PALYNOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY OF THE LOWER PALEOZOIC SEQUENCE IN THE NORTHEASTERN ALBORZ RANGE (KOPET-DAGH REGION) OF IRAN

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Abstract

Palynomorphs recovered from the Lashkarak, Ghelli and Niur formations of eastern part of Kuh-e-Saluk (northeastern Alborz Range, Kopet-Dagh region) were used to more precisely determine the age of these units and assess their paleogeographic importance in Southern and Northern Hemispheres. These formations yielded 56 acritarch taxa permitting the recognition of six stratigraphic zones. Zones I-III represent the Early Ordovician (Tremadoc– Arenigian), Zones IV-V indicate the Middle and Late Ordovician and Zone VI suggests the Early Silurian age. This is the first report of Rhipsalidiphus and Palaeosiphonidium from the Lower Ordovician strata of northeastern Alborz Range (Kopet-Dagh region). The presence of these two genera in the Arenigian acritarch assemblage of Lashkarak Formation suggests the Iranian Platform and southwestern China occupied similar paleolatitudes along the southern shore of the Tethys Ocean during the Early Ordovician.

Comparison of acritarch taxa from the Ghelli (Middle–Late Ordovician) and Niur (Early Llandovery) formations with those from other parts of the world indicate a broad similarity with those of the United States, southern Europe and northern Africa. This similarity suggests that the peri-Gondwanan Paleocontinent began moving northward during the Late Ordovician and by the Silurian formed the supercontinent of Pangaea. The diverse acritarch taxa in the Early Ordovician (Lashkarak Formation), Middle and Late Ordovician (Ghelli Formation) and Early Llandovery (Niur Formation) indicate a marine depositional environment.

INTRODUCTION

Lower Paleozoic strata in the northeastern Alborz Range (Kopet-Dagh region), have yielded a diverse and well preserved acritarch assemblage. This study is directed toward developing palynological information from the Ordovician (Lashkarak and Ghelli formations) and Silurian strata (Niur Formation) of northeastern Alborz Range to aid in establishing the age relationships of the strata and resolve aspects of paleogeography and depositional environments.

PREVIOUS STUDIES

The Kuh-e-Saluk study area is approximately 32 km south of Bojnourd city (Text-Figure 1). The road from Bojnourd to Esfarayan is the main route into the region. The measured and sampled stratigraphic section was chosen along this road (Text-Figure 2). The total thickness of the Lower Paleozoic strata is 1200 m.

The Lower Paleozoic strata in Kuh-e-Saluk has been divided in ascending order, into Milla, Lashkarak, Ghelli and Niur formations (Text-Figure 2) by Afshar-harb (1979). The study area is located in the Kopet-Dagh region (northeastern Alborz Range) where the Lower Paleozoic rock units extend towards the southern and eastern Caspian Sea.

The Milla Formation consists mainly of medium to thin-bedded, cream-reddish brown limestones. Poorly preserved megafossils, such as brachiopods and trilobites, are not identifiable to the generic level. Based on stratigraphic position, the Milla Formation has been assigned to the Middle and Late Cambrian (Afshar-harb, 1979).

The Lashkarak Formation is a very distinctive sedimentary facies consisting of dark-gray shales, siltstones and fine-grained sandstones which are interbedded with thin limestones (Text-Figure 2). In the study area the Lashkarak Formation contains brachiopods and conodonts which have been assigned to the Tremadocian (Ahmadzadeh-heravi, 1983).

The Ghelli Formation consists mainly of olive-gray shales, micaceous siltstones, fine-grained sandstones and a few meters of limestones at the top. Near the upper part of the unit is a 44 m thick igneous sill. The Lower and Upper contact of Ghelli Formation are conformable with underlying and overlying formations (Text-Figure 2). Some intervals of this rock unit contain brachiopods, graptolites and conodonts. Ahmadzadeh-heravi (1983) recorded conodonts indicative of Late Ordovician age.

The Niur Formation, although well-developed in central Iran, was first described by Afshar-harb (1979) from the northeastern Alborz Range. In the study area, this formation consists of limestones, shales and sandstones. The fauna includes abundant corals, brachiopods and crinoids. Based on the brachiopod fauna Ahmadzadeh-heravi (1983) assigned a Silurian age to the Niur Formation.

LABORATORY TECHNIQUES

Palynological study was carried out on 140 samples from Lashkarak Formation, Ghelli Formation and Niur Formation. The field and laboratory description of the samples has been plotted on the stratigraphic section in
Text-Figure 1. Location map of study area.

Text-Figure 2. The code and number of each sample follow the policy of the National Iranian Oil Company. Fifty grams of rock were randomly selected from each sample and processed in the palynology laboratory of the Exploration Department of the National Iranian Oil Company.

Disaggregation of the rock samples was conducted using standardized techniques. All slides used in this study are housed in the Paleontology Section collections of the Exploration Department of the National Iranian Oil Company.

STRATIGRAPHIC PALYNOLGY

The objectives of this study are to summarize the stratigraphic range of assemblages and species that occur in the Lashkarak, Gheili and Niir formations and to compare these data with zonal assemblages that have been reported from other parts of the world. A total of 56 acritarch taxa were identified and their distribution is plotted on Text-Figure 2. Selected acritarch taxa are illustrated in Plates I-VIII. Six acritarch assemblages have been recognized and are discussed below in ascending stratigraphical order.

Text-Figure 2 (opposite page). Stratigraphic distribution of acritarch taxa in the lower Paleozoic strata of the northeastern Alborz Range (Kopet-Dagh region) of Iran. List of recorded taxa are noted below (numbers refer to the corresponding columns on Text-Figure 2). 1-Multiplicisphaeridium cervinacomum (Welch); 2-Acanthodiscodium echinatum (Timofeev) Delfandre & Delfandre-Rigaud; 3-Acanthodiscodium rana (Deunff) Eisenack et al.; 4-Cymatogaleria cuvieri (Deunff) Deunff; 5-Saharidina downiei Comba et al.; 6-Cymatogalea veletans (Downie) Martin; 7-Vulcanisphaera britannica Rasul; 8-Vulcanisphaera africana Deunff; 9-Vulcanisphaera cincta Rasul; 10-Dactylosphaera squama (Deunff) Comba et al.; 11-Athabascaella playfordi Martin; 12-Goniosphaeridium piliferum Martin; 13-Porphosphaeridium torum Rasul; 14-Acanthodiscodium angustum (Downie) Comba et al.; 15-Stelliferidium strigatum (Vavrdova) Deunff et al.; 16-Stelliferidium stelliferum (Gorka) Deunff et al.; 17-Acanthodiscodium rectipe Bumman; 18-Arbusculidium filamentosum (Vavrdova) Vavrdova; 19-Arbusculidium sp.; 20-Marcocianum simplex (Cramer et al.; 21-Striatotheca triangularis (Cramer et al.); 22-Striatotheca principalis Bumman; 23-Striatotheca rugosa Tongiorgi et al.; 24-Pirea bacillifera Tongiorgi et al.; 25-Coryphidium elegans (Cramer et al.; 26-Coryphidium minutum Cramer & Diez; 27-Petrolithothamnium tenuifolium Tongiorgi et al.; 28-Petrolithothamnium armatum Tongiorgi et al.; 29-Petrolithothamnium robustum Tongiorgi et al.; 30-Petrolithothamnium angustissimum Playford et al.; 31-Cymatogalea deunffii Jardiné, Comba et al.; 32-Rhopaliphora palmata (Comba & Penigals) Playford & Martin; 33-Rhopaliphora mamillosa L.; 34-Actinotodiscus crassus Loeblich & Tappan; 35-Veryhachium redutum (Deunff) Jekhoweky; 36-Oxovorticoidium elegantum Tappan & Loeblich; 37-Veryhachium oklahomensense Loeblich; 38-Balitritophidium perclavatum Loeblich Jr. & Tappan; 39-Navifusa ancepsopuncta Loeblich; 40-Orthosphaeridium tenuatum (Bumman) Eisenack et al.; 41-Villosacapsula setosa spinulifera (Loeblich Jr.) Loeblich et al.; 42-Veryhachium subglobosum Jardiné et al.; 43-Orthosphaeridium infatum Loeblich; 44-Orthosphaeridium insculptum Loeblich; 45-Pokifusus spinatus Staplin et al.; 46-Rhizosphaerina impressa (Loeblich); 47-Dactylosphaera striata (Staplin et al. 1965) Fenstone et al.; 48-Discophora denticulata (Stevenson & Willier) Loeblich; 49-Dactylosphaera australis (Cramer & Diez); 50-Dactylosphaera striatula (Cramer, 1964) Fenstone et al.; 51-Tunisphera lemniscata (Martin) Cramer; 52-Orthosphaeridium clavispinulosum Lister; 53-Multiplicisphaeridium neaghii Cramer; 54-Vulcanisphaera piriformis (Eisenack) Lister; 55-Vulcanisphaera oliviformis (Eisenack) Hill; 56-Vulcanisphaera brevifurcata (Eisenack) Le Hérité;
Acrirach Assemblage Zone I

Assemblage Zone I begins at the lowermost part of the Lashkarak Formation and extends through a thickness of 368 m of the studied stratigraphic section (Text-Figure 2). This zone is characterized by the presence of the acritarch taxa *Multiplicisphaeridium carnosorum*, *Acanthodiakrocidium rais*, *Acanthodiakrocidium echinatum*, *Cymatiolella lucullieri*, *Saharidium downii*, *Cymatiolella velifera*, *Vulcanisphaera africana*, *Vulcanisphaera britannica*, *Vulcanisphaera cinnula*, *Dactylofusa squama*, *Athalascascia playfordii*, and *Coniosphaeridium piliforme*. This assemblage zone is considered to be Lower Ordovician (Early Tremadocian) based on the stratigraphic occurrence of acritarchs in England (Rasal, 1976, 1979; Downie, 1981), France (Rausch, 1974), Belgium (Martin, 1965), Germany (Reitz, 1991), Norway (Welsch, 1986), Czech Republic (Vavrdo, 1974), Ireland (Combas, 1967; Combas et al., 1973; Jardiné et al., 1973), Sweden (Bagnoli et al., 1988), Ahmadzadeh-Heravi (1983) has assigned an Early Ordovician (Tremadocian) age to this part of the Lashkarak Formation based on conodont and brachiopod data (Text-Figure 2).

Acrirach Assemblage Zone II

This zone is marked by the first appearance of *Lophosphaeridium torum*, *Acanthodiakrocidium angustum*, *Stelliferidium stritulum*, *Stelliferidium stelligerum*, and *Acanthodiakrocidium rectinerve*. This zone occurs in 132 m of the Lashkarak Formation (Text-Figure 2). The assemblage species are indicative of the Early Ordovician (Late Tremadocian) compared to their occurrence in strata from Algeria (Combas, 1967; Combas et al., 1974; Jardiné et al., 1974), southern Europe (Vavrdo, 1974) and southern and northern Iran (Ghadivel-Syooki, 1995).

Acrirach Assemblage Zone III

This zone comprises 60 m of the upper part of Lashkarak Formation. It is characterized by the presence of *Striatotaxa triangulata*, *Striatotaxa principalis*, *Striatotaxa rugosa*, *Arbusculidium filamentosum*, *Arbusculidium sp.*, *Marroanum simplex*, *Pirea baculifera*, *Corphidium elegans*, *Corphidium minus*, *Petenosphaeridium nervoliforme*, *Petenosphaeridium armatum*, *Petenosphaeridium velatum*, *Petenosphaeridium robustiramosum*, *Petenosphaeridium angustilamamae*, *Cymatiolella deufrifi*, *Rhopalophora palmera* and *Rhopalophora maniliformis.*

Although some species of zones I and II extend into this zone there is a marked qualitative reduction in taxa (Text-Figure 2). Based on the above mentioned acritarchs, this zone is considered to belong to the uppermost part of the Early Ordovician ( Arenigian). Acrirach taxa of this zone have been recorded in the Arenigian strata of southern Europe (Vavrdo, 1974; Rausch, 1974; Burman, 1968; Downie, 1981), Morocco (Cramer et al., 1974; Cramer and Diez, 1977), Algeria (Jardiné et al., 1974), southern and western China (Lu, 1985; Martin and Yin, 1986), Tongjo et al., 1995), southern and northern Iran (Ghadivel-Syooki, 1990, 1993, 1996), and Argentina (Ozono and Torr, 1992). The assemblage contains typical Mediterranean taxa including *Corphidium*, *Arbusculidium* and *Striatotaxa*, which have been reported from the Arenigian of peri-Gondwanan (Mercadina-Medrano) acritarch paleo-province (Vavrdo, 1974). This is the first record of *Petenosphaeridium* and *Rhopalophora* from the lower Ordovician strata of Iran. These two genera have also been recovered from the Arenigian sediments of China (Tongjo et al., 1995). The occurrence of Mediterranean acritarch taxa and *Rhopalophora* and *Petenosphaeridium* indicates that Iran Platform and southwestern China were in close proximity and about the same paleolatitude along the southern shore of the Tethys Ocean.

Acrirach Assemblage Zone IV

This assemblage zone begins in the lowermost part of the Ghelli Formation and spans a thickness of 320 m (Text-Figure 2). This zone is marked by the absence of several lower Ordovician taxa and appearance of Middle and Late Ordovician acritarch species. The latter includes *Acrisintodiellus crassus*, *Veehuctium reductum*, *Orsididaulium elegantulum*, *Veehuctium skinnisomentum*, *Naviculaceocispectaculum*, *Baltisphaeridium percellorum*, *Orthochoeridium lernum*, *Orthochoeridium inflatum*, *Orthochoeridium insculptum*, *Veehuctium subglobose* and *Veehuctium setosepliculata*. Many species present in this zone continue into the succeeding zone (Text-Figure 2). Acrirach species present in Zone IV indicate a Middle and Late Ordovician age based on comparisons with assemblages in the United States (Loeblich and Tappan, 1970, 1971 and 1978), Canada (Jacobson and Achar, 1985), England (Turner, 1984, 1985), southern Europe (Vavrdo, 1974), Sweden (Kjellström, 1971), Czech Republic (Dufka and Fatka, 1990), Libya (Molyneux et al., 1983), Algeria (Jardiné et al., 1974), Morocco (Eloudad-Debaj, 1988), Jordan (Keegan et al., 1990), Saudi Arabia (Jachowicz, 1998) and Iran (Ghadivel-Syooki, 1996; Ghadivel-Syooki and Khosravi, 1995).

Acrirach Assemblage Zone V

This zone comprises 28 m of the Ghelli Formation (Text-Figure 2). The assemblage is characterized by occurrence of *Rhiphosferma improvisa*, *Poiakuloidea spinula*, *Dactylofusa*...
striata and Dixieplithus denticulata. This zone is assigned to the uppermost part of Late Ordovician (Ashgillian).

The acritarch taxa in this zone have been recorded from the Ashgillian strata in the United States (Loeblich and Tappan, 1978), Canada (Jacobson and Acha, 1985), Libya (Molyneux et al., 1985), Algeria (Jardine et al., 1974) and Iran (Ghavidel-syooki, 1996). Ahmadzaadeh-heravi (1983) suggested an Ashgillian age for this part of Gheffi Formation based on the presence of the conodonts Zigygenathus plieki, Pandercus gracilis and Cordylodus flexus (see Text-Figure 2; limestone horizon yielding conodonts is designated with an asterisk). A basaltic sill has intruded the upper part of Gheffi Formation and resulted in color changes in the acritarchs from orange to brown, reflecting contact metamorphism (Text-Figure 2).

Acritarch Assemblage Zone VI

This zone begins at the base of Niur Formation and extends through a thickness of 128 m (Text-Figure 2). The characteristic Silurian index acritarch species present include: Dactylosphaera strigilis, Heliopehryx monospondylum, Multiplicisphaeridium neogaeum, Dactylosphaera striatella, Tunisphaeridium tentacularum, Vizysphaera piriforma, Vizysphaera oligoformata and Vizysphaera breviserrata.

This zone is considered the lowermost Silurian (Rhindanian) based on acritarch taxa recorded from the Early Llandovery strata in the United States (Cramer, 1971; Miller and Eames, 1982), England (Hill, 1974; Downie, 1984), Norway (Smelror, 1987), Sweden (Le Hérisse, 1989), Algeria (Jardine et al., 1974), Libya (Hill et al., 1985), Jordan (Keegan et al., 1990), Saudi Arabia (Le Hérisse et al., 1995) and southern Iran (Ghavidel-syooki, 1990, 1996).

CONCLUSIONS

The Lashkarak, Gheffi and Niur formations yielded 56 acritarch taxa. The local stratigraphic distribution of these acritarchs is shown in Text-Figure 2. Zones I to III are present in the Lashkarak Formation and suggest a Early Ordovician (Tremadoc-Arenigian) age for this interval. Comparison of these Early Ordovician acritarch assemblages with acritarch taxa from other parts of the world indicates broad similarity with those from the Mediterranean Acritarch Province (Vavrdová, 1974).

This acritarch province includes southern Europe, northeastern Africa, southwestern China, Saudi Arabia and Zagros basin of Iran. The presence of Mediterranean acritarch taxa in the Lashkarak Formation of northeastern Iran suggests that both southern and northern Iran were part of Peri-Gondwanan paleocontinent, possibly positioned along the southern shore of the Paleo-Tethys Ocean.

Zones IV to V occur in the Gheffi Formation and indicate a Middle and Late Ordovician age.

Acritarch species from Gheffi Formation suggest a similarity with those of recorded from Middle and Upper Ordovician strata in Morocco, Algeria, Libya, Jordan, Saudi Arabia, England, Germany, Czech Republic and United States of America.

This supports the opinion that the peri-Gondwanan paleo-continent and the United States have occupied a similar paleolatitude during the Middle and late Ordovician. Zone VI is present in the Niur Formation and the acritarch assemblage suggests Early Silurian (Rhindanian) for the basal part. Comparison of this Early Silurian acritarch assemblage with those of other parts of the world indicates broad similarity with those from the United States, northern Africa and southern Europe.

This suggests that the Peri-Gondwanan or Mediterranean paleo-continent began to move up toward the Baltic paleo-continent in Middle and Late Ordovician and by the Silurian formed the supercontinent of Pangaea.

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References Cited

APSHAR-HARB, A.

AHMADZAADEH-HERAVI, M.

BAGNOLI G., STOUGE, S. and TONGIORGI, M.

PLATE 2

All figures x1000 except fig. 7.

1 Acanthodiaceodrum echinatum (Timofeev 1959) Deflandre & Deflandre Bigaud 1962.
2 Acanthodiaceodrum rectinerum Burmann 1968.
4 Cymatiosphaera velata (Downie 1958) Martin 1966.
7 Orthopetraeridium inflatum Loeblich 1969 (x500).
8 Saharida darii Combaz 1967.
9 Lophosphaeraeridium tornus Rasul 1979.
MARTIN, F., and YIN, LEIMING

MILLER, M.A., and EAMES, L.E.

MOLYNEUX, S.G., and PARIS, F.

MOLYNEUX, S.G., and RUSHTON, A.W.A.

OTTONE, E.G., TORO, B.A., and WAIFEL, B.G.

PLAYFORD, G., RIBICAI, C., and TONGIORGI, M.

RASUL, S.M.


RAUSCHER, R.

REITZ, E.

SMELROR, M.

STAPLIN, F.L., JANSONIUS, J., and POCKET, S.A.J.

TONGIORGI, M., YIN, L.M., and DI MILIA, A.

TURNER, R.E.

 PLATE 4

All figures x1000.


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PLATE 5

All figures x1000.

1, 6  Peteinosphaeridium robustiramosum Tongjorgi et al. 1995.


3  Peteinosphaeridium velatum Kjellström 1971.

4, 7  Peteinosphaeridium angustilaminae Playford et al. 1995.

8  Pirca baculifera Tongjorgi, Yin & Di Mills 1995.

9  Peteinosphaeridium angustilaminae Playford et al. 1995.
PLATE 6

All figures x1000 except number 2.

1 Actinotodissus crassus Loeblich & Tappan 1978.
2 Dactylocysta striata (Staplin et al. 1965) Fensome et al. 1990 (x500).
3 Striatotheca rugosa Tongiorgi et al. 1995.
4 Villosacapsula setosapellucula (Loeblich) Loeblich & Tappan 1976.
6 Navifusa ancepspuncta Loeblich 1970.
7 Veryhachium subglobosum Jardiné et al. 1974.
8 Veryhachium oklahomense Loeblich 1969.
PLATE 7

All figures x500 with exception of figs. 2, 7, 8 and 9.

1.4 Orthosphaeridium insculptum Loeblich 1969.
2 Nanofusa ancepsipuncts Loeblich 1970 (x1000).
5 Orthosphaeridium inflatum Loeblich 1969.
6 Baltisphaeridium perclavum Loeblich & Tappan 1978.
7 Orkovicidium elegansium Tappan & Loeblich 1971 (x1000).
8 Poikilosphaera spinata Staplin et al. 1965 (x1000).
9 Sieralophusida denticulata (Stockmanns & Willier 1963) Loeblich 1970 (x1000).
PLATE 8

All figures x 1,000.

1 Helosphaeridium clavispinulosum Lister 1970.
2 Dactylofasa esillis Cramer & Diez 1972.
8 Multiplicisphaeridium neaghe Cramer 1970.