

Nannostratigraphy and Palaeoecology of the Uppermost Mozduran Formation in the Jozak Section in West Kopet-Dagh (NE Iran)

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ABSTRACT

This paper discusses the biostratigraphy and palaeoecology of calcareous nannofossils of the uppermost Mozduran Formation in the Jozak section in west Kopet-Dagh basin. The Mozduran Formation consists of white to grey Limestone. In the studied sections, samples are taken and prepared with smear slides. In the Jozak section, 17 species have been determined. Based on nannoplanktons and as a result of biostratigraphy studies, the nannofossil standard zones (CC4) are identified. According to this zone, the age of the studied thickness is Early Hauterivian in this section in west Kopet-Dagh basin. The presence of warm water indicators (*Nannoconus*, *Watznaueria*, *Lithraphidites*) suggests warm surface water conditions in the studied thickness. In the Jozak section based on *Nannoconus* spp., low fertility conditions are suggested. The studied area is deposited in low to middle latitudes and shallow marine environments.

KEYWORDS

Nannostratigraphy; Paleoecology; Mozduran; Shurijeh; Kopet-Dagh; Iran

1. Introduction

Kopet-Dagh has a complete Cretaceous sedimentary succession comprising marine shales, marly limestone and subordinate sandstones. This sequence seems to represent all stages of the Cretaceous [1].

The earliest paleontological studies of the Cretaceous Formations of the Kopet-Dagh and particularly Mozduran Formation have been focused on the base on foraminifera.

The first comprehensive research on the calcareous nannofossils of the Mozduran Formation in the east of Kopet-Dagh in the Mozduran and Taherabad sections was undertaken by Hadavi and Khodadadi [2].

Based on Calcareous nannofossils, the age of the boundary between the Mozduran and Shurijeh Formations is Early Berriasian in the Mozduran section and Late Valanginian in the Taherabad section.

All of previous studies were inclusive study of whole formation, but in the present study, for the first time, biostratigraphy and paleoecology of the uppermost Mozduran Formation in the Jozak section in west Kopet-Dagh basin were discussed.

2. Geological Setting

The Mozduran Formation consists of shallow marine dolomite and thin gypsum layers in the eastern part of Kopeh-Dagh basin, suggesting that the basin is shallower in the east than the west [3]. At Mozduran pass, the type locality, the unit is about 500 m thick and overlies the Mozduran Formation with an apparent unconformity and is overlain by red clastic beds of Shurijeh Formation. From the type locality southeastwards the thickness of the Mozduran Formation decreases considerably and the limestone and dolomites are replaced by sandstones, red clastic rocks, and evaporites similar to the Shurijeh li-

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thology [4].

The Shurijeh Formation consists of conspicuous red beds, mainly sandstones and conglomerates; in more northwestern outcrops the unit contains also some thin gypsum layers and oolitic Limestone bands. Later, The Shurijeh Formation was found to interfinger laterally with the overlying Tirgan Formation northwest of the Shurijeh type area. The thickness of the Shurijeh Formation varies from about 250 to 900 m [3].

The detailed observation of nanofossils gave us very useful data, so this study is based on microscopic analyses of the calcareous nanoplanktons found in the samples that were taken from the boundary between Mozduran and Shurijeh Formations in west Kopet-Dagh (**Figure 1**).

The thickness of the samples was 60 m in this section and contained white to grey Limestone and brown to red alternation of shale and sandstone (**Figure 2**).

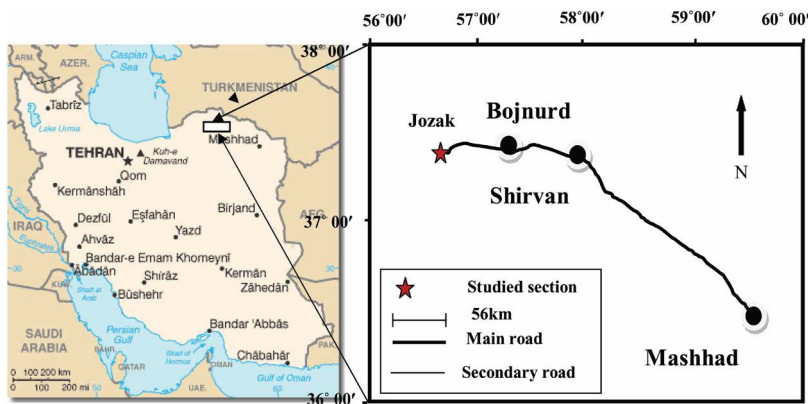


Figure 1. Geographical situation of studied section.

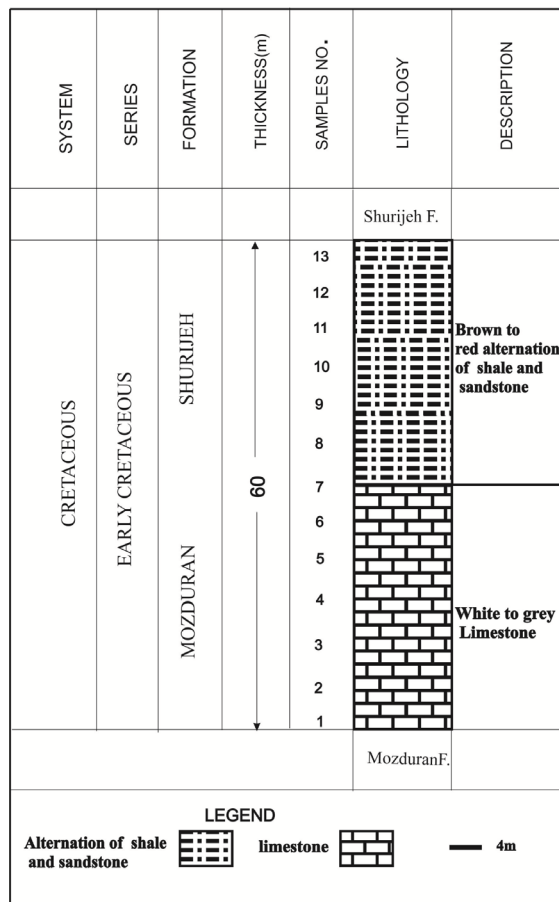


Figure 2. Lithostratigraphic column of the boundary between Mozduran and Shurijeh Formations in the Jozak section.

3. Samples and Methods

A total of 13 samples from the boundary between Mozduran and Shurijeh Formations were collected. For calcareous nannofossils preparation, a small surface of the sample was scraped with a razor blade (the razor used in these preparations was washed with distilled water between samples) until a fresh surface was obtained, and then, a small amount of sediment was mixed with a drop of distilled water and spread out evenly across a microscope cover glass (we paid attention to the homogeneity of the deposition so that calcareous nannofossils are evenly distributed on the slide); after this, suspension has dried up on a hot plate. The work area and the hot plate that were used in making the smear slides were cleaned using 10% HCl between sample preparations. This was done to reduce the chance of contamination. The examination of nannofloras was performed by using a light

microscope at 1250× magnification. Digital images were captured with a digital camera. All images were taken in either cross polarized light (XPL) or plane polarized light (PPL), they are shown on the (Plates 1-3). At first all calcareous nannofossil specimens encountered were identified following the taxonomic schemes of several renowned authors [5-9] and then counted for the purpose of palaeoecological studies. For counting in some purview, all nannofossil species were counted. The percentage of each species for drawing the diagrams was calculated (Tables 1, 2).

4. Nannofossils Biostratigraphy and Zonation

In the boundary between Mozduran and Shurijeh Formations, biostratigraphic studies of calcareous nannofossils have allowed the identification of calcareous nannofos-

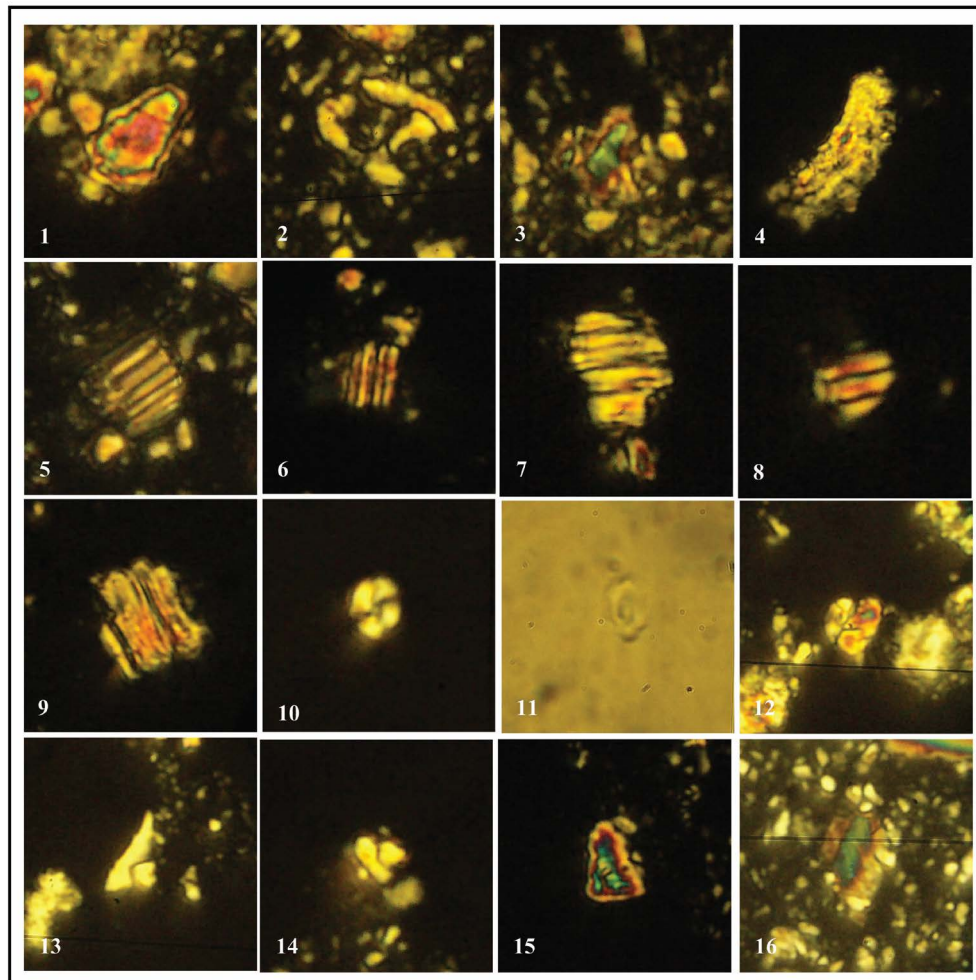


Plate 1. All figures ×1250. (1): *Nannoconus kamptneri*, sample No. 5; (2): *Zeughrabdotus erectus*, sample No. 1; (3, 4): *Nannoconus steinmannii*, 3 sample No. 5, 4 sample No. 8; (5-7): *Conusphaera mexicana*, 5 sample No. 3, 6 sample No. 7, 7 sample No. 10; (8, 9): *Nannoconus dolomiticus*, 8 sample No. 2, 9 sample No. 7; (10, 11): *Watznaueria barnesae*, 10 sample No. 1, 11 sample No. 1; (12): *Assipetra terebrodentarius*, sample No. 1; (13, 14): *Didemnum minutum*, 13 sample No. 1, 14 sample No. 4; (15): *Nannoconus kamptneri*, sample No. 9; (16): *Nannoconus* sp. sample No. 12.

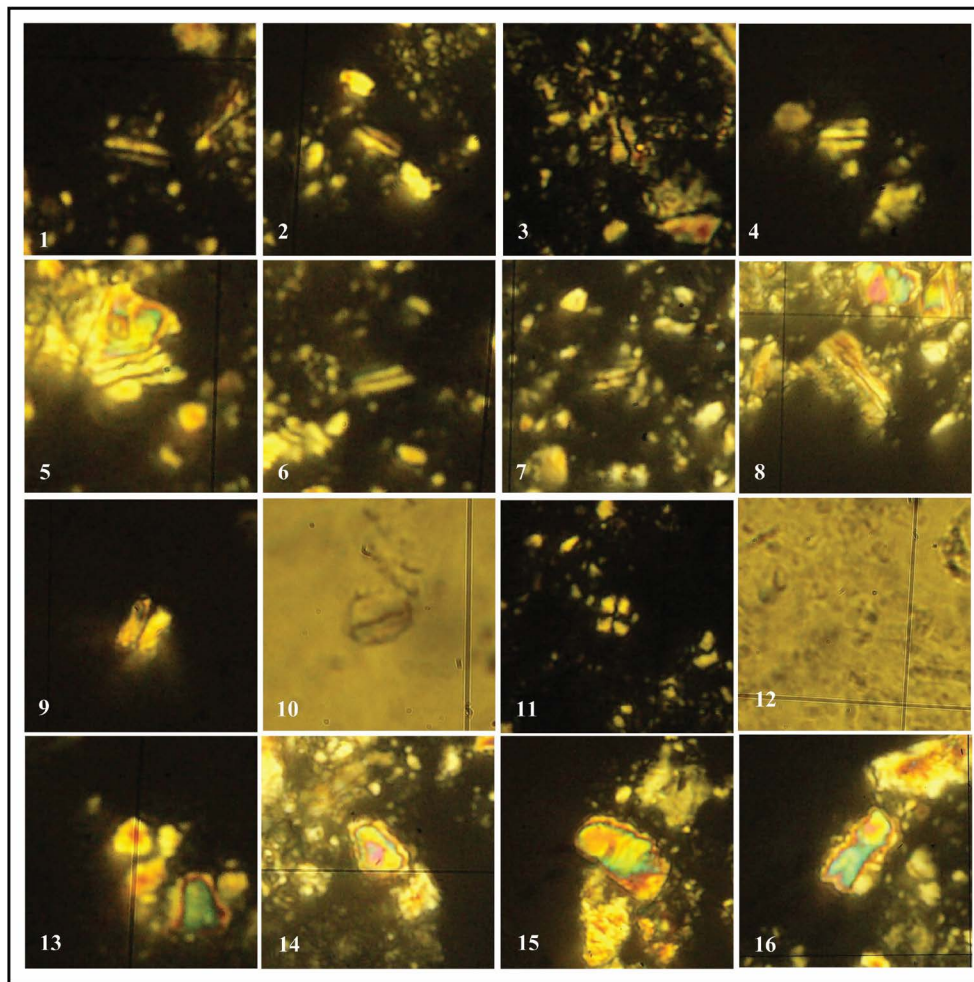


Plate 2. All figures $\times 1250$. (1-8): *Lithraphidites bollii*, 1 sample No. 2, 2 sample No. 5, 3 sample No. 9, 4 sample No. 6, 5 sample No. 1, 6 sample No. 4, 7 sample No. 6, 8 sample No. 5; (9, 10): *Nannoconus dolomiticus*, 9 sample No. 5, 10 sample No. 2; (11, 12): *Watznaueria biporta*, 11 sample No. 1, 12 sample No. 1; (13): *Tetralithus pseudotrifidus*, sample No. 6; (14-16): *Nannococcus bucheri*, 14 sample No. 6, 15 sample No. 4, 16 sample No. 11.

sils biozone CRETARHABDUS LORIEI (CC 4) in the Jozak section with Early Hauterivian eage. This zone was proposed by Sissingh [10]. The base of this zone is defined as the first occurrence (FO) of *Cretarhabdus loriei* and the last occurrence (LO) of *Speetonia colligata* defines the top of the zone.

Remarks: The FO of *Chiastozygus striatus* is used in the Boreal realm as a substitute marker for *C. loriei*. Sissingh suggested [10] a subdivision of CC 4 by the LO of *Biscutum salebrosum*. This has been found to be an unreliable event, since *B. salebrosum* was found by several authors in the Barremian and the Aptian/Albian. Perch-Nielsen [11] suggested the FO of *Eprolithus antiquus* and the LO of *Crucellipsis cuvillieri* as additional events to subdivide the Hauterivian in the Boreal realm. She also used the LO of *Chiastozygus striatus* as a substitute marker event for the top of CC 4. Thierstein [12] had used the FO of *Lithraphidites bollii* and the LO of *C.*

cuvillieri for the subdivision of the Hauterivian in the Tethyan realm. *L. bollii* was not found in the Boreal realm.

In this boundary, *Cretarhabdus loriei* was absent but *L. bollii* is present, therefore according to Thierstein [12] the age of the studied thickness is Early Hauterivian.

5. Nannofossils Diversity and Abundance

Abundant nannofossil assemblages and their occurrence in shallow, neritic settings in the Early Cretaceous tropics migration events into other eutrophic settings may have occurred during periodic warming intervals [13].

In the uppermost Mozduran Formation, 17 species were identified (Tables 1, 2). In spite of the indurated lithology of the Mozduran and Shurijeh Formations, Nannofloras are moderately preserved and relatively low in diversity in this boundary. In these intervals, the low nannofossil total abundances, and the poorly diversified

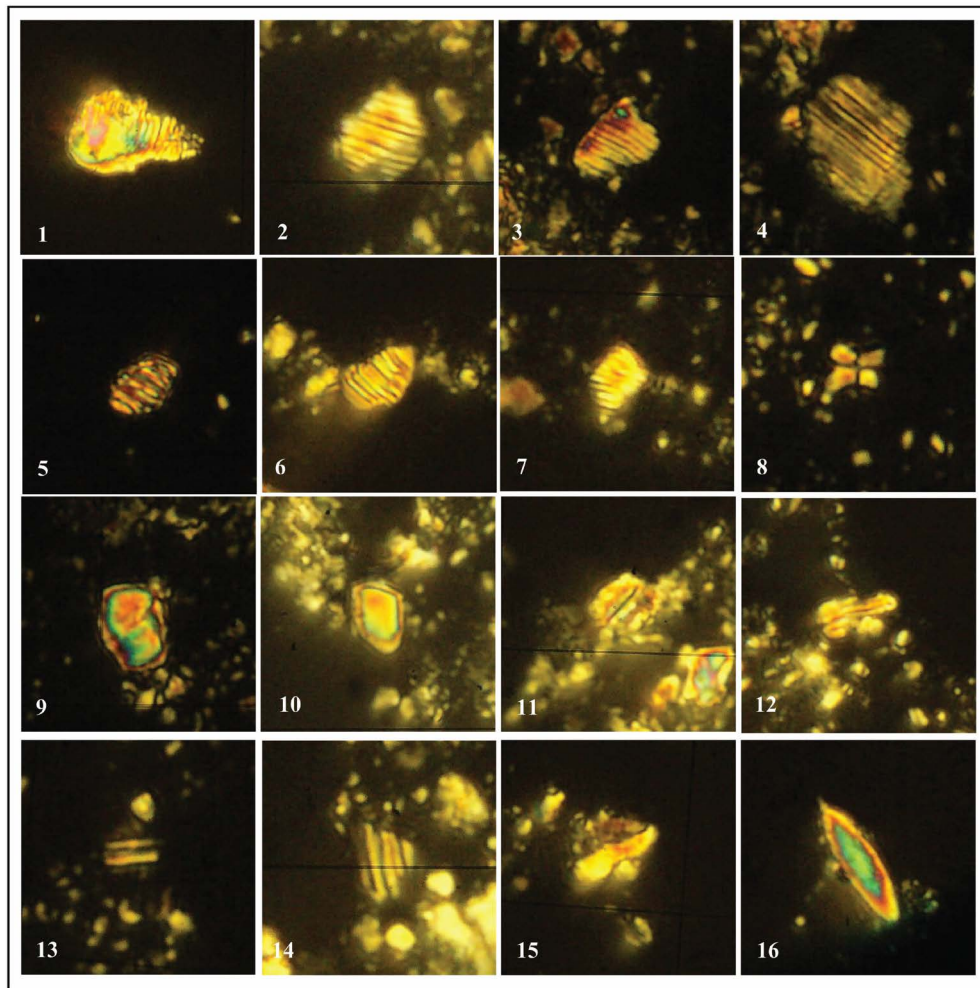


Plate 3. All figures $\times 1250$. (1): *Nannoconus colomii*, 1 sample No. 3; (2-7): *Calcicalathina alta*, 2 sample No. 6, 2 sample No. 4, 3 sample No. 9, 4 sample No.10, 5 sample No. 12, 6 sample No. 2, 6 sample No.7; (8): *Tetralithus cassianus*, 8 sample No. 3, (9, 10): *Nannoconus bucheri*, 9 sample No. 8, 10 sample No. 2; (11): *Nannoconus dolomiticus*, 11 sample No. 2; (12, 13): *Lithraphidites bollii*, 12 sample No. 5, 13 sample No. 10; (14): *Conusphaera Mexicana*, 14 sample No. 5; (15): *Didemnum minutum*, 15 sample No. 4; (15): *Scapholithus fossilism*, sample No. 6.

nannofossil assemblages are probably indicative of unfavorable conditions in the water column [14]. The abundance of all species does not follow a general pattern as some species tend to increase or decline from base to top. The most common genera within the assemblage are *Nannoconus*. In addition, Some species belonging to the genera *Watznaueria*, *Zeugrhabdotus*, *Tetralithus*, *Assipetra*, *Calcicalathina*, *Conusphaera* and *Lithraphidites* are present in the assemblage but occurred only sporadically with relatively low percentage (Tables 1, 2).

6. Palaeoecology

Calcareous nannoplanktons are widespread in the recent oceans, from coastal areas to open ocean settings. The distribution of calcareous nannoplankton is intimately linked to climatic zones and climate changes [15]. In the present studies the following results obtained based on

the abundance species of calcareous nannofossils.

6.1. Fertility Indices

It has been demonstrated that calcareous nannofossil fertility can play an important role in the reconstruction the paleoenvironmental settings. Some nannofossil species are good indicators of surface water fertility. *Biscutum* spp. (mainly *B. constans* and *B. ellipticum*) and *Zeugrhabdotus* spp. (mainly *Z. erectus*) are considered as indicators of high surface water fertility in unstable environments such as oceanic sites of upwelling or shelf areas where trophic conditions may have been enhanced by storm mixing or by runoff [16]. However, *Biscutum* (mainly *B. constans*) is considered as an indicator of less eutrophic conditions than *Zeugrhabdotus* spp. [17]. *Creterhabdus* spp., *T. orionatus* and *Nannoconus* spp. are classified as indicators of low fertility conditions by dif-

Table 1. Abundance table of the recognized calcareous nannofossil species in samples from the uppermost Mozduran Formation in the the Jozak section.

EARLY HAUTERIVIAN												AGE	
MOZDURAN						SHURJEH						FORMATION	
1	2	3	4	5	6	7	8	9	10	11	12	13	SAMPLE No.
12.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Assipetra terebrodentarius</i>
0.00	16.64	0.00	14.28	18.00	20.02	35.20	0.00	25.50	40.20	26.00	0.00	52.70	<i>Calcicalathina alta</i>
0.00	0.00	37.30	0.00	9.09	0.00	15.00	0.00	7.50	0.00	24.40	0.00	0.00	<i>Conusphaera mexicana</i>
12.50	0.00	0.00	28.57	0.00	0.00	20.00	0.00	17.20	0.00	0.00	0.00	0.00	<i>Didemnum minutum</i>
12.00	16.66	0.00	20.50	18.19	23.00	0.00	0.00	8.69	22.20	26.00	0.00	0.00	<i>Lithraphidites bollii</i>
0.00	16.60	0.00	36.65	0.00	10.44	0.00	55.20	18.36	0.00	0.00	53.30	0.00	<i>Nannoconus bucheri</i>
0.00	0.00	32.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Nannoconus colomii</i>
0.00	50.10	0.00	0.00	17.18	0.00	29.80	0.00	10.80	21.00	0.00	0.00	0.00	<i>Nannoconus dolomiticus</i>
0.00	0.00	0.00	0.00	9.09	20.32	0.00	0.00	11.95	16.60	23.60	46.70	0.00	<i>Nannoconus kamptneri</i>
12.50	0.00	0.00	0.00	18.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.30	<i>Nannoconus</i> sp.
0.00	0.00	0.00	0.00	0.00	14.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Scapholithus fossilis</i>
0.00	0.00	0.00	0.00	10.27	0.00	0.00	44.80	0.00	0.00	0.00	0.00	0.00	<i>Nannoconus steinmannii</i>
0.00	0.00	30.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Tetralithus cassianus</i>
0.00	0.00	0.00	0.00	0.00	12.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Tetralithus pseudotrifidus</i>
10.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Watznaueria barnesae</i>
16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Watznaueria biporta</i>
24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<i>Zeugrhabdotus erectus</i>
												<i>C. loriei</i>	
												Nannofossil event	
												Nannofossil zone	
												(Sissingh 1977)	

Table 2. Distribution of calcareous nannofossils in the uppermost Mozduran Formation from the Jozak section.

EARLY HAUTERIVIAN												AGE	
MOZDURAN						SHURJEH						FORMATION	
CC4												ZONE Sissingh (1977)	
1	2	3	4	5	6	7	8	9	10	11	12	13	SAMPLE No.
◆													<i>Assipetra terebrodentarius</i>
	◆		◆	◆	◆	◆		◆	◆	◆		◆	<i>Calcicalathina alta</i>
		◆		◆		◆		◆		◆			<i>Conusphaera mexicana</i>
◆			◆			◆		◆					<i>Didemnum minutum</i>
◆	◆		◆	◆	◆			◆	◆	◆			<i>Lithraphidites bollii</i>
	◆		◆		◆		◆	◆				◆	<i>Nannoconus bucheri</i>
		◆											<i>Nannoconus colomii</i>
				◆		◆		◆	◆				<i>Nannoconus dolomiticus</i>
				◆	◆			◆	◆	◆	◆		<i>Nannoconus kamptneri</i>
◆				◆								◆	<i>Nannoconus</i> sp.
				◆			◆						<i>Scapholithus fossilis</i>
					◆								<i>Nannoconus steinmannii</i>
		◆											<i>Tetralithus cassianus</i>
					◆								<i>Tetralithus pseudotrifidus</i>
◆		◆			◆	◆			◆			◆	<i>Watznaueria barnesae</i>
◆													<i>Watznaueria biporta</i>
◆													<i>Zeugrhabdotus erectus</i>

ferent authors [16,18]. *Nannoconus* spp. is the most abundant nannofossil group in all samples examined in this study but *Biscutum* spp. were absent and *Zeugrhabdotus* spp. were very rare. According to abundance of nannofossil assemblage in the Jozak section, were suggested that the basin supported a restricted nannoflora, dominated by shelf-adapted taxa with low fertility conditions of surface waters.

6.2. Depth

The limiting role of water depth may be explained by a number of interrelated neritic factors including environmental stability, turbulence, transparency, salinity, and nutrients or even water depth itself if the organism had a benthic life-cycle stage [19]. The reasonably comprehensive Early to Mid-Cretaceous biogeographic data suggest there is now little doubt that the paleoecology of nannoconids was in some way related to water depth. *Nannoconus* spp. has been interpreted as restricted to the lower photic zone and to be controlled by fluctuations of the depth of the nutricline [20]. Consequently, changes in abundance of nannoconids and other coccoliths have been used to reconstruct the fertility of surface waters and nutrient dynamics. High abundances of *Nannoconus* spp. may indicate a deep chlorophyll maximum zone (DCM) with an increased productivity in the lower photic zone [21]. Therefore, based on the high abundances of *Nannoconus* spp., the Mozduran and Shurijeh Formations were deposited in the relatively shallow marine environment.

6.3. Temperature and Latitudinal Distribution

Various species of Mesozoic calcareous nannofossils have different temperature ranges [22]. Cosmopolitan taxa like *Watznaueria barnesae* covered a broad temperature range, being common both in the low and the high latitudes throughout most of the Mesozoic. *Watznaueria barnesae* was common in tropical and subpolar regions and may thus be viewed as a eurythermal taxon [23]. Other groups (e. g. *Nannoconus*, *Conusphaera*, *Micula*) are most common in low latitudinal settings where they were partly rock forming. Since they are rare in the Boreal Realm they have often been interpreted as Tethyan warm water taxa [24]. Some cold water taxa (e. g. *Stephanolithion*, *Biscutum*, *Crucibiscutum*, *Repagulum parvidentatum*, *Seribiscutum primitivum*, *Sollasites falklandensis*, *Ceratolithina*, *Kamptnerius*, *Nephrolithus*) show restricted palaeobiogeographic distribution patterns. These taxa are most common only in the high latitudes [25].

The diverse assemblages of the low latitudes are dominated by *Watznaueria* spp., *Rhagodiscus asper*, *Nannoconus* spp., *Micrantholithus* spp. and *Conusphaera* spp.

These thermophile warm water taxa [17,26] indicate relatively warm surface water temperatures of the tropics and subtropic. These evidences suggest warm surface water conditions and relatively low-middle latitude in the uppermost Mozduran Formation in the Jozak section.

7. Comparison of Calcareous Nannofossils in the West and East Kopet-Dagh

According to biostratigraphic studies, in the east Kopet-Dagh, 19 species belonging to 12 genera of calcareous nannofossils were recognized from the uppermost Mozduran Formation in the Mozduran section and 19 species belonging to 13 genera in the Taherabad section. No calcareous nannofossils were found in the lower part of the Shurijeh Formation [2]. But In the Jozak section 17 nannoplanktonic species of 10genera were identified from Mozduran and Shurijeh Formations (**Tables 1, 2**), unlike the east Kopet-Dagh, Calcareous nannofossils existed in the Shurijeh Formation in the west Kopet-Dagh, therefore, we conclude that environmental conditions in the Mozduran and the Taherabad sections in the east of Kopet-Dagh were better for calcareous preservation nannofossils than the west of Kopet-Dagh.

palaeoecological Comparison of the uppermost Mozduran Formation in the Jozak section in the west and Mozduran and Taherabad sections in the east Kopet-Dagh shows low fertility conditions, relatively low latitude, warm water condition and shallow marine environments. Based on Calcareous nannofossils, the uppermost Mozduran Formation is assignable to Sissingh's (1977) [10] biozone CC1 (Early Berriasian) at the Mozduran section and to biozone CC3 (Late Valanginian) at the Taherabad section in the east [2] and biozone CC4 (Early Hauterivian) at the Jozak section in the west, indicating that the age of the top of the Mozduran Formation is diachronous across the basin and the uppermost Mozduran Formation is younger from east to west in the Kopeh-Dagh basin.

8. Conclusion

In this study, 17 species were identified in the boundary between Mozduran and Shurijeh Formations in the Jozak section. As the result of biostratigraphic studies, a biozone is suggested which is equivalent to CC4 of Sissingh [10]. In the base of this zone, the age of studied thickness is Early Hauterivian. According to the studies, the nannofossil assemblages show moderately preservation and the abundant variation of species suggests that the Mozduran and Shurijeh Formations were deposited in the relatively shallow marine environments in low to middle latitudes with warm surface water and low fertility conditions.

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