New biostratigraphic data from Cretaceous planktic foraminifera in Sahlabad province, eastern Iran

Nouvelles données biostratigraphiques des foraminifères planctoniques du Crétacé dans la province de Sahlabad, Iran oriental

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Abstract

The foraminiferal content of two stratigraphic sections, located in eastern Iran within the Sahlabad province, between the Lut and Afghan blocks and ranging in age from Turonian to Campanian is investigated. Previous studies were general and only indicated the presence of planktonic foraminifera in this province. This paper presents a detailed study of planktonic foraminifera of the Shirshotor unit and establishes for the first time a local biostratigraphy consisting of five biozones. Biozones from the upper Turonian to lower Campanian are recognized, but the upper lower Campanian to lower upper Campanian strata are missing, as demonstrated by the lack of the Globotruncana ventricosa biozone. Tectonic activity in this region during the late early Campanian and mid-Campanian resulted in the presence of an unconformity together with debrites (debris flow deposits) in the lower upper Campanian. About twenty-five planktonic foraminiferal species are reported and illustrated. The largest faunal diversity is encountered in the upper Santonian. The planktonic foraminiferal biozones are precisely defined in selected stratigraphic sections and allow age determinations for the deepest marine sediments (pelagic limestones and bedded cherts) before the collision of the Lut and Afghan blocks.

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Résumé

Des séries stratigraphiques situées en Iran oriental, dans la province de Sahlabad entre le bloc de Lut et le bloc afghan, ont livré des foraminifères. Leur étude, dans deux coupes, a permis de les dater du Turonien au Campanien. Les travaux antérieurs signaleraient seulement la présence de foraminifères planctoniques dans cette zone de suture. Cet article présente une étude détaillée des foraminifères planctoniques de l’unité de Shirshotor et définit, pour la première fois, une biostratigraphie locale comportant cinq biozones. Les biozones du Turonien supérieur au Campanien inférieur sont en continuité, mais l’absence de la biozone à Globotruncana ventricosa atteste d’une lacune depuis les niveaux supérieurs du Campanien inférieur jusqu’aux niveaux de base du Campanien supérieur. L’activité tectonique de cette région, durant le Campanien inférieur terminal et le Campanien moyen, se manifeste par la présence d’une discordance associée à des débrites (coulées boueuses ou debris-flows) au cours du Campanien supérieur basal. Environ 25 espèces de foraminifères planctoniques sont signalées et illustrées. La plus grande diversité s’observe dans le Santonien supérieur. Les biozones de foraminifères planctoniques sont définies de façon précise dans des coupes stratigraphiques choisies et permettent de dater les sédiments les plus profonds (calcaires pélagiques et cherts lités), avant la collision des blocs de Lut et Afghan.

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Keywords: Planktic foraminifera; Cretaceous; Sahlabad province; Eastern Iran

Mots clés : Foraminifères planctoniques ; Crétacé ; Province de Sahlabad ; Iran oriental

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1. Introduction

The studied area (Shirshotor region) is situated in eastern Iran within the Sistan Ocean that is between two blocks: the Lut in the west and Afghan in the east. The Sistan Suture Zone (Tirrul et al., 1983), is part of Cenozoic Alpide suture of Sengor et al. (1988), and is subdivided into two provinces: Gazik and Sahlabad provinces in north-central part of Sistan Ocean (Babazadeh, 2003). The Shirshotor region is situated in the northern part of this suture at the Sahlabad Province. The study area is located between 59°56′ to 59°58′E longitude and 32°14′ to 32°17′N latitude (Fig. 1).

The planktic foraminifera in the Upper Cretaceous sections of eastern Iran were rarely studied in previous works (Stocklin et al., 1972; Tirrul et al., 1983; Fauvelet and Eftekhar-nezhad, 1990). In this paper the stratigraphy and micropalaeontological investigation of outcrop samples, collected in measured sections from the Tethyan Sistan Ocean, in the Shirshotor region, are presented and discussed. The material is composed of 55 samples which all have been examined in thin section.

The aim of this paper is to present Upper Cretaceous biostratigraphic data that allows reconstruction of the palaeogeography of this region during the Late Cretaceous.

2. Regional setting

Iran is a part of short sections of the Alpine orogenic belts that is located between the Arabian–African Block (Gondwana margin) and the Asian Plate (Eurasia margin). It is interpreted as an assemblage of marginal Gondwana fragments detached from the Gondwanian–Arabian plate during the late Paleozoic (Permian) or early Triassic (Stocklin, 1977). It has been attached to the Turanian (Eurasia) Plate at the end of middle or late Triassic (Stocklin, 1974, 1977; Sengor and Kidd, 1979; Wensink and Varekamp, 1980; Soffel and Forster, 1980; Davoudzadeh and Schmidt, 1982). In the late Cretaceous, Iran again rejoined with the Gondwanian Afro–Arabia plate, but the ocean area was not completely closed as evidenced by the presence of Cretaceous-Tertiary flysch deposits in eastern Iran (Babazadeh, 2003).

Three major tectonic units (Turanian, Iranian and Arabian plates) recognized by Lensch et al. (1984) in Iran, are separated from each other by ophiolitic complexes (Stocklin, 1977) (Fig. 2). These are subdivided into smaller elements, such as Kopet Dagh, Southern Caspian Sea, Zagros Thrust, Zagros folded Belt, Alborz mountain and Central Iran. The Central Iran comprises Sanandaj–Sirjan Belt, Orumiyeh–Dokhtar Belt, Central-East-Iran microplate (Davoudzadeh and Schmidt, 1982).

![Geologic map of Shirshotor region and the location of studied sections (Eftekhar-nezhad and Stocklin, 1974). Ksh: Shirshotor section; Ch: Chatot section.](image-url)
1981), the latter is subdivided into Yazd, Tabas and Lut blocks (Fig. 2).

There are the remnants of oceanic basin that separated segments of the Alpine belt. The three components of the inner microcontinental nucleus (formerly termed the Lut block by Stocklin, 1968), including the Yazd, Tabas, and Lut blocks, are separated by fracture zones and have been rearranged from their original position (Sengor et al., 1988).

In Central Iran, there are two ophiolite belts that include mélanges and deep marine sedimentary rocks: (I) one of these ophiolite complexes extends from Esfandagheh to the Nain area and along the Great Kavir Fault to the extensive ophiolitic mélanges exposures around Sabzevar and (II) the second major belt, the Sistan Suture Zone (Sistan Ocean), branches from the central Makran Ranges northward to the Birjand area, but does not join the mélanges of the Sabzevar Zone (Stocklin, 1977) (Fig. 2). The ophiolite-flysch range in the Sistan suture zone belonging to the second belt is subdivided into two provinces: the Gazik and Sahlabad provinces in the north-central part of the Sistan Ocean. The studied area is situated within this ocean, at the Sahlabad Province (Babazadeh, 2003).

3. Lithology

Most sedimentary outcrops across the Upper Cretaceous in eastern Iran consist of three facies: a mixture of deep and shallow sedimentary rocks, turbidites (flysch) and reefs. This paper discusses the deep oceanic sedimentary rocks as basin facies and sedimentation depends on the amount of influx of fine argillaceous, calcareous and siliceous material together with the plankton rain. In the Shirshotor unit (informal lithostratigraphic subdivision), these rocks were deposited...
**Fig. 3.** Correlation chart for the two studied sections in the Shirshotor region.

<table>
<thead>
<tr>
<th>Age</th>
<th>Member</th>
<th>No.</th>
<th>Lithology</th>
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<td>?</td>
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<td>Chatatos Section</td>
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<tr>
<td>Titonian</td>
<td>Member I</td>
<td>Cl10</td>
<td>Vitric Tuff</td>
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<td>Cl9</td>
<td>Tuff &amp; Basalt (Ophiolitic suit)</td>
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<td>Cl8</td>
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<td>Cl7-2</td>
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<td>Cl6</td>
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<td>Cl29</td>
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0 | 5 | 10 | 20 m
during the opening of an oceanic area between the Lut and Afghan blocks. In order to develop a comprehensive biostratigraphic record of the planktonic foraminifera, the Shirshotor and Chatot sections located in this area, were examined (Ksh and Ch, respectively in Fig. 1).

In general, the Shirshotor unit is divided in two members: Member I consists of sedimentary and volcano-sedimentary lithologies and Member II is made of re-sedimented deposits.

3.1. Shirshotor section

In this section, the Shirshotor unit includes only Member I, which is mainly composed of sedimentary and volcano-sedimentary lithologies (Fig. 3).

Above tuffs and diabases, the sequence begins with a succession of gray to cream bedded micritic limestones and argillaceous limestones contains radiolaria and planktonic foraminifera. It passes upward to the limestones and red radiolarian clasts with the intercalated layers of volcano-sedimentary rocks. The volcano-sedimentary rocks consist of green vitric tuffs, radiolarian tuffs and tuffaceous sandstones. The upper part consists of gray to cream fine-grained limestones without volcano-sedimentary rocks. The thickness of the Shirshotor section reaches about 64 m. This unit conformably overlies the tuffs and diabases of Late Cretaceous age (Cenomanian?) and is covered by a conglomerate layer.

3.2. Chatot section (Fig. 3)

In contrast with the preceding one, the Chatot section is composed of both Members I and II. At the base of Member I, there are bedded volcano-sedimentary rocks (green tuffs) with underlying breccia and intercalations of red radiolarian clasts. This sequence continues with gray limestones containing radiolaria and planktonic foraminifera. The upper part of Member I is dominated by the bedded limestone, such as in the Shirshotor section. The thickness of Member I is 85 m. The top of the sequence is unconformably overlain by a conglomeratic horizon passing upward to a debris flow deposit (debrisite) assigned to Member II. The latter consists of mixed lithologies ranging from sandy mudstones to boulder-sized clasts to a boulderly mass containing mud. This deposit is an “olistostrome”. The planktonic foraminifera are found in the mudstone. The thickness of Member II attains 115 m; it is composed of three parts. Each part begins with a muddy gravel body resulting from proximal currents with high density (Lowe, 1979), changes to medium grained carbonate turbidites (Meischner, 1964), and is terminated by argillaceous limestones and biomicrites. This cycle is repeated three times in this re-sedimented unit. The lower and upper contacts of the section are faulted. The total thickness of the Shirshotor unit is 200 m in the Chatot section.

4. Biostratigraphy

The Shirshotor unit was deposited in a deep marine environment and it is more accurately dated with the succession of index planktonic foraminiferal species. Also, the presence of a well-preserved globotruncanid assemblage makes this region important for biostratigraphic studies.

4.1. Zonal subdivisions

Five biozones have been identified on the occurrence of index planktonic foraminifera in the Shirshotor unit (Figs. 4 and 5). Four biozones are recognized from the upper Turonian to the Lower Campanian in the Shirshotor section and five biozones are distinguished in the Chatot section. Identification of specimens is based on microscopic observations of thin sections (Fig. 6). The definitions of the biozones are given following the works of Caron (1985), Sliter (1989), Premoli Silva and Sliter (1994) and Robaszynski and Caron (1995).

- **Biozone A: Marginotruncana sigali Zone**
  - **Age:** Late Turonian.
  - **Definition:** Interval zone between the last occurrence (LO) of Helvetoglobotruncana helvetica (supposed) and the first occurrence (FO) of Dicarinella concavata.
  - **Remarks:** The diversification of Marginotruncana and the presence of the large, compressed marginotruncanids (Marginotruncana undulata) (Sliter, 1989) fall within this zone. This interval is also known as Marginotruncana schneegansi zone (Sliter, 1989; Robaszynski and Caron, 1995). This zone includes: Hedbergella delrioensis, Marginotruncana sigali, Marginotruncana schneegansi and Marginotruncana renzi.

  In the **Shirshotor section**, from bed of nos. k-sh-1 to k-sh-8, this interval contains Marginotruncana cf. renzi, M. cf. schneegansi, M. sigali, Dicarinella cf. primitiva and Hedbergella cf. simplex.

  In the **Chatot section**, from bed of nos. Ch1 to Ch2, this interval contains Marginotruncana sigali, Dicarinella cf. primitiva, Gavellinella sp.

- **Biozone B: Dicarinella concavata Zone**
  - **Age:** Latest Turonian to Early Santonian.
  - **Definition:** Interval zone between the FO of Dicarinella concavata and the FO of Dicarinella asymmetrica.
  - **Remarks:** This zone contains the LO of Marginotruncana sigali and the FO of Contusotruncana near the upper boundary. In this zone, the dominant taxa belong to the genus Marginotruncana (e.g., M. marginata, M. renzi, M. sinuosa, M. pseudolimneiana) and Dicarinella concavata. The species Contusotruncana fornicata and Hedbergella sp. are rare.

  In the **Shirshotor section**, from bed of nos. k-sh-9 to k-sh-11. The age of this succession is given on the basis of the assemblage Dicarinella concavata, Marginotruncana sigali, M. sinuosa, M. cf. pseudolinneiana and Contusotruncana fornicata.

  In the **Chatot section**, from bed of nos. Ch3 to Ch5. This interval yields Dicarinella concavata, Marginotruncana sinuosa, M. sigali, M. marginata, M. cf. pseudolinneiana and M. coronata.

- **Biozone C: Dicarinella asymmetrica Zone**
  - **Age:** Santonian.
Fig. 4. Planktonic foraminiferal distribution from the Shirshotor section.
Fig. 5. Planktonic foraminiferal distribution from the Chatot section.
Definition: The total range of the nominal species (Sigal, 1977; Sliter, 1992; Robaszynski and Caron, 1995).

Remarks: The upper boundary of this zone coincides with the extinction of Dicarinella. The marginotruncanids tend to become rare except for M. pseudolinneiana and M. coronata, whereas M. renzi and M. sigali become extinct before this zone. In this zone: Dicarinella asymetrica, D. concavata, Contusotruncana fornicata, Marginotruncana...
coronata, M. marginata and M. pseudolinneiana can be found.

In the Shirshotor section, from bed of nos. k-sh-12 to k-sh-15. The faunal assemblage observed in the entire interval is as follows: Dicarinella asymetrica, Contusotruncanina fornicata, Marginotruncanina coronata, M. undulata and M. marginata.

In the Chatot section, from bed of nos. Ch6 to Ch7-2. The faunal assemblages is represented by Dicarinella asymetrica, D. concavata, Marginotruncanina marginata, M. cf. pseudolinneiana, Contusotruncanina fornicata, Hedbergella flandrini and H. holmdelensis.

- **Biozone D: Globotruncanina elevata Zone**
  - **Age:** Early Campanian.
  - **Definition:** Zone defined by the FO of Globotruncanina elevata.
  - **Remarks:** This zone is characterized by the presence of Globotruncanina elevata, Globotruncanina stuartiformis associated with Globotruncanina arca, Globotruncanina linneiana, Globotruncanina bulboides and Contusotruncanina fornicata.

In the Shirshotor section, from bed of nos. k-sh-16 to k-sh-22. This interval yields Globotruncanina elevata, Globotruncanina stuartiformis, Globotruncanina arca, Globotruncanina lapparenti, Globotruncanina bulboides, Globotruncanina linneiana and Contusotruncanina fornicata.

In the Chatot section, from bed of nos. Ch7-3 to Ch9. This interval contains Globotruncanina elevata, Globotruncanina stuartiformis, Globotruncanina arca, Globotruncanina bulboides, Globotruncanina linneiana and Contusotruncanina fornicata.

- **Biozone E: Globotruncanina ventricosa Zone**
  - **Remarks:** As the succession is truncated by an olistostrome this biozone is lacking.

- **Biozone F: Globotruncanina calcarata Zone**
  - **Age:** Early Late Campanian.
  - **Definition:** It is defined as total range zone of Globotruncanina calcarata.
  - **Remarks:** The planktonic foraminifera assemblage of this zone includes Globotruncanina stuarti, Globotruncanina calcarata, Globotruncanina arca and Contusotruncanina fornicata.

In the Chatot section, from bed of nos. Ch10 to Ch25. It is dated by the presence of Globotruncanina calcarata and Globotruncanina stuarti.

5. Conclusions

The planktonic foraminifera assemblages from the upper Cretaceous of eastern Iran belong to the Tethyan warm water bioprovince, which is characterized by diverse keeled associations rich in thick-walled species. This assemblage is composed of representatives of the genera Marginotruncanina, Globotruncanina and Globotruncanina. Five planktic foraminiferal biozones have been identified in the Shirshotor area. In ascending order they are Biozone A (Marginotruncanina sigali Zone), Biozone B (Dicarinella concavata Zone), Biozone C (Dicarinella asymetrica Zone), Biozone D (Globotruncanina elevata Zone) and Biozone F (Globotruncanina calcarata Zone). A distinct unconformity has been identified in the Shirshotor unit (section B). This unconformity is here correlated with a major tectonic activity of the Laramide Orogeny.

The succession of planktic foraminiferal assemblages in the Shirshotor unit shows a continuity of the sedimentation during the Late Cretaceous from the late Turonian to early Campanian, but during the late-early Campanian and middle Campanian, there is sedimentary gap evidenced by the lack of the Globotruncanina ventricosa Zone. There is no record of Maastrichtian biozones such as: the Gansserina gansseri and Abathomphalus mayaroensis Zones in any of the two studied sections.

The age of the re sedimented deposits or Member II in the section B formerly attributed to the Eocene (Eftekhar-nezhad and Stocklin, 1974), on the basis of the new data is changed to early late Campanian.

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