Investigation of the Boundary between Abderaz and Kalat Formations Based on Calcareous Nannofossils in West Kopet-Dagh (NE IRAN)

Mohammad Anvar Moheghy*, Fatemeh Hadavi, Behname Rahimi
Department of Geology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran
Email: *moheghy@gmail.com

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ABSTRACT
The biostratigraphy of calcareous nannofossils of the Cretaceous is investigated in the boundary between Abderaz and Kalat Formations through the record of species richness, diversity and distribution patterns in the west Kopet-Dagh region. The Kalat Formation comprising of coarse-grained detritus limestone with subordinate sandstone intercalations and the Abderaz Formation mainly consists of limestone, Shale and Limy marl. Nannofossils of this boundary in each of studied sections are listed and figured. 21 species in Ghalehzoo section, 29 species in Sheikh section and 19 species in Jozak section have been determined. Biostratigraphy based on calcareous nannofossil allow the identification of nannofossil standard zones CC21 and CC26 in all of sections, According to these zones in all of sections, the age of the studied thickness is Early Late Campanian-Late Late Maastrichtian in these sections.

Keywords: Nannofossils; Biostratigraphy; Abderaz; Kalat; Iran; Kopet Dagh

1. Introduction
The investigation of calcareous nannofossil assemblages from the boundary of Aberaz and Kalat Formations allowed for the testing of nannofossil biozonation schemes and will be used to document the biostratigraphical changes throughout the late Cretaceous of the Kopet Dagh basin.

The sediments are preserved and including several species recently described from the upper boundary of Abderaz Formation and lower boundary of Kalat Formation in west Kopet Dagh that have not been recorded previously from these regions (Figure 1). The aim of this study is to provide a catalogue of the species encountered in this boundary to serve as a guide for future studies in this area.

2. Geological Setting
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 [1,2].

The Abderaz Formation is composed of light gray to grayish white shale and three to four chalky limestone beds.

Abderaz Formation is exposed in vast area in Kopet-Doghrange. An indication of thickness increases of Abderaz Formation in the eastern Kopet-Dogh from 500 m in the southern (Shurijeh) to 1500 m in the northeast (Taherabad) [1].

The Kalat Formation is a unit of limestone contains subordinate sandstones intercalation and is conformably interbedded between the Abderaz Formation below and Nafteh Formation above. Thicknesses of this formation decrease from east to west of Kopet Dagh [3].

As it is shown in Figure 2, four biozones of CC22-CC25 are missed in all three sections the reason for that could possibly be related to the disconformity between Kalat and Abderaz formations. According to the Stocklin 1968, the Abderaz formation is overlaid by Abtalkh and this formation is covered by Neyzar formation in the east of Kopet-Dagh, as all these two formations are missed in these three studied sections. We can conclude that the contact between Abderaz and Kalat formations would be unconformable as discussed previously by Afshar-Harb...
[4]; the lack of Abtalkh Formation in the west of Kopet-Dagh could possibly be related to the disconformity that happened after sedimentation of Abderaz formation. Stocklin [1] also reported that in the west of Kopet-Dagh Kalat formation overlie Abderaz formation. According to these observations we conclude that there has been a probable disconformity between Kalat and Abderaz formations in all three studied sections in the west of Kopet-Dagh.

In this study samples from the upper part of Abderaz Formation and lower part of Kalat Formation in Ghalehzoo, Sheikh and Jozak sections were taken. The sampling was done with the thickness of 30 meters and contained limestone, Shale, Limy marl and sandy limestone (Figure 3).

3. Samples and Methods

A total of twelve samples of this boundary was collected. Samples were collected at about 2.5-m intervals around the boundary. Nannofossils with smear-slides were prepared following the standard procedure [5] for this, the surface of each sample was scraped with a razor blade until a fresh surface was obtained, and then, a small amount of sediment was scraped onto a glass coverslip and diluted with distilled water. The suspension was smeared with a flat-sided toothpick along the surface of the coverslip and then dried on a hot plate.
Figure 3. (a) Lithostratigraphic column of the boundary between Abderaz and Kalat Formations in Sheikh section; (b) Lithostratigraphic column of the boundary between Abderaz and Kalat Formations in Ghalehzoo section; (c) Lithostratigraphic column of the boundary between Abderaz and Kalat Formations in Jozak section.

preparations, the razor blade was washed in distilled water. The counter and the hot plate were cleaned with 10% HCl between sample preparations. This was done to reduce the chance of contamination. The twelve samples were examined on a light-polarized microscope BH2 model and photographed with a digital camera (Plates 1-3); in these plates “Gh” in Ghalehzoo section and, “Sh” in Sheikh section and “J” is as a picture of fossil in Jozak section).

All calcareous nannofossils specimens encountered, were identified following the taxonomic schemes of several renowned authors [6-14].

The earliest biostratigraphical studies of the Cretaceous formations of the Kopet Dagh and particularly of Abderaz and Kalat Formations have been focused on the base on foraminifera e.g. Afshar Harb [15]. Some sedimentology investigation has been done too.

The previous nannofossils studies of Abderaz and Kalat Formations were by Hadavi and Moheghy [16], Hadavi and Notghi Moghaddam [17,18] and Moheghy and Hadavi [19].

All of previous studies, were inclusive study of whole formations especially investigation of biostratigraphy in the east, but in the present study for the first time biostratigraphy of the boundary between Abderaz and Kalat Formations in west Kopet-Dagh were discussed.

4. Calcareous Nannofossil Preservation

In the studied samples, all specimens in west are well to moderately preserved, showing a slight degree of etching and overgrowth.

In the Maastrichtian, the most resistant taxon to dissolution is *Micula decussata* but *Micula murus* has a much lower ratio of resistance to [20]. The abundance of *Watznaueria barnesae* also considered as a solution-resistant species, though with a lower ratio of resistance to dissolution than *M. decussata* [20].

Hence a visual evaluation of etching and overgrowth using a light microscope was performed to specify the preservation state of the counted assemblages following the method of Bown and Young [5].

In the present samples structures of central area of hetercoccoliths were identified, therefore in this boundary, diagenetic processes did not profoundly alter the original nannofossil assemblages.

5. Nannofossils Diversity and Abundance

In the studied sections, 21 species in Ghalehzoo section, 29 species in Sheikh section and 19 species in Jozak section were identified (Tables 1-3). In this boundary diversity tends to increase toward up section, patterns of abundances as well as diversity indices can be interpreted as a reflection of original paleoecological conditions.

The abundance of samples varies, for example *Watznaueria barnesae* toward up section decrease and *Micula decussata* from base to top, increase. Some species belonging to the genera *Zeugrhabdotus* and *Tranolithus* occurred only sporadically with relatively low percentage.
In the studied sections *Quadrum* spp. has the most abundant in the first samples while *Micula prinsii* identified only from uppermost of this sections.

Other taxa such as *Braarudosphaera* spp., *Calcilathina alta*, *Acuturris scouts*, *Eiffellithus* spp. are present in these samples in much lower abundances.

6. Biostratigraphy and Zonation

The studied interval spans the calcareous nanofossil zones CC21 and CC26 of Sissingh [20] that modified and illustrated in Perch-Nielsen [9].

These biozones cover the EarlyLate Campanian to Late Late Maastrichtian. The proposed biozones are arranged from base to top and they are *Quadrum sissinghii* and *Nephrolithus frequens* zones.

6.1. Quadrum Sissinghii Zone (CC21)

The *Quadrum sissinghii* zone was proposed by Sissingh [21]. The age of this zone is Early Late Campanian. Sissingh [21] suggested that this zone is identified from the first occurrence *Quadrum sissinghii* to Fo *Quadrum trifidium*. 

**Plate 1. All figures, light micrographs magnified ×2500.**

- *Arkhangel'skaya specillata* Image # Abderaz4 (Sh)
- *Zieglerhabdus embergeri* Image # Abderaz 6 (Gh)
- *Microrhabdus decoratus* Image # Abderaz 4 (Sh)
- *Calculites obscurus* Image # Abderaz 3 (Gh)
- *Calculites ovalis* Image # Abderaz 4 (J)
- *Calculites ovalis* Image # Abderaz 4 (J)
- *Lucianorhabdus cayeuxii* Image # Abderaz 6 (Sh)
- *Lucianorhabdus maleformis* Image # kala10 (Gh)
- *Calcilathina alta* Image # kala 8 (J)
- *Watznaueria barnesae* Image # Abderaz 3 (J)
- *Watznaueria biporta* Image # Abderaz 4 (J)
- *Watznaueria biporta* Image # Abderaz 4 (J)
This zone is suggested for the upper part of Abderaz Formation in Jozak, Ghalehzoo and Sheikh sections and it is dominated besides the marker species by *Lucianorhabdus cayeuxii-Lucianorhabdus maleformis-Watznaueria barnesae-Watznaueria biporta-Micula decussate-Eiffellithus gorkae-Eiffellithus turriseiffelii-Quadrum gothicus-Quadrum gartneri*.

6.2. Nephrolithus Frequens Zone (CC26)

This zone is proposed by Cepek and Hay [6]. The age of this zone is Late Late Maastrichtian. It includes the interval from Fo to Lo *N. frequens* in high latitude but in low latitude Fo *M. murus* or Fo *Micula prinsii* can be used to determine the upper boundary of this zone. The most dominant species in this zone addition to the marker species are *Lucianorhabdus cayeuxii-Eiffellithus gorkae-Eiffellithus turriseiffelii-Quadrum gothicus-Lithraphidites carniolensis-Lithraphidites quadratus-Micula murus-Micula premurus-Micula decussate-Micula prinsii-Watznaueria barnesae*.

Base on the calcareous nannoplankton zones, especially lack of CC22-CC23-CC24 and CC25 between the uppermost of Abderaz Formation and lower part of Kalat Formation, a discontinuous sedimentary sequence across the Abderaz and Kalat Formations boundary were suggested.
7. Conclusions

The nannofossil assemblages of the boundary between Abderaz and Kalat Formations are relatively medium in abundant and diversity with well to moderate preservation. In this study, 21 species in Ghalehzoo section, 29 species in Sheikh section and 19 species in Jozak section were recognized. Absolute abundances of upper calcareous nannofossils allowed us to infer the biozonation and record local bioevents in this boundary.

In these sections, base on calcareous nannofossils, the age of the studied sections is Early Late Campanian-Late Maastrichtian. According to this investigation and base on the calcareous nannoplankton zones, especially lack of CC22-CC23-CC24 and CC25 between the uppermost of Abderaz Formation and lower part of Kalat
Table 1. Distribution of calcareous nannofossils in the boundary between Abderaz and Kalat Formations from the Sheikh section.

| EARLY LATE CAMPANIAN | LATE LATE MASSTRICHTIAN | AGE |
|----------------------|--------------------------|-----|
| ABDERAZ              | KALAT                    | FORMATION |
| CC21                 | CC26                     | ZONE (Sissingh 1977) |
| 1 2 3 4 5 6 7 8 9 10 11 12 | SAMPLE No. | |

- Acuturris scotus
- Arkhangelskiella specillata
- Aspidolithus parcus constrictus
- Aspidolithus parcus parcus
- Braarudosphaera bigelowii
- Calccialathina alta
- Calculites obscurus
- Calculites ovalis
- Cyclagelosphaera reinhardtii
- Eiffellithus eximius
- Eiffellithus gorkae
- Eiffellithus turrisieffeli
- Epopilitus floralis
- Lucianorhabdus arcuatus
- Lucianorhabdus cayeuxii
- Lucianorhabdus maleformis
- Microrhabdulus decuratus
- Micula concava
- Micula decussata
- Micula prinsii
- Micula swastica
- Quadrums sissinghii
- Reinhardtites levis
- Watznaueria barnesae
- Watznaueria biporta
- Zeugrhabdotus erectus
- Zeugrhabdotus noeliae

Table 2. Distribution of calcareous nannofossils in the boundary between Abderaz and Kalat Formations from the Ghalehzoo section.

| EARLY LATE CAMPANIAN | LATE LATE MASSTRICHTIAN | AGE |
|----------------------|--------------------------|-----|
| ABDERAZ              | KALAT                    | FORMATION |
| CC21                 | CC26                     | ZONE (Sissingh 1977) |
| 1 2 3 4 5 6 7 8 9 10 11 12 | SAMPLE No. | |

- Aspidolithus parcus constrictus
- Braarudosphaera bigelowii
- Calccialathina alta
- Calculites obscurus
- Cyclagelosphaera reinhardtii
- Eiffellithus eximius
- Eiffellithus gorkae
- Eiffellithus turrisieffeli
- Lithraphidites carniolensis
- Lucianorhabdus maleformis
- Micula decussata
- Micula prinsii
- Micula swastica
- Quadrums sissinghii
- Tranolithus gabalus
- Watznaueria barnesae
- Watznaueria biporta
- Zeugrhabdotus embergeri
Table 3. Distribution of calcareous nannofossils in the boundary between Abderaz and Kalat Formations from the Jozak section.

| EARLY LATE CAMPANIAN | LATE LATE MASSTRICHTIAN | AGE |
|----------------------|------------------------|-----|
| ABDERAZ              | LATE LATE MASSTRICHTIAN|
| CC21                 | CC26                   | FORMATION |
| SAMPLE No. |                     | ZONE (Sissingh 1977) |
| 1 2 3 4 5 6 7 8 9 10 11 12 | | |
| Aspidolithus parcus constrictus | Braarudosphaera bigelowii |
| Calcicalathina alta | Calculites obscurus |
| Calculites ovalis | Effelliithus eximius |
| Effelliithus gorkae | Lucianorhabdus cayneixii |
| Micula decussata | Micula murus |
| Micula prinsii | Micula swastica |
| Nannoconus sp | Quadrum gartneri |
| Quadrum gothicum | Quadrum sissinghii |
| Watznaueria barnesae | Watznaueria biporta |
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