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Eocene benthic foraminiferal assemblages from Central Anatolia (Turkey): Biostratigraphy, stable isotope data, paleoenvironmental and paleontological interpretations

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ABSTRACT

Stable isotope ($\delta^{13}C$ and $\delta^{18}O$) values from Eocene aged shallow marine deposits in two different basins (Haymana and Kırşehir-Kaman) of Central Anatolia and benthic foraminiferal biostratigraphy's corresponding sequences were analyzed to determine paleontological and paleoenvironmental changes. The shallow marine units (Çayraz and Altıpınar formations), deposited as a result of different geological processes in the same period, show differences in paleontological and geochemical properties of the tests. The geological process controlled by environmental factors affect the formation of the chemical structure of foraminiferal calcite. These Lutetian and Bartonian aged formations are represented by five Shallow Benthic Zones. While, the Çayraz section is represented by SBZ 14–18, Boztepe section is represented by SBZ 13–17. With an increase in temperature, the variety of benthic foraminifera decreased, and *Assilina exponens* became the dominant species in the warm conditions. The most important proxy is $\delta^{13}C$, which reflects the paleoproductivity (food supply) where benthic foraminifera lived. In addition, food supply can be considered to be a more important factor than temperature, as it controls the diversity and abundance of benthic foraminifera.

1. Introduction

As well as being the most important carbonate source of their time, foraminifer shells are a major component of many marine sediments (Pearson, 2012). Various environmental conditions, such as temperature, salinity, depth, food source, and oxygen, control the variety and distribution of foraminifera. Combinations of parameters, such as environmental conditions, water chemistry, biological processes, and living references (extant species) determine the geochemical structure of calcite in foraminifera. For this reason, geochemical proxies (trace elements, heavy metals, stable isotopes, etc.) belonging to the carbonate shells hold key pieces of evidence about the foraminiferal environment and the ocean and climatic conditions at the time (Shackleton and Kennett, 1975; Thomas and Shackleton, 1996; Billups and Schrag, 2002, 2003; Katz et al., 2003; Yu and Elderfield, 2007; Katz et al., 2010; Gebhardt et al., 2013). As food supply and oxygen concentration are the primary parameters affecting the distribution of benthic foraminifera, the abundance of specific benthic foraminifera can be used to determine the presence of food and oxygen in past times (Lutze, 1978; Schnitker, 1979; Miller and Lohmann, 1982; Katz and Miller, 1993; Gooday, 1994; Rathburn and Corliss, 1994; Smart et al., 1994; Jorissen et al., 1995; Thomas and Gooday, 1996; Bernhard et al., 1997; Schmiedl et al., 1997; Cannariato and Kennett, 1999; Gooday and Rathburn, 1999; Van Der Zwaan et al., 1999; Kaiho, 1999; Schmiedl et al., 2000; Morigi et al., 2001).

In this study, the shallow marine Eocene deposits in the northern branches of the Neo-Tethys were analyzed for benthic foraminiferal content and paleoenvironmental conditions. The Eocene aged Çayraz and Altıpınar Formations and shallow marine units of Haymana Basin and Kırşehir-Kaman Basin in central Anatolia were investigated (Fig. 1). The Çayraz Formation, with a rich fossil content, has been the subject of many paleontological studies to date (Sirel and Gündüz, 1976; Ünalan et al., 1976; Toker, 1979, 1980; Sirel et al., 1986; Özcan, 2002; Özcan et al., 2007; and Sirel, 2010). No detailed paleontological study has been performed for the Altıpınar Formation, however, the relevant unit has been stratigraphically interpreted by Atabey et al. (1988). It was determined that only the Boztepe Member of the formation contained fossils. The same unit was described by Köksal and Göcüoğlu (1997)

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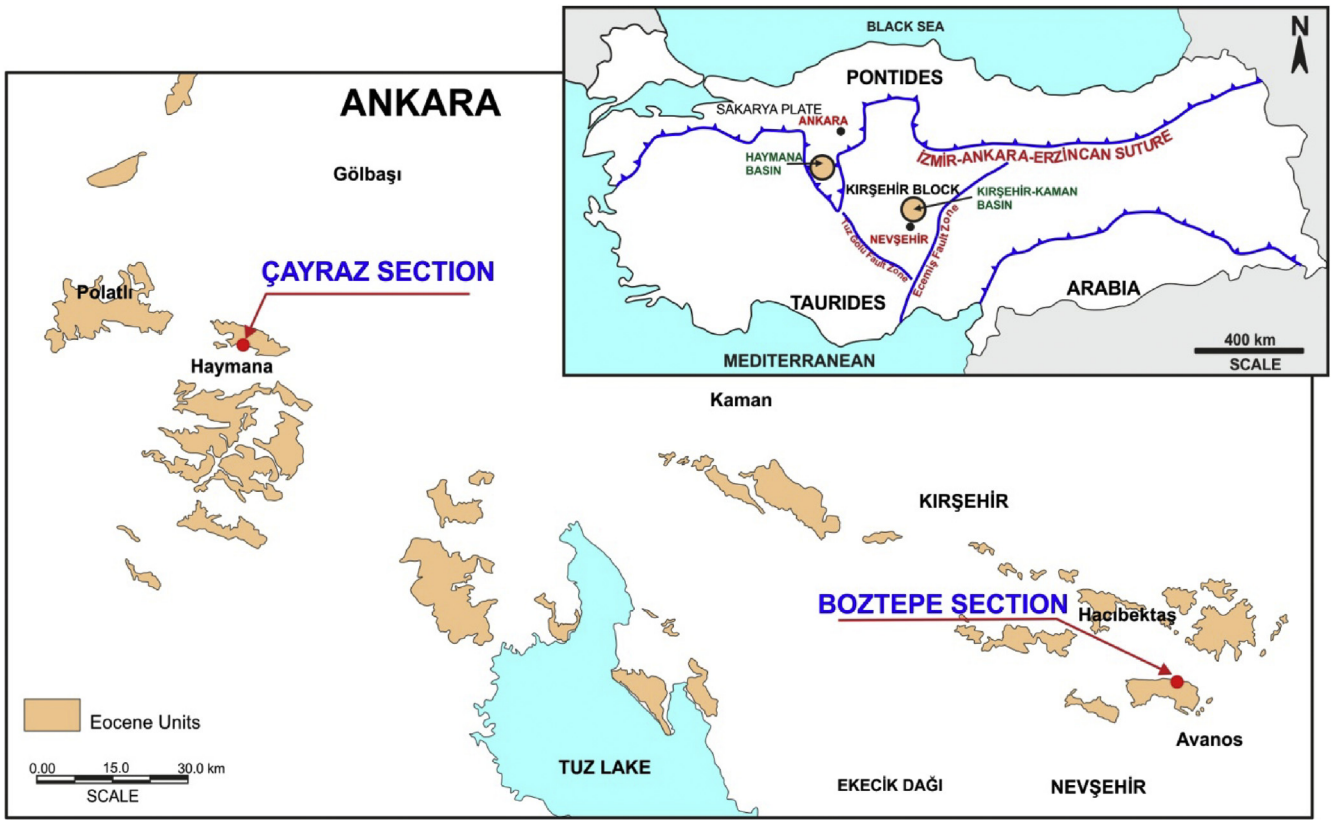

Fig. 1. Location map of the Haymana Basin and the Kırşehir-Kaman Basin showing the measured stratigraphic sections and the main Eocene units in central Anatolia.

as the Ayhan Member of the Mucur Formation.

The aim of present study is to identify environmental conditions that affected benthic foraminiferal distribution, abundance and variety, based on micropaleontological and stable isotope ($\delta^{13}C$ and $\delta^{18}O$) data. The biostratigraphic and paleoenvironmental interpretations on the composition of the benthic foraminifers were also discussed.

2. Materials and methods

A combination of field and laboratory techniques were used in the study, including measured stratigraphic sections of Çayraz in the Haymana Basin and Boztepe in the Kırşehir-Kaman Basin, orientated rock thin sections, preparation of fossil thin sections, stable isotope analysis, and paleontological identification. All paleontological, sedimentological and geochemical analyses were carried out on the 203 m and 63 m thick Çayraz and Boztepe measured stratigraphic sections. Initially, foraminiferal shells are obtained throughout the sections from 22 points on the Çayraz section and 9 on the Boztepe section. After that, 599 shell thin sections and 15 orientated rock thin sections were prepared at the laboratory to define biozones on the basis of species and type descriptions. The shallow benthic foraminiferal biozones were defined based on Serra-Kiel et al. (1998a, b). Diversity and distribution ratios of benthic foraminifera were defined for each section. The samples from which shell thin sections were made were taken as a basis for this. To achieve this aim, benthic foraminifera were divided into three groups at each sample point as small (diameter <5 mm), medium (5 mm–10 mm) and large (>10 mm). 10 thin sections were taken from each group, making 30 thin sections from each point and an overall total of 599 shell thin sections (Fig. 2a). Based on the descriptions, a percentage ratio was determined for each species at that sample point. Percentage (%) abundances of benthic foraminifera and the Shannon Index (Shannon and Weaver, 1949) were also used to evaluate the diversity and abundance of species in this study. Generally, the Shannon Index varies between 0 and 5 (De Benedictis, 1973; Washington, 1984), with values varying between 1.0 and 1.5 indicating low diversity. If the value is close to 5, it can be stated that diversity is high.

Isotope analyses were carried out in the Geology Department of University of Georgia, United States of America. Isotope analyses were carried out using the method modified by Mc Crea (1950). The samples used in the analyses were prepared by grinding up tests of benthic foraminifera with an agate mortar (Fig. 2b). To minimize the effects of life features and micro-environmental factors, the sampling strategy recommended by Katz et al. (2010) was used during sample selection in which different types of a single species (monogeneric) are sampled. For this sampling, types belonging to the *Nummulites* genus were used, as they were abundant in the sections used in this study (Fig. 2c). In the analysis, approximately 5 mg of sample was reacted with 50 °C 100% phosphoric acid. CO_2 was placed into react in a vacuum. The Finnigan MAT252 mass spectrometer was used in the analysis. The isotope results of the samples were normalized using a dual point scale, with $\delta^{13}C$ and $\delta^{18}O$ values given according to Vienna Pee Dee Belemnite (VPDB) standards. 21 tests (17 Haymana and 4 Boztepe) and 9 rocks (4 Haymana and 5 Boztepe) were used to make a total of 30 $\delta^{13}C$ and $\delta^{18}O$ analyses.

3. Geological setting and stratigraphy

The current tectonic structure of Turkey developed during the late Mesozoic and Cenozoic with the closure of the Neo-Tethys Ocean (Şengör and Yılmaz, 1981). The northern part of the Neo-