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Palaeoenvironmental reconstruction of the Çardak coal seam, SW Turkey

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ABSTRACT

The study focuses on the firstly documented Çardak coal seam cored in the Neogene Acıgöl Basin (Denizli Province) being formed in a late stage of Alpine orogeny in SW Turkey. The aim is to contribute reconstructing the palaeoenvironmental conditions before, during and after coal formation, on the basis of coal-petrology, mineralogical and palaeontological data combined with the results of previous studies. The basin infilling consists of alluvial, fluvial and lacustrine sediments; their deposition depended on the water level in the basin, which in turn, was controlled by the interplay between tectonics and climate. Coal seam was probably formed in Latest Miocene/Early Pliocene under the influence of basin's fluvial regime in oxbow and terminal lakes. The coal seam comprises alternating inorganic and coal layers logged between depths of 599.00 to 627.00 m beneath surface. The coal being lignite to subbituminous in rank, displays moderate to high ash yield (21.31–46.11 wt.%, on dry basis) and high total sulphur content (up to 13.30 wt.%, on dry, ash-free basis). The maceral composition points to an origin from mainly herbaceous helophytes along with woody species. In the upper part of the core the presence of salinity-tolerant ostracod species along with gypsum and halite are documented. The palaeontological and mineralogical data obtained imply changes of climate, water level and lake chemistry in the basin.

1. Introduction

The last stage of Alpine orogenic movements was followed by the establishment of a post-orogenic extensional regime in SW Turkey, which resulted in the formation of several NE-trending basins during Late Cenozoic (Alçiçek et al., 2013; Helvacı et al., 2013; Koçyiğit, 2005; Ten Veen et al., 2009). The regional extension, which followed the final stage of Neotethys closure, caused Tauride Orogeny (also called Lycian Orogeny) from Late Cretaceous to Eocene, and controlled the formation of several fault-bounded intermontane basins (Alçiçek and Ten Veen, 2008; Collins and Robertson, 1997; Robertson and Dixon, 1984; Şengör and Yılmaz, 1981; Şengör et al., 1985; Sözbilir, 2005; Zanchi et al., 1993).

During Palaeogene conditions appropriate for coal formation in SW Turkey dominated in the mollase facies (Akgün and Akkiraz, 2005; Akgün and Sözbilir, 2001; Toker et al., 2012). During Neogene times tectonic subsidence along with climate created favourable palaeoenvironmental conditions for peat accumulation in intermontane basins; hence, several basins host economic coal deposits within terrestrial and lacustrine sediments (Alçiçek, 2010; İnaner and Nakoman, 1997; Oskay et al., in press).

Acıgöl Basin is located at the east of Çardak town (Denizli, SW Turkey) and hosts today the homonymous lake (Fig. 1). The modern Acıgöl Lake (literally 'the bitter lake' in Turkish) with an area extent varying between 100 km^2 in spring and 35 km^2 in late summer, is the second largest alkaline lake in the world (Garnett, 2001; Helvacı et al., 2013) being economically important due to sodium sulphates (e.g. mirabilite, thenardite) extracted from lake water (Garnett, 2001; Savascın and Birsoy, 1993). Previous studies focussed on sedimentary and tectonic features of Acıgöl Basin (Alçiçek, 2009; Alçiçek and Ten Veen, 2008; Alçiçek et al., 2006; Erinç, 1967; Helvacı et al., 2013; Sulpizio et al., 2013; Zedef et al., 2000) and lake-water chemistry (Helvacı et al., 2013; Mutlu et al., 1999; Savascın and Birsoy, 1993). The studies document water-level fluctuations during lake evolution and changes in sedimentation (periodical changes of the Mg/Ca ratio along with terrigenous mud supply). Magnesium-rich terrigenous input, being related with widespread ultramafic bedrock (Alçiçek, 2009), changed lake-water chemistry resulting in Mg-carbonate (especially magnesite) deposition. The modern lake is supplied with carbonate (Mg-HCO_3 type) groundwater and sulphate-rich (Na-SO_4 type) spring water (Helvacı et al., 2013; Savascın and Birsoy, 1993). Besides, evaporite minerals and clastic input along with high TOC values in recent gel-like sediments are related to high bacterial activity in the modern Acıgöl Lake (Mutlu et al., 1999; Savascın and Birsoy, 1993).

Even though, in general, conditions dominated during Neogene and Quaternary times did not favour peat accumulation and no coal is

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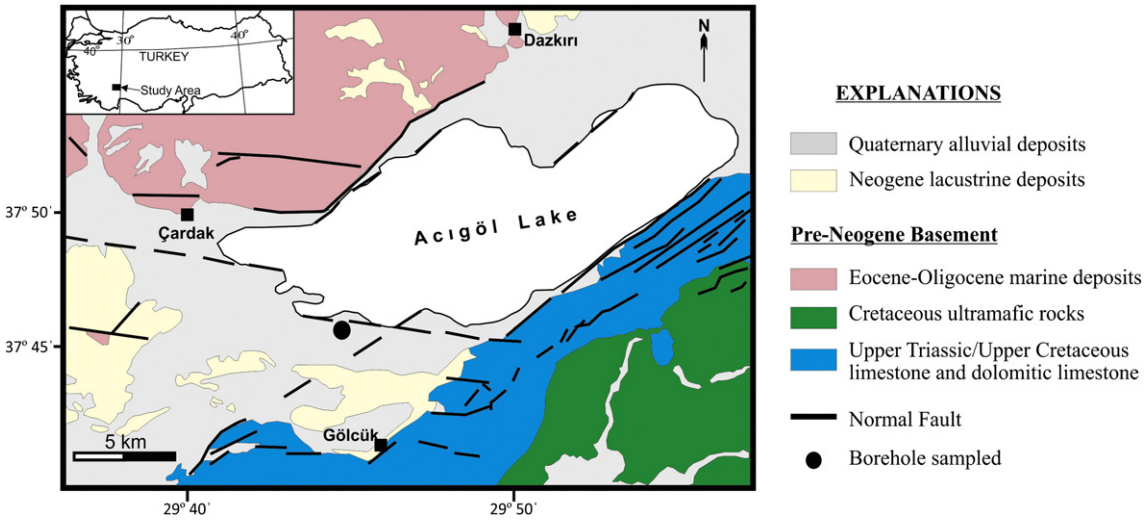

Fig. 1. Geological map of Acıgöl Basin (from Helvacı et al., 2013, simplified).

reported in previous studies (Alçiçek, 2009; Göktaş et al., 1989; Şenel, 1997), Helvacı et al. (2013) reported the presence of Pliocene peat layers at a depth interval of 148–152 m in a borehole drilled at the west of Acıgöl Lake. In the studied core a coal seam consisting mainly of clayey coal and containing gastropod shells in white colour, was logged between depths of 599 to 627 m beneath surface.

The aim of this study is to present for the first time data from organic layers hosted in the Late Miocene–Pliocene sedimentary sequence of Acıgöl Basin, by means of mineralogy, palaeontology and coal petrography.

2. Geological setting

The Acıgöl Basin (Fig. 1) is a NE-trending, 60-km long and 25-km wide basin at altitudes up to 836 m above sea level in SW Turkey (Alçiçek, 2009; Alçiçek et al., 2013; Helvacı et al., 2013; Price and Scott, 1994). The basement and the margins of the basin are mainly composed of marine carbonates (limestone and dolomite) deposited from Jurassic to Oligocene. Also Cretaceous ultramafic (harzburgite, serpentinite, dunite and gabbro) and crystalline (marble) rocks outcrop (Fig. 1). Pre-Neogene rocks are exposed at southern margin (Alçiçek et al., 2006; Hayward, 1984; Helvacı et al., 2013; Şenel, 1997), whereas mainly Oligocene coal-bearing marine sediments and Eocene marine carbonates dominate at northern basin margin (Toker et al., 2012).

Post-orogenic extension, which caused NE–SW trending normal faulting, resulted in the creation of accommodation space for the accumulation of lacustrine sediments (Alçiçek et al., 2013; Price and Scott, 1994). Basin formation commenced during Late Miocene (Alçiçek, 2009; Helvacı et al., 2013). Basin-filling (Fig. 2) overlies unconformably the basement rocks and consists of Neogene and Quaternary terrestrial and lacustrine deposits (Alçiçek, 2009; Göktaş et al., 1989; Şenel, 1997). Late Miocene sediments being widely exposed in western part of the basin, consist of three distinguishable units (Alçiçek, 2009): Alluvial fan deposits (conglomerate, reddish mudstone, stratified pebbly sandstone and clayey dolomite), lacustrine deposits (magnesite alternating with clayey dolomite and dolomitic or clayey marlstone) and fluvial deposits (alternations of conglomerate, sandstone and mudstone). Pliocene commenced with the deposition of alluvial fan/fluvial–palustrine sediments consisting of conglomerate, sandstone, and ripple cross-laminated sandstone intercalated with mudstone layers, laminated siltstone and marlstone and mudstone with peat layers (Helvacı et al., 2013). Lacustrine sediments interfinger with alluvial fan–palustrine ones and consist of alternations of lacustrine magnesite, and dolomite, dolomitic clayey marl, laminated mudstone, gypsum and gypsarenite

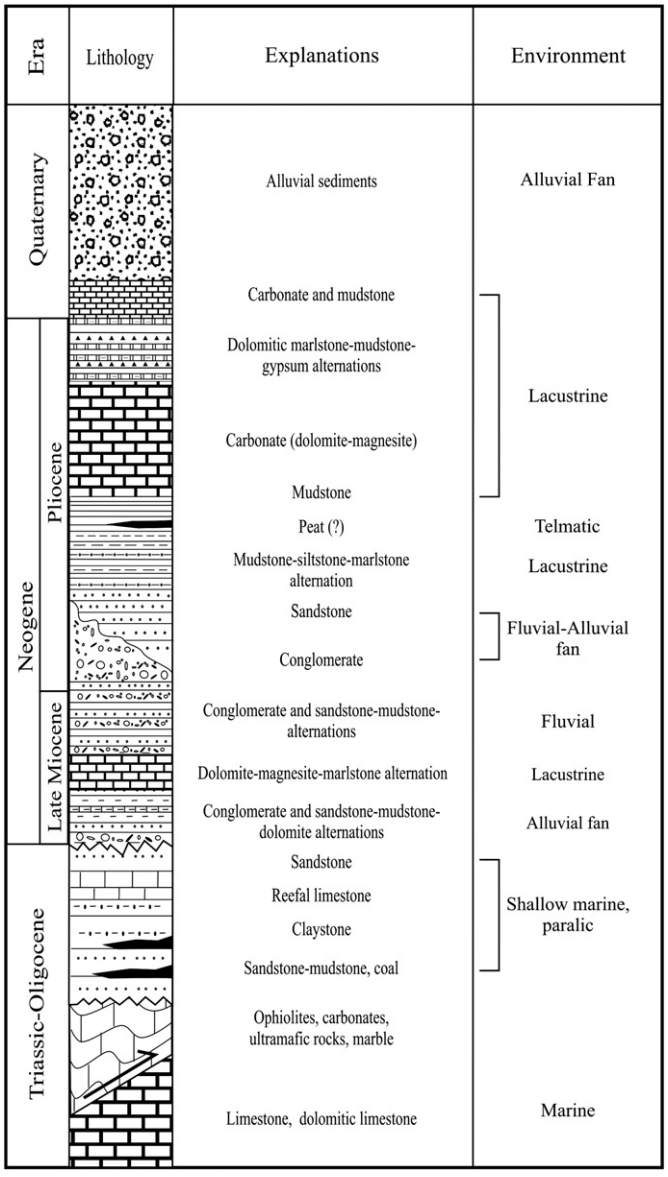

Fig. 2. Lithological column of Acıgöl Basin (modified from Alçiçek, 2009; Helvacı et al., 2013; Sulpizio et al., 2013; Toker et al., 2012; not to scale).