Biostratigraphy of Faraghan formation in Zagros basin

In Iran, the palynological studies of upper paleozoic sediments are not complete unless sediments of the same interval from Zagros basin are added into the investigation. Furthermore, the reconstruction of the paleogeographic relationships of Iran to north and the south hemispheres during the Paleozoic intervals without considering the effects of Zagros is not conclusive or complete. For this reason a thick sequence of paleozoic strata called "Faraghan formation" has been selected for this purpose. As distribution of this formation is wide and it extends all over the Zagros basin of Iran. This unit was named from one of the best developed and most accessible sections at Kuh-e-Faraghan. Thickness of this clastic deposits varies from place to place and it may differ in thickness from 100 to 500 meters. Another reason for the selection of Faraghan formation is the productivity of this rock unit from the palynological point of view. As this formation has always been known barren from any marine or non-marine and microscopic or non-microscopic fossils. From the processed samples of this rock unit a total of 136 acritarch , spore and pollen species have been identified. Out of this number of palynomorphs 19 genera and 26 species are acritarch , 36 genera and 59 species are spores and 33 genera and 51 species are pollen. This palynofloral collection gives the precise geological age determination for this rock unit and resolve the contorversy age problem. This palynomorph collection has enabled the author to interpret the paleogeographic relationships and paleoenivronment of the depositional site of formation. Based on the encountered palynomorph taxa five biostratigraphic zones are identified in the Faraghan formation (Figs. 5-6). Zones I through IV represent part of Lower Devonian into Middle-Upper Devonian (Gedinnian - Frasnian) while zone V represents Lower Permian which begins from Sakmarian and ending into Kungurian time. This finding indicates existence of a hiatus within the Faraghan formation. This break encomposes from Famennian , the whole Carboniferous system into the Lower Permian. This hiatus possibly coincides with the Hercynian Orogeny that resulted in emergence of

this part of Zagros basin. The recognized five biostratigraphic assemblage zones of the Faraghan formation are as follows:

Assemblage zone I

This zone starts at the base of Faraghan formation and continues upwards to about 100 meters from the bottom of both study sections in the Faraghan area (Figs. 5-6). This zone is characterized by *Ambitisporites avitus* , *Chelinospora* spp., and *Retusotriletes dittonenesis.* Longer-ranging spore species also occur in this zone and continue into the succeeding zones , including *Cyclogranulatisporites rotundus* , *Cymbosporites catillus* , *Cymbosporites cyathus* , *Retusotriletes distinctus* , *Retusotrileles dubiosus* , *Retusotriletes rotundus* , and so on. Near the 15 meters top of this zone the genus, Emphanisporites appears, and includes the species of *E.annulatus* , *E.erraticus* , and *E.rotatus.*

Acritarch species also occur in this interval, consisting of *Cymatiosphaera perimembrana* , *Gorgonisphaeridium* spp. , *Leiosphaeridia* spp., *Lophosphaeridium segregum* , *Polyedryxium decorum* , and *Veryhachium trispinosum.*

In terms of relative abundance, the dominant species are *Ambitisporites avitus* , *Retusotriletes dittonensis* , *Chelinospora* spp. , *Gorgonisphaeridium* spp. , *Leiosphaeridia* spp., and *Lophosphaeridium segregum.* Based on the presence of *Retusotriletes dittonensis* , *Ambitisporites avitus* , *Emphanisporite annulatus* , and *Emphanisporites erraticus* , this assemblage zone is considered to be Lower Devonian, probably Gedinnian to Emsian. In general, this assemblage zone is low in number of spore and acritarch species, which are simple and small in size (30-50 um).

Spore assemblage zone II

This zone begins with a conglomeratic bed at the top of zone I in both study sections. The thickness of this zone is 35 meters in section one and 42.5 meters in section two. This zone is recognized by occurence of *Acinosporites ancanthomammillatus* , *Apiculiretusispora granulata* , *Auroraspora aurora* ,

Auroraspora macromanifestus , *Bullatisporites bullata* , *Calyptosporites velatus* , *Cymbosporites cyathus* , *Cymbosporites catillus* , *Densosporites devonicus* , *Dibolisporites eifeliensis*, *Emphanisporites orbiculris* , *Emphanisporites rotatus* , *Grandisporites longus* , *Grandispora mammillata* , and *Rhabdosporites langi*. Several longer- ranging acritarch and spores which also occur in zone I are present, in this zone including *Cymatiosphaera Perimembrana* , *Gorgonisphaeridium abstrusum* , *Gorgonisphaeridium disctssum* , *Leiosphaeridia* sp. , *Polyedryxium decorum* , *Veryhachium trispinosum* , *Calamospora pannucea* , *Retusotriletes distinctus* , *Retusotriletes dubiosus* , and *Retusotriletes rotundus*. Moreover a few typical Lower Devonian forms occur at the base of this zone , such as *Emphanisporite annulatus* and *Emphanisporites erraticus*. The dominant genera are *Acinospora* , *Apiculiretusispora*, *Bullatisporites*, *Retusotriletes* and *Leiosphaeridia* (figs.5,6).

This assemblage zone is considered to be Middle Devonian and is correlatable with those from the Middle Devonian of France, Fedral Republic of Germany, Canadian Arctic Islands, England, Belgium, Poland and Saudi Arabia. However, This assemblage zone differs from the Middle Devonian assemblage zones of Europe and North America in lacking bifurcate spore genera such as *Hystricosporites* and *Ancyrospora* , but the Faraghan zone is quite similar to zone III and IV of the Arabian Peninsula (Hemer& Nygreen,1967).

Assemblage zone III

This zone covers 50.7 meters of section one and 20 meters of section two. It is marked by appearance of *Geminospora antaxios* , *Geminospora micropaxilla* , and *Geminospora punctata* , *Raistrickia aratra* , *Retusotriletes rugulatus* , and *Retispora lepidophyta*. This zone is also characterized by a reduction in numbers of spore species which had previously appeared in zone II, such as *Calyptosporites velatus* , *Dibolisporites eifeliensis* , *Emphanisporites rotatus* , *Grandispora longus* , *Grandispora mammillata* and *Rhabdosporites langi*. A few acritarch taxa that occur in the underlying zone persist in this zone but none are well represented.

This zone is considered to be upper Givetion in age and includes some genera and species that become dominant in overlying zone IV. In general, this zone is similar to zones II and III in the Arabian Peninsula (Hemer & Nygreen,1967), and is also similar to those recorded from France, Germany and the Canadian Arctic Islands.

Assemblage zone IV

This zone is the youngest Devonian time-unit of the Faraghan formation in Kuh-e-Faraghan. This zone is 20 meters thick in section one and 30 meters in section two, and it is characterized by the almost complete disappearance of the taxa from underlying zones and the appearance of new spore species such as *Ancyrospora ampulla* , *A. ancyrea* , *A. grandispinosa, A. longispinosa* , *A. magnifica* , *Geminospora lemurata* , *Hystricosprites corystus* , *Retispora lepidophyta* , *Rugospora flexuosa* , *Spelaeotriletes crustus* , *Spinozonotriletes naumovii* and *Samarisporites triangulatus.* In addition to the spore species, several new acritarch taxa also appear in this assemblage zone , including *Chomotrileles bistchoene, Chomotriletes vedugensis* , *Deltotosoma intonsum* , *Dictyotidium granulatum* , *Duvernaysphaera tessella* , *Navifusa excilis* , *Papulogabata annulata* , *Somphophragma miscellum* and *Stellinium micropolygonale* (figs.5,6).

In terms of relative abundance, the dominant spore and acritarch species are: *Samarisporites triangulatus* , *Geminospore lemurata* , *Ancyrospora acyrea* , *A. ampulla* , *A. magnifica* , *A. grandispinosa* , *Spinozonotriletes naumovii* , *Hystricosporites corystus* , *Chomotriletes vedugensis* , *C. bistchoene, Deltotosoma intonsum* , *Navifusa excilis* , and *Papulogabata annulata.*

This zone is considered to be Frasnian in age based on the occurrence of stratigraphically diagnostic taxa such as *Samarisporites triangulatus* , *Geminospora lemurata, Chomotriletes vedugensis* , *C. bistchoense* , *Deltotosoma intonsum* and *Papulogabata annulata.* This zone is equivalent to those which have been recorded

from the Frasnian of Canadian Arctic Islands , China , Australia , Belgium and Lower Frasnian of France and the Arabian Peninsula.

One of the most marked aspects of this zone is the occurrence of bifurcating spinous spores, such as *Ancyrospora* and *Hystricosporites.* Species of these two genera have been recorded elsewhere from Middle Devonian deposits, suggesting the possibility of a Middle Devonian age assignment for this zone. But the numerous Upper Devonian index spore and acritarch species which are present , suggesting Frasnian age. Thus it must be assumed that bifurcate spinous spores are confined to the Upper Devonian in the Faraghan area. A similar pattern has been recorded by Hemer and Nygreen (1967) from the Frasnian of Arabian Peninsula. The similarity of spore assemblage zone of the Faraghan area with the Saudi Arabian zones suggests that these two areas were the same palaeophytogeographic province in the Upper Devonian.

The two study sections differ appreciably in the relative importance of the acritarch assemblage. This would suggest a high degree of diversity in source plant environments within the Devonian, in the Faraghan Basin, exerting strong control on the relative abundance of marine phytoplankton.

The Faraghan acritarch assemblage has some species in common with those recorded from the Frasnian of Europe and North America, including *Chomotriletes bistchoense* (Canada) and *Chomotriletes vedugensis* (U.S.S.R). However there are 10 acritarch species which have been recorded only from the Frasnian of Australia. Playford and Dring (1981) suggested a notable degree of endemism for the new acritarch species that they recorded from the Australian Gneuda formation. The presence of their acritarch species in the Faraghan formation implies the possiblility of marine continuity between Austrial and southeastern Iran.

Based on available palynological data, the Devonian portion of the Faraghan formation begins with the Lower Devonian (probably Gedinnian) and ends with the Frasnian (Possibly the Lower Frasnian).

Assemblage zone V

This assemblage zone just begins above the uppermost Devonian unit or zone IV and extends to the top of the Faraghan formation, with a thickness of about 40 meters. This zon is characterized by the appearance of many gymnospermous pollen species. The various pollen types of this zone contrast strongly with the spore-dominate Devonian zones. Significant pollen groups in zone V include:

1) Disaccate-striatiti pollen, with the greastest relative percentage about 60.0 of different palynomorph groups, including the following genera such as *Complexisporites* , *Corisaccites* , *Hamiapollenites* , *Kosankeisporites* , *Lueckisporites*, *Protohaploxypinus* , *Rhizomaspora* , *Striatoabietites* , *Striatopodocarpites*, and *Vittatina.*

2) Disaccate non-striatiti pollen (%5.1) such as *Hegiasaccites* , *Pityosporites* , *Platysaccus*, *Sulcatisporites*, and *Walikalesaccites.*

3) Monosaccite striatiti pollen group (%10) representing genera such as *Boutakoffites*, *Constapollenites*, *Decussatisporites* and *Mabuitasaccites.*

4) Monosaccite non-striatiti pollen (%9.15) including *Caheniasaccites* , *Nuskoisporites*, *Plicatipollenites* and *Potonieisporites.*

5) Polysaccate striatiti pollen (%1.8) such as Crustaesporites and *Schizopollis.*

6) Polycolpate (Polyplicate) pollen (%2.85) represented by genera such as *Ephedripites*, and *Schizaeoisporites.*

7) Monosulcate pollen (%5.5) represented by genera such as *Fuscacolpites* and *Ginkgocycadophytus.*

In addition to pollen, zone V is characterized by spores (ea %5.35) of "lower" vascular plant groups , represented by genera such as *Horriditriletes* , *Laevigatosporites* , *Leiotriletes*, *Punctatisporites* and Tiwariasporites (=Tiwariaspora).

The base of this zone is less productive when the floral contents are compared with those that are present in middle and upper parts of the zone. Detailed study for

the species identification, near the base, has resulted in the following species : *Corisaccites alutas* , *Costapollenites ellipticus* , *Ginkgocycadophytus cymbatus* , *Hamiapollenites perisporites* , *Nuskoisporites rotatus* , *N. triangularis* , *potonieisporites neglectus* , *Striomonosaccites triangularis* , *Sulcatisporites splendence* and *Vittatina costabillis*. Diversity within the zone rapidly increases after the few basal samples with appearance of other pollen and spore species(fig.5,6). Some of the identified forms of this composite assemblage are : *Boutakoffites elongatus* , *B.quibus* , *Caheniasaccites ovatus* , *C.ellipticus* , *Complexisporites polymorphus* , *Crustaesporites globosus* , *Decussatisporites* sp., *Ephedripites ellipticus* , *Fusacolpites fusus* , *F.ovatus* , *Hamiapollenites karrooensis* , *H.saccatus* , *H.tractiferinus* , *Hegiasaccites transistus* , *Horriditrileles ramosus* , *Lavigatosporites vulgaris* , *Leiotriletes* sp. , *Lueckisporites* sp., *Mabuitasaccites ovatus* , *Nuskoisporites rotatus* , *Pityosporites giganteus* , *Platysaccus papilionis* , *P.densus* , *Plicatipollenites indicus* , *Potonieisporites granulatus* , *Punctatisporites gretensis* , *Rhizomasporites radiata* , *Schizaeoisporites microrugosus* , *Striatoabietites multistriatus* , *Striatopodocarpites cancellatus* , *S.rarus* , *Tiwariasporites gondwanensis* , *T.flavatus* , *Vittatina lata* , *V.subsaccata* , and *Walikalesaccites ellipticus*.

The assemblage zone V in Faraghan formation indicates Lower Permian age. This Early Permian morphotypes are similar to those have been recorded from the gondwanic countries. Also some palynological associations of Chal-i-Sheh area shows a close similarity to the African countries as well as to Turkey. These similarities suggest that the vegetation of Chal-i-Sheh region have had relationships to the Cathaysian source area and Faraghan area to Gondwana Landmass.

Discussion on Paleogeography and Paleoecology:

Records of the plant microfossil and megafossil floras, both demonstrate that the earliest landplant evolution goes back to the Silurian or perhaps slighlty earlier. Based on simple triletes spores from the coeval strata of Europe, Africa, North and

South America, Gray and Boucot (1977) have suggested that spore producing plants were widespread. Bank (1975) suggested that both plant megafossil remains and spore microfossils have broad cosmopolitanism distribution through much of the Devonian period. However, Edwards (1973) argues that there are distinction between northern and southern hemisphere megafossils through Early and Middle Devonian. Although the Australian floras show a high portion of northern hemisphere types , distinction between southern microfloras is becoming increasingly apparent. Palaynological distinction between Euramerican and Gondowanic provinces has been suggested by Bar and Riegel (1974). They claim that the distinction is most pronounced during the Middle Devonian. These authors also claim that provincialism diminished in the Late Devonian, resulting from the formation of Pangaea. The past decades have been proliferation of papers in describing the Devonian spore zonal assemblages. Most of these papers have been concerned with descriptive taxanomy and with the refinement of stratigraphic information. There is little comment in these papers as to whenther these assemblages constitute a single or numerous phytogeographic provinces. However , the possibility of regional differences and also similarities have been suggested by some authors. Richardson (1969) suggested that there are sufficient data for intercontinental correlation between two sides of present Altantic by using microfloras at the generic level. But this is not true at the species level, since there are differences that indicate clear regional provincialism which prevents intercontinental correlation. Streel (1974) suggested that the global distribution of *Retispora lepidophyta* indicates a cosmopolitan terrestrial vegetation during the Upper Devonian. According to streel (1974) and also the paleogeographic map of Smith et al., (1973), the distribution of *Retispora lepidophyta* was confined to a wide equatorial belt in which migration to regions such as Australia was possible along the shore of the Tethys Sea.

Playford (1976) described a spore assemblage from the Devonian strata of

northern Australia and emphasized strongly on the endemic character of the Australian sites. In 1981 , Playford has documented data on the acritarch of Upper Devonian in western Australia and the presented data show that some acritach taxa are endemic in the Upper Devonian of this country. Playford in his study (1976) claims that there is no phytogeographic link between North America and Europe during the Upper Devonian time. He thinks that Australian spore assemblages may have links with southern Tethyan localities such as Morocco, Algeria and Libya, although there are very poorly documented data for detial comparison.

McGregor (1979,1980) has made an important general survey of world distribution of the Devonian spores. McGregor has suggested that the relative paucity of data outside the Old Red Sandstone Continent (Europe and North America) make it premature to define spore provinces outside that region. McGregor makes some very general points in 1979. These are some comments on certain cosmopolitanism spore taxa such as *Retispora lepidophyta* that suggest a wider equatorial zone of distribution for this species than proposed by Streel (1974). He also suggested that the genus of *Archaeoperisaccus* was confined to the paleoequatorial regions of Northern Hemisphere, extending in Southwest-Northeast direction through the Hudson Bay, southern Greenland and southern Scandinavia.

Generally speaking, the Devonian spore assemblage zone in Faraghan formation (Zagros), Geirud, Padeha and Khoshyeilagh formation in northeastern parts of Alborz region, as well as the Devonian spores of Northern Hemisphere share certain genera and species in common with those of Old Red Sandstone continents especially in the Early and Middle Devonian spore assemblages. Moreover, the most precise comparison are apparent in the assemblages from Saudi-Arabia and western Australia , particularly in the pattern of occurrence of bifurcate-spined spores such as *Hystricosporites* and *Ancyrospora*. These genera occur in the Middle Devonian sediments of Old Red Sandstone-Continent but appear to be confined to the Upper Devonian of Saudi Arabia, Western Australia and Iran. In addition, marine

microphytoplankton taxa of Devonian in Zagros (Faraghan formation) and Alborz (Kuh-e-Ozom and Hassanakdar) are quite similar to those of Western Australia of Playford and Dring 1981. These marine palynomorph species which all or some of them are also present in the studied areas of Iran consisting of *Cymatiosphaera spicigera* , *Cymatiosphaera subtrita* , *Deltotosoma intonsum* , *Dictyotidium confragum* , *Dictyotidium granulatum* , *Gneudnaella psilata* , *Gorgonisphaeridium condensum* , *Gorgonisphaeridium discissum* , *Lophosphaeridium deminutum* , *Navifusa exilis* , *Papulogabata annulata* , *Saharidia lusca* , *Synsphaeridium catenarium* , *Tunisphaeridium flaccidum* , *Unellium piriforme* , and *Unellium winslowae.*

Apart from the above mentioned widely distributed marine acritarch taxa, there are also some terrestrial spore species which are only found in the Upper Devonian deposits of Iran (e.g.Geirud Fm. , Faraghan Fm. , Khoshyeilagh Fm , Bahram Fm., and Padeha Fm.) and Western Australia (Gneudna Fm.) These terrestrial spore taxa include *Apiculatisporites adavalensis* , *Calyptosporites proximocavatus, C. stolidotus, Cymbosporites hormiscoides* , *Dibolisporites turriculatus, Grandispora fibrilabrata, Grandispora megista* , and *Gneudnaspora kernickii.*

It should also be mentioned that there is a similar pattern of distribution between the Upper Devonian (Frasnian) acritarch and spore assemblage of Iran (S.E Zagros, N.E Alborz), Arabian Peninsula and western Australia. This conclusion is based on the very good percent (almost over 1/3) of all the yielded Devonian palynomorphs of this study while the rest of them are widespread through the Devonian sediments of Europe and/or other parts of the world.

Finally, it is reasonable to consider that Iran , Saudi-Arabia and Western Australia were at similar paleolatitudes along the southern shore of the Tethys Sea during the Late Devonian (Frasnian). Such reconstruction based on palynomorpb data supported by Devonian paleogeographic maps of Heckel and Witzke (1979) and paleogeography and biogeography maps of Mckerrow and Scotese (1990).

In Permian the corresponding results obtained from palynology and the plant megafossil floral provinces are clearer in Iran than any other Late Paleozoic times. The palynological characteristics of four major provinces (Euramerican, Angaran, Cathaysian and Gondwonian) of classical paleobotany are summarized by Hart (1964). He also proposed finer subdivisions of these provinces, Particularly in Eurasia suggesting a complex of latitudinally controlled plant geographic zones for Permian.

From the palynological point of view and based on the related genera and species encountered in this study the floral regions of Iran can clearly be defined in the Lower Permian strata. Such deposits are from Dorud formation in the northeastern part of Alborz ranges, with Chal-i-Sheh and Faraghan areas in the Zagros belts. In general, the Lower Permian assemblage of the Faraghan area is similar to those recorded from Gondwanic assemblages, and if not identical, it is most similar to those of Africa (Table 1). At the same time, the encoontered pollen taxa of Dorud formation is also much similar to those of Lower Permian of the African Plate. Gondwanic elements are present in the Chali-Sheh area but they are less diverse than at Faraghan or the Dorud formation (Chateuneuf & Stampfli, 1979) of northern Iran. This contrast may reflect the relative proximity of the Faraghan area to the Gondwanic Landmass and relatively more distant position of Chal-i-Sheh toward a Cathaysian source area (Table 2). It is also concluded that Zagros basin and portions of the African Plate were not very distant from one another and they may have been at about the same palaeolatitude along the southern shore of the Tethys Sea.

From all the above information , this kind of reconstruction can present that portions of Iran were geographically disjunction in the Permian, a suggestion which has not been previously made on the basis of other geological data. Another favorable explanation that may be added to this view is the difference in Palynological assemblages from Chal-i-Sheh and Faraghan, as the Chal-i-Sheh

Table 1 Comparsion of the Lower Permian Miospore Assemblages of the Faraghan Area with Gondwanaland Countries, Middle East and North America

Encountered taxa of Faraghan area	Turkey N. Iran	Saudi Arabia	Gabon Congo S.Africa	India	West Pakistan	Australia	N.America U.S.A. Canada
Pityosporites giganteus	–	–	+	+	–	+	–
Striatopodocarpites rarus	–	–	+	–	+	–	–
Striatopodocarpites cancellatus	–	–	+	+	–	–	+
Platysaccus papilionis	–	–	+	+	–	–	+
Platysaccus densus	–	–	+	–	–	–	–
Hamiapollenites saccatus	+	+	+	+	+	+	+
Protohaploxypinus diagonalis	–	+	+	+	+	–	–
Striomonosaccites triangularis	–	–	+	+	–	–	–
Striomonosaccites ovatus	–	–	+	+	–	–	–
Horriditriletes ramosus	–	–	+	–	–	+	–
Potonieisporites neglectus	–	–	+	+	–	–	–
Potonieisporites granulatus	–	–	+	–	–	–	–
Nuskoisporites triangularis	–	–	+	+	–	–	–
Plicatipollenites indicus	+	+	+	+	+	+	–
Nuskoisporites rotatus	–	–	+	+	+	+	–
Complexisporites polymorphus	–	–	+	+	–	–	+
Caheniasaccites ovatus	–	–	+	–	–	–	–
Caheniasaccites ellipticus	–	–	+	–	–	–	–
Fusacolpites ovatus	–	–	+	–	–	–	–
Vittatina subsaccata	–	–	+	–	–	–	–
Vittatina costabilis	+	+	+	–	–	–	+
Vittatina lata	–	–	+	–	–	–	+
Decussatisporites sp.	–	–	+	+	–	–	–
Corisaccites alutas	–	–	+	+	+	+	–
Walikalesaccites ellipticus	–	–	+	–	–	–	–
Hegiasaccites transitus	–	–	+	–	–	–	–
Costapollenites ellipticus	–	–	+	–	–	–	+
Schizaeoisporites microrugosus	–	–	–	–	–	–	+
Sulcatisporites splendens	+	–	–	+	+	+	+
Hamiapollenites perisporites	–	–	+	–	–	–	+
Laevigatosporites vulgaris	+	–	–	+	+	+	+
Kosankeisporites elegans	–	–	–	+	–	–	+
Hamiapollenites karrooensis			+	–	–	–	+
Hamiapollenites tractiferinus		+	+	–	–	–	+
Mabuitasaccites ovatus	–	–	+	–	–	–	–
Boutakoffites quibus	–	–	+	–	–	–	–
Boutakoffites elongatus	–	–	+	–	–	–	–
Tiwariasporis gondwanensis	+	–	+	+	–	–	–
Tiwariasporis flavatus	–	–	+	–	–	–	–
Schizopollis spp.	–	–	+	+	–	–	–
Ginkgocycadophytus cymbatus	–	+	+	+	+	–	+
Stritoabietites multistriatus	–	+	+	–	–	+	+
Rhizomaspora radiata	–	–	+	+	+	–	+
Ephedripites ellipticus	–	–	+	+	+	–	+

Table 2 Point Counts Data of the Permian Palynomorphs and Scolecodonts in Chal-i-Sheh Area.

This composite assemblage is based on seven samples taken from the base of the Lower Permian section at Chal-i-Sheh.

This is the part of the section in which Sigillaria persica (Seward 1932) was first collected by Harrison in the early 1930 s.

List of species	MG-148	MG-149	MG-150	MG-151	MG-152	MG-153	MG-154
Calamospora microrugosa *	–	–	–	2	–	–	–
Ephedripites ellipticus	–	–	–	–	–	2	–
Fusacolpites ovatus	–	–	2	–	–	–	–
Ginkgocycadophytus cymbatus	–	–	2	4	–	7	–
Grandispora sp. *	–	–			–	2	–
Gulisporites cochlearius *	–	–	–	–	–	3	–
Hamiapollenites perisporites	2	3	68	17	6	105	6
Hamiapollenites saccatus	–	–	19	24	7	21	21
Horriditriletes ramosus *	–	–			3		
Kraeuselisporites splendens *	–	–	13	67	17	23	3
Laevigatospoites vulgaris *	–	–	11	3	7	10	3
Leiotriletes sp. *	–	–	9	3	18	4	-
Nuskoisporites triangularis	–	–	3	4	2	6	2
Nuskoisporites rotatus	–	–	5	2	1	2	–
Pityosporites giganteus	–	–	8	14	8	13	5
Plicatipollenites indicus	–	–	–	–	3	7	4
Potonieisporites granulatus	–	5	23	6	–	9	10
Protohaploxypinus diagonalis	–	4	1	1	1	3	–
Punctatisporites gretensis *	–	–	18	10	11	9	2
Scolecodonts **	–	–	6	16	11	8	2
Striatopodocarpites sp.	–	–	–		2	–	–
Sulcatisporites splendens	–	–	22	12	8	41	3
Thymospora perverrucosa *	–	–	10	8	4	10	3
Vittatina costabilis	2	2	16	2	–	–	–
Veryhachium riburgense ***	–	–	2	–	–	–	–

* Spore species

** Jaw of Permian worms

*** Acritarch species

Table 3 Comparsion of the Lower Permian Miospore Assemblages from the Faraghan Formation in the Chal-i-Sheh Area with Gondwanaland Countries, Middle East and North America

Encountered species of Chal-i-Sheh	Turkey N. Iran	Saudi Arabia	Gabon Congo S.Africa	India	West Pakistan	Australia	N.America U.S.A. Canada
Ephedripites ellipticus	–	+	+	+	+	–	
Fusacolpites fusus	–	–	+	–	–	–	–
Ginkgocycadophytus cymbatus		+	+	+	+	–	+
Hamiapollenites perisporites	–	–	+	–	–	–	+
Hamiapollenites saccatus	+	+	+	+	+	+	+
Nuskoisporites triangularis			+	+			
Nuskoisporites rotatus			+	+	+	+	–
Pityosporites giganteus	–	–	+	+	–	+	–
Pilicatipollenites indicus	+	+	+	+	+	+	–
Potonieispoites granulatus	–	–	+	–	–	–	–
Protohaploxypinus diagonalis		+	+	+	+	–	–
Sulcatisporites splendens	+	–	+	+	+	+	+
Vittatina costabilis	+	+	+	–	–	–	+
Kraeuselisporites splendens	+	+	–	–	–	+	–
Calamospora microrugosa *	+	–	–	–	–	–	–
Laevigatosporites vulgaris *	+	–	–	+	+	+	+
Gulisporites cochlearius	+	–	–	–	–	–	–
Harriditriletes ramosus		–	+	–	–	+	–
Thymospora perverrucosa	+	–	–	–	–	–	–
Puctatisporites gretensis	+	+	+	+	+	+	–

material has higher spore and lower pollen diversity when compared with the pollen and spore diversities of the Faraghan formation. In Chal-i-Sheh the Liminic condition which was the predominant condition in Turkey had the same effect on the vegetation of Kuh-e-Gereh and Zard-Kuh. This is indicated by the remnants of Carbonifereous forests in Chal-i-Sheh and coalseams in Khu-e-Gereh and Turkey. Due to the similarity of the Lower Permian assemblage, of Chal-i-Sheh vegetation with those of Early Permian of Turkey, it might be suggested that the vegetation in northwestern Zagros basin had similarity to that of the Cathaysian province, which this may represent of these provinces, as particularly Eurasia that suggesting a complex of latitudinally controlled plant geographic zones for the Permian. Other subdivisions represent concentrically arranged belts in the northern temperate zone and equatorial belt and comprise flora of the Middle East, the Salt Range of Pakistan and Southern Indo-China. An equatorial position for part of southeast Asia during the Permian has also been suggested by Kremp (1974-1975). He restated the earlier paleobotanical arguments based on the similarity of megafossils of the Cathaysian flora with floras of the western United States. Kremp claims that palynological data support this comparison. He also suggests that both Chinese and North American assemblages reflect a tropical flora in the Permian

The biogeographic relationships of floras from the southern coastal region of Permian Tethys have been the subject of speculation with regard both to the palynoflora and plant megafossils. Balme (1970) has described palynological assemblages of Salt Range Pakistan in detail. Waterhouse (1976) described the Middle Permian assemblages of Pakistan that show similarites to those from Urals and Gondwana. The Middle East palynofloras suggest a position of landmass that lay between India and the east coast of Africa. Chateauneuf and Stampfli (1979) have recorded palynofloras from Permian sequences in northern part of Iran (Alborz Mountain) that they believe are intermediate in composition between those of the Salt Range of Pakistan and Iraq.

Akyol (1975) has documented assemlages from coal seams of Early Permian age in Turkey which contain genera and species in common with assemblages from southeastern China. The present palynological investigation suggests that the southeast and western regions of Iran have a southeast Asian influence. A similar mixture of Cathaysian elements has long been recognized in megafossil floras from Hazro (Turkey) that leading Lacey (1975) to speculate on a possible migration route for these taxa. Migration along the northern shore of the Tethyan sea appears to be ruled out by the absence of any known Cathaysian types in Europe or the U.S.S.R., suggesting a possible southern route for ancestral lineages, perhaps in the Carboniferous period. The palynological results of this study are consistent with paleogeographic world map of smith et al. (1983) and paleogeographic maps of Hart (1969). These maps have placed Iran, Saudi Arabia and Africa between 30 to 60 degrees of south Paleolatiutde during the Lower Permian.

Plate 1

Fig.1 - *Acanthodiacrodium bicornatum* Welsch, 1986, (Lower Ordovician of Hassanakdar area).

Fig.2 - *Acanthodiacrodium seratimum* Timofeev, 1959, (Lower Ordovician of Hassanakdar area).

Fig.3 - *Acanthodiacrodium spinum* Rasul, 1974 (Lower Ordovician of Hassanakdar area).

Fig.4 - *Acanthodiacrodium tadlense* Cramer & Diez, 1977 (Lower Ordovician of Hassanakdar area).

Fig.5 - *Acanthodiacrodium vavrdovae* Cramer & Diez, 1977 (Lower Ordovician of Hassanakdar area).

Fig.6 - *Acanthodiacrodium zonoconstrictum* Welsch, 1986 (Lower Ordovician of Hassanakdar area).

Fig.7 - *Acinosporites salpionensis* Richardson & Lister, 1969 (Upper Devonian of Hassanakdar area).

Fig.8 - *Ancyrospora ampulla* Owens, 1971 (Devonian of Kuh-e-Faraghan).

Fig.9 - *Ancyrospora ancyrea* Richardson, 1962 (Devonian of Kuh-e-Faraghan).

Fig.10 - *Ancyrospora capillata* Dolby and Neves, 1970 (Upper Devonian of Kuh - e - Ozom).

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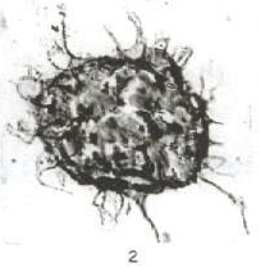

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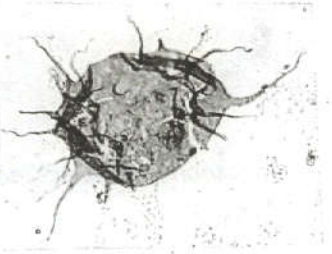

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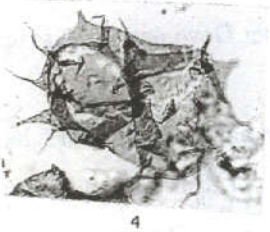

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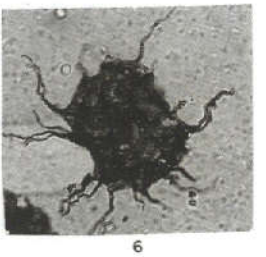

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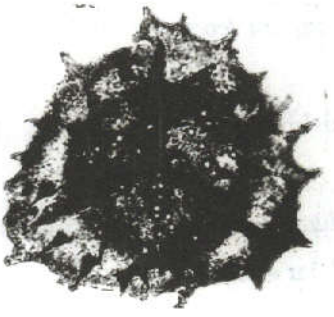

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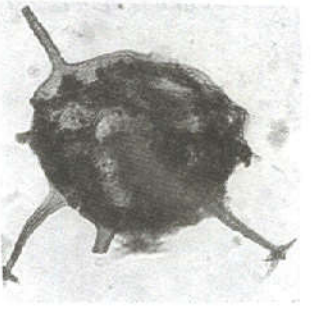

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Plate 2

Fig.1- *Ancyrospora grandispinosa* Richardson, 1950 (Upper Devonian of Kuh-e-Faraghan).

Fig.2- *Ancyrospora langii* (Taugourdeau-Lantz) Allen, 1956 (Upper Devonian of Khoshyeilagh area).

Fig.3- *Ancyrospora longispinosa* Richardson, 1962 (Upper Devonian of Hassanakdar area).

Fig.4- *Ancyrospora magnifica* Owens, 1971 (Upper Devonian of Kuh-e-Faraghan).

Fig.5- *Ambitisporites avitus* Hoffmiester, 1959 (Devonian of Kuh-e-Faraghan).

Fig.6- *Apiculatispora adavalensis* De Jersey, 1966 (Upper Devonian of Kuh-e-Ozom).

Fig.7- *Apiculiretusispora leberidos* McGregor , 1982 (Upper Devonian of Kuh-e-Ozom).

Fig.8- *Apiculiretusispora granulata* Owens, 1971 (Upper Devonian of Kuh-e-Faraghan).

Fig.9- *Arbusculidium filamentosum* (Vavrdova) Vavrdova, 1972 (Lower Ordovician of Hassanakdar area).

Fig.10- *Arbusculidium rammelaerei* Martin, 1981 (Lower Ordovician of Hassanakdar area).

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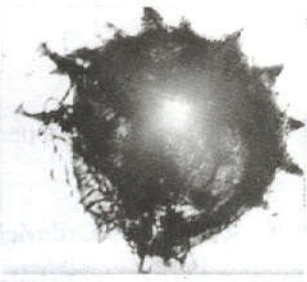

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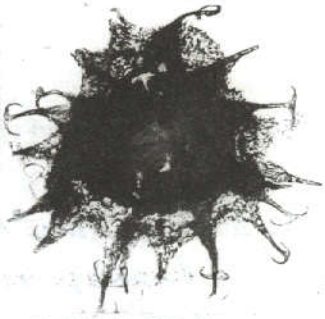

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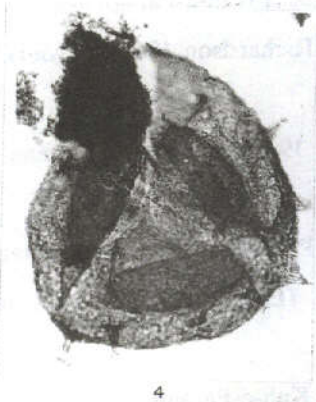

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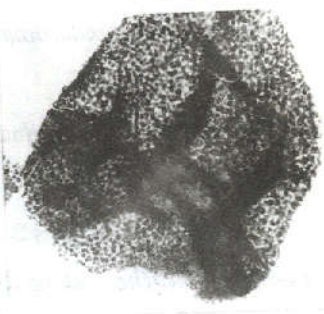

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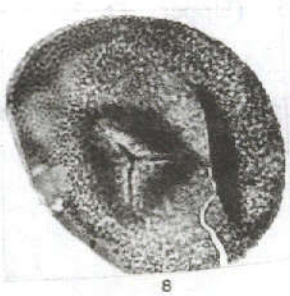

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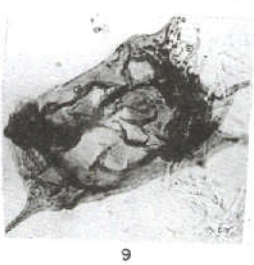

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Plate 3

Fig.1- *Archaeoperisacous opiparus* Owens, 1971 (Upper Devonian of Khoshyeilagh area).

Fig.2- *Athabascaella rossii* Martin , 1984 (Lower Ordovician of Hassanakdar area).

Fig.3- *Athabascaella penika* (Martin) Marthin & Leiming, 1988 (Lower Ordovician of Hassanakdar area).

Fig.4- *Auroraspora aurora* Richardson, 1960 (Devonian of Kuh-e-Faraghan).

Fig.5- *Auroraspora macromanifestus* (Hacquebard) Richardson 1960 (Devonian of Kuh-e-Faraghan).

Fig.6- *Auroraspora hyalina* (Naumova) Streel, 1967 (Upper Devonian of Khoshyeilagh area).

Fig.7- *Boutakoffites quibus* Bose & Kar, 1968 (Lower Permian of Kuh-e-Faraghan).

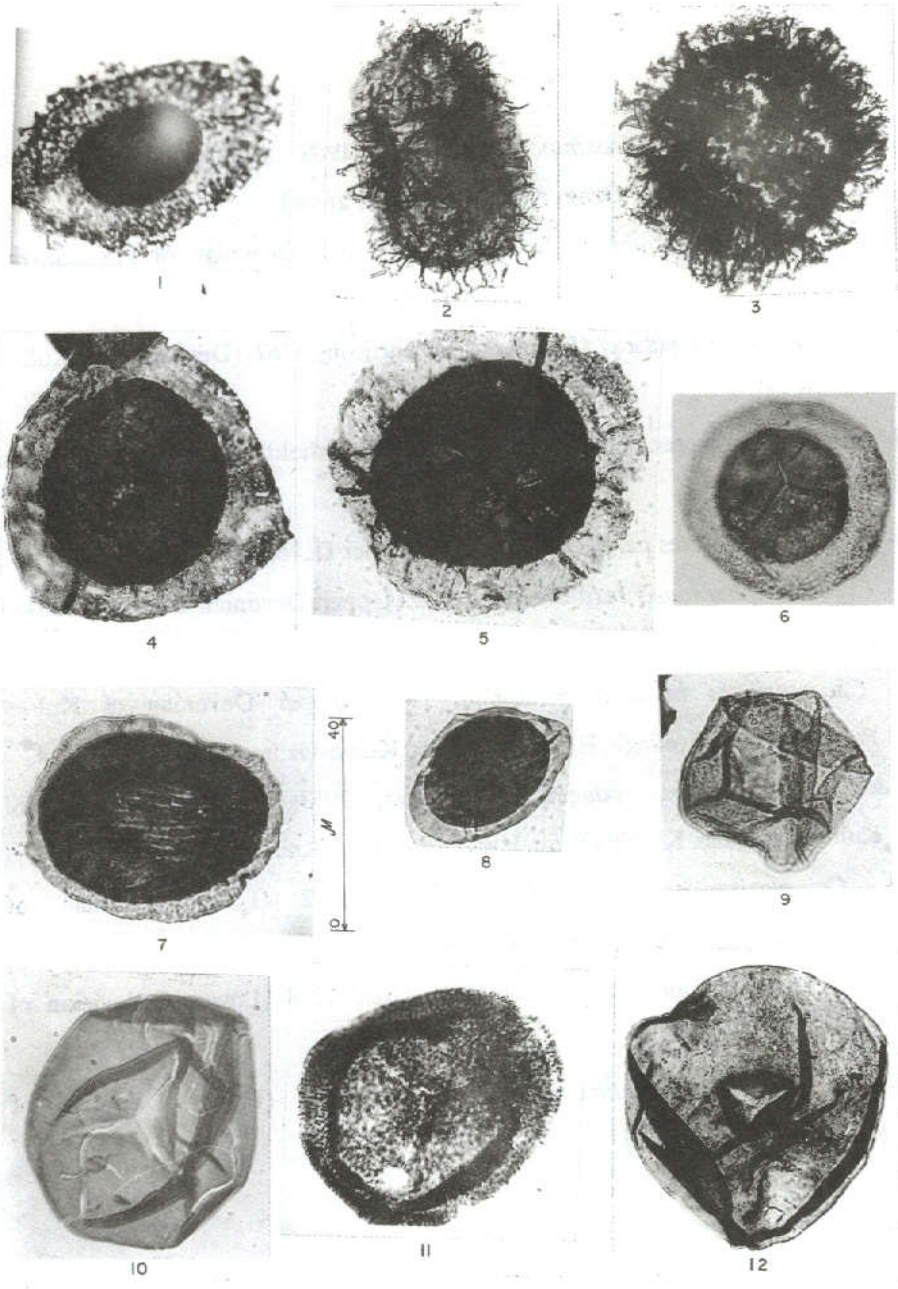
Fig.8- *Boutakoffites elongatus* Bose & Kar, 1966 (Lower Permian of Kuh-e-Faraghan).

Fig.9- *Bullatisporites bullata* Allen, 1965 (Devonian of Kuh-e-Faraghan).

Fig.10- *Calamospora microrugosa* (Ibrahim) Schopf et al., 1944 (Lower Permian, Kuh-e-Faraghan).

Fig.11- *Calamospora pannucea* Richardson, 1965 (Upper Devonian of Khoshyhyeilagh area).

Fig.12- *Calamospora pannucea* Richardson, 1965 (Upper Devonian of Kuh-e-Faraghan).



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