Iranian Int. J. Sci. ***2****(2) 2001*

Palynostratigraphy and Palaeobiogeography of a Lower Palaeozoic Sequence in the Type-Section of Shirgesht Formation, Northern Tabas City, East-Central Iran

Hussein Mehrjerdi
Central office of Jahad-E- Daneshgahi, Opposite of Tehran University
P.O.Box, 14155-4364, Tehran, I.R.Iran.
(received: 20/2/2001 ; accepted:12/6/2001)

Abstract

This study was carried out to the southern part of the Derenjal mountains, some ten kilometers north of Shirgesht village in East-Central Iran. Stratigraphy of Derenjal, Shirgesht and Niur localities indicate some Lower Palaeozoic rock units in these areas. Among the above-mentioned rock units, the uppermost part of Derenjal Formation, Shirgesht Formation and Niur Formation were studied from palynological point of view. For this purpose the upper part of the Derenjal, Shirgesht and Niur formations were systematically measured and sampled.

Based on appearance and disappearance of the identified palynomorph taxa, six acritarch biozones were established. Biozone-I appears in the uppermost part of the Derenjal Formation and lowermost Shirgesht Formation, and suggests the uppermost Cambrian to lowermost Tremadocian age.Biozones II through V occur in the Shirgesht Formation, representing the Tremadocian to Llanvirnian age. Biozone VI appears in the Niur Formation and suggests an early Silurian age for this Formation.

Therefore, there is a major "hiatus" within the Lower Palaeozoic sequence in the studied area. This appears between the Shirgesht and Niur formations and includes the upper Ordovician strata. This hiatus possibly corresponds to the Caledonian Orogeny.

In this study a palynological zonation has been established and compared with those of the other parts of the world. The comparison reveals that East-Central Iran has been a part of the Mediterranean acritarch province during the Early/Middle Ordovician age.

Keywords*: Lower Palaeozoic; East-Central Iran; Palynostratigraphy; Acritarchs.*

Introduction

The studied section which is called Shirgesht, is located in the eastern part of the Central Iran; at both side of the Dahaneh Kolut Valley in the Southern part of the Derenjal mountains (10 kilometers North of Shirgesht) north Tabas city (Fig.1). The approximative coordinates of stratigraphic section are: long. 56° 47?Q56° 48?Q at. 34° 05?Q34° 06?Q

The upper part of the Mila Group in East Iran (Cambrian- Ordovician sequence) was named Shirgesht Formation. The group then was divided into the Kalshaneh, Derenjal, and Shirgesht formations by A.Ruttner, M.H.Nabavi, and J.Hajian (1968).

The Shirgesht Formation has a very distinctive sedimentary facies which is easily separable from underlying and overlying formations. The Formation rests conformably on the Derenjal Formation. The boundary of these formations is marked by “Billingsella Limestone” a brown- red, sandy, brachiopod- bearing calcareous bed in the Derenjal Mountains, at the Shirgesht type-section. The Shirgesht Formation mainly consists of olive-grey shale and sandstone with some interbedded limestone. The Niur Formation comprises alternation of shale and limestones intruded by igneous rocks in some horizones. The contact between the Shirgesht and Niur formations is disturbed by basic igneous intrusions, but it can be inferred from adjacent sections to be conformable (Stocklin, J., 1977).

The field work was carried out in 1995 and the stratigraphic column was measured and sampled at the type locality which is called Dahaneh Kolut by Author and Dr. M. Ghavidel – Syooki.

Previous Studies

The Shirgesht area has been visited and studied from stratigraphical point of view by A.Ruttner et al. (1968).

Preliminary determinations of bryozoans by N.Spjeldnas and of a few brachiopods, gastropods, cephalopods and trilobites by T.S.Winsnes, all done on material obtained from the middle part of the Formation in its general type area (Derenjal Mountains), have resulted in the following list :

Dekayella sp., Hallopora sp., Nicholosonella sp., Ceramoporella sp., Anolotichia aff. rombica, Stictoporella sp., Strombopora sp., Escharopora sp., Nicolella sp., Dalmanella sp., Plectambonites? sp., Ophileta? sp., Michelinoceras sp., Endoceras sp., Megala spides sp.,

Illaenus cf. centaurus, Symphysurus sp., Hystricurus sp., Ningkiangolithes cf. welleri, and *Marrolitus? Sp.,* This assemblage indicates Middle Ordovician, Possibly including late Early Ordovician. From the stratigraphic position, an Early Ordovician age is inferred for the lower part of the Formation, from which no determinable fossils have been obtained.

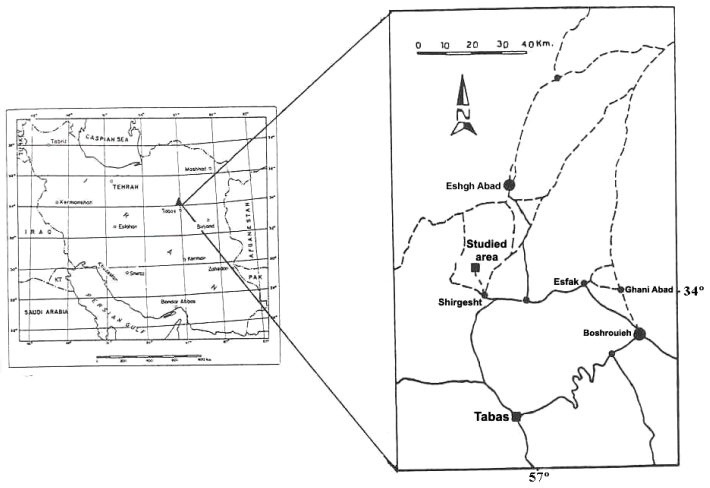

Figure 1. Location map of the studied area.

Palynological Laboratory Techniques

A total of 99 samples from the Lower Palaeozoic sequence of the Shirgesht area, were selected for palynological study. Thirty gram of sediments were randomly selected from each sample and processed in the palynology laboratory of the Exploration and Production Department of the National Iranian Oil Company.

The samples were treated by standard techniques, using hydrochloric, hydroflouric and nitric acids. About 30 ml of saturated Zinc Bromide ($ZnBr_2 + H_2O$) solution with specific gravity 1.95, was added to the residues in order to seperate the organic residues from inorganic materials. Then three non-oxided slides from each sample were prepared for determination palynomorph taxa. The rest of

residues were treated by Schultrz's solution and two further slides were prepared for photography.

A Leitz Orthoplan microscope in the palynological laboratory of the National Iranian Oil Company was used for all observations and photographies. The developing and printing process was carried out using existing facilities at the laboratory of the National Iranian Oil Company. The identification of various palynomorphs was accomplished by using those methods described and illustrated in the most available literature. All slides are stored in the palaeontology collections of the Exploration and Production Division of the National Iranian Oil Company.

Biostratigraphical Palynology

Microscopic studies of the samples yielded a total of 62 palynomorph species belonging to 23 acritarch genera and one genus of Chitinozoa. The palynomorphs were mostly restricted to shale layers, and in some extent to the limestone beds. On the basis of first appearance and final extinction of palynomorph taxa six biozones were established. These are plotted on Figure 2.

Acritarch Assemblage Zone *I*

This zone extends from the upper part of the Derenjal Formation through the basal part of the Shirgesht Formation (72m from Derenjal Formation and 28m from Shirgesht Formation). Acritarch assemblage zone I is characterised by the appearance and disappearance palynomorph taxa, such as: *Cristallinium cambriense, Dactylofusa squama, Leiofusa fusiformis, Timofeevia lancarae;* and appearance of other acritarch taxa consisting of: *Cristallinium ovillense, Leiofusa simplex, Leiosphaeridia sp., Lophosphaeridium sp., Saharidia downiei, Saharidia fragile, and Tasmanites sp.*

Based on biostratigraphic value of the above-mentioned palynomorph taxa, the uppermost Cambrian and lowermost Tremadocian is assigned to this thickness of Derenjal and Shirgesht fromations, suggesting a transitional zone. The acritarch taxa of this zone have been recorded from strata of this age from Iran (Ghavidel-Syooki, 1994, 1995), England (Downie, 1981), Belgium

(Vanguestaine, 1978), Ireland (Gardiner & Vanguestaine, 1971), Spain (Cramer & Diez, 1972; Fombella, 1982,1987), Canada (Martin & Dean, 1988), France (Martin, 1973; Cocchio, 1982), Algeria (Combaz, 1966,1967; Jardine et al.,1974), Norway (Welsch, 1986), and Turkey (Erkmen and Bozdogan, 1981). In terms of relative frequency, the genera of *Timofeevia* and *Cristallinium* are abundant (13.5%-12%) whereas the *Lophosphaeridium* and *Cymatiogalea* are rare (1%-0.9%).

Acritarch Assemblage Zone II

The biozone II occurs in the Shirgesht Formation and includes a thickness of 125 meters. The studied samples of this zone contain many acritarch taxa, consisting of: *Acanthodiacrodium angustum, Acanthodiacrodium echinatum, Acanthodiacrodium serotimum, Acanthodiacrodium simplex, Acanthodiacrodium spinum, Acanthodiacrodium ubui, Acanthodiacrodium unigerminum, Cymatiogalea cuvillieri, Cymatiogalea diversita, Goniosphaeridium dentatum, Goniosphaeridium tuberatum, Goniosphaeridium sufflatum, Pirea fausta, Stelliferidium cortinulum, Stelliferidium furcatum, Stelliferidium gautieri, Stelliferidium simplex, Veryhachium trispinosum,* and *Vulcanisphaera imparilis.*

This zone is marked by the appearance and disappearance of some acritarch species such as: *Acanthodiacrodium complanatum, Acanthodiacrodium rectinerve, Acanthodiacrodium zonaconstrictum, Annulum squamaceum,* and *Vulcanisphaera britannica.*

In addition to the foregoing acritarch species, this biozone contain, a few acritarch taxa from assmblage zone I.The dominant genera in this assemblage zone are: *Acanthodiacrodium, Cymatiogalea, Pirea, Priscogalea,* and *Vulcanisphaera.*Based on the presence of these index taxa, this zone is considered to be the Early Tremadocian in age.

This assemblage zone is quite similar to those recorded from Lower Ordovician strata in Ilebeck and Zard Kuh formations in the Zagros Mountain Ranges (Ghavidel-Syooki, 1991, 1993).The acritarch species of this biozone have also been recorded from the Early Tremadocian in Norway (Welsch, 1986), Morocco (Elaouad-Debbaj, 1988 ; Fournier – Vinas, 1985), Algeria Sahara (Denuff, 1961,1964; Baudelot& Gery, 1979), Combaz, 1967; Jardine et al., 1974), Bohemia

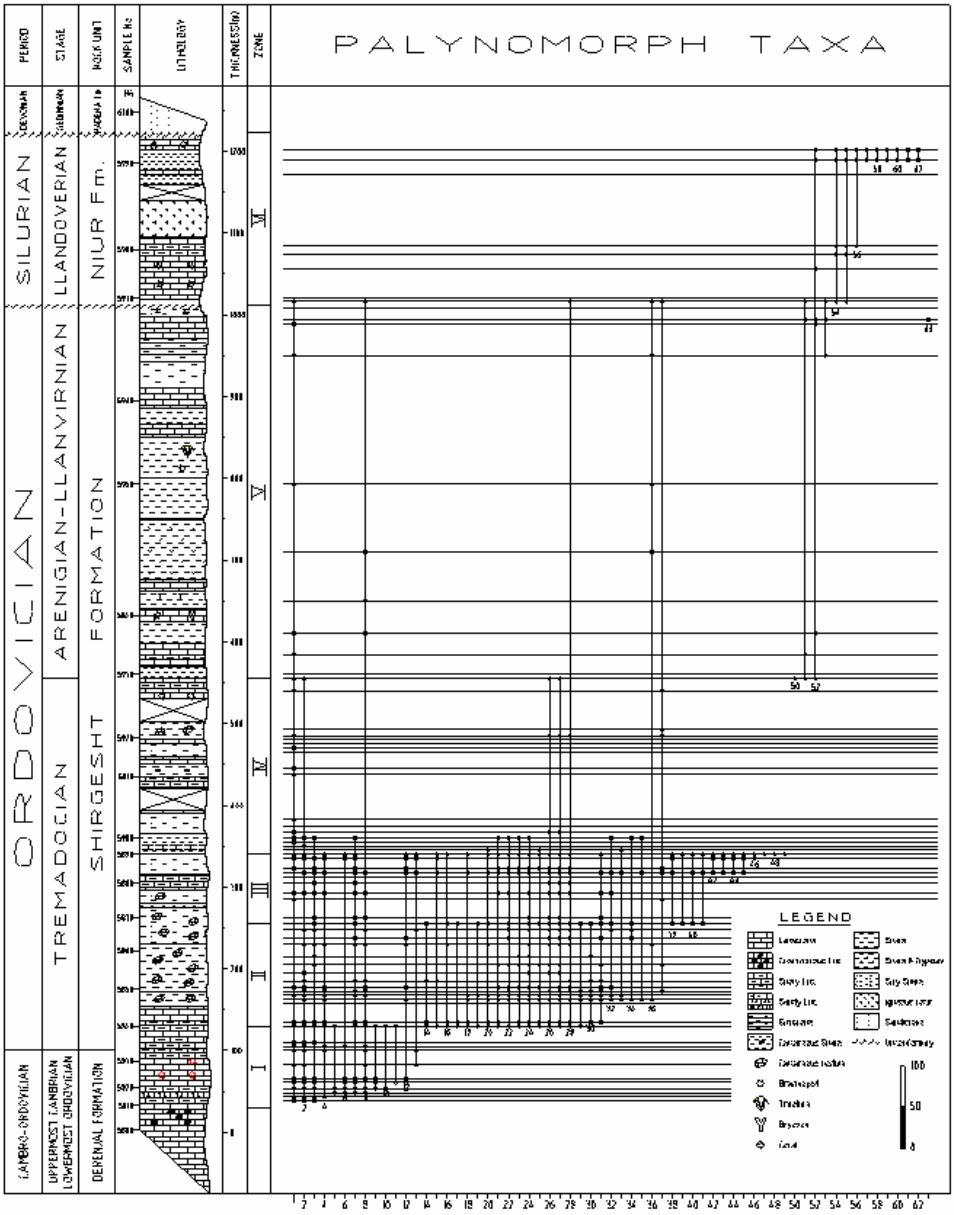

Fig. 2. Stratigraphic distribution of palynomorph Taxa throughout Lower Palaeozoic Sequence (Derenjal, Shirgesht and Niur formations) at the Shirgesht area, East-Central Iran.

List of recorded taxa (numbers refer to the corresponding columns on Fig.2):

1. Algal claster,
2.Leiosphaeridia sp. ;
3. Saharidia downiei ;
4. Tasmanites sp.;
5. Cristallinium cambriense;
6. Cristallinium ovillense;
7. Saharidia fragile;
8. Lophosphaeridium sp.;
9. Timofeevia lancarae;
10. Leiofusa fusiformis;
11. Dactylofusa squama;
12. Leiofusa simplex;
13. Cymatiogalea sp.;
14. Annulum squamaceum;
15. Goniosphaeridium sufflatum;
16. Acanthodiacrodium angustum;
17. Acanthodiacrodium rectinerve;
18.Cymatiogalea diversita;
19.Acanthodiacrodium zonaconstrictum;
20.Acanthodiacrodium ubui;
21.Acanthodiacrodium spinum;
22. Acanthodiacrodium unigerminum;
23. Goniosphaeridium tuberatum;
24. Goniosphaeridium dentatum;
25. Acanthodiacrodium simplex;
26. Acanthodiacrodium echinatum;
27. Cymatiogalea cuvillieri;
28. Stelliferidium simplex;
29. Vulcarisphaera britannica;
30. Acanthodiacrodium complanatum;
31. Stelliferium cortinulum;
32. Acanthodiacrodium serotimum;
33. Vulcanisphaera imparilis;
34. Stelliferidium gautieri;
35. Stelliferidium furcatum;
36. Veryhachium trispinosum;
37. Pirea fausta;
38. Vulcanisphaera africana;
39. Priscogalea barbara;
40. Stelliferidium cylindratum;
41.Stelliferidium stelligerum;
42. Vulcanisphaera nebulosa;
43. Athabascaella playfordii;
44. Cymatiogalea multarea;
45. Goniosphaeridium splendens;
46. Cymatiogalea elgassiensis;
47. Cymatiogalea cristata;
48. Arbusculidium rammelaerei;
49. Acanthodiacrodium tasselii;
50. Striatotheca triangulata;
51. Veryhachium lairdii;
52.Leiosphaeridia tenuissima;
53.Dactylofusa spinata;
54. Leiosphaeridia laevigata;
55. Dictyotidium sp. ;
56. Dictyotidium perlucidum;
57. Dactylofusa maranhensis;
58.Visbysphaera microspinosa;
59. Visbysphaera pirifera;
60. Visbysphaera oligofurcata;
61. Veryhachium europaeum;
62. Evittia denticulata;
63. Chitinozoa;

(Vavrdova, 1974, 1990), Spain (Fombella, 1986, 1987), Belgium (Martin, 1968; Vanguestaine, 1974, 1991, 1992), England (Downie, 1958, 1984; Rasul, 1976, 1979; Rasul & Downie, 1974; Lister, 1970), Sweden (Bagnoli, Stouge& Tongiorgi, 1988), Libya (Deunff& Massa, 1975), Canada (Dean& Martin, 1982), France (Martin, 1973; Rauscher, 1974), and Germany (Reitz, 1991).

In terms of relative frequencies, in this biozone the genera of *Goniosphaeridium* and *Acanthodiacrodium* are abundant (29%-25%), but the species of *Veryhachium trispinosum* is very rare(0.08%).

Acritarch Assemblage Zone III

This zone comprises 85m of the Shirgesht Formation and it is marked by appearance of various acritarch species to supplement those of zone II, such as: *Athabascaella playfordii, Cymatiogalea elgassiensis, Cymatiogalea multarea, Goniosphaeridium splendens, Priscogalea barbara, Stelliferidium cylindratum, Stelliferidium stelligerum, Vulcanisphaera africana,*and *Vulcanisphaera nebulosa.*

Although many species of biozones I and II extend into this zone, a marked reduction in the number of species is obvious (Fig. 2). According to the stratigraphical potential of the above-mentioned palynomorph species, this zone is considered to be the middle part of the Tremadocian.

The acritarch assemblage zone III is equalent to the assemblage zone II of the Chal-i-Sheh area in southwestern Iran (Ghavidel-Syooki, 1993). The palynomorph species of this zone have been recorded so far from the Middle Tremadocian strata of Algeria Sahara (Denuff 1961; Jardine et al., 1974), England (Rasul, 1974; Rasul & Downie, 1974; Turner,1984; Downie, 1984), Norway (Welsch, 1986), China (Leiming, 1986; Martin& Leiming, 1988), and France (Martin, 1972, 1984).

Among the palynomorphs of this biozone, the acritarch genera of *Goniosphaeridium* and *Stelliferidium* are very abundant (43%-16%), whereas the acritarch species of *Athabascaella playfordii* is very rare (0.22%).

Acritarch Assemblage Zone IV

This zone appears in the middle part of the Shirgesht Formation and extends through a thickness of 215m of this rock unit. The assemblage zone IV is characterized by the appearance of index acritarch taxa, including: *Acanthodiacrodium tasselii, Arbusculidium rammelaerei,* and *Cymatiogalea cristata.*

The encountered palynomorph taxa in this zone suggest a Late Tremadocian age for this part of Shirgesht Formation.Therefore, based on the palynological data of biozones II through IV, the Shirgesht Formation is Lower Ordovician (Tremadocian) in age. In general, this assemblage zone is equalent to the assemblage zone II of the

Lashkarak Formation in the Central Alborz range and zone III of the Ilebeck and Zard Kuh formations in the Zagros Basin (Ghavidel-Syooki, 1990, 1993,1995), and it is similar to those recorded from Norway (Welsch, 1986), Algeria (Combaz, 1967), Belgium (Martin,1968, 1977), Spain (Fombella, 1987), England (Rasul, 1974 ; Deunff et al., 1974; Cooper& Molyneux, 1990;Downie, 1984), France (Rauscher, 1974),Canada (Martin& Dean, 1988), and Germany (Reitz, 1991).

In terms of relative frequencies in assemblage zone IV, the acritarch genera of *Acanthodiacrodium* and *Stelliferidium* are abundant (46.7%-14.6%), and the genera of *Cristallinium* and *Priscogalea* are very rare (0.16%-0.11%).

Acritarch Assemblage Zone V

This zone encompasses the upper portion of the Shirgesht Formation and includes 457m of this rock unit. This biozone is marked by the disappearance of many acritarch taxa of biozones I to IV and appearance of such acritarch taxa as: *Dactylofusa spinata*, *Leiosphaeridia tenuissima*, *Striatotheca triangulata*, and *Veryhachium lairdii*.

The biozone V is equalent to the assemblage zone IV of the Ilebek Formation in the zagros Range (Ghavidel-Syooki, 1991).The acritarch taxa of this zone have been recorded so far from the Arenigian and Middle Ordovician strata, of Morocco (Cramer et al., 1974; Elaoud-Debbaj, 1988; Eisenack et al., 1976), Bohemia (Vavrdova, 1974), China (Li Jun, 1987), England (Turner, 1984), Argentina (Otton et al., 1992),Libya (Molyneux & Paris, 1985), Norway (Smelror, 1987), Russia (Sheshegova, 1975),North of Africa (Richardson& Loannides, 1973), and Algeria (Jardine et al., 1974; Combaz, 1966). Therefore, the Arenigian-Llanvirnian age is suggested for this part of the Shirgesht Formation.

Among the palynomorph taxa of this biozone, the acritarch genera of *Striatotheca* is abundant (15%) and Chitinozoan form is common (5%).

Acritarch Assemblage Zone VI

This zone occurs in the Niur Formation and includes a thickness of 210 meters of this rock unit. This acritarch assemblage is marked by disappearance of Ordovician taxa and appearance of Early Silurian index acritarch species such as: *Dactylofusa maranhensis, Dictyotidium perlucidum, Dictyotidium sp., Evittia denticulata, Leiosphaeridia laevigata, Veryhachium europaeum, Visbysphaera microspinosa, Visbysphaera oligofurcata,* and *Visbysphaera pirifera.* Based on the above-mentioned acritarch species, the Early Silurian (Llandovery) is suggested for this thickness of Niur Formation. The above-mentioned acritarch taxa have been recorded from Llandoverian deposits of Zagros Basin (Ghavidel – Syooki, 1995), Central Iran (Bakhtiari Fard, 1993), America (Cramer, 1971; Cramer& Diez, 1972), Norway (Smelror, 1987), Russia (Sheshegova, 1975), Sweden (Le Herisse, 1989), and England (Lister, 1970).

Among the palynomorph taxa of Niur Formation, the genera of *Visbysphaera* is very abundant (32.5%) and *Lophosphaeridium* is very rare (0.83%).

Discussion

Based on the biostratigraphical potential of the acritarch assemblage zone I through VI, there is a hiatus between the Shirgesht and Niur formations. This hiatus encompasses the upper Ordovician strata in the studied area, possibly equating to the Caledonian Orogeny. On the other hand, based on palynological data of Padeha and Niur formations (A. Bakhtiari Fard, 1993; N.Raphighi Oskouei, 1993), there is a major hiatus between the Niur and Padeha formations. This hiatus includes the Middle/Upper Silurian and Lower/Middle Devonian strata, probably equating to the Hercynian Orogeny.

The known acritarch taxa were counted and their total percentages calculated in all samples. In this study, the relative frequency of acritarch taxa is indicated by quantifiers, such as very rare (<1%), rare (1%-2%), common (3%-5%) and abundant (>5%).

In this study the acritarch species of the Derenjal, Shirgesht and Niur formations were compared with those reported from Alborz and

Zagros Mountain Ranges, Central Iran, Saudi Arabia, China, North Africa, Europe and America.

The comparison showed broad similarly with those of the Alborz, and Zagros Mountain Ranges and Norway, Spain, Belgium, Morocco, Algeria, Saudi Arabia, France, Great Britain, and Czechoslovakia.

The acritarch taxa such as: *Acanthodiacrodium, Arobusculidium, Cymatiogalea, Pirea, Priscogalea, Saharidia, Striatotheca,* and *Vulcanisphaera* have so far been recorded from the "Mediterranean acritarch province". This acritarch province includes North Africa, Southern Europe, China, Saudi Arabia, and southern and northern Iran. Therefore, the occurrence of acritarch species of the Mediterranean province in the Shirgesht Formation, suggests that the East Central Iran has been part of the Mediterranean acritarch province during the Ordovician time, and with the Alborz and Zagros basins formed one continent on the north Gondwana Supercontinent.

Conclusions

The following results can be derived from the palynological study of the lower Palaeozoic sequence of Shirgesht area:

(1) Based on palynological data of the Shirgesht and Niur formations, there is a hiatus within the Palaeozoic sequence of studied area. This hiatus occurs between the Shirgesht and Niur formations and spans the Late Ordovician time, possibly equating to the Caledonian Orogeny.

(2) The occurrence of acitarch species such as: *Acanthodiacrodium complanatum, Acanthodiacrodium serotimum, Acanthodiacrodium simplex, Acanthodiacrodium tasselii, Acanthodiacrodium zonaconstrictum, Arbusculidium rammelaerei, Cymatiogalea diversita, Cymatiogalea elegassiensis, Cymatiogalea multarea, Dactylofusa spinata, Dactylofusa squama, Goniosphaeridium sufflatum, Goniosphaeridium tuberatum, Leiofusa simplex, Pirea fausta, Priscogalea barbara, Saharidia downie, Saharidia fragile, Stelliferidium cylindratum, Stelliferidium gautieri, Striatotheca triangulata, Vulcanisphaera africana, Vulcanisphaera britannica, Vulcanisphaera imparilis,* and *Vulcanisphaera nebulosa;* in the Shirgesht Formation reveals that East Central Iran have been part of

the Mediterranean acritarch province as well as northern part of Gondwana supercontinent.

3) Six biozones were established. Biozone I appears in the uppermost part of Derenjal Formation and lowermost Shirgesht Formation, suggesting Late Cambrian and Early Tremadocian age as a transitional zone. Biozones II through V occur in the Shirgesht Formation, indicating the Tremadocian to Llanvirnian age for this Formation. Biozone VI appears in the Niur Formation, considering the Early Silurian (Llandovery) for this rock unit.

Acknowledgements

The author expresses his sincere appreciation to Dr. M. Ghavidel-Syooki for his constructive criticisms, and supervison of this research and to the management of the National Iranian Oil Company for making this research possible and for generous help during the course of this investigation.

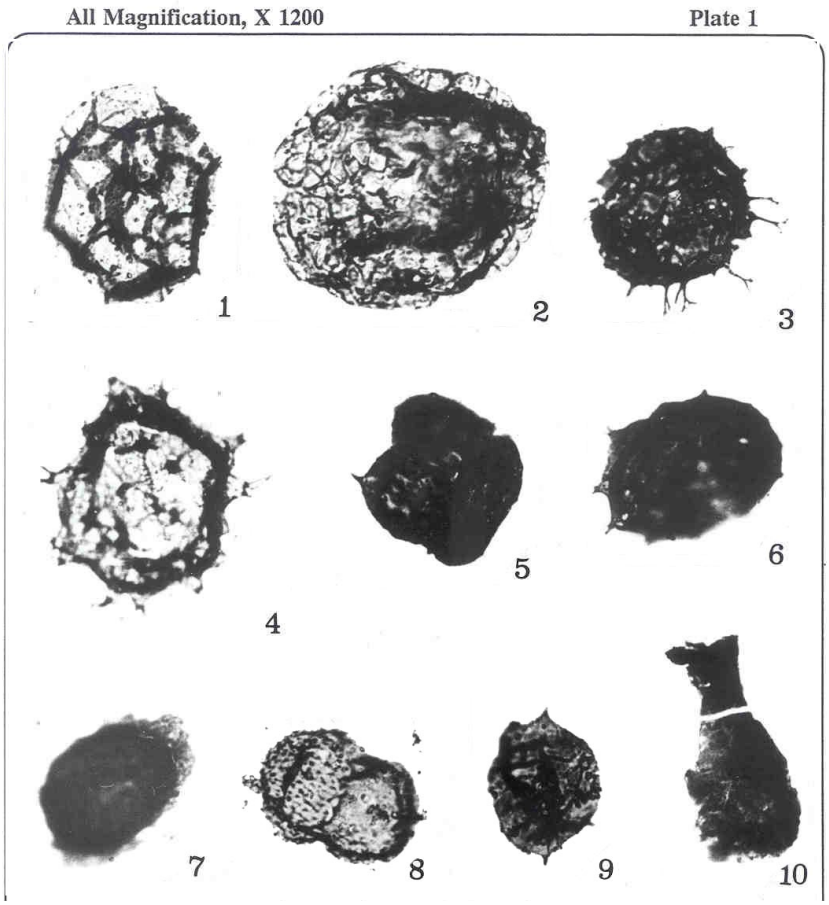

Fig.1. *Cristallinium cambriense* (Slavikova) Vanguestaine, 1978.
Fig.2. *Cristallinium ovillense* (Cramer & Diez) Martin, 1981.
Fig.3. *Cristallinium lancarae (*Cramer & Diez) Vanguestaine, 1978.
Fig.4. *Vulcanisphaera africana* Deunff, 1961.
Fig.5. *Goniosphaeridium sufflatum* Welsch, 1986.
Fig.6. *Vulcanisphaera imparilis* Rasul, 1976.
Fig.7. *Annulum squamaceum* (Volkova) Martin & Dean, 1983.
Fig.8. *Acanthodiacrodium angustum* (Downie) Combaz, 1968.
Fig.9. *Acanthodiacrodium simplex* Combaz, 1967.
Fig.10. *Chitinozoa.*

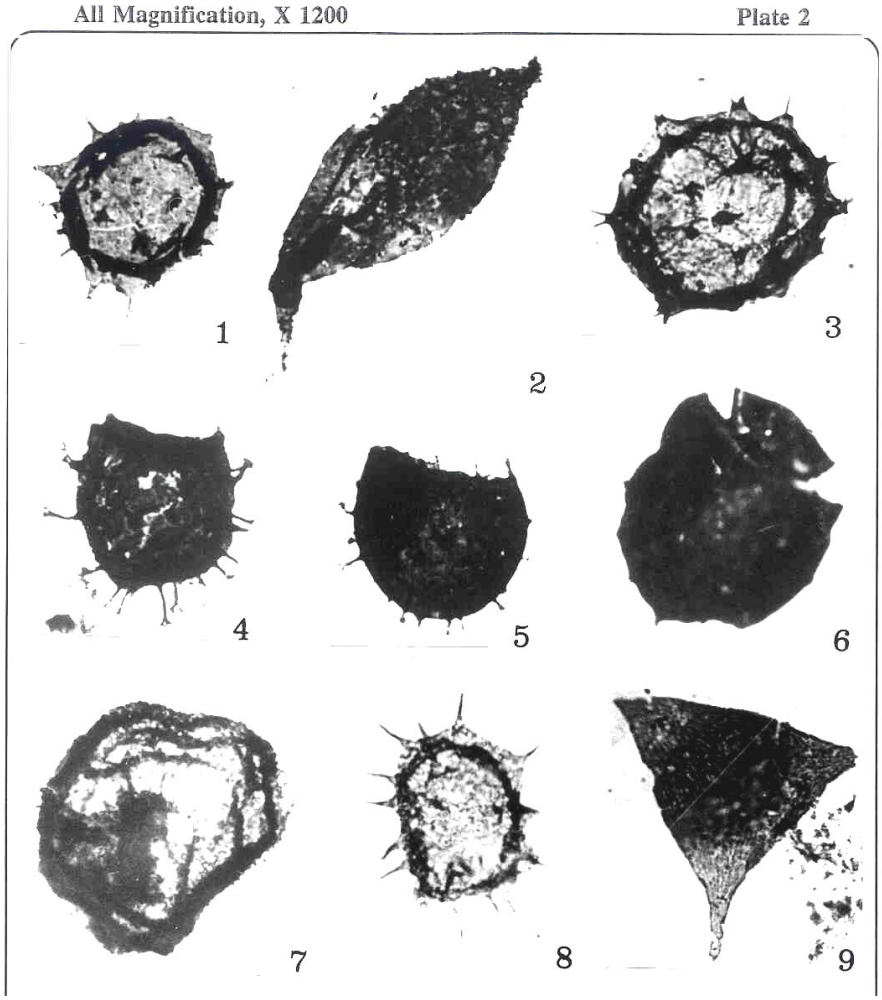

Fig.1. *Vulcanisphaera britannica* Rasul, 1976.
Fig.2. *Dactylofusa squama* (Deunff) Cramer, 1967.
Fig.3. *Vulcanisphaera nebulosa* Deunff, 1961.
Fig.4. *Stelliferidium cylindratum* (Rasul) Elaouad-Debbaj, 1988.
Fig.5. *Cymatiogalea multarea* (Deunff) Eisenack et al., 1973.
Fig.6. *Stelliferidium cortinulum (*Deunff) Gorka, Rauscher, 1947.
Fig.7. *Saharidia downiei* Combaz,1967.
Fig.8. *Acanthodiacrodium complanatum* (Deunff) Vavrdova., 1965.
Fig.9*. Striatotheca triangulata* (Cramer et al.) Eisenack et al., 1976.

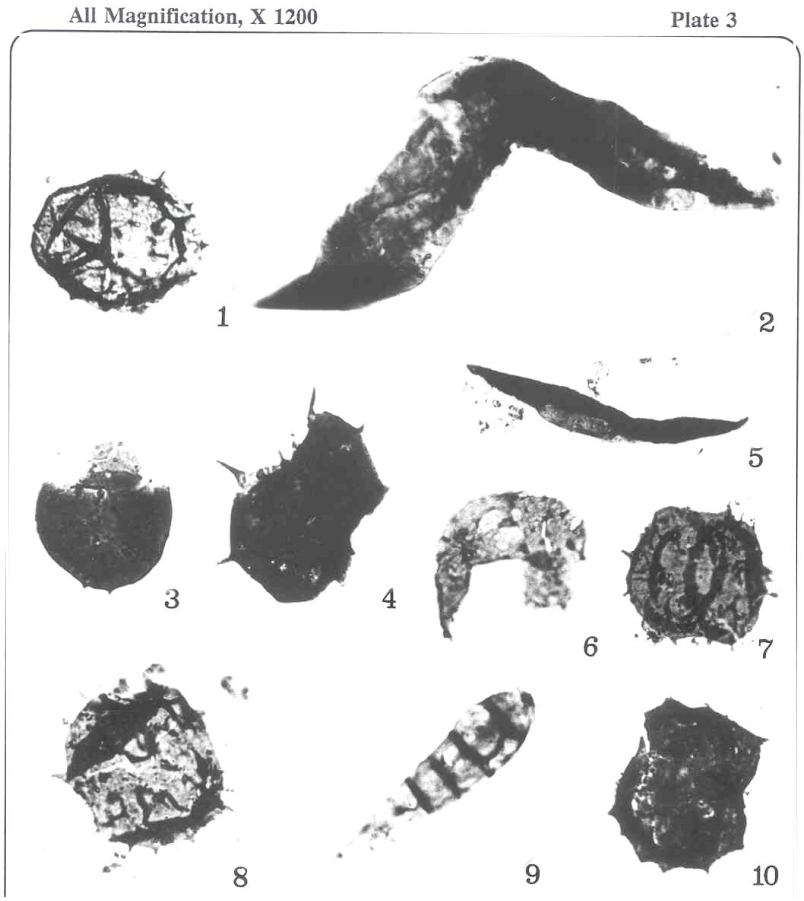

Fig.1. *Stelliferidium stelligerum* (Gorka) Deunff, Rauscher,1947.
Fig.2. *Leiofusa fusiformis* (Eisenack) Eisenack, 1938.
Fig.3. *Cymatiogalea cuvillieri* (Deunff) Deunff, 1964.
Fig.4. *Acanthodiacrodium spinum* Rasul, 1979.
Fig.5. *Leiofusa simplex* (Combaz) Martin, 1975.
Fig.6. *Dactylofusa maranhensis* Brito & Santos, 1965.
Fig.7.*Acanthodiacrodium echinatum* (Timofeev) Downie&Sarjeant, 1965.
Fig.8. *Acanthodiacrodium ubui* Martin, 1968.
Fig.9. *Pirea fausta* Fombella, 1986.
Fig.10.*Acanthodiacrodium unigerminum* (Timofeev) Downie& Sarjeant, 1965.

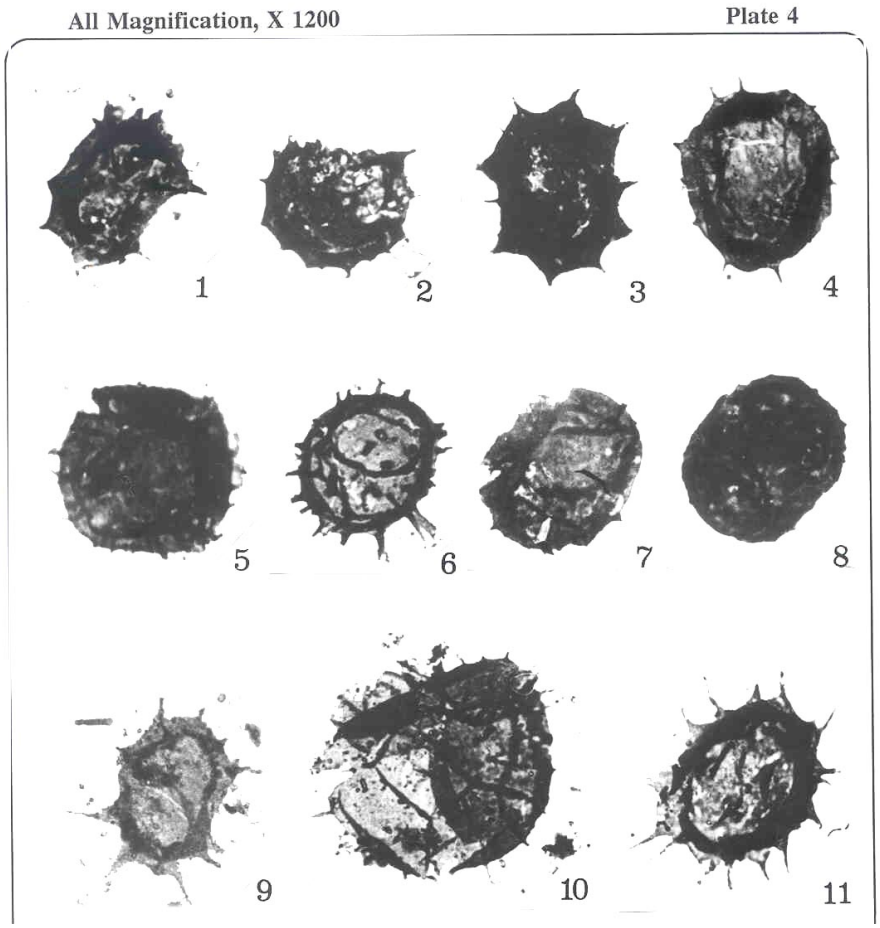

Fig.1. *Arbusculidium rammelaerei* Martin, 1981.
Fig.2. *Cymatiogalea diversita* Deunff, 1961.
Fig.3. *Acanthodiacrodium zonaconstrictum* Welsch, 1986.
Fig.4. *Acanthodiacrodium serotimum* Timofeev, 1959.
Fig.5. *Cymatiogalea elgassiensis* (Deunff) Jardine et al., 1974.
Fig.6. *Stelliferidium cortinulum* (Deunff) Gorka, Rauscher, 1974.
Fig.7. *Stelliferidium furcatum* (Deunff) Gorka, Rauscher, 1974.
Fig.8. *Acanthodiacrodium rectinerve* Burmann, 1968.
Fig.9. *Acanthodiacrodium tasselii* Martin, 1969.
Fig.10. *Cymatiogalea cristata* (Downie) Deunff et al., 1974.
Fig.11. *Goniosphaeridium dentatum* (Timofeev) Cocchio, 1982.

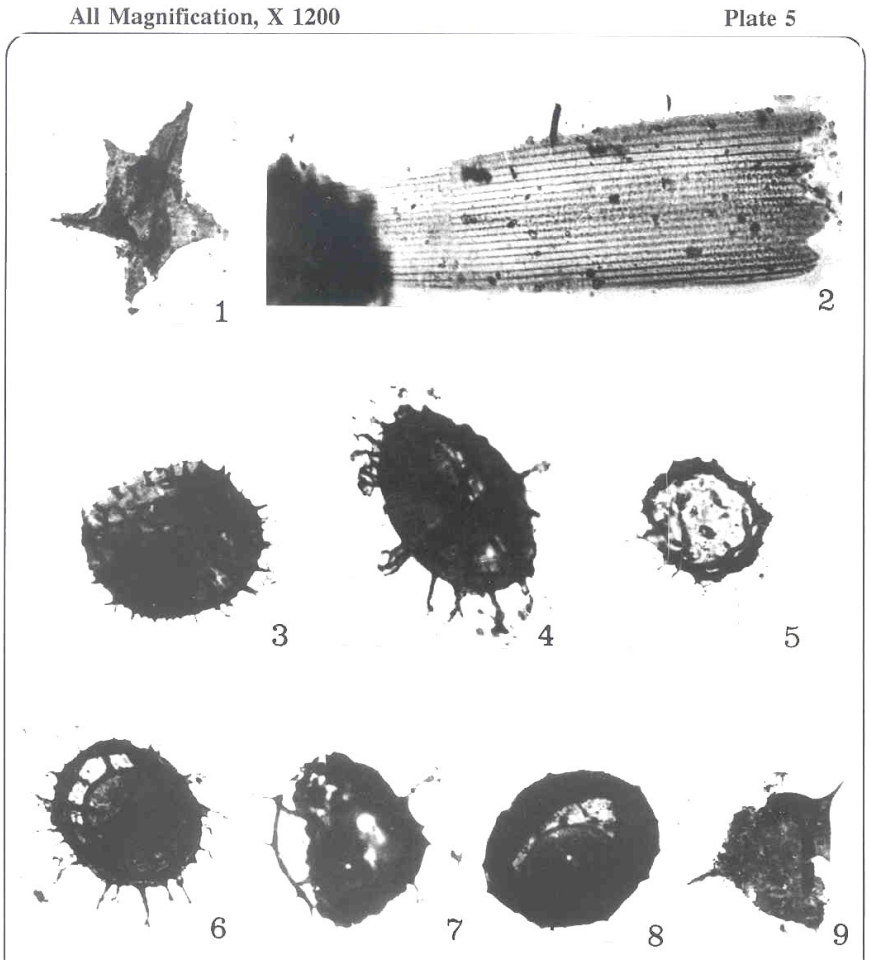

Fig.1. *Goniosphaeridium splendens* (Paris & Deunff) Turner, 1984.
Fig.2. *Dactylofusa spinata* (Staplin et al.) Eisenack et al., 1976.
Fig.3. *Cymatiogalea multarea* (Deunff) Eisenack et al., 1973.
Fig.4. *Athabascaella playfordii* Martin, 1984.
Fig.5. *Goniosphaeridium tuberatum* (Downie) Welsch, 1986.
Fig.6. *Priscogalea barbara* Deunff, 1961.
Fig.7. *Stelliferidium gautieri* (Martin) Pittau, 1985.
Fig.8. *Stelliferidium simplex* (Deunff) Deunff, Gorka, Rauscher, 1974.
Fig.9. *Veryhachium trispinosum* (Eisenack) Downie, 1959.

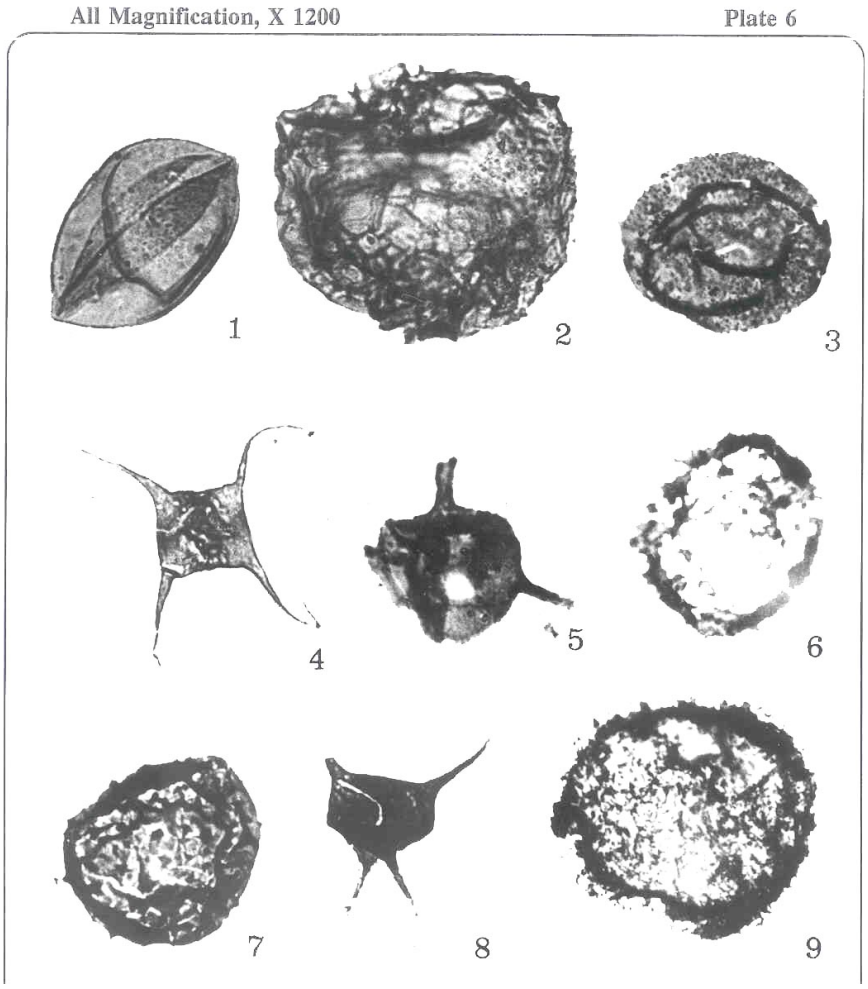

Fig.1. *Leiosphaeridia laevigata* Stockmans and Williere, 1963.
Fig.2. *Dictyotidium perlucidum* Le Herisse, 1989.
Fig.3. *Visbysphaera microspinosa* (Eisenack) Hill, 1974.
Fig.4. *Veryhachium lairdii* (Deflandre) Deunff, 1959.
Fig.5. *Evittia denticulata* (Cramer) Le Herisse, 1989.
Fig.6. *Visbysphaera oligofurcata* (Eisenack) Dorning, 1981.
Fig.7. *Visbysphaera pirifera* (Eisenack) Kiryanov, 1978.
Fig.8. *Veryhachium europeum* Stockmans & Williere, 1960.
Fig.9. *Leiosphaeridia tenuissima* Eisenack, 1958.

References

Bagnoli, G., Stouge, S., & Tongiorgi, M., (1988) *Acritarchs and Conodonts From the Cambro-Ordovician Furuhall (Kopingsklint) section (Oland, Sweden);* Riv. It. Paleont. Strat., **94(2)**, 163-248.

Baudelot, S., & Gery, B., (1979) Decouverte d*á*critarches du Cambrien Superieur et du Tremadoc dans le massif ancien de Grande Kabylie (Algerie), C.R. Acad. Sc. Paris, S. D. V. **288**, 1513-1516.

Bakhtiari Fard, A., (1993) *An Investigation of Palynostratigraphy and Paleaobiogeography of Niur Formation in the type section of Ozbak-Kuh*, Thesis for the degree of Master of Geology, Shahid Beheshti University.

Combaz, A., (1966) *Remarques sur les niveaux a Tasmanacées du paleozoique Saharien*, Palaeobotanist., **15(1/2)**, 29-34.

Combaz, A., (1967) *Un microbios du Tremadocien dans un sondage d Hassi- Messaoud. Actes de la Societe Linneenne de Bordeaux,* Ser.B. **104(29)**, 1-26.

Cooper, A.H., & Molyneux, S.G., (1990) *The age and Correlations of Skiddaw-Group (Early Ordovician sediments in the cross fell inlier Northern England),* Geol. Mag. **127(2)**, 147-157.

Cramer, F., H., (1971) *Distribution of selected Silurian acritarchs*, Rev. Espanol. Micropaleont., **3(1)**, 1-3.

Cramer, F.H., Diez, M.D., C.R., (1972) *Acritarchs from the Upper Middle Cambrian Oville Formation of Leon. Northwestern Spain*, Rev. Espanola de Micropaleont., núm. Extraord., xxx Aniv. E. N. Adaro., 39-50.

Cramer, F.H., Kanes W.H., Diez, M.C.R., and Christopher, R.A., (1974) *Early Ordovician acritarchs from the Tadla Basin of Morocco*, Palaeontographica Abt. B., **146**, 57-64.

Dean, W. T. & Martin, F., (1982) *The sequence of trilobite faunas and acritarch microfloras at the Cambrian - Ordovician boundary, Wilcox Pass, Alberta*, Canada. Nat. Mus. Wales, Geol. Ser., **No. 3**, 131-140.

Deunff, J., (1961) *Un microplancton a Hystrichospheres dans le Tremadoc du Sahara*, Rev. Micropaléont., **4(1)**, 37-52.

Deunff, J., (1964) *Systematique du Microplancton fossile A Acritarches Révision de deux genres de L'Ordovicien Inferieur*, Rev. Microplancton. **7(2)**, 119-124.

Deunff, J., Górka, H., & Rauscher, R., (1974) *Observations nouvelles et précisions sur les acritarches a large ouverture polaire du paleozoique Inférieur,* Géobios, **7(1)**, 5-18.

Deunff, J., Massa, D., (1975) *Palynologie et Stratigraphie du Cambro - Ordovician (Libye nord - occidentale*). C. R. Acad. Sci. Paris, **281(1)**, 266.

Downie, C., (1984) *Acritarchs in British Stratigraphy. Geological Society*, London Special Report, **17**, 1-27.

Eisenack, A., Cramer, F.H., & Diez, M. del C.R., (1976) Katalog der fossilen Dinoflagellaten Hystrichospharen und Verwandten Mikrofossillien Band IV. Acritarcha, 2. Teil.

Elaouad-Debbaj, z., (1988) *Tremadoc Acritarchs and Chitinozoa from the Middle Anti-Atlas (Morocco).* Rev. Micropaleont., **31(2)**, 85-128.

Erkmen,U. &Bozdogan,N., (1981) *Cambrian Aritarchs from the Sosink Formation in southeast Turkey.* Rev. Esp. Micropaleont.**8(1).**47-60.

Fombella, M.A., (1982) *Determinacion palinologica del Tremadoc en la localidad de Verdiago,* Provincia de Leon, No de Espana. Rev. Espanola de Micropaleont., **14**, 13-22.

Fombella, M.A., (1986) *El transito Cambrico - Ordovicico, Palinologiay diacronismo*, Provincia de Leon, No de Espana. Rev. Espanaola de Micropaleont., **18(2)**, 165-179.

Fombella, M.A. (1987) *Resemblaces and differences between the palynological associations of Upper Cambrian age in the NW of Spain (Vozmediano) and North of Africa; Rev. Micropaleont.* **30(2),**111-116.

Fournier- Vinas. C., (1985) *Acritarches Ordoviciennes des zekkara (Maroc oriental),* Geobios, **18(6)**, 807-813.

Gardiner, P.R.R., & Vanguestaine, M., (1971) *Cambrian and Ordovician microfossils from South-East Ireland and their implications*. Geol. Surv. Ireland, Bull., **1(2)**, 163-210.

Ghavidel-Syooki, M., (1990) *The encountered Acritarchs and Chitinozoans from Mila. Ilbek, and Zard- kuh Formations in Tang – e- Ilebek at Zard- kuh and their correlation with Paleozoic sequence at Chal- i - Sheh area. Symposium on diapirism with special reference to Iran, **1**, 140-218.*

Ghavidel-Syooki, M., (1993) *Palynological Study of Paleozoic Sediments of the Chal - i - Sheh Area, Southwestern Iran*, J. Sci. I. R. Iran, **4(1)**, 32-46.

Ghavidel-Syooki, M., (1994) *Palynological Study and Age Determination of the Ordovician Sediments and Faraghan Formation in Kuh - E - Surmeh at Southern Iran*, Geo Sciences, Scientific Quarterly Journal, **3(12)**, 28-35.

Ghavidel-Syooki, M., (1994) *Biostratigraphy and Paleo - biogeography of some Paleozoic rocks at Zagros and Alborz mountains*. Geological survey of Iran, Deputy Ministry of Projects & Planning, **18**, 1-143.

Ghavidel-Syooki, M., (1995) *Palynostratigraphy and Palaeogeography of a Palaeozoic sequence in the Hassanakdar area*, Central Alborz Range, Northern Iran. Rev. Palaeobot. Palynol., **86(1/2)**: 91-109.

Jardine, S., Combaz, A., Magloire, L., Peniguel, G. & Vachey, G., (1974) *Distribution stratigraphique des Acritarches dans le Paleozoique du Sahara Algerien*. Rev. Palaeobot. **18(1/2)**, 99-129.

Le Herisse, A., (1989) *Acritarches et kystes d algues Prasinophycees du Silurian de Gotland, Suede. Palaeontographica Italica*, **76**, 57-302.

Li, J., (1987) *Ordovician Acritarchs from the Meitan Formation of Guizhou province, South–West China*. Palaeontology, **30**(3), 613-634.

Lister, T.R., (1970) *The method of opening, orientation and morphology of the Tremadocian acritarch, Acanthodiacrodium ubui Martin.*, Proceedings of the Yorkshire Geol. Soc., **38(1/2)**, 47-55.

Martin, F., (1968) *Les Acritarches de ?zOrdovicien et du Silurien Belg*. Inst. Roy. Sci. Nat. Belg. Memoire, No. 160.

Martin, F., (1973) *Les Acritarches de ?ØOrdovicien inferieur de la Montagne–Noire (Herault, France)*. Bull. Inst. Roy. Sci. Nat. Belg. V.48, Science de la Terre, No. 10.

Martin, F., (1977) *Acritarches du Cambro- Ordovicien du massif du Brabant*, Belgique; Bull. Inst. Roy. Sci. Nat. Belg. V.51, Science de la Terro, No. 1.

Martin, F., & Dean, W.T., (1988) *Middle and Upper Cambrian Acritarch and Trilobite zonation at manuels river and random Island, Eastern Newfoundland*. Canada, Bull., **381,** 1-91.

Martin, F., & Leiming, Y., (1988) *Early Ordovician acritarchs from Southern Jilin Province, North–East China*. Palaeontology, **31(1)**, 109-127.

Molyneux, S.G. and Paris, F., (1985) *Late Ordovician Palynomorphs*. J. Micropalaeontology, **4(1)**, 11-26.

Otton E.G., Toro, B.A., & Waisfield, B.A., (1992) *Lower Ordovician Palynomorphs from the Acoite Formation*, Northwestern Argentina. Palynology, **16**, 93-116.

Rasul, S.M., (1974) *The Lower Palaeozoic acritarchs Priscogalea and Cymatiogalea*. Palaeontology, **17(1)**, 41-63.

Rasul, S.M., (1976) *New species of the genus Vulcanisphaera (Acritarcha) from the Tremadocian of England*. Micropaleont. **22(4)**, 479-484.

Rasul, S.M., (1979) *Acritarch Zonation of the Tremadoc series of the Shineton Shales, Wrekin, Shropshire, England*. Palynology, **3**, 53-72.

Rasul, S.M. & Downie, C., (1974) *The stratigraphic distribution of Tremadoc arcritarchs in the Shineton Shales succession, Shropshire, Englan*. Rev. Palaeobot. Palynol., **18(1/2)**, 1-9.

Rauscher, R., (1974) *Les Acritarches de 1'Ordovicien en France*. Rev. Paleobot. & Palynol, **18(1/2)**, 83-97.

Raphighi Oskouei, N., (1993) *Palynostratigraphy and Palaeobiogeography of Padeha Formation in the type section of Ozbak-Kuh*, Thesis for the degree of Master of Geology, Shahid Beheshti University.

Reitz, E., (1991) *Acritarchs of Early Tremadoc sediments in the western Fr?ªnkenwald area*, NE, Bavana. N.Jb. Geol. Palaeont. Mh., 97-104.

Richardson, J.B., & Loannides, N., (1973) *Silurian Palynomorphs from Tanezzuft and Acacus Formations*, Tripolitania, North Africa; Micropaleontology, **19(3)**, 257-307.

Ruttner, A., Nabavi M.H.& Hajian, J., (1968) *Geology of the Shirgesht Area (Tabas area, East Iran)*; Geol. Surv. Iran, Rep. **4**,33-40.

Sheshegova, L., (1975) *Phytoplankton of the Silur from the Tuva (the section of the Alegest)*, Transactions of instiute of geology and geophysics, **224**, 1-100.

Smelror, M., (1987) *Early Silurian acritarchs and Prasinophycean Alage from the Ringerike district, Oslo Region (Norway)*. Rev, Palaeobot & Palynol., **52**, 137-159.

Stocklin, J., (1977) *Stratigraphic Lexicon of Iran*, Geol. Surv. Iran, Rep. **18**, 159, 221-223.

Turner, R.E., (1984) Acritarchs from the type area of the Ordovician Caradoc Series Shropshire, England. Paleontogrophica Abt. B, **190(4/6),** 87-157.

Vanguestain, M., (1974) *Especes Zonales d Acritarches du Cambro – Tremadocien de Belgique et de 1' Ardenne Francaise. Rev.* Paleobot. Palynol., **18(1/2)**,63-82.

Vanguestaine, M., (1978) *Criteres palynostratigraphiques conduisant a la reconnaissance d'un pil couche Revinien dans le sondage de Grand-Halleux.* Annales de la Societe Geologique de Belgique, T. **100**, 249-276.

Vanguestaine, M., (1991) *Datation par Acritarches des Couches Cambro- Tremadociennes Les Plus Profondes du Sondage de Lessines (bord meridional du Massif du Brabant, Belgique).* Annales de la Societe Geologique de Belgique, T. **114**, 213-231.

Vanguestaine, M., (1992) *Biostratigraphie par Acritarchs du Cambro – Ordovicien de Belgique et des Regions Limitrophes: Synthese et Perspectives D'Avenir*, Annales de la Societe Geologique de Belgique, **115(1)**, 1-18.

Vavrdova, M., (1974) *Geographical differentiation of Ordovician acritarch assemblages in Europe.* Rev. Paleobot. Palynol. **18(1/2)**, 171-175.

Vavrdova, M., (1990) *Early Ordovician acritarchs from the locality Myto near Rokycany (Late Arenig, Czechoslovakia).* Casopos Promineralogiia geologii, roc. **35**, C. 3: 239-259.

Welsch, M., (1986) *The acritarchs of the Upper Digermul group. Middle Cambrian to Tremadoc, eastern Finnmark northern Norway*. Palaeontographica Abt., B., **201**, 1-109.