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

Mohammad Ghavidel-Syooki

## 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 *Rhopaliophora* and *Peteinospheridium* 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 Pangea. 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 Albroz 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 Esfarayen 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 Mila, 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.

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 ISBN 0–931871–06–9

The Mila 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 Mila Formation has been assigned to the Middle and Late Cambrian (Afshar-harb, 1979).

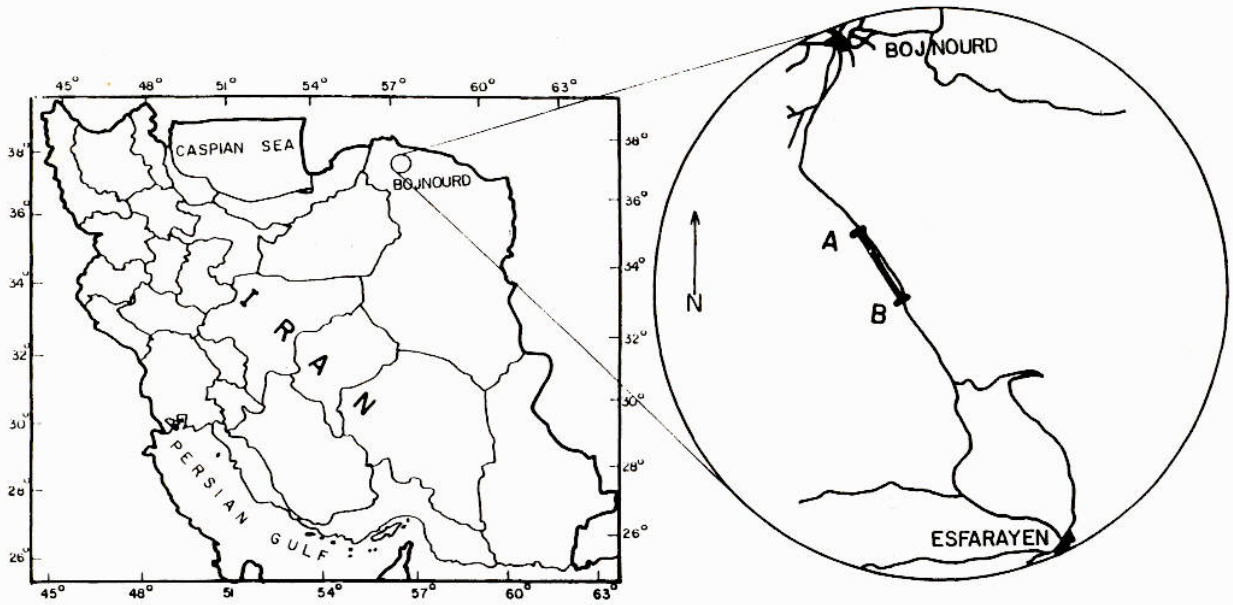
The Lashkarak Formation is a very distinctive sedimentary facies consisting of dark-gray shales, siltstones and fine-grained sandstones which are interbedded with thin limestones (Text-Figure 2). In the study area the Lashkarak Formation contains brachiopods and conodonts which have been assigned to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

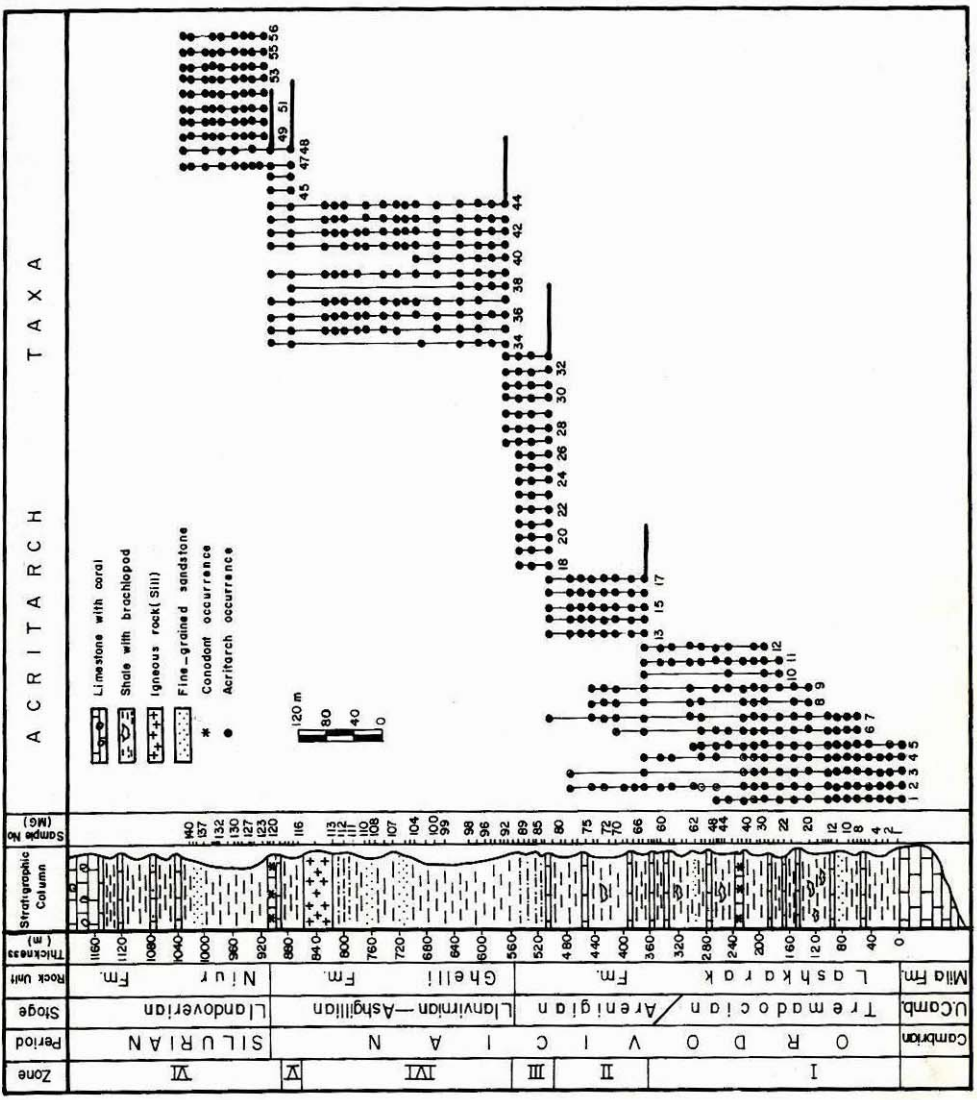
Text-Figure 2. The code and number of each sample follow the policy of the National Iranian Oil Company. Fifty grams of rock were randomly selected from each sample and processed in the palynology laboratory of the Exploration Department of the National Iranian Oil Company.

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 PALYNOLOGY

The objectives of this study are to summarize the stratigraphic range of assemblages and species that occur in the Lashkarak, Ghelli and Niur 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 cervinacornuum* Welsch; 2–*Acanthodiacrodium echinatum* (Timofeev) Deflandre & Deflandre-Rigaud; 3–*Acanthodiacrodium raia* (Deunff) Eisenack et al.; 4–*Cymatiogalea cuvillieri* (Deunff) Deunff; 5–*Saharidia downiei* Combaz; 6–*Cymatiogalea velifera* (Downie) Martin; 7–*Vulcanisphaera britannica* Rasul; 8–*Vulcanisphaera africana* Deunff; 9–*Vulcanisphaera cirrita* Rasul; 10–*Dactylofusa squama* (Deunff) Combaz et al.; 11–*Athabascaella playfordii* Martin; 12–*Goniosphaeridium piliferum* Martin; 13–*Lophosphaeridium torum* Rasul; 14–*Acanthodiacrodium angustum* (Downie) Combaz; 15–*Stelliferidium striatulum* (Vavrdovà) Deunff et al.; 16–*Stelliferidium stelligerum* (Gôrka) Deunff et al.; 17–*Acanthodiacrodium rectinerve* Burmann; 18–*Arbusculidium filamentosum* (Vavrdová) Vavrdovà; 19–*Arbusculidium sp.*; 20–*Marrocanium simplex* Cramer et al.; 21–*Striatotheca triangulata* (Cramer et al.) Eisenack et al.; 22–*Striatotheca principalis* Burmann; 23–*Striatotheca rugosa* Tongiorgi et al.; 24–*Pirea baculifera* Tongiorgi et al.; 25–*Coryphidium elegans* Cramer et al.; 26–*Coryphidium minutum* Cramer & Díez; 27–*Peteinosphaeridium tenuifilosum* Tongiorgi et al.; 28–*Peteinosphaeridium armatum* Tongiorigi et al.; 29–*Peteinosphaeridium robustiramosum* Tongiorgi et al.; 30–*Peteinosphaeridium angustilaminae* Playford et al.; 31–*Cymatiogalea deunffii* Jardiné, Combaz et al.; 32–*Rhopaliophora palmata* (Combaz & Peniguel) Playford & Martin; 33–*Rhopaliophora mamilliformis* Lu; 34–*Actinotodissus crassus* Loeblich & Tappan; 35–*Veryhachium reductum* (Deunff) Jekhowsky; 36–*Ordovicidium elegantulum* Tappan & Loeblich; 37–*Veryhachium oklahomense* Loeblich.; 38–*Baltisphaeridium perclarum* Loeblich Jr. & Tappan; 39–*Navifusa ancepsipuncta* Loeblich; 40–*Orthosphaeridium ternatum* (Burmann) Eisenack et al.; 41–*Villosacapsula setosapellicula* (Loeblich Jr.) Loeblich & Tappan; 42–*Veryhachium subglobosum* Jardiné et al.; 43–*Orthosphaeridium inflatum* Loeblich; 44–*Orthosphaeridium insculptum* Loeblich. 45–*Poikilofusa spinata* Staplin et al.; 46–*Rhiptosocherma improcera* (Loeblich) Loeblich & Tappan; 47–*Dactylofusa striata* (Staplin et al. 1965) Fensome et al.; 48–*Diexallophasis denticulata* (Stockmann & Williéré) Loeblich; 49–*Dactylofusa estillis* Cramer & Díez; 50–*Dactylofusa striatifera* (Cramer, 1964) Fensome et al.; 51–*Tunisphaeridium tentaculiferum* (Martin) Cramer; 52–*Helosphaeridium clavispinulosum* Lister; 53–*Multiplicisphaeridium neaghae* Cramer; 54–*Visbysphaera pirifera* (Eisenack) Lister; 55–*Visbysphaera oligofurcata* (Eisenack) Hill; 56–*Visbysphaera brevifurcata* (Eisenack) Le Hérissé;


ACRITARCH TAXA
Limestone with coral
Shale with brachiopod
Igneous rock( Sill)
Fine-grained sandstone
Conodont occurrance
Acritarch occurrance
120 m
80
40
0
Zone
Period
Stage
Rock unit
Thickness (m)
Stratigraphic Column
Sample No (MG)
Cambrian
U.Camb.
Mila Fm.
I
II
III
IV
V
VI
ORDOVICIAN
SILURIAN
Tremadocian
Arenigian
Llanvirnian—Ashgillian
Landoverian
Lashkarak Fm.
Ghelli Fm.
Niur Fm.

## Acritarch 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 presence of the acritarch taxa *Multiplicisphaeridium cervinacornuum, Acanthodiacrodium raia, Acanthodiacrodium echinatum, Cymatiogalea cuvillieri, Saharidia downiei, Cymatiogalea velifera, Vulcanisphaera africana, Vulcanisphaera britannica, Vulcanisphaera cirrita, Dactylofusa squama, Athabascaella playfordii* and *Goniosphaeridium piliferum*. This assemblage zone is considered to be Lower Ordovician (Early Tremadocian) based on the stratigraphic occurrence of acritarchs in England (Rasul, 1976, 1979; Downie, 1984), France (Rauscher, 1974), Belgium (Martin, 1965), Germany (Reitz, 1991), Norway (Welsch, 1986), Czech Republic (Vavrdová, 1974), Algeria (Combaz, 1967; Combaz et al., 1974; Jardiné et al., 1974), Sweden (Bagnoli et al., 1988). Ahmadzadeh-heravi (1983) has assigned an Early Ordovician (Tremadocian) age to this part of the Lashkarak Formation based conodont and brachiopod data (Text-Figure 2).

## Acritarch Assemblage Zone II

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

## Acritarch Assemblage Zone III

This zone comprises 60 m of the upper part of Lashkarak Formation. It is characterized by the presence of *Striatotheca triangulata, Striatotheca principalis, Striatotheca rugosa, Arbusculidium filamentosum, Arbusculidium sp., Marrocanium simplex, Pirea baculifera, Coryphidium elegans, Coryphidium minutum, Peteinosphaeridium tenuifilosum, Peteinosphaeridium armatum, Peteinosphaeridium velatum, Peteinosphaeridium robustiramosum, Peteinosphaeridium angustilaminae, Cymatiogalea deunffii, Rhopaliophora palmata* and *Rhopaliophora mamilliformis*.

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). Acritarch taxa of this zone have been recorded in the Arenigian strata of southern Europe (Vavrdová, 1974; Rauscher, 1974; Burmann, 1968; Downie, 1984), Morocco (Cramer et al., 1974; Cramer and Díez, 1977), Algeria (Jardiné et al., 1974), southern and western China (Lu, 1987; Martin and Yin, 1988; Tongiorgi et al., 1995), southern and northern Iran (Ghavidel-syooki, 1990, 1993, 1995, 1996) and Argentina (Ottone and Toro, 1992). The assemblage contains typical Mediterranean taxa including *Corphidium, Arbusculidium* and *Striatotheca*, which have been reported from the Arenigian of peri-Gondwana (Mediterranean) acritarch paleo-province (Vavrdová, 1974). This is the first record of *Peteinosphaeridium* and *Rhopaliophora* from the lower Ordovician strata of Iran. These two genera have also been recovered from the Arenigian sediments of China (Tongiorgi et al., 1995). The occurrence of Mediterranean acritarch taxa and *Rhopaliophora* and *Peteinosphaeridium* indicates that Iranian Platform and southwestern China were in close proximity and about the same paleolatitude along the southern shore of the Tethys Ocean.

## Acritarch Assemblage Zone IV

This assemblage zone begins in the lowermost part of 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 *Actinotodissus crassus, Veryhachium reductum, Ordovicidium elegantulum, Veryhachium oklahomense, Navifusa ancepsipuncta, Baltisphaeridium perclarum, Orthosphaeridium ternatum, Orthosphaeridium inflatum, Orthosphaeridium insculptum, Veryhachium subglobosum* and *Villosacapsula setosapellicula*. Many species present in this zone continue into the succeeding zone (Text-Figure 2). Acritarchs 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 Achab, 1985), England (Turner, 1984, 1985), southern Europe (Vavrdová, 1974), Sweden (Kjellström, 1971), Czech Republic (Dufka and Fatka, 1993), Libya (Molyneux et al., 1985), Algeria (Jardiné et al., 1974), Morocco (Elaouad-Debbaj, 1988), Jordan (Keegan et al., 1990), Saudi Arabia (Jachowicz, 1995) and Iran (Ghavidel-syooki, 1996; Ghavidel-syooki and Khosravi, 1995).

## Acritarch Assemblage Zone V

This zone comprises 28 m of the Ghelli Formation (Text-Figure 2). The assemblage is characterized by occurrence of *Rhiptosocherma improcera, Poikilofusa spinata, Dactylofusa*

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## PLATE 1

All figures x1000.

1 *Stelliferidium striatulum* (Vavrdová 1966) Deunff, Górka & Rauscher 1974.

2 *Dactylofusa squama* (Deunff 1961) Combaz, Lange & Pansart 1967.

3 *Stelliferidium stelligerum* (Górka 1967) Deunff, Górka & Rauscher 1974.

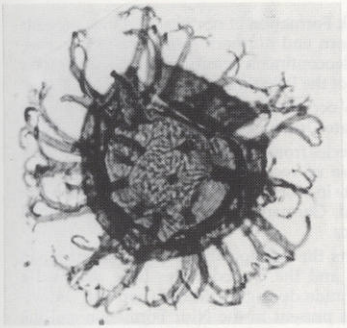
4, 7 *Vulcanisphaera africana* Deunff 1961.

5 *Acanthodiacrodium angustum* (Downie 1958) Combaz 1967.

6 *Vulcanisphaera cirrita* Rasul 1976.

8 *Cymatiogalea cuvillieri* (Deunff 1961) Deunff 1964.

9 *Acanthodiacrodium raia* (Deunff 1961) Eisenack et al.



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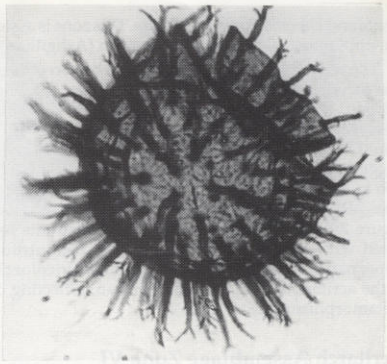

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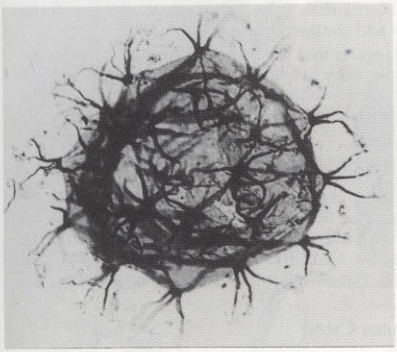

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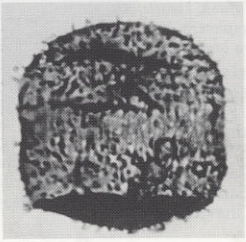

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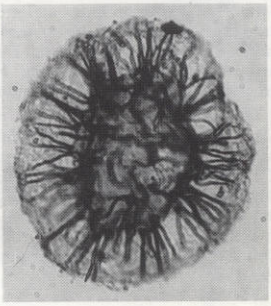

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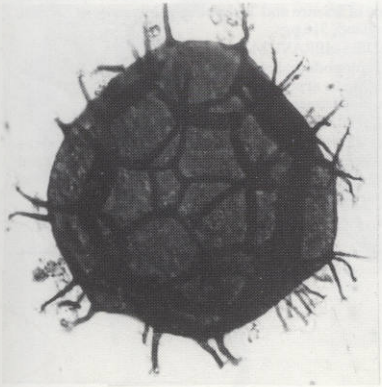

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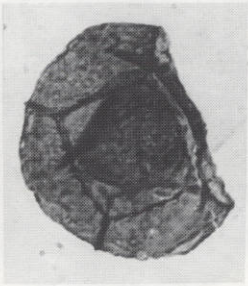

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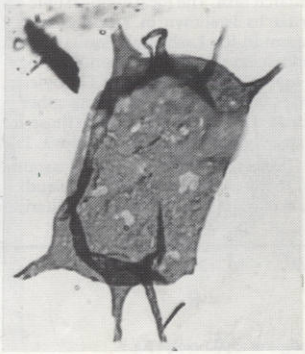

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*striata* and *Diexallophasis denticulata*. This zone is assigned to the uppermost part of Late Ordovician (Ashgillian).

The acritarch taxa in this zone have been recorded from the Ashgillian strata in the United States (Loeblich and Tappan, 1978), Canada (Jacobson and Achab, 1985), Libya (Molyneux et al., 1985), Algeria (Jardiné et al., 1974) and Iran (Ghavidel-syooki, 1996). Ahmadzadeh-heravi (1983) suggested an Ashgillian age for this part of Ghelli Formation based on the presence of the conodonts *Zygeganthus plebia, Panderedus gracilis* and *Cordyledus flexus* (see Text-Figure 2; limestone horizon yielding conodonts is designated with an asterisk). A basaltic sill has intruded the upper part of Ghelli 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 *Dactylofusa estillis, Helosphaeridium clavispinulosum, Multiplicisphaeridium neaghae, Dactylofusa straitifera, Tunisphaeridium tentaculiferum, Visbysphaera pirifera, Visbysphaera oligofurcata* and *Visbysphaera brevifurcata*.

This zone is considered lowermost Silurian (Rhuddanian) 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 Hérissé, 1989), Algeria (Jardiné et al., 1974), Libya (Hill et al., 1985), Jordan (Keegan et al., 1990), Saudi Arabia (Le Hérissé et al., 1995) and southern Iran (Ghavidel-syooki, 1990, 1996).

## CONCLUSIONS

The Lashkarak, Ghelli 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 (Vavrdovà, 1974).

This acritarch province includes southern Europe, northern 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 Ghelli Formation and indicate a Middle and Late Ordovician age.

Acritarch species from Ghelli 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 (Rhuddanian) 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 Pangea.

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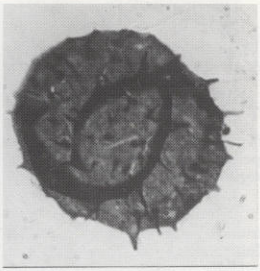
## PLATE 2

All figures x1000 except fig. 7.

1 *Acanthodiacrodium echinatum* (Timofeev 1959) Deflandre & Deflandre Rigaud 1962.
2 *Acanthodiacrodium rectinerve* Burmann 1968.
3 *Multiplicisphaeridium cervinacornuum* Welsch 1986.
4 *Cymatiogalea velifera* (Downie 1958) Martin 1968.
5 *Dactylofusa squama* (Deunff 1961) Combaz et al. 1967.
6 *Goniosphaeridium piliferum* (Martin 1966) Eisenack et al. 1973.
7 *Orthosphaeridium inflatum* Loeblich 1969 (x500).
8 *Saharidia downiei* Combaz 1967.
9 *Lophosphaeridium torum* Rasul 1979.



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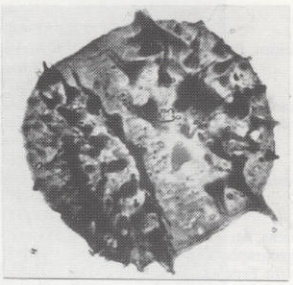

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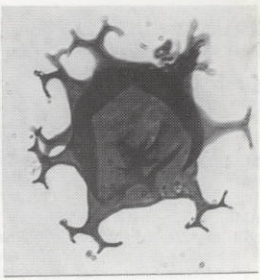

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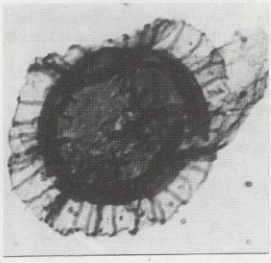

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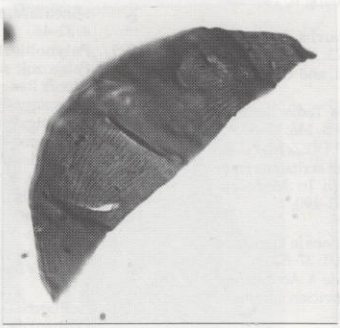

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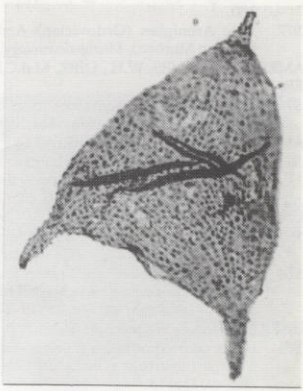

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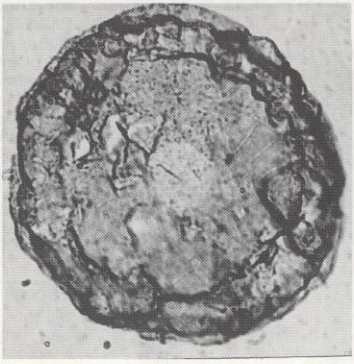

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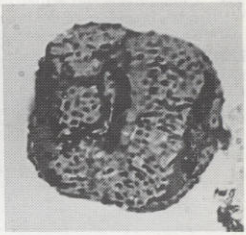

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## PLATE 3

All figures x1000.

1 *Arbusculidium filamentosum* (Vavrdová 1965) Vavrdová 1972.
2 *Marrocanium simplex* Cramer et al. 1974.
3 *Arbusculidium* sp.
4 *Striatotheca triangulata* (Cramer et al. 1974) Eisenack et al. 1976.
5 *Pirea baculifera* Tongiorgi et al. 1995.
6 *Striatotheca principalis* Burmann 1970.
7 *Peteinosphaeridium tenuifilosum* Tongiorgi et al. 1995.
8 *Coryphidium minutum* Cramer & Déz 1976.
9 *Peteinosphaeridium armatum* Tongiorgi et al. 1995.



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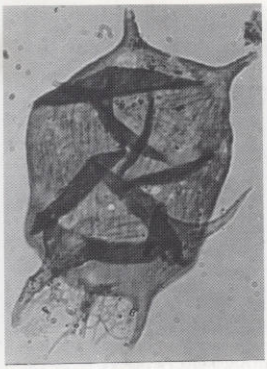

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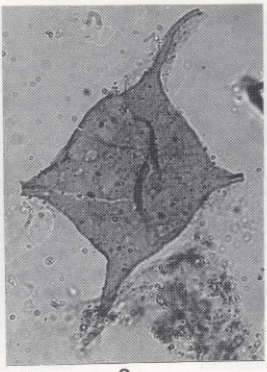

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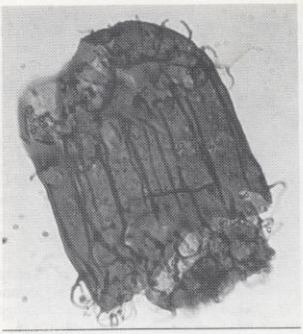

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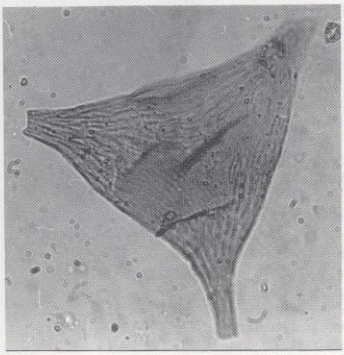

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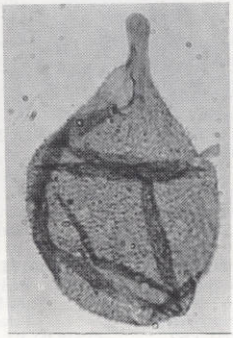

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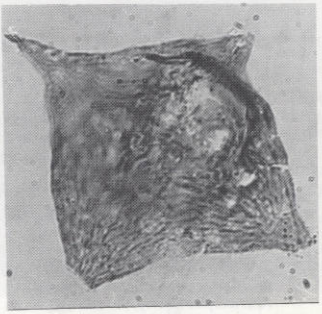

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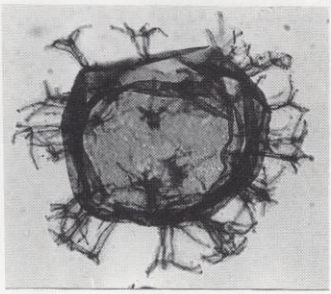

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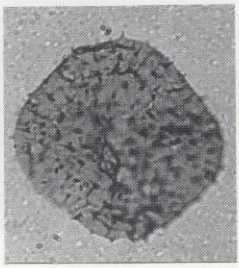

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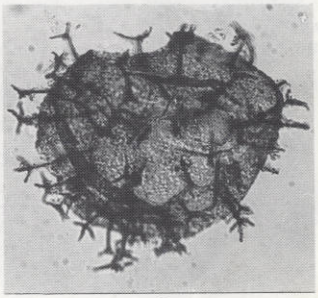

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## PLATE 4

All figures x1000.

1 *Rhopaliophora palmata* (Combaz & Peniguel 1972) emend. Playford & Martin 1984.

2, 3 *Rhopaliophora mamilliformis* Lu 1987.

4, 6 *Cymatiogalea deunffii* Jardiné, Combaz et al. 1974.

5 *Vulcanisphaera britannica* Rasul 1976.

7 *Athabascaella playfordii* Martin 1984.

8 *Pirea baculifera* Tongiorgi et al. 1995.

9 *Rhiptosocherma improcera* (Loeblich 1970) Loeblich & Tappan 1978.



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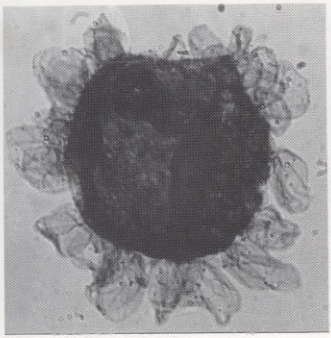

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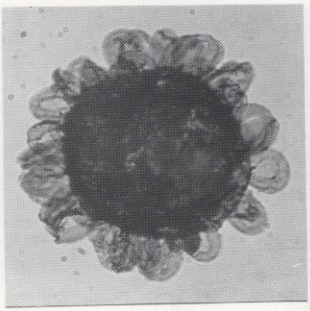

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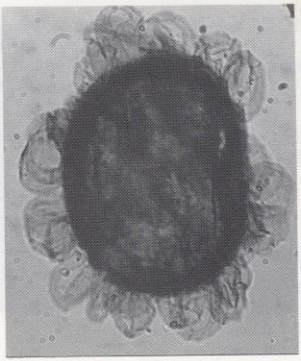

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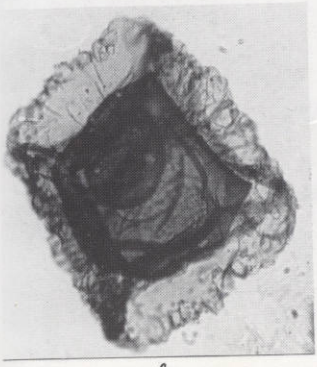

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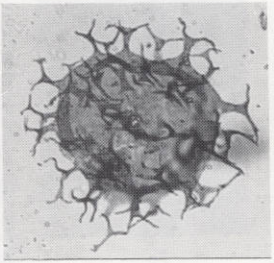

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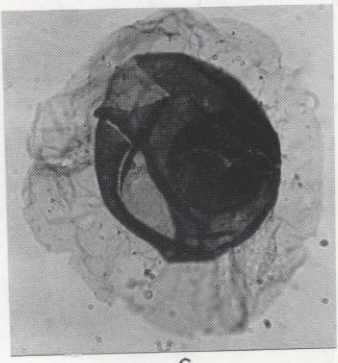

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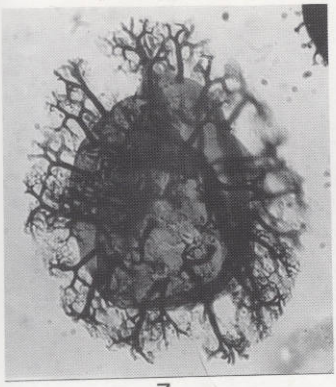

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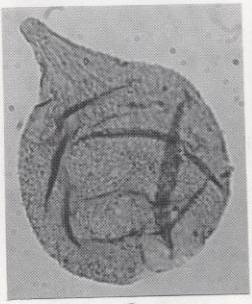

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Iran

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## PLATE 5

All figures x1000.

1, 6 *Peteinosphaeridium robustiramosum* Tongiorgi et al. 1995.
2, 5 *Coryphidium elegans* Cramer et al. 1974.
3 *Peteinosphaeridium velatum* Kjellström 1971.
4, 7 *Peteinosphaeridium angustilaminae* Playford et al. 1995.
8 *Pirea baculifera* Tongiorgi, Yin & Di Milia 1995.
9 *Peteinosphaeridium angustilaminae* Playford et al. 1995.



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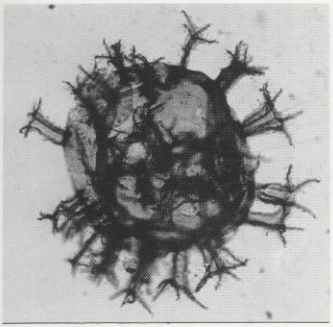

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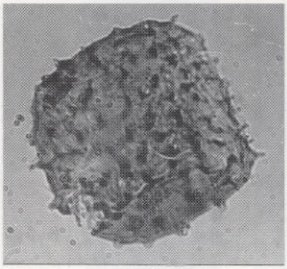

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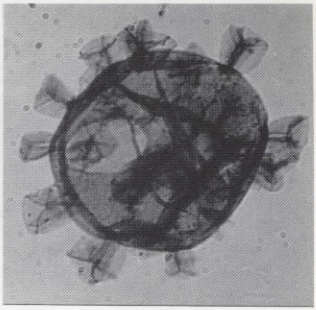

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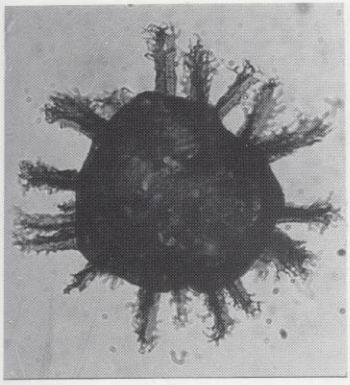

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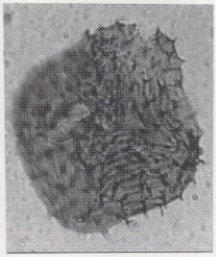

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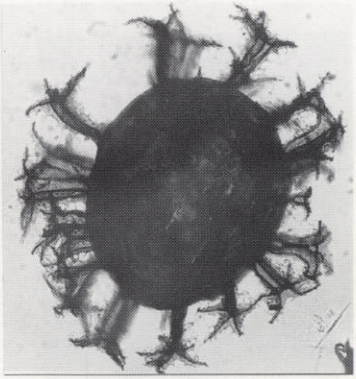

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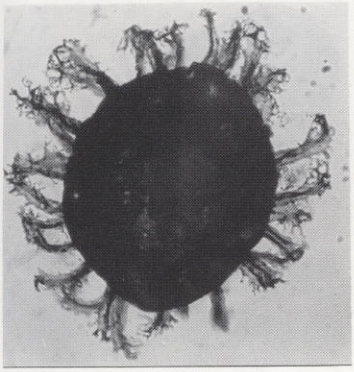

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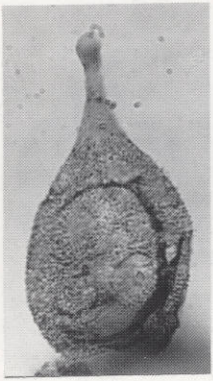

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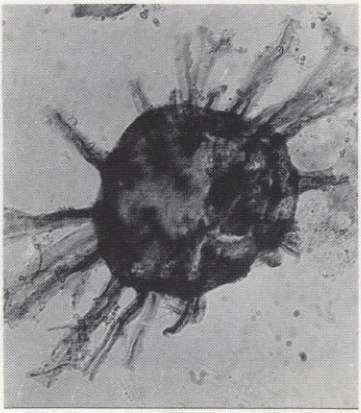

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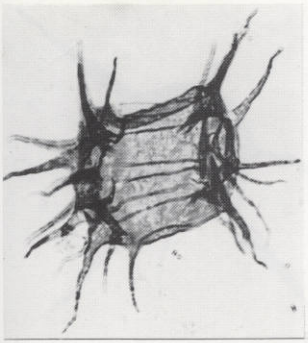
## PLATE 6

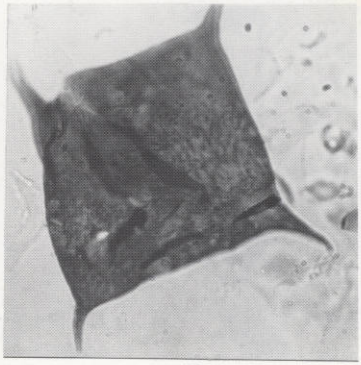
All figures x1000 except number 2.

1 *Actinotodissus crassus* Loeblich & Tappan 1978.
2 *Dactylofusa striata* (Staplin et al. 1965) Fensome et al. 1990 ( x500).
3 *Striatotheca rugosa* Tongiorgi et al. 1995.
4 *Villosacapsula setosapellicula* (Loeblich) Loeblich & Tappan 1976.
5 *Veryhachium reductum* (Deunff 1959) Jeknowsky 1961.
6 *Navifusa ancepsipuncta* Loeblich 1970.
7 *Veryhachium subglobosum* Jardiné et al. 1974.
8 *Veryhachium oklahomense* Loeblich 1969.



1

2



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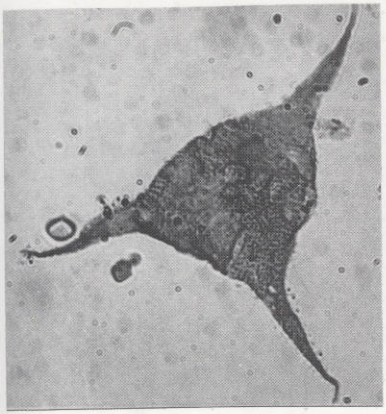

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5

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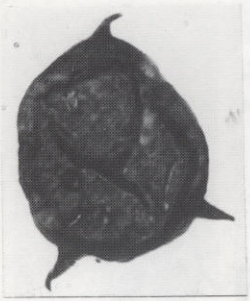


7

8

## *PLATE 7*

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

1, 4 *Orthosphaeridium insculptum* Loeblich 1969.

2 *Navifusa ancepsipuncta* Loeblich 1970 (x1000).

3 *Orthosphaeridium ternatum* (Burmann 1970) Eisenack et al. 1976.

5 *Orthosphaeridium inflatum* Loeblich 1969.

6 *Baltisphaeridium perclarum* Loeblich & Tappan 1978.

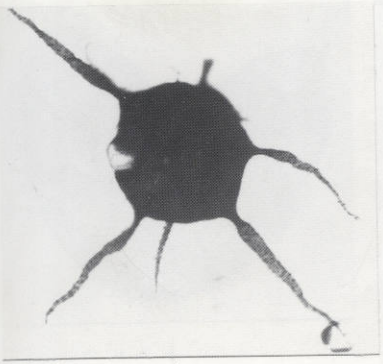
7 *Ordovicidium elegantulum* Tappan & Loeblich 1971 (x1000).

8 *Poikilofusa spinata* Staplin et al. 1965 (x1000).

9 *Diexallophasis denticulata* (Stockmanns & Williéré 1963) Loeblich 1970 (x1000).

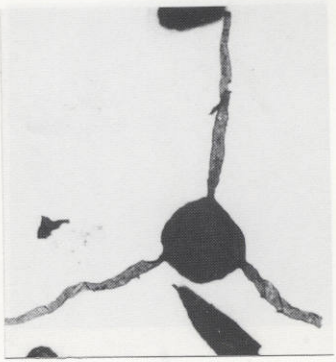


1+9



1

2



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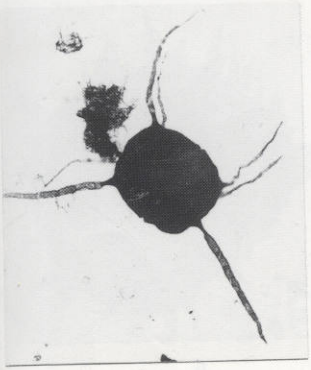

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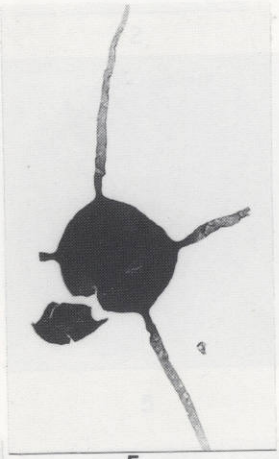

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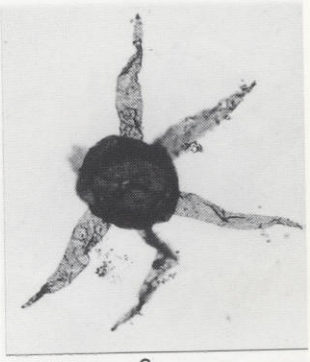

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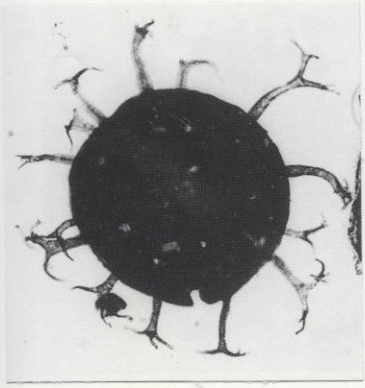

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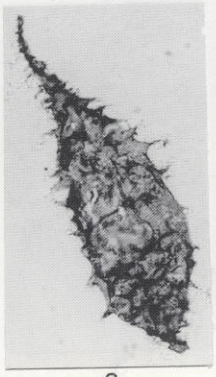

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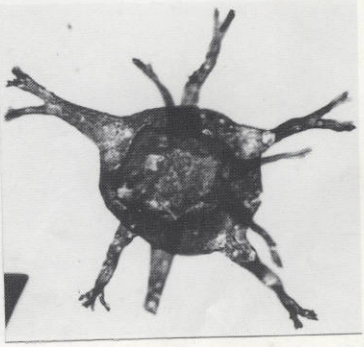
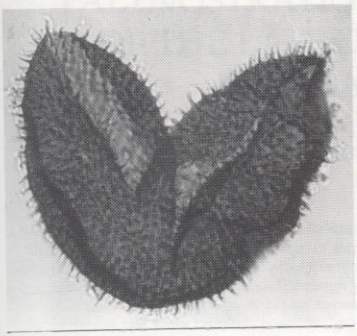


9

## PLATE 8

All figure x1,000.

1 *Helosphaeridium clavispinulosum* Lister 1970.
2 *Dactylofusa estillis* Cramer & Díez 1972.
3 *Dactylofusa striatifera* (Cramer 1964) Fensome et al. 1990.
4 *Visbysphaera oligofurcata* (Eisenack 1959) Hill 1974.
5 *Tunisphaeridium tentaculiferum* (Martin 1967) Cramer 1970.
6 *Visbysphaera brevifurcata* (Eisenack 1954) Le Hérissé 1989.
7 *Visbysphaera pirifera* (Eisenack 1954) Lister 1970.
9 *Multiplicisphaeridium neaghae* Cramer 1970.



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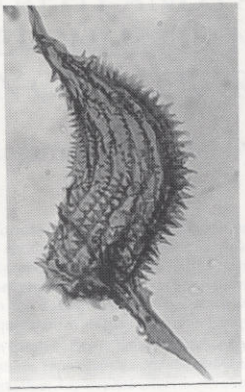

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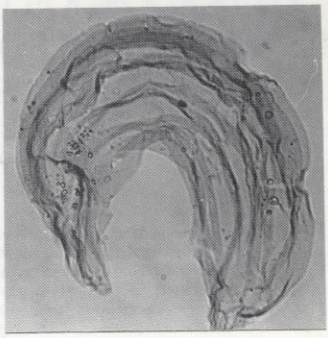

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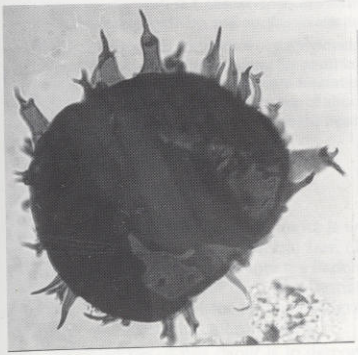

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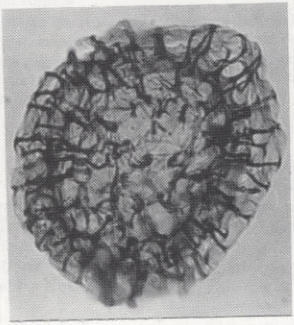

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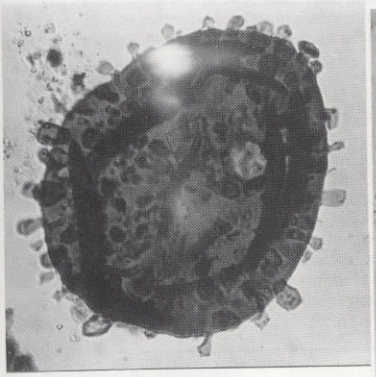

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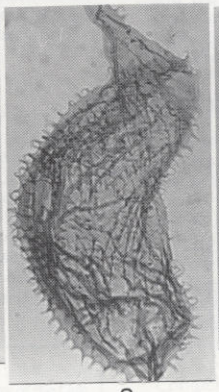

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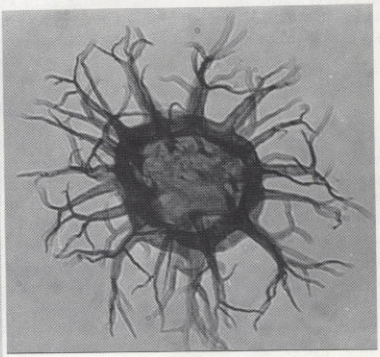

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