

## Early-Miocene Gastropods from Khavich Area, South of Sirjan, (Kerman, Iran): Biostratigraphy, Paleogeography and Paleoecology

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Received: 21 October 2010 / Revised: 16 April 2011 / Accepted: 20 July 2011

### Abstract

A total of 12 species of marine gastropods, among which two taxa are new, is reported for the first time from the Miocene deposits of Khavich section, south of Sirjan, Kerman. Gastropods assemblage in Khavich area indicates deposition in shallow, warm ramp-type carbonate platform. The Miocene and even Oligocene gastropod assemblages, relatively similar to Khavich section, reported from the other parts of the Tethys, show a possible passage, having been open during this interval, although a considerable provincialism is also evident. Therefore the gastropods can be used for the correlation of Oligo-Miocene age formations in many places in the region and the world.

**Keywords:** Gastropods; Miocene; Tethyan Seaway; Kerman; Iran

### Introduction

During Late Oligocene-Early Miocene in west and southwestern parts of central Iran zone, some marine deposits, mostly marls and limestones were deposited. These deposits are called the Qom Formation in general. After oil was discovered in porous bioclastic limestones in 1934 the Qom Formation regarded as one of the most important topics for the scientific research [1-44].

Precipitation of these deposits during Oligo-Miocene refers to presence of a marine habitat with various depths in different parts of Iran [3]. Deposits of these marine habitats are full of fossil fauna such as corals, mollusks, echinoderms, foraminifers and ostracods, among which mollusks, especially gastropods are more conspicuous, not only because of their abundance, but also of their diversity.

The importance of this study is despite of detailed

studies carried out on gastropods of Oligo-Miocene time in Mediterranean and Indian basins, unfortunately there is a little studies and literatures on these fauna in Iran, in spite of their very diverse and abundance assemblages, therefore in this study authors try to introduce a part of this important fauna and reconstruct their biostratigraphy and plaeoenvironment as well.

### Materials and Methods

To study the gastropods assemblage of Lower Miocene deposits in Kerman area, one section was prepared in Esfahan-Sirjan fore-arc basin (Kuh-e-Khavich), and 48 specimens collected from its gray marls. The material, although plentiful, includes a large proportion of crushed, distorted, imperfect, or weathered individuals. Well preserved specimens were cleaned, using a mild detergent and whenever necessary

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by using an ultrasonic vibrator and a preparation needle. If necessary, a light binocular microscope was used. Finally.

The material used in this study is housed in Paleontology Laboratory of Shahid Bahonar University of Kerman, Iran.

### Geological Setting and Stratigraphy

The gastropod fauna, described here, have been collected from the Lower Miocene strata which cropping out in Khavich area, at 29° 11' 13" N and 55° 34' 51" E, west of Sirjan city (Fig. 1). The Miocene sediments of Khavich consist essentially of 60 m green to light gray marls and 40 m cream limestones. This section overlay Paleozoic metamorphic rocks (Khajoo Complex) nonconformably and the upper boundary of it limited by an erosional surface (Fig. 2). The marls are Aquitanian to Burdigalian in age and consist of a diverse benthic fauna such as corals, bivalves, echinoids, ostracods and foraminifers. Gastropods are also among the most conspicuous and diverse constituents of the marly facies fauna of Khavich area, among which following taxa are identified:

*Warakia khavichensis* sp. nov., *Globularia carlei*, *Plesiotrochus* sp. cf. *P. stephanensis*, *Plesiotrochus* sp., *Conus* (*Cleobula*) *steindachneri*, *Bayania semidecussata*, *Varicospira zuschini*, *Globularia gibberosa*, *Gurmya baluchistanensis*, *Zaria angulata*, *Architectonica* sp. cf. *A. carocollata*, *Globularia globulus* sp. nov.

The marls overlies by Burdigalian sediments, which consist of bioturbated, and thick-bedded limestones, relatively barren of macroinvertebrates, but containing abundant corallinaceans, foraminifers (lepidocyclinids, heterosteginids, *Rotalia viennoti*, operculinids, *Amphistegina* sp., *valvulina* sp., peneropelids, *Austrotrillina howchini*, *Dendritina rangi*, *Borelis mellocuridica*, *Gypsina globulus*, miogypsinids) and bryozoans.

### Systematic Paleontology

Class Gastropoda Cuvier 1969, [12]

Super order Caenogastropoda Cox 1960, [11]

Superfamily Ampullinoidea Cossman [9]

Family Ampullinidae Cossman [9]

Genus *Warakia* Harzhauser [26]

*Warakia khavichensis* sp. nov. Hasani & Vaziri (2011)

Fig. 7A<sub>1</sub>-A<sub>3</sub>

**Diagnosis:** Medium sized ampullinid with a shoulder ornamented with axially elongated nodes and a strongly thickened columellar callus bearing 4-5 prominent

parietal swelling. Body whorl increases rapidly in width and has a pronounced convexity in its middle part. The body whorl passes nearly into the base forming a slight angulations. A row of spiny, slightly axially elongated, nodes decorates the last whorl.

**Remarks:** *Warakia khavichensis* sp. nov. differs from *Warakia pilleri* Harzhauser, Oligocene of Oman [26] by having a more rounded aperture and smaller size ornaments.

**Type locality:** This species is collected first time from Kuh-e-Khavich area, south of Sirjan.

**Derivation name:** The name of this species is derived from its type locality (Kuh-e-Khavich).

**Holotype:** The holotype of *Warakia khavichensis* sp. Nov. is collected from Kuh-e-Khavich and is housed in Paleontology Laboratory of Shahid Bahonar University of Kerman, Iran.

Subclass Orthogastropoda Ponder & Lindberg 1996, [49]

Superorder Vetigastropoda Salvini-Plawer 1980, [55]

Super family Trochoidea Rafinesque 1815, [50]

Family Trochidae Rafinesque 1815, [50]

Subfamily Trochinae Rafinesque 1815, [50]

Genus *globularia* Swainson 1840, [64]

*Globularia gibberosa* Grateloup 1847, [20]

Fig. 7B<sub>1</sub>, B<sub>2</sub>

1847 *Natica gibberosa*, [20]

1853 *Natica decipiens* nov. sp. [13]

1870 *Natica gibberosa*, [18]

1891 *Globularia gibberosa*, [57]

1900 *Globularia gibberosa*, [54]

1900a *Natica* (*Ampullina*) *gibberosa*, [47]

1910 *Natica* (*Ampullina*) *gibberosa*, [38]

1910 *Natica auriculata*, [38]

1913 *Ampullina gibberosa*, [48]

1914 *Ampullina Auriculata*, [65]

1928 *Ampullina* (*Globularia*) *gibberosa*, [66]

1958 *Globularia auriculata*, [58]

1964 *Globularia* (*Globularia*) *gibberosa*, [37]

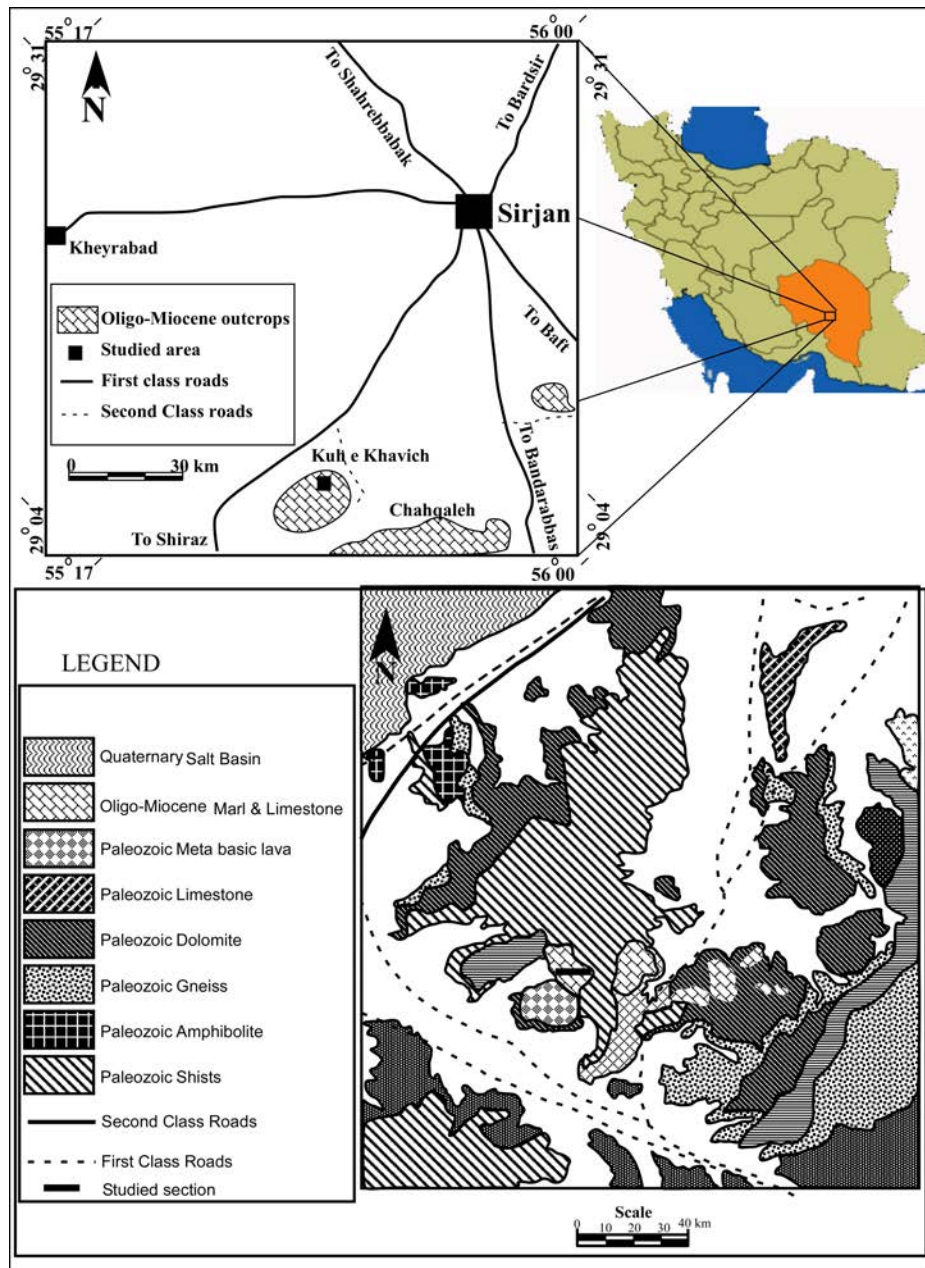
1971 *Natica gibberosa*, [2]

1973 *Globularia gibberosa*, [4]

1980 *Globularia* cf. *gibberosa*, [35]

2004 *Globularia gibberosa*, [25]

**Discussion:** *Globularia gibberosa* differs from *Globularia auriculata* by having a covered umbilicus, although Badli [4] considered both umbilicated specimens and those with covered umbilicus as *Globularia gibberosa* and regarded them as two subspecies. The species is reported from Oligocene of Italy [18], France [20], Hungary [4], Bulgaria [37] and Pakistan [65-35]. It has also been reported from early Miocene of Italy [57].



**Figure 1.** Location and simplified geological map of the Khavich area in southeastern of Iran, from where gastropods have been collected [56].

- Globularia carlei* Finlay 1927, [16]  
 Fig. 7C<sub>1</sub>, C<sub>2</sub>  
 1840 *Natica callosa*, [60]  
 1927 *Natica carlei*, [16]  
 1928 *Ampullina (Cernina) callosa*, [61]  
 2009 *Globularia carlei*, [31]

**Diagnosis:** This globulariid is distinguished from the other species of the genus by having a huge last whorl and also its depressed spherical outline. *Natica callosa* [7,9,45,46] differs from *Globularia caelei* by having a pointed spire. *Globularia carlei* is reported from Burdigalian of India.

*Globularia globulus* sp. nov. Hasani & Vaziri (2011)  
Fig. 7D<sub>1</sub>, D<sub>2</sub>

**Diagnosis:** A globularid with a spherical shape and a four whorl body. The last whorl overlies the umbilical part. The spire of the shell is slightly stand up and the first whorl is highest than the other whorls. Aperture is holostomatus and surface of the shell is not ornamented.

**Remarks:** *Globularia globulus* sp. nov. differs from other globularids found in the section by having a more spherical shape and also its high stand of the first whorl.

**Type locality:** This species is collected from Kuh-e-Khavich area, south of Sirjan

**Derivation name:** The name of this species derived from its spherical shape.

**Holotype:** The holotype of *Globularia globulus* sp. nov. is collected from studied area and is housed in Paleontology Laboratory of Shahid Bahonar University of Kerman, Iran.

Family Plesiotrochidae Houbriek 1992, [34]

Genus *Plesiotrochus* Fischer 1884, [15]

*Plesiotrochus* sp.

Fig. 7E<sub>1</sub>, E<sub>2</sub>

**Diagnosis:** A turritellid gastropod with six whorls and apical angle between 30° to 35° base on the size of the shell. The growth lines are narrow and shell is not ornamented. The whorls become wider progressively.

**Remarks:** *Plesiotrochus* sp. differs from *Plesiotrochus stephanensis* by its wider growth lines and more voluminous body, specially near the aperture whorls.

*Plesiotrochus* sp. cf. *P. stephanensis* Cossman & Peyrot 1922, [8]

Fig. 7F<sub>1</sub>, F<sub>2</sub>

1922 *Hemicerithium stephanensis*, [8]

2004 *Plesiotrochus stephanensis*, [25]

**Remarks:** *Plesiotrochus stephanensis* is reported from the Oligocene of Abadeh, Iran [25] and also from the Chatian of France [42,8].

Superfamily Conoidea Rafinesque 1815, [50]

Family Conidae Rafinesque 1815, [50]

Genus *Conus* Linne 1758, [40]

Subgenus *Cleobula* Iredale 1930, [36]

*Conus (Cleobula) steindachneri* Hornes & Auinger 1879, [32]

Fig. 7G<sub>1</sub>, G<sub>2</sub>

1856 *Conus venetricosus*, [33]

1879 *Conus (Dendroconus) Hoehnestetteri*, [32]

1879 *Dendroconus steindachneri*, [32]

1966 *Conus (Coleobula) steindachneri*, [63]

2002 *Conus (Coleobula) steindachneri*, [27]

**Diagnosis:** A small size *Conus* with a very low spire and apical angle between 105°-110°, the body whorl, in contrast to others, is very big and lasted in a narrow aperture. The base angle is 38°-40° and this part is pointed by an elegance siphon. The whorls growth gently, while the width of them increase slowly.

**Remarks:** *Conus (Coleobula) steindachneri* differs from *C. berghausi* [5] by having a wider apical angle. This species is synonymus to *C. steindachneri* in Hall [23].

Superfamily Pseudomeanoidea Cossman & Peyrot 1909, [8]

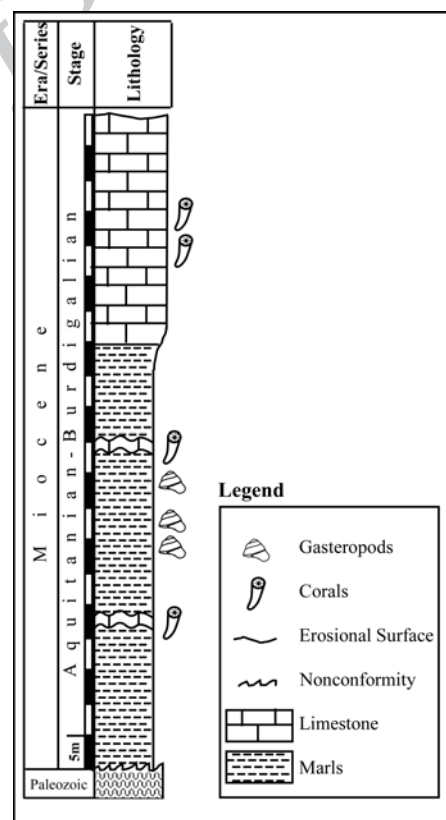
Family Pseudomelaniidea Cossman & Peyrot 1909, [8]

Genus *Bayania* Cossman & Peyrot 1909, [8]

*Bayania semidecussata* Lamarck 1805, [39]

Fig. 7H

**Diagnosis:** The specimens recovered from Khavich section is characterized by being spiny and have a large-size. The species is widespread in the Oligocene of some parts of the words such as France, Rumania, Italy and also Abadeh in Iran [25].



**Figure 2.** Schematic lithological succession of Lower Miocene strata in Khavich area.



Superorder Hypsgastropoda Ponder & Lindberg 1996, [49]

Infraorder Littorinimorpha Golikov & Starobogatov 1975, [19]

Superfamily Strombodia Rafinesque 1815, [50]

Family Strombidae Rafinesque 1815, [50]

Subfamily Strombinae Rafinesque 1815, [50]

Genus *Varicospira* Eames 1952, [14]

*Varicospira zuschini* Harzhauser 2007, [26]

Fig. 7I<sub>1</sub>-I<sub>4</sub>

**Diagnosis:** The species is characterized by having a high spire, moderately slender shell and short body whorl. *Varicospira Zuschini* reported for the first time from Upper Oligocen of Oman [26]. The specimens recovered from Khavich area, have slender outline than those reported from Oman and show early Miocene age for the sediments.

Order Sorbeoconcha Ponder & Lindberg 1996, [49]

Superfamily Cerithioidea Fleming 1822, [17]

Family Cerithiidae Fleming 1822, [17]

Subfamily Cerithiinae Fleming 1822, [17]

Genus *Gourmya* Fischer 1884, [15]

*Gourmya baluchestanensis* Vredenburg, 1928, [66]

Fig. 7J

**Remark:** *Gourmya baluchestanensis* is very similar to *Gourmya delbosi* [43]. However, *Gourmya delbosi* is distinguished by its stocky outline, conspicouse suture and low whorls. This species is known from Upper Oligocene Nari Formation of Pakistan and Upper Oligocene Warak Formation of Oman [26]. The specimens found in Khavich indicate an early Miocene age for the strata.

Order Sorbeoconcha Ponder & Lindberg 1996, [49]

Superfamily cerithioidea Fleming 1822, [17]

Family Turritellidae Loven 1847, [41]

Subfamily Turritellinae Loven 1847, [41]

Genus *Zaria* Gray 1847, [21]

*Zaria angulata* Sowerby 1840, [60]

Fig. 7K

1840 *Tutella angulata*, [60]

1853 *Tulla angulata*, [13]

1928 *Turritella angulata*, [66]

2009 *Zaria angulata*, [31]

**Remarks:** The growth lines are the main characteristic feature in distinction of this turritellid from the other species of the genus. *Zaria angulata* is known from the Aquitanian and Burdigalian outcrops in India, Pakistan and also from Qom Basin in Iran [24]. The younger representatives of the species reported from Late Miocene to Pliocene of Iran and Indonesia [10,46,59].

Superorder Heterobranchia Gray 1847, [21]

Superfamily Architectonicoidea Gray 1850, [22]

Family Architectonica Gray 1850, [22]

Genus *Architectonica* Roding 1798, [52]

*Architectonica* cf. *carocollata* Lamarck 1805, [39]

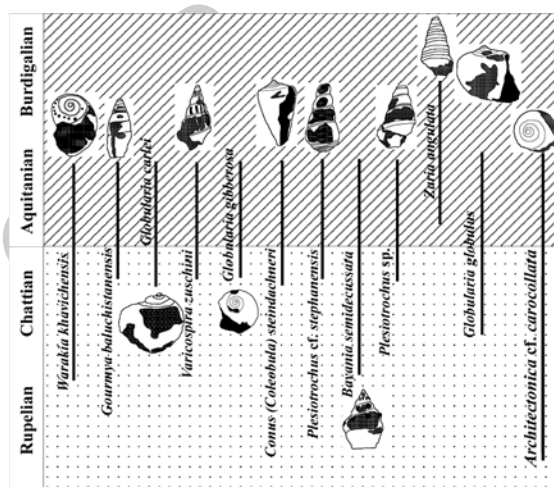
Fig. 7L

1891 *Solarium carocillatum*, [57]

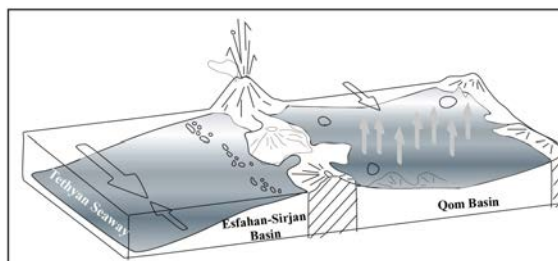
1900 *Solarium carocollatum*, [54]

2004 *Architectonica carocolata*, [25]

**Discussion:** *Architectonica carocolata* differs from *Architectonica simplex* (Bronn) by its smaller protoconch and having granulated spiral ribs. It can be distinguished from *Architectonica umbrosa* (Brongniart) by its less sculptured base. *Architectonica carocolata* is known from Miocene of North Sea Basin, the



**Figure 3.** Stratigraphic distribution of gastropods in Khavich section and adjacent areas [24-31], during the Oligocene to Miocene interval.



**Figure 4.** Schematic block diagrams illustrating the development of the Esfahan-Sirjan Basin and Qom Basin in Early Miocene. The white arrows show the gateways. (Modified from Harzhauser [26]).

Mediterranean and the Paratethys and also Oligocene of Abadeh, Iran [25].

## Results and Discussion

### a) Biostratigraphy

Marine gastropod assemblage recovered from Khavich area represents an Early Miocene age for the section, although in some regions, adjacent to the studied section, some of them are found in Chattian to Tortonian age as well. Early Miocene age is also supported by benthic foraminifera and ostracods, found with gastropods in Khavich section. The similar assemblages have reported from the other regions of the world eg. [28,30,31], documenting Late Oligocene to Late Miocene age for the gastropods and indicate a possible Tethyan Seaway for nearshore gastropods. However a relatively provincialism is obvious as well. Stratigraphic distribution of recovered gastropods in khavich section and adjacent area is shown in Figure 3.

### b) Paleogeography

According to Stocklin [62], Berberian and King [6] and Rosenberg [53] the following major structural zones can be distinguished in Iran: Folded Zagros, High Zagros, Sanandaj-Sirjan Ranges, Central Iran, Alborz Mountains, Kopet Dagh, Lut Block, and East Iran/Makran Ranges. Geological studies indicate that the southeastern Sanandaj-Sirjan Zone, located in the Southeastern Zagros Orogenic Belt is subdivided transversally into the Esfahan-Sirjan Block with typical Central Iranian stratigraphic features and the Qom Basin. The studied area is part of Esfahan-Sirjan Basin, which is a foreland basin (Fig. 4), separated by an Eocene volcanic arc system from the Qom back arc Basin [25].

During Oligo-Miocene, both basins were located at the Eurasian margin of the Tethyan Seaway (Fig. 5), which connected the western and eastern regions of the Tethys Ocean at least until the Late Burdigalian [51].

The Seaway was closed due to the collision of the African/Arabian and Iranian/Eurasian plates.

### c) Paleocology

Although the Early Miocene strata of the khavich area yield about 12 species of gastropods, nevertheless, this small assemblage is important as it is the first record of gastropod faunas from that area. The composition of the fauna displays that *Plesiotrochus* sp. cf. *P. stephanensis*, *Globularia gibberosa* and

*Architectonica* sp. cf. *A. carocollata* are dominant species of the community (Fig. 6).

Two of the taxa are new and reported for the first time. This suggests that Oligo-Miocene gastropods of the Esfahan-Sirjan Basin are still largely unknown.

Comparison with previous studies on gastropod fauna, which are similar to Khavich section [29, 51, 31], led us to conclude that gastropods assemblage of Khavich area lived in a shallow and quite environment, with a soft and fine grained carbonated mud floor. Furthermore, benthic foraminifera and ostracods accompanied with gastropods belong to a soft and muddy Substrate, with low agitation of the water, where epifaunal deposit feeders are able to flourish. Autotrophic algae are also present and confirm a shallow, photic environment during the deposition of the strata. The high abundance of hermatypic scleractinian corals occurring in the section, provided a suitable shelter for the gastropod fauna and indicate a near tropical and warm water environment for the

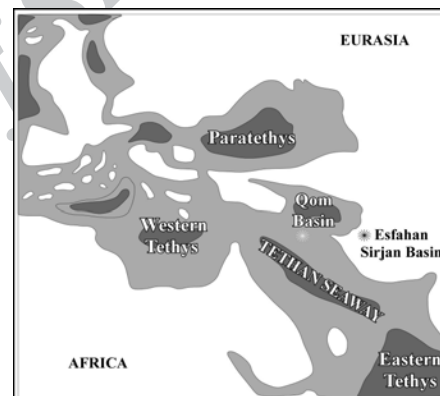


Figure 5. Late Oligocene paleogeography of the Tethyan Seaway and adjacent regions Modified from Harzhauser [26].

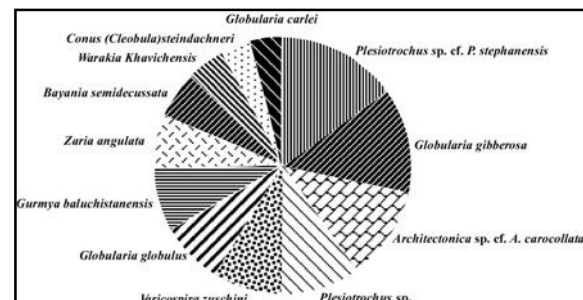
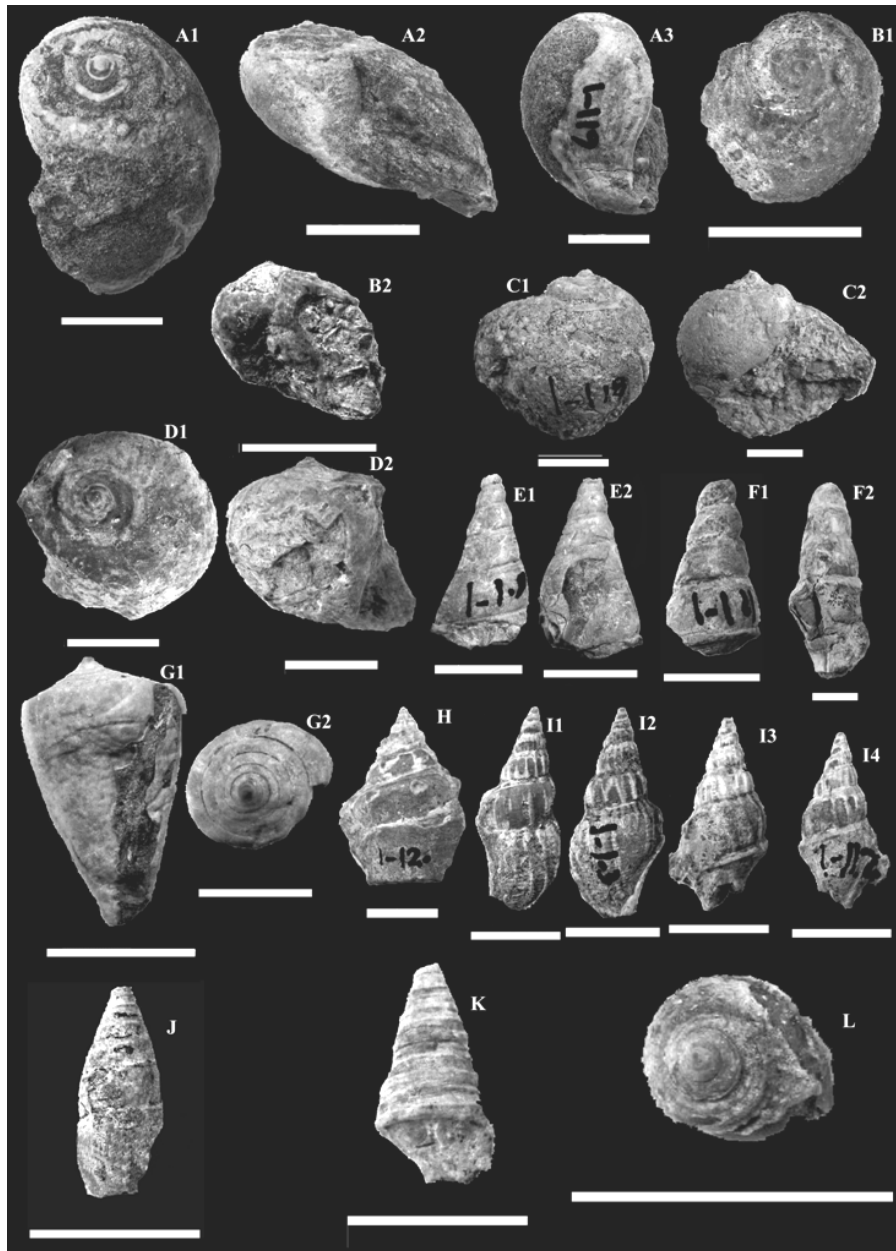


Figure 6. Relative abundance of gastropods of the Khavich area.



**Figure 7.** Gastropods from the Oligo-Miocene of Khavich area. A<sub>1</sub>-A<sub>3</sub>: *Warakia Khavichensis*; B<sub>1</sub>, B<sub>2</sub>: *Globularia gibberosa*; C<sub>1</sub>, C<sub>2</sub>: *Globularia carlei*; D<sub>1</sub>, D<sub>2</sub>: *Globularia globulus* sp. nov.; E<sub>1</sub>, E<sub>2</sub>: *Plesiotrochus* sp.; F<sub>1</sub>, F<sub>2</sub>: *Plesiotrochus* cf. *stephanensis*; G<sub>1</sub>, G<sub>2</sub>: *Conus (Cleobula) steindachneri*; H: *Bayania semidecussata*; I<sub>1</sub>-I<sub>4</sub>: *Varicospira Zuschini*; J: *Gourmya baluchistanensis*; K: *Zaria angulata*; L: *Architectonica* cf. *carocollata*. Scale bars represent 1 cm.

studied section. Consequently, the gastropods lived in a shallow, gentle, warm and muddy substrate. However, there are some supersaline taxa in the assemblage, among which some lived in brackish waters. This suggests that the salinity of the environment is doubtful

and needs isotopic analysis to make absolute decision.

1- The Miocene deposits of Khavich area comprises twelve species of marine gastropods, of which two taxa are new.

2- Despit the relatively diverse assemblage of

gastropods, only 4 species dominating the fauna. *Plesiotrochus* sp. cf. *P. stephanensis*, *Globularia gibberosa*, *Architectonica* sp. cf. *A. carocollata* and *Plesiotrochus* sp. constitute about 50% of all examined species.

3- The Miocene gastropod faunal similarities are very strong between khavich district and other Tethyan regions. It suggests the strong paleogeographic connections at this time, therefore the gastropods may be used as excellent index species for the correlation of Miocene and even Oligocene age formations in many places of the Tethys regions.

4- The paleoecological analysis of the gastropod fauna in Khavich area indicate that a shallow and suitable environment prevailed during the deposition of the Miocene strata. The setting is characterized by a soft and fine grain substrate, located in photic zone of the water column, near the tropical region.

### Acknowledgments

Authors are thankful for Dr. A. Arab for his helps in collecting samples and also from Dr. H. Hoseinipour for her fruitful suggestions during the study.

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