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Chitinozoan Biostratigraphy and Palaeogeography of Silurian Strata (Niur Formation) at Eastern Alborz Range (Kopet-Dagh Region) Northeastern Iran

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Abstract

The Silurian strata in eastern Alborz Range is called Niur Formation. This formation is well-developed between the Esfarayien and Bojnourd road, approximately 35 km southeastern Bojnourd city (35 km southeastern Caspian Sea). The Niur Formation is 750 thick and in ascending stratigraphic order, it has been divided into Member I and Member II. The Member I is 500 m thick and consists mainly of black shale with subordinate thin-bedded limestone. The Member II is 250 m thick and comprises of white sandstones, changing into red shale towards upward. The lower and upper contacts of Niur Formation are conformable with underlying Ghelli Formation and overlying Padeha Formation. A total of 76 surface samples were treated for chitinozoans from this formation, in order to establish a chitinozoan biozonation and to determine the palaeogeographic relationships of eastern Alborz Range (Kopet-Dagh Region) to Zagros Basin of southern Iran as well as other parts of the world. All samples of Member I, contain well-preserved and abundant palynomorphs (acritarchs, chitinozoans, cryptospores and scolecodonts), but those of Member II are barren. Thirty-two chitinozoan species (6 genera) were recognized in this study, and arranged in four biozones. Biozone of *Ancyrochitina merga* appears in the upper part of Ghelli Formation, suggesting the Ashgillian age. The biozones of *Ancyrochitina laevaensis*, *Ancyrochitina ramosaspina*/*Angochitina aff. longicollis* and *Plectochitina saharica* occur through Member I of Niur Formation suggesting Early Silurian for this part of formation. Member II lacks of chitinozoans, but some samples contain cryptospores and a few acritarchs, indicating Wenlockian age. 15 chitinozoan species out of 32 are new, including *Ancyrochitina angelinae, A. bojnourdensis, A. pelmisensis, A. silurica, A. heterospinosa, A. alborzensis, A. niurensis, A. longifilosa, A. fatema, Angochitina kalatensis, Angochitina minor, Angochitina caspiensis* and *Angochitina multipodspina*. Except for the new species, the remainder is similar to those of the same age in Zagros Basin southern Iran, Saudi Arabia, Algeria, Libya, Morocco and Spain, suggesting the eastern Alborz Range has been part of North Gondwana Domain.

Keywords: Chitinozoan, Early Silurian, North Gondwana, eastern Alborz Range, Biostratigraphy, Palaeogeography.

Introduction

This paper aims to demonstrate the utility of chitinozoan taxa in providing a powerful tool not only for chronostratigraphy but also for palaeobiogeography in lower Silurian strata (Niur Formation) of northeastern Alborz Mountain Range, along the southern shores of Caspian Sea.

The only previous study of Early Silurian chitinozoans from Iranian platform is concerned to the Sarchahan Formation in southern Iran (Ghavidel-syooki 2000), where two assemblage zones were established. Likewise, the Sarchahan Formation in southern Iran, was recently sampled and extensive Scanning Electron microscopy was carried out on chitinozoans of this rock unit. This study was resulted in more chitinozoan taxa as well as assemblage zones. Moreover, the chitinozoan biozones of Qalibah Formation in Saudi Arabia provide another basis for comparison and potential for accurate regional correlation. The main targets of this study were to determine the precise age, relationships of Niur Formation and to construct the chitinozoan biozones of North Gondwana Domain for northeastern Iran.

Stratigraphy

The studied area is located in the eastern part of Kuh-e-Saluk (Kuh=means mountain), approximately 35 km southeastern Bojnourd city (Fig. 1). The road from Bojnourd city to Esfarayien city is the principle link to the study area.

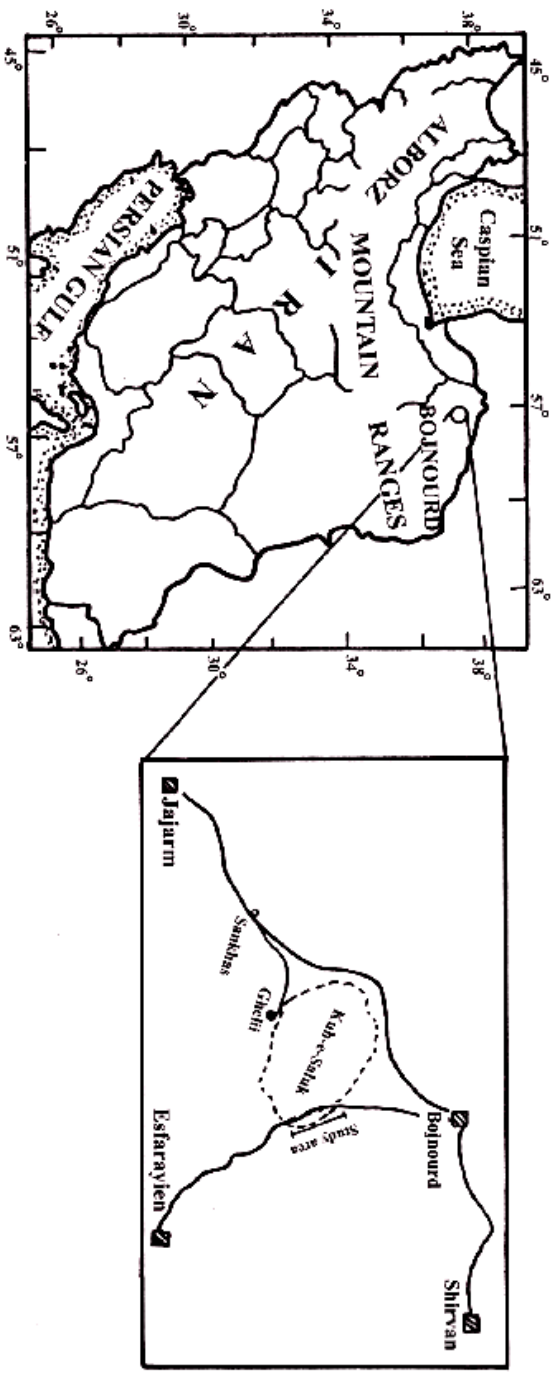

Fig. 1- Location map of study area.

A thick lower Palaeozoic sequence is well-developed between Bojnourd and Esfarayien cities, consisting of, in ascending stratigraphical order, the Lalun, Mila, Lashkarak, Ghelli and Niur formations. This area is part of Kopet-Dagh Region (north-eastern Alborz Range) where these rock units extend towards the southern and eastern parts of the Caspian Sea. The Mila Formation rests on the Lalun Formation (mainly red sandstone with Early Cambrian age) and it is overlain by the Ghelli Formation. The Mila Formation consists of limestones which contain poorly preserved trilobites and brachiopods. Based on stratigraphic position (Afshar-harb 1979) and palynological data (Ghavidel-syooki 2000), the Middle and Late Cambrian has been assigned to the Mila Formation. The Lashkarak Formation is 250 m thick and consists mainly of olive-grey shale with subordinate rubble limestone beds. Both lower and upper contacts of this formation are conformable with underlying (Mila Fm.) and overlying (Ghelli Fm.) formations. Based on acritarch assemblage zones, the Early Ordovician has been assigned to the Lashkarak Formation (Ghavidel-syooki 2000). The Ghelli Formation has a thickness of 1000 m and it consists mainly of dark to olive-grey shale, associating with subordinate siltstone and fine-grained sandstone layers. The lower and upper contacts of this formation are conformable with underlying (Lashkarak Fm.) and overlying (Niur Fm.) formations. Based on acritarch assemblage zones (Ghavidel-syooki 2000) and chitinozoan biozones (Ghavidel-syooki & Winchester-seeto 2002), the Middle-Late Ordovician have been assigned to the Ghelli Formation. In the study area, the youngest lower Palaeozoic rock unit is Niur Formation. The Silurian strata were recorded by Afshar-harb (1979) for the first time, in northeastern Alborz Range. Based on lithological data, in ascending stratigraphic order, the Niur Formation has been divided into two members (Afshar-harb 1979). Member I of Niur Formation is 500 m thick and it consists mainly of dark to olive-grey shale which is associated with subordinate fossiliferous limestone beds. This member contains some coral specimens (e.g. *Crystiphyllum silurience, Halysites catenularis, Halysites labyrinthicus* and so on) in certain horizones, but all thickness of this formation has abundant and well-preserved palynomorphs. Based on palaeontological data, this member of Niur Formation has been assigned to the Early Silurian (Ghavidel-syooki 2000). The Member II of Niur Formation has a thickness of 250 m and it consists mainly of white sandstones, red-purple shale (a few olive-bluish shale layers are present in the Middle part of this member). The sedimentary structures such as cross-bedding, graded bedding, asymmetrical ripple mark and mud-crack are abundant in this part of Niur Formation. This member lacks fauna, but it contains cryptospore taxa in some horizones. Based on palynological data, this part of

Niur Formation has been assigned to the Middle Silurian (Wenlockian) by Ghavidel-syooki (2000).

The Niur Formation has gradational contact with the Ghelli Formation (Late Ordovician) in below and it has disconformable contact with the Padeha Formation (Late Devonian). Therefore, based on palynological data, this rock unit has an Early-Middle Silurian age (Ghavidel-syooki 2000) in the study area.

Materials and Methods

Seventy-six surface samples from the upper part of Ghelli Formation and Niur Formation were treated and investigated for chitinozoans taxa (sample numbers of MG-7680 to MG-7756). The palynomorphs were extracted from shale, siltstone and sandstone by standard palynological procedures, including treatment of the residues of each sample with 30 ml of saturated zinc bromide in order to separate the organic residues from the inorganic materials, screening of the organic residue through 20 microns nylon mesh sieves. Extensive Scanning Electron and Transmitted Light microscopic slides which are used in this study are in file in the palaeontological collections of the Exploration Directorate of the National Iranian Oil Company under the sample numbers of MG-7680 to MG-7756. Most surface samples contain well-preserved and abundant palynomorphs (chitinozoans, acritarchs, small trilete spores and scolecodonts). In general, the chitinozoans are abundant and well-preserved. The thermal maturity is medium to low, but many specimens show some degree of flattening, most probably due to being preserved in shale and siltstones. Diversity is relatively high, ranging from 5 to 25 species per sample.

Systematic Paleontology

For taxonomic description, the classification system which has been proposed by Paris *et al* (1999) is used. The species with well descriptions, only their relevant remarks are made herein, but the new species have been fully described and measurements are given in microns. In some specimens, the qualifiers of aff., cf., and sp., have been used. "Aff." is used to indicate that the species differs clearly from the holotype, but it may still fall within the limits of variation of the species. "cf "is used to indicate that the determination is uncertain because of poorly preserved material."Sp." is used to indicate that the specimens can not be related to any established species. Likewise, the following symbols are adopted for the systematic description and biometric value: L=total length of vesicle, l=length of chamber, ln=length of neck with collarette, D=maximum diameter of vesicle, d=diameter of neck, dcoll=diameter of collarette, ls=length of spines, L/D=total length of vesicle/maximum of diameter of vesicle And L/ln=total length of vesicle/ length of neck.

When the chamber is less flattered than the neck, their respective diameter is restaured by using a coefficient of 0.7 for neck and 0.8 for the chamber.

Taxonomic Part

Order: Prosomatifera Eisenack 1972
Family: Conochitinidae Eisenack 1931
Subfamily: Conochitininae Paris 1981
Genus: *Conochitina* Eisenack 1931
Type species: *Conochitina claviformis* Eisenack 1931

Conochitina edjelensis Taugourdeau 1963
Plate 2, figs. 4-5

In the Niur Formation, *Conochitina edjelensis* is common and it is restricted to the middle part of this formation. This species is more similar to that of Estonian form than elsewhere. So far, this species has been recorded from Lower Silurian strata in Saudi Arabia (Paris *et al.* 1995), Libya (Paris 1985), Spain (Cramer 1966) and Estonia (Nestor 1994). In global biozonation of chitinozoans, this species is restricted to the Middle Llandovery beds (Vernier *et al.* 1995).

Conochitina armillata Taugourdeau & de Jekhowsky 1960
Plate 7, fig. 2

This species is common in the Niur Formation and it is associated with *Conochitina edjelensis*. So far, this species has been recorded from Middle-Upper Llandovery beds of Libya (Paris 1985), Lower Silurian strata of Brazil and Paraguay (Grahn & Bergamaschi 2000) and Algerian Sahara (Taugourdeau & de Jekhowsky 1960).

Family: Lagenochitinidae Eisenack 1931
Subfamily: Angochitininae Paris, 1981
Genus: Angochitina Eisenack 1931

Type species: *Angochitina echinata* Eisenack 1931
Angochitina aff. *longicollis* Eisenack 1959a
Plate 3, figs. 5 & 9

This species has cylindro-spherical vesicle. The flexure is conspicuous, but the shoulder is absent. The neck widens towards aperture with distinct collarette. The basal margin is rounded with flat or slightly convex base. The spinose ornamentation is regular and distributed on the whole vesicle surface. The spines are simple and sometimes split in proximal or distal parts. The biometrical values of this species are: L=129, ln=59, D=69, dcoll=38, ls=6, L/D=1.9, L/ln=2.2. This species of Niur Formation differs from *Angochitina longicollis* Eisenack (1959b) and other species of *Angochitina* in smaller biometrical values. The *Angochitina longicollis* has been reported from the beds of Adavere stage of Estonia (Nestor 1994), and Upper Llandovery beds of Sweden (Lanfeld 1974, Grahn 1995).

Angochitina multipodspina nov. sp.
Plate 5, fig. 4.

Derivation of the name: reference to multipod spinose ornamentation.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, 35 km southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=120, ln=60, D=62, dcoll=29, ls=7, L/D=2 and L/ln=2. Measurment has carried out on 18 specimens.

This species has cylindro-spherical vesicle with flat to slightly concave base. The length of neck is 1/2 vesicle length. The flexure is broadly rounded, but lacks shoulder. The basal margin is rounded and provided with short, simple spines. The chamber gradually changes to neck. The neck widens slightly towards aperture. The whole vesicle surface is covered by spinose ornamentation, but their distribution is variable. The spines are bi- or multipodal at proximal end and simple at distal part. This species differs from previously encountered species of *Angochitina* in morphological characteristics and spinose ornamentation. *Angochitina multipodspina* is common in the Niur Formation.

Angochitina minor nov. sp.
Plate 5, fig. 8

Derivation of the name: reference to small size of specimens.
Type locality: Kuh-e-Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, 35 km southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=81, ln=30, D=69, dcoll=37, ls=8, L/D=1.2 and L/ln=2.7.
This species has fairly small cylindro-spherical vesicle with flat or slightly concave base. The neck is short with a distinct collarette. The basal margin is rounded and provided by filiform spines. The spines are bi- or multipodal at proximal and simple at distal ends. Besides of spines, delicated granules are distributed over the whole vesicle. In general, this species is characterized by small size, short neck, distinct collarette and large chamber.

Angochitina kalatensis nov. sp.
Plate 5, fig. 2

Derivation of the name: reference to Kalat village nearby the Niur Formation outcrop.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, 35 km southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=109, ln=47, D=60, dcoll=28, ls=28, L/D=1.8 and L/ln=2.3.
The vesicle is cylindro-spherical with flat or slightly convex base. The flexure and shoulder are conspicuous. The neck is 1/2 vesicle length and widens towards aperture and it forms a district fringed collarette. The basal margin is broadly rounded and carries numerous filose spines at basal

edge. The chamber and 2/3 neck are covered by filiform spines and delicate granules. This species is similar to *Ramochitina martinssonii* Laufeld (1974), but the former differs from latter in biometric values and density of spinose ornamentation.

Angochitina caspiensis nov. sp.
Plate 3, fig. 2

Derivation of the name: reference to the Caspian Sea which locates northwestern of Bojnourd city.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, 35 km southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Direct-orate of the National Iranian Oil Company.
Dimensions: L=123, ln=62, D=35, dcoll=30, ls=8, L/D=2.2 and L/ln=2.
This species is characterized by cylindro-spherical vesicle and lacks of flexure and shoulder. The neck is 1/2 vesicle length and chamber gradually goes towards neck. The basal margin is broadly rounded and carries numerous Y-shaped spines. Most of spines are broken, but they distribute uniformly on the whole vesicle. The neck widens towards aperture and provides a distinct collarette which carries simple intented spine. This species differs from other species of *Angochitina* in shape, ornament-ation and biometric values.

Genus: *Ramochitina* Sommer & Van Backel 1964
Ramochitina martinssonii (Laufeld 1974) emend.
Plate 7, fig. 5

Based on definition of Ramochitina (Sommer and Van Backel 1964) and Gotlandochitina (Laufeld 1974) and the discussion on these genera, Gotlandochitina (Laufeld 1974) is synonym of Ramochitina (Sommer & Van Backel 1964). This species in the Niur formation has subcylidro-spherical vesicle with distinct flexure and poorly developed shoulder. The vesicle surface is covered by filose spines which are arranged in longitudinal rows. The spinose ornamentation has high concentration on the chamber, but they decrease towards aperture. The neck widens towards aperture and forms a fringed collarette. The filose spines are splitting at proximal part and simple at distal end. The biometric values of this species in the Niur Formation are: L=124, ln=58, D=67, dcoll=42, ls=19, L/D=1.85 and L/ln=2.1. However, it should be mentioned that the biometric values of Iranian species differs from Gotlandian species. So far, this species has been recorded from Slite Beds of Sweden (Laufeld 1974).

Subfamily: Ancyrochitininae Paris 1981
Genus: *Ancyrochitina* Eisenack 1995
Type species: *Conochitina ancyrea* Eisenack 1931
Ancyrochitina merga Jenkins 1970
Plate 1, figs. 1-2

Ancyrochitina merga is a well-known Ashgillian species which was known from the Sylvan Shale of Oklahoma (Jenkins 1970). Likewise, this species has been recorded from the Ashgillian sediments in Libya (Molyneux & Paris 1985; Paris 1988), Morroco (Elaouad-Debbaj 1984), Saudi Arabia (Al-Hajri 1995), Southern Iran (Ghavidel-syooki 2000), Northeastern Alborz Mountain Range (Ghavidel-syooki & Winchester-seeto 2004). The total range of this species was used to define the *Ancyrochitina merga* biozone (Paris 1990). This species is com-mon in the uppermost part of Ghelli Formation which is overlain by the Niur Formation. The biometric values of this species in the Ghelli Formation are:L=105, ln=43, D=71, dcoll=43, ls=21, L/D=1.5 and L/ln=2.4.

Ancyrochitina persica Ghavidel-syooki & Winchester-seeto 2004
Plate 1, figs. 4-6

Ancyrochitina persica has been fully described from the Late Ordovician sediments of northeastern Iran. In this paper, well-preserved specimens are illustrated to complete introduction of this species in previous description. This species appears in the upper part of Ghelli Formation and it is associated with *Ancyrochitina merga* (Jenkins 1970). The biometric values of illustrated specimens of this paper are: L=104-114, ln=57-82, D=70-79, dcoll= 32-50, ls=24-30, L/D=1.4-1.5 and L/ln=1.4-1.8.

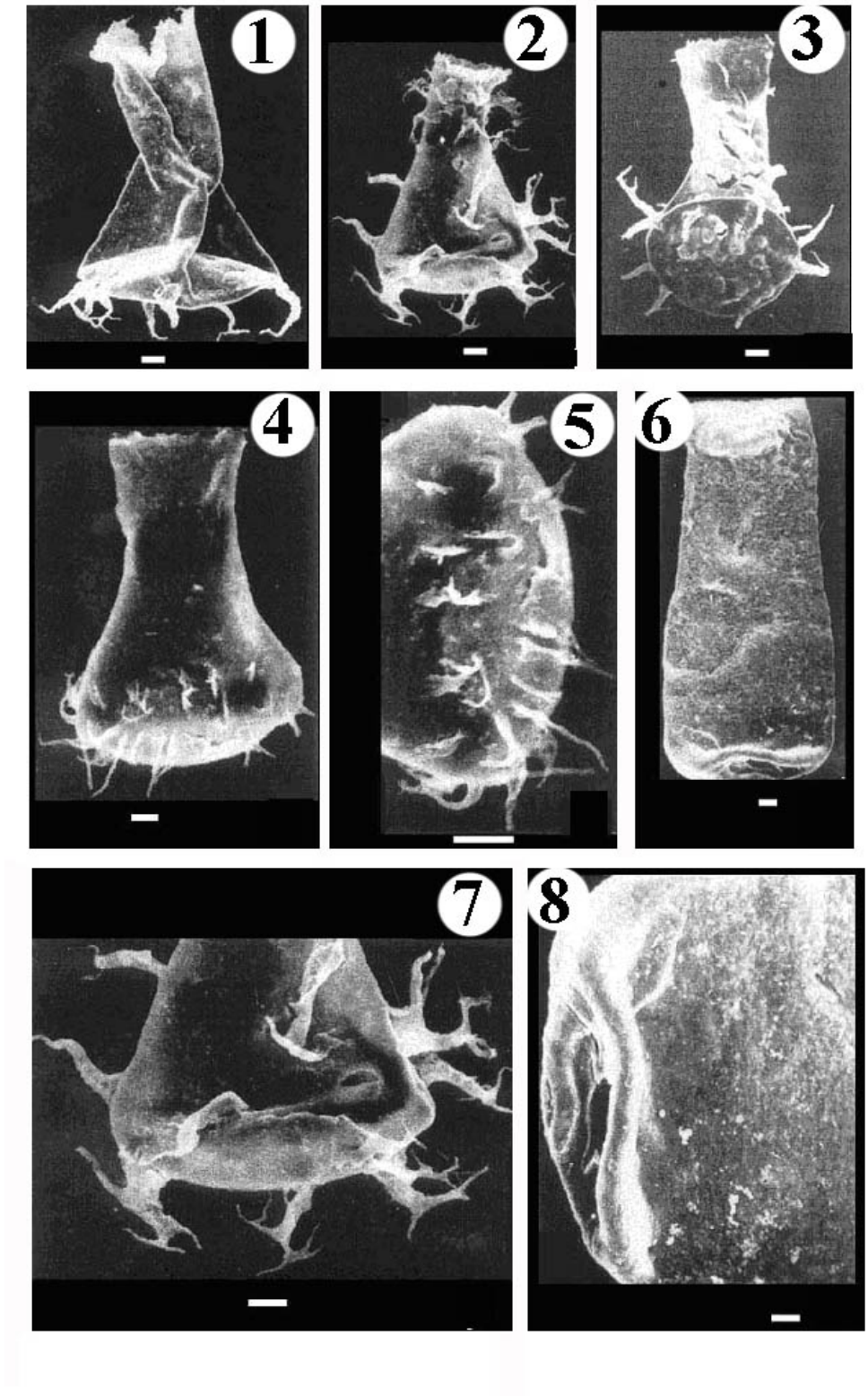

Plate 1- Chitinozoan taxa from the uppermost part of Ghelli Formation (Late Ordovician and Niur Formation (Silurian) with bar scale, in northeastern Alborz range, southern Caspian Sea. Fig. 1. *Plectochitina spongiosa* (Achab 1977a), MG-2865 to Mg-7692, × 400. Figs. 2-3. *Ancyrochitina persica* Ghavidel-syooki & Winchester-Seeto 2002, MG-2865 to MG-2875, × 400. Fig. 4. *Ancyrochitina merga* (Jenkins 1970), MG-2865 to MG-7682, × 600 Fig. 5. Enlargement of Fig. 4 × 1200. Fig. 6. *Chonochitina edjelensis* (Taugourdeau 1963), 260m-307m, × 400. Fig. 7. Enlargement of Fig. 2 ×800. Fig. 8. Enlargement of Fig. 6 × 1300. Scale bar = 10 μm

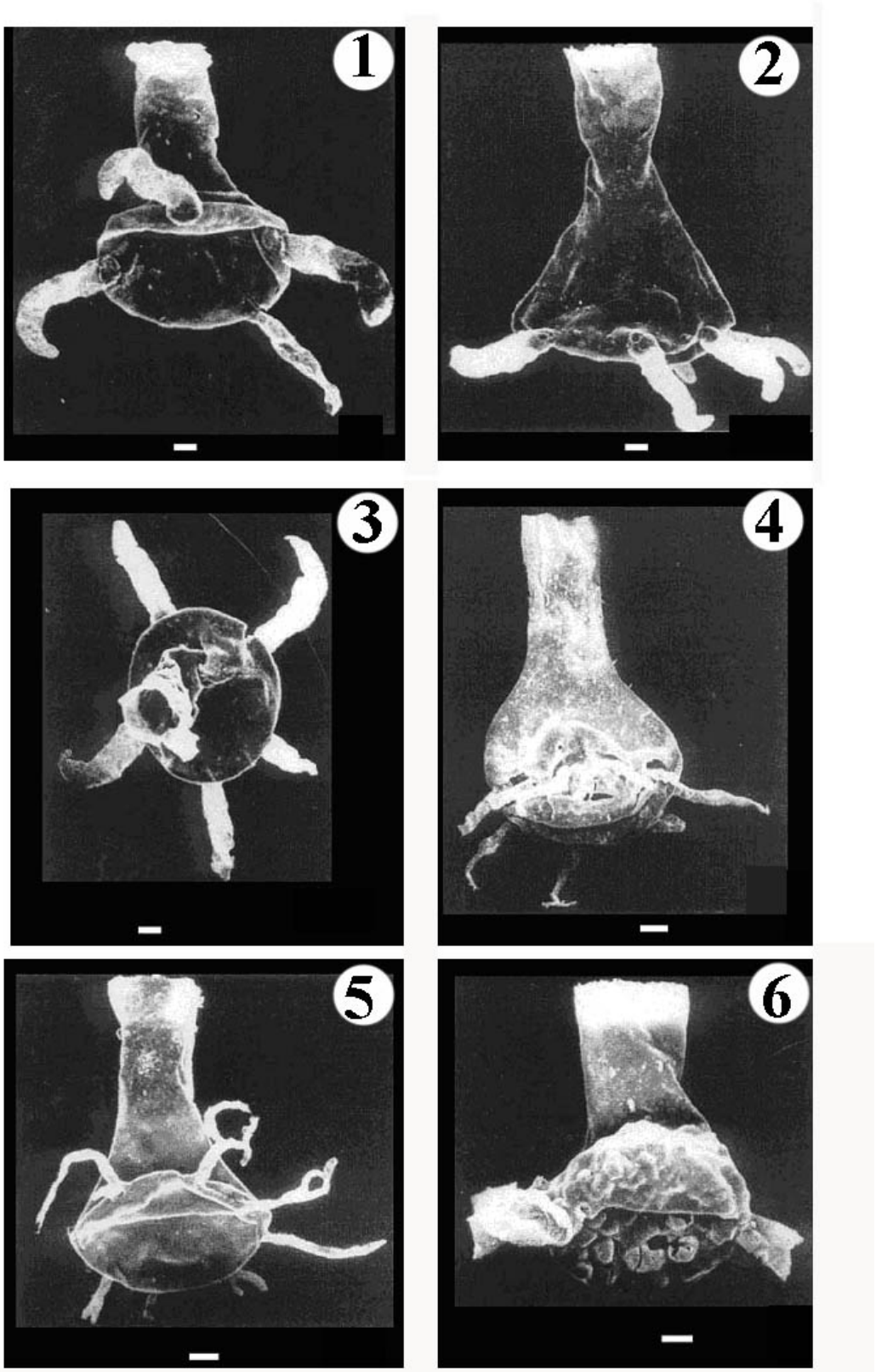

Plate 2 - All chitinozoan taxa from the Niur Formation of northeastern Alborz range, southern Caspian Sea. Fig. 1. *Plectochitina pseudoagglutinans* (Taugourdeau 1963), 307m-421m, × 400. Fig. 2. *Plectochitina pseudoagglutinans* (Taugourdeau 1963), 307m-421m, × 500. Fig. 3. *Plectochitina pseudoagglutinans* (Taugourdeau 1963), 307m-421m, × 450. Fig. 4. *Plectochitina nodifera* (Nestor 1994), 0.0m-46m, × 600. Fig. 5. *Ancyrochitina ancyrea* (Eisenack 1931), MG-2865 to MG-7757, × 450. Fig. 6. *Plectochitina paraguayensis* (Wood & Miler 1991), (specimen with broken appendages), 207m-260m, × 550. Scale bar = 10 μm.

Ancyrochitina ramosaspina Nestor, 1994
Plate 4, figs. 4, 9; Plate 6, figs. 5-6, 8

This species of Niur Formation has cylindro-conical vesicle with convex base which carries 4-8 appendices which branched 3-4 times. The flexure is broadly rounded and the shoulder is absent. The neck widens towards aperture which is provided with short intended spines. The flexure carries short triangular spines. The biometric values of this species in the Niur Formation are: L=135, ln=50-67, D=67-70, dcoll=27-39, ls=22-35, L/D=1.3-2.6 and L/ln=1.7-2.2. So far, this species has been recorded from Middle Llandoverian sediments of Estonia (Nestor 1994), or Raikkula Stage. This species is abundant in the investigated samples of Niur Formation.

Ancyrochitina bifurcaspina Nestor, 1994
Plate 4, figs. 3, 6; Plate 5, fig. 5

The vesicle is cylindro-conical with conspicuous flexure and lack of shoulder. The basal margin is rounded with short appendices which have coalescent in proximal part and distal part regularly branching 2 times. The neck widens towards aperture and carries short intended spines. The vesicle surface is smooth or granulate. The biometric values of this species in the Niur Formation are: L=118-123, ln=61-62, D=57-60, dcoll=27-35, ls=26-35, L/D=2 and L/ln=1.7-2. So far, this species has been recorded from the uppermost part of Ohne Formation of the Juru Stage and in the Slitere Member of the Raikkula Stage of Estonia (Nestor 1994).

Ancyrochitina aff *porrectaspina* Nestor 1994
Plate 4, fig. 8

The vesicle is cylindro-conical with flat to concave base. Both chamber and neck are equival and each of them is 1/2 vesicle length. The flexure is conspicuous and shoulder is absent. The basal margin is rounded, carrying 7-8 long branching appendices. The neck widens towards aperture which is provided with simple spines. The vesicle surface is covered by delicate granules. The biometric values of this species in the Niur Formation are: L=83, ln=42, D=53, dcoll=25, ls=22, L/D=1.6 and L/ln=2. This species is quite similar to *Ancyrochitina porrectaspina* Nestor (1994) but the former differs from the latter in biometric values. Therefore, this species is probably the same as *Ancyrochitina porrectaspina* Nestor (1994). So far, similar species to specimens of Niur Formation has been recorded from Estonia upper Llandovery.

Ancyrochitina alborzensis nov. sp.
Plate 2, figs. 10-11

Derivation of the name: reference to the Alborz Mountain Range in northern Iran, or southern Caspian Sea.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=137, ln=64, D=60, dcoll=33, ls=13, L/D=2.3 and L/ln=2.1 (measurement was carried on 25 specimens).
The vesicle is cylindrical with convex base and lacks shoulder and flexure. The basal margin is rounded and provided with a numerous nodular appendices. The neck widens slightly towards aperture. The whole vesicle surface is covered by densely nodular filose spine and granules. The ornamentation decreases towards neck and aperture. This species differs from other species of *Ancyrochitina* in cylidrical vesicle, filose nodular appendices and densely filose and granulate ornamentation on the vesicle surface.

Ancyrochitina pelmisensis nov. sp.
Plate 4, figs. 2, 5; Plate 2, figs. 2-3, 7

Derivation of the name: reference to Pelmis passed road which cut the Niur Formation and it is well-known in Iran for heavy snow during winter.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeo-ntological collections of Exploration Direct-orate of the National Iranian Oil Company.

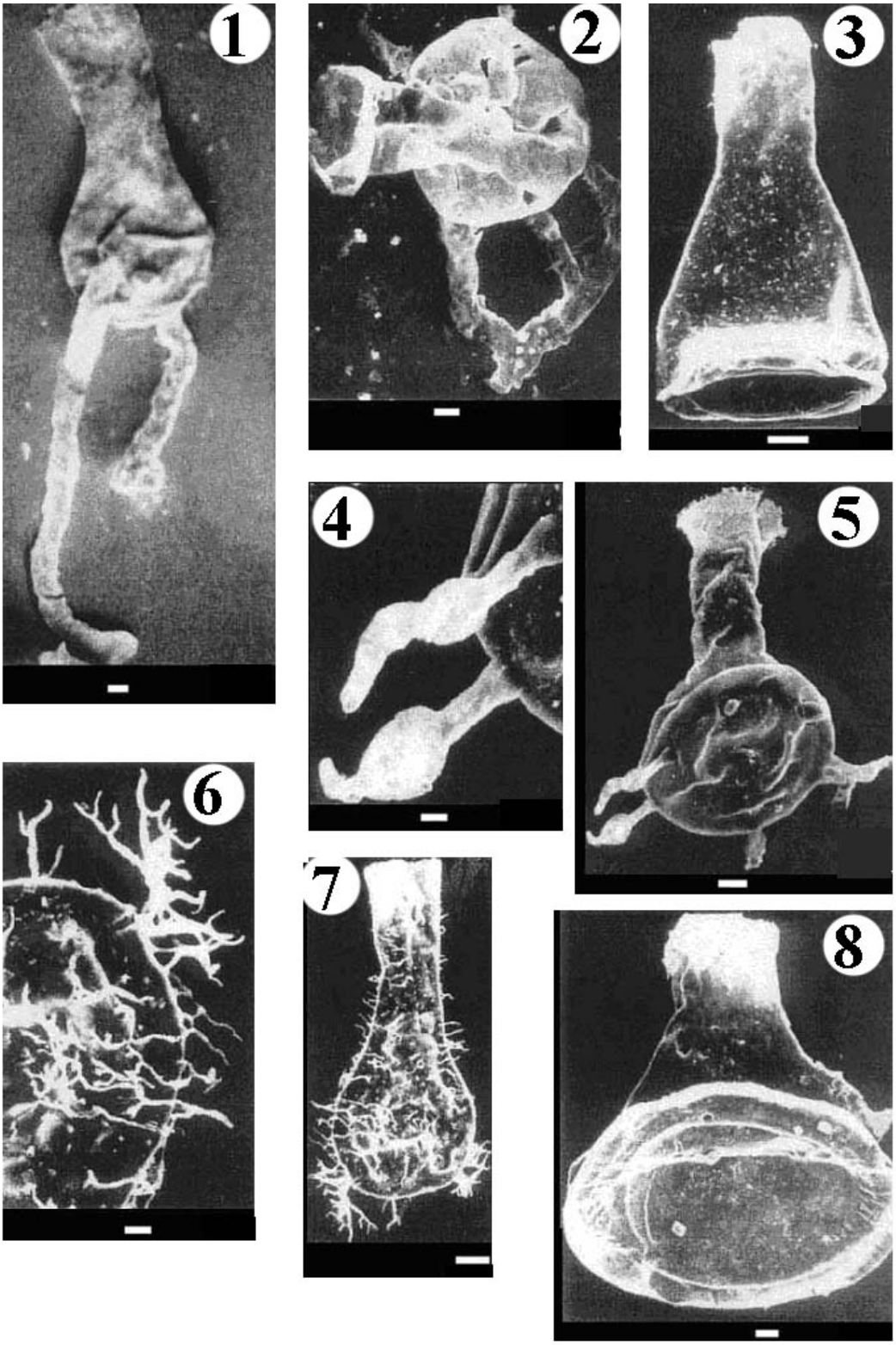

Plate 3 - All chitinozoan taxa from the Niur Formation of northeastern Alborz range, southern Caspian Sea. Fig. 1. *Plectochitina paraguayensis* (Wood & Miler 1991), 207m-260m, × 450. Fig. 2. *Plectochitina saharica* (Taugourdeau 1962), 307m-421m, × 450. Fig. 3. *Cyathochitina campanulaeformis* (Eisenack 1931), MG-2865 to MG-7727, × 350. Fig. 4. Enlargement of Fig. 5, ×1500. Fig. 5. *Plectochitina ralphi* (Nestor 1994), 418m-500m, × 550. Fig. 6. Enlargement of Fig. 7, × 1300. Fig. 7. *Ancyrochitina fatema* nov. sp., 315m-500m, × 600. Fig. 8. *Cyathochitina kuckersiana* (Eisenack 1934), MG-2865 to MG-7703, × 400. Scale bar = 10 μm.

Dimensions: L=126-147, ln=61-81, D=62-68, dcoll=28-38, ls=19-28, L/D=2-2.3 and L/ln=1.8-2 (measurement was carried on 25 specimens).
The vesicle is cylindro-conical with flat, convex or concave base.The flexure is conspicuous, but shoulder may be distinct or absent. The basal margin is broadly rounded and provided with 5-8 appendices which branch 3 times. The appendices are splitting at proximal part and simple at distal end. The basal part of chamber has a distinct basal scare in some specimens of this species.
However, the appendices are variable from specimen to specimen. The neck widens towards aperture with intented simple spines. The vesicle is covered by filose spines which decrease their density towards the neck as well as collarette.
This species is similar to *Ancyrochitina laevaensis* (Nestor 1994), but the former differs from latter in having densely filose spinose ornamentation and biometric values.

Ancyrochitina bojnourdensis nov. sp.
Plate 4, fig. 1, Plate 5, fig. 1, Plate 6, fig. 1

Derivation of the name: reference to Bojnourd city, 35 km northern Kuh-e Saluk.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeont-ological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=77-117, ln=42-48, D=70-79, ls=15-20 (measurement was carried on 20 specimens).
This species has cylindro-conical vesicle with flat or concave base. The maximum diameter is equival to the total length of vesicle. The vesicle is small and it is covered by high density of filiform spines and granules. The flexure is conspicuous and shoulder is absent. The neck is short and almost equal to length of chamber. The neck widens towards aperture. The basal margin is bluntly rounded and carries a numerous appendices at basal edge. The appendices branch 2-3 times and even more. The vesicle is covered by spines and granules. The spines are splitting in the proximal part and simple at the distal end. This species is similar to *Angochitina* sp. A. *sensu* (Grahn & Paris 1992), but the former differs from the latter in biometric values and fairly long processes at basal edge. This species is common in the Niur Formation and similar specimens to *Ancyrochitina bojnourdensis* have been recorded from Early Silurian of Parana Basin in Brazil and Paraguay (Grahn & Pereira 2000)

Ancyrochitina silurica nov. sp.
Plate 4, fig. 7; Plate 2, figs. 9-10

Derivation of the name: reference to Silurian period.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=78-112, ln=33-35, D=62-70, dcoll = 25-35, ls=25-29, L/D=1.2 and L/ln=1.8 (measurement was carried on 25 specimens).
This species has cylindro-conical vesicle with convex base. The flexure and shoulder are conspicuous. The basal margin is bluntly rounded and it carries 8-10 appendices which are divided into two groups. Each group contains 4-5 appendices which locate at basal edge. The whole vesicle surface is covered by simple spines which is splitting at proximal part and tapered at distal end. This species is similar to *Ancyrochitina laevaensis* (Nestor, 1994), but the Iranian species differs from Estonian one in biometric values and spinose ornamentation on vesicle surface.

Ancyrochitina heterospinosa nov. sp.
Plate 2, fig. 8

Derivation of the name: reference to different types of spines.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Directorate of the National Iranian Oil Company.

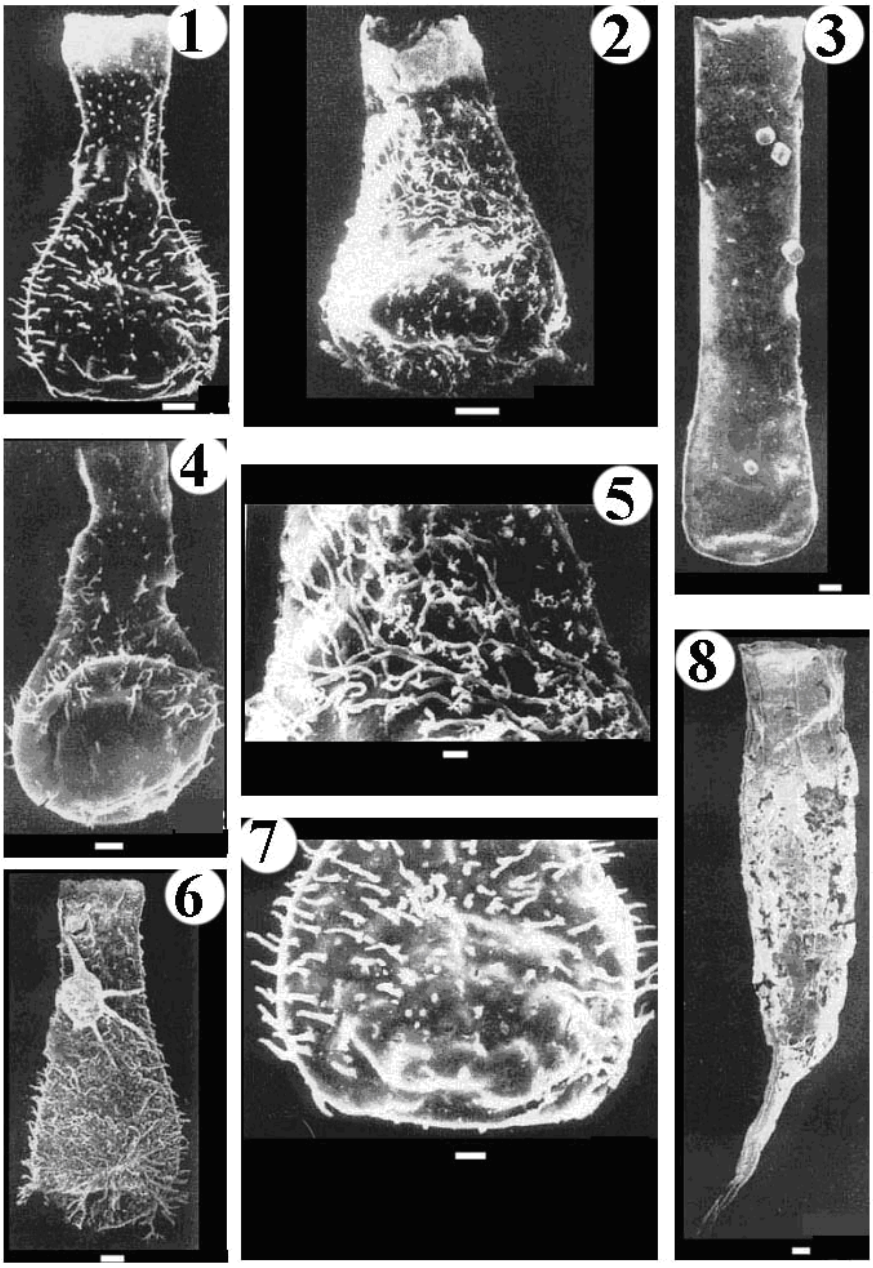

Plate 4. **Fig. 1.** ***Angochitina caspiensis*** **nov. sp., 418m-500m, × 400**. **Fig. 2.** ***Angochitina longifilosa*** **nov. sp., 148m-500m, × 850**. **Fig. 3.** ***Conochitina alargada*** **(Cramer 1967), 220m-307m, × 400**. **Fig. 4.** ***Angochitina multipodspina*** **nov. sp., 314m-500m, × 600**. **Fig. 5. Enlargement of Fig. 2, × 1500**. **Fig. 6.** ***Ancyrochitina*** **sp. A., 418m-500m, × 450**. **Fig. 7. Enlargement of Fig. 1, × 2000**. **Fig. 8. Chitinous graptolite remains, × 270. Scale bar = 10 µm.**

Dimensions: L=83, ln=42, D=62, dcoll=25, L/D=1.3 and L/ln=2.

This species has small cylindro-spherical vesicle with flat or slightly convex base. The basal margin is rounded and provided with different type of spines and appendices on the basal edge. The small spines of basal edge are splitting proximal part and simple at distal end. The flexure and shoulder are absent. The neck widens towards aperture without spines. Two appendices appear at basal edge and they are divided 3-4 times.

Ancyrochitina longifilosa nov. sp.
Plate 5, figs. 3, 6

Derivation of the name: reference to longifilose ornamentation on vesicle surface.

Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.

Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeont-ological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=93, ln=42, D=57, dcoll=30, ls=17, L/D=1.6 and L/ln=2.2 (measurement was carried on 19 specimens).
This species has small cylindro-spherical vesicle with flat or concave base. The flexure and shoulder are absent. The neck and chamber are equal and each is 1/2 vesicle length. The chamber gradually changes into the neck. The basal margin is bluntly rounded and it carries 4-8 nodular appendices at basal corners. The vesicle is covered by long filose spines and delicated granules. The filose spines are splitting at proximal part and tapered at distal end. This new species differs from all previously species of *Ancyrochitina* in the Niur Formation.

Ancyrochitina niurensis nov. sp.
Plate 3, fig. 8

Derivation of the name: reference to Niur Formation that this species is found.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeo-ntological collections of Exploration Direct-orate of the National Iranian Oil Company.
Dimensions: L=83, ln=42, D=50, dcoll=28, ls=33, L/D=1.7 and L/ln=2.
This species has cylindro-conical vesicle with convex base. The chamber is 1/2 vesicle length. The basal margin is rounded and it carries 6-10 appendices which branch 2-3 times. The flexure is conspicuous, but the shoulder is absent. The neck widens towards aperture and it forms a distinct collarette which is provided with intented simple spines. The vesicle surface is smooth. In some extent, this species is similar to *Ancyrochitina bifurcaspina* (Nestor 1994), but the former differs from latter in biometric values and intented simple spines of collarette.

Ancyrochitina fatemae nov. sp.
Plate 5, figs. 7, 9; Plate 6, fig. 4

Derivation of the name: reference to the name of my wife who encouraged me on research works.
Type locality: Kuh-e-Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeontological collections of Exploration Direct-orate of the National Iranian Oil Company.
Dimensions: L=121-145, ln=63-75, D=57-60, ls= 14-29, L/D=1.4-2.1 and L/ln=1.85-1.9 (measure-ment was carried on 20 specimens). This species has cylindro-conical vesicle with flat, or convex base. The flexure is broadly rounded and conspicuous, but without shoulder. The basal margin is broadly rounded and it carries 4-8 web-like appendices at basal edge.
The appendix branches 3-4 times at distal part and coalescent at proximal end. The chamber changes gradually to neck. The neck is long and widens towards aperture. The neck is 1/2 total length of vesicle and forms a distinct collarette which provided with intented simple spines. The whole vesicle is covered by uniform small spines which are mostly broken. The small spines of basal margin is splitting at proximal and tapered at distal end. This species differs from other species of *Ancyrochitina* in biometric values, shape and spinose ornamentation.

Ancyrochitina angelinae nov. sp.
Plate 6, fig. 7; Plate 7, figs. 3-4

Derivation of the name: This species is dedicated to little daughter of my colleague, Theresa Winchester-seeto.
Type locality: Kuh-e Saluk, 35 km southeast of Bojnourd city, eastern Caspian Sea.
Type stratum: from Niur Formation of Kuh-e Saluk, southeast of Bojnourd city.
Holotype: the specimens are housed under sample numbers of MG-6782 to MG-7757, in the palaeont-ological collections of Exploration Directorate of the National Iranian Oil Company.
Dimensions: L=129-130, ln=59-60, D=68, dcoll=36-38, ls=21-25, L/D=1.9 and L/ln=2.2.
This species has cylindro-conical vesicle with convex base. The length of neck is 1/2 vesicle length. The flexure is broadly rounded and shoulder is conspicuous.

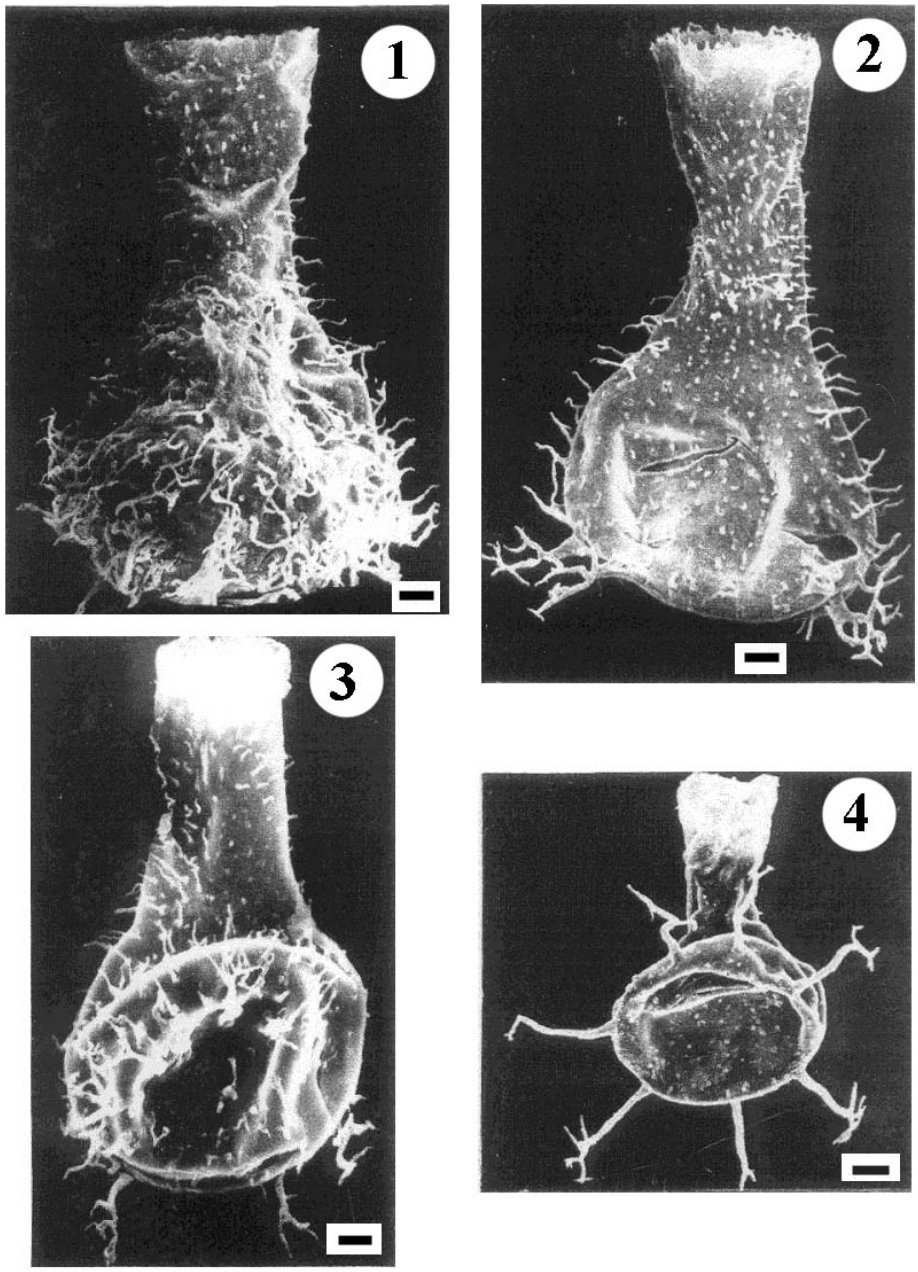

Plate 5- All chitinozoan species from the Niur Formation northeastern Alborz range, southern Caspian Sea. Fig. 1. *Angochitina iranica* nov. sp., 418m-500m, × 700. Fig. 2. *Ancyrochitina angelinae* nov. sp., 314m-500m, × 700. Fig. 3. *Ancyrochitina kalatensis* nov. sp., 314m-500m, × 700. Fig. 4. *Ancyrochitina porrectaspina*; 418m-500m, × 700. Scale bar = 10 µm.

The basal margin is bluntly rounded and it carried 6-8 appendices which become width at proximal part and branch 3-4 times and even more at distal ends. The neck gradually widens towards aperture and forms collarette with intented simple spines. The whole vesicle surface is covered by simple spines which are mostly splitting at proximal part. This species is similar to *Ancyrochitina laevaensis* (Nestor 1994), but the former differs from latter in biometric values and spinose ornament-ation of vesicle surface.

Genus: *Plectochitina* Cramer 1964
Type species: *Plectochitina carminae* Cramer 1964
Plectochitina spongiosa Achab 1977
Plate 1, fig. 9.

This species is common in the upper part of Ghelli Formation and it is associated with *Ancyrochitina merga* and *Ancyrochitina persica.* So far, this species

has been recorded from Ashgill-Llandovery strata in Libya (Paris 1985), Laurentia-northern Gondwana (Paris 1992), Estonia (Nestor 1994) and Anticosti Island of Canada (Achab 1977).

Plectochitina pseudoagglutinans Taugourdeau 1963
Plate 1, fig. 5; Plate 3, figs. 1, 3-4, 6

This species is abundant in some horizons of Niur Formation. The biometric values of this species in the Niur Formation are: L=108-145, ln=43-86, D=35-77, ls=30-52 (width of 15 microns), L/D= 1.9-2.5 and L/ln=1.4-1.7. So far, *Plectochitina pseudoagglutinans* has been recorded from Lower Silurian strata in southern Iran (Ghavidel-syooki 2000), Saudi Arabia (Paris *et al.* 1995), Libya (Paris 1985), northern Africa (Taugourdeau *et al.* 1967), Spain (Cramer 1966, Preiwalder 1997) and a global chitinozoan biozonation for the Silurian (Vernier *et al.* 1995). This species is restricted to the Early Silurian strata in northern Gondwana Domain.

Plectochitina aff. *ralphi* Nestor 1994
Plate 3, figs. 4, 7

This species has cylindro-conical vesicle with flat or slightly convex base. The basal margin is rounded, providing with 6-8 simple, unbranched, irregularly nodular appendices. The flexure is conspicuous, but shoulder is missing. The neck widens towards aperture. The collarette is distinct and provided with small simple spines. The vesicle is smooth or granulate. The biometric values of this species in the Niur Formation are: L=108, ln=50, D=59, dcoll=34, ls=24, L/D=1.8 and L/ln=2.2. Based on biometric values, the Iranian species differs from that of Estonia (Nestor 1994). So far, this species has been recorded from Rumba Formation of Adavere stage in Estonia (Nestor 1994)

Plectochitina nodifera Nestor 1994
Plate 6, fig. 3

This species has cylindro-conical vesicle with flat, or convex base. The flexure and shoulder are conspicuous. The basal margin is broadly rounded and it is provided with 6 spongy irregular thickening appendices which are nodular in proximal part and bifurcate in distal end. The vesicle surface has spinose ornamentation in this species. The biometric values of this species in the Niur Formationare: L=105, ln=49, D=70, dcoll=29, ls=18, L/D=1.6 and L/ln=2.3. However, it should be mentioned that based upon biometric values, the Iranian form has a little bit differs from Estonian species. So far, *Plectochitina nodifera* has been recorded from the uppermost beds of the Juuru stage in Estonia (Nestor 1994) and Early Silurian Qalibah Formation in Saudi Arabia (Paris *et al.* 1995).

Subfamily: Cyathochitininae Paris 1981
Genus: *Cyathochitina* Eisenack 1935
Type species: *Conochitina campanulaeformis* Eisenack 1931
Cyathochitina campanulaeformis Eisenack 1931
Plate 1, fig. 3

This species is common in the Niur Formation as well as Ghelli Formation. *Cyathochitina campanulaeformis* Eisenack (1931) has cylindro-conical vesicle. The vesicle surface is granulate. The biometric values of this species in the Niur Formation are: L=242, ln=82, D=75, dcoll=36, L/D=3.2 and L/ln=2.9. This species ranges from Ordovician through Llandovery elsewhere.

Cyathochitina aff. campanulaeformis Eisenack 1931
Plate 1, fig. 7

This species is common in the Niur Formation. *Cyathochitina aff. campanulaeformis* has cylindro-conical vesicle.
The specimens have flexure and shoulder is missing. The chamber is slightly convex, or straight and neck gradually widens towards aperture. The vesicle surface is granulate. The basal margin is rounded with a narrow carina and concave base. The biometric values of this species are: L=146, D=91, dcoll=65, L/D=1.6. This species differs from *Cyathochitina campanulaeformis* in biometric values and other species of *Cyathochitina*.

Biostratigraphy

The chitinozoans are microfossils which have hollow, organic walled tests. They thrived during the Ordovician, Silurian and Devonian periods. The chitinozoans are exclusively marine and uncertain biological affinity, most probably with planktonic life style. The utility of chitinozoans in stratigraphy are enhanced by their rapid evolution, wide diversity and short vertical ranges of many species.

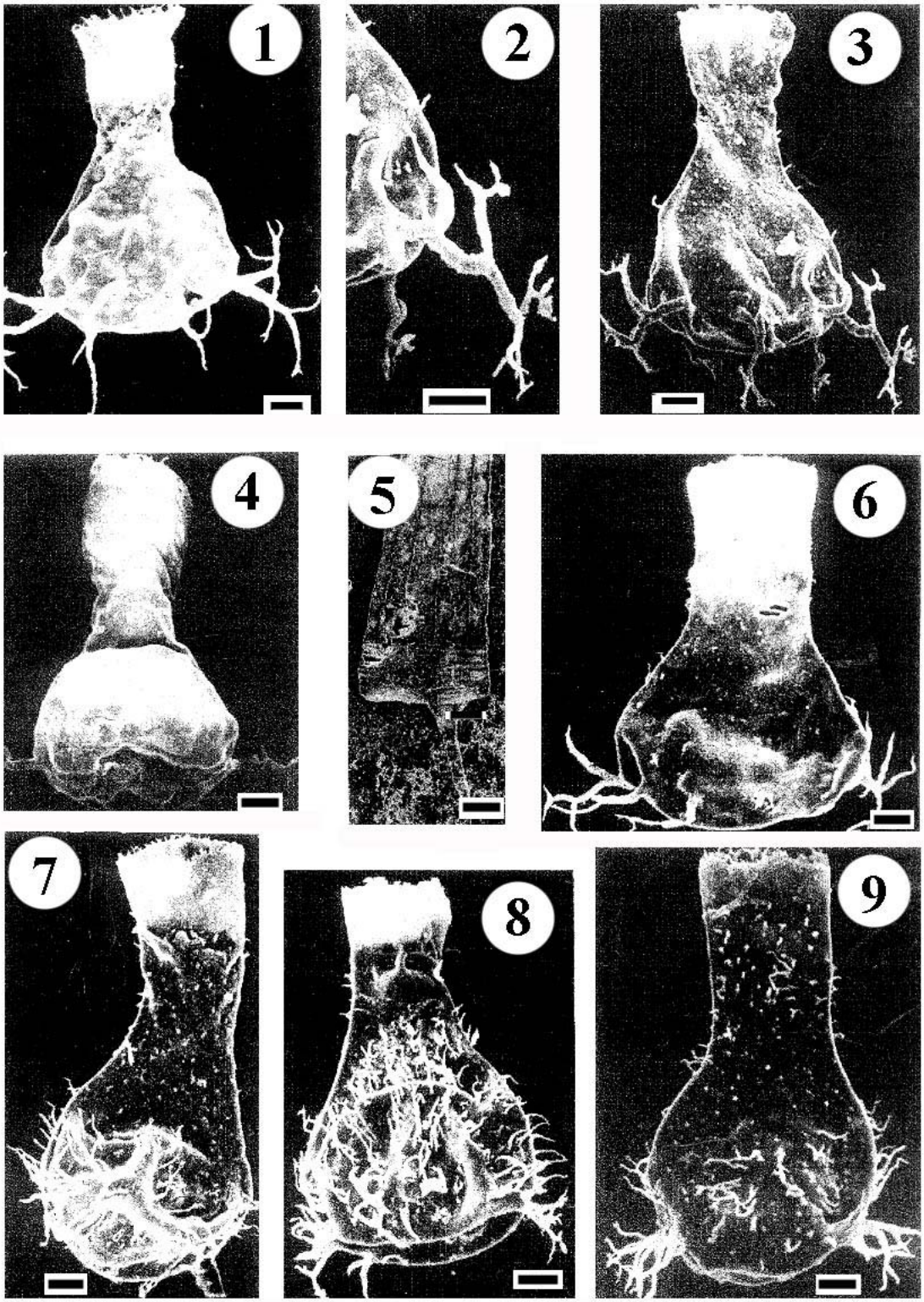

Plate 6- All chitinozoan taxa from the Niur Formation of northeastern Alborz Range, southern Caspian Sea. Fig. 1. *Ancyrochitina niurensis* nov. sp. (260m-500m) × 600. Fig. 2. Enlargement of Fig. 3, × 1100. Fig. 3. *Ancyrochitina ramo-saspina* (Nestor 1994), 139m-220m, × 700. Fig. 4. *Ancyrochitina bifurcaspina* (Nestor 1994), 0m-139m, × 700. Fig. 5. Chitinous graptolite remains. × 270. Fig. 6. *Ancyrochitina silurica* nov. sp., (260m-500m) × 700. Fig. 7. *Angochitina pelmisensis* nov. sp., (148m-500m) × 700. Fig. 8. *Ancyrochitina bojnourdensis* nov. sp. (148m-500m) × 750. Fig. 9. *Ancyrochitina laevaensis* (Nestor 1980), 0m-139m, × 700. Scale bar = 10 µm.

This group of organisms is found not only in sedimentary rocks, but also in greenschists which are a metamorphic facies (Verniers & Grootel 1991). For Silurian period, several chitinozoan biozonal schemes demonstrate a comparable or greater resolution over large areas than traditional graptolite or conodont biozonation (Verniers *et al.* 1995).

The chitinozoan biozonation has been proposed not only for local (national) levels but also for global schemes (Verniers *et al.* 1995, Paris 1995, Laufeld, 1974, Cramer 1967). Therefore, this paper aims to demonstrate utility of chitinozoan biozonation for the Niur Formation. Seventy-six surface samples from this formation were treated and investigated for chitinozoan species. All samples contain well-preserved and abundant palynomorphs (acritarchs, chitinozoans, cryptospores, scolecodont and chitinous graptolite remains). The relative frequency of each group and chitinozoan species have shown on figures of 2-7. A total of 32 chitinozoan species were identified from the uppermost part of Ghelli Formation and the whole Niur Formation. These have been arranged in four local biozones (Fig. 8), which are discussed in below.

Ancyrochitina merga biozone

This biozone is defined by total range of *Ancyrochitina merga* and *Ancyrochitina persica* that they extend through a thickness of 20 m. at the uppermost part of Ghelli Formation (Fig. 8). This part of Ghelli Formation consists mainly of silty shales. Likewise, the species of *Plectochitina spongiosa* appears in this biozone and it continues into the succeeding biozone. This biozone is restricted to uppermost part of Ghelli Formation which have already discussed in chitinozoan biozonation of this formation (Ghavidel-syooki & Winchester-seeto 2002). Paris (1990) and Paris *et al.* (2000) have shown the *Ancyrochitina merga* biozone from North Gondwana Domain, suggesting the Middle Ashgillian age. This biozone has been established in the Late Ordovician of Seyahou Formation, in southern Iran (Ghavidel-syooki 2000), indicating a good chronostratigraphic correlation between the Alborz Mountain Ranges and Zagros Mountain Ranges, respectively, in northern and southern Iran.

Ancyrochitina laevaensis biozone

This chitinozoan biozone occurs in the basal part of Niur Formation and includes a thickness of 79 m, which mainly consists of black-olive grey shales (Fig. 8). This biozone corresponds to the total range of *Ancyrochitina laevaensis* Nestor (1980, 1994) with Early Llandovery age. Other chitinozoan species of this biozone are *Ancyrochitina bifurcaspina, Ancyrochitina ancyrea* and *Plectochitina spongiosa* that they are associated with a great number of chitinous graptolite remains. Among these accompanied species, *Ancyrochitina bifurcaspina* is restricted to this biozone and so far, it has been recorded from the uppermost part of the Ohne Formation of Juuru stage and the Slitere Member of Raikkula stage in Estonia (Nestor 1980, 1994). The species of *Plectochitina spongiosa* has been recorded from the sedimentary strata of Juuru and Raikkula stages in Estonia (Nestor 1994). The Llandovery material of Canada (Achab 1977) and Libya (Paris 1995). The species of *Ancyrochitina ancyrea* is a long-ranging form (Ordovician up to Late Silurian). Based on chitinozoan biozonations of Ghelli and Niur formations and comparison with those of North Gondwana Domain (Al-Hajri 1995, Paris 1990, Oulebsir & Paris 1995), the chitinozoan biozone of *Tanuchitina elongata* is absent in the study area. Therefore, there is a minor hiatus between the Ghelli and Niur formations. This hiatus encompasses the Late Ashgillian strata.

Ancyrochitina ramosaspina/*Angochitina* aff. *longicollis* conccurent biozone

This chitinozoan biozone is defined in the middle part of Member I of Niur Formation and it extends through a thickness of 368.5 m. (Fig . 8). This part of the Niur Formation consists mainly of black-olive grey shales and subordinate fossiliferous limestones. This biozone correspond to total range of *Ancyrochitina ramosaspina*,or *Angochitina aff. longicollis.* This part of Niur Formation contains high diversity of chitinozoan taxa rather than other parts of this formation. Other chitinozoan species of this biozone consist of *Conochitina edjelensis, Cyathochitina campanulaeformis, Ramochitina martinssonii, Ancyrochitina bojnourdensis, A. caspiensis, A. pelmisensis, A. silurica, A. heterospinosa, A. alborzensis, A. niurensis, A. longifilosa, A. fatemae, A. angelinae, A. nestorae, A. concava, Angochitina kalatensis, Angochitina minor* and *Angochitina*

multipodspina. Among the chitinozoans of this biozone, the species of *Ancyrochitina ramosaspina* has been recorded from Slitere, Kolka and Ilka members of Saarde Formation, which ranges from upper Juuru stage to the Raikkula stage in Estonia (Nestor 1994). *Angochitina aff. longicollis* (probably synonym with *Angochitina longicollis*) with *Ramochitina martinssonii, Conochitina edjelensis* and *Cyathochitina campanulaeformis* have the same distribution of *Ancyrochitina ramosaspina* in the Niur Formation. So far, *Angochitina longicollis* has been recorded from Gotland and Central Sweden from Middle-Upper Llandovery as well as *Cono-chitina edjelensis*. Likewise, *Cyathochitina cam-panulaeformis* appears abundantly in the middle and rarely in upper parts of Niur Formation. This species ranges from Late Ordovician-Early Silurian. The species of *Ramochitina martinssonii* is another long-ranging species which has been recorded from Middle-Upper Llandovery of Sweden (Laufeld 1974, 1977) and Middle-Late Silurian of Estonia (Nestor 1994). Therefore, based on stratigraphic potential of *Ancyrochitina ramosaspina* and *Angochitina aff. longicollis* (= *Angochitina longicollis*) the Late Rhuddanian-Late Aeronian is assigned to the middle part of Member I of Niur Formation.

Plectochitina saharica/*Plectochitina pseudoagglutinans* concurrent biozone

This chitinozoan biozone is defined in the upper part of Member I of the Niur Formation and it extends through a thickness of 52.5 m. This biozone is characterized by appearance and disappearance of *Plectochitina saharica, Plectochitina pseudoagglutinans*, *Plectochitina nodifera, Plectochitina aff. ralphi* and *Conochitina armillata*. So far, the chitinozoan species of *Plectochitina saharica, Plectochitina pseudoagglutinans*, *Plectochitina nodifera, Plectochitina* aff. *ralphi* and *Conochitina armillata* have been recorded from the Middle-Late Llandovery strata in Algerian Sahara (Taugourdeau & de Jekhowsky 1960), Libya (Paris 1985), Saudi Arabia (Paris *et al.* 1995), Southern Iran (Ghavidel-syooki 2000), northwestern Spain (Cramer 1967), Llandovery subsurface material of Florida (Cramer 1973) and Estonia (Nestor 1980, 1994).

However, it should be mentioned that species of *Plectochitina nodifera* has been recorded from Ohne and Staciunai formations which have Early Llandovery age, but it is found only the upper part of Member I of Niur Formation.

Conclusions

From investigation of surface samples of Niur Formation in northeastern Alborz Mountain Range of Iran, the following conclusions can be derived:

1) Based on stratigraphic distribution of chitinozoan taxa, the Member I of Niur Formation is assigned to the Early-Late Llandovery (Rhuddanian-Telychian). Therefore, this part of Niur Formation is equivalent to the Sarchahan Formation in Zagros basin, southern Iran.

2) There is a minor hiatus between Ghelli and Niur formations, encompassing the Late Ashgillian strata.

3) Except for new chitinozoan species, the remainders have broad similarity with North Gondwana Domain. Since *Plectochitina pseudoagglutinans, Plectochitina saharica, Conochitina edjelensis Conochitina armillata* and *Plectochitina nodifera* have been so far recorded from North Africa (Paris 1985, Taugourdeau & de Jekhowsky 1960), northwestern Spain (Cramer 1967, Priewalder 1977).

4) Saudi Arabia (Paris *et al.* 1995), and southern Iran (Ghavidel-syooki 2000). This similarity indicates that the Alborz Mountain Ranges has been part of North Gondwana Domain during the Silurian period.

5) Member II of Niur Formation lacks of chitinozoans, but it contains some cryptospores in same horizones. Based on cryptospore taxa, this part of Niur Formation is assigned to Middle Silurian.

6) Therefore, there is a hiatus between the Niur and Padeha formations in northeastern Alborz Range. This hiatus encompasses the Late Silurian and Early-Middle Devonian, possibly corresponding to Caledonian Orogeny.

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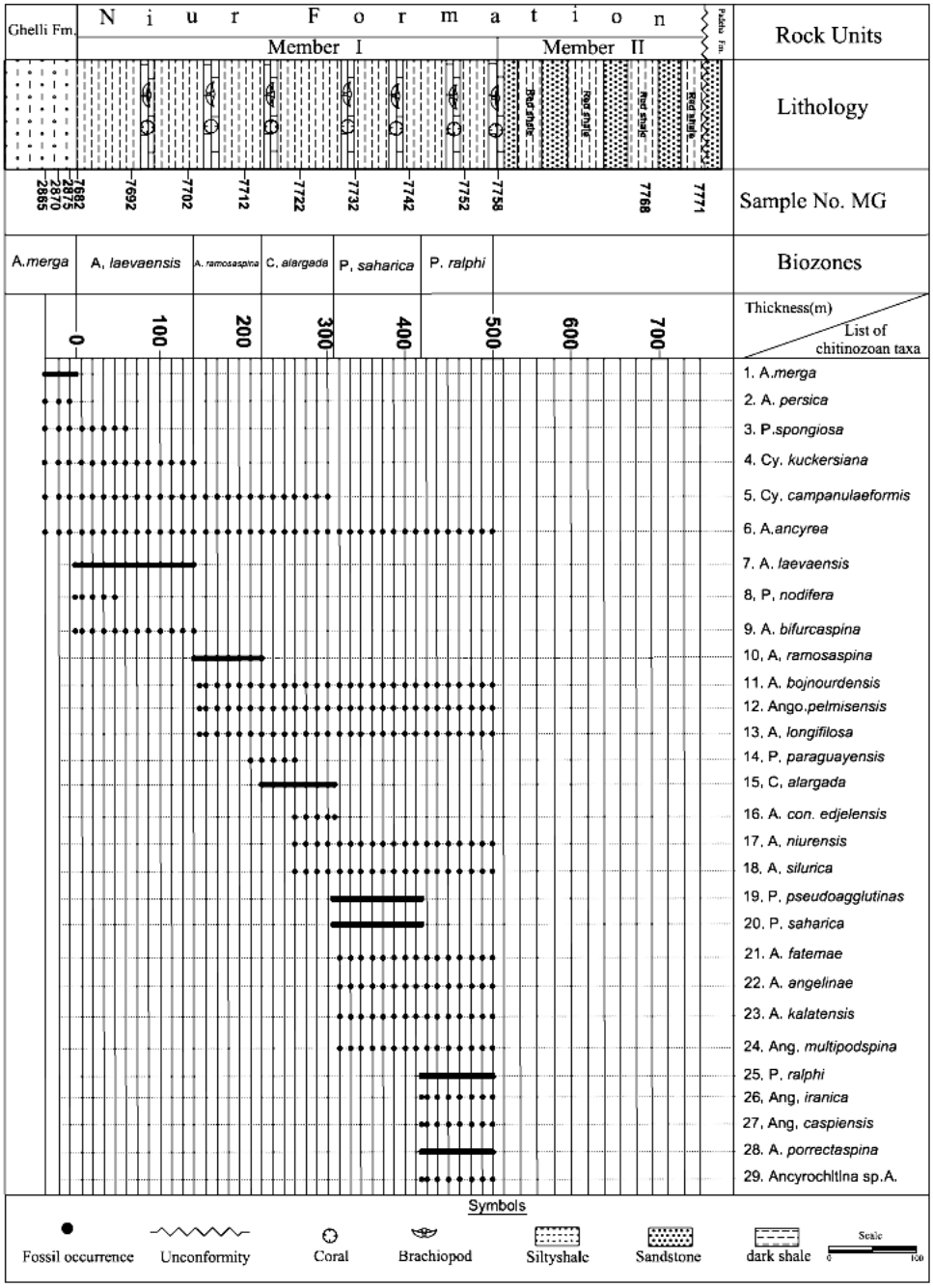

Figure 2- Stratigraphical distribution of selected chitinozoan taxa in the Niur and Ghelli formations.

References

Achab A. 1977: Les chitinozoaires de la zone a Climagraptus prominens-elongatus, de la Formation de Vaureal, Ordovicien superieur, Ile d'Anticosti, Quebec. *Can. J. Earth Sci*. **14:** 2193

Achab A., Bertrand R., Van Grootel G. 1992: Chitinozoan contribution to the Ordovician and lower Silurian. *J. Geol.* **100:** 621-629.

Afshar-harb A. 1979: The stratigraphy, tectonic and petrolium geology of Kopet-Dagh region, northern Iran. Ph.D. Thesis. Petroleum Geology Collections of School of Mine, Imperial College, London.

Al-Hajri S. 1995: Biostratigraphy of Ordovician chitinozoa of northwestern Saudi Arabia. *Rev. Palaeobot. Palynol.* **89(1/2):** 27-48

Cramer F.H. 1967: Chitinozoans of composite collections of upper Llandovery to basal Gedinnian sediments in northern Leon, Spain. A preliminary report. *Bull. Soc. Belg. Geol*. **75:** 69-129.

Cramer F.H. 1973: Middle and Upper Silurian succession in Florida subsurface. *J. Paleontology* **47(2):** 279-288.

Dufka P. 1992: Lower Silurian chitinozoans of Prague Basin (Barrandian-Czecoslovakian) preliminary results. *Rev. Micropalaeontol*. **34(1):** 1-10.

Eisenack A. 1931: Neue Mikrofossilien des baltischen Silures, *I. Palaontol*. **13:** 74-118.

Eisenack A. 1959a: Chitinozoen, Hystrichospharen und andere Microfossilien aus dem Silur des Baltikums und dem Devon der Eifel. *Senck. Leth*. **36:** 311-319.

Eisenack A. 1959b: Neotype baltischer Silur Chitinozoen und Arten. *N. Jb. Geol. Pal. Abh*. **108:** 1-20.

Eisenack A. 1962: Neotype baltischer Silur-Chitinozoen und neue Arten. *N. Jb. Geol. Pal. Abh*. **114:** 219-316.

Eisenack A. 1968: Über Chitinozoen des baltischen Gebietes. *Palaeontographica* **131 Abt. A:** 137-198.

Eisenack A. 1972: Chitinozoen und andere microfossilien aus der Bohrung Leba, Pommern. *Palaeontographica* **139 Abt. A.:** 64-87.

Ghavidel-syooki M. 2000: Biostratigraphy and palaeobiogeography of Late Ordovician and Early Silurian chitinozoans from Zagros Basin, southern Iran. *Hist. boil.* **15:** 29-39.

Ghavidel-syooki M. 2000: Palynostratigraphy and palaeobiogeography of Lower Palaeozoic strata in northeastern Alborz Range (Kopet-Dagh region). *J. Sci. I.R. Iran* **11(4):** 305-318.

Ghavidel-syooki M., Winchester-seeto T. 2002: Biostratigraphy and palaeobiogeography of Late Ordovician strata of northeastern Alborz Range Iran. *Rev. Palaeobot. Palynol.* 118(1-4): 77-99.

Grahn Y. 1995: Lower Silurian chitinozoan and biostratigraphy of subsurface Gotland. *GFF* **117:** 57-65.

Grahn Y., Bergamaschi S. 2000: Silurian and Lower Devonian chitinozoan biostratigraphy of the Parana Basin in Brazil and Paraguay. *Palynology* **24:** 147-176.

Jenkins W.A.M. 1970: Chitinozoan from the Ordovician Sylvan Shale of Arbuckle Mountains Oklahoma. *Palaeontology* **13(2):** 261-288.

Laufeld S. 1974: Silurian chitinozoa from Gotland. *Fossils Strata* **5:** 1-130.

Nestor V. 1980: Middle Llandoverian chitinozoans from Estonia. *Eesti NSV Tread.* Akad. *Toim. Koide Geol.* **29(4):** 136-142.

Nestor V. 1994: Early Silurian chitinozoans of Estonia and north Latvia. *Academia* **4:** 1-163.

Oulebsir L. Paris F. 1995: Chitinozoens ordoviciens du Sahara Algerien: biostratigraphie et affinites paleogeographiques. *Rev. Palaeobot. Palynol.* **86(1/2):** 49-68.

Paris F. 1981: Les chitinozoaires dans le palaeozoique, du sud-ouest de Í Europe (Cadre geologique-Etude systematic biostratigraphie). *Mem. Soc. Geol. Mineral. Bretagne* **26:** 1-412.

Paris F., Al-Hajri S. 1995: New chitinozoan species from the Llandovery of Saudi Arabia. *Revue de micropaleontologie* **38(4):** 311-328.

Paris F., Verniers J. Al-Hajri S., Al-Tayyar H. 1995: Biostratigraphy and palaeogeographic affinities of Early Silurian chitinozoans from central Saudi Arabia. *Rev. Palaeobot. Palynol*. **89(1-2):** 75-90.

Paris F., Grahn Y., Nestor V., Lakova I. 1999: Correlation of Ordovician regional chitinozoan biozonation. *Acta Universitatis Carolinae-Geologica* **43:** 291-294.

Priewalder H., 1997. SEM-Revision of a chitinozoan assemblage from the uppermost San Pedro Formation (Pridoli) Cantabrian Mountain (Spain). *Jb. Geol. B-A.* **140:**73-93.

Richards R.B., Wright A.J., Hamedi A.M. 2000. Late Ordovician and Early Silurian graptolites from southern Iran. *Records of the Western Australian Museum*, Supplement No. **58:** 103-122.

Taugourdeau P., 1962. Association de chitinozoaires dans quelques Sondages de la region d' Edjelé (Sahara). *Rev. Micropaleotol.* **4(4)**: 229-236.

Taugourdeau P., 1963. Etude de quelques especes critiques de chitinozoaires de la Edjelé et complements a la faune locale. *Rev. Micropaleotol.* **6(3):** 130-144.

Taugourdeau P., de Jekhowsky B., 1960. Repartition et description des chitinozoaires Siluro-Dévoniéns de quelques Sondages de la C.R.E.P.S. de la C.F.P.A. et de la S.N. Repal. au Sahara. *Rev. Inst. Fr. Pet.* **15(9):** 1199-1260.

Taugourdeau P., Bouché P., Combaz A., Magloire L., Millepied P. 1967. Microfossiles organiques du palaeozoique (chitinozoaires). Center National de le Recherche Scientifique. Paris, pp. 1-96

Verniers J., Nestor V., Paris F., Dufka P., Sutherland S.J.E., Van Grootel G. 1995. A global chitinozoan biozonation for the Silurian. *Geol. Mag.* **132(6):** 651-666.

Wood G., Miller M.A. 1991. Distinctive Silurian chitinozoans from Itacurubi Group (Vargas Pena Shale) Chaco Basin Paraguay. *Palynology* **15:** 181-192.