located within Miocene lacustrine and terrestrial sequences in the western Turkey (Toprak, 2009; Kayseri-Özer, 2017).

The Soma Basin hosts the most significant coal deposits in the western Turkey. The total coal reserves of the Soma Basin are about 738 Mt; about 10.4 Mt coal are annually produced by mainly open-pit mines, of which annually 7.7 Mt are consumed in Soma coal-fired power plants with 990 MW total installed capacity, whereas 2.7 Mt are used for domestic heating and industrial purposes (TKİ-ELİ, 2015). The basin is divided into several sectors, and hosts three coal seams, kM2 (lower-seam), kM3 (middle-seam) and kP1 (upper-seam). The coal features and the thickness of these seams vary from sector to sector (Tuncalı

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et al., 2002). Another distinct feature of the Soma Basin is the presence of several altered tuff layers and basaltic intrusions within the coal seams (Karayiğit and Whateley, 1997). The tuff layers, particularly identified within the kM2 seam, could be useful for stratigraphic correlation during underground mining operations and can also give information about mineral input during peat accumulation.

Several studies dealing with Soma Basin mainly focused on geological setting, palynological, environmental and economic aspects (Nebert, 1978; Akgün et al., 1986; Gemici et al., 1991; Takahashi and Jux, 1991; Akgün, 1993; İnci, 1998a,b, 2002; Karayiğit et al., 2000, 2006; Vassilev et al., 2005; Tercan et al., 2013; Hokerek and Ozcelik, 2015; Baysal et al., 2016; Kayseri-Özer, 2017). Petrographical and geochemical studies of coals in this area are limited (Karayiğit and Whateley, 1997; Karayiğit, 1998; Tuncalı et al., 2002; Bulut and Karayiğit, 2006; Toprak, 2009). All these studies focused on either certain mining sectors or the suitability of coal for power plants, and none of them reported any correlation among the coal seams within the basin. It is noteworthy that detailed study on altered tuff layers within the coal seams is also lacking. In this paper, the main goal is to determine coal features, to reconstruct the palaeoenvironmental conditions during peat accumulation, and to determine the oil-and gas-generation potential of the kM2, kM3 and kP1 coal seams at the Eynez, Işıklar and Deniş sectors, using coal petrography, mineralogy and geochemical techniques. The specific aim of the study is to identify the features of tuff layers occurring within the seams and to assess their impacts on mineralogical and elemental compositions of the coal seams.

2. Geological setting

The Soma Basin is a NE–SW trending, approximately 20-km long and 5-km wide, fault-controlled basin in western Turkey (Seyitoğlu and Scott, 1991; İnci, 2002). The margins of the basin are mainly built of Upper Cretaceous-Palaeocene carbonates (recrystallized limestone) and Miocene volcanic rocks; furthermore, small greywacke and diabase blocks are outcrop on southern margin (Fig. 1a). The regional extensional tectonics initiated during the early Miocene, created depositional space for the basinal infillings (Nebert, 1978; Seyitoğlu and Scott, 1996; İnci, 1998a); consequently, the major coal-bearing Soma Formation started deposition during Early to Middle Miocene (Benda, 1971; İnci, 2002). The Formation is composed of alluvial sediments and lacustrine carbonates which host the kM2 and kM3 seams (Fig. 1b). The total thickness of the kM2 seam reaches up to 27 m, whereas the kM3 seam with thicker calcareous intercalations reaches up to 15 m. The overlaying Deniş Formation (Fig. 1b) commenced with alluvial sedimentation and turned to fluvial sediments and lacustrine carbonates along with the kP1 seam (İnci, 2002). The total thickness of the kP1 seam is variable within the basin; it is only mineable at the Deniş sector. This seam hosts several coal layers and thick intercalations (fossiliferous claystone and clayey limestone/marl); therefore, it can be distinguished into lower, middle and upper parts. The Pliocene Soma volcanics overlie the Deniş Formation (Fig. 1b). Furthermore, Pliocene-Pleistocene basaltic intrusions caused the contact metamorphism in the kM2 coal seam resulting in natural coke occurrences near to the contact zone (Karayiğit and Whateley, 1997; Karayiğit, 1998). Finally, Quaternary unconsolidated sediments unconformably overlay the older units (Fig. 1b).

3. Material and methods

A total of 64 coal samples and 18 intercalations samples, of which 6 samples are from altered tuff layers, 7 samples from clayey limestone/marl, 4 samples from claystone and 1 sample from fine grained sandstone, were gathered using channel sampling technique from five profiles in the Eynez, Işıklar and Deniş sectors (Fig. 2). The kM2 seam was

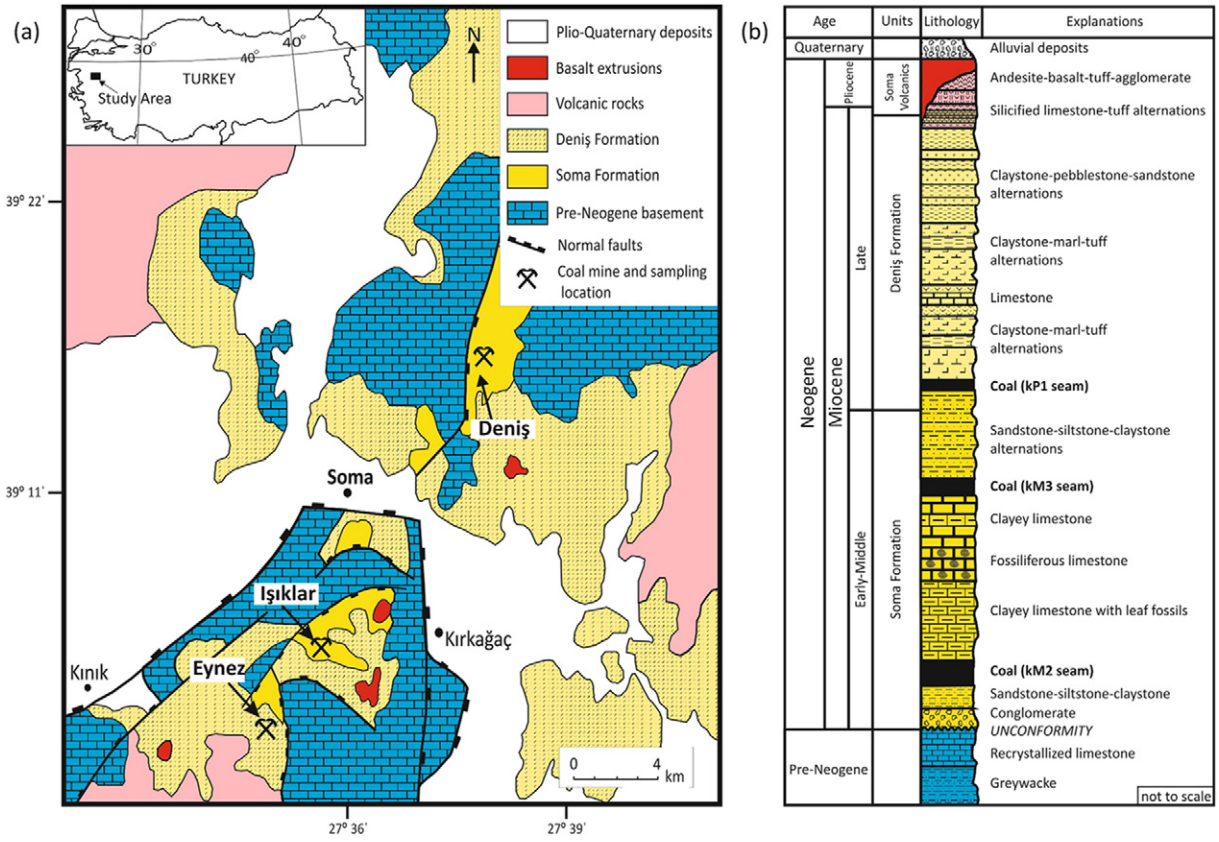

Fig. 1. a) Geological map of surrounding area of the Soma Basin (modified from İnci (1998a), Karayiğit (1998)); (b) Stratigraphic column of the Soma Basin (modified and simplified from Karayiğit and Whateley (1997), İnci (1998a)).