

Determining the Gender of Nano-Fossils in the Lower Part of the Abtalkh Formation (150 M Primary)

Jafar Ghomi, Bahram Moradzadeh

Islamic Azad University, Chalous Branch, Chalous, Iran

Email: j.ghomi1388@gmail.com, bahram.moradzadeh@yahoo.com

How to cite this paper: Ghomi, J. and Moradzadeh, B. (2016) Determining the Gender of Nano-Fossils in the Lower Part of the Abtalkh Formation (150 M Primary). *Open Journal of Geology*, 6, 1481-1498.

<http://dx.doi.org/10.4236/ojg.2016.611105>

Received: September 29, 2016

Accepted: November 25, 2016

Published: November 28, 2016

Copyright © 2016 by authors and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

A structural zone of Dagh Kopet as sediment (Trough) has created in the late Triassic. There are two different views of Dagh Kopet zone: A) Eurasian theory; B) Gondwana theory. The main fault zones are divided into two groups of foundation faults and overthrust. Abtalkh formation is one of the most important Late Cretaceous rock units in the Kopet Dagh sediment Basin and the geographic location of the study area is "03'43"37 north latitude and "47'35"55 the east. The calcareous nanoplanktons are the first links in the food chain and are the main producers in the seas and oceans. The calcareous Nannoplankton is found in fine sediments such as shale and marl and for study and examination; the presence of trace amounts of sample is enough. The calcareous Lannoplankton is used to identify and introduce Nannofossils of Abtalkh in the bottom of the cut, to determine biozones available at the cutting zone and comparing it with the world standard, to determine their age. In the study section, Nannofossil is in glauconitic sandstone, conglomerate, siltstone, marl, shale, limestone, clay, marl and clay marl and Chuck. Their small size makes that a very small amount of samples are sufficient for the study. The most important method for sample preparation in this study is a smear slide method. In laboratory studies and identification of Nannofossil and counting them, the optical microscope and the object lens 50* and 100* are used. To take pictures of samples, 100× objective lens and digital camera were used. In the course of this study, for the lower part of Abtalkh, Aytamir cutting was studied and 12 genera were identified. The calcareous Nannofossils were recognized and have relatively good diversity and abundance. In general, the greater thickness of the study samples had an average preservation. In some cases, the impact of dissolution was so great that the wall or part of the main sections of the species was corroded.

Keywords

Structural Zone Kopet Dag, Trough, Abtalkh Formation, Calcareous Nannoplankton

1. Introduction

Sedimentary-structural Kopet Dag is one of the geological units that in line with WNW to ESE, start from the East of the Caspian Sea and after passing through Turkmenistan and Iran enter Afghanistan. South of Kopet Dag is too limited to Binalood and the northern limit is the plateau Turan fault. The Kopet Dag zone becomes sediment basin after the early Cimmerian orogeny, when apparently a collision between Iran and Turan was ended [1]. Kopet Dag is a mountainous region. Studies show that a Kopet Dag Basin as a sediment (Trough) has created in the Late Triassic and continental sediments (Rhaetic-Liassic) in the upper Lias have been turned into marine sediments entirely. Kopet Dag basin morphology was at the young stage and the topography of the area has a direct relation to the geological structures. Most areas of the region have a temperate climate so cold. Two different views exist about the place of Kopet Dag zone: A) The Eurasian theory that is in the Agh Darband, Lias deposits, with a clear unconformity, on the row of pyroclastic deposits, with complex structure and the Middle-Late Triassic. They know Kopet Dag to be a part of the Eurasian continent and ultramafic rocks of the Mashhad area as the remains of the ocean. B) Gondwana theory [2] that knows the late-Precambrian-Paleozoic rocks of the Ghare bil as the same ore deposits, both in central Iran and Alborz East and it believes that, Epitangayi Paleozoic platform of the Iranian plate is all over or part of Kopet Dag mountains. General trend of winds is in the region of north, south, but seasonal winds are trending east-west in the summer and, west-east in the winter. The winds of winter have high speed, and are capable of carrying large quantities of fine sediments and cause soil degradation and the development of wind hills and their move. In the Kopet Dag zone, asymmetric folds are continuous and parallel to each other and are arranged in a SE-NW trend. Apart from the advance and recession, and due to the movement of drought, desertification, lack of younger marine strata than Eocene can indicate performance of Pyrene event that has a remarkable effect in the long geographic area. Kopet Dag current folding model is the resulting of performance orogeny event in the late Pliocene. In terms of time, the formation mechanism of action, the fault Kopet Dag, can be divided into two groups. The first group, basin subsidence faults at the same time in general, have trended east, west and northeast south-west, and the second group faults fold axes intersect and are converge kind, which may be dextral strike-slip, to the northwest, and left-lateral strike-slip, with the northeast. From the middle Cambrian to the present, five phases of orogeny have occurred in the region: 1) orogenic late Kimerin, places Kashafrud formation with Bajocian age, for unconformably on Triassic rocks in the Aghband Darband area; 2) sub-Hercynian orogeny of Kalat formation, in

the Shlamiy syncline, as unconformity, on Sanganeh horizons formation and Aitami; 3) orogenic styrene upper folds of Ab-Talkh Formation with Late Eocene age, or oligo old age, tune with older formation and collapse of continental red clastic sediments on the Formation of Oligocene to Miocene Khangiran in accordance with Khangiran formation, is representative of styrene orogenic activity; 4) orogenic Aitken rocks, continental red clastic with Late Miocene age in the region, folded and with unconformity on the older rocks; 5) Pasadenian orogenic with the folding conglomerate with Pliocene age that is placed in the form of unconformably on the Red continental Miocene sediments and older formations. Dryness in an area is at the same time with the major phases of orogeny of the world, the first drought is at the end of Lower Cambrian and the last drought is the beginning of the late Eocene age.

The main fault zone, into two groups: a) the fault that caused by vertical movements of the basement and contributed in the land formation and deposition of the area (Foundation faults); b) faults that have emerged in thrust in the orogenic phase and simultaneously with folding (the thrust) (**Figure 1**).

2. Research Background

Geological research in the Kopet Dag has done by Grisbakhaz of India geology organization in 1881. Geologists of Amiranin Oil Company did the first systematic studies of geology and operations in the region. This enterprise geologist has studied the East and Northeast of Iran in the years 1938. 1937. From 1938 to 1951, an important geological work has not been done in the area. Ganser, Switzerland, geologist, in 1951, that was employed by the national oil company, for two months of working geological, has recognized the outcrops surrounding Gorgan to Maravetappe meridian, and has prepared the geological maps in the scale of 100000:1. Goldashmit and Fakhraei in 1952 by the National Iranian Oil Company, for two months field work, from ferns to the Maravetappe meridian with geological maps identifying the scale of 253, 440:1. In 1956 Perrin and Jahanbeglo, Iranian oil company geologists' prepared stratigraphic sections in Sarakhs.



Figure 1. Map Kopet Dag fault zone (adapted from Afshar Harb, 1994).

[3] has studied geological exploration of gas fields in Sarakhs and Khangiran. [4] has studied foraminifera in sediment sequence of Kopet Dagh of the Middle Jurassic to Upper Cretaceous. [5] [6] [7] during six months of field work in the area, has performed stratigraphic complementary harvest and Geology, which results are in his doctoral thesis. [8] has drawn the geological map at 1:50,000 scale of the anticline Khangiran in Sarakhs. [9] has studied Mozduran formation depositional environment in East of Kopet Dagh. [10] have studied the geodynamic ophiolite importance in late Paleozoic rocks in the north east of Iran. [11] has studied calcareous Nannoplankton of the sedimentary sequence starting Maastrichtian-Tertiary in Sarakhs region. [12] has studied and examined the calcareous Nannoplankton of North Khorasan, it is worth mentioning that several doctoral dissertations and master's degree has been written in the Kopet Dagh area based on calcareous foraminifera and Nannofossil, because of a plurality we ignore to mention them.

3. The Geological Area

Abtalkh Formation is one of the most important Late Cretaceous rock units in the Kopet Dagh Basin (North East Iran). In order to study the formation, a cut was selected and sampled in Kopet Dagh Basin West, geographical coordinates of the cut were the "03'43"37 north latitude and "47'35"55 east (Figure 2).

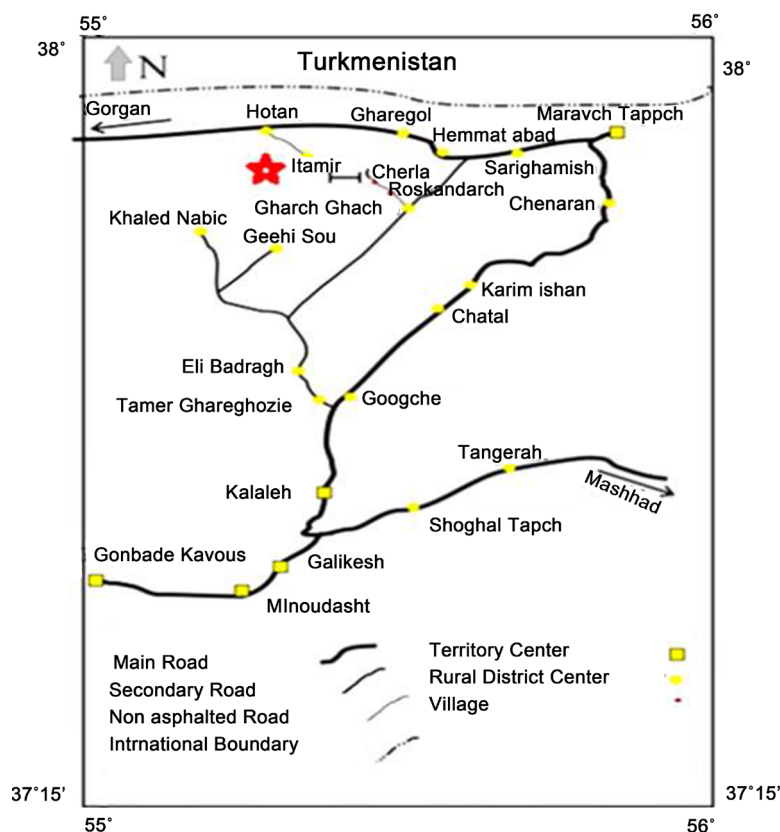


Figure 2. Access to cutting Aitimir.

4. Calcareous Nannoplankton

Nannoplankton calcareous (**Figure 3**) are exclusively marine planktonic organisms (marine unicellular algae), which are scattered in open-ocean, pelagic environment to the environment close to the beach and lagoon. Now, their emergence is clear in the late Triassic sedimentary strata (Norin-the retina) and until the present, they live with more than hundreds of species in the sea and ocean basins in Kulob bio. Note that because they belong to the group of plant and to continue to live, need sunlight, they are placed near the water surface and in the region Footic zone floating. The existing is the first link in the food chain and is the major producers in the seas and oceans.

A German biologist, called Ehrenberg, was the first person who worked on calcareous Nannoplankton.

A German biologist, Lohman, has studied calcareous Nannoplankton of the Mediterranean Sea.

Bramlette and Riedel, in 1954, have proposed that the maximum benefit and the use of Nannofossils are in the Mesozoic and Tertiary biostratigraphy.

In addition to the studies mentioned above, at present, many researchers are studying calcareous Nannofossils that among the most important are the [12] [13] that noted his research results in a book entitled Biostratigraphy Calcareous Nannofossil.

4.1. Haptophyte Algae

A Haptophyte alga is one of the most abundant algae that are reported compared to other fossil branches. These groups of algae are present from late Triassic to Recent. Calcareous Nannofossils are haptophyte algae remains. A cell has a nucleus and greater chloroplast. Flagella (flagella) are protruding from the membrane and has a complex structure toward below. There are two flagella of the same size and a third structure of flagella such as Haptonema. Haptonema task is helping to buoy the Coccolithophores and absorbing materials and components (Kawachi and Inou, 1994). Coccolithophores (living cells) are as a single cell and the phytoplankton have flagella. Different types

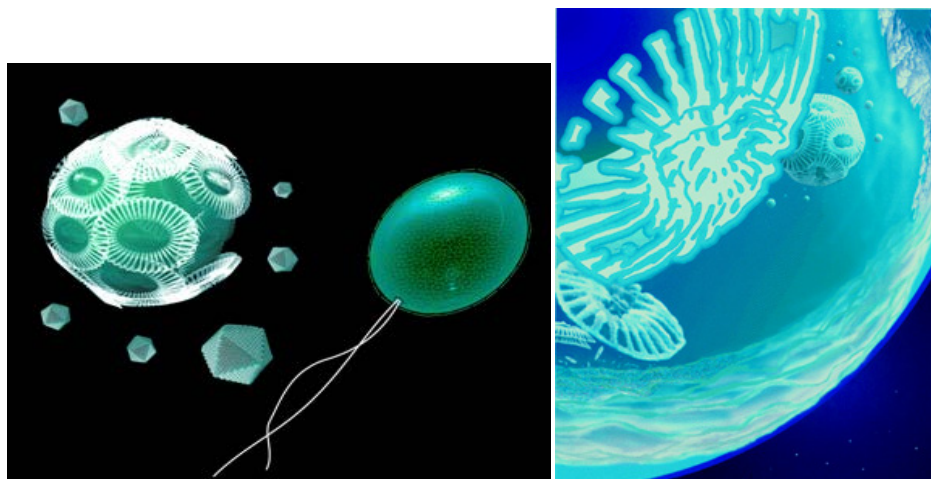


Figure 3. Pictures of nanotechnology calcareous plankton.

Coccolith include Heathrow Coccolith, Holo Coccolith, are Nannolith. Coccolith protects the cellular cells against UV radiation; of course, there is another theory that considers the Coccolith as a lens that focuses the sunlight to the intracellular. Coccolithophores accumulate in areas where food is abundant is more. Coccolithophores live reproduction is in optical zone 100-0 meters in water.

4.2. Evolution and the Time Extend of Calcareous Nannoplankton

The first presence of calcareous Nannofossil was in the late Triassic (retinal-Norin), but the diversity of their accumulation was low and apparently, at low latitudes, they were resistant. All of them, except one species are becoming extinct in the Triassic-Jurassic boundary. Most families appeared during the Jurassic beginning. First variation of calcareous the Nannofossil index was observed in the floor Oxfordan-(Late Jurassic) and the subsequent diversity was in Aptian and Albian.

In the Maastrichtian, it reached the peak frequency, but at the end of the Maastrichtian, a general extinction appended in the sea creatures, and as a result of it, oceans were empty from calcareous Nannoplankton and only 4 or 5 of the epoch Danian (Tertiary start) remained.

5. Research Methodology

5.1. Preparation Method and Study Calcareous Nannofossil

Calcareous Nannoplankton is single cells seaweed that lives in the Open Ocean and pelagic environment in the environment near the beach and lagoon. Calcareous Nannoplanktons due to the very small size (an average of 20-1 microns) are frequently found in the fine grain sediments such as shale and marl.

5.1.1. Sampling

Nannofossils are in a wide range of rocks: including glauconitic sandstone, conglomerate, siltstone, marl, shale, limestone clay, marl and clay marl and Chuck and so on. Their small size makes that a very small amount of sample is sufficient for the study.

5.1.2. Sample

Nannofossils are in large numbers, per gram of sample (millions of units per gram), therefore, to study, the presence of trace amounts of sample is enough.

5.1.3. Appropriate Sediments for Sampling

Nannofossils can be found in marine carbonate sediments, Mesozoic and Cenozoic. Of course, these stones should not undergo diagenesis, and metamorphism and weathering.

5.2. Calcareous Nannofossil Sampling in the Study Section

Calcareous Nannofossil sampling is the way that at first, after identifying the location of the studied sections, with the help of latitude, longitude and geological maps, field operations were done for sampling and preparation of the corresponding stratigraphic column. Harvest was done layering of shale and marl and during sampling; we tried to

take samples from layers without weathering. So that, to ensure accurate sampling, samples were taken from a depth of 50 cm of layers and after each use of the hammer, its tip was clean with tissue paper to minimize the amount of pollution and previous samples that have infected the tip of the hammer do not transfer to the next samples and do not cause errors in zoning and laboratory activities. After sampling, we place them in thick and small plastic bags and seal them tightly with an adhesive package to not be contaminated.

Then, by a waterproof marker on the sampling bag label of containing the sample number, sampling date and place of sampling were recorded. It should be noted that the best samples are for calcareous Nannofossil, marl and Chile layers studies and usually the Nannofossil sample preparation are easier than them. Layers of limestone and sand are not appropriate due to technical difficulties. The sample to study the calcareous Nannofossil is 1 - 2 cubic meters and this amount is sufficient for preliminary studies. In this study, a total of 30 samples were taken from the sequences that were transferred to the laboratory and prepared for laboratory activities.

5.3. Preparation Method

There are several methods for preparing Nannofossils limestone as follows (**Figure 4**).

1. Pipette strews slide method; 2. Smear slide; 3. Gravity steeling; 4. Short Centrifuging. In the following picture, sample preparation steps of smear slide are visible.

5.4. How to Study

Nannofossil laboratory studies and identification and counting, the optical microscope and the object lens 50* and 100* are used. The calcareous Nannofossils study is necessary in both light XPL and PPL. Also when using lenses 100*, using immersion oil is necessary for transparency.

To take pictures of the samples, 100* objective lens and a digital camera is used.

The study is by scanning electron microscopy (SEM) to determine the more precise of the Nannofossil because their study with an electron microscope can provide useful information about the surface morphological structures.

5.5. The Purpose of Study

In Biostratigraphy and paleoecology studies of knowledge and practical application of microfossils to determine the age and condition of the mines formation and different sedimentary deposits and exploration of oil and gas resources have long been of interest to geologists. Due to the extensive geographic diversity, determining more appropriate age and microfossils diversity, the results from the microfossils are more accurate than the microfossils diversity. Among different microfossils group, Calcareous Nannofossils are selected due to their importance in oil discoveries and also due to these fossils features in determining the stratigraphic age and also their quick preparation method. Relative frequency and short stratigraphic range of Nannofossil has caused the fossils are used as a group for Biostratigraphy subdivisions of Mesozoic and Cenozoic layers.



Figure 4. Preparation process microscopic sections, to the method smear slide.

Fluidity features and therefore their distribution in wide geographical areas add to their usefulness as a tool for matching between regions. In this study, in order to achieve the following objectives, calcareous Nannoplankton has been used:

- Identifying and introducing Nannofossil of the bottom Abtalkh formation in the cutting;
- Determining biozones available in this section and compare it with the world standard zone;
- Determining the age of the formation in the studied section.

6. Results

Microfossils Biozonation

In this classification, a number is expressed of microfossils. Based on studies in the studied section, 12 genera were identified and photographed. The form of any fossils is at the beginning of each gender and it is then explained.



Plate 1. Genus, *Aspidolithus*, *Aspidolithus parvus parvus* [14].

Plate 1: This Coccolith is elliptical shape. Its central region is extensive and consists of 8 pieces and each piece is pore. Its margin consists of two rows of calcite and its age range is Campanian. This species have been reported from Israel [15], West Indian Ocean, Alabama [16] and Mississippi [17].

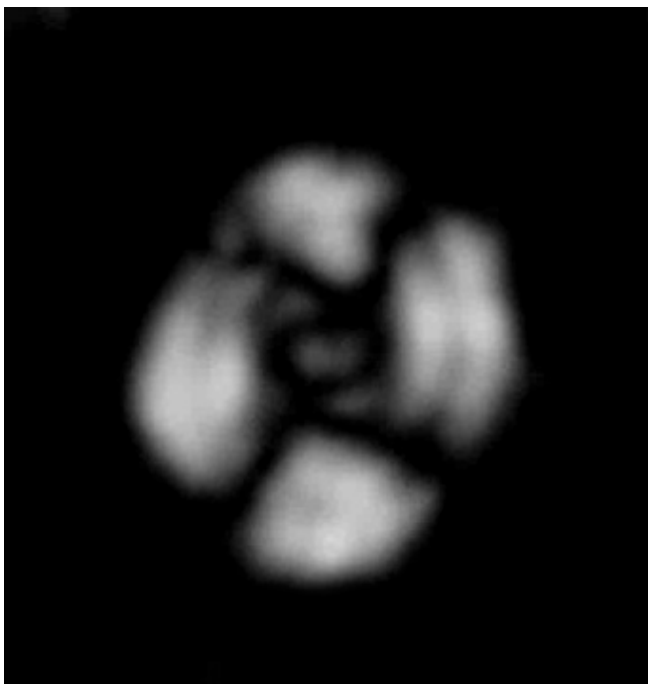


Plate 2. Genus, *Aspidolithus* [14] *Aspidolithus parvus constrictus*.

Plate 2: This Coccolith is an elliptical shape that its central region is small and has thick walls. Its age range is Albian-Maastrichtian. This species have been reported from France [17], North West Egypt [18], the border of Georgia and Alabama [19].

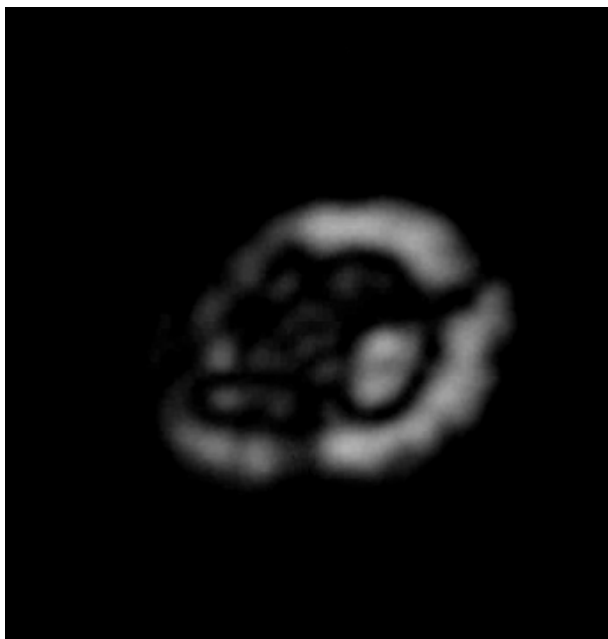


Plate 3. Genus, *Aspidolithus*, *Aspidolithus parvus expansus* [14].

Plate 3: This Coccolith is an elliptical shape that its margin consists of two rows of calcite. The central area is so vast. It is a Campanian age range. This species have been reported from Israel [20], West Indian Ocean [21], Mississippi [22].

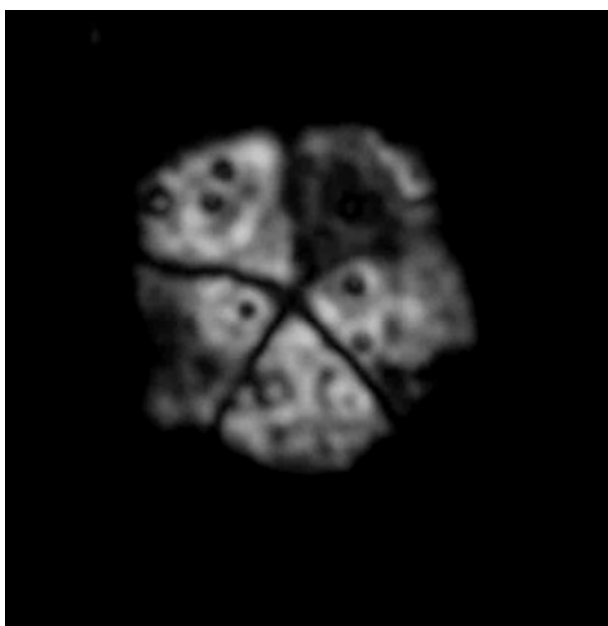


Plate 4. Genus, *Braarudosphaera*, *Braarudosphaera bigelowii* [23].

Plate 4: It is a pentagon Coccolith that consists of five pieces of calcite and there is a compression on every piece. Its age range is Cenomanian-present. These types of sediments have been reported from the late cretaceous Alabama border and Georgia [24].

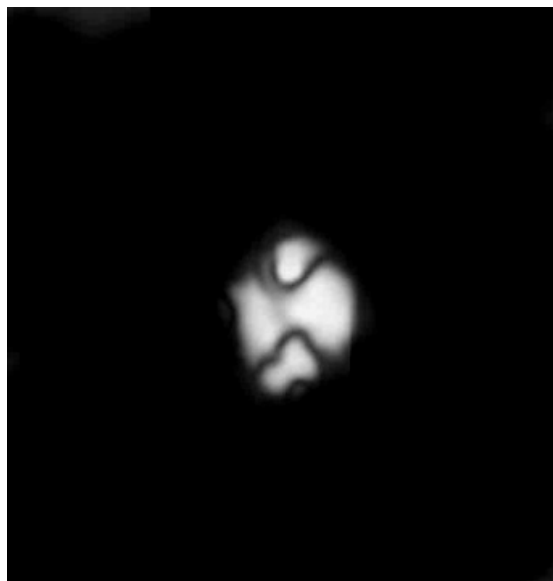


Plate 5. Genus, *Calculites*, *Calculithes obscurus* [25].

Plate 5: This Coccolith is elliptical shape and consists of four blocks of calcite which are surrounded by a narrow margin. This does not have a stem; the presence of this species is used as an indicator of CC17 zone in zoning [26]. Its age range is late Santonian-Maastrichtian. This species have been reported from deposits of the Israel Cretaceous [27], South Africa [28], the Netherlands and France [29], Texas [30] France West rival [31].

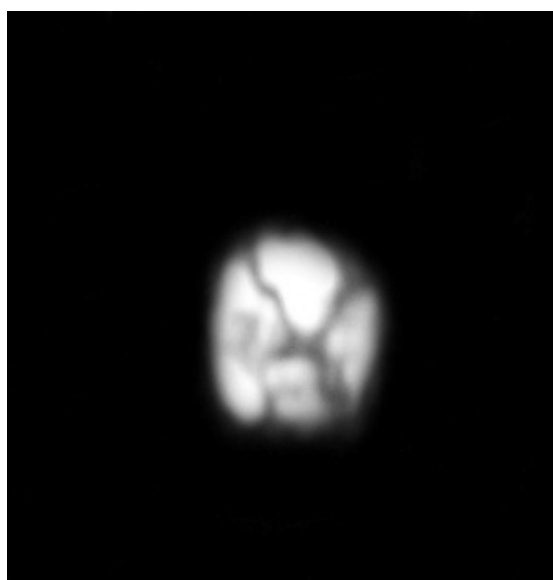


Plate 6. Genus, *Calculites*, *Calculithes ovalis* [32].

Plate 6: This Coccolith is elliptical shape and has four blocks of calcite that is surrounded by a slim margin, consisting of a ring. This species do not have a stem. Its central region is open.

The age range is the Late Cretaceous-Campanine that such Coccolith has been reported from Late Cretaceous sediments of South Africa [33].



Plate 7. Genus, *Lucianorhabdus*, *Lucianorhabdus cayeuxii* [34].

Plate 7: This Coccolith is conical or column-shaped that has a thin base disc and a narrow margin. Two sides of this species are more or less parallel and this has caused distinguishing it with other species. The first presentation of this specie as an indicator zone CC16 was used in zoning [35].

The age range is Coniacian-Maastrichtian. This species of sediments have been reported from southern Spain, Tunisia [36], southern Africa [37] and Texas [38].

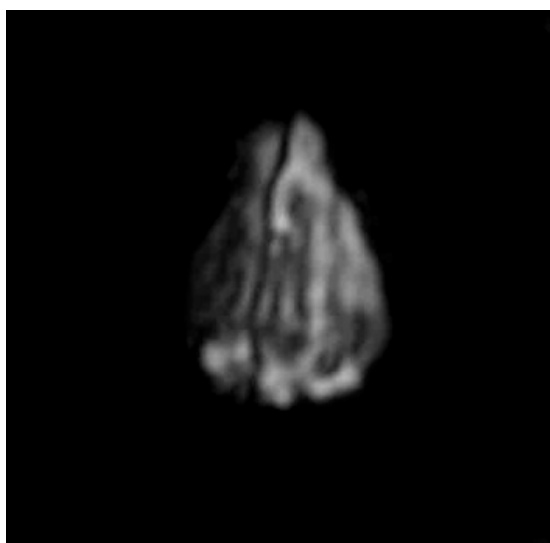


Plate 8. Genus, *Lucianorhabdus*, *Lucianorhabdus maleformis* [39].

Plate 8: This Coccolith is cone-shaped or column-shaped and in side-view, it has a stem, the stem is split at the end. Margin of this species makes a 120 degrees angle to its stem. Its proximal disk is flattened. The emergence of this Coccolith in zoning [40] is used as an indicator.

This age range is late Turonian-Campania. This species of late Cretaceous sediment have been reported from Southern Africa [41] and Tunisia [42].

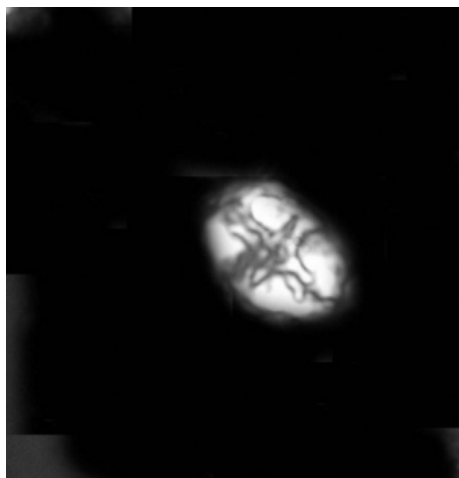


Plate 9: Genus, *Eifellithus*, *Eifellithus eximius* [43].

Plate 9: This Coccolith is an elliptical shape with a cross in the central region. The cross is shaped + and matches with the ellipsoid axes of Coccolith. This group wall is narrow and made of one row element.

This species first presence of zones CC12 has been reported [44] and [45] and UC16 [46].

The age range is Turonian-Campania. This species have been reported from the Late Cretaceous deposits in southern Africa [47] Texas [48], Israel [39] and the North West Australia [40].

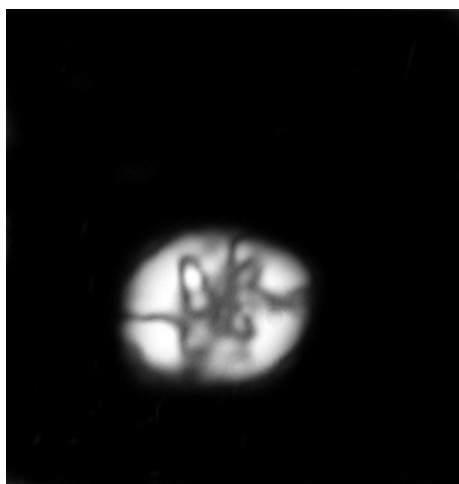


Plate 10. Genus, *Eifellithus*, *Eifellithus gorkae* [41].

Plate 10: This Coccolith is oval that the central cross in the central region does not comply with the ellipsoid axes of Coccolith. This species is smaller than other species of *Eiffellithus* and its central region is smaller and closer.

The age range is Santonian-Maastrichtian. This type of Late Cretaceous sediment [15] has been reported.

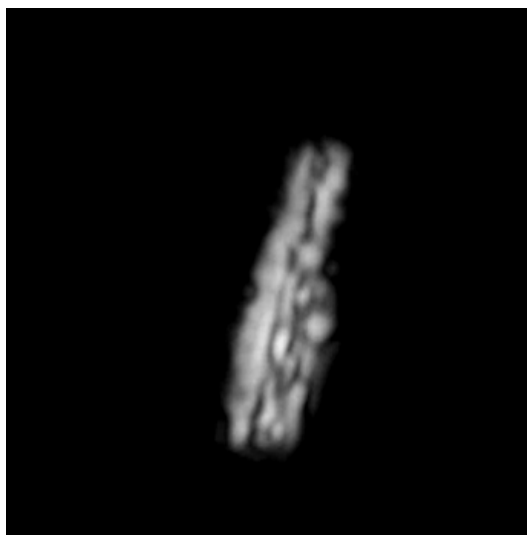


Plate 11. Genus, *Lithraphidites*, *Lithraphidites carniolensis* [20].

Plate 11: This species are stretching and column-shaped with blade elements which its sides are more or less parallel and is unclear in polarized light and can be seen in linear clear.

Its age range is Berriasian-Maastrichtian. This species have been reported from the France [35], Late Cretaceous sediments Israel [39], France and the Netherlands [45], South West Spain and Tunisia [17], Texas [40] and South Dakota [49].

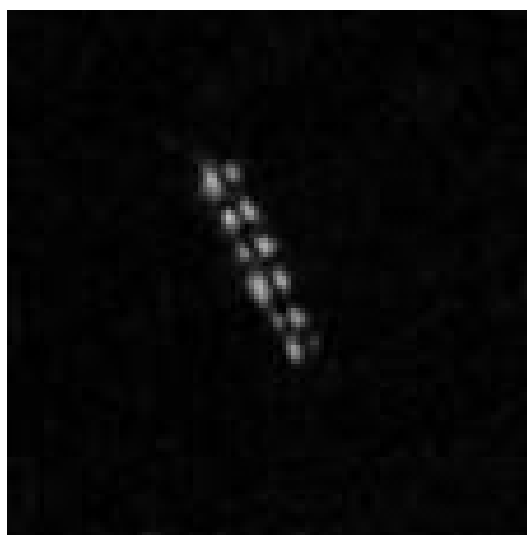


Plate 12. *Microrhabdulus decoratus* [26].

Plate 12: This type is rod-shaped and its wall is interrupted. Both sides are parallel and its cross section is circular. The first presence of this species is at the base of the Cenomanian CC10 zone.

Its age range is Cenomanian-Maastrichtian. This species have been reported from France [32], South Africa [14], the Netherlands and France [50], southern Spain and the Paris Basin [24], the North West of Egypt [51], west Atlantic [52], North west Australia [53] and south Dakota [54].

7. Conclusions

According to studies carried out on Calcareous Nannofossil, the bottom sediments of Abtalkh formation in the study section, the following results were obtained from different perspectives.

In this study, for the lower part of Abtalkh formation in Aitamir cutting, a total of 12 genera were identified. Calcareous Nannofossils have diversity and abundance, relatively well. In general, in the greater thickness of the study, samples had average preservation. In some cases, the phenomenon of dissolution (Dissolution) was so much that wall or a part of the main species was Etching. In total, the dissolution phenomenon has been affected in some parts of the cuts.

References

- [1] Agha Nabati, A. (2004) Iran's Geology. Geological Survey of Iran, Tehran, 586 p.
- [2] Khosrow Tehrani, Kh. (1988) General Information about Iran Stratigraphy and Sections Brigades. Tehran University Press, Tehran, 1977 numbers.
- [3] Darvishzadeh, A. (1991) Geology of Iran. Dissemination of Knowledge Today. Amirkabir Publishing Institute, Tehran.
- [4] Sanaati, A. (1998) AbDeraz Formation Biostratigraphy Based on Calcareous Nannoplankton. The Senior Thesis, Ferdowsi University of Mashhad, Mashhad.
- [5] Moteie, H. (2003) Iran's Geology (Geology of the Zagros). Geological Survey of Iran, Tehran, 84.
- [6] Hadavi, F. (2001) Nannofossils Abtalkh Formation in the West Village of Chehchehe. the Twentieth Meeting of Earth Sciences.
- [7] Hadavi, F., Pooresmael, A. and Notghi Moghadam, M. (2008) Calcareous Nannoplankton. Mashhad Ferdowsi University Press, Mashhad.
- [8] Arkhangelsky, A.D. (1912) Upper Cretaceous Deposit of East European Russia. *Materialien zur Geologie Russlands*, **25**, 1-631.
- [9] Berberian, M. and King, G.C.P. (1981) Towards a Paleogeographic and Tectonic Evolution of Iran. *Canada Journal of Earth Science*, **18**, 210-265. <https://doi.org/10.1139/e81-019>
- [10] Bown, P.R. (1993) New Holococcoliths from the Toarcian-Aalenian (Jurassic) of Northern Germany. *Senckenbergiana Lethaea*, **73**, 407-419.
- [11] Braarud, T. and Nordli, E. (1952) Coccoliths of *Coccolithus Huxleyi* Seen in an Electron Microscope. *Nature*, **170**, 361-362. <https://doi.org/10.1038/170361a0>
- [12] Bralower, T.J. (1987) Valanginian to Aptian Calcareous Nannofossils Stratigraphy and Correlation with the Upper M-Sequens Magnetic Anomalies. *Marine Micropaleontology*, **11**,

- 293-310. [https://doi.org/10.1016/0377-8398\(87\)90003-X](https://doi.org/10.1016/0377-8398(87)90003-X)
- [13] Bramlette, M.N. and Riedel, W.R. (1954) Stratigraphic Value of Discoasters and Some Other Microfossils Related to Recent Coccolithophore. *Journal of Paleontology*, **28**, 385-403.
 - [14] Bronnimann, P. (1965) Microfossils *Incertain sedis* from the Upper Jurassic and Lower Cretaceous of Cuba. *Micropaleontology*, **1**, 28-51. <https://doi.org/10.2307/1484409>
 - [15] Bukry, D. (1969) Upper Cretaceous Coccoliths from Texas and Europe. The University of Kansas Paleontological Contributions, Article 51 (Protista 2), 1-79.
 - [16] Bukry, D. and Bramlette, M.N. (1970) Coccolith Age Determination Leg 3. *DSDP Initial Reports. Deep Sea Drilling Project Reports*, **3**, 589-611.
 - [17] Bukry, D. (1973) Coccolith Stratigraphy, Eastern Equatorial Pacific. *DSDP Initial Reports. Deep Sea Drilling Project Reports*, **16**, 611-653.
 - [18] Burnett, J.A. (1998) Upper Cretaceous. In: Bown, P.R., Ed., *Calcareous Nannofossils Biostratigraphy*; Chapman & Hall, London, 132-199.
 - [19] Cepek, P. and Hay, W.W. (1970) Zonation of the Upper Cretaceous Using Calcareous Nannoplankton. *Palaobotanik B*, **3**, 333-400.
 - [20] Crux, J.A. and Heck, S.E. (1987) Nannofossils and Their Applications. *Proceedings of the International Nannofossil Association Conference*, London, 1987, 356.
 - [21] Dercourt, J., et al. (1986) Geological Evolution of the Tethys Belt from the Atlantic to the Pamirs since the Lias. *Tectonophysics*, **123**, 241-315.
[https://doi.org/10.1016/0040-1951\(86\)90199-X](https://doi.org/10.1016/0040-1951(86)90199-X)
 - [22] Ehrenberg, C.G. (1836) Bemerkungen über feste mikroskopische anorganische Formen in den erdigen und derben mineralien. Bericht. Verh. K. Preuss. Akad. Wiss., Berlin, 84-85.
 - [23] Erba, E., (2004) Calcareous Nannofossils and Mesozoic Oceanic Anoxic Events. *Marine Micropaleontology*, **52**, 85-106. <https://doi.org/10.1016/j.marmicro.2004.04.007>
 - [24] Grun, W. and Zweili, F. (1980) Das Kalkiage Nannoplankton der Dogger-Malm-Grenze im Berner Jura bei Liesberg (Schweiz). *Jahrbuch Geologischen Bundesanstalt*, **123**, 231-341.
 - [25] Gvirtzman, G., Almogi-Labin, A., Moshkovitz, S., Lewy, Z., Hrigstein, A. and Reiss, Z. (1989) Upper Cretaceous Arabian Platform, Central Israel. *Cretaceous Research*, **10**, 107-135. [https://doi.org/10.1016/0195-6671\(89\)90001-3](https://doi.org/10.1016/0195-6671(89)90001-3)
 - [26] Hadavi, F. and Khodadadi, L. (2002) Calcareous Nannoplankton of the Campanian-Maastrichtian of NE Iran. *Journal of Nannoplankton Research*, **24**, 109.
 - [27] Hadavi, F. (2004) Calcareous Nannofossils from the Abtalkh Formation (Campanian-Maastrichtian), Kopet-Dogh Range, NE Iran. *Journal of Nannoplankton Research*, **26**, 63-68.
 - [28] Haq, B. (Ed.) (1983) Nannofossil Biostratigraphy. Benchmark Papers in Geology, Vol. 79, Hutchinson and Ross, Stroudsburg.
 - [29] Hay, W.W., Deconto, R.M., World, C.N., Wilsone, K.M., Voigt, S., Schulz, M., World-Rossby, A., Dullo, W.C., Ronov, A.B. (1999) An Alternative Global Cretaceous Paleogeography. *Geological Society of American Special Paper*, **332**, 1-47.
<https://doi.org/10.1130/0-8137-2332-9.1>
 - [30] Van Heck, S. (1979) Nannoplankton Contents of the Type-Maastrichtian. *INA Newsletter*, **1**, N5-N6.
 - [31] Huber, B.T., Hodell, D.A. and Hamilton, C.P. (1995) Middle-Late Cretaceous Climate of the Southern High Latitudes: Stable Isotopic Evidence for Minimal Equator-Pole Thermal Gradients. *Geological Survey of America Bulletin*, **107**, 1164-1191.
[https://doi.org/10.1130/0016-7606\(1995\)107<1164:MLCCOT>2.3.CO;2](https://doi.org/10.1130/0016-7606(1995)107<1164:MLCCOT>2.3.CO;2)

- [32] Huxley, T.H. (1868) On Some Organism Living at Great Depths in the North Atlantic Ocean. *Quarterly Journal of Microscopical Science*, **8**, 203-212.
- [33] Inouye, I. and Kawachi, M. (1994) The Haptonema. In: Green, J.C. and Leadbeater, B.S.C., Eds., *The Haptophyte Algae*, The Systematics Association Special Volume No. 51, Clarendon Press, Oxford, 73-89.
- [34] Jafar, A.S. (1983) Significance of Late Triassic calcareous Nannoplankton from Austria and Southern Germany. *Neues jahrbuch fur Geologie und Palaontologie, Abhandlungen*, **166**, 218-259.
- [35] Lauer, G. (1975) Evolutionary Trends in the Arkhangelskiellaceae of the Upper Cretaceous of Central Oman, SE Arabia. *Archives des Sciences*, **28**, 259-262.
- [36] Lohmann, H. (1902) Die Coccolithporidae. *Arch. Protistenk.*, **1**, 89-165.
- [37] Moshkovitz, S. and Habib, D. (1993) Calcareous Nannofossil and Dinoflagellate Stratigraphy of the Cretaceous-Tertiary Boundary, Alabama and Georgia. *Micropaleontology*, **39**, 197-191. <https://doi.org/10.2307/1485838>
- [38] Murray, J. and Renard, A.F. (1891) Report on Deep-Sea Deposits Based on the Specimens Collected during the Voyage of HMS Challenger in the Years 1872 to 1876. Report on the Scientific Results of the Voyage of HMS Challenger during the Years 1873-76, Part 3, Deep-Sea Deposits, HMSO, London.
- [39] Paasche, E. (1968) Biology and Physiology of Coccolithophorids. *Annual Review of Microbiology*, **22**, 71-86. <https://doi.org/10.1146/annurev.mi.22.100168.000443>
- [40] Perch-Nielsen, K. (1983) Recognition of Cretaceous Stage Boundaries by Means of Calcareous Nannofossils. *Symposium on Cretaceous Stage Boundaries*, Copenhagen, 18-21 October 1983, 152-156.
- [41] Perch-Nielsen, K. (1985a) Mesozoic Calcareous Nannofossils. In: Bolli, H.M., Saunders, J.B. and Perch-Nielsen, K., Eds., *Plankton Stratigraphy*, Cambridge University Press, Cambridge, 329-426.
- [42] Prokoph, A., Rampino, M. and Eibili, H. (2004) Periodic Components in the Diversity of Calcareous Plankton and Geological Events over the Past 230 Myr. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **207**, 105-125. <https://doi.org/10.1016/j.palaeo.2004.02.004>
- [43] Reinhardt, P. (1965) Neue Familien fur fossile Kalkflagellaten (Coccolithophoriden, Coccolithineen). *Monatsberichte der Deutschen Akademie der Wissenschaften zu Berlin*, **7**, 30-40.
- [44] Romein, A.J.T. (1979) Lineages in Early Paleogene Calcareous Nannoplankton. *Utrecht Micropaleontological Bulletins*, **22**, 1-230.
- [45] Roth, P.H. and Thierstein, H. (1972) Calcareous Nannoplankton: LEG 14 of the Deep Sea Drilling Project, 421-453.
- [46] Sissingh, W. (1977) Biostratigraphy of Cretaceous Calcareous Nannoplankton. *Geologic en Minjbouw*, **56**, 37-65.
- [47] Siesser, W.G. (1993) Calcareous Nannoplankton. In: Lipps, J.H., Ed., *Fossil Prokaryotes and Protists*, Blackwell Scientific Publications, Cornwall, 169-201.
- [48] Sorby, H.C. (1861) XIX.—On the Organic Origin of the So-Called “Crystalloids” of the Chalk. *Annals and Magazine of Natural History*, **8**, 193-200.
- [49] Stradner, H. (1962) Uber neue und wenig bekannte Nannofossilien aus Kreide und Alttertiar. *Sonderabdruck aus den Verhandlungen der Geologischen Bundesanstalt*, **2**, 363-377.
- [50] Stanley, S.M. (2006) Influence of Seawater Chemistry on Biomineralization throughout Phanerozoic Time: Paleontological and Experimental Evidence. *Palaeogeography, Palaeoc-*

- limatology, Palaeoecology*, **232**, 214-236. <https://doi.org/10.1016/j.palaeo.2005.12.010>
- [51] Thierstein, H.R. (1971) Tentative Lower Cretaceous Calcareous Nannoplankton Zonation. *Eclogae Geologicae Helveticae*, **64**, 459-488.
- [52] Wallich, G.C. (1861) Remarks on Some Novel Phases of Organic Life, and on the Boring Powers of Minute Annelids, at Great Depths in the Sea. *Annals and Magazine of Natural History*, **8**, 52-58.
- [53] Watkins, D.K., Wise Jr., S.W., Pospichal, J.J. and Crux, J. (1996) Upper Cretaceous Calcareous Nannofossil Biostratigraphy and Paleoceanography of the Southern Ocean. In: Mokuilevsky, A. and Whatley, R., Eds., *Microfossils and Oceanic Environments*, British Micropalaeontological Society, University of Wales, Aberystwyth Press, Aberystwyth, 355-381.
- [54] Wise, S.W. and Wind, F.H. (1977) Mesozoic and Cenozoic Calcareous Nannofossils Recovered by Deep Sea Drilling Project Leg 71 in the Falkland Plateau Region, Southwest Atlantic Ocean. *DSDP Initial Reports: Deep Sea Drilling Project Reports*, **36**, 259-491.



Scientific Research Publishing

Submit or recommend next manuscript to SCIRP and we will provide best service for you:

Accepting pre-submission inquiries through Email, Facebook, LinkedIn, Twitter, etc.

A wide selection of journals (inclusive of 9 subjects, more than 200 journals)

Providing 24-hour high-quality service

User-friendly online submission system

Fair and swift peer-review system

Efficient typesetting and proofreading procedure

Display of the result of downloads and visits, as well as the number of cited articles

Maximum dissemination of your research work

Submit your manuscript at: <http://papersubmission.scirp.org/>

Or contact ojg@scirp.org

