Foraminiferal Responses to Sea Level Changes Across the Mid-Carboniferous Boundary in Central Taurides (Turkey)

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Abstract

The response of benthic foraminiferal assemblages to relative sea-level changes during the mid-Carboniferous succession of the Yarıcak Formation in the Central Taurides is assessed with respect to sedimentary cyclicity and sequence stratigraphy by quantitative analysis. The data derived from the relative abundances of foraminifera have critical significance in the understanding of cyclic patterns and sea level changes in carbonate deposits. Calcareous foraminiferal groups including archaediscids, eostaffellids, irregularly coiled bilocular forms, unilocular forms, paleotextularids, biseriamminids, endothyrids, and pseudoendothyrids have been counted and analysed in this study. The mid-Carboniferous boundary succession predominantly covering uniform lithology of carbonates alternated with sandstone layers involves shallowing upward cycles used for the revealing of sea-level fluctuations. The relative abundances of these foraminiferal groups reveal a striking response to cyclicity with the reductions in the abundances towards the upper part of the cycles. Conversely, the abundances of pseudoendothyrids and endothyrids do not exhibit any considerable variations within the studied interval.

Keywords: foraminiferal responses, sea level, mid-carboniferous boundary, central taurides, turkey

Introduction

One of the most important bioclastic components in Carboniferous carbonates are calcareous foraminifers . They are more sensitive to environmental conditions and commonly controlled by changes in these conditions hence most of the studies revealed that benthic foraminifers are facies controlled [1–6]. Foraminiferal assemblages serving as important biostratigraphic indicators due to their abundance, diversity, and rapid evolution, play a crucial role in interpreting paleoenvironments closely linked to sea level changes. Most of the studies have used foraminifera as a precise sea-level indicator to determine high-resolution sea-level changes [5,7–12].

Shallow marine carbonates are the best indicators of sea level fluctuations since their deposition is dependent on the parameters such as, water depth, energy, and faunal content [13]. Meter scale depositional cycles defined by the stratal repetition of physical and chemical characters of sedimentary rocks, such as, lithofacies and biofacies, are fundamental stratigraphic units [14]. Stacking patterns of the meter-scale cycles can be used to define large scale sequences, systems tracts and long-term relative sea-level fluctuations [13,15]. The reliability of paleoenvironmental interpretations can be improved by integrating biofacies, lithofacies, biological responses with cyclicity. Subsequently, the purpose of this paper is to conduct quantitative analysis in order to determine the biological response, particularly of calcareous foraminifera, to carbonate cyclicity in shallow subtidal carbonate deposits by integrating foraminiferal records with lithofacies. The studied section in Central Taurides involving chiefly limestone comprises various types of fossils, such as fusulinids, smaller foraminifers, echinids, crinoids, gastropods, brachiopods. The calcareous foraminiferal groups considered for this study are the principal forms within the studied section. The main groups used in the analyses are archaediscids, eostaffellids, irregularly coiled bilocular forms, unilocular forms, endothyrids, pseudoendothyrids, paleotextularids and biseriamminids.

Study Area

The study area is located in the Aladağ Unit of [16,17] approximately 10 km southwest of the town of Hadim in the Central Taurides (Figure 1). In the study area, Devonian – Triassic carbonate deposits of the Aladağ Unit are widely exposed and the Upper Paleozoic succession, in particular, is nearly complete. The stratigraphic section, consisting of a 26 m-thick succession, has been studied previously by [18] and [19]. The section comprising the mid-Carboniferous boundary embraces the Mantar Tepe member of the Yarıcak Formation (Figure 1). The succession is mainly characterized by limestone and sandstone intercalations. The succession starts with quartz arenitic sandstones at the base and continues upward with peloidal grainstones rich in quartz grains intercalated with quartz arenitic sandstones [18,19]. It passes upward into bioclastic and oolitic grainstones containing abundant microfossils and ooids [18,19]. The middle of this interval includes a prominent dark calcareous mudstone facies. Towards the upper part of the section, oolitic grainstones with quartz grains and quartz arenitic sandstones become dominant [18,19]. This interval is overlain by oolitic and bioclastic grainstones including mudstone level in the upper part [18,19].

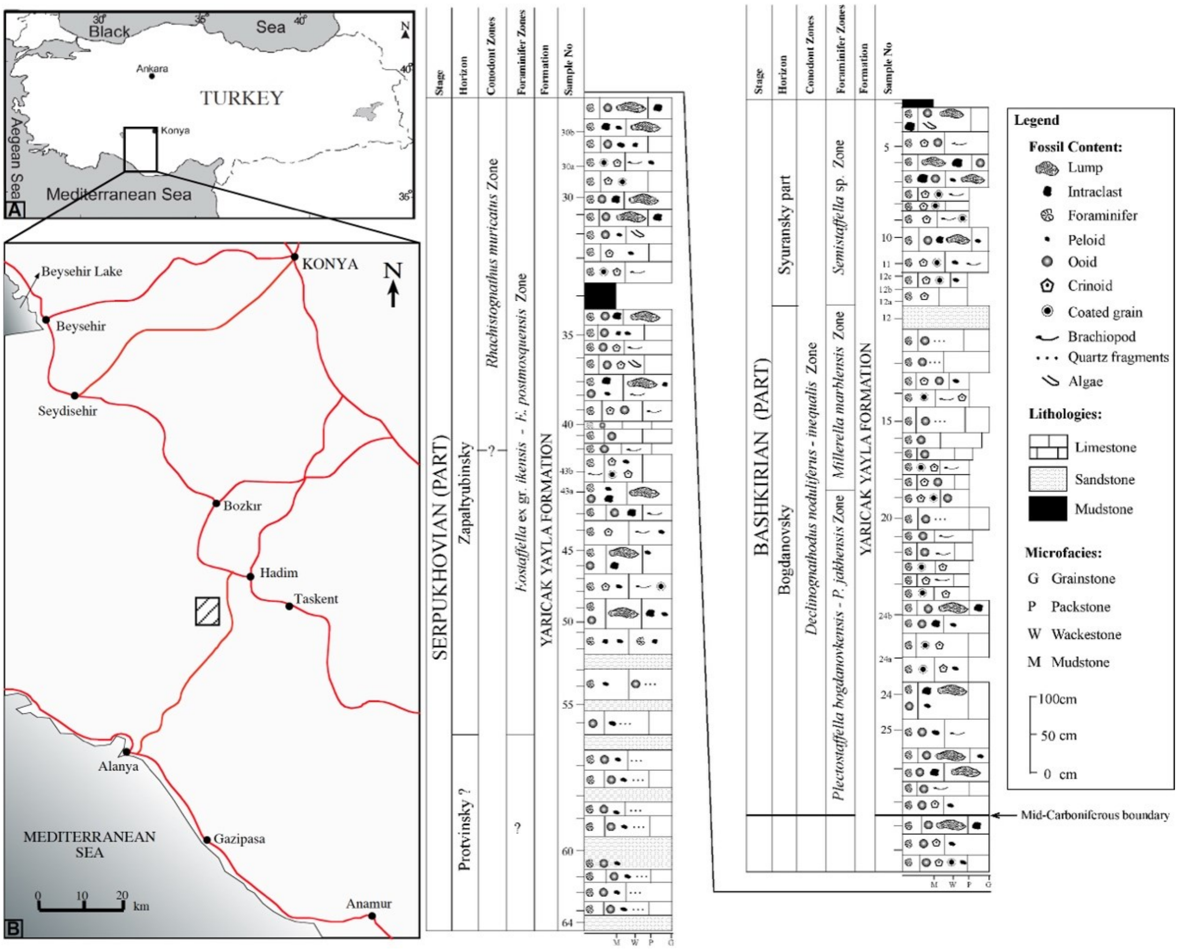

Fig. 1. Geographic setting of the study area and the columnar stratigraphic section of the studied succession displaying the position of mid-Carboniferous boundary [19,20].

Biostratigraphy and Cyclicty

The studied section is divided into four foraminiferal zones corresponding in age to the Zapaltyubinsky, Bogdanovsky and Syuransky horizons the Eostaffella ex gr. ikensis – E. postmosquensis Zone, the Plectostaffella bogdanovkensis – P. jakhensis Zone, Millerella marblensis Zone and Semistaffella sp. Zone by [18,19]. Additionally, [20] have described two conodont zones within the section as the Rhachistognathus muricatus Zone and the Declinognathodus inaequalis - Declinognathodus noduliferus Zone. The mid-Carboniferous boundary has been delineated at the base of the sample HB-27, coincident with the boundary between the Rhachistognathus muricatus and Declinognathodus noduliferus - inaequalis conodont zones [20] and Eostaffella ex gr. ikensis - Eostaffella postmosquensis and the Plectostaffella bogdanovkensis - P. jakhensis foraminiferal zones of [18,19] (Figure 1). Based on the detailed microfacies studies of mid-Carboniferous carbonates eight different microfacies types were documented in the studied interval [19]. The defined microfacies are coated crinoidal packstone, coated bioclastic grainstone, oolitic grainstone, oolitic packstone-grainstone, intraclastic grainstone, mudstone-wackestone, quartz-peloid grainstone, and quartz arenitic sandstone which are assembled to four distinct depositional belts (peritidal flat, lagoon, oolitic shoal, and open marine) [19] (Figure2). The stacking patterns of these microfacies depict shallowing upward cycles in the Yarıcak Formation and the genetic organization of those shallowing upward meter-scale cycles has yielded cycles of higher order (Figure 2). Based on the vertical evolution of microfacies and the interaction of cycle types within the studied mid-Carboniferous boundary beds, two depositional sequences and part of a third sequence have been determined by abrupt facies changes [19].

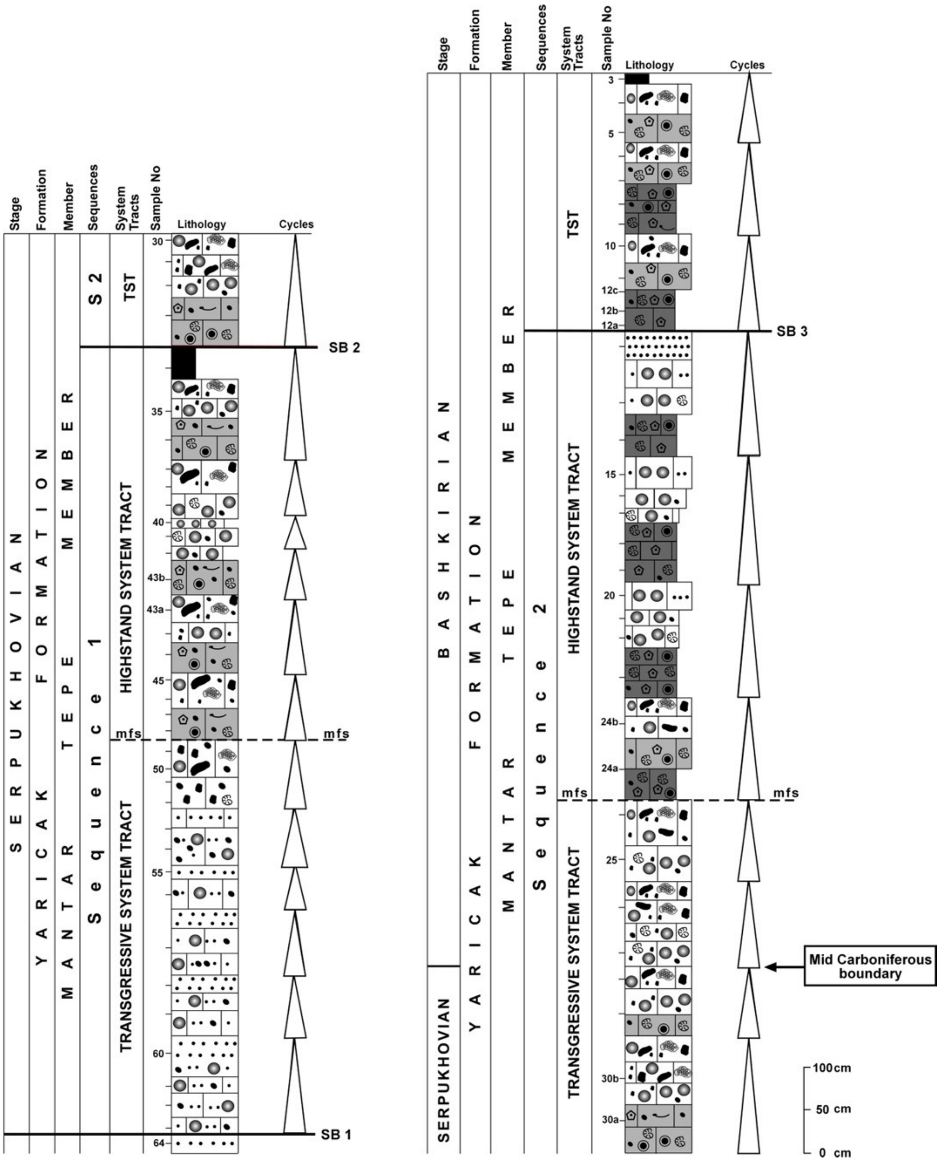

Fig. 2. Meter scale shallowing-upward cycles and sequences in the mid-Carboniferous boundary beds in the Central Taurides [19].

Foraminiferal Responses to Sedimentary Cycles

The abundance of foraminifera provides useful tools in determining shallowing upward cycles. A crucial quantitative study has been carried out in order to determine the biological response of foraminifera to carbonate cyclicity in the studied shallow subtidal carbonate deposits. The sequences recognized in the mid-Carboniferous succession may result from the sea-level variation. In order to test the response of foraminifers to cyclicity within the studied succession, a number of counting experiment has been carried out with a point counter. A total of 62 Carboniferous species are broadly categorized into 8 groups, archaediscids, eostaffellids, irregularly coiled bilocular forms, unilocular forms, paleotextularids, biseriamminids, endothyrids, and pseudoendothyrids. In most of the cycles, the total abundance of counted forms presents a good response to cyclicity. Although there are some variations within the cycles, the total abundance presents a decreasing trend toward the top of the shallowing upward cycles. The responses of archaediscids and eostaffellids similar to those of the total abundance of foraminifera express consistent responses to sedimentary cyclicity (Figure 3). Similarly, the relative abundances of unilocular forms, paleotextularids, irregularly coiled forms, and biseriamminids are dominant at the bottom of the cycles and less at the top (Figure 3). Though, the faunal variations within some cycles are not significant and the abundances of pseudoendothyrids and endothyrids do not display any considerable variations so do not give any remarkable response to sea level changes (Figure 3). Principally, the total abundance of counted foraminifera points out the deepening and shallowing responses in the studied section. The general trend obtained from the point counting results exhibits that the total abundance of foraminifera increases at the bottom of the cycles as a sign of a deepening trend. However, the abundance decreases at the top of the cycles, which is probably evidence of a shallowing trend. In addition to the abundance of the foraminifera, the volume of dark clasts and lumps also specifies a good response to cyclicity. Towards the upper part of the cycle, the volume of these grains increases in contrast to the abundance of foraminifera.

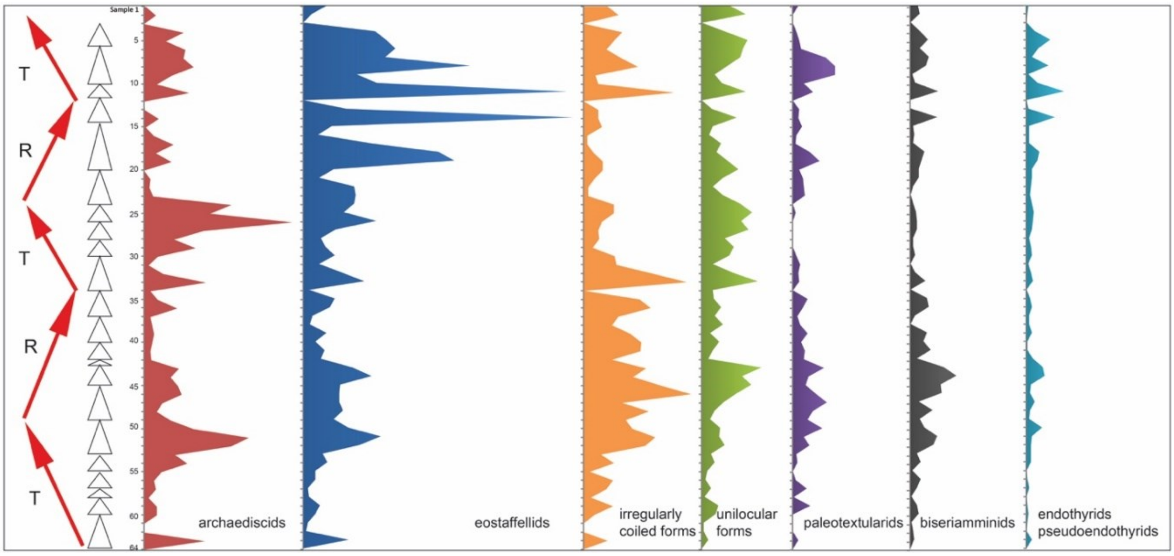

Fig. 3. The abundances of bentic foraminiferal groups including archaediscids, eostaffellids, irregularly coiled bilocular forms, unilocular forms, paleotextularids, biseriamminids, endothyrids, and pseudoendothyrids across the mid-Carboniferous boundary beds in Central Taurides.

Conclusion

The benthic foraminiferal groups acquired from the mid-Carboniferous boundary beds within the Yarıcak Formation in Central Taurides have been investigated to determine the response to sea level changes. The relative abundances of the benthic foraminiferal groups provide insights into the sedimentary cyclicity by quantitative analysis to understand the sea level changes during the mid-Carboniferous. The results of quantitative analysis of benthic foraminifera have been used to demonstrate the biological response to cyclicity. Within the studied section, foraminiferal assemblages are diverse and the abundances of foraminifera reveal a proper response to sedimentary cyclicity. In general, the abundance of foraminifera increases in bioclastic and coated-grain grainstone facies which occur at the bottom of cycles, and decreases in sandy oolitic grainstone and sandstone facies which mainly caps the cycles. Eostaffellids, archaediscids, unilocular forms, and irregularly coiled bilocular forms are the calcareous foraminiferal groups responding to the meter-scale cycles.

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