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*ORIGINAL ARTICLE*

# Paleoecology investigations of lower eocene sediments, West Tafresh, using large benthic foraminifera distribution

**H. Noroozpour[1], M. Yousefi-Rad[2]**

*[1]Department of Geology, Faculty of Science, Payam-e-Noor University of Tehran, Iran*

*[2]Department of Geology, Faculty of Science, Industrial University of Arak, Iran*

*E-mail: Hamidehnoroozpour@yahoo.com (or) Radyousefi@yahoo.com*

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Regarding the*consequential role* of large benthic foraminifera associations in detecting undersea conditions, we have attempt to study these faunas in the 27 samples derived from Paleocene-Eocene sediments with a thickness of nearly 110 meters belonging to the Naghusan section located in the west Tafresh. The studied interval lithologically made up of sandy-marly limestone and tuff with a low percentage of sedimentary rocks such as sandstone. In this study, 17 species belonging to 9 genera of benthic foraminifera were identified and based on environmental index fossils, as various species of Assilina, Discocyclina and Nummulites genera, a carbonate semi-deep open marine environment has been suggested for these sediments. Indeed, an oligotrophic condition with relatively high lightening and normal salinity in a limy-sandy floor has been reported for the studied succession.

**Keywords:** Paleoecology; lower eocene; west tafresh

## Introduction

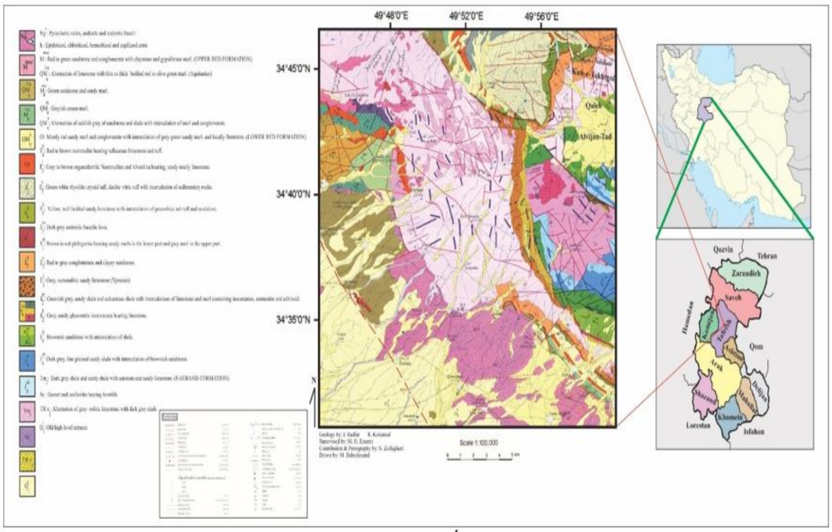
Over the last 65 Myr (million years) the Earth has experienced both a "greenhouse" climate with no polar ice present and an "icehouse" climate with large continental ice sheets (Zachos et al., 2001, 2008). The Paleocene-Eocene Thermal Maximum (PETM) at 55.5 Ma was a high peak in global temperatures fueled by methane levels that resulted in a four to five degrees celsius increase in the deep oceans and a three to four degrees celsius increase of sea surface temperature (SST) in subtropical and tropical oceans.

There was a large extinction of benthic foraminifera during the PETM caused by a decrease in oxygen in the deep sea and a decrease in concentration of carbonate ions in sea water (Tripati and Elderfield, 2005). After the PETM the earth had a warm but not extreme climate. At 53.5 Ma there was a second warming trend referred to as Eocene Thermal Maximum 2 (ETM2) and 100,000 years later it was followed by the H2 event. On the other hand, Benthic microfauna show a detectable response even to small changes of environmental parameters, making them good palaeoenvironmental markers. In particular,benthic foraminifers have long been considered proxies to define in detail environments and to associate environmental parameters - such as water depth, salinity and oxygenation - to benthic foraminifer associations (e.g., Murray, 1991; Hayward et al., 1999; Sen Gupta, 1999; Scott et al., 2001). Numerous studies on benthicforaminifers have demonstrated that their diversity, number, microhabitat structure and species composition are mainly controlled by a combination of oxygen concentration and food level at the sea floor (e.g., Gooday, 1994; Jorissen et al., 1995).

This study uses benthic foraminifer species abundance records, to determine both biostratigraphy and changes in environmental conditions in the lower Eocene shelf environment, in the West Tafresh (Naghusan section) (Figure 1).

The study area is a sector of Orumieh – Dokhtarzone that compasses Eocene to Miocene rock units and their sediments are generally similar to the other areas of Central Iran. These sediments initiate with basal conglomerate and continues with volcanic lava, tuff, sandstone, marl and limestone (Hajian, 1996).The studied area is located in Markazi province in West of Tafresh city (nearly 6 kilometers of southeast Naghusan) and the planned location of the appraisal area is as follow:

(UTM ZONE: 39 CM: 51 WGS84)
Latitudes: 34˚ 43' 4.48"N




Longitudes: 49˚ 56' 32.82" E

**Figure 1.** Geographical location of study area in west of Tafresh (Modified from 1:100000 geological map of Farmahin, Geological Survey of Iran (GSI)).

## Materials and methods

In this study, 116 rock samples were collected from the Paleocene-Eocene sediments at Naghusan section, West Tafresh and prepared in the paleontology laboratory of the PNU (Payam Noor University). Finally, the prepared microscopic slides were examined with an optical microscope equippedwith a Delta Pix (DP 450) Camera by which the index species were photographed and the photomicrographs of the selected foraminifera specimens have been compiled and presented in Plates I. Indeed, the factors affecting the distribution and dispersion of benthic foraminifera in the study area was undertaken and environmental factors (such as temperature, light intensity, water energy, salinity, nutrient) have been surveyed.

## Discussion

**Biostratigraphy**

In this research a detailed biostratigraphic study of the Paleocene-Eocene successions was undertaken and comparisons done with traditional reference sections, allow sub-division of the studied deposits into two main biozones as follow:

**Nummulites globulus range zone**

This zone spans from the FO to LO of Nummulites globulus, which is coincided withthe LO of Nummulites atacicus. The FO and LO of Nummulites globulus was recorded in an interval with a thickness of 43 meter that contains a dominant lithology of marly limestones, interbedded sandstones, sandy limestones and sandy tuffs. This biozone is equivalent to Nummulites globulus/Nummulites atacicus Zone of Swati et al., 2013 and SBZ8 of Zhang et al., 2013. The index species Nummulites globulusdetected an age of Early Eocenefor this biozone (Figure 2).

Globigerina CarpulentaInterval Zone

This zone with a thickness of 50 meter spans from the FO of Globigerina Carpulenta and the FO of Morozovella Sp. species. This biozone has an age of Middle Eocene and is equivalent with P6 standard biozone (Figure 2).

**Paleoecology**

The effect of environmental factors on the distribution of foraminifera in the studied area

Regarding the dominant presence of B forms foraminifera (microspheric type) in the studied section, the environment of investigated succession assigned to steady deep sea-water due to the fact that the B forms foraminifera are the index markers of deep sea conditions (Figure 3A). On the other hand, "the salinity" also affects the development of large benthic foraminifera, therefore concerning the existence of large and long Assilina in a sandy soft mudy floor, which are indicators of a normal salinity of seawater with a low energetic condition (Scheibneral, 2005), in the studied interval indicate a normal salinity of under investigated area (Figure 3B). Another vitally important factor is "water temperature"that influences on benthic fauna associations(carbonate producers) by affecting the metabolic activities and dissolution of carbon dioxide. By temperature decreasing, the metabolic activities will reduce and consequently the organism'srequirements tothe nutrient will decrease. As a result, the amount of nutrients will increase and finally the oligotrophic conditions will change to eutrophic condition. In the studied area it seems to have a eutrophic condition (Figure 3C). It is apparent that each group of organisms live in a particular temperature range, for instance most of the large benthic foraminifera live in a tropical and subtropical water conditions with a temperature of 18 to 20 degrees Celsius in the warm seasons (Adams, et al., 1990). Low water temperatures increase the growth of larger benthic foraminifera (Hallock, 2005).All the mentioned indicators show that the Eocene sediments of the studied interval probably had a tropical-subtropical climate due to the extensive occurrence of benthic foraminifera, algae and bryozoa.

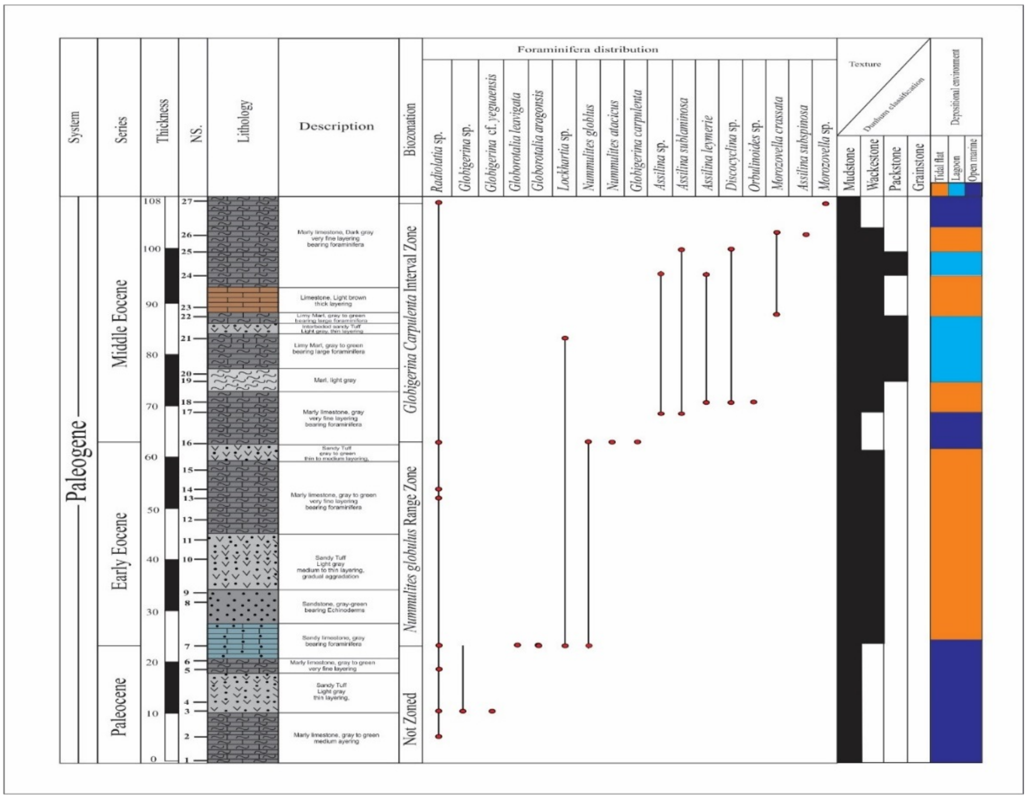



**Figure 2.** Stratigraphic distribution of benthic foraminifera in the studied section along with identified microfacies and paleoenvironments.

Nummulites are Tertiary (Late Palaeocene to mid-Oligocene) benthic rotalid foraminifera which are particularly common throughout the Tethyan region (Racey, 2001). Individuals are characterized by their large, generally lenticular tests which comprise a single planispirally-coiled layer subdivided into numerous simple chambers (Racey, 2001). Nummulite accumulations or “banks” commonly occur in platform- or shelf-margin settings and mid- to outer ramp settings, particularly in the circum-Mediterranean region, the Middle East and the Indian Subcontinent (Racey, 2001) (Figure 4). Most bank-forming species appear to be stratigraphically restricted to the uppermost Lower to Middle Eocene and generaaly are indicators of a nutrient-poor (oligotrophic) environment and/or an environment with significant hydrodynamic sorting (Racey, 2001).In addition, some other factors, such as turbulent flow, can cause the fracturing of foraminifera (Beavington et al., 2004) that in the present study some fractured Nummulites with echinoid fragments have been reported (Figure 3D).

In terms of morphology and alsohigh water motility impact on the foraminifera, they have a thicker wall (test) in a high energy condition and thinner wall in a low energy estate. Medium to large sized lenticular to globular shaped Nummulitestend to occupy an intermediate position in the environment (Racy, 2001). In the present study, most of the recorded forms were the thinner test foraminifers in deep seawaters (Figure 3F) and by approaching to the shallow waters, the thick shell foraminifers revealed (Figure 3E).

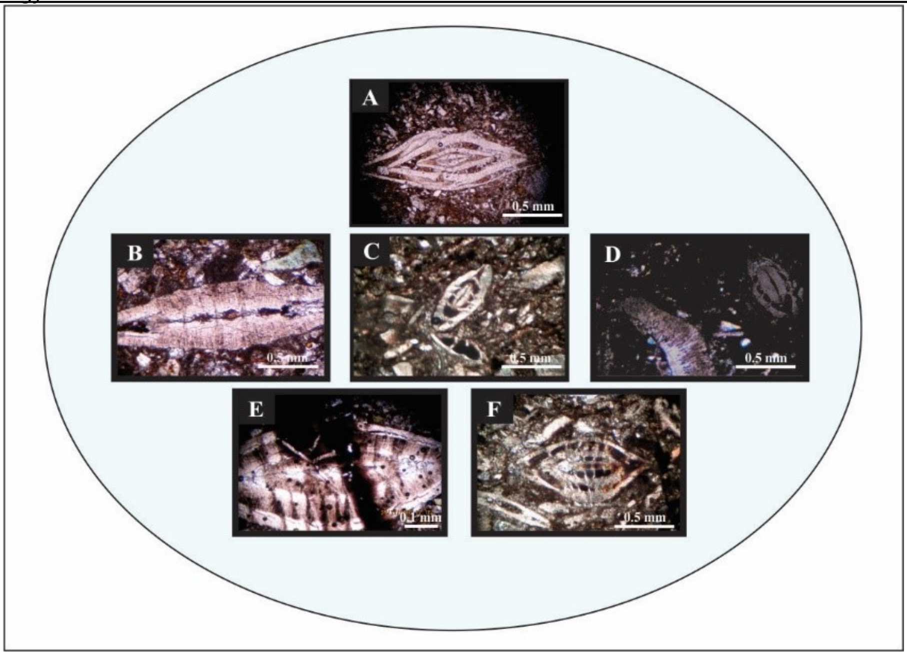



**Figure 3.** Distribution of benthic foraminifer affected by environmental changes.

Light intensity is considered to bethe other most important factor controlling the distribution of larger foraminifera which declines by decreasing in water depth (Hallock, 1987; Racy, 2001). Three groups of organisms, based on the dependence to the light,is considered as follow (Pomar, 2001a & b):

- Light-dependent organisms: These organisms (algae, corals, foraminifers with porcelaneous test, milliolids) require a bright conditionand live in a shallow water environment like lagoon.
- Low-light-dependent organisms: These organisms (algae and foraminifers like Operculina or Lepidocyclina) live in a low light shaded areas or deeper parts of the continental shelf (in the lower parts of the upperlightening zone)
- Light-independent organisms: These organisms (such as bryozoa, Molluscs, crinoid and sponges) are Light-independent.

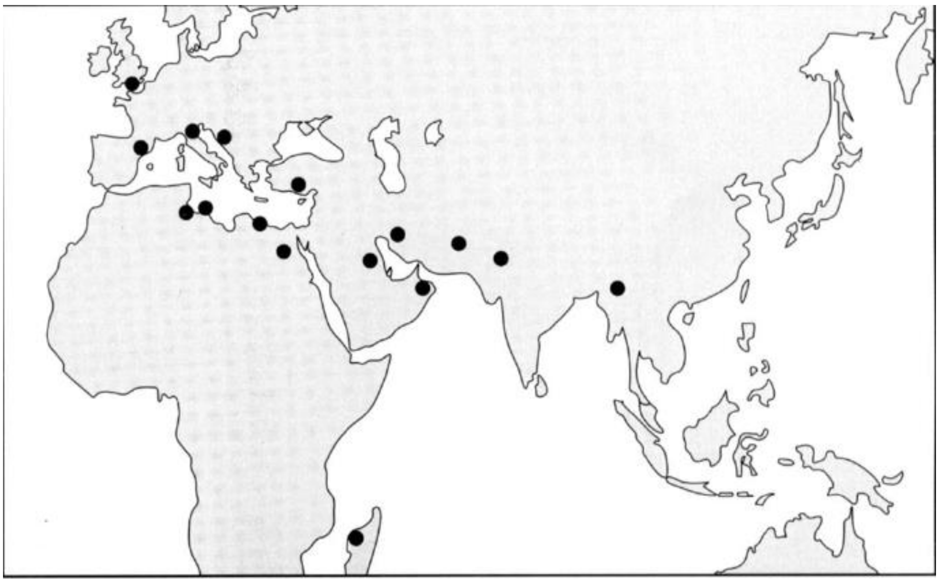


**Figure 4.** Significant associations of Eocene Nummulites in carbonates (Racey, 2001).

Different species of foraminifera are one of the best indicators to reconstruct the paleo-depth conditions of seawater as Porcelaneous forms, which are light-dependent, are abundant in shallow marine environments while they are rarely found in deep waters. In contrast, the number of hyaline foraminifera fauna is mostly enhanced by increasing the water depth. Inflated and thick lenticular Nummulites occur in in shallow marine environments (located in the lower part of the upper photic zone) while Nummulites with a shelly thin test are frequently found in deep waters (Beavington et al., 2004). Plankton foraminifers are also presented in deepest parts of a carbonate slope (Beavington et al., 2004) (Figure 5).

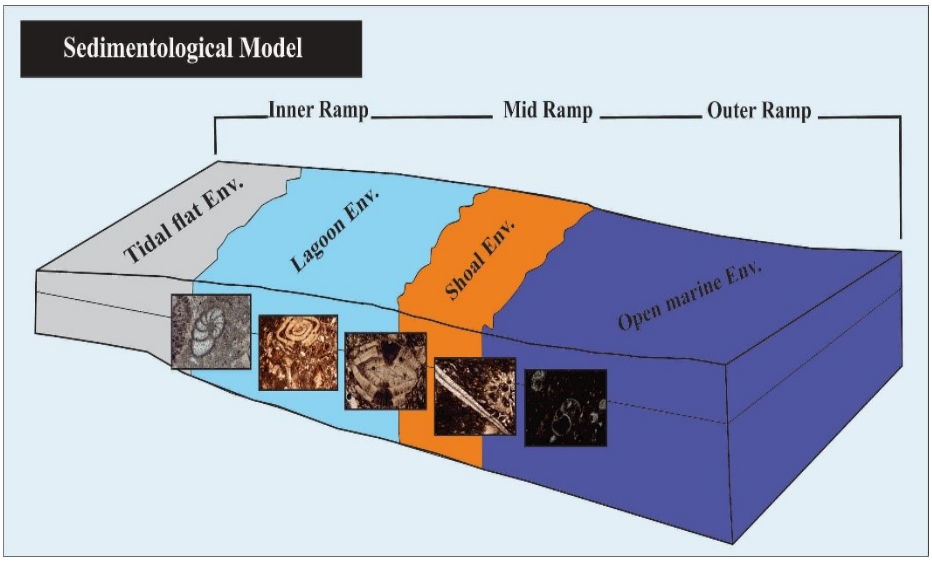



**Figure 5.** The relationship between depth and distribution of benthic foraminifera.

## Conclusion

Foraminifera content of 27 samples from Paleocene-Eocene sediments belonging to the Naghusan section located in the west Tafresh were examined. The host strata have a thickness of nearly 110 meters and investigated in aspect of biostratigraphy and paleoecology. As a result, Paleocene rock units (approximately 25 meters) are mainly composed of marly limestone and sandy tuff which have been assigned to relatively deep marine environments because of rich mudstone microfacies included of pelagic foraminifers and sponge spicules. It is worthmentioning that no biozone has been detected in Paleocene sequences due to there were not any index species in this interval. In addition, Eocene sediments (about 80 meters) have significantly made of marly limestone along with sandy tuff, sandstone, sandy limestone, marl and limestone. Thebiostratigraphy studies of Eocene sequences led to identification of two biozones including Nummulites globulusrange zone and Globigerina Carpulentainterval zone with Early and Middle Eocene ages, respectively.The biozones have a close resemblance to Sbz8 of Zhang et al., 2013 and Swati et al., 2013 and P6 worldwide standard biozone in tropical and semi-tropical regions. Additional, the effect of environmental factors on the distribution of foraminifera in the studied area has been assessed precisely that indicated the studied rock units are probably deposited in semi-deep and warm water conditions with a mainly oligotrophic and rarely eutrophic nutrient circumstances. Also, a relatively bright condition in a normal salinity on the sandy and limy sea floor.

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