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# Organic geochemistry and depositional environments of Eocene coals in northern Anatolia, Turkey

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## HIGHLIGHTS

- The Eocene coals, Turkey, were studied by geochemical methods.
- Yeniçeltek and Eskiçeltek coals were deposited in suboxic lacustrine or lacustrine swamp.
- Armutlu and Aspiras coals were deposited in paralic, suboxic marine swamps.
- Salıpazarı coals were deposited in a suboxic lacustrine or lacustrine swamp.
- Coals were of different ranks, i.e. we have lignite, subbituminous C, high volatile bituminous C.

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## ABSTRACT

This study is the first attempt which provides information regarding the organic geochemical, biomarker and petrographical characteristics of the Eocene coal deposits found in the Yeniçeltek, Eskiçeltek, Armutlu (Amasya), Aspiras (Kastamonu) and Salıpazarı (Bolu) fields in the northern part of Turkey.

Proximate analyses including total ash and total sulphur contents and upper heat values of the coal samples from each fields exhibit significant differences. The Armutlu coal samples have the highest ash value (average 42.25%) and represented by relatively low upper calorific value (3868 kcal/kg). In contrary, the Salıpazarı coal samples have the lowest ash content (average 3.37%) and the highest upper calorific value (7250 kcal/kg). The average total % sulphur contents of all samples are generally high and quite different for each field. Total sulphur contents of Eskiçeltek, Yeniçeltek and Armutlu samples are similar and vary from 1.01% to 1.86. Samples from Aspiras and Salıpazarı fields have high total sulphur contents as 6.29% and 13.82%, respectively. Based on the vitrinite reflectance values, all coals are in the diagenetic stage and their coalification degrees are subbituminous A or high volatile bituminous C for the Yeniçeltek (0.55% $R_o$), Eskiçeltek (0.50% $R_o$) and Armutlu (0.50% $R_o$) coals, and subbituminous C for the Salıpazarı (0.39% $R_o$) coals, and lignite for the Aspiras (0.36% $R_o$) coals.

All samples have high Total Organic Carbon (TOC) values, but low bitumen/TOC ratios. The average TOC values of Yeniçeltek, Eskiçeltek, Armutlu, Aspiras and Salıpazarı fields are 49.67%, 68.51%, 35.35%, 46.27% and 66.47%, respectively. Extraction analysis applied to one sample from each field yielded very low bitumen/TOC values ranging from 0.01%, to 0.07. The Hydrogen Index values of the Yeniçeltek, Eskiçeltek and Salıpazarı samples between 272 mgHC/gTOC and 329 mgHC/gTOC indicate that their organic matter type is Type II kerogen, whereas the other coal samples have Type III and Types II–III kerogen. Gas chromatograms indicate dominant odd-carbon-number *n*-alkanes, indicating terrestrial organic matter.

The parameters obtained from mass spectrometer data on *m*/*z* 191 and *m*/*z* 217 indicate that the Yeniçeltek and Eskiçeltek coals were deposited in suboxic lakes or lacustrine swamps; the Armutlu and Aspiras coals were deposited in suboxic brackwater swamps (paralic environment); and the Salıpazarı coals were deposited in suboxic lakes or lacustrine swamps.

An Unresolved Complex Mixture (UCM) observed in the gas chromatograms display immature organic matter and biodegradation. The $T_{max}$, mean reflectance and biomarker maturity data show that coal samples are thermally immature.



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## 1. Introduction

Even though oil and gas are very rare in Turkey there is a great potential of coal deposits. The total coal reserve of Turkey is estimated about 12 billion tons. A small amount of this reserve (about 1 billion ton) is in the hard coal category. Since the second half of 20th century, several lignite deposits in the Neogene basins of Anatolia have been discovered and exploited by public and private sectors. Most of these deposits contain low calorific coals which are mostly used in thermic plants. Eocene coal deposits found in the northwestern basins of Anatolia are composed mainly of high calorific coals which greatly contributes the energy demand of Turkey.

Amasya, Bolu and Kastamonu regions located in the northwestern Anatolia contain three coal deposits with having reserves of more than 1 million tons (Fig. 1). In this study, the organic geochemical properties of these coal deposits were investigated, and their organic matter type, maturity and depositional conditions were assessed and correlated to each other using particularly biomarker data.

These Eocene clastic sediments have been the subject of many previous geologic studies [1–10]: the Eocene (Ypresian) coals in Aspiras (Kastamonu) having high calorific value and total sulphur content were deposited in a shallow-marine environment and overly marine sediments including conglomerate, radiolarian limestones and yellow–grey marly limestones [1]. Limestones bearing nummulites and the observed primary sedimentary structures indicate that the Eocene (Ypresian) Eskiçeltek and Yeniçeltek (Amasya) strata were deposited in lacustrine and swamp environments on a delta plain. The Eocene (Ypresian) Armutlu (Amasya) coals were deposited in a lagoon [2]. Petrographic characteristics of the Eskiçeltek and Yeniçeltek coals also indicate a lacustrine environment. The TPI and GI ratios for the coals plot in limno-telmatic fields where the peats accumulated between high and low water table. This result is supported by the presence of a minor amount of inertinite and cutinite within coal samples from both basins. The presence of alginite and significant amount of attrinite, densinite and corpohuminite type macerals in the Suluova samples are also important evidence. Additionally, some vertebrate bones, turtle fossils and teeth are also occasionally found within the Yeni Çeltek coal seam [6]. The Lutetian (Middle Eocene) Salıpazarı (Bolu) coals were deposited under limnic conditions [5]. The Çeltek and Armutlu samples are composed mainly of Type II and Type III kerogens and organic matter are chiefly derived from terrestrial sources [10].

## 2. Geological setting

The northern Anatolian region is located in the Pontide Tectonic Unit [11]. The basement of this unit comprises metamorphic and ophiolitic rock assemblages overlain by the Tertiary sequences. The Eocene sediments in the Bolu, Kastamonu and Amasya provinces contain economically important coal deposits. The stratigraphic columnar sections and geological maps of the studied regions are shown in Figs. 2–5.

### 2.1. Suluova and Armutlu coal fields

Suluova and Armutlu coal fields are located at 25 km northwest of Amasya. Cretaceous limestones are the older basement lithologies in the Amasya region. This unit is overlain unconformably by the Eocene clastics with a thickness of 500 m. The Eocene sequence is divided into three formations: the coal-bearing Çeltek formation at the bottom, the coal-bearing Armutlu formation in the middle and the Osmanoğlu formation at the top (Figs. 2A and 3). Eocene units covered unconformably with the Pliocene deposits ([3,5]). Coal bearing strata in the Amasya region are located at two different fields, namely, the Suluova (Eskiçeltek and Yeniçeltek) and Armutlu fields. The thickness of the coals in the Eskiçeltek open pit field is approximately 5 m (Fig. 6B) and 2 m in thickness in the gallery of the Yeniçeltek field (Fig. 6A). Claystones comprise the basement of the sequence, and shales rich-in organic matter are observed at the upper part of the sequence. The proven and probable reserves in the basin are 2 and 17 million tons, respectively. The measured thickness of the coals is 90 cm in the gallery of the Armutlu field, where both the basement and roof rocks are composed only of claystones (Fig. 6C). The estimated total coal reserve in this field is about 750,000 tons. Regional tectonic movements through the Late Alpine tectonism affected intensively the region and caused the volcanic activities. Strike-slip faults that affect the basement rocks appear mostly NW-SE and NE-SW

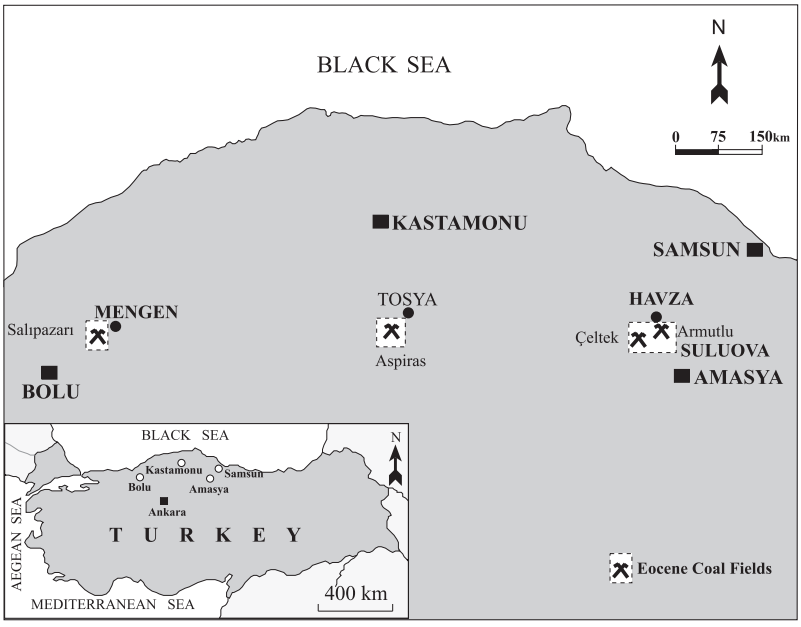


**Fig. 1.** Location map of Eocene coal fields.