Sedimentological and Geochemical Records of Lower Cretaceous Carbonate Successions Around Trabzon (NE Turkey): Implications for Paleoenvironmental Evolution and Paleoclimatological Conditions of Tethys

Merve Özyurt, M. Ziya Kirmaci, İ. Ömer Yılmaz, and Raif Kandemir

Abstract

Upper Jurassic–lower Cretaceous carbonates (Berdiga Fm.) are widely exposed in the NE Turkey. An integrated study of sedimentological and geochemical analysis was carried out on the lower Cretaceous carbonates of Berdiga Fm. in Trabzon area in order to reveal the paleoenvironmental and paleoclimatological conditions of northern Tethyan Ocean. Three microfacies types were identified corresponding to inner to slope environments. Inner platform environment developed during the Hauterivian–Aptian interval. End of the Aptian, syn-sedimentary extensional tectonic regime might probably have caused the progressive deepening of the environment, so the inner platform environment evolved into an outer platform and then into slope during the late Aptian–Albian time. Additionally, $\delta^{18}O$ stable isotope values of the belemnites of studied section indicate that paleotemperature ranged between 25 and 26 °C during Aptian–Albian interval. Therefore warm Cretaceous climate conditions were recorded in the Eastern Pontides.

Keywords

Carbonates • Paleotemperature • Paleoenvironment NE Turkey

M. Özyurt (✉) · M. Ziya Kirmaci
Department of Geological Engineering, Karadeniz Technical University, 61080 Trabzon, Turkey
e-mail: merveyildiz@ktu.edu.tr

İ. Ömer Yılmaz
Department of Geological Engineering, Middle East Technical University, 06800 Ankara, Turkey

R. Kandemir
Department of Geological Engineering, Recep Tayyip Erdoğan University, 53100 Rize, Turkey

1 Introduction

The upper Jurassic–lower Cretaceous carbonates crop out extensively along with EW trending belt at the northern part of Turkey. They have the potential to serve as an excellent archive for paleoenvironment and paleoclimatic record of northern Tethyan Ocean (Fig. 1f). The carbonates successions in the western part of Turkey are well documented [1]. However, only a few studies studied the coeval carbonates that crop out in the eastern part of this belt [2]. Therefore, our study focused on the eastern part of Turkey (Fig. 1c, d) presenting new microfacies records of the lower Cretaceous carbonates, corroborated by detailed stable isotope analysis aimed at inferring paleoclimatic and paleoenvironmental conditions in NE Turkey.

2 Methods

Samples were collected from the studied stratigraphic section in Trabzon (NE Turkey) (Fig. 1a, c, d) and were examined under a polarizing microscope to determine the microfacies. Microfacies types were described and interpreted based on the textural and compositional characteristics [3, 4]. Stable isotope analyses ($\delta^{18}O$ and $\delta^{13}C$) of selected samples (belemnite) were conducted at the laboratories of the Friedrich-Alexander Universität Erlangen-Nürnberg (FAU). Carbonate powders were reacted with 100% phosphoric acid at 70 °C using a Gasbench II connected to a Thermo Fisher Delta V Plus mass spectrometer. All values are reported in per mil relative to V-PDB.

3 Results

3.1 Microfacies

In the study area comprising one of the rare typical exposures of the formation, the lower part is completely

Z. Zhang et al. (eds.), *Patterns and Mechanisms of Climate, Paleoclimate and Paleoenvironmental Changes from Low-Latitude Regions*, Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-030-01599-2_5

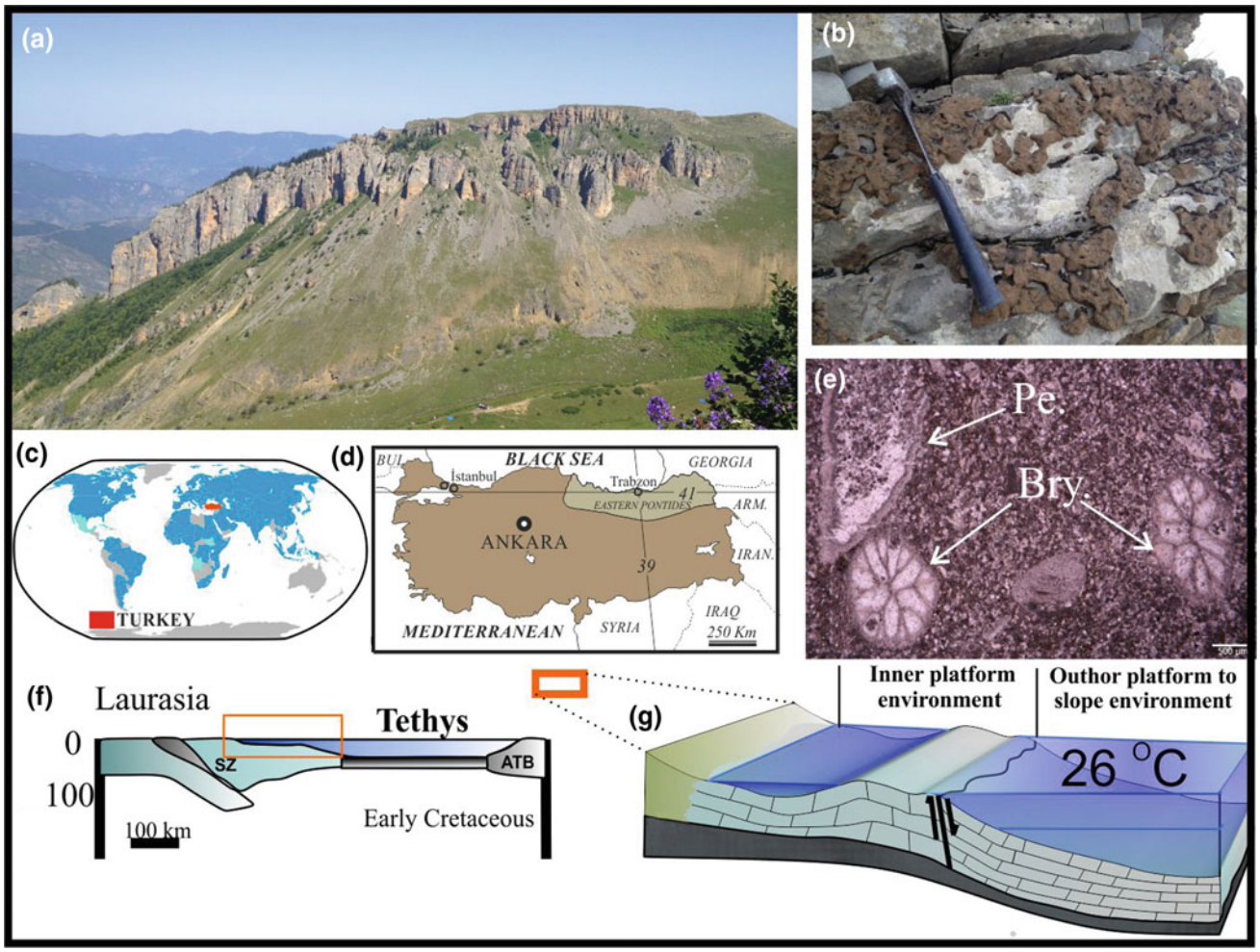

Fig. 1 **a** Field view of the section. **b** Limestone with chert nodules. **c** and **d** Location of study area. **e** Photomicrograph of the outer platform, Pe: pelecypoda, Bry: Bryozoa. **f** Schematic cross section of the NE Turkey (SZ) and **g** paleoenvironmental reconstruction of the study area

dolomitized. The middle and upper parts of the section are represented by grey-beige colored and medium-thick bedded limestone. General fauna community consists of benthic foraminifera. In addition, different facies contain echinoderm, belemnite, brachiopoda, pelecypoda, gastropoda, ostracoda, algae, sponge spicules and radiolaria with changing density. The middle and upper parts of the section are characterized by three different microfacies in time. (1) Benthic foraminiferal/peloidal packstone microfacies: The dominant carbonates are skeletal grains with an important amount of benthic foraminifera and pelloids. The fossil content of the facies indicates that these rocks were deposited in the interval of Hauterivian–Aptian times. (2) Allochtonous skeletal packstone microfacies: Almost all the entire carbonate component has been reworked, most of which are skeletal grains. Another important component is authigenic glauconite. (3) Sponge spicule packstone/wackestone microfacies: The carbonate components of these layers are generally represented by small benthic foraminifera and pelagic skeletal grains including radiolaria, calcisphere and Microhedbergellagi. The presence of *Microhedbergella rischi* indicates that the age of the facies is no older than late Albian [5].

3.2 Stable Isotope Analysis

Average $\delta^{13}C$ and $\delta^{18}O$ values of fossils are 1.47 and −3.57 respectively. The values agree well with early Cretaceous seawater, which enable us to reconstruct paleotemperature evidence. Paleotemperature calculations have been $14\ \Delta c + 0.13\ \Delta c^2$ [6]. $\delta^{18}O$ values for the non-glacial period were considered as −1.2 per mil (SMOW) [7]. The $\delta^{13}C$ curve of the whole sequence is sketched and correlated with published the $\delta^{13}C$ curve of the lower Cretaceous [8]. Moreover, the average temperature value for the fossil samples was taken as 26 °C.

4 Discussion

The middle part of the section is represented by benthic foraminiferal/peloidal packstone microfacies. According to benthic foraminifers, peloids, the lack of biodiversity and the muddy texture suggest that these beds were deposited on lagoon during the Hautrivian–Aptian. MF-1 corresponds to SMF18 [4]. Starting from the late Aptian, the inner platform environment changed into an outer platform with an abrupt transition to allochthonous facies. The predominance of bioclastic debris flow and local glauconitic grains imply that MF-2 deposited in the outer-platform to toe-of-slope (Fig. 1e, b). MF-2 corresponds to SMF 5-6 [4]. The gradual transition to the overlying MF-2, predominance of mud-rich texture, decrease in abundance of allochthonous fragments and presence of the planktonic organism indicate that the depositional environment was deeper and changed into a slope environment during the late Albian. MF-3 corresponds to SMF 3 [4] (Fig. 1g).

$\delta^{18}O$ values of the carbonates have widely been used to reconstruct the sea surface paleotemperature of the Tethyan Ocean and carbon isotope profiles were used for higher resolution stratigraphic correlations [9]. Therefore, carbon values derived from bulk rock samples and fossil shells were used to reconstruct paleoceanographic events and correlated with global and European carbon isotope profiles. Temperature value (26 °C) was conformable with the temperature interval recorded in the upper Barremian–lower Albian successions of the Caucasus and Russian basins [10]. Based on the paleotemperature analysis and carbon isotope profiles, a warm Cretaceous climate was characteristic of NE Turkey.

5 Conclusions

Microfacies analyses suggest that the inner platform environment existed during the Hauterivian–Aptian. However, the syn-sedimentary extensional tectonic regime might have caused the progressive deepening of the environment during the late Aptian–Albian time. So the inner platform evolved into an outer platform to a slope environment. Based on paleotemperature analysis and carbon isotope profiles a warm Cretaceous climate was characteristic of NE Turkey (Fig. 1f, g).

Acknowledgements The authors would like to thank Karadeniz Technical University (Project no.: FBA-2015-5160) and TUBİTAK (ÇAYDAG, Project no.: 115Y005 and International PhD Research Scholarship Program-2214-A-BIDEP) for their financial support. The authors wish to thank Prof. Dr. Ihsan Al-Aasm (University of Windsor, Canada) for his support and Prof. Dr. Kemal TASLI (Mersin University, Turkey) for the foraminifera determinations.

References

1. Yılmaz, C.: Platform–slope transition during rifting: the mid-Cretaceous succession of the Amasya region (northern Anatolia), Turkey. J. Asian Earth Sci. **27**(2), 194–206 (2006)
2. Vincent, S.J., Guo, L., Flecker, R., BouDagher-Fadel, M.K., Ellam, R.M., Kandemir, R.: Age constraints on intra-formational unconformities in upper Jurassic-lower Cretaceous carbonates in northeast Turkey; geodynamic and hydrocarbon implications. Mar. Petrol. Geol. **91**, 639–657 (2018)
3. Dunham, R.J.: Classification of Carbonate Rocks According to Depositional Textures (1962)
4. Flügel, E.: Microfacies Analysis of Carbonate Rocks. Analysis, Interpretation and Application. Springer, Berlin (2004)
5. Huber, B.T., Leckie, R.M.: Planktic foraminiferal species turnover across deep-sea Aptian/Albian boundary sections. J. Foramin. Res. **41**(1), 53–95 (2011)
6. Sharp, Z.D.: Principles of Stable Isotope Geochemistry, 2nd edn, p. 310. http://digitalrepository.unm.edu/unm_oer/1 (2017)
7. Vincent, B., Emmanuel, L., Houel, P., Loreau, J.P.: Geodynamic control on carbonate diagenesis: petrographic and isotopic investigation of the upper Jurassic formations of the Paris Basin (France). Sediment. Geol. **197**(3), 267–289 (2007)
8. Scott, R.W.: Barremian–Aptian–Albian carbon isotope segments as chronostratigraphic signals: numerical age calibration and durations. Stratigraphy **13**, 21–47 (2016)
9. Price, G.D., Passey, B.H.: Dynamic polar climates in a greenhouse world: evidence from clumped isotope thermometry of early Cretaceous belemnites. Geology **41**(8), 923–926 (2013)
10. Zakharov, Y.D., Kakabadze, M.V., Sharikadze, M.Z., Smyshlyaeva, O.P., Sobolev, E. S., Safronov. P.P.: The stable O- and C-isotope record of fossils from the upper Barremian-lower Albian of the Caucasus-paleoenvironmental implications. Cretac. Res. 1–19 (2017, in press)