Distribution and Paleoenvironment of the Middle Jurassic Foraminifera from Eastern Alborz (Goznawwi section)

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Abstract
Analysis of benthic foraminiferal assemblages was performed in Callovian deposits of the Farsian Formation Northeastern Alborz; Iran. The sequence of Callovian at the Goznawwi area consists mainly of soft marls, which contain high-diversity calcareous assemblages. In this foraminiferal succession nine morphogroups were differentiated according to shell architecture (general shape, mode of coiling and number of chambers), integrated with the supposed microhabitat (epifauna, shallow infauna and deep infauna) and feeding strategy (suspension-feeder, herbivore, bacterivore, etc.). Based on foraminiferal assemblage, we have distinguished nine type of morphogroups, including seven calcareous benthic and two agglutinated benthic morphogroups. The environmental evolution of the analyzed section is interpreted by using the stratigraphic distribution of morphogroups, combined with species diversities and sedimentary data, in a sequence stratigraphic framework. Palaeoenvironmental analysis of the foraminiferal assemblages based on morphogroups analysis and macroinvertebrate has shown that this sediment was deposited on the open marine, deeper of the shelf water, with normal saline (eualine), with sub-oxyed (or dysoxic) condition and eutrophic environment.

Keywords: Foraminifera, Morphogroup, Farsian Formation, Iran.

Introduction
Benthic foraminifera are good indicators of physical and chemical features of the sea-bottom. The composition of benthic foraminiferal assemblages is a valuable tool for interpreting water mass and sediment properties, as shown in numerous studies (e.g., Murray, 1991, 2001; Sjoerdsm & Van der Zwaan, 1992; Jorissen et al., 1995; Jorissen, 1999; Van der Zwaan et al., 1999; Abu-Zied et al., 2008; Reolid et al., 2012; Talib et al., 2012). The analysis of foraminiferal morphogroups is especially useful for interpreting the major factors that control the ecosedimentary environment (Nagy, 1992; Nagy et al., 1995, 2009; Reolid et al., 2008b). Benthic habitat fluctuations in nutrient availability and oxygenation rate are limiting palaeoenvironmental parameters, exerting considerable control on the composition and relative abundance of foraminiferal assemblages and morphogroups (Sjoerdsm & Van der Zwaan, 1992; Jorissen et al., 1995; Van der Zwaan et al., 1999), particularly in shelf and marginal marine environments (e.g., Bernhard, 1986; Corliss & Chen, 1988; Nagy, 1992; Tyszka, 1994; Fugagnoli, 2004; Reolid et al., 2008b; Reolid et al., 2012).

Studies on recent and ancient benthic foraminiferal assemblages demonstrate that the characteristics of the foraminiferal test (chamber arrangement, mode of coiling, features of aperture, position of perforation) are directly related to lifestyles and trophic strategies (e.g., Nagy, 1992; Tyszka, 1994; Nagy et al., 2009; Jones, 2014). On the basis of modern faunas, morphogroups of benthic foraminifera were proposed by Jones & Charnock (1985). Subsequent studies have proposed analogous morphological groupings in fossil assemblages (Nagy, 1992; Tyszka, 1994; Kuhnt et al. 1996; Nagy et al., 2009; Reolid et al., 2010, 2012; Smolen, 2012), in order to interpret palaeoenvironmental conditions, such as nutrient availability or redox conditions (Nagy, 1992; Tyszka, 1994; Nagy et al., 1995, 2009; Reolid et al., 2008a, 2010, 2012). Furthermore, the pervious study about the Jurassic isolated foraminiferal assemblage in Iran; mostly is not performed and only at Korkhurd area introduced by Kalantari (1969) from Chaman Bid Formation.

The type locality of the Farsian Formation was coined by the Stampfli (1978). At type locality, near the Farsian village, for the main part, it consists of red and yellow limestone, silt and marl. Stampfli (1978) considered the red sediments to be a transitional unit sandwiched between the Shemshak Group and the Lar Formation. In the Goznawwi section, the Farsian Formation scarcely studied and the present contribution constitutes the first morphogroup analysis of foraminiferal assemblages from Iran. This research involves
palaeoecologic analysis of foraminiferal assemblages, according to the differentiated morphogroups, and their stratigraphic evolution as a response to change in environment of conditions during the sedimentation of Farsian Formation.

**Geological setting**

The Middle and Late Jurassic (Magu Group) is one of the most extensive lithostratigraphical units in the Iran Plate (Aghanabati, 1998). The Iran Plate; composed of the central-east Iranian microcontinent, northwestern Iran and the Alborz Mountains (Aghanabati, 1998). The Alborz belt is a 1500 km-long mountain system extending from Azerbaijan to Afghanistan, flanking in its central part the southern coast of the Caspian Sea. The belt was affected by several successive tectonic events, from the Eo-Cimmerian orogeny to the Late Tertiary-Quaternary intracontinental transgression (Allen et al., 2003). The result of Early Cimmerian orogeny is detached the north eastern margin of Gondwana during the Early Permian (Stampfli & Borel, 2002) and moved northwards during the Triassic, thereby gradually closing the Palaeotethys Ocean. It collided with Eurasia towards the end of the period (e.g., Stampfli & Borel, 2002), although the precise age of collision is still under debate (e.g. Sengor et al., 1988; Sengor, 1990; Alavi et al., 1997; Saidi et al., 1997; Seyed-Emami, 2003; Golonka, 2004). Denudation of this mountain chain produced large quantities of sediment that collected in an extensive foreland basin situated to the south. This elongated basin is named the Greater Caucasus-Proto-Caspian back-arc basin (Golonka, 2004). In this basin, at Jurassic time, marine sedimentation began in the Late Bajocian and Bathonian time interval when the Northern Alborz, Kopet–Dagh, and Central Iran basins formed on the Iranian Plate (Aghanabati, 1998). Initial siliciclastic deposits have been termed the Shemshak Group by various authors (e.g. Asserto, 1966; Bragin et al., 1976; Nabavi & Seyed-Emami, 1977; Fakhr, 1977; Nabavi, 1980; Seyed-Emami & Nabavi, 1985; Repin, 1987; Seyed-Emami, 1987; Seyed-Emami & Hosainzadeh, 2006; Seyed-Emami & Wilmsen, 2007; Fursich et al., 2005; Fursich et al., 2009a; Vaez-Javadi, 2016 and ...). The group is followed by another carbonate unit, the Dalichai–Lar basin-carbonate platform complex named as Magu Group, from which it is separated by another unconformity, reflecting the so-called Mid-Cimmerian tectonic event (Wilmsen et al., 2009). In the north margin Alborz belt; Middle Jurassic introduce by carbonates of Farsian Formation; equivalent with Dalichai Formation in the south margin; possibly reflecting lower rates of subsidence (Fursich et al., 2009 b). The growing deposition of carbonates was also facilitated by southward migration of the Iranian plate, which had occupied a fairly high latitudinal position of approximately N 44° during the Early Jurassic (Dercourt et al., 2000), to a lower latitude of ca. 20–30° N during the Middle Callovian (Thierry, 2000; Seyed-Emami et al., 2008; Wilmsen et al., 2010; Ghasemi-Nejad et al., 2012).

**Materials and methods**

The succession studied preserves an essentially continuous benthic foraminiferal record from 16 levels. Most of the samples were collected from soft marl that characterizes the main body of the Farsian Formation. A smaller number of samples were taken from clay sandy limestone and fine-grained claystone from the uppermost part of the formation. In the laboratory, the rock samples were disintegrated using the leached in synthetic light vinegar method described by Yazdi (non. published). In this method; the samples were crushed, washed and leached in synthetic light vinegar (for 24 hours) in diluted water. Residue out of washed samples were separated and dried, the dried residue then was picked under binocular microscope. Some of the samples required two repetitions of this step of the procedure to obtain an adequate degree of disintegration.

**Locality, stratigraphy and lithology of the study section**

In this research, the carbonate outcrops of the Farsian Formation were measured in Goznawwi area, located in 22 km of south eastern Azadshar (Fig. 1). The geography coordinates of the section are 36° 57'53'' N and 55° 27'00'' E. Delta plain to marginal marine elastic of Dansirit Formation and carbonate ramp of the Lar Formation are respectively the older and younger sedimentary successions deposited before and after the sedimentation of the carbonate settings of the Farsian Formation (Fig. 2, 3).

In the investigated area, the Farsian Formation consists of 109m thickness; including marl, sandstone and claystone, in follow described bed by bed:

**Bed1 (9 m);** consist of yellow marl without any
fossils.

Bed 2 (21m); including milky fine to coarse grained siliceous sandstone, ferruginous thin bedded clay levels and calcareous sand levels.

Bed 3; measured by with 62 m thickness, consists of gray-bluish marl with richness in fauna. The biota including foraminifera, ammonite, belemnite, echinoid debris, starfish (Marginalia and Terminalia fragments), bivalve, gastropod, brachiopod, coral, shark tooth, marine worm tubes, ostracod, and frequented scattered wood petrified (Fig. 4).

Those layers are bioturbation and the coprolite is frequencies. Secondary structural sedimentary e.g., Septarian concretion (Fig.4), ferriferous nuggets and crystals of gypsum, perite and limonite are occurred. In this bed; we collected 12 samples (G1 to G12) for washing and extracted many of foraminiferal assemblage from them (Fig. 5).

Bed 4 (8m); consists of alternation of brown gypsiferous clay-sandy-limestone and gray claystone with foraminifera, ammonite and belemnite. The foraminiferal assemblage yelled from one sample (G13).

Bed 5 (2m); consists of gray bioclastic sandy limestone. The two samples (G14 and G15) are gathered from this bed.

Bed 6 (1m); including blue claystone with foraminifera and ammonite; the foraminifera collected from sample G16.

Bed 7 (6m); alternation of yellow to brown claystone with intercalation of thin bedded red sandstone.

From the basal sediments of the Farsian Formation towards the upper parts; in despite of 30m in the base, the Foraminifera in this study are identified in through the stratigraphical column.

Figure 1. Geological map of the studied section in the Goznawwi area (Pavlov & Razavi, 1977).
The first identified foraminiferal assemblage almost appears in the middle to upper parts of this sequence (Fig. 5) and is composed of 39 species including; Bathysiphon sp., Saccammina compacta, Reophax sterki, Haurania deserta, Ophthalmodium aff. carinatum, Quinqueloculina sp., Vinelloidea tibia, Proentalina cf. fragilis, P. subsiliqua, Dentalina pseudocommunis, D. bicornis, D. terquemi, D. conferva, D. quenstedti, D. guembeli, D. jurensis, D. cf. multivariabilis, Laevidentalina aff. sarthacensis, Nodosaria simplex, N. fontinensis, N. plicatilis, N. aff. biloculina, Pseudodosaria sowerbyi, P. aff. volgata, Clarifove brandi, Lenticulina subalata, L. munsteri, L. quenstedti, Astacolus filose, Marginulina costata, M. epicharis, Marginulina sp., Vaginulopsis bozorgnia, Planularia beierrana, Vaginulina anomala, Lagena sp., Bullopora rostrate, Ramulina apheilolocula, Trocholina sp.
Benthic foraminiferal morphogroups

Based on test shape and chamber arrangement, as well as on microhabits (feeding strategy and/or living position), nine morphogroups within the benthic foraminifers have been distinguished; two in agglutinated (ag1–ag2; Table 1) and seven in calcareous foraminifera (c1–c7; Table 1).

The grouping is based on models proposed
earlier for agglutinated (Jones & Charnock, 1985; Nagy, 1992; Tyszka, 1994; Kuhnt et al., 1996; Nagy et al., 2009; Reolid et al., 2010, 2012; Smolen, 2012) and calcareous assemblages (Bernhard, 1986; Koutsoukos et al., 1990; Szydło, 2004; Reolid et al., 2008a, 2008b; Reolid et al., 2012; Smolen, 2012).

**Morphogroups of agglutinated foraminifers**

Morphogroup ag1: Consists of multilocular foraminifera with subcylindrical or tapered morphotypes. The majority of species belong to infaunal deposit feeders, detritivorous and microbial scavengers (Jones & Charnock, 1985; Kaminski et al., 1988; Nagy, 1992; Reolid et al., 2008b). In the studied succession this morphogroup includes representatives of the genera *Reophax* and *Bathysiphon*, which are the most frequent in samples of G3 and G4 at level 35 to 40 m of the stratigraphic column.

Morphogroup ag2: Composed of one morphotype with usually globular tests (also irregular in shape), which often live at or just below the sediment surface. Extant foraminifera of this morphotype represent suspension feeding and or passive deposit feeding, shallow infauna. Modern representatives of *Saccammina*, for instance, live with the test partially exposed, and the aperture submerged in the sediment (Christiansen, 1971). Recent of this morphotype; is common in the bathyal and abyssal zone (Murray, 2006).

**Morphogroups of calcareous foraminifera**

Morphogroup c1: Composed of forms lenticular in shape, with multilocular, planispirally coiled smooth and or coarsely ornamented tests. The genera of *Claritoeva* and *Lenticulina* are belonging here. Included taxa are deep infaunal active deposit feeders having both herbivorous and detritivorous diet. They are selected the r-strategist for their life (Reolid et al., 2012). They prefer well ventilated shelf environments with high oxygen content in the bottom waters (Bernhard, 1986; Koutsoukos et al., 1990, Smolen, 2012). Jurassic’s *Lenticulina* had a higher ecological tolerance and opportunistic behavior than extant forms (Rey et al., 1994, Tyszka, 1994, Reolid et al., 2008b).

In the studied succession a mass occurrence of morphogroup c1 is observed in throughout stratigraphic column.

Morphogroup c2: Composed of multilocular, elongated flattened morphotypes with a planispiraly coiled that followed by an uncoiled part.

Table 1. Morphogroups of benthic foraminifers distinguished in the Callovian deposit from the Gognawwi section.

<table>
<thead>
<tr>
<th>Morphotypes test shapes</th>
<th>Life position</th>
<th>Feeding strategy</th>
<th>Genus (in this paper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag1</td>
<td>Subcylindrical, multilocular</td>
<td>Infaunal, free?</td>
<td>deposit feeders, detritivorous, bacterial scavenger</td>
</tr>
<tr>
<td>Ag2</td>
<td>Globular</td>
<td>Shallow infaunal, Common in bathyal and abyssal</td>
<td>Suspension feeding and/or Passive deposit feeding</td>
</tr>
<tr>
<td>C1</td>
<td>Lenticular, planispirally coiled, multilocular</td>
<td>Deep infaunal (r-strategist).</td>
<td>active deposit feeders, detritivorous, herbivorous</td>
</tr>
<tr>
<td>C2</td>
<td>Elongated flattened</td>
<td>shallow infaunal (k-strategist).</td>
<td>active deposit feeders, omnivorous</td>
</tr>
<tr>
<td>C3</td>
<td>Elongate, straight to arcuate, multilocular</td>
<td>Shallow to deep infaunal (k-strategist)</td>
<td>deposit feeders, herbivorous, omnivorous, bacterial detrital scavenger</td>
</tr>
<tr>
<td>C4</td>
<td>Fusiform in outline, multilocular</td>
<td>epifaunal</td>
<td>active deposit feeders, detritivorous, herbivorous</td>
</tr>
<tr>
<td>C5</td>
<td>Globular to ovate, discoidal to conical</td>
<td>epifaunal</td>
<td>deposit feeders, herbivorous, omnivorous, bacterial detrital scavenger</td>
</tr>
<tr>
<td>C6</td>
<td>Sphaerical</td>
<td>Infauna</td>
<td>Deposit feeding</td>
</tr>
<tr>
<td>C7</td>
<td>Globular</td>
<td>Epifaunal, free?</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4. Assemblage of foraminifera and macrofauna (in microscopic and macroscopic scale) collected from Goznawwi section; 1: Clarifovae brandi (× 35); 2: Lenticulina subelata (× 42) (morphogroup c1); 3: Ramulina ophiolocula (morphogroup c6, × 69); 4: Lagena sp. (morphogroup c5, × 68); 5: Saccamina compacta (morphogroup ag2, × 97); 6: Dentalina sp. (morphogroup c3, × 45); 7: Nodosaria simplex (morphogroup c3, × 59); 8: Planularia beierana (morphogroup c2, × 70); 9: Quinqueloculina sp. (morphogroup c4, × 84); 10: Bullopora rostrate (morphogroup c7, × 84); 11-12: Gastropods (× 25 and 12 × 20); 13: Element of Crinoid (18×); 14: Sponge (× 28); 15: Wood changed to pyrite (× 22); 16: Ammonite (from Peltoceratidae), (size of vision, 5×4.5 cm); 17: Bivalve (size of vision 1.3×0.9 cm); 18-23: Belemnite (size of vision: 18- length, 2 cm and average of width, 0.6 cm; 19- length, 1.8 cm and average of width, 0.5cm; 20- length, 3.3 cm and average of width, 0.7cm; 21: length, 3.3 cm and average of width, 0.8cm; 22- length, 7 cm and average of width, 1.7cm; 23: length, 6 cm and average of width, 1.4 cm); 24: Septarian concretion (size of vision, 12×5 cm); 25: 31 Scattered pieces of wood (size of vision: 25- 8×4 cm; 26: 2×2 cm; 27: 2.5×2 cm; 28: 2.2×1.8 cm; 29: 2.5 × 1.5 cm; 30: 2 × 1.2 cm; 31: 2 × 2 cm).
In the material studied, morphogroup c2 is represented by *Astacolus*, *Planularia* and *Vaginolinopsis*. Extant counterparts inhabit shelf environments where they live in the sediment surface as deposit feeders, active detritivorous or omnivorous shallow infaunal taxa. They are selected the k-strategist for their life (Reolid *et al.*, 2012). In the Jurassic, a moderate frequency of small-sized taxa is reported from environments with depleted oxygen content (Reolid *et al.*, 2012).

Morphogroup c3: Represented by elongate, straight to arcuate morphotypes, with multilocular smooth or ornamented tests, of the genera *Pseudonodosaria*, *Nodosaria*, *Dentalina*, *Proentalina*, *Leavidentalina*, *Marginulina* and *Vaginulina*. These are Shallow to deep infaunal (k-strategist, Reolid *et al.*, 2012), having the deposit feeders, herbivorous, omnivorous, bacterial detrital scavenger. Morphogroup c3 occurs most frequently in through the secession in this study.

Morphogroup c4: Composed of benthic calcareous foraminifera with porcellaneous tests. These are multilocular taxa with an elongate test of fusiform and truncate outline, represented by miliolids belonging to the genera *Ophthalmidium* and *Quinqueloculina*. Recent foraminifera with similar morphology are epifaunal, active deposit feeders (both detritivorous and herbivorous). They prefer shallow, well ventilated and oxygenated shelf environments (Koutsoukos *et al.*, 1990). Morphogroup c4 is frequent in the base of blue marl, occurrence in level 35 to 40 m in the
stratigraphic chart.

Morphogroup c5: Composed of diverse morphotypes of conical and globular to ovate shells. Their representatives, *Lagena*, *Trocholina* and *Vinelloidea*, are active deposit feeders (herbivorous, omnivorous, and microbial scavengers), and they are epifaunal. Some are shallow omnivorous infauna living at the watersediment interface (Koutsoukos et al., 1990). They prefer well oxygenated environments, although can tolerate depleted oxygen content (Szydło, 2005; Reolid et al., 2008b). In the studied material morphogroup c5 is rare.

Morphogroup c6: Consists of sphaerical forms living as infaunal deposit feeding. *Ramulina* is the representative genus of this morphogroup. In this study, Morphogroup c6 is occurs in level 35 to 40 m.

Morphogroup c7: Consists of globular form living as epifaunal and/or? Free. The genius of *Bollupora* is present in the morphogroup c7 and occurs throughout the succession.

**Discussion**

**Paleoenvironmental implications**

Foraminifera are extremely sensitive to environmental fluctuations and are used worldwide as reliable palaeoecological indicators. This agrees well with numerous reports emphasizing that benthic foraminifera are very good indicators of the nature of the sea bottom (e.g., Rey et al., 1994; Tyszka, 1994; Nagy et al., 1995; Fugagnoli, 2004; Gaur & Talib, 2009; Reolid et al., 2010; Talib et al., 2012; Smolen, 2012). Palaeoecological interpretations of Jurassic foraminiferal assemblages are difficult to make due to a general lack of direct modern-day analogues (Ballent & Whatley, 1999).

The predominant the group of foraminifera in the Jurassic sediments were the Lagenina and Textularina, which are believed to have occupied a far more diverse range of habitats than their living representatives (Nagy et al., 1990). These groups in the Recent, occupy deeper water settings than in the Jurassic (Ballent & Whatley, 1999). In the Callovian, at the Goznawwi area, foraminiferal assemblages are shows significant changes in their morphogroup composition (Table1). The foraminiferal assemblage consisting four suborders include; Textularina, Miliolina, Involutinina and Lagenina, among them the Textularina is seldom and the Lagenina are abundances. These changes are recorded by fluctuating frequencies of particular morphotypes, which apparently reflect fluctuating palaeoenvironmental conditions during sedimentation in this area.

It seems to be currently accepted among authors that Textularina-dominated faunas develop under conditions divergent from those of a normal marine shelf. In Jurassic shelf to marginal marine areas such divergences, Nagy et al., (1990) were mentioned to two factors that controlled Textularina-dominated faunas; one of them, runoff from land areas to the basin and other high organic supply to the bottom waters. The runoff will promote brackish conditions and high sedimentation rates, both of which are assumed to produce low diversity Textularina-dominated faunas (Nagy et al., 1990). An extensive supply of organic matter (locally mainly land-derived) to the bottom sediments potentially results in oxygen deficiency commonly associated with low pH, both possible producers of low diversity agglutinated faunas. The ubiquity of terrestrial elements (wood scattered, *Xenoxylon* sp. (personal communication, 2017, Professor Philip., University of Lion, France) in all of the samples in this study, a part of displaying significant vertical fluctuations in its content. The high frequency of wood fragments of lowland occur in samples collected from the succession, especially from there samples (G3, G4 and G8), at Goznawwi area, which may be related to an increased influx of terrestrial organic matter from the surrounding land. At sample number G6; the morphgroupe ag; is increase (with 40%), which shows decrease in oxygenation than lower and upper layers, and also through the succession. On the other hand, with increase in organic matter content or with increase in nutrient supply, the morphgroung ag1 and ag2 (from textularids) is increase (total with 40% at G8, and 31% at G3), at these two points (38m and 60 m from the base succession), oxygenate are decrease. Numerous authors have shown that an increase in the organic matter content of the sediment produces an increase in the metabolic activity of the microbiota, consuming the oxygen of the pore water (Jones, 2014). The degree of oxygenation controlled the structure of the benthic foraminiferal communities. Under conditions of very high organic influx, the redox boundary may be close to the sediment-water interface, favoring opportunistic forms dominated by epifaunal, detritus feeders and shallow infaunal forms (Kuhnt et al., 1996;
Fugagnoli, 2004; Reolid et al., 2008b, 2010). In this area, these wood fragments (in post sedimentation phenomena) are pyritized, which the pyritization interpreted as redox potential condition after sedimentation (Fig.4).

In the Jurassic sediments at Goznawwi basin, Textularina introduced by two morphotype; sub-cylindrical or tapered, elongate forms which make up morphogroup ag1, tend to live infaunally under normal conditions. A good example is the genus Reophax, which modern has been found burrowing to a sediment depth of 15 cm in the deep Panama basin (Kaminski et al., 1988). Under normal marine conditions, the genus is able to live in lowered oxygen levels (-0.5 mill) off southern California (Kaminski et al., 1995). So also Reophax spp., prefer a cold–temperate environment (Ola & Bamisile, 2014). Second morphogroup (ag2) include globular, shallow infaunal belong to Saccamina. Both morphogroups (ag1 and ag2) are occurrence in the base and middle of succession.

As maintained; the dominant tax in the Goznawwi area consist of Lagenina (with 83%); among them the Nodosariidae and Vaginulinae are dominant taxa. Many of authors believe that preferred habitat of Jurassic Lagenina seems to have been shelf waters of normal marine salinity and oxygenation (Bielecka & Pozaryski, 1954; Wall, 1960; Johnson, 1976; Nagy et al., 1990; Bhalla & Talib, 1991; Talib & Gaur, 2005; Talib et al. 2012). Ancient Nodosariids are interpreted on the basis of analogy with their modern counterpart as marine, shallow to deep, and as having been tolerant only of normal salinity; and are further interpreted as characteristic of deep marine, upper bathyal environments (Jones, 2014). The dominance of vaginulinids in the studied foraminiferal assemblage suggests shallow water, open marine environment, most probably the deeper shelf (Barnard, 1948; Coleman, 1981; Bhalla & Abbas, 1984; Gaur & Talib, 2009).

Of the lenticular, biconvex, planispirally coiled Vaginulinid (morphogroup c1), the representatives of Clarifovea and Lenticulina (with 100-200µ in size) are the most abundant and richest taxonomically nearly at throughout the succession (Figs. 6, 7). This morphogroup consist of 100 percentage of total sample from G5 (level 42m), G6 (level 45m), G7 (62m), G10 (67m) and G11 (level 74m). In the early Jurassic, the lenticular morphogroup predominates in oxic sediments (Bernhard, 1986); however, the cosmopolitan Lenticulina successfully occupied a wide range of microhabitats during the Jurassic (Bernhard, 1986; Corliss & Chen, 1988; Koutoukou et al., 1990; Rey et al. 1994; Tyszka, 1994). Studies on Recent foraminifers inhabiting oxygen restricted environments demonstrate that such forms are frequently of small size because of their rapid reproduction in stress conditions (Phleger & Soutar, 1973; Fugagnoli, 2004). In total, Lenticulina (morphogroup c1), Dentalina and Nodosaria (agency of morphogroup c2) assign to sub-oxyed environment (Jones, 2014). At the Goznawwi region, normal oxygen values are also indicated by the presence of unornamented tests of flattened genera like Planularia and Astacolus (from morphogroup c2), and Vaginulina (from morphogroup c3) (Bernhard, 1986). Alike morphogroup c1, morphogroup c3 is also dominant at the Goznawwi area, course at the G1 (with 67.5 percentage), G4 (with 33 percentage), G12 (84%), G13 (93%) and G16 (86%). As seen at figure 6 and figure 7, the morphogroups c2 were increased at top of the succession, occur at uppermost of the gray-blueish marl (bed 3), gray bioclastic sandy-limestone (bed 5) and blue clayston (bed 6).

The high frequency of both the planoconvex (c1) and the elongate (c2 and c3) morphogroups, together with the presence of seven other morphogroups, and the relatively high species diversity interpreted as intensive exploitation of both the epifaunal and infaunal niches. It is of interest to note, that the infaunal component (morphogroups c1-c5, c6 and ag1-ag2) makes up 90% of total the assemblages (Figs. 6, 7).

This component suggests that the redox boundary was situated below the sediment-water interfaces, which are in accordance with the presence of bioturbation the marls. In additional, at the middle part of Goznawwi succession, foraminiferal assemblage imply to unstable condition because abundant of infoulnal opportunistic taxa i.e., Lenticulina and Clarifovea. These taxa selected r-strategists and also the ornamentation in Clarifovea is very sharp; interpreted as low dissolved oxygen condition.

In the base and upper parts of succession improved the ecological condition; due to dominant fauna with k-strategists (i.e., Dentalina, Nodosaria, Lavidentalina, Marginulina, Prodentalina, Pseudonodosaria, Vaginulina); thus pointing to a stable and constant benthic environment (see the Fig. 7).
In additional, the pick of the Infaunal morphotypes were introduced the eutrophic condition and low oxygenated (Kaminski et al., 1988). These conditions were visible at the Goznawwi area (fig. 7).

In the base of section; the degree of dysoxia was, however, moderate as suggested by the relatively high species diversities. Further evidence for this is provided by observation of bioturbation preserved in marls, indicating the presence of a burrowing infauna. The absence of textural lamination in the Goznawwi sediments provides further evidence for the presence of bioturbation.

Furthermore, benthic foraminifera are the principal group of use in palaeobathymetric interpretation in the region. Many of arthouse suggested that the upper bathyal zone were distinguished by *Lenticulina*, *Bathysiphon* and *Reophax* and also *Dentalina guembeli* may be interpreted as the neritic to the bathyal zone. But; according to Stampfli (1978), based on occurrence of the *Lenticulina* and *Nodosaria*, the Farsian Formation was deposited in infra-littoral to circum-littoral environments. These taxa were exited in the Goznawwi area and in total; the Farsian Formation was deposited at littoral (neritic) zone; deeper of the shelf water.
Ammonites (Phylloceratidea, Oppelidea, Perisphinctidea and Peltoceratidea belong Callovian age), belemnites, Crinoide’s elements, sponge, bivalves and gastropod are observed throughout the Farsian Formation; are common levels. The presence of this fossil group suggests normal marine salinity conditions at least in the deeper parts of the water column. The comparatively high diversity displayed by the foraminiferal assemblages also rules out brackish conditions (Fig. 4).

Conclusion
Callovian deposits, composing the upper half of the Farsian Formation in the Goznawwi section, eastern Alborz, consist mainly of marls. This sedimentary succession contains an essentially continuous foraminiferal record, composed almost exclusively of calcareous taxa forming high-diversity assemblage, but only in the three levels (G2, G7 and G14) foraminiferal species aren’t observed in this section. In the foraminiferal succession, nine morphogroups have been differentiated, based on morphological features combined with inferred microhabitat preferences and feeding strategies. Palaeoecological analysis of the foraminiferal assemblages based on morphogroups analysis performed in the Goznawwi area for the first time from Iran. In this area, middle Jurassic sediments (Callovian stage) show an initial phase of

Figure 7. Distribution of calcareous and agglutinated foraminiferal morph-groups in the Goznawwi section based on percentage
unstabilization of the benthic environment (levels of G1 to G4). Certain species are affected while others remain constant, and some opportunistic forms increase (Clarifovea and Lenticulina), (with r-strategist) under these new conditions (levels of G5, G6 and levels G9 to G11). In these levels, the morphgroups of c1 is dominants, in following, toward the upper part of the Farsian Formation, in levels of G12 to G16 the morphgrop c1 (with r-strategist) replaced by members of morphgroup c3 (with k-strategist).

Figure 8. Blok-diagram of the distribution of Foraminiferal assemle at Goznawwi area and correlation with the stratigraphical distribution of them in 26 localities in the World: 1. Goznawwi area in this paper; 2. kourkhord mountain at Kopet Dagh, Iran (Kalantari, 1969); 3. Spain, Fuentelsaz section (Hererro & Canales, 1997); 4. France (Bouhamdi et al., 2000); 5. Portugal, Murtinheira (Canales & Henriques, 2008); 6. Portugal, Lusitanian Basin (Henriques, et al., 2016); 7. Portugal, Sao Giao section (Henriques & Canales, 2013); 8. Portugal, Cape Mondeago area (Canales and Henriques, 2013); 9. Portugal, Maria Pares and the Zambujal de Alcaria sections (Figueiredo et al., 2014); 11- Scotland, Brora section (Gordon, 1965); 12.Poland, Gnaszyn area (Smolen, 2012); 13. Hungary, Villany mountains (Gorog et al., 2012); 14. Hungary (Szinger et al., 2007); 15. England, Oxford Clay (Barnard, 1953); 16. England, Dorset (Henderson, 1997); 17. India, Kutach region, Gujrat section (Sabeena, 2015); 18- India, Kutach region, Jumara section (Gaur & Talib, 2009); 19. India, Kutach region, Keera Dome-section (Talib et al., 2012); 20- India, Rajasthan area (Talib et al., 2014); 21- India, Kutach region, Jumara Dome-section (Talib & Gaur, 2008); 22. India, Jhura, Kamaguna and Jumara Dome sections (Alhussein, 2014); 23. Qatar and Arabia Saudi, compsite section (Al -Saad, 2008); 24. Bulgaria (Metodieva et al., 2004); 25. Norwege (Basov et al., 2008); 26. Norwegian (Nagy et al., 1990); 27. Canada, Queen Charlotte Islands (Kottachchi et al., 2002).
This condition interpreted as an optimal ecological redound to dominance assemblage consisting of high-diversity k-strategists and to lesser extent low-diversity r-strategists, which evidences a stable and constant benthic environment with good oxygen and nutrient availability in the infaunal microhabitats. But, throughout at the Goznawwi area, based on the ratio of the infaunal/epiphanal; eutrophic condition is dominant. Palaeobathymetricaly, two genera of Bathysiphon and Reophax occur at the base sediment and also Dentalina guembeli and Lenticulina, which dominance in throughout the section; may be interpreted as the littoral (or neritic zone). Also, the presence of macrofossil e.g. ammonite, belemnite, Crinoide’s elements, sponge, bivalves and gastropod suggests normal marine salinity conditions at least in the deeper parts of the water column. The comparatively high diversity displayed by the foraminiferal assemblages also rules out brackish conditions. Also, for the distribution of Foraminiferal assemblage in this research and correlation with the stratigraphical distribution of them in 26 localities in the World, see the figure 8.

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