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Spatial and temporal variability in vegetation and coal facies as reflected by organic petrological and geochemical data in the Middle Miocene Çayirhan coal field (Turkey)

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ABSTRACT

Coal channel samples of Middle Miocene age are collected from the first (Tv) and second (Tb) seams from underground mines and from exploration boreholes within the Çayirhan coal field in the Beypazari Basin (Turkey). They are investigated in order to detect spatial and temporal changes in maceral and molecular composition of coal and to relate them to changes in vegetation and depositional environment.

The mean random reflectance values of ulminite (0.40% Rr) indicate a lignite to subbituminous-C coal in rank. Maceral composition and biomarker ratios of the samples from both seams at the Çayirhan deposit argue for coal formation in a limno-telmatic environment under dysoxic to anoxic conditions. Alkaline surface waters of changing pH-values and a high and unstable water level at the palaeomire are evidenced by moderate to high gelification index (GI) and ground water influence (GWI) values, as well as high sulphur contents. Variations in tissue preservation index (TPI) and vegetation index (VI) values point to minor variations in the palaeovegetation during peat formation. Herbaceous plants dominated in both Tb and Tv palaeomires (low TPI and VI values), whereas in the surroundings arboreal vegetation were predominant.

The decreasing trends in pristane/phytane ratios and carbon preference index (CPI) values towards the NE are suggested to reflect oxygen deficient conditions during peat formation due to a higher (ground)water level in this part of the basin. The occurrence of C_{29} diasterenes in low abundances provides evidence for periods of lower pH in the mire. The borehole samples from the NE show slightly enhanced contributions of *n*-alkanes from algal and microbial sources. The terpenoid hydrocarbons present in the lignite argue for a major contribution of angiosperms to peat formation and slightly enhanced proportions of gymnosperms in the Tv palaeomire in the NE. Based on the high concentrations of lupane-type triterpenoids in the coal seams from the underground mine, a higher density of Betulaceae in the arboreal vegetation in the SW is indicated.

1. Introduction

Standard methods for the investigation of coal and coaly sediments include geological, petrological, and palaeobotanical techniques to acquire information about the sedimentary environment, type of vegetation, and transformation processes during diagenesis. In the past few decades, the analysis of the organic matter in coal has gained essential importance in the reconstruction of depositional environment and floral changes (Bechtel et al., 2002, 2003, 2005, 2008; Otto and Wilde, 2001; Stefanova et al., 2011; Stojanović and Životić, 2013; Zdravkov et al., 2011). Gas chromatography and mass spectroscopy techniques on extractable organic matter (i.e. lipids) or compounds released during pyrolysis provide important information about plant remains involved in coal formation. Biomarker molecules are used for taxonomic differentiation of the source plants and for coal rank determination. Furthermore, from organic geochemical studies information about the effects of humification, microbial activity and environmental changes during coal formation has been derived.

In the Beypazari Basin (Central Anatolia, Turkey), the Çoraklar Formation of Middle Miocene age hosts the Tv and the Tb seams, mined by underground methods in the Çayirhan coal field. Despite the great lateral extension and economic importance, the Çayirhan deposit has so far mainly been investigated for the mineralogy of the coal seam and associated zeolites (Whateley and Tuncali, 1995a,b). Based on proximate and elemental analyses, temporal and lateral variations in coal

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quality have been outlined. Mean random reflectance data (0.36% Rr) of huminite for the upper seam classify the coals as lignite in rank (Whateley and Tuncali, 1995a; Querol et al., 1996). Organic geochemical data of coal samples, obtained during previous studies, are limited to a few samples (Özçelik and Altunsoy, 2005). Recently, the forms of organic sulphur in the Beypazari lignite and the effect of desulphurisation on lipid composition were outlined (Gonsalvesh et al., 2012, 2014).

In this study, coal channel samples of the first (Tv) and second (Tb) seams from the underground B, C and G mines, and from exploration boreholes, recently drilled within the Çayirhan coal field in the Beypazari Basin (Turkey), are investigated by organic petrological and geochemical methods. The aim of the study was to detect spatial and temporal changes in maceral and molecular composition of coal and to relate them to changes in vegetation and depositional environment.

2. Geological setting

The large Neogene Beypazari Basin lies about 100 km NW of Ankara in Central Anatolia (Fig. 1). The basin is filled with mainly lacustrine and volcano-sedimentary rocks and the sequence contains economic resources of coal, clay and trona (Yağmurlu et al., 1988; İnci, 1991; Whateley and Tuncali, 1995a). The coal-bearing strata are located in the NW-SE trending area centred at Çayirhan (Fig. 1) and near Koyunağili in the southwest. The margins of the Çayirhan coal field are controlled by faults developed under an extensional regime during the Miocene (Yağmurlu et al., 1988). A detailed description of the Miocene formations is provided by several authors such as Whateley et al. (1996) and García-Veigas et al. (2013).

The coal seams are found at the top of the fining-upward sediments of the Çoraklar Formation, which rests unconformably upon the basement rocks (Fig. 2). Deposition of the coal is associated with synchronous volcanic activity, responsible for its unusual characteristics such as high zeolite contents. The main coal seam (3 m thick) is split by a 1 m-thick tuffaceous siltstone into the first (Tv) and the second (Tb) seams. The Tv seam contains Ca-rich zeolites (clinoptilolite/heulandite) while the Tb seam includes Na-rich zeolites (analcime). A change towards hotter and drier climate is reflected by the change in sedimentation from peat to the deposition of bituminous shale and trona (sodium hydrogen carbonate hydrate) in the overlying Hirka Formation (Whateley et al., 1996). Increasing aridity resulted in the deposition of carbonate rocks, lacustrine claystones and gypsiferous sedimentary rocks such as, from bottom to the upward, Karadoruk, Akpınar, Çakıloba, Bozçayır, Acısu, Kırmızıtepe and Softa Formations (Fig. 2). Evaporitic gypsum in this basin was identified as Softa 2 Formation.

Mainly white, greyish white coloured tuffs of the Galatean volcanic massif, which were identified as Zaviye Formation in the coal field, are derived from a calc-alkaline, andesite–dacite complex (Teke volcanics; Fig. 2) lying to the east of the Beypazari basin, as the complex was most active during the Miocene (Keller et al., 1992).

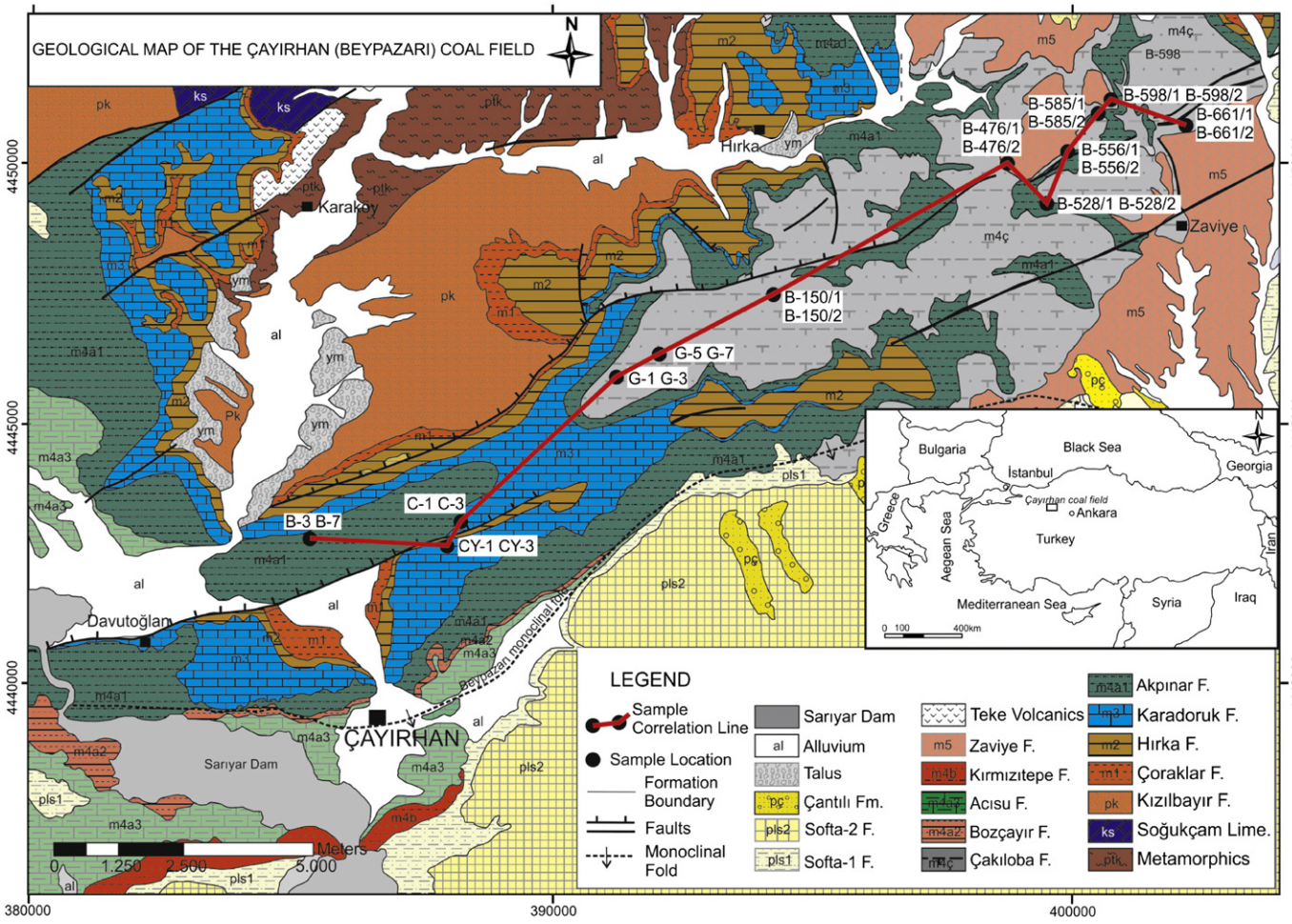

Fig. 1. Geological sketch map of the Çayirhan coal field (Beypazari basin, Central Anatolia, Turkey). Sampling position of the coal channel samples from the underground mine (B-3 B-7, Cy-1 Cy-3, C-1 C-3, G-1 G-3, G-5 G-7) and from boreholes (B-150, B-476, B-528, B-556, B-585, B-598, B-661) is shown (simplified from Siyako (1984, unpublished report of Mineral Research and Exploration (MTA, Ankara)), and Besbelli (2010, unpublished report of MTA). The location of the study area and its size compared to the Turkey overview map is indicated.