IJES *Iranian Journal of Earth Sciences*
Vol. 11, No. 1, 2019, 47-55.

Calcareous nannofossils from chalky limestone intervals of the Abderaz formation in the Kopet Dagh range, NE Iran

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Received 4 February 2017; accepted 24 March 2018

Abstract

A biostratigraphic study based on calcareous nannofossils was performed on the chalky limestone from the Abderaz Formation in the Mozduran section (Kopet Dagh basin, NE Iran). Semiquantitative estimates of total nannofossil and single species abundances showed that calcareous nannofossil assemblages are common and their preservation is good. In this study 37 species have been identified in chalky limestone beds. The following biohorizons were identified: the first occurrence (FO) of *Broinsonia parca parca*; the last occurrence (LO) of *Marthasterites furcatus*; the FO of *Ceratolithoides aculeus*; and the FO of *Uniplanarius sissinghii*. Based on nannofossil assemblages' four biozones were determined in this section which is the time equivalent of UC14 to UC15cTP of (Burnett 1998), and CC18 to CC21 of (Roth et al. 1986). According to present biozones, early Campanian to early late Campanian ages are suggested. Calcareous nannofossils allow the detailed reconstruction of paleoecological trends in the chalky limestone beds. The chalky limestone of the Abderaz Formation was deposited in a shallow-marine environment, at relatively low latitude with low primary productivity.

Keywords: *Calcareous nannofossil, Chalky limestone, Abderaz, Kopet Dagh, Iran*

1. Introduction

The Kopet Dagh orogenic belt constitutes an inverted basin extending from the east of the Caspian Sea to NE Iran, Turkmenistan and northern Afghanistan (Afshar-Harb 1979; Buryakovsky et al. 2001). Following the closure of the Palaeo-Tethys in the Middle Triassic (Alavi et al. 1997) and the opening of the Neo-Tethys during the Early to Middle Jurassic (Buryakovsky et al. 2001), the Kopet Dagh Basin formed in an extensional regime during the Middle Jurassic. Over 6000 m of sediments ranging in age from Middle Jurassic to Miocene were deposited in the basin (Afshar-Harb 1979). Jurassic– Cenozoic carbonates and siliciclastics unconformably overlie Paleozoic (basement) and Triassic rocks (Thierstein 1976).One of the Cretaceous units in the Kopet Dagh basin is the Abderaz Formation that is located in eastern Kopet Dagh and is composed mainly of shale, and three to four chalky limestone intervals. The earliest paleontological studies of the Abderaz Formations have focused on foraminifera (Afshar-Harb 1969; Sissingh 1977). Some sedimentologic investigations have been also performed by (Moussavi-Harami 2009), previous nannofossils studies of the Abderaz Formation were done on the whole of Abderaz Formation, but a study on calcareous nannofossils of the chalky limestone bands of this formation has not been carried out.

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Only (Hadavi et al. 2002) have studied the uppermost chalky limestone of this formation in East Kopet Dagh. Therefore, in the present research for the first time detailed studies of calcareous nannofossils under the optical microscope of samples from the three intervals of chalky limestone of the Abderaz Formation in the Mozduran section were performed. The aim of this study is to determine the calcareous nannofossil assemblages, to discuss the possibility of applying standard zonations, and interpretation of the paleoecological conditions of chalky limestones from Abderaz Formation.

2. Geological framework

The Abderaz Formation is exposed in the east of the Kopet Dagh basin and occur between the Aitamir Formation below and the Abtalkh Formation above. Thickness of the Abderaz Formation increases in the eastern Kopet Dagh from 500 meters in the southeast (Shurijeh) to 1,500 meters in the northwest Taherabad (Afshar-Harb 1969).

The studied section at Mozduran(X= 59º 44' 41"; Y= 36º 59' 42") is located in the Kopet Dagh basin, northeast Iran which is 530 km off the main access road of Mashhad to Sarakhs. The Abderaz Formation in the Mozduran section trends NW-SE (Fig 1) and is a unit of prevailing monotonous bluish- grey to light green- grey shale, marly limestone and limy marl with three intervals of chalky limestone; the thickness of the first chalky limestone unit is 16 meters, the thickness of the

second is 16 meters, and the thickness of the third is 4 meters (Fig 2). For this study, samples from the 3 units of chalky limestone of the Abderaz Formation (Fig 3) were taken.

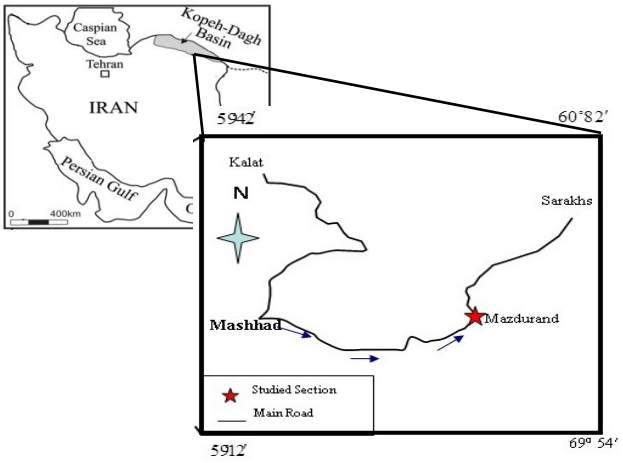

Fig 1. Sample locality of Abderaz Formation in the Mozduran section (Kopet Dagh basin).

3. Material and methods

Three intervals of chalky limestone are well exposed in the Abderaz Formation along the Mozduran section (Fig 2). Smear slides for calcareous nannofossil study were prepared for 17 samples of chalky limestone, taken at regularly spaced points along the interval studied. Sample preparation consisted of a simple mechanical crushing of a small piece of rock, its dilution with water and spreading onto a slide. After drying in a stove, the slides were mounted with cover slip. Special care was taken to prepare the samples as homogeneously as possible so that particle density in different slides would be comparable. This preparation technique was used to retain the original composition of calcareous nannofossil assemblages. All the smear slides were investigated for nannofossil content using a polarizing light microscope at 1250x magnification (Plates 1 and 2).Relative abundance analyses were performed with a light microscope and counting at least 300 specimens per sample. Then the percentages of each species for drawing the diagrams were calculated.

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4. Results and Discussion

4.1. Calcareous nannofossils

In the Mozduran section, 37 species of calcareous nannofossilsbelonging to 29 genera were identified. Calcareous nannofossils in these chalky limestone intervals are mainly cosmopolitan and Tethyan taxa that were irregularly distributed throughout the studied intervals. Nannofossils in the studied chalky limestone are generally abundant, and are well preserved, and in these samples, structures of the central area in nannofossil species were identified accordingly (for example pores in *C. ehrenbergii*, bars in *Eiffellithus* spp., (see Plates 1 and 2). In all of chalky limestone intervals consistent record of *Watznaueria barnesae, Calculites obscurus, Lucianorhabdus cayeuxii*, and *Micula decussata* is noticeable in the studied chalky limestone. On the other hand they are present in all of samples.

In the samples from chalky limestone intervals the calcareous nannofossils*Lucianorhabdus cayeuxii*, *Calculites obscurus*, and *Calculites ovalis* have been the subject of considerable attention because of its large variability in size. We distinguished two groups of this species across the Abderaz Formation using the size of them. When observed with the polarizing light microscope, the two groups show a development of the marginal area and size of coccolith. Throughout the chalky limestone intervals, the mean size of *Lucianorhabdus cayeuxii*. *Calculites obscurus*, and *Calculites ovalis* tends to increase relative to other parts of this formation. These evidences indicate distinct ecological preferences that have been inferred for small and large morphotypes of these species, and show that in the chalky limestone intervals living conditions for nannoplankton especially holococcoliths were better than other part of Abderaz Formation.

4.2. Biostratigraphy

Calcareous nannofossils are one of the primary microfossil groups that are very useful for Mesozoic biostratigraphy (Bukry 1973; Roth et al. 1986). The main events in terms of nannofossils have been recognized in the three intervals of chalky limestone in the Mozduran section, as discussed in the following:

- First chalky limestone (samples 31-35):

Lithology: White, thin bedded chalky limestone, with inoceramids and some ammonites

Calcareous nannofossils: *Acuturris scotus, Braarudosphaera bigelowii, Broinsonia parca parca, Bukryaster hayi, Calcicalathina alta, Calculites obscurus, Calculites ovalis, Cribrosphaerella ehrenbergii, Eiffellithus eximius ,Eiffellithus gorkae, Eiffellithus turriseffelii, Eprolithus floralis, Glaukolithus diplogrammus, Lithastrinus grillii, Lithraphidites carniolensis*, *Lucianorhabdus cayeuxii, Lucianorhabdus maleformis,Lucianorhabdus quadrifidus, Marthasterites furcatus, Microrhabdulus belgicus, Micula concava, Micula decussata, Prediscosphaera cretacea, Quadrum gartneri, Quadrum gothicus, Reinhardtites anthophorus, Repagulum parvidentatum, Retecapsa angustiforata, Tranolithus gabalus, Watznaueria barnesae, Watznaueria biporta, Zeugrhabdotus erectus.*

Age:According to the occurrence (FO) of *Broinsonia parca parca* in sample 31 and the last occurrence (LO) of *Marthasterites furcatus* in sample 36, the age of this chalky limestone is Early Campanian which is equivalent to CC18 of (Roth et al. 1986) and UC14 of (Bukry 1973).

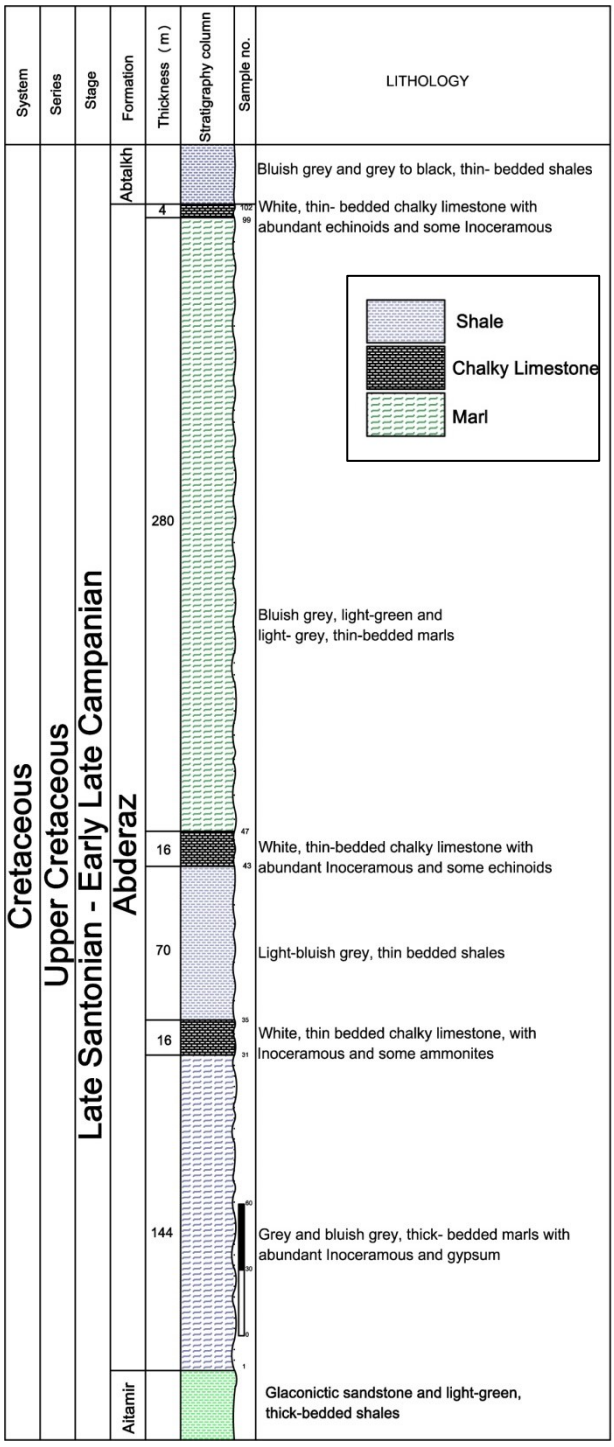

Fig 2. Lithostratigraphic column of the Abderaz Formation in Mozduran section

- Second chalky limestone (samples 43-47):

Lithology: White, thin-bedded chalky limestone with abundant inoceramids and some echinoids

Calcareous nannofossils: *Acuturris scotus, Braarudosphaera bigelowii, Broinsonia parca parca, Calcicalathina alta, Calculites obscurus, Calculites ovalis, Eiffellithus eximius ,Eiffellithus gorkae, Eiffellithus turriseffelii, Eprolithus floralis, Gartnerago segmentatum, Lithastrinus grillii, Lithraphidites carniolensis*, *Lucianorhabdus cayeuxii, Lucianorhabdus quadrifidus, Microrhabdulus belgicus, Microrhabdulus decoratus, Micula concave, Micula decussata, Prediscosphaera cretacea, Quadrum gothicus, Reinhardtites anthophorus, Repagulum parvidentatum, Retecapsa angustiforata, Tranolithus gabalus, Watznaueria barnesae ,Watznaueria biporta, Zeugrhabdotus erectus.*

Age: On the base of FO *Ceratolithoides aculeus* in sample 44, the base of the chalky limestone is late early Campanian which is equivalent to CC20 of (Roth et al. 1986) and UC15bTP of (Bukry 1973).However, we couldn't find any nannofossil marker in the upper part of this interval.

- Third chalky limestone (samples 99-102):

Lithology: White, thin- bedded chalky limestone with abundant echinoids and some inoceramids

Calcareous nannofossils: *Acuturris scotus, Arkhangelskiella specillata, Braarudosphaera bigelowii, Broinsonia parca parca, Calcicalathina alta, Calculites obscurus, Calculites ovalis, Ceratolithoides aculeus, Eiffellithus eximius, Eiffellithus gorkae, Lithastrinus grillii, Lithraphidites carniolensis, Lucianorhabdus cayeuxii, Lucianorhabdus quadrifidus, Microrhabdulus decoratus, Micula concava, Micula decussata, Quadrum gothicus, , Prediscosphaera cretacea, Microrhabdulus Reinhardtites anthophorus, Repagulum parvidentatum, Retecapsa angustiforata, Uniplanarius sissinghii, Watznaueria barnesae, Watznaueria biporta.*

Age: According to the FO of *Uniplanarius sissinghii* at the base of this chalky limestone, the age of this intervals is early late Campanian which is equivalent to CC21 of (Roth et al. 1986) and UC15cTP of (Bukry 1973).

4.3. Paleoecology

Calcareous nannoplankton constitutes one of the most abundant groups of extant phytoplankton and play major roles in marine primary production and consequently they have obvious potential as a key fossil group for paleoecological studies. In the present studies, based on the presence of calcareous nannofossil markers, the following paleoecological interpretations are obtained:

4.3.1. Depth

Nannofossil species such as *Micula decussata* as becoming more abundant with increasing depth, and *W. barnesae* is one of the dominant species that shows a strong inverse correlation with depth on the other hand *W. barnesae* becoming more abundant with decreasing depth (Tavakoli et al. 2007).

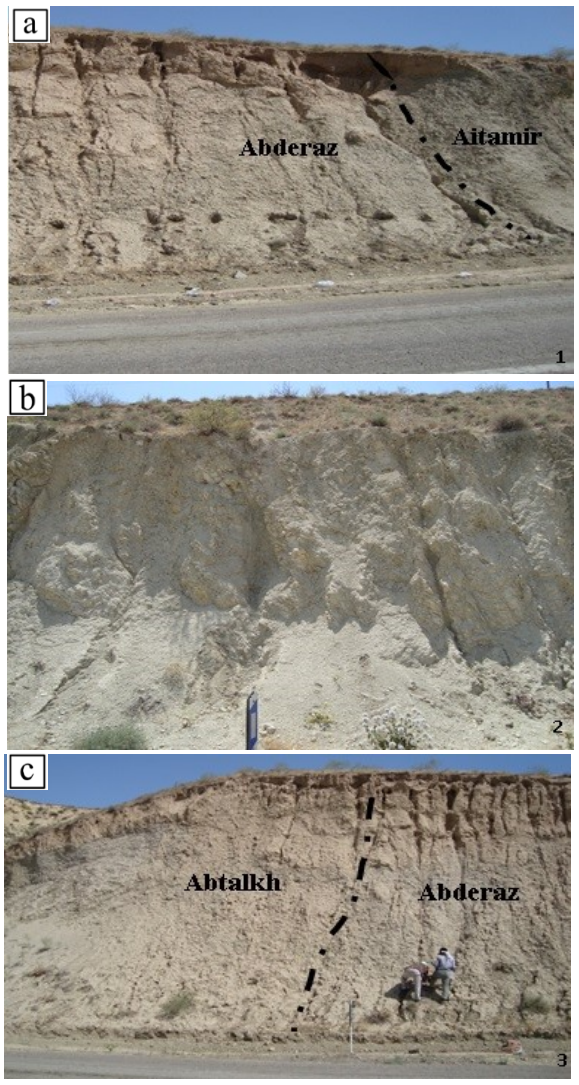

Fig 3. a) The boundary between the Abderaz and Aitamir formations (View to the West), b) The chalky limestone of Abderaz Formation in the Mozduran section, c) The boundary between the Abderaz and Abtalkh formations (View to the West)

Some researchers reported that holococcoliths such as *C.obscurus* and *L. cayeuxii* in coastal region are recorded as abundant (Ulmishek 2004) and abundance of holococolith is high in shallow-waters of the shelf regions (Florindo et al. 2009).

In the three chalky limestone of the Abderaz Formation, abundances of *W. barnesae, C. obscurus* and *L. cayeuxii*decrease from first to third chalky limestone intervals and the abundance of *M. decussata* increases. The average percentage of *W. barnesae* in the first chalky limestone interval is 39.2%, in the second interval 37.6%, and in the third interval 35.1% (Fig 4a). The average percentage of *M. decussata* in the first chalky limestone interval is 7.6%, in the second intervals 12.9%, and in the third interval 17.2% (Fig 4b). The average percentage of *C. obscurus* in the first chalky limestone interval is 7.8%, in the second interval 6.3%, and in the third interval 4.1% (Fig 4c). The average percentage of *L. cayeuxii* in the first chalky limestone interval is 16.1%, in the second interval 11.5%, and in the third interval 7.4% (Fig 4d).

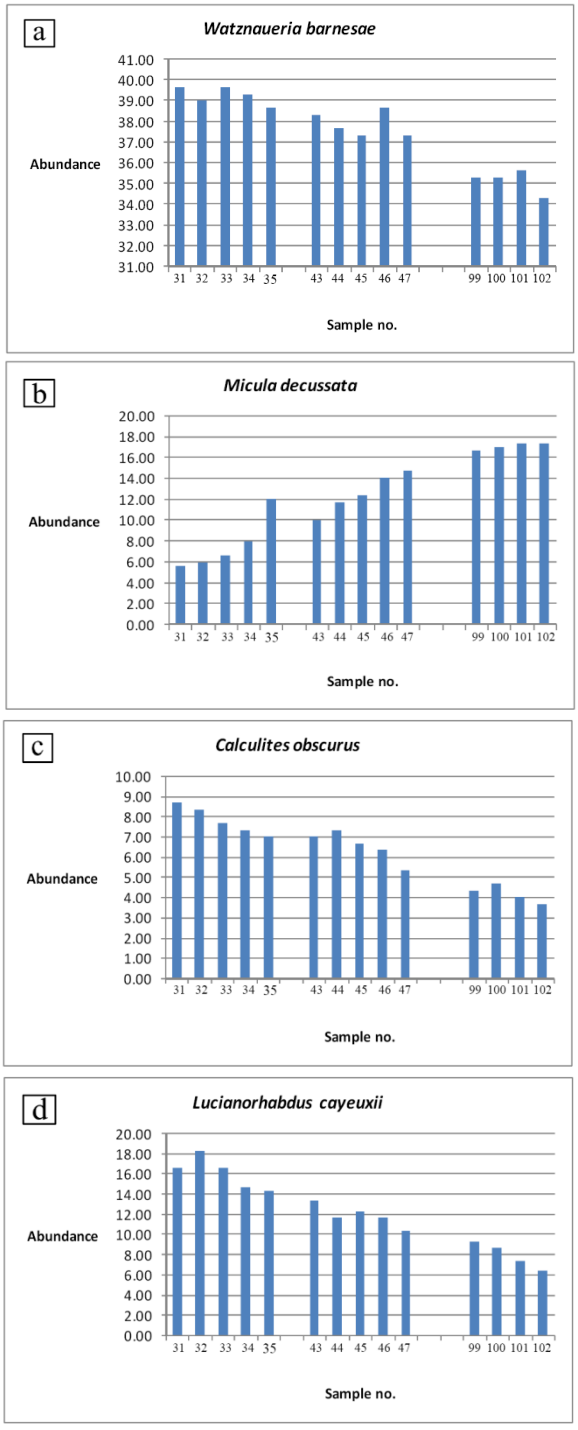

Fig 4. Vertical changes in the relative abundance of the a) *Watznaueria barnesae, b) Micula decussate, c) Calculites obscures* and d) *Lucianorhabdus cayeuxii.*

These observations(increase in abundance of *M. decussata* and decrease in abundance of *W. barnesae* from base to top of the chalky limestone intervals) indicate increase in depth from base to top in chalky limestonein the Mozduran sectionand cooling of waters (Figs 4-5). Therefore it is interpreted that the third chalky limestone was deposited in deeper part of the basin rather than the first chalky limestone.

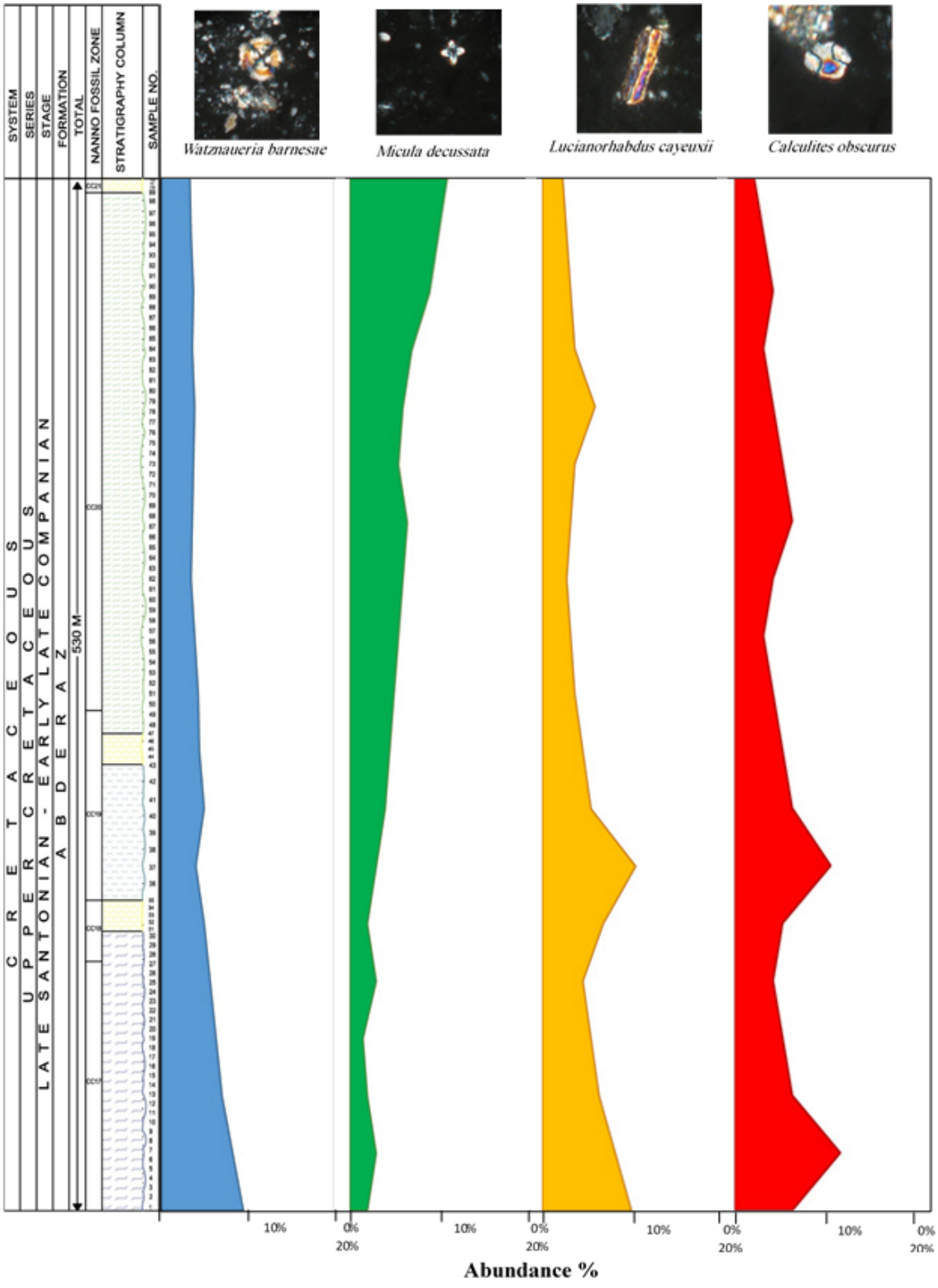

Fig 5. Vertical changes in the relative abundance of the index nannofossil species for temperature and depth.

4.3.2. Productivity

Upper Cretaceous nannoplankton diversity patterns are markedly more variable than those of the Lower Cretaceous, and there is good correlation between diversity and climate trends. Notably, diversity maxima are associated with warm intervals and minima correlated with cooler intervals. This suggests that climate driven changes in ocean productivity, and diversification should be favored by low-nutrient availability coupled with stable conditions (Erba 2006). Calcareous nannoplankton are mesotrophic to oligotrophic and dominate stable (and generally warm) environments. Nutrient availability in the surface waters is among the most prominent parameters influencing the distribution and composition of calcareous nannoplankton (Herrle et al. 2003)

Productivity indices based on the distribution and the ecological significance of the index species selected in this study, were created in order to establish trophic conditions.Among nannofossil species, *W. barnesae* was interpreted as a low to medium productivity indicator, *Biscutum* spp. was used to establish the high nutrient index corresponding to eutrophic conditions, and *L. carniolensis*, related to mesotrophic conditions (Perch-Nielsen 1985; Erba et al. 1992; Watkins 1996).

In the present study existence of *W. barnesae* and *L. carniolensis* and absence of *Biscutum* ssp, refer to low productivity for this area.

4.3.3. Temperature and latitude index

Cretaceous calcareous nannofossil assemblages show significant differences in abundance and diversity dependent on temperature and latitude. Researcher observed that some nannofossil species such as *W. barnesae* in the Cretaceous demonstrate dominant presence in areas of low latitudes and high temperatures (Bukry 1973; Huber et al. 1992; Huber 1998; Ulmishek 2004). Among nannofossil species, *Microrhabdulus* and *Braarudosphaera* are usually considered as low palelolatitudinal, Tethyan, neritic and warm water taxa (Perch-Nielsen 1985; Watkins 1992) has suggested in the Upper Cretaceous nannofossil assemblages that *U.sissinghii* is an index warm water species and disappears in high latitudes.

Enrichment in *E. floralis* has been described previously by others (Perch-Nielsen 1985) who interpreted it as a characteristic of high latitudes and indicative of colder and/or lower salinity water.

Based on the nannoplankton species in chalky limestone of the Abderaz Formation especially the presence of *W. barnesae*, *Microrhabdulus* spp., *B. bigelowii* and *U. sissinghii* and the presence of low amounts of *E. floralis*, reveal that chalky limestone in this section were deposited in low latitudes with high water temperatures.

5. Conclusions

Quantitative analyses of calcareous nannofossil assemblages at the Mozduran section permit the following conclusions:

- The nannofossil species of the chalky limestone intervals from Abderaz Formation are relatively high in abundance and diversity with good preservation.
- An abundant and diverse nannofossil assemblages occurs across the chalky limestone through the Campanian interval at the Mozduran section in the Kopet Dagh Basin, and allows recognition of four biozones, CC18-CC21 of (Roth et al. 1986) and UC14-UC15cTP of (Bukry, 1973) in this section.
- In the chalky limestone intervals the variability of species abundance refers to low productivity for the studied basin.
- In this section, the dominant species, warm water *W. barnesae*, and *U. sissinghii* suggest warmtropical to sub-tropical climatic conditions for the basin through Campanian.
- Presence of index nannofossil species such as *W. barnesae*, and holococcolith species show that chalky limestone intervalss were deposited in relatively shallow marine environments in -low latitudes.
- Variability of species size especially in *C. obscurus, C. ovalis*, and *L. cayeuxii* in chalky limestone intervals and other parts of the Abderaz Formation, indicate that in the chalky limestone intervals living conditions for nannoplankton especially holococcoliths that prefer shallow-water were better than other part of this formation.
- According to above interpretation, the environmental conditions of the studied chalky limestone are comparable to the other Tethys area, such as Egypt (Hamza et al. 2014), Iraq (Al-Badrani et al. 2014) and Turkey (Kaya-Ozer 2014).

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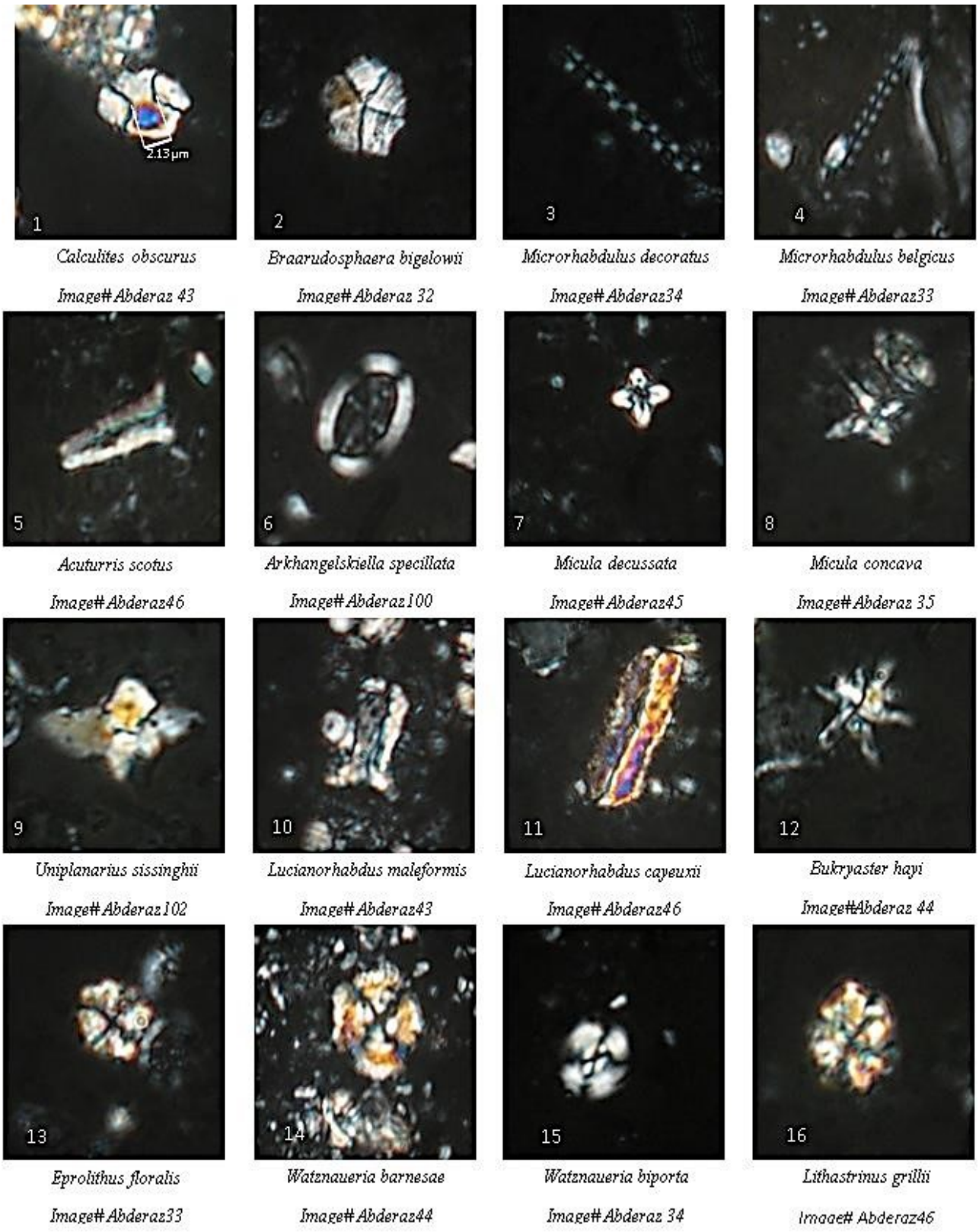

Plate 1. Pictures of the calcareous nannofossil species from chalky limestone of Abderaz Formation in the Mozduran section (All Figures, light micrographs magnified X 1250)

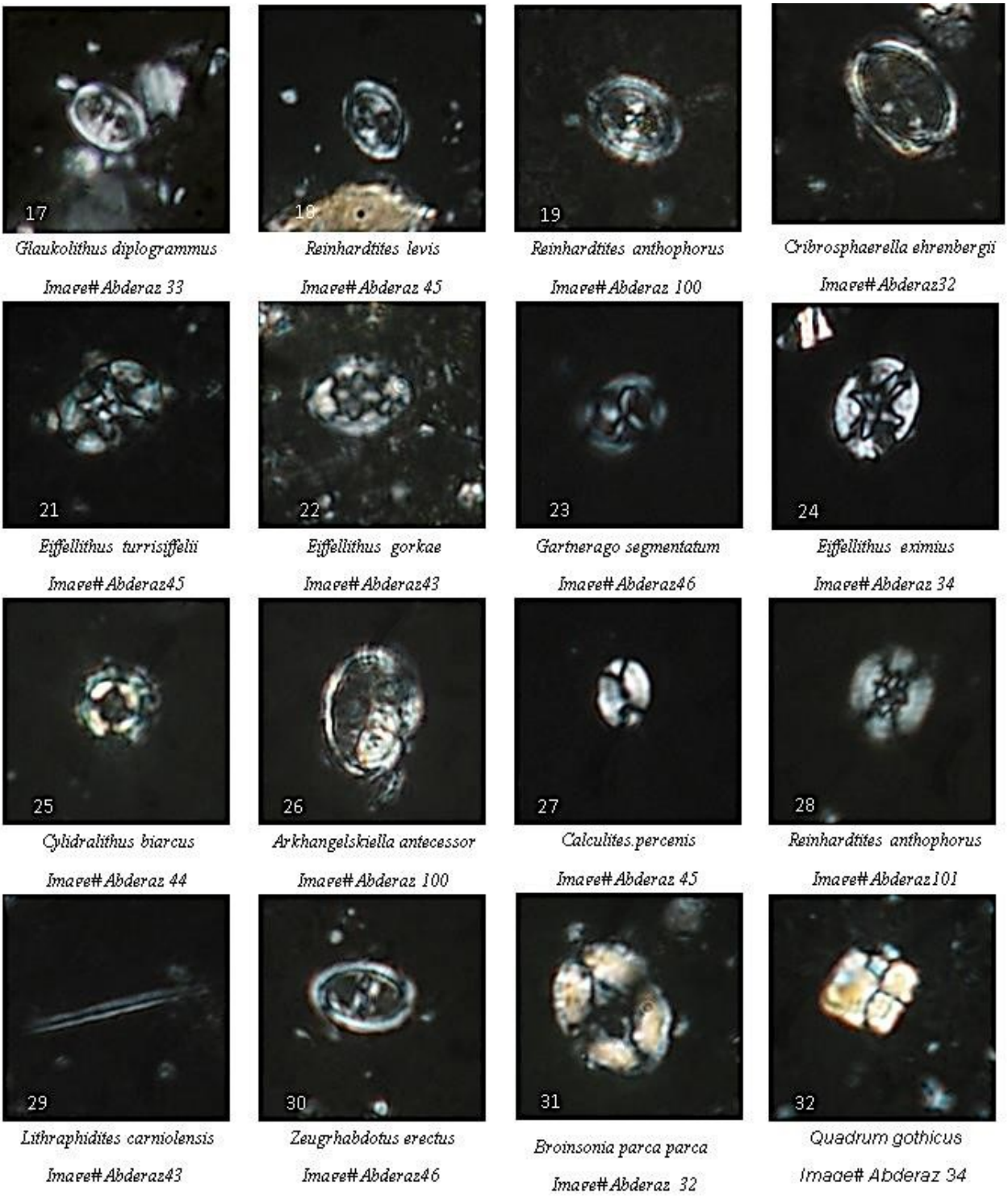

Plate 2. Pictures of the calcareous nannofossil species from chalky limestone of Abderaz Formation in the Mozduran section (All Figures, light micrographs magnified X 1250)