Systematic notes on Burdigalian Echinoids from the Qom Formation in the Bagher Abad area, Central Iran

Maryam Nouradini[1*], Mehdi Yazdi[2], Alireza Ashouri[1]
[1] Department of Geology, Faculty of Science, Ferdowsi University of Mashhad, Iran
2 Department of Geology, Faculty of Science of Isfahan, Iran
**Corresponding author, e-mail: maryam.nouradini@gmail.com*
(*received: 18/05/2014 ; accepted: 08/12/2014*)

Abstract
Echinoids fauna are common and distributed in the Lower Miocene deposits of the Bagher Abad area, northeast Isfahan, Central Iran. There are six Echinoid taxa belonging to the Echinoidea Class that can be described as: *Clypeaster intermedius, Prinocidaris* sp. and spines related to: *Eucidaris zaemays, Stylocidaris Polyacantha, Spatangoid* sp. and *Prinocidaris* sp. Bivalves, Foraminifers, Bryozoans, Brachiopods, scatter fragment of Crabs and Corals can obviously be seen in this section. The presence of Echinoids and Bivalves fauna indicated that, the shallow and warm water environment was dominated by them in Central Iran at the Lower Miocene (Burdigalian). From a palaeobiogeographic point of view, the fauna from the Qom Formation were similar to the West and Central parts of the Paratethys and confirmed that, the Bagher Abad area was located in the marginal seaways, which connected the West, Central Paratethys and Indo-pacific Ocean at that time (Lower Miocene).

Keywords: *Central Iran, Echinoids, Lower Miocene, Qom Formation*

Introduction

The Oligo–Miocene deposits consist of marine marls, limestone, gypsum and siliciclastic levels which are known as the Qom Formation. This formation is distributed in the Central part of Iran (Stöcklin and setudehnia, 1991; Reutner *et al*., 2007; Yazdi *et al*., 2012) (Fig. 1).

The study section is located in the Isfahan–Sirjan basin. The creation of this basin (Isfahan– Sirjan basin) was accompanied by subduction and a final collision of the African/Arabian plate to the Iranian plate. The tectono stratighraphical events and collision of the African/Arabican plate to the Iranian plate started during the Late Cretaceous (Berberian and King, 1981; Coleman-Sadd, 1982; Rögl, 1998; Harzhauser and Piller, 2007). The most important effect of this collision was a closure of the Tethyan seaways and formation of the volcanic arc system during the Eocene (Fig. 1).This event led to a subdivision of the Qom basin into the back–arc basin (Qom Basin) and fore–arc basin (Isfahan–Sirjan basin) at the north–eastern margin of the Tethys seaway (Rögl, 1998; Harzhauser *et al*., 2002, 2007; Aubry *et al*., 2007; Reutner *et al*., 2007). The best description of the back-arc basin and fore-arc basin is given by Reutner *et al*., (2007).

Jalali and Feizi (2010) stated that the thickness of the Qom Formation has been mainly affected by plate collision. In other words, the paleo high–lands and depressions were the factors controlling the thickness of the Qom Formation at the time of deposition.

The Qom basin has been examined since 1934 because of economic interests (Abaie *et al*., 1964). Furrer and Soder (1955) divided the Qom basin into six members (a–f: a– basal limestone, b– sandy marls, c– alternating marls and limestones, d– evaporites, e– green marls, f– limestone).

Abaie *et al*., (1964) subdivided the Qom Formation into ten members in a type section, from the Chattian to Burdigalian time interval. Bozorgnia, (1966) identified ten members from Rupelian to Burdigalian. The age determination of the Qom Formation was assigned to the Middle Oligocene to Early Miocene time interval (e.g., Rahaghi, 1980; Chahida *et al*., 1977; Daneshian & Ramezani Dana, 2007; Reutner *et al*., 2007; Behforozi & Safari, 2011; Hasani & Vaziri, 2011).

A number of systematic studies have been published on corals (Toraby, 2003; Reutner *et al.*, 2007; Yazdi *et al*., 2012) foraminifera (Bozorgnia, 1966; Rahaghi, 1980; Daneshian & Ramezani Dana, 2007, Behforozi & Safari, 2011) and molluscs (Hasani & Vaziri, 2011) from the Qom Formation, but from a systematic point of view, they have been poorly studied, the studies being particularly devoted to the echinoids of the Qom Formation. Khaksar and Maghfouri Moghaddam (2007) suggested shallow and warm water with high energy for the Qom Formation in the Kashan area based on the *Clypeaster* and *Scutella* genera. Kroh *et al*., (2011) also provided a detailed investigation on the pectinid bivalves and echinoids of the Miocene deposits and concluded the shallow warm marine water existed for the Aquitanian to Middle Burdigalian sediments in the south of Iran (Mishan Formation). The main purpose of this research was to study the taxonomy of echinoderms from the Qom Formation (Burdigalian) in Central Iran (Bagher Abad area).

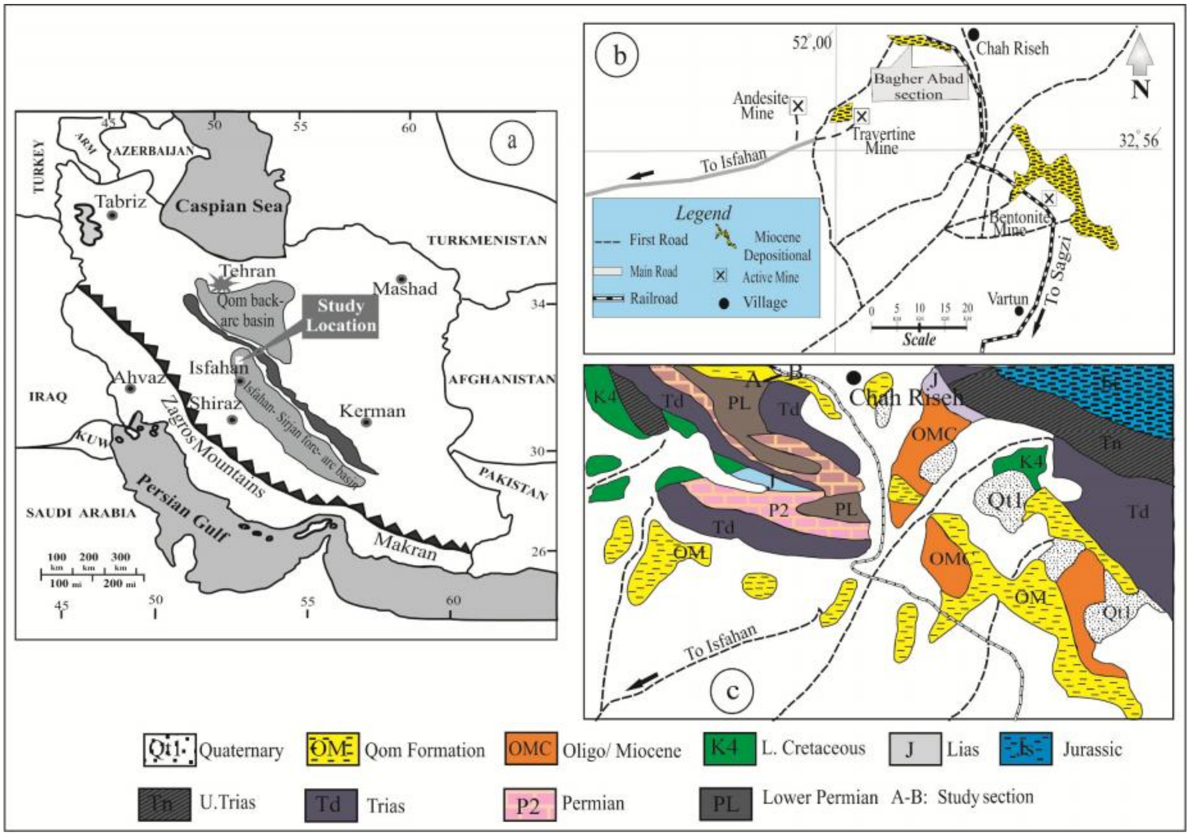

Figure 1. Location and geological map of the studied section in the Bagher Abad area, northeast of Isfahan (modified from Reutner *et al.*, 2007). a). The geological position of the outcrop, the position of the Isfahan–Sirjan basin and the Qom Basin (modified from Schuster & Wieland, 1999; Reutner *et al.*, 2007), b). simplified main road toward Naein in the northeast of Isfahan, c). A geological map of the Bagher Abad area, northeast of Isfahan (modified from Zahedi & Amidi, 1978).

Materials and methods

The identified fossil echinoderms were collected from the distinctive sandy limestone associated with Bivalves (e.g., *Oopecten persicus*, *Gloripallium* sp., *Ostrea* sp., *Crassostrea gryphoides* and *Spondylus decussatus*). The paleontology materials were taken in the form of echinoderm tests and isolated skeletal ossicles. The following abbreviations were applied for description in the echinoderm tests: Lo = Length, la = width, h = height.

For microscopic studies, the isolated ossicles were in the form of bulk samples that were splinted into grain-size fractions (under 20 mm). The bulk samples were cleaned by washing. The collected samples from the levels were pressed and cleaned by diluting them in vinegar for 24 hours. The residue from these samples were picked under the binocular microscope. Subsequently, the samples were cleaned with an ultrasonic bath to remove small materials from the cavity (Pojeta and Balanc 1989). The SEM method was used to take photos of the picked samples. A camera was utilized for bigger isolated ossicles and echinoderm tests.

The specimens described and reported here were housed in the repository of the Isfahan University, Faculty of science under a type registration number. (EUIE, 101829).

Geological setting and lithostratigraphy details

The study section is situated in the Bagher Abad area, northeast of Isfahan city, Central Iran (Isfahan–Sirjan, fore–arc basin). The geography coordinates of the measured section are 32˚57΄42˝N and 52˚01΄41.4˝ E (Fig 1).

The basal unit of the section consists of a medium to coarse alternation of limestone and marl, with 65 M thickness. The basal unit is dominated by Corals (*Tarbellastraea* sp., *Leptoseris* sp., *Porites* sp.) that increased in size toward the upper levels and disappeared in the beds at 10 m (Fig 2). The microfossils in this unit include: *Nephrolepidina* cf. *morgani*, *Nephrolepidina morgana*, *Lepidocyclina* (*Eulepidina*) sp., *Lepidocyclina* (N.) *howchini*, *Amphistegina* sp., *Eulepidina dilatata*, *Quinqueloculina* sp., *Operculina* sp., *Lepidocyclina* sp., *Triluculina trigouenula*, *Operculina* cf. *complanta*, *Miogypsinoides* sp., *Textularia* sp., *Amphistegina lessonii* and *Spiroclypeus* sp., which can be dated to the Upper Oligocene (Table 1). This unit is overlain by 30 m of marl, which shows a vertical change in color from brown to green. This marl succession yielded abundant Foraminifers, Echinoids spines, Gastropods and scattered fragment of Crabs. The foraminifers are represented by: *Nephrolepidina tournoueri*, *Cycloclypeus* sp., *Quinqueloculina trianqularis*, *Triloculina tricarinata*, *Operculina complanta*, *Nummulites willcoxi*, *Nummulites* sp., *Elphidium* sp, *Nummulites intermedius*, *Elphidium fichielianum*, *Heterostegina* sp., *Amphistegina lessonii*, *Miogypsina* spp, *Miogypsina globulina*, *Asterigerina rotula*, *Meandropsina* sp., *Rotalia viennotti*, *Amphistegina hauerina*, *Textularia mariae*, *Textularia mayori*, *Textularia agglutinans*, *Textularia* sp., *Triloculina gibba* and *Triloculina scapha*,. The symbiotic-bearing large foraminifera (Lepidocyclina) are associated with Brachiopods (*Argyrotheca cordata*, *Terebratulina palmeri*), Ostracods (*Bairdoppilata willisensis*, *Neonesidea* sp., *Aureilia* sp., *Grineioneis haidingeri*, *Grineioneis* sp., *Heliocythere* sp., *Macrocypris* sp) and Echinoids spines (*Diadematidae* sp., *Spatangoids* sp., *Eucidaris zeamays*,). The upper part of the section is followed by brown sandy limestone and marl units with 20 m thickness. This bed also represents abundant Echinoids (*Clypeaster intermedius*, *Arbacina* sp., *Eucidaris zaemays*, *Stylocidaris polyacantha* and *Prionocidaris* sp.) and bivalves (*Spondylus decussatus*, *Oopecten persicus*, *Gloripallium* sp., *Amussiopecten* sp., *Ostrea lamellosa*, *Ostrea edulis* and *Ostrea gryphoides*) (Fig. 2). On account of its typifying large fauna and lateral continuity, this bed can be considered as an excellent stratigraphical marker or key bed of the Lower Miocene (Burdigalian) stage.

Table 1. Biozonation of the Oligocene–Early Miocene sediments of the larger benthic foraminifera (Wynd, 1965; Laursen *et al*., 2009)

<table>
<tr><th>Epoch</th><th>Stage</th><th colspan="2">Biozonation of Laursen et al. (2009)</th><th colspan="2">Biozonation of Wynd (1965)</th></tr>
<tr><td rowspan="3">Miocene</td><td>Burdigalian</td><td colspan="2">Borelis melo curdica- Borelis melo melo</td><td colspan="2">Borelis melo curdica Assemblage zone (zone 61)</td></tr>
<tr><td rowspan="2">Aquitanian</td><td colspan="2" rowspan="2">Miogypsina- Elphidium sp.14 Peneroplis farsenensis</td><td colspan="2">Assemblage zone (zone 59)</td></tr>
<tr><td>Archaias operculinoformis Assemblage zone (zone 58)</td><td>Nummulites intermedius Nummulites vascus Assemblage zone (zone 57)</td></tr>
<tr><td rowspan="3">Oligocene</td><td>Chattian</td><td>Archaias hensoni- Miogypsinoides complanatus</td><td rowspan="2">Lepidocyclina- Operculina- Ditrupa</td><td colspan="2">Lepidocyclina- Operculina- Ditrupa Assemblage zone (zone 56)</td></tr>
<tr><td rowspan="2">Rupelian</td><td>Nummulites vascus Nummulites fichteli</td><td colspan="2" rowspan="2">Globegerina spp. Assemblage zone (zone 55)</td></tr>
<tr><td colspan="2">Globigerina- Turborotalia cerroazulensis Hantkenia</td></tr>
</table>

Biostratigraphy of the Qom Formation in the Bagher Abad Area

The formal biozonation and biostratigraphy have not been proposed for the Qom Formation in Central Iran. Thus far, according to the considerable similarity and proximity of the larger benthic foraminifera between the Qom Formation and the Lower Asmari Formation (Zagros region in SW Iran), paleontologists (e.g., Toraby, 2003; Daneshian and Ramezani Dana 2007; Behforozi and Safari 2011; Rahiminejad *et al*., 2011; Yazdi *et al*., 2012) compared these two Formations.

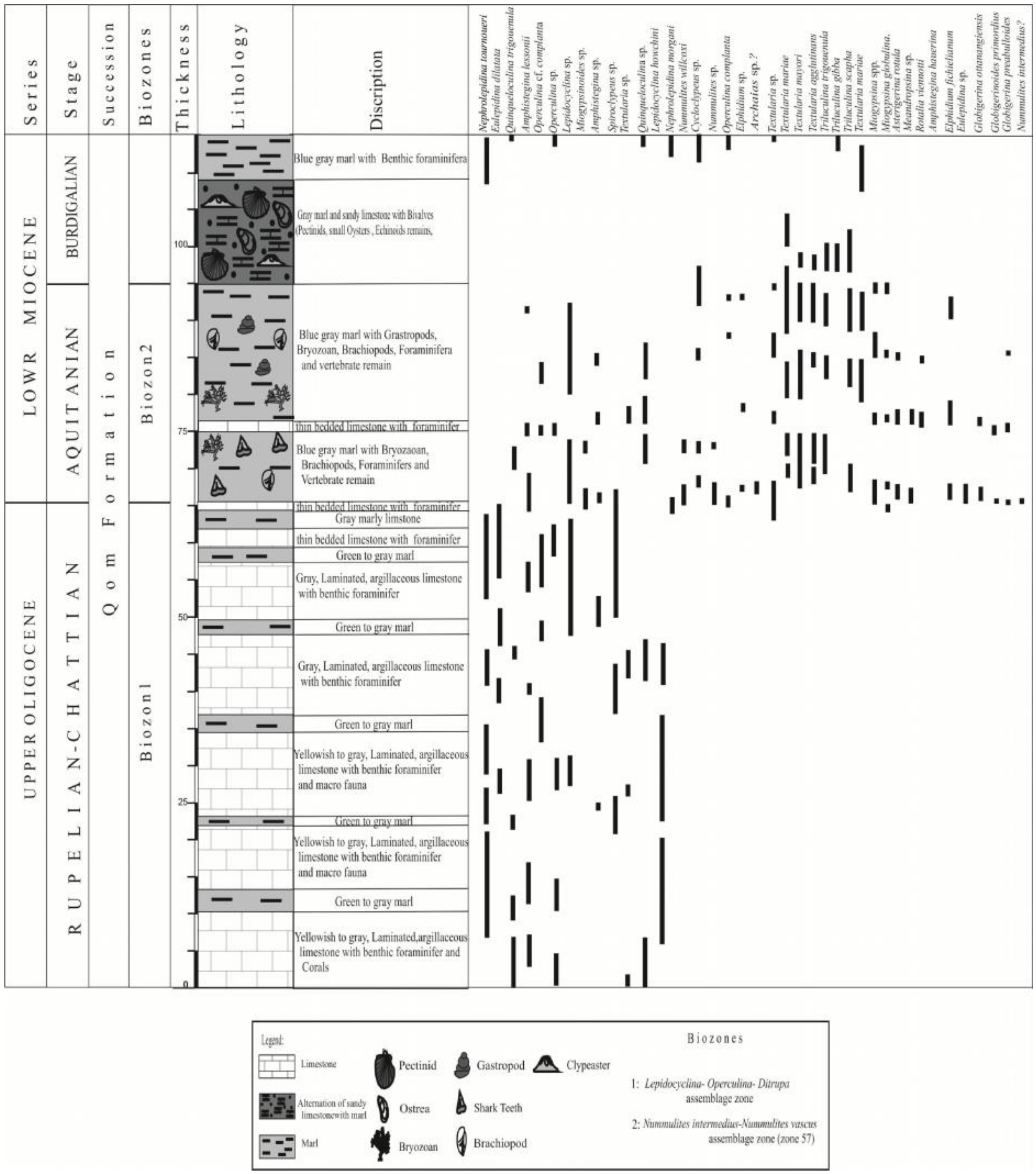

Figure 2. Schematic of the lithostratigraphic column and vertical distribution of foraminifera in the Bagher Abad section, northeast of Isfahan

The biozonations established for the Qom Formation were based on the biozonations of Wynd (1965) and Adams and Bourgeois (1967). The assemblage biozonation introduced by Laursen *et al*., (2009) could be applied for the biozonation of the Qom Formation (Rahiminejad *et al*., 2011; Yazdi *et al*., 2012). In the investigated section, two biozones can be determined in the lower and middle parts of the profile (Fig. 2).The lower part of the succession was defined based on the larger benthic foraminifers' assemblage. This assemblage corresponded with the "*Lepidocyclina*- *Operculina*- *Ditrupa* assemblage zone of Laursen *et al*., (2009) or zone 56 of Wynd (1965), which was Rupelian-

Chattian in age.

The second biozone is correlated to the *Nummulites intermedius–Nummulites vascus* assemblage zone of Wynd (1965), which can be dated to the Aquitanian stage (Table 1), which is supported by the associated planktonic foraminifera such as: *Globigerinoides trilobus*, *Globigerinoides primordius*, *Globigerina ottnangiensis*, *Globigerina preabulloides* (Bolli *et al*., 1987).

Biozonation and age dating of the upper part of this section are not possible due to lack of dominating foraminifera. Hence, age determination has been made on the basis of a macrofossil (Bivalves and Echinoids). Echinoids lived in sand about 20–25 cm below the surface or moved along the surface with their tube feet in the infralittoral zone (Kier, 1997). Based on the stratigraphical position, this part of the section is not younger than the Burdigalian and also not older than the Aquitanian stage. The fauna (Echinoderms and Bivalves) in the studied section, are similar to the fauna reported from other parts of the world such as: France (Sismonda, 1842; Pomel, 1883), Portugal (Pomel, 1883), Greece (Tsparas *et al*., 2007), India (Moore, 1966; Jain, 2002), Turkey (Moore, 1966), Poland (Mwczmsk, 1996), Austria (Kroh and Harzhauser,1999; Kroh, 2003), Czech (Zágrošek *et al*., 2009) and Jamaica (Donovan *et al*., 2005), which revealed that the path way (shallow and warm water) was dominated from the Paratethys to the Indo-Pacific Ocean during the Burdigalian time (Early Miocene).

Conclusions

The Miocene echinoids of the Bagher Abad section have low diversity, so this phenomenon is significant with regard to the first taxonomy record of the Miocene echinoids from the Qom Formation. Echinoids that have been documented from the Bagher Abad section consists of: *Clypeaster intermedius*, *Arbacina* sp., *Eucidaris zaemays*, *Stylocidaris polyacantha*, *Prionocidaris* sp. and *Spatangoid* sp. Generally, the echinoid with a thick margin is typical with high energy, light intensity and found in warm water with coarse sediment environments (Tsaparas *et al*., 2007). Bivalves (Ostrea and Pectinid) and symbiotic large benthic foraminifera support this data and indicate that the Upper part of the Qom Formation is not younger than the Burdigalian. The similarity between the Miocene echinoids of the Qom Formation and those from the other parts of Paratethys and the Indo–Pacific Ocean, also support the idea that the Miocene echinoids belong to the fauna of the province and are distributed from Western Paratethys to the Indian Ocean.

Systematic palaeontology

Phylum Echinodermata Klein, 1734

Subphylum Echinozoa Haeckel in Zittel, 1895

Class Echinoidea Leske, 1778

The description of the echinoids corresponds with the Treatise on Invertebrate Paleontology by Moore (1969).

Order Cidaroida Claus, 1880

Family Cidaroidae Gray, 1825

Subfamily Rhabdocidarinae Lambert, 1900

Genus *Prionocidaris* A. Agassiz, 1863

***Prionocidaris* sp.**

(Pl. 2, figs. 4, 14–20)

Type species. *Cidarites pistillaris* Lamarck, 1816.

2000 Unidentified Cidaroid Danovan & Portell, pp. 168, 169, fig. 1c (none).

2002 Prionocidaris Jain, pl. I, Figs. a-h, j, k, n.

2005 *Prionocidaris* sp. Danovan *et al*., pl. 1, Figs. 1-7; pl. 6, Figs. 1-3.

Occurrences. fourteen isolated ossicles were collected from a distance of 95–110 m the top profile (EUIE, 101896–101909)

Description. Many echinoid spines, mostly from Order Cidaroida have been collected. The primary spines are tapered with a coarse thorn arranged along the length of the shaft. The thorns are commonly elongated and globular toward the tip. Some spicules are pronounced and appear in a thorn like circle. The primary spines are long and robust. The shaft is distally winded and thorny. The acetabulum is depressed and circular. The maximum length is 30 mm.

Distribution. The similarities in these spicules were reported from Eocene (Indo–pacific), Oligo–Miocene (Australia), Lower Miocene (Jamaica) and Early–Middle Miocene (India).

Order Spatangoida Claus, 1876

Family Cidaroidae Gray, 1825

***Spatangoid* sp.**

(pl. 1, figs.7–9)

2003*Spatangoid* indet Kroh. pl. 4, Figs. 16.

2005 *Spatangoid* sp. Danovan *et al*., pl. 1, Figs. 1–7; pl. 6, Figs. 1–3.

Occurrences. six spines were collected from a distance of 95–100 m of the top profile (EUIE, 101838–101843)

Description. The incomplete preservation of these specimens makes this genus difficult to determine. The primary radioles are delicate and relatively fragile. The spine was ornamented with longitudinal striated ridges on the shaft. Test was thin, short, and cylindrical with a transversely straight–cup at the base. The milled ring was linear and smooth.

Distribution. Spatangoids are common in the Oligocene–Miocene deposits of the Central Paratethys.

Remark: Although we were not able find a large number of this genus in sediments and often the remains were broken and crushed, so the following detailed description was not possible.

Family Cidarinae Gray, 1825

Genus ***Stylocidaris Polyacantha***

(Pl. 2, figs. 5–13)

1981 *Cidaris* cf. *belgica* Hamršmid, p. 105, tab. 11.

1984 *Cidaris* sp. Hamršmid, p. 43, tab. 7.

2005 *Stylocidaris Polyacantha* Kroh, pp. 2–4; pl.1, figs 11–19; pl.2, figs. 1, 2; pl.3, figs 1–6.

2009 *Stylocidaris Polyacantha* Zágoršek *et al*., p. 484, pl.12, figs. F–G.

Occurrences. Twenty spines were collected from a distance of 90–115 m of the top profile (EUIE, 101876–101895)

Description. Numerous *Stylocidaris Polyacantha* occur through the Upper parts of the profile. This genus is distinguished here by its primary spine. The primary spine comprises of a fine granules arranged in a regular longitudinal row on the shaft. The base of the primary spine is expressed by means of the tubercle of its plate, by means of a cup shaped depression. The top of the base is milled with a thick neck above it. The primary spine is usually thick, long and decreases in thickness toward the point and tapers to a point at the top.

Distribution. This genus refers to the period from the Eocene–Pliocene to Holocene (Central Paratethys), Early–Middle Miocene (Indio–pacific).

Remark. *Stylocidaris Polyacantha* can be recognized by its tubercles arrangement. The tubercles are coarse, spherical and turn into very fine thorns at the tip. This genius compares well with the *Stylocidaris schwabenaui* reported by Zágoršek *et al.*,(2009) from Middle the Miocene of Central Paratethys.

Subfamily Cidarinae Gray, 1825

Genus *Eucidaris* Pomel, 1883

Eucidaris zeamays (Sismonda, 1842)

(pl. 1, figs. 13–18)

1989*Eucidaris zeamais* Philippe, 27; tab. 1.

1993 *Cyathocidaris avenionensis* Mwczymska, 106; pl. 1, figs. 3–4; pl. 6, fig. 1c

1996 *Cidaris zeamais* Mwczymska, 40; pl. 1, fig. 1

1996 *Cyathocidaris avenionensis* Mwczymska, 40–41; pl. 1, figs. 2-3

1998 *Eucidaris zeamais* Philippe, 44–46; pl. 4, figs. 8–15

Occurrences. Fifteen spines were collected from a distance of 95–110 m of the top profile (EUIE, 101859–101874)

Description. The collected spines related to the study section are restricted only to spines without any perfect species. Primary radioles have small arranged spinules enlarged along the shaft. The size of the spines decreases toward the top, tapering to point. The acetabulum is compressed, circular and comprises about half the diameter of base. Some spines are pro–nounced and include thorn–like circlets. The primary spines can be identified with a long cylindrical collar below the long shaft. The interambulacral plates are in pentagonal form with distinct tubercles and bosses that, are surrounded by secondary tubercles.

Distribution. The *Eucidaris zeamays* spine is locally common in the Lower to the Upper Badenian of the Central Paratethys and Burdigalian to the Langhian of the Mediterranean Sea.

Remark. This genus is very close to the *Eucidaris tribuloides* or *Stylocidaris affinis* (Philippi) on the basis of the spines characteristics. This genus is distinguished from the other genera by its longitudinal arrangement of granules and change to a ribbed crown on the top.

Superorder Camarodonta Jackson, 1922

Order Temnopleuroida Mortensen, 1942

Family Temnopleuridae A. Agassiz, 1872

Genus *Arbacina* Pomel, 1869

***Arbacina* sp.**

(pl. 1, figs. 1–6)

Occurrences. Nine spines were collected from the top profile (EUIE, 101829–101837).

Description. The small size of the recovered echinoids is related to *Arbacina* spp. The *Arbacina* test is small and sub–hemispherical to hemispherical. The apical system is lacking in all

Plate 1

Plate 1. (1: *Arbacina* sp., Oral surface. (EUIE, 101829), 2: *Arbacina* sp., Aboral surface. (EUIE, 101830), 3: *Arbacina* sp., Aboral surface. (EUIE, 101831), 4: *Arbacina* sp., Oral surface. (EUIE, 101832), 5: *Arbacina* sp., Oral surface. (EUIE, 101833), 6: *Arbacina* sp., Lateral view. (EUIE, 101834), 7-9: *Spatangoid* sp., Primary spine. (EUIE, 101838-101840), 10-12: Unidentified ossicle (EUIE, 101843-101845), 13- 18: *Eucidaris zeamays*. (101859- 101864)

Plate 2

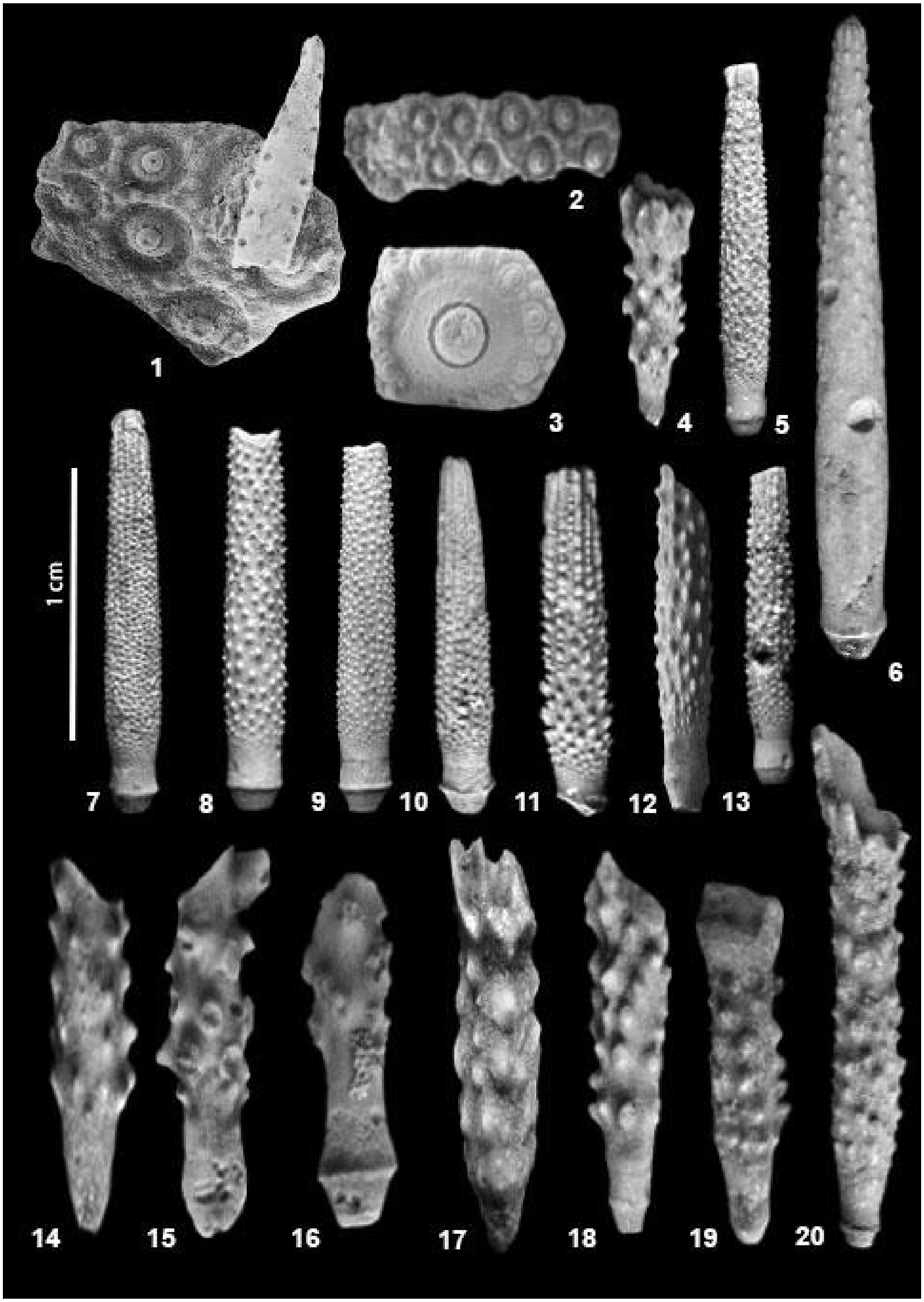

Plate 2. (1-2: Loveniidae indet (Interambulacral corona fragments, 101874- 101875), 3: *Eucidaris zeamays*(EUIE, 101865), 5-13: *Stylocidaris*? *Polyacantha*, Primary spine. (EUIE, 101876- 101884), 4, 14-20: *Prionocidaris* sp., Primary spine. (EUIE, 101896-101902)

Plate 3

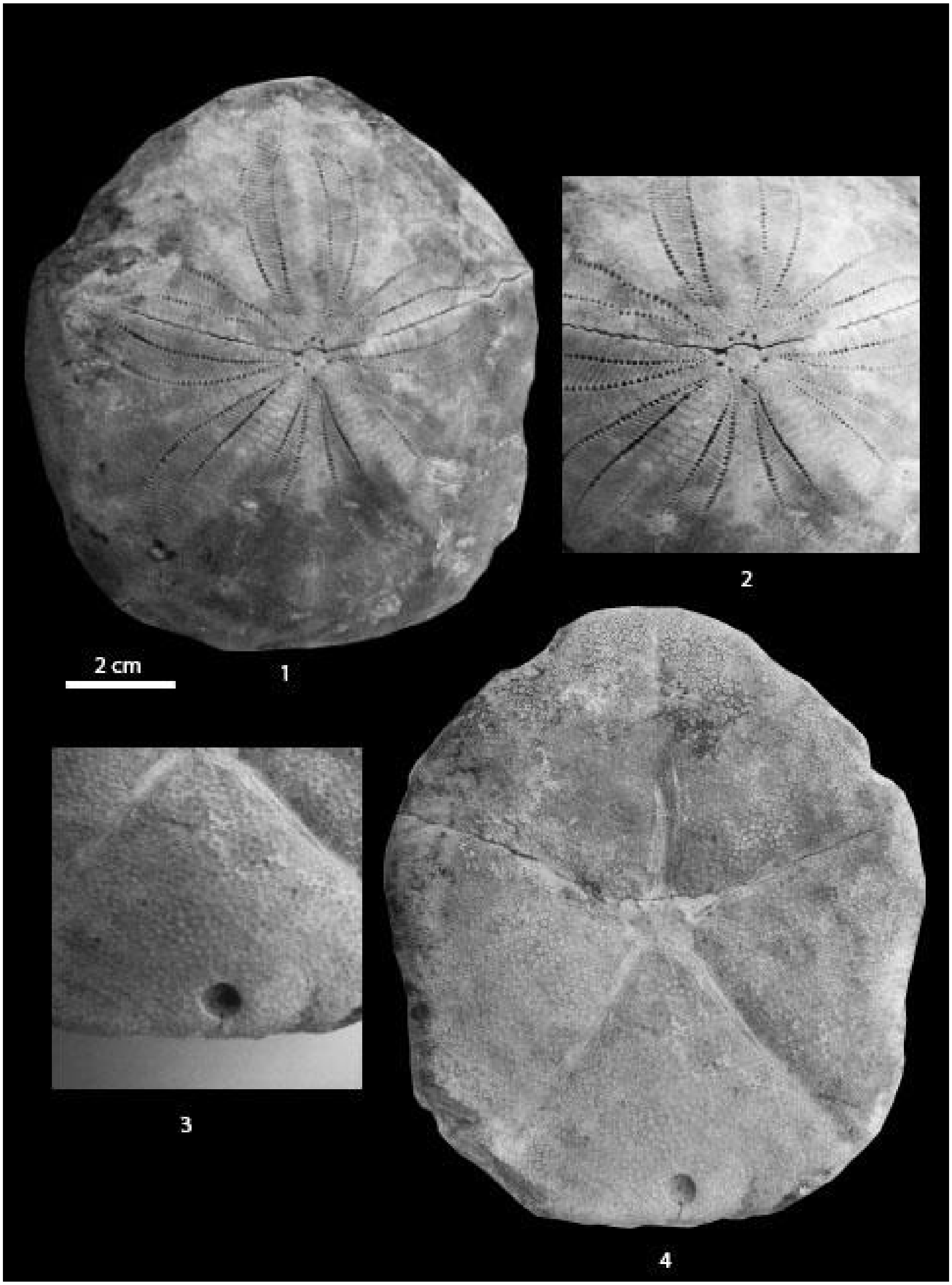

Plate 3. (1-2: *Clypeaster intermedius,* Apical view. (EUIE, 101921), 3-4: 1-2: *Clypeaster intermedius,*Oral view. (EUIE, 101921)

species. This genius is characterized by it's interambulacral plates with non-crenulated marginal tubercles. The marginal tubercles are surrounded by small internal tubercles. The internal tubercles are postulated on each side of the marginal tubercles. Each marginal tubercle has a distinct and sharp boss, with a globular areole around it. In all species reported here, the outer pores and inner pores are filled with fine-grained sediment. The peristome is situated in the center of the aboral pole; in both the circular, and sub-circular outline.

Distribution: Early-middle-Miocene (France, Poland, Egypt, Italy, Australia, Middle East), Lower Miocene (Greece).

Remark: The specific characters are well-described by Moore (1966) and Kroh and Harzhauser (1999). The present hemispherical test, ornamentation, interambulacral plates, ambulacral plates, circular tubercles and dense secondary tubercles distinguish this genus as well.

Suborder: Clypeasterina Agassiz 1872
Family: Clypeasteridae Agassiz 1835
Genus: *Clypeaster* Lamarck 1801
Clypeaster intermedius Desmoulins, 1837

(pl. 3, figs. 1-4)

1985 *Clypeaster intermedius* Marcopoulou-Diacantoni, p. 128, 134, 159, 176, pI.1.

1998 *Clypeaster intermedius* Philippe, p.302, pI. 11, fig. 4 pI 6, pI. 12, fig. 1-4.

2000 *Clypeaster intermedius* Marcopoulou-Diacantoni, p. 178, PI. Ill, fig. 1a, b, PI. V, fig. 3a, b, PI. VI, fig. 1.

2007 *Clypeaster intermedius* Tsaparas *et al*., p. 230, pl. 2, figs. F. c, G. c.

Occurrencens. Ten spines were collected from a distance of 95-110 m of the top profile (EUIE, 101921-101930)

Description. Marginal contour sub-pentagonal with rounded angles. The apical disk is slightly in the center. The petal edges are not sharp and open at the extremity. The greatest width of the petal is in the middle. The ambulacral plates are moderately long and wide. The petals subequal in length. The pristome is small, circular and located at the center. The ornamentation of the ambulacrum and interambulacrum consists of very small military tuberceles. The lateral sides are distinctly in-curved and the margins are thick and tumid (Table 2).

Table 2. Description of echinoderm test from Bagher Abad area

Sample No	Lo	h	Lo/h	La
101922	85	100	0.85	20
101923	85	75	1.13	15
101924	65	85	0.75	15
101925	85	100	0.85	10
101926	95	110	0.86	10
101927	80	95	0.84	10

Distribution: Early-Neogene (France, Egypt, Italy, Australia, Middle East), Lower Miocene (Iran), Middle-Late Miocene (Greece).

Remark. This genius is from other Iranian *clypeaster* by the irregularly pentagonal outline. The petals are tumid, long and broad. Its bear's five gonopores. This genius belongs to the *Clypeaster scillae* group (Tsaparas *et al*., 2007). *Clypeaster rogersi* is very similar to *Clypeaster intermedius*, but its lateral side has a very large bulge.

Undetermined echinoid ossicles

(pl. 1, figs. 10-12)

There were several echinoid ossicles in the key bed. They could not be identified, but the author's believed that, these ossicles belonged to Echinoidea. Fifteen ossicles were collected from a distance of 95-115 m of the top profile (EUIE, 101910-101915)

Achnowledgement

The article is a part of a PhD study in the Ferdousi University of Mashad, Iran. We hereby wish to thank Professor Steve Donovan from the Department of Naturalis Biodiversity Center, Leiden, for the systematic determination of the Echinoid.

References

Abaie, I., Ansari, H.J., Badakhshan, A., Jaafari, A., 1964. History and development of the Alborz and Sarajeh fields of Central Iran. Bulletin of Iranian Petroleum Institute, 15: 561-574.

Adams, T.D., Bourgeois, F., 1967. Asmari biostratigraphy. Iranian Oil Operating Companies, Geological and Exploration Division, Report 1074 (unpublished), 1–37.

Agassiz, L., 1836. Prodrome d'une monographie des radiares ou échinodermes. Mémoires de la Société Neuchâteloise des Sciences Naturelles, 1 (for 1835): 168-199.

Agassiz, A., 1863. List of the echinoderms sent to different institutions in exchange for other specimens, with annotations, Bulletin of the Museum of Comparative Zoology, Harvard, 1: 17-28.

Aghanabati, A., 2003. Geology of Iran, Geological Survey of Iran, 586 pp. (in Persian).

Aubry, M.P., Wielandt-Schuster, U., Hamedani, A., The Oligo-Miocene Qom Formation (Iran)- evidence for an early Burdigalian restriction of the Tethyan Seaway and closure of its Iranian gateways, International Journal of Earth Sciences. (2007), doi: 10.1007/s00531-007-0269-9.

Behforouzi, E., Safari, A., 2011. Biostratigraphy and paleoecology of the Qom Formation in Chenar area (northwestern Kashan), Iran. Revista Mexicana de Ciencias Geológicas, 28(3): 555-565.

Bozorgnia, F., 1966. Qom Formation stratigraphy of the central basin and its intercontinental position Bull. Iran Pet. Inst., 24: 69-76.

Berberian, M., King, G.C.P., 1981. Towards a paleogeography and tectonic evolution of Iran. National research Council of Canada, 210-263.

Bolli, H. B., Saunders, J. B., and Perch-Neilsen, K., 1987. Plankton Stratigraphy. Cambridge University Press, Cambridge, 1032 pp.

Claus, C. F. W., 1880. Grundzu¨gue der Zoologie (fourth edition). N.GElwert, Marburg, 2: 522 pp.

Coleman-Sadd, SP., 1982. Two stage continental collision and platedriving forces. Tectonophysics, 90: 263-282.

Chahida, M.R., Papp, A., Steininger, F., 1977. Fossilführung der Oligo/Miozänen Qum-formation in Profilen bei Abegarm-Zefreh beiIsfahan (Zentraliran). Beitr Palaönt Österr, 2: 79- 93.

Daneshian, J., Dana, L.R., 2007. Early Miocene benthic foraminifera and biostratigraphy of the Qom Formation, Deh Namak, Central Iran. Journal of Asian Earth Sciences, 29: 844- 858.

Desmoulins, C., 1837. Troisieme memoire sur les Echinides. Synonymie generalc, Actes Soc. Linn. Bordeaux, 49: 45-364.

Donovan, S.K., Portell, R.W., 2000. Incipient ‘crystal apples’ from the Miocene of Jamaica. Caribbean. Journal of Science, 36: 168-170.

Donovan, S.K., Portell, R.W., Veltkamp, C.J., 2005. Lower Miocene echinoderms of Jamaica, West Indies. Scripta Geologica, 129: 91-135.

Furrer, M.A., Soder, P.A., 1955.The olige-miocene marine formation in the Qom region (Central Iran). Proc. 3th world Petrol. Cengr. Rom. Sect. I/A/5, 267-277.

Gray, J.E., 1825. An attempt to divide the Echinida or sea eggs into natural families. Annals of Philosophy (series 2), 10: 423-431.

Hamršmíd, B., 1981. Paleoekologická analỳza faunistickỳch společenstev terciérních sedimentu lokality Kralice nad Oslavou. MSc. Thesis, UJEP (MU) Brno. 56 pp.

Hamršmíd, B., 1984. Pokus o rekonstrukci podmínek sedimentace spodnobadensỳch usazenin z okoli Kralic nad Oslavou. Zemní plyn a nafta, 29 (1): 13-46.

Harzhauser, M., 2002. Marine und brachyhaline Gastropoden aus dem Karpatium des Korneuburger Beckens und der Kreuzstettener Bucht (Österreich, Untermiozän).Beiträge zur Paläontologie, 27: 61-159.

Harzhauser, M., Kroh, A., Mandic, O., Piller, W.E., Göhlich, U., Reuter, M., Berning, B., 2007. Biogeographic responses to geodynamics: a key study all around the Oligo-Miocene Tethyan Seaway. Zoologischer Anzeiger, 246: 241-256.

Harzhauser, M., Werner, E. P., Benchmark data of a changing sea-Palaeogeography, Palaeobiogeography and events in the Central Paratethys during the Miocene. Palaeogeography, Palaeoclimatology, Palaeoecology. (2007), doi:10.1016/j.palaeo.2007.03.031.

Hasani, M.J., Vaziri, M.R., 2011. Early-Miocene Gastropods from Khavich Area, South of Sirjan, (Kerman, Iran): Biostratigraphy, Paleogeography and Paleoecology. Journal of Sciences, Islamic Republic of Iran, 22(2): 125-133.

Jackson, R.T., 1922. Fossil echini of the West Indies. Publications of the Carnegie Institution, Washington, 306: 1-103.

Jain, R. L., 2002. Echinoids from the Gaj Formation (early and middle Miocene) of Kathiawar, Gujarat, India. Journal of Paleontological society of India, 47: 107-135.

Jalali, M., and feizi, M., 2010. Introduction of Miocene deposits turbidities in the Saveh-Takab area (NW of central Iran basin). The first International Applied Geological Congress, Department of Geology, Islamic Azad University- Mashad Branch, Iran, 26-28.

Kashfi, M.S., 1988. Evidence for non-collision geology in the Middle East. Journal of Petroleum Geology, 11 (4): 443-460.

Khaksar, K., Maghfouri-Moghadam, I., 2007. Paleontological study of the echinoderms in the Qom Formation (Central Iran): Islamic Azad University, Earth Science Research, 11(1): 57-79.

Kier, P. M., 1972. Tertiary and Mesozoic Echinoids of Saudi Arabia. Washington, Smithsonian institution press, 242 pp.

Kier, P. M., 1997. Oligocene Echinoids of North Carolina. Washington, Smithsonian institution press, 37 pp.

Kroh, A., Harzhauser, M., 1999. An Echinoderm Fauna from the Lower Miocene of Austria: Paleoecology and Implications for Central Paratethys Paleobiogeography. Annalen des Naturhistorischen Museums in Wien, 101(A): 145-

191.
Kroh, A., 2003.The Echinodermata of the Langhian (Lower Badenian) of the Molasse Zone and the northern Vienna Basin (Austria). Naturhistorisches Museum Wien, 104: 155–183.
Kroh, A., 2005. Catalog us Fossilium Austriae. Band 2. Echinoidea neogenica. Wien, Österreichische Akademie der Wissenschaften, 210 pp.
Kroh, A., Gholamalianl, H., Mandic, O., Ćorić, S., Harzhauser, M., Reuter, M., Pillar, W.E., 2011. Echinoids and pectinid bivalves from the Early Miocene Mishan Formation of Iran. Acta Geologica Polonica, 4: 419-439.
Lamarck, J.B., 1801. Systeme des Animaux sans Vertebres, VIII, 432pp.
Lamarck, J.B., 1816. Histoire naturelle des animaux sans vertèbres, présentant les caractères, généralaux et particuliers de ces animaux, leurs distribution, leurs classes, leurs familles, leurs genres et la citation synonymique des principales espèces qui śy rapportent. First edition, 3: 586.
Lambert, J., 1900. Sur les Échinides de la faune coralligène du Vésulien de Saint-Gaultier (Indre), recueillis par M. E. Benoist. Bulletin de la Societe Géologique du France, 28: 473-489.
Laursen, G.V., Monibi, S., Allan, T.L., Pickard, N.A., Hosseiney, A.,Vincent, B., Hamon, Y., Van-Buchem, F.S.P., Moallemi, A.,Druillion, G., 2009. The Asmari Formation revisited: changed stratigraphic allocation and new biozonation: Shiraz, First International Petroleum Conference & Exhibition, European Association of Geoscientists and Engineers.
Leske, N.G., 1778. Iacobi The odori Klein naturalis disposito Echinodermatum, Accesserunt lucubratiuncula de aculeis echinorum marinorum et spicilegium de belemnitis. Edita et descriptionibus novisque inventis et synonymis auctorem aucta. Officina Gleditschiana, Lipsiae, 278 pp.
Marcopoulou-Diacantoni A., 1985. The Morphology and evolution of the genus Clypeaster (Echinoidea, Clypeasteroida), Monography University Thessaloniki., 23: 257.
Marcopoulou-Diacantoni, A., 2000. The Occurrence of Echinoids in the Upper Tortonian sediments of tile Plakiotissa region (province of Heraklion, Monofatsiou district, C Crete). Palaeoenvironmental interpretation, Proceedings Interim Colloquium R. C. MN.S. Special Publications, 9: 173-186.
Moore, R.C., 1966. Treatise on Invertebrate Paleontology. Echinodermata vols (3), Geologiacl Society of America and University of Kansas press, 366 pp.
Mortensen, T. 1942. Monograph of the Echinoidea. C. A. Reitzel, Copenhagen, 553 pp.
Mwczymska, S., 1993. Echinoids from the Pińczów Limestones (Middle Miocene; Holy Cross Mountains, Central Poland). Acta Geolical Polonica, 43(1-2): 103-114.
Mwczymska, S., 1996. Middle Miocene (Badenian) echinoids from Niechobrz near Rzeszów (southern Poland). Prace Muz. Ziemi, 43: 39-46.
Philippe, M., 1998. Les Échinides Miocènes du Bassin du Rhône: révision systématique. Nouvelles
Archives du Muséum d'Histoire Naturelle de Lyon, 36: 249-441.
Pojeta, J., and Balanc, M., 1989. Used of Ultrasonic cleaners in Paleontological laboratories. Paleotechniques, 4: 213-217.
Pomel, A., 1869. Revue des e´chinodermes et de leur classfication pourservir d introduction á létude des fossils. Deyrolle, Paris, 67 p.
Pomel, A., 1883. Classification méthodique et genera des échinides vivantset fossiles. Adolphe Jourdan, Alger, 131 pp.
Rahaghi, A., 1980. Tertiary faunal Assemblage of Qum-Kashan, Sabzewarand Jahrum area. National Iranian Oil Company, Geological Laboratories, Publication 8.
Rahiminejad, A. H., Yazdi, M., Ashouri, AR., 2011. Reconstruction of the last marine connectivity of the Zagros basin, based on fossil evidences of the clastic-dominated Bakhtiari Formation. Historical Biology, 23: 155-167.
Rahiminejad, A. H., Yazdi, M., Ashouri, AR., 2011. Miocene scleractinian corals from a mix siliciclastic- carbonate system: Bakhtiari succession, Zagros Basin (central- western Iran). Alcheringa, 35: 571-592.
Reuter, M., Pillar, W.E., Harzhauser, M., Mandic, O., Berning, B., Rögl,F., Kroh, A., Aubry, M.P., WielandtSchuster.,U., Hamedani, A., 2007. The Oligo-Miocene Qom Formation (Iran): evidence for and early Burdigalian restriction of Tethyan Seaway and clouser of its Iranian getways. International Journal of Earth Sciences, 98: 627-650.
Rögl, F., 1998. Palaeogeographic considerations for Mediterranean and Paratethys seaways (Oligocene to Miocene). Annalen des Naturhistorischen Museums in Wien 99: 279- 310.
Sismonda, E., 1842. Appendice alla Monografia degli Echinidi Fossili del Piemonte. Memorie della Reale Accademica delle Scienze di Torino, 2(4): 385-394.
Stöcklin, J., 1952. Stratigraphical investigation in the Qoum-Arak-Gulpaigan Delidjan area. National Iranian of Oil Company, Report 95.
Stöcklin, J., Setudehina, A., 1991. Stratigraphic lexicon of Iran. Geological Survey Iran, Report 18: 1-376.
Toraby, H., 2003. Stratigraphy of Oligocene-Miocene Sediments (Qom Formation), West Ardestan-North Nain. PhD. Dissertation. University of Isfahan, 256pp.

Tsaparas, N., Drinia, H., Antonarakou, A., Marcopoulou-Diakantoni, A.I., Dermitzakis, M. D., 2007.Tortonian clypeaster fauna (Echinoidea: Clypeasteroida) from Gavdos Island (Greece). Bulletin of the Geological Society of Greece, 4: 225-237.

Vaziri Moghaddam, H., Kimiagari, M., Taheri, A., 2010. Principles of Foraminifera: Isfahan, Isfahan, 366 pp.

Wynd, J., 1965. Biofacies of Iranian oil consortium agreement area. Iranian Oil Off shore Company, Report 1082, unpublished.

Zahedi, M., Amidi, M., 1978. Geologic map of the Isfahan. Geological survey of Iran, scale 1/250000.

Yazdi, M., Parvanenejad Shirazi, M., Rahiminejad, A H., Motavalipoor, Razieh., 2012. Paleobathymetry and paleoecology of colonial corals from the Oligocene- early Miocene (?) Qom Formation (Dizlu area, centralIran). Carbonates and Evaporotes, 06: 395-405.

Zágrošek, K., Holcová, K., Nehyba, S., Kroh, A., Hladilova, Š., 2009. The invertebrate fauna of the Middle Miocene (Lower Badenian) sediments of Kralice nad Oslavou (Central Paratethys, Moravian part of the Carpathian Foredeep). Bulletin of the Geosciences, 84 (3): 465-496.

Zhu, Y., Qi, Y., Zhang, B., Yang, H., He, C., Wang, S., Zhou, W., Zhu, Q., Li, Z., 2007. Revision of the age of the Qom Formation in the Central Iran Basin, Iran. Journal of Asian Earth Sciences, 29: 71.