PALYNOLOGICAL STUDY OF PALEOZOIC SEDIMENTS OF THE CHAL-I-SHEH AREA, SOUTHWESTERN IRAN

M. Ghavidel-Syooki

National Iranian Oil Company, P.O. Box 1065 Tehran, Islamic Republic of Iran

Abstract

The Paleozoic sediments of the Chal-i-Sheh area in southwestern Iran comprising of Mila Formation, Ilebek Formation and Faraghan Formation, were studied palynologically. The samples containing well-preserved palynomorphs include *acritarchs, chitinozoans, scolecodonts* and *pollen/spores*. A palynological zonation has been established and comparison was made with other parts of the world. Based on stratigraphic potential of the diagnostic taxa, the Mila Formation is uppermost Cambrian to lowermost Tremadocian, Ilebek Formation Tremadocian and the Faraghan Formation is Lower Permian. Therefore, there is a hiatus within the Paleozoic sequence of the Chal-i-Sheh area extending from Upper Ordovician into the Lower Permian. This hiatus possibly coincides with Hercynian Orogeny which resulted in the emergence of the Zagros Basin and produced extensive erosion. Comparing palynomorphs of the Paleozoic sediments of Chal-i-Sheh with published palynological data, reveals that the Zagros Basin has been part of the "Mediterranean Acritarch Province" during the Lower Ordovician. The presence of gondwanic palynomorphs within the Faraghan Formation suggests a gondwanic relationship in the Permian period.

Introduction

The study area is called Chal-i-Sheh which is located in the western part of the Zagros Basin, southern Iran (Fig.1). The stratigraphic sequence of Chal-i-Sheh ranges in age from Cambrian to Quaternary. J.V. Harrison (1932) of the Anglo-Iranian Oil Company visited the area in the course of a geological reconnaissance. Then, Chal-i-Sheh was visited by F. Szabo, *et al.* (1977). They measured and sampled the whole Paleozoic sequence of the study area. The Paleozoic sequence in Chal-i-Sheh is 1700 meters thick and consists mainly of dark-gray shale, siltstone, sandstone with a few limestone stringers. The Paleozoic sequence of Chal-i-Sheh has been divided into the Mila Formation, Ilebek Formation, and Faraghan Formation by F. Szabo (1977). The Mila Formation and Ilebek Formation contain abundant Brachiopods and the Faraghan Formation has plant remains in the lower part and echinoid fragments in the upper part. The Mila Formation and Ilebek Formation have been tentatively assigned to the Middle-Upper Cambrian. The plant remains of the Faraghan Formation collected by J.V. Harrison (1932) were identified as *Sigillaria persica* by A.C. Seward (1932). Based on this plant species, Seward suggested Upper Carboniferous (Westphalian) or Lower Permian for the Faraghan Formation. In this study, the Paleozoic sequence of the Chal-i-Sheh area was investigated palynologically in

Keywords: Acritarchs of Ordovician; Palynology of Chal-i-Sheh; Palynology of South western Zagros; Acritarchs of Cambrian; Pollen/Spores of Early Permian

order to identify the diagnostic palynomorph taxa and to give a more complete evaluation of biostratigraphic potential of palynomorph taxa as well as the paleogeographic relationships of the Zagros Basin with other parts of the world.

Sample Preparation and Analytical Techniques

A total of one-hundred samples from the Paleozoic sequence of the Chal-i-Sheh area, southwestern Iran, were selected for this study. 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 separate the organic residues from inorganic materials. Then three unoxided slides from each sample were made for environmental indicators. The rest of residues were treated by Schultz'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 photography. Kodak Panatomic X film (32 ASA/16 Din) was used. The developing and printing process was carried out using existing facilities at the laboratory of the National Iranian Oil Company. Identification of various palynomorphs was accomplished using those methods described and illustrated in the most available literature. All slides are stored in the paleontology collections of the N.I.O.C.

Palynological Discussion

It is common practice to use both individual taxa and assemblage palynomorph taxa for correlating Paleozoic sequences. Individual taxa are used with caution and their local stratigraphic ranges are controlled, to some extent, by depositional factors.

The various species of an assemblage responds somewhat differently during the depositional processes due to differences in size, shape and structure. Some winnowing occurs and certain taxa that are abundant in one depositional environment may be less common or even absent in another. For the purposes of zonation and correlation, it is common to employ assemblage taxa which are characterized by several relatively distinct forms. The presence of a substantial number of index taxa would be sufficient to identify a zone. Based on this method, palynologists have recognized palynomorph assemblage zones in the British Isles [24], Northern Norway [65,80], Belgium [74], France [62], Algeria [44], the Canadian Arctic Islands [58], Central Poland [73], Arabian Peninsula [38] and Iran [32].

One of the objectives of this investigation is to compile the known range of palynomorphs in Chal-i-Sheh and compare them with those that have been reported from other parts of the world.

In this study, 52 pollen/spores and acritarchs representing 43 morphotype genera have been identified from the Paleozoic sequence of the Chal-i-Sheh area (Plates 1-6). The stratigraphic distribution of these forms has been plotted in Figure 2. Four successive palynomorph assemblage zones have been recognized in this investigation:

Acritarch Assemblage Zone I:

This zone begins close to the base of the Mila Formation and is about 300 meters at the Chal-i-Sheh area.

This zone is characterized by the presence of *Zonosphaeridium ovillensis, Cristallinium cambriense, Timofeevia lancarae, Timofeevia phosphoritica* and *Vulcanisphaera frequens* most of which occur and continue into the succeeding zone, including *Timofeevia lancarae, Timofeevia phosphoritica* and *Vulcanisphaera frequens*. In the term of relative abudance, the dominant acritarch taxa are *T. lancarae, T. phosphoritica, Zonosphaeridium ovillensis* and *Cristallinium cambriense*. Based on the presence of these species, this assemblage zone is considered to be uppermost Cambrian to lowermost Tremadocian.

Acritarch Assemblage Zone II:

This zone begins with a few meters of fossiliferous limestone beds at the top of zone I. The thickness of this zone is 350 meters and is marked by the occurrence of *Vulcanisphaera nebulosa, Vulcanisphaera africana , Ooidium rossicum, Cymatiogalea cuvillieri, Priscogalea guitieri, Priscogalea tumida, Priscogalea glabra, Priscogalea cortinula, Acanthodiacrodium unigerminum, Acanthodiacrodium simplex* and *Acanthodiacrodium spinum*.

Several acritarch taxa including *Timofeevia lancarae* and *Timofeevia phosphoritica* also persist in the base of this assemblage zone. The dominant genera are *Vulcanisphaera, Acanthodiacrodium, Cymatiogalea* and

Priscogalea.

Based on the above index taxa this assemblage zone is considered to be Tremadocian. This assemblage zone is quite similar to those recorded from Lower Ordovician of Norway [80], Belgium [76,77], England [24,71,61,51], France [62], Morocco [13,20,17], Europe [78] and Iran [33].

Acritarch Assemblage Zone III:

This zone comprises 45 meters of the upper part of the Ilebek Formation. Zone III is characterized by the appearance of *Acanthodiacrodium angustum, A. echinatum, A. rectinerve, A. ubui, A. bicoronatum, A. complanatum, Lophodiacrodium torum, Leiofusa fragelaris, Goniosphaeridium dentatum, Arbusculidium mamillosum* and *Tectitheca sp.* Most of the taxa which occur in the underlying zone persist in this assemblage zone. The dominant genera in this zone are *Acanthodiacrodium, Lophodiacrodium* and *Arbusculidium.*

Based on the above acritarch taxa, this zone is considered to be the uppermost part of the Tremadocian. Therefore, based on the palynological data of zones II and III, the Ilebek Formation is related to the Lower Ordovician (Tremadocian). In general, this assemblage zone is similar to those recorded from Norway [80], Belgium [77], England [24], France [62] and Morocco [13,20]

Pollen Spore Assemblage Zone IV:

This assemblage zone begins at the base of the Faraghan Formation and extends to the whole thickness of the rock unit, with a thickness of 500 meters. This zone is marked by the disappearance of Ordovician acritarch taxa and the occurrence of gymnosperm pollen and lower vascular plant spores. The significant pollen species of this zone are:

Hamiapollenites perisporites, Vittatina costablilis, Potonieisporites granulatus, Fusacolpites fusus, Nuskoisporites triangularis, N. rotatus, Protohaploxypinus diagonalis, Sulcatisporites splendens, Ginkgocycadophytus cymbatus, Ephedripites ellipticus, Pityosporites giganteus, Striatopodocarpites sp. and *Alisporites sp.* In addition to the pollen species, the following spore species are also encountered in this zone. *Punctatisporites gretensis, Thymospora perverrucosa, Kraeuselisporites splendens, Calamospora microrugosa, Horriditriletes ramosus, Grandispora sp., Gulisporites cochlearius* and *Laevigatosporites vulgaris.*

A detailed, microscopic study of palynological samples of this zone reveals that the base of zone IV coincides with the appearance of pollen species such as *Vittatina costabilis, Hamiapollenites perisporites, Potonieisporites granulatus* and *Fusacolpites fusus.* Diversity within this zone rapidly increases with the appearance of pollen and spore species (Fig.2). Based on the above-mentioned index pollen and spore taxa, this zone is considered to be Lower Permian in age from part of Sakmarian to Kungurian. In general, this zone is correlatable with the *Vittatina costabilis* (VS) and *Disaccate striatiti* zones (DS) of Western Europe [11].

Some of the morphotype components of this zone are similar to those of the Lower Permian of Northern Iran [12], Southeastern Iran [32], the United States [69], Turkey [1], Arabian Peninsula [39], Australia [64], Africa [44] and India [60,8]. Except for *Laevigatosporites vulgaris,* which is a Carboniferous relict form, the other pollen and spore species are diagnostic taxa of lower Permian. The palynological slides of this assemblage zone were examined for reworked palynomorphs. A few reworked specimens were observed in the lowermost part of the Faraghan Formation, including *Acanthodiacrodium spinum, Lophodiacrodium torum* and *Acanthodiacrodium complanatum.* All reworked forms have been extensively altered and they are quite rare in contrast to their abundance and excellent preservation in the Lower Ordovician samples. Based on these palynological data, there is a major "hiatus" in the Chal-i-Sheh area that lasted from the Upper Ordovician to the end of the Carboniferous period. Part of this diastem may represent non-depositional or the extensive erosion of the Upper Ordovician and Silurian-Devonian-Carboniferous sediments.

Conclusion

This study was undertaken to determine, more precisely, the geological age of the Paleozoic sequence of the Chal-i-Sheh area and to make an interpretion of the paleogeographic relationships of the Zagros Basin to Gondwana and Laurasia during the Paleozoic era. Fifty-two palynomorph taxa encountered in this investigation are included, 30 acritarchs (21 genera), 13 spores (13 genera) and 9 pollen (9 genera). Distribution of these taxa have been arranged in four ascending stratigraphic assemblages.

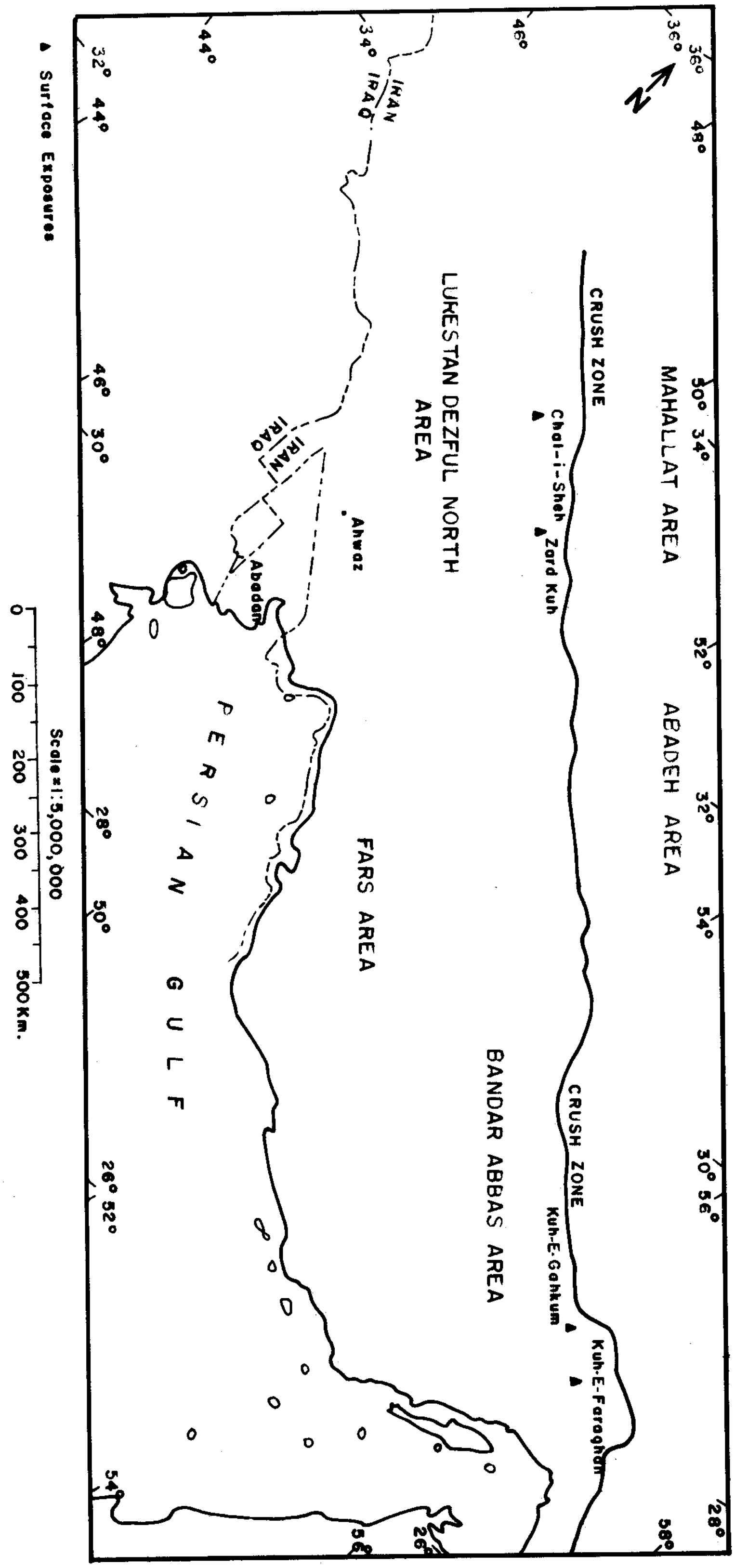

Fig. 1. Location map of study area to the main Zagros thrust

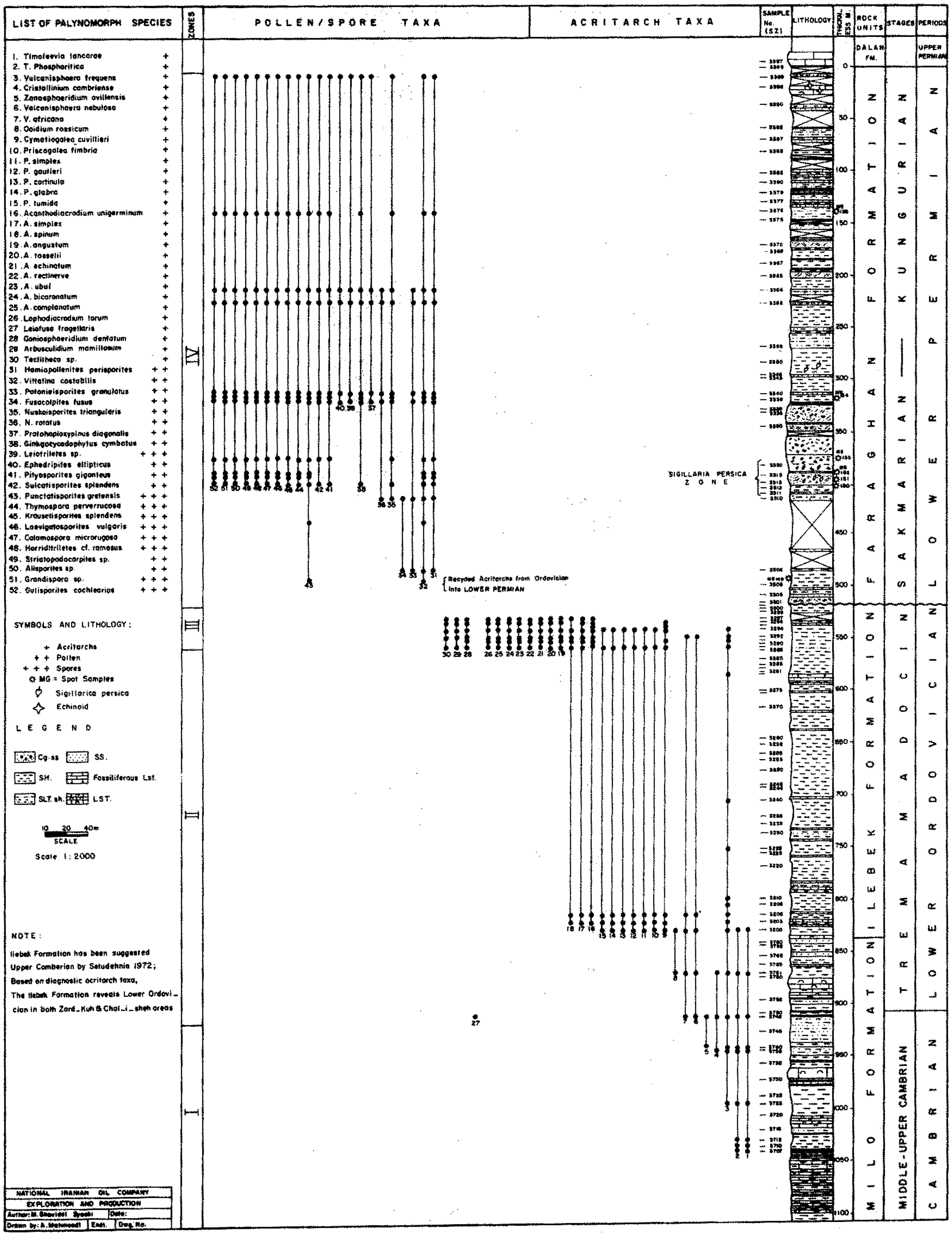

Fig. 2. Stratigraphic distribution of pollen/spore & acritarch taxa throughout palaeozoic sequence at chal-i-sheh area

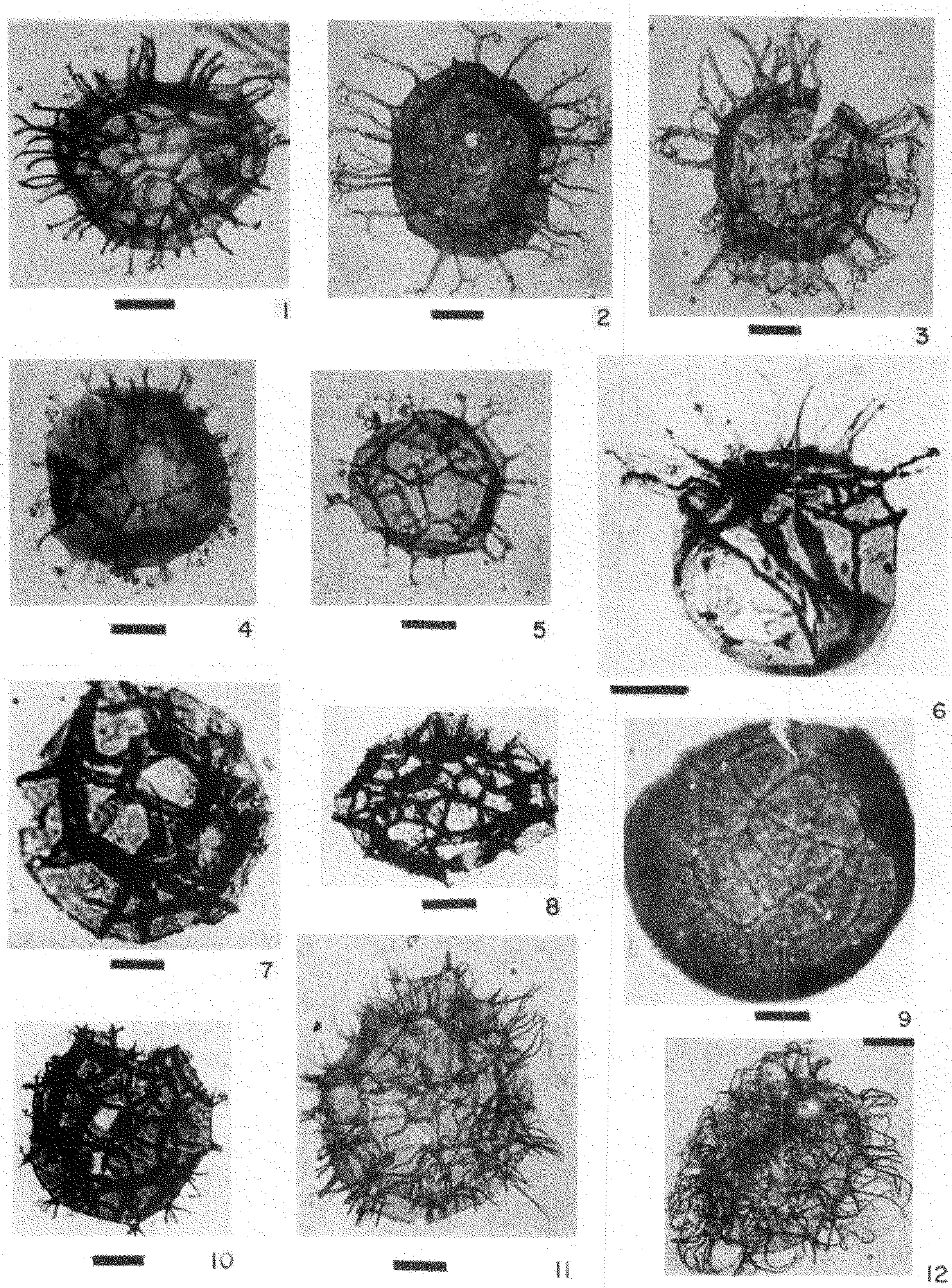

Plate 1

Fig.1. *Timofeevia lancarae* (Cramer & Diez, 1972) Vanguestaine, 1978.
Figs.2-3. *Timofeevia phosphoritica* Vanguestaine, 1978.
Figs.4-5. *Timofeevia lancarae* (Cramer & Diez, 1972) Vanguestaine, 1978.
Fig.6. *Ooidium rossicum* Timofeev, 1957.
Figs.7-8. *Cristallinium cambriense* (Slavikova) Vanguestaine, 1978.
Fig.9. *Zonosphaeridium cambriense* Cramer & Diez, 1972.
Fig.10. *Vulcanisphaera frequens* Gorka, 1967.
Fig.11. *Vulcanisphaera nebulosa* Deunff, 1961.
Fig.12. *Vulcanisphaera africana* Deunff, 1961.

Scale bar is 10 micrometers.

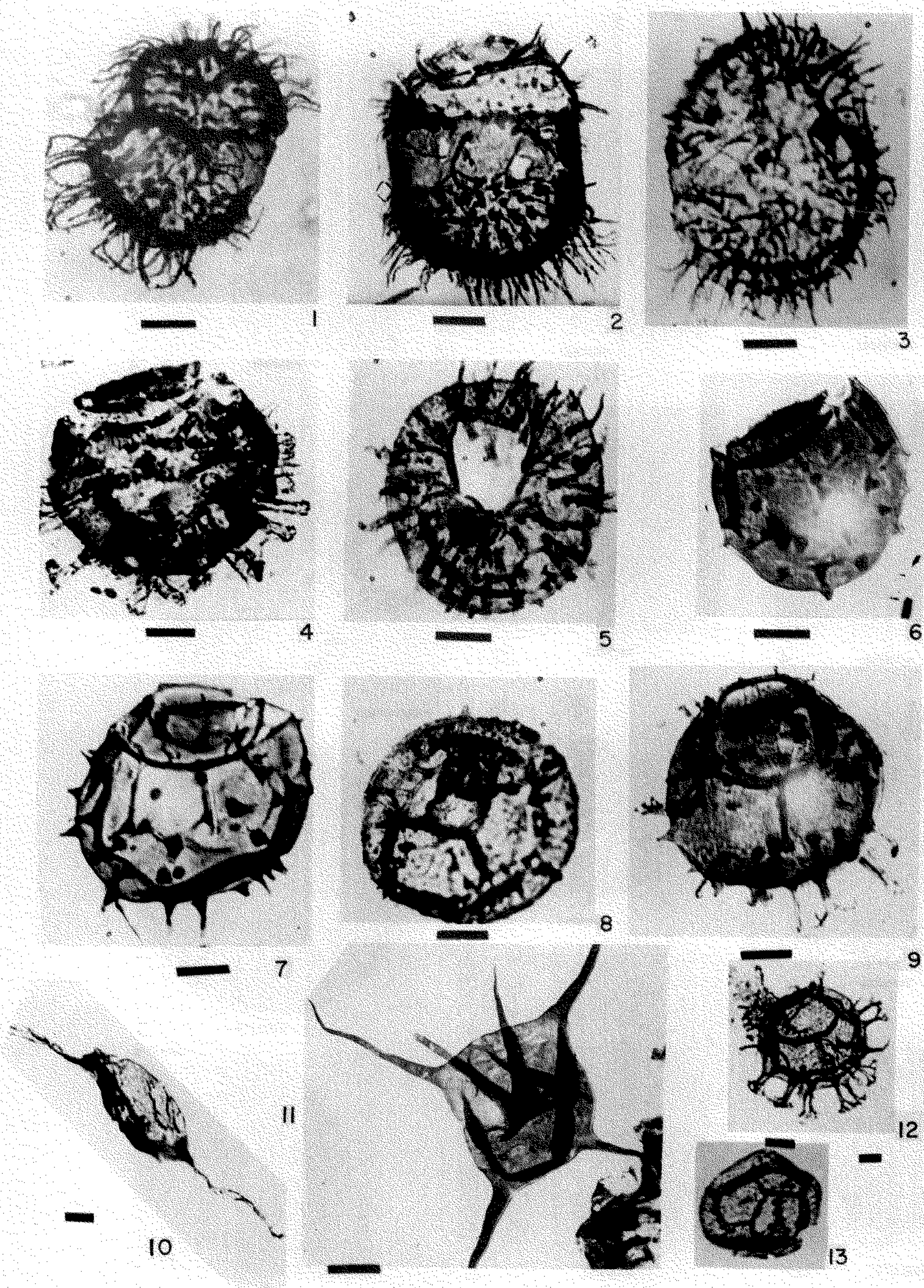

Plate 2

Fig.1. *Acanthodiacrodium bicoronatum* Welsch, 1986.
Figs.2-3. *Acanthodiacrodium ubui* Martin, 1986.
Fig.4. *Priscogalea cortinula* Deunff , 1961.
Fig.5. *priscogalea fimbria* Rasul, 1974.
Fig.6. *Priscogalea glabra* Martin, 1972.
Fig.7. *Cymatiogalea cuvillieri* (Deunff) Cramer & Diez, 1973.
Figs. 8&13. *Cymatiogalea cuvillieri* (Deunff) Cramer & Diez, 1973.
Figs.9&12. *Priscogalea gautieri* Martin, 1972.
Fig.10. *Leiofusa fragellaris* Burmann, 1986.
Fig.11. *Tectitheca sp.*

Scale bar is 10 micrometers.

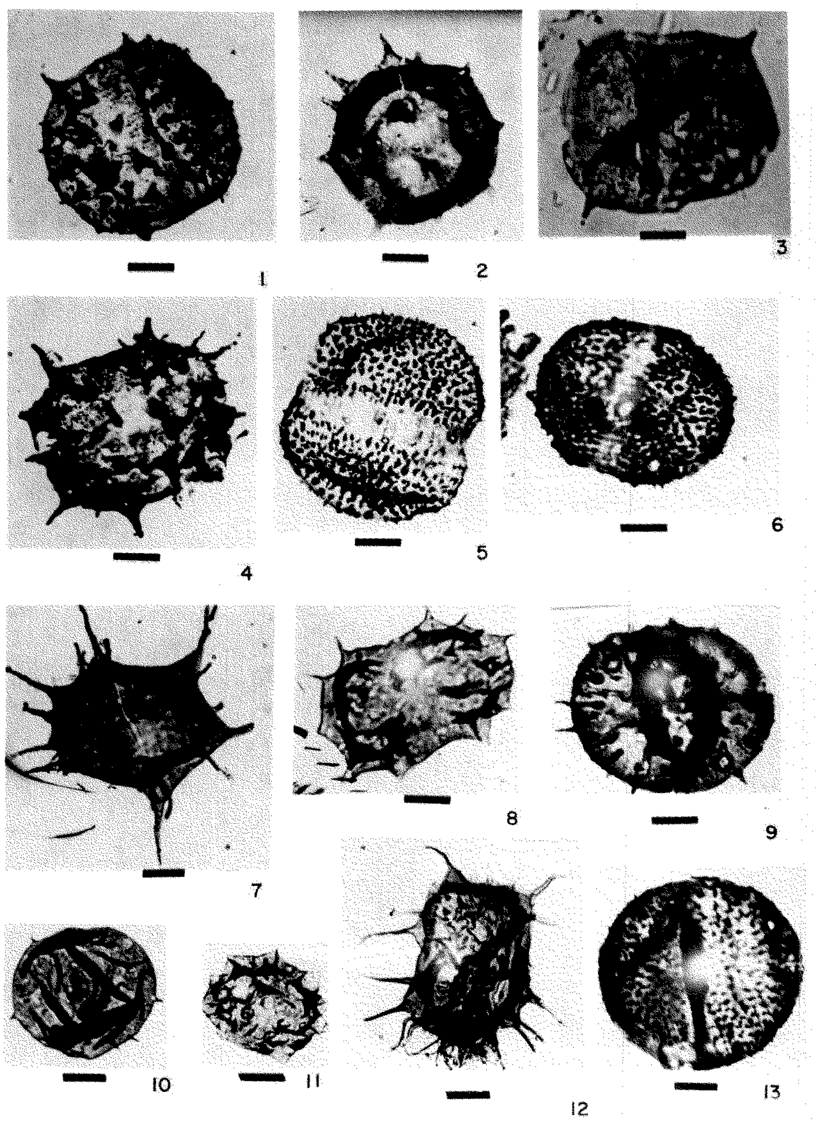

Plate 3

Fig.1. *Acanthodiacrodium rectinerve* Burmann, 1968.
Fig.2. *Goniosphaeridium dentatum* Timofeev, 1959.
Fig.3. *Priscogalea tumida* Deunff, 1961.
Fig.4. *Acanthodiacrodium spinum* Rasul, 1979.
Figs.5-6. *Acanthodiacrodium angustum* (Downie 1958) Combaz, 1968.
Fig.7. *Acanthodiacrodium complanatum* (Deunff, 1961) Cocchio, 1982.
Fig.8. *Acanthodiacrodium tasselii* Martin, 1969.
Fig.9. *Acanthodiacrodium echinatum* (Timofeev, 1959), Deflandre & Deflandre-Rigaurd, 1962.
Fig.10. *Acanthodiacrodium simplex* Combaz, 1967.
Fig.11. *Acanthodiacrodium unigerminum* (Timofeev, 1959), Deflandre & Deflandre-Rigaurd, 1962.
Fig.12. *Arbusculidium mamillosum* Welsch, 1986.
Fig.13. *Lophodiacrodium torum* Rasul, 1979.

Scale bar is 10 micrometers.

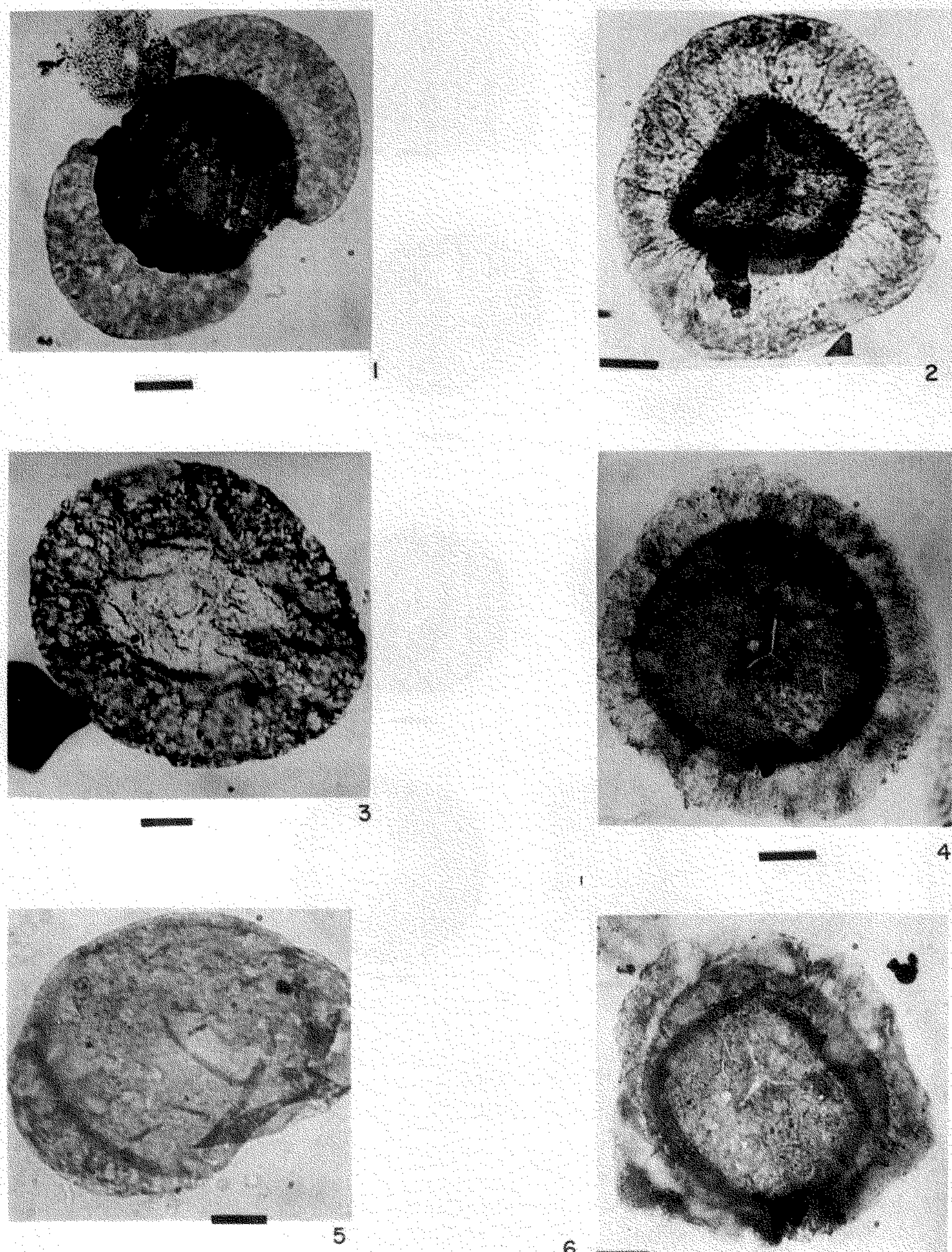

Plate 4

Fig.1. *Striatopodocarpites sp.*
Fig.2. *Nuskoisporites rotatus* Blame & Hennelly, 1965.
Fig.3. *Potonieisporites granulatus* Bose & Kar, 1966.
Fig.4. *Nuskoisporites triangularis* Potonie & Lele, 1959.
Fig.5. *Pityosporites giganteus* Balme & Hennelly 1955.
Fig.6. *Nuskoisporites triangularis* Potonie & Lele, 1959.
Scale bar is 10 micrometers.

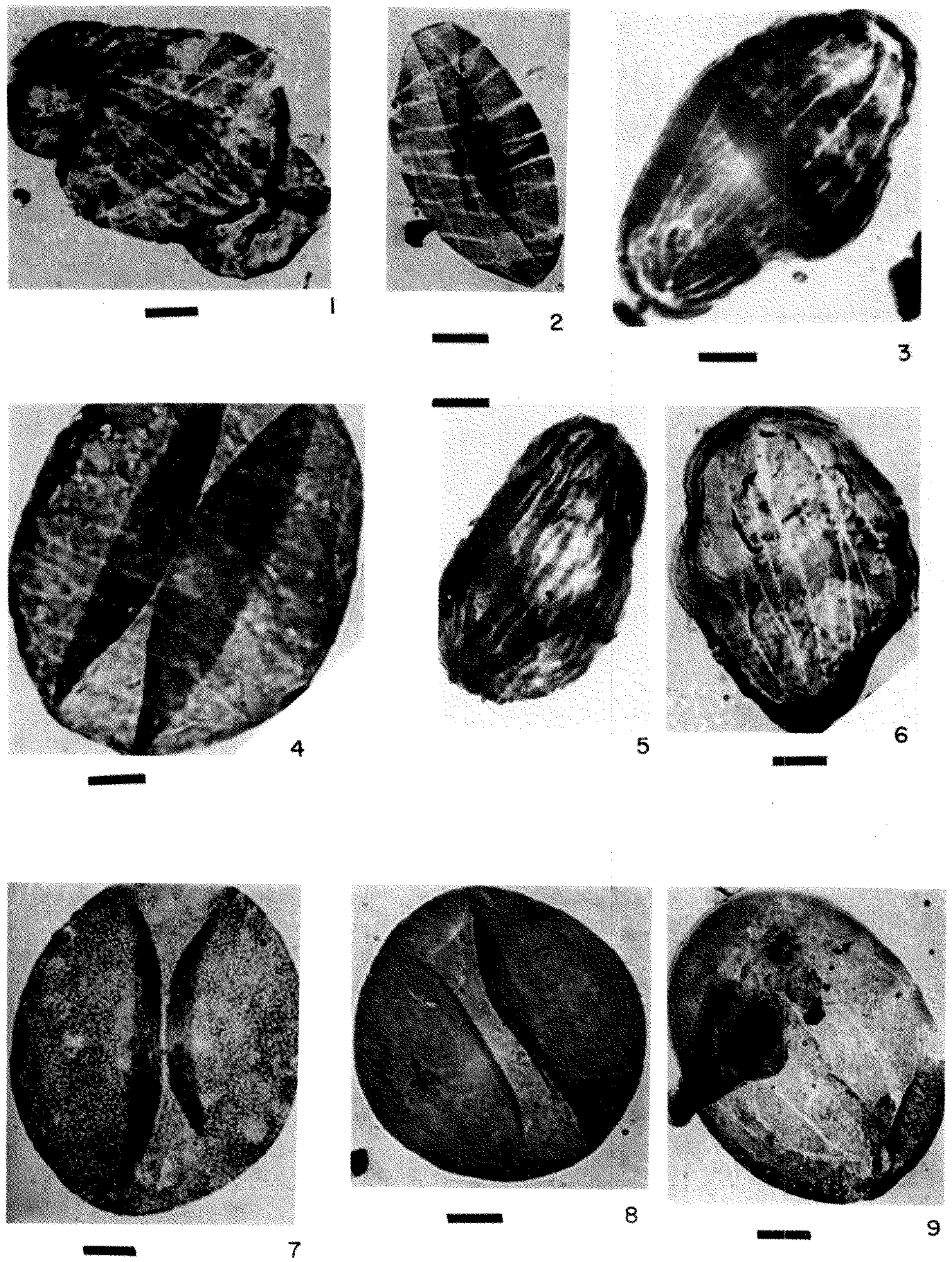

Plate 5

Fig.1.	*Hamiapollenites perisporites* (Jizba) Tschudy & Kosanke, 1966.
Figs.2&4.	*Fusacolpites fusus* Bose & Kar, 1966.
Figs.3&6.	*Vittatina costabilis* (Wilson) Tschudy & Kosanke, 1966.
Fig.5.	*Ephedripites ellipticus* Kar, 1966.
Fig.7.	*Ginkgocycadophytus* cf. *cymbatus* (Balme & Hennelly) Potonie & Lele, 1961.
Fig.8.	*Ginkgocycadophytus cymbatus* (Balme & Hennelly) Potonie & Lele, 1961.
Fig.9.	*Protohaploxypinus diagonalis* Balme, 1970.

Scale bar is 10 micrometers.

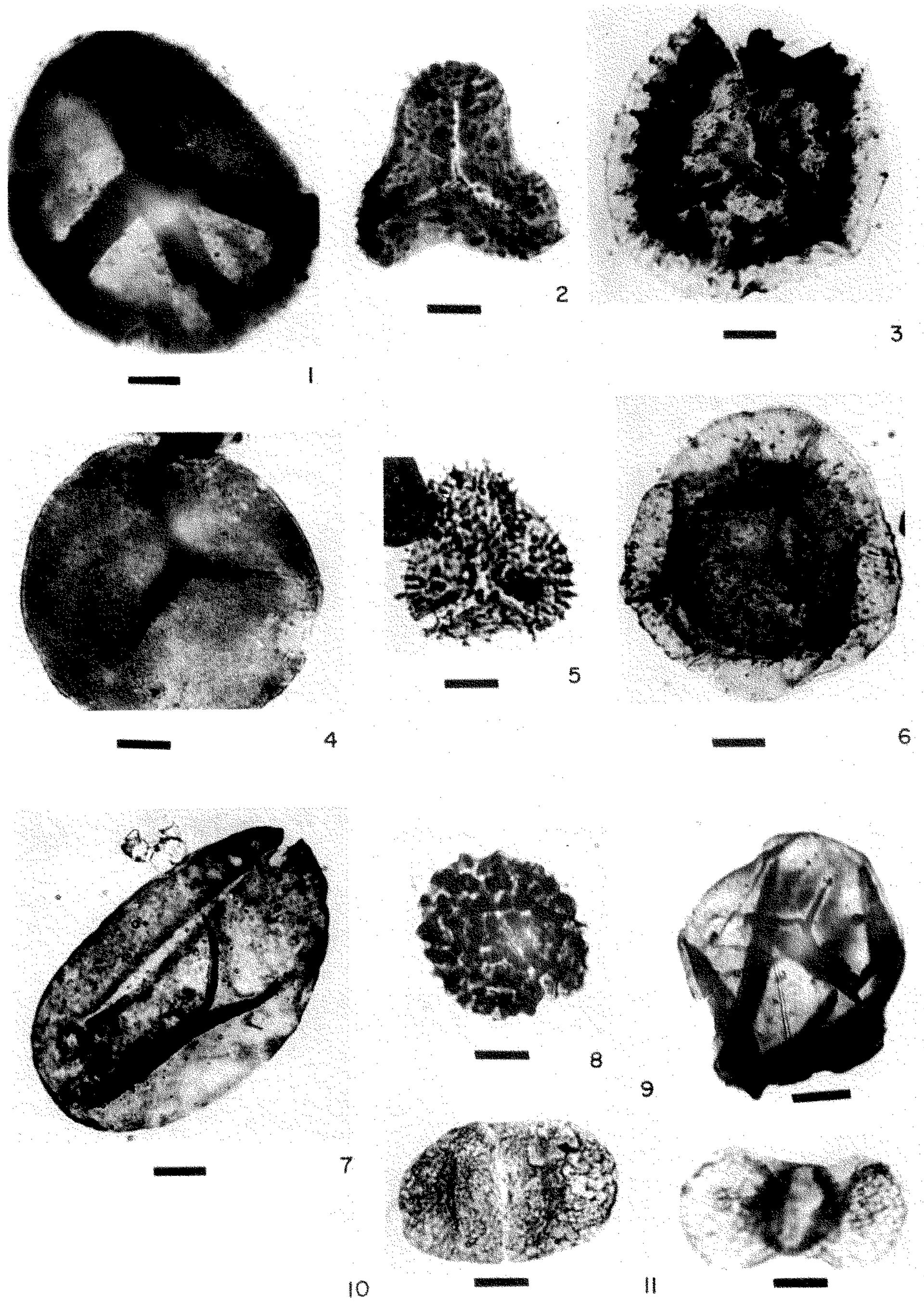

Plate 6

Fig.1.	*Gulisporites cochlearius* Imgrand, 1960.
Figs. 2&5.	*Horriditriletes remosus* (Balme & Hennelly) Bharadwaj & Salujha, 1964.
Fig.3.	*Kraeuselisporites splendens* (Balme & Hennelly) Segroves, 1970.
Fig.4.	*Punctatisporites gretensis* Balme & Hennelly, 1956.
Fig.6.	*Grandispora sp.*
Fig.7.	*Laevigatosporites vulgaris* Ibrahim, 1933.
Fig.8.	*Thymospora perverrucosa* (Alpern) Wilson & Venkatachala, 1963.
Fig.9.	*Calamospora microrugosa* (Ibrahim) Schopf, Wilson & Bentall, 1944
Fig.10.	*Sulcatisporites splendens* Leschik, 1966.
Fig.11.	*Alisporites* sp.

Scale bar is 10 micrometers.

According to palynological data, the Mila Formation is assigned to uppermost Cambrian and lowermost Tremadocian (zone I), the Ilebek Formation is considered to be Lower Ordovician (zones II & III) and the Faraghan Formation is related to Lower Permian at the Chal-i-Sheh. Based on these assemblage zones, there is a "hiatus" within the Paleozoic sequence of the Chal-i-Sheh area extending from the Upper Ordovician to the end of Carboniferous period. This major hiatus possibly coincides with the Hercynian Orogeny that resulted in the emergence of this part of the Zagros Basin. A hiatus may be produced by extensive erosion of the Upper Ordovician, Silurian, Devonian and Carboniferous sediments, or by a combination of non-deposition and erosion. The palynological associations of the Mila Formation and Ilebek Formation at the Chal-i-Sheh area, appear to be most similar to those of southern Europe, Morocco, Algeria and the Arabian Peninsula. Therefore, it can be suggested that this part of the Zagros Basin has been part of the "Mediterranean Acritarch Province" which extends from Belgium, France, Spain, southern Germany, Central Bohemia, Bulgaria and Northern Africa. Moreover, the Early Permian morphotypes derived from the Faraghan Formation of the Chal-i-Sheh area, to some extent, are similar to those discovered in Turkey, Europe, Northern Iran and the Arabian Peninsula. The presence of Gondwanic species such as *Fusacolpites fusus*, suggests a Gondwanic relationship.

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