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Early Miocene (Burdigalian) Gastropod Faunas of Vareh Zard section, North of Pole-Dokhtar, (Lorestan, Iran)

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Abstract

A total 7 species and 13 genera of marine gastropod assemblages are reported for the first time from the Varehh Zard section (Asmari Formation), north of Pole Dokhtar, Lorestan Basin. The section under study, the Asmari Formation, lies between the Shahbazam Formation at the base and Gachsaran Formation at the top. According to the distribution of index foraminifera, the Asmari Formation is Early Miocene (Aquitanian-Burdigalian) in age. In general, gastropod assemblages have been observed in the upper part of Asmari Formation (Burdigalian). The Miocene and even Oligocene gastropod faunas, relatively similar to the Vareh Zard section, reported from Tethys and Proto- Indo- Pacific Ocean, indicate that a passage was open during this interval. In this study, Oostrombus auricularius, Anazola elavula, Conus diversiformis, Turbo thouvignoni, Campanile pseudoobeliscus, Cassis mamilliaris, Psudophasianus elatus, Paroxystele, Ampullina sp., Architectonica cf. carocollata are described with special emphasis on their distribution in the Tethys and adjacent bioprovinces. Lyra sp., Cerithium rude and Ampullospira sp. are restricted to the Proto- Indo- Pacific Ocean.

Keywords: Asmari Formation; Gastropods; Miocene; Lorestan Basin.

Introduction

The Cenozoic stratigraphy of the Zagros Mountains has been the subject of detailed study ever since the first petroleum reservoirs were discovered, in Masjed Soleyman area, in the Oligo- Miocene carbonate deposits (the Asmari Formation). The Oligo- Miocene reservoirs are currently being utilized prolifically not only in Iran but also in other parts of the Middle East e.g. Kirkuk Field in Iraq [50]. Stratigraphical investigations of the Asmari Formation in Zagros were started with the work of Busk and Mayo [11]. Subsequent writers such as Richardson [53] and Thomas [67] reported the lithostratigraphical and biostratigraphical properties of the Asmari Formation. James & Wynd [36] Wynd [71], Adams & Bourgeos [1] and Laursen et al, [41] introduced the microfaunal characteristics and assemblage zones for the Asmari Formation. More recent studies of the Asmari Formation have been conducted on the sequence

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stratigraphy [3, 4, 44, 61, 62, 68, 69, and 70]. Deposits of the Asmari Formation are full of fossil fauna such as corals, echinoderms, foraminifers, ostracoda and mollusks especially gastropods. Unfortunately, there is few studies on these fauna in Iran. In this study, therefore, the author tries to introduce some of the gastropod assemblages and reconstruct their biostratigraphical and plaeoenvironmental properties.

Materials and Methods

The stratigraphic section under study is located at the northeastern flank of Maleh Kuh anticline with geographic coordinates of 47° 51′ 22″ E and 33° 15′ 03″ N (Fig. 1). 43 samples from the Shahbazan and Asmari Formations were studied in the selected stratigraphic section. All rock samples and thin sections are housed in the Department of Geology, Lorestan University. The material includes a large proportion of crushed, distorted, imperfect, or weathered individuals, although it is plentiful, Well preserved specimens were cleaned by means of a mild detergent, and whenever necessary, an ultrasonic vibrator and a preparation needle. Finally, a light bionocular microscope was used, where it was necessary.

Geological setting

The Zagros Mountain is the southern part of an Alpine Orogaenic Belt [64]. It extends from southeastern Turkey through the northern Syria and Iraq to western and southern Iran [3]. Post -tectonic and sedimentary events in the Zagros Mountain resulted in the formation of several definable basins (Fig.2): Thrust Zone, Lorestan, Izeh, Dezful Embayment, Abadan Plain, Fars, Bandar Abbas Hinterland [62]. By the end of Mesozoic time, the principle palaeogeographic features of southwestern Iran were the main trough of the Tethys, and Lorestan and Khuzestan towards Central Fars province to the north were the smaller minor trough which runs from eastern Iraq southwestward with an elongate ridge between these two troughs [47].

The pelagic sedimentation continued during the Paleogene time in this subsidiary trough with the sedimentation of marls and shales intercalated with subordinate argillaceous limestones, which form the present day Pabdeh Formation (Fig.3). On the southwestern side of this trough, carbonate sedimentation continued during the Paleogene conformably onto the Arabian shield forming the Radhuma and Dammam Formations. These two formations were separated by an evaporite unit called the Rus Formation, which pinches out towards southwest Iran where the entire carbonate sequence is called the Jahrum Formation.

In central and northeastern Lorestan, the uplift, and then the erosion of radiolarites, produced a great quantity of detritus that was carried southwestward, and the detritus was accumulated as flysch-type sediments forming the present Amiran and Kashkan Formations during Late Maastrichtian-Eocene time. These two units are separated by the carbonates of the Taleh Zang Formation. The Kashkan is also overlain by the dolomites of the Shahbazan Formation. The Sachun Formation can be seen along with the radiolarian cherts

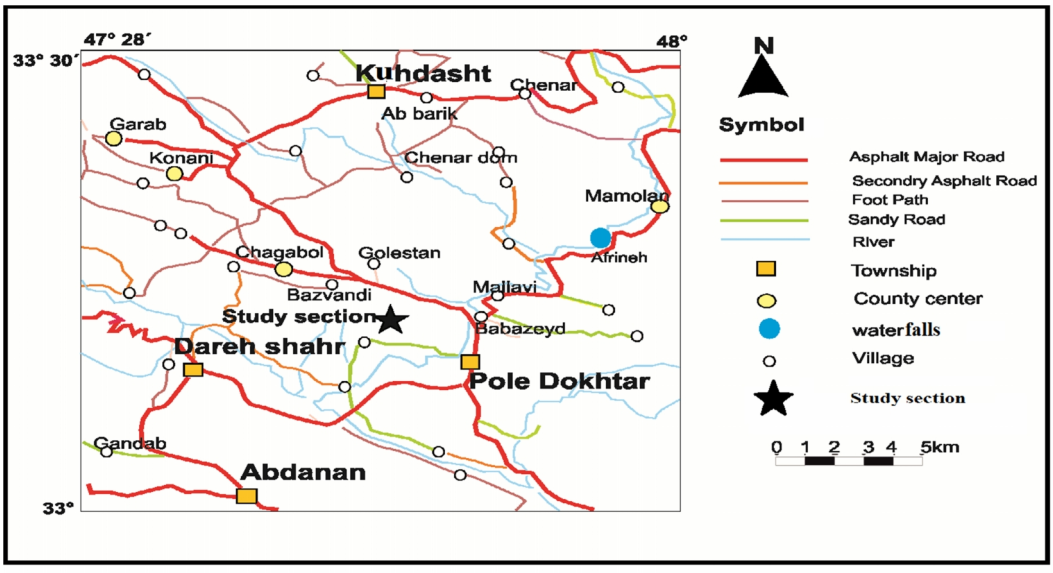

Figure 1. A Location map of Vareh Zard section in southwestern Iran.

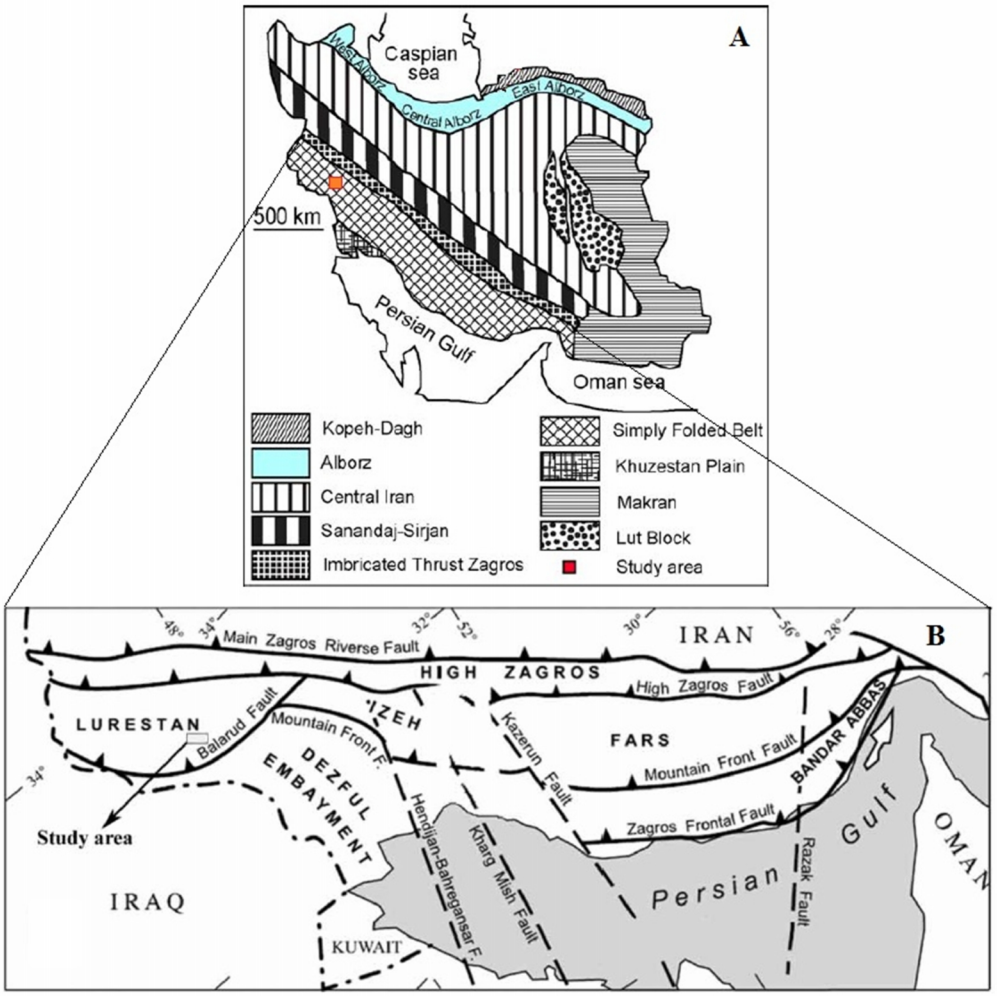

Figure 2. Location map. **(a)** General map of Iran showing nine geologic provinces [64], **(b)** Structural-sedimentary zones of Zagros province [62].

in the interior Fars province, which is a tongue of carbonate materials. By the end of Eocene time, the widespread regression caused the greater portion of the region to emerge except the central parts of the troughs. The resulting disconformities exist over the entire area where Jahrum and Shahbazan formations are developed

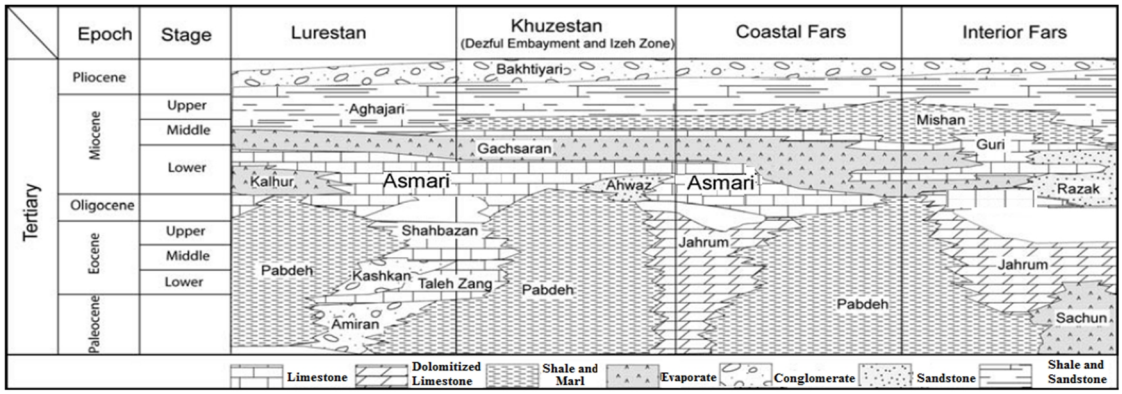

Figure 3. A schematic stratigraphic section of the Cenozoic deposits of southwestern Iran, adapted from James and Wynd [71].

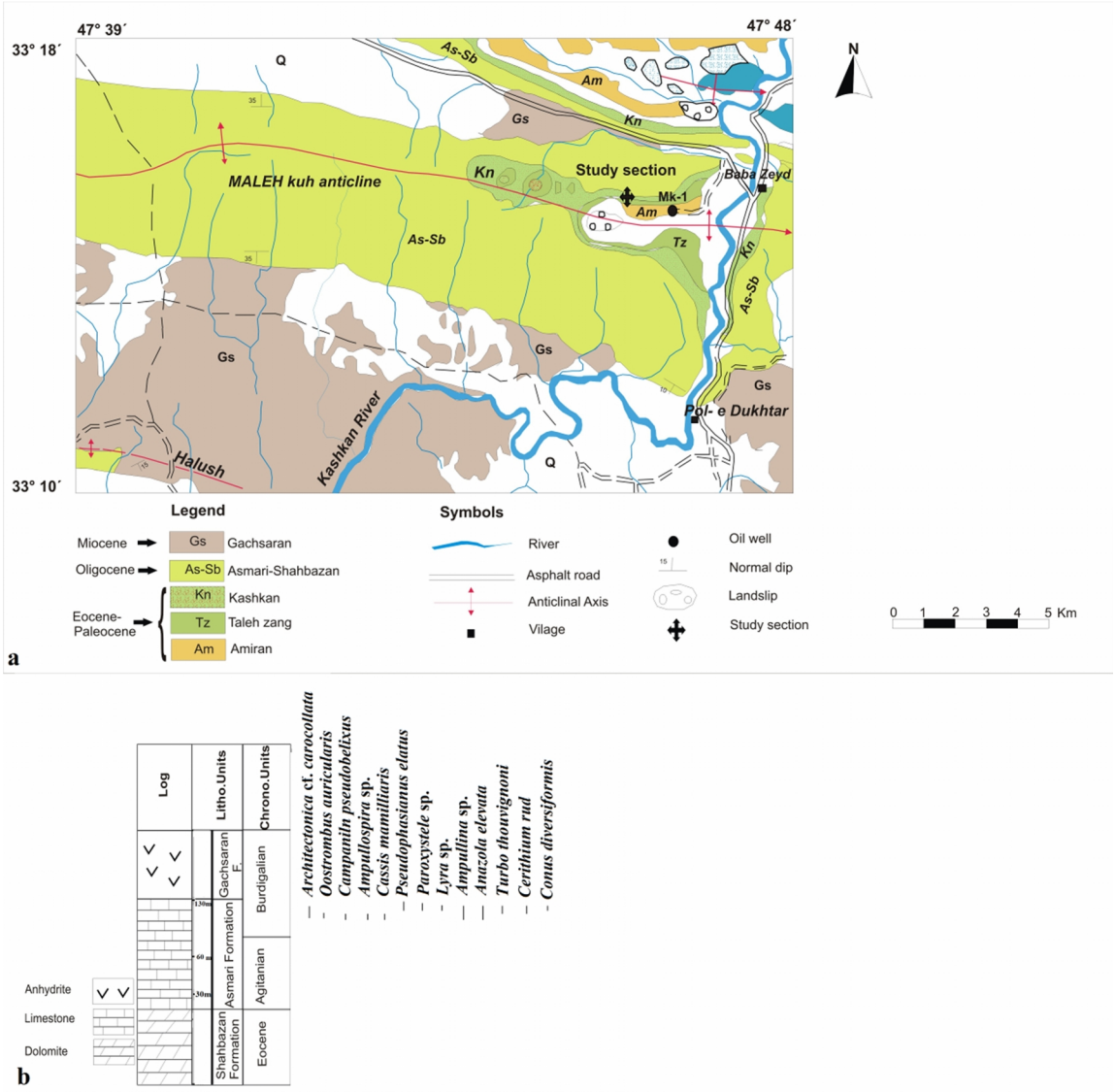

Figure 4. a) Schematic lithological succession of the Asmari Formation. b) Simplified geological map of the Varehzard area in southwestern Iran.

[65].The Shahbazan Formation has been deposited in the Lorestan Basin at a flanking shelf (Fig.3). The upper contact of the Shahbazan Formation is disconformable with the Asmari Formation limestone. In the northern and northeastern Lorestan, the Shahbazan and Asmari Formations form a prominent topographic unit. The Shahbazan Formation is distinct from the Asmari Formation by an intervening conglomeratic leached zone and a change from of the Shahbazan Formation dolomite to the Asmari limestone. This boundary is often difficult to determine, thus making it necessary to map the two formations as one unit. In this way, the two names form hyphenation[37]. The upper contact of Asmari Formation is overlain by the Gachsaran Formation (Miocene).

Systematic paleontology

The systematic arrangement of higher taxa largely follows the proposal of [8].

Class Gastropoda Cuvier 1797 [14]
Superorder Hypsogastropoda Rafinesque 1815 [49]
Infraorder Littorinimorpha Haller 1892 [26]
Superfamily strombodia Rafinesque 1815 [50]
Family Strombidae Rafinesque 1815 [50]

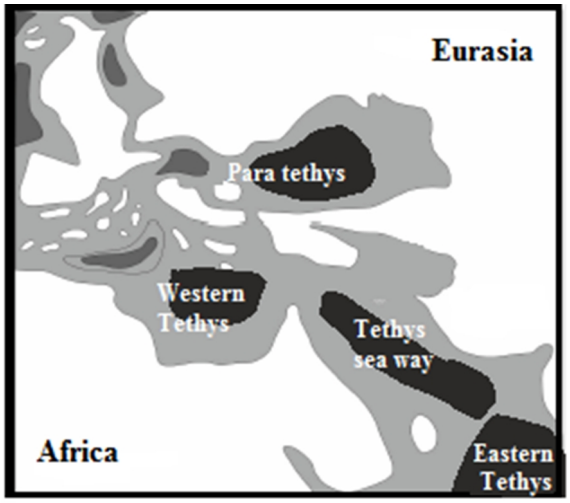

Figure 5. Late Oligocene- Early Miocene paleogeography of Tethys and the adjacent region, [35].

Subfamily Strombinae Rafinesque 1815 [50]

Genus *Oostrombus* Scopoli 1777 [59]

Oostrombus auricularius Grateloup 1828-1935[21]

Fig. 6b

Strombus auricularius Grateloup 1828-1935 [21]

Strombus auricularius Grateloup 1847 [22]

Strombus problematicus Michelotti1861 [44]

Strombus exauriculatus Scopoli 1777 [59]

Strombus problematicus var. *longovata* Taylor, Morris and Taylor 1980 [66]

Strombus problematicus var. *regularis* Scopoli 1777 [60]

Strombus problematicus var. *regularis* Fleming 1822 [20]

Strombus problematicus ? Var. *cyathiformis* Sacco 1891[59]

Strombus auricularius var. *regularis* Rafinesque 1815[51]

Diagnostic: Shell conical and large- sized. The outline of the specimens is a result of the striking enveloping of the previous whorls by the following ones, thus producing a heavy dome of calcareous layers which form a coeloconoid spire of the juvenile specimens is pointed, without the thick covering of the adult whorls.

Measurements: height: > 105 mm

Age: Burdigalian

Distribution: *Oostrombus auricularius* is documented from the France, Italy, Bulgaria and Iran [28,35].

Infraorder Neogastropoda Rovereto 1899[56]

Superfamily Olivellidoidea [15]

Family Olividae Davoli1989 [43]

Genus *Anazola* Gray *1847* [23]

Anazola elavula Lamark 1805[40]

Fig.6f

1954 *Olivella (Lamprodoma) clavula vindobonensis* Csereghy- Meznercis 1954 [13]

Description: Shell spindle-shaped and medium-sized. Four whorls are separated by narrow, incised sutures, the spire is tall, conical, measuring approximately slightly more than one fourth of the total height. The aperture is narrow, ending anteriorly in a small notch.

Measurements: height: > 40 mm

Age: Burdigalian

Distribution: It is known from the Oligocene of France, Northern Italy, Hungary and Central Iran [34]. A rather species was described by [2] as *Tortoliva s*p. from the Early Miocene (Aquitanian) of Sw of Shiraz (Zagros Basin).

Family Volutidae Rafinesque 1815 [51]

Subfamily Lyriini Gray 1854[25]

Genus *Lyra* Gray 1850 [24]

Fig. 6c

Type species: Voluta pattersonia Perry 1811. Recent, Pacific

Diagnosis: A conical form gastropod with five whorls. The whorls become wider progressively. The sutures are completely deep and moderately dip. The Middle part of the last whorl is more convex.

Measurements: height: > 270mm

Age: Burdigalian

Distribution: It is known from Early Miocene of India, Pakistan and Madagascar [31, 9] and Bakhtyary Formation in Central-Western Iran [52] and Sirjan area in East Iran [33].

Superfamily Conoidea Rafinesque 1815 [51]

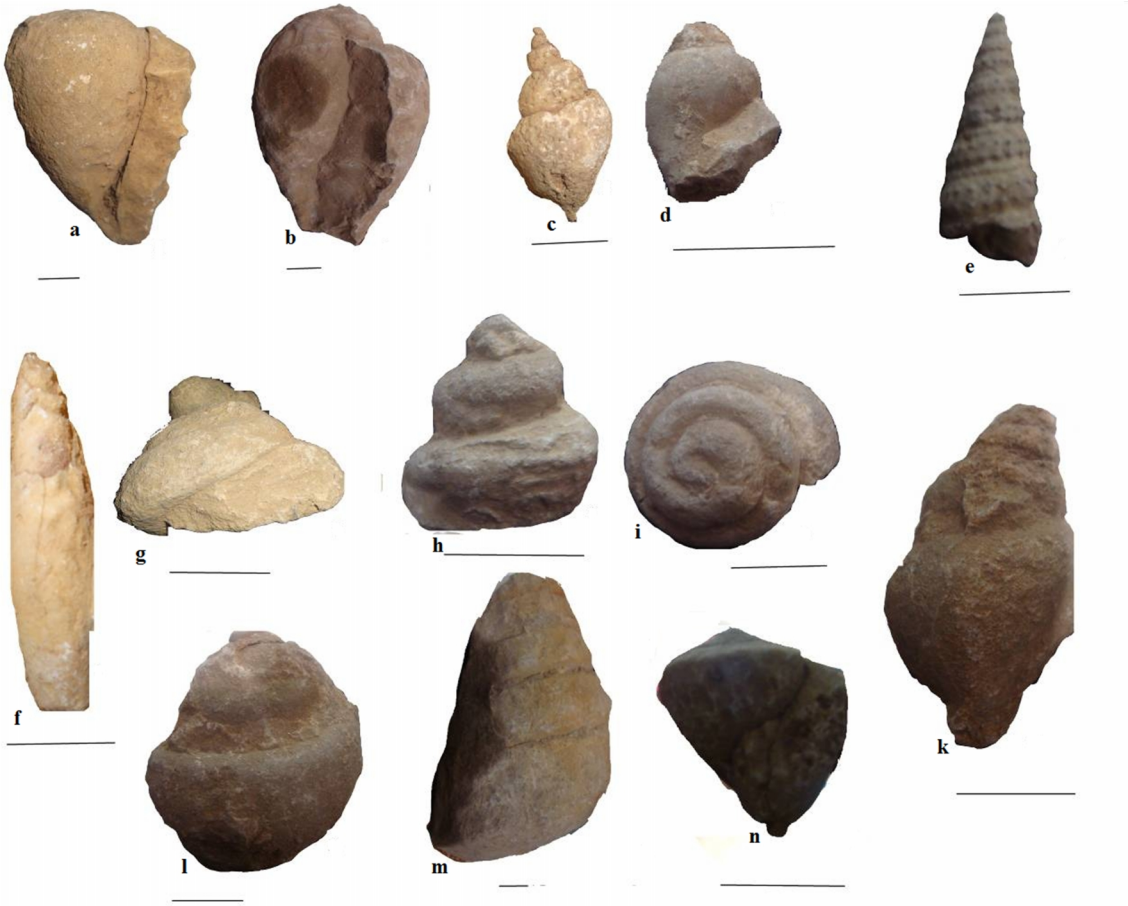

Figure 6. Gastropods from the Miocene of Vareh Zard area, a: *Conus diversiformis*, sample no.40; b: *Oostrombus auricularius*, sample no.34; c: *Lyra* sp., , sample no.41; d :*Ampullina* sp., sample no.32; e: *Cerithium rude*, , sample no.39; f: *Anazola elavula*, , sample no.40; g: *Paroxystele* sp., , sample no.41; h: *Turbo thouvignoni,* , sample no.42; i: *Architectonica* cf.*carocollata*, , sample no.29; k: *Psudophasianus elatus*, , sample no.37; l: *Ampullospira* sp., , sample no.37;: *Campanile pseudoobeliscus*, , sample no.29; n: *Cassis mamilliaris*, sample no.28; .Scale bars represent 1 cm.

Family Conidae Rafinesque 1815[51]

Genus *Conus* Linne 1758[42]

Conus diversiformis Deshayes 1864[17]

Fig.6a

1856 *Conus niscoides* Hornes and Auinger 1879 [36]

1870 *Conus diversiformis* Davoli1989 [16]

1893 *Lithoconus ineditus* var. *longispirata* Sacco1891 [59]

Diagnosis: A conical form gastropod with five whorls. The whorls become wider progressively. The sutures are completely deep and moderately dip. The Middle part of the last whorl is more convex. This *Conus* is a polymorph species resulting in several synonymous identifications [19], after analyzing biometrical data, consider as much as eight species of *Conus* from the Italian Eocene to Oligocene as synonymous with *Conus diversiformis* DesShays, From the described species and subspecies Sacco's "*Lithoconus ineditus var longispirata*" corresponds in its heigh spire and convex spire whorls completely to the Iranian and the Medium-sized Greek Shells[35].

Measurements: height: > 90 mm

Age: Burdigalian

Distribution: It ranges from the Eocene to the Early Miocene and occurs during the Eocene in England, Belgium, France, Italy and Iran [52] and [35].

Superfamily Cerithioidea Fleming 1822 [19]

Family Cerithiidae Ferrussac, Audebard and Tableaus 1822[18]

Subfamily Cerithiinae Fleming 1822 [19]

Genus *Cerithium* Bruguie´re1789–1792 [10]

Cerithium rude owerby 1840[63]

Fig.6e

Diagnosis: A coniform gastropoda with eight whorls and apical angle between 35° to 40° base on the size of the shell, the sutures are deep. The species display a

marked change of ornamentation during ontogeny, starting with densely spaced straight to slightly axial ribs. After about seven telecoch whorls this sculpture is replaced by broad, rounded and sometimes angulated axial ribs crossed by 8-10 thin spiral threads.

Measurements: height: > 25mm

Age: Burdigalian

Distribution: This is known from the Lower to Upper Miocene of Pakistan (Beets 1986), Oman [31] and from the Miocene of southern India [29].

Family Turbinidae Rafinesque1815 [51]

Subfamily Turbininae Rafinesque1815 [51]

Genus *Turbo*. Linne 1758 [42]

Fig. 6h

Diagnosis: A coniform gastropoda with four whorls, somewhat flattened in their adapical region. The base is convex. There is hardly visible spiral ornamentation at the adapical suture, but none at the main part of the whorls, which is only decorated by weak growth lines.

Measurements: height: > 20mm

Age: Burdigalian

Distribution: *Turbo thouvignoni* occurs in the Greece and France [31].

Order Architaenioglossa Golikov1975 [26]

Superfamily Ampullinoidea Cox 1960[12]

Family Campanilidae Csereghy- Meznercis 1954 [13]

Genus Campanile Grateloup 1847[22]

Campanile pseudoobeliscus Grateloup 1847 [22]

Fig.6 m

1832 Cerithium pseudo-obeliscus Grateloup 1828-1835 [21]

Diagnosis: A coniform gastropoda with five whorls and apical angle between 55° to 60° base on the size of the shell, the sutures are deep and shell is not ornament. The whorls become wider progressively.The strict separation of *Campanil pseudoobeliscus* from *C. charpentieri* as proposed by Cossman & Peyrot [12] is based on the more obtuse shell of *C. pseudoobelisus* and the finer granulations of *C. charpentieri.*

Measurements: height: > 110mm

Age: Burdigalian

Distribution: This is a wesrern Tethyan species, which is known from the Chattian(Late Oligocene) to Aquitanian(Early Miocene) of France, Northern Italy, Bulgaria, Iran, Pakistan[30]. According to Lozouet *et al*. [43] Campanile charpentieri is restricted to the Early and Middle Oligocene and was replaced by Campanile pseudobeliscus (Grateloup) in the Oligocene and Early Miocene.

Superfamily Ampullinoidea Bruguie´re1789–1792 [10]

Family Ampullinidae Bruguie´re1789–1792 [10]

Genus *Ampullina* Fuchs1870 [20]

Subgenus *Ampullospira* Haller1892 [27]

Ampullospira sp.

Fig.6 l

Diagnosis: A conical form gastropod with three whorls. Sutures deep s and are very clear and shell is not ornament. The whorls become wider progressively and end quite broad and can swell.

Measurements: height: > 60mm

Age: Burdigalian

Distribution: This species is known from the Chattian (Late Oligocene) to Aquitanian (Early Miocene) of Indonesia, Jamaica and Iran [34].

Superfamily Naticoidea Kranz and Tertiar 1910 [39]

Family Naticidae Lamark *1805* [40]

Subfamily Polinicinae Gray 1850 [24]

Genus Cassis Bail and Poppe 2001 [6]

Cassis mamilliaris Grateloup 1847 [22]

Fig.6n

Diagnosis: A conical form gastropod with three whorls. The whorls are low but body whorl is highly elongated and is the largest portion of the shell.. Suture lines have low slopes and are depressed. Body whorl is swollen and ovoid.

Measurements: height: > 25mm

Age: Burdigalian

Distribution: *Cassis mamilliaris* is known from Central Iran (33).

Suborder Vetigastropoda [58]

SuperFamily Trochoidea Rafinesque 1815 [51]

Family Trochoidae Rafinesque 1815 [51]

Subfamily Trochinae Rafinesque 1815 [51]

Genus Psudophasianus Fuchs 1870 [20]

Psudophasianus elatus Fuchs 1870[20]

Fig.6k

1870 *Turbo elatus* [21]

Diagnosis: A conical form gastropod with five whorls. The whorls are swollen and separate by a deep suture line. Suture lines have low slopes and are depressed. Body whorl is swollen and ovoid.

Measurements: height: > 35mm

Age: Burdigalian

Distribution: *Psudophasianus elatus* is known from Central Iran and Italy (33).

Genus Paroxystele Sowerby 1840[63]

Paroxystele sp.

Fig.6g

Diagnosis: A conical form gastropod with three whorls. The whorls become progressively wider. Suture lines have low slopes and are depressed. Body whorl is twisted and swollen

Measurements: height: > 25mm

Age: Burdigalian

Distribution: This species is known from Sirjan in SE Iran (2)

Super order Catenogastropods Cox 1960 [12]

Order Architaenioglosa Haller 1892[27]

Superfamily Ampullinoidea Csereghy- Meznercis 1954[13]

Family Ampullinoidae Csereghy- Meznercis 1954 [13]

Genus *Ampullina* Kranz 1910 [39]

Genus *Ampullina* sp.

Fig. 6d

Diagnosis: A conical form gastropod with four whorls. The whorls become wider progressively. Body whorl is oval and extremely swollen and has a big mouth. Suture lines are a little steep.

Measurements: height: > 80mm

Age: Burdigalian

Distribution: This is a cosmopolitan genus, which is known from Northern Italy, Bulgaria, and Iran [30].

Suborder Heterobranchia Grateloup 1847 [22]

Superfamily Architectonicoidea Grateloup 1847 [22]

Family Architectonicidea Grateloup 1847 [22]

Genus *Architectonica* Röding 1798 [54]

Architectonica cf. *carocollata* Lamark 1805 [40]

Fig. 6i

1891 *Solarium carocillatum*, Salvini-Plawen and Haszprunar 2003 [58]

1900 *Solarium carocollatum* Rögl 1998[55]

2004 *Architectonica carocolata* Gray 1854 [25]

Diagnosis: A small shell with conical to slightly cyrtoconoid spire and an apical angle of about 105°. Due to the weathered shell surface of this species its identification is difficult. The poorly preserved but obviously protoconch and the granulated spiral ribs distinguish the shell from *Architectonica simplex* (Brown).

Measurements: height~ 20mm

Age: Burdigalian

Distribution: This species is known from Miocene of North Sea Basin, Mediterranian and the Paratethys and Oligocene of Abadeh, Iran [32] and also khavich area, Central Iran [35].

Results and Discussion

a) Paleoecology

The composition of the highly diverse benthic foraminiferal fauna in the carbonate of the Asmari Formation is typical for a shallow coastal / inner-shelf system and the middle-lower part of the photic zone [49]. The larger benthic foraminifera thrive in oligotrophic [5] or possibly slightly mesotrophic waters [27] since the abundance of foraminifera (*Borelis*, *Archias*, *Peneroplis*), is not consistent with persistently high nutrients on many of the platforms. These biotic assemblages of the Asmari Formation belong to heterozoan assemblages [27]. The most common gastropod taxa in this section include strombids and others and exclude any reduced salinity gastropods since all these taxa require full marine conditions [46]. Scattered corals are also due to marine conditions. A considerable percentage of taxa such as the abundant carnivorous ampullinids live infaunally or semi-infaunally. In the Soft sediment, *Cassis* prey on echinoids [71]. Strombids are important herbivorous browsers. The giant strombids such as *Oostrombus auricularius* populated the soft, sandy bottom. They are too large to become fully covered by the sediment [9]. Carnivorous snails, probably associated with the patch reefs, are represented by shells of *Architectonica crocollata* which feed on coelenterates [7].

b) Paleogeography

During Oligocene and Miocene, Tethys Realm was composed of two major biogeography compartments (Fig.5), namely the Western Tethys Region and the Proto-Indo West Pacific Region (Eastern Tethys) [30]. At that time, a broad connection still existed between the Western Tethys and the Eastern Tethys via the Mesopotamian trough and Zagros zone [55]. Due to the collision of the African/Arabian and Iranian/Eurasia plates, the water- way was closed. Various papers have discussed the faunistic relations between Oligo-Miocene faunas from Iran and those from other parts of Tethys [31]. Many studies [30, 28, 2 and 52] have pointed out the drasticly reduced similarities between the Western Tethys faunas and the Iranian ones during the Early Miocene. Like previous studies on gastropod faunas, the present study concludes that gastropod assemblages of Vareh Zard section is similar to those of Central Iran[35] and Asmari Formation in Fars Province[2]. Ten of the taxa (*Oostrombus auricularius*, *Anazola elavula*, *Conus diversiformis, Turbo thouvignoni* , *Campanile pseudoobeliscus*, *Cassis mamilliaris*, *Psudophasianus elatus*, *Paroxystele* sp., *Ampullina* sp., *Architectonica* cf. *carocollata*)are specific to the Burdigulian of western Tethys and *Lyra* sp., *Cerithium rude and Ampullospira* sp. are usually limited to the Proto- Indo- Pacific Ocean. The Late Oligocene and Early Miocene marine fauna of these regions lived along the southern coast of the Tethys basin.

Conclusion

9 species of gastropods have been found in the Early

Miocene of the Asmari Formation of the Vareh Zard section. The Early Miocene age is confirmed by the benthic foraminifera found in Vareh Zard section. Previous studies on gastropod faunas suggest that carbonate sedimentation of the Asmari Formation took place in tropical waters under oligotrophic or possibly slightly mesotrophic conditions. Gastropod assemblages of Vareh Zard lived in a shallow and quiet environment, with a soft and fine- grained carbonated mud floor. The gastropod taxa mentioned above are similar to other assemblages of the Proto- Indo- Pacific Ocean and western Tethys that show the existence of a possible passage which was open during this interval.

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