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PALYNOSTRATIGRAPHY AND PALEOECOLOGY OF THE FARAGHAN FORMATION OF SOUTHEASTERN IRAN

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This copy of the Ph.D. Dissertation of Mohammad Ghavidel-Syooki is to be forwarded to the National Iranian Oil Company, Tehran. This completes the requirements for the degree of Doctor of Philosophy in Geology, Michigan State University. It has my full approval

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PALYNOSTRATIGRAPHY AND PALEOECOLOGY OF THE FARAGHAN FORMATION OF SOUTHEASTERN IRAN

By

Mohammad Ghavidel-Syooki

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ABSTRACT

PALYNOSTRATIGRAPHY AND PALEOECOLOGY OF THE
FARAGHAN FORMATION AT SOUTHEASTERN IRAN

By

Mohammad Ghavidel-Syooki

The Faraghan Formation, a thick sequence of Upper Paleozoic strata of southern Iran, was studied palynologically to establish the palynofloras and determine more precisely the geological age of the Formation, and make logical interpretations of the depositional sites in order to reconstruct the palaeogeographic relationships of the Zagros Basin to northern and south hemispheres during the Upper Palaeozoic interval represented by these strata.

130 outcrop samples from the Faraghan area and 7 samples from the Chal-i-Sheh area were processed and the organic residues concentrated for microscopic analyses. The spores, pollen, acritarchs and some other organic entities were identified to genera and species and their relative abundances were calculated.

136 pollen, spores and acritarch species were described including 59 spores (36 genera), 51 pollen (33 genera) and 26 acritarchs (19 genera). These are arranged in five

ascending stratigraphic assemblage zones. Zones I through IV represent part of Lower Devonian into middle Upper Devonian (probably Gedinnian to Frasnian). Zone V represents Lower Permian beginning during Sakmarian and ending in the Kungurian. The "hiatus" within the Faraghan Formation extends from Famennian through the Carboniferous period into Lower Permian. This "hiatus" possibly coincides with the Hercynian orogeny that resulted in emergence of this part of the Zagros Basin producing extensive erosion of part of Late Devonian and the whole of the Carboniferous sediments or the combination of lack of deposition and erosion.

Diverse acritarchs (25 species) in the Devonian of the Faraghan sections indicate a marine environment. However, the presence of 25 genera (48 species) of terrestrial spores suggests nearby terrestrial communities. Some of the Faraghan acritarchs are also recorded from Europe and North America, including Chomotriletes vedugensis. However, 10 species have been recorded only from Frasnian sediments of western Australia Patterns of Devonian palynomorphs are also similar to those recorded from the Arabian peninsula indicating a similar paleophytogeographic province, possibly proximal.

Scolecodonts in the Lower Permian zone of the Faraghan sections, suggest marine influence. The terrestrial miospores of this interval include of 52 pollen species (33 genera) and 5 spores. These suggest the existence of diverse, proximal conifer communities.

This Lower Permian assemblage contains some species in common with those of North America, Europe and the Middle East. However, it contains many index species which have been recorded only from gondwanic continents, indicating that the Zagros Basin may have been part of Gondwana.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. Ralph E. Taggart, Professor of Botany and Plant Pathology and the Department of Geological Science at Michigan State University. Dr. Taggart, in serving as a major advisor this dissertation, provided encouragement and assistance during all phases of this study. His efforts over the past years, both as advisor and teacher, have, above all else, provided the atmosphere and motivation that is necessary for graduate research.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Today, palynology is an accepted approach in coal and oil exploration. This approach includes a study of palynomorphs that are useful in age determination, interpreting different environments, correlation of wells and outcrop sections, and for suggesting favorable areas for oil exploration. Palynomorphs can be obtained in abundance from acid-insoluble residues of shales, siltstones, peats, lignites and some limestones, but they are typically rare or absent in coarse-grained sandstones and conglomerates. Some factors that make palynology an important subdiscipline of paleontology are the small size and good preservation of the fossil spores, pollen, and algal cells or cysts available in many sedimentary environments. A very high percentage of sedimentary rocks contain some type of palynomorphs. They are especially suitable for determining age or environmental conditions from even small samples. Chemical maceration of sedimentary rocks often releases plant microfossils even when no macrofossils are present.

Pollen and spores of vascular plants have been described at the level of genera and species, but the precision, accuracy, and equivalency of generic/specific assignment to modern plants is quite variable for many palynomorphs. The plants of Paleozoic age have few, if any, modern equivalents. But knowledge of spores and pollen in fertile fossil organs has made it possible to relate some fossil spores and pollen to specific source plants of the Paleozoic.

With some knowledge of source plants, and sufficiently characteristic microscopic fossils, the investigator can often make actual microfloristic zonation. In fact, these microfossils often represent a larger fossil plant inventory than do the macrofossils of correlative deposits. For instance, Chaloner (1967) has plotted the time of appearance of Devonian spore genera showing that the first terrestrial meiospores appeared in Silurian strata. New genera appeared in Gedinnian, and still more in Siegenian and Emsian times. Subsequently, the evolution of new kinds of vascular plants continuously expanded throughout Devonian and later Paleozoic time.

Despite the fact that only few of the these genera of spores or pollen have been found within sporangia or pollen-bearing structures of identifiable plants, we are safe in assuming that many morphotypes belonged to different plants. On this basis, the evidence from studies of spores and pollen closely parallels that of microflora derived from plant macrofossils.

Similar studies made on rocks of other geological periods have resulted in reconstruction of the basic history of vegetation on the earth. Palynological fossils often occur in distinctive assemblages which are indicative of specific environments or habitats at the time of deposition. Moreover, the determination of paleoecological conditions is significant for recognition of shorter geological time units, proximity of ancient shorelines, correlation of marine and continental deposits and paleoclimatic trends. Palynomorphs are generally treated statistically using techniques applicable to analyses of data from other kinds of fossils. Such studies reveal supplementary information relating to small lithological units and geological structures.

Reports of palynological studies in Iran, in comparison to those in Europe, the United States of America, Canada, and the Soviet Union, have been restricted to a few papers on the Devonian-Carboniferous sediments in northern Iran (Kimyai, 1979). Therefore, the interpretation of most Paleozoic rock units in all parts of Iran may be affected by the exemplary problems under study. For this research, I have chosen one of the stratigraphic rock units from the southern part of Iran to introduce the nature and significance of palynology in both economic and scientific aspects of the geology of older rocks.

PURPOSE OF STUDY

The purpose of this research is to study palynological aspects of the Faraghan Formation in Iran. The Faraghan Formation, in the vicinity of the Zagros Main Thrust, has been previously assigned to the Carboniferous or Permian period. Some preliminary palynological studies have indicated that the age of this sequence is Devonian and Permian with no Carboniferous recognized (Ghavidel-Syooki, 1984a).

Recognition of Problem

The Faraghan Formation is located in the critical area where the southeast margin of the Iranian plate has been overthrust onto the Arabian plate. It is thus desirable to determine whether the source plants for the palynomorphs in the Faraghan Formation were derived from Gondwanian or Laurasian floras and whether these sources were consistent or continuous from Devonian into earliest Permian.

The overlying and underlying rock units of the Faraghan Formation contain abundant marine invertebrate fossils, but the Faraghan Formation lacks such fossil faunas. The age of this formation has thus been the subject of major controversy since 1977. Most geologists, however, have assigned the Faraghan Formation to the Permo-Carboniferous, based largely on Seward´s work (1932) in the Chal-i-Sheh area in the southwestern part of the Zagros. Consequently, Iranian geologists assumed that the Devonian was a non-depositional period in southern Iran since there have been no rocks of that age distinguished in this region before the present study.

The author has studied the stratigraphic sections which were measured and sampled by other geologists in the Faraghan and Gahkum areas (Ghavidel-Syooki, 1984b, and 1986). The first study focused on palynological characteristics of the Faraghan Formation in the Faraghan and Gahkum areas. The author´s previous research revealed that 200 meters out of 300 of the Faraghan Formation contain Middle-Upper Devonian age rocks and the remainder belongs to the Lower Permian. Thus, I concluded, tentatively, that the Carboniferous Period is probably not represented in south Iran. These preliminary results indicated the need for more detailed palynological studies of the Faraghan Formation.

Objectives of Study

This research is directed toward developing information from the palynology and sedimentology of the Faraghan Formation to aid in establishing age relationships, correlation of the strata, resolving some aspects of the paleoecology of floras, the paleogeography, and depositional environment of the Faraghan Formation sediments. The paleogeography of the Faraghan Formation is important in relationship to the central and northern part of Iran as well as to neighboring countries.

The objectives of this research are:

1) Identify, describe, and illustrate the spores, pollen, acritarchs, and chitinozoans of the Faraghan Formation in order to determine:
   a) Age limits of Devonian rocks of the Faraghan Formation.
   b) Position of Frasnian-Famennian boundary.
   c) Any evidence of presence of Carboniferous strata in the Faraghan Formation.
   d) Age limits of Permian rocks of the Faraghan Formation.
2) Determine the source, Gondwanian or Laurasian, of the land plants represented in the Faraghan Formation.
3) Interpret the different paleoenvironments represented by the plants of the Faraghan Formation.
4) Resolve stratigraphic problems of age and correlation of the Faraghan Formation.

HISTORY OF GEOLOGIC STUDIES IN THE ZAGROS BASIN

The Zagros Basin is located in the southwestern part of Iran and most of the Persian Gulf. It is located southwest of the "Main Zagros thrust" or "crush zone". The basin forms a SE-NW-trending linear belt approximately 1400 km long and 250 km wide that is separated from the Central Iranian Basin by the "crush zone" which is 5-10 km wide (Figures 1 and 2). The Zagros Basin extends from 26 degrees north latitude on the south to 35 degrees north. The eastern boundary is at 56 degrees east longitude and the western boundary is at 46 degrees east.

The Zagros Basin has been a center of oil exploration by international oil companies in Iran for a long time in the past, and by the National Iranian Oil Company at the present time. Thus, most of the formation designations and nomenclature for the sediments of the Zagros Basin have been established by petroleum companies.

Geological Study: 1930's to 1968

The first phase of geological investigation was carried out by J.V. Harrison in the Zagros Basin in the early 1930's. This study resulted in the establishment of the lithostratigraphic nomenclature for the Zagros Basin by G.A.

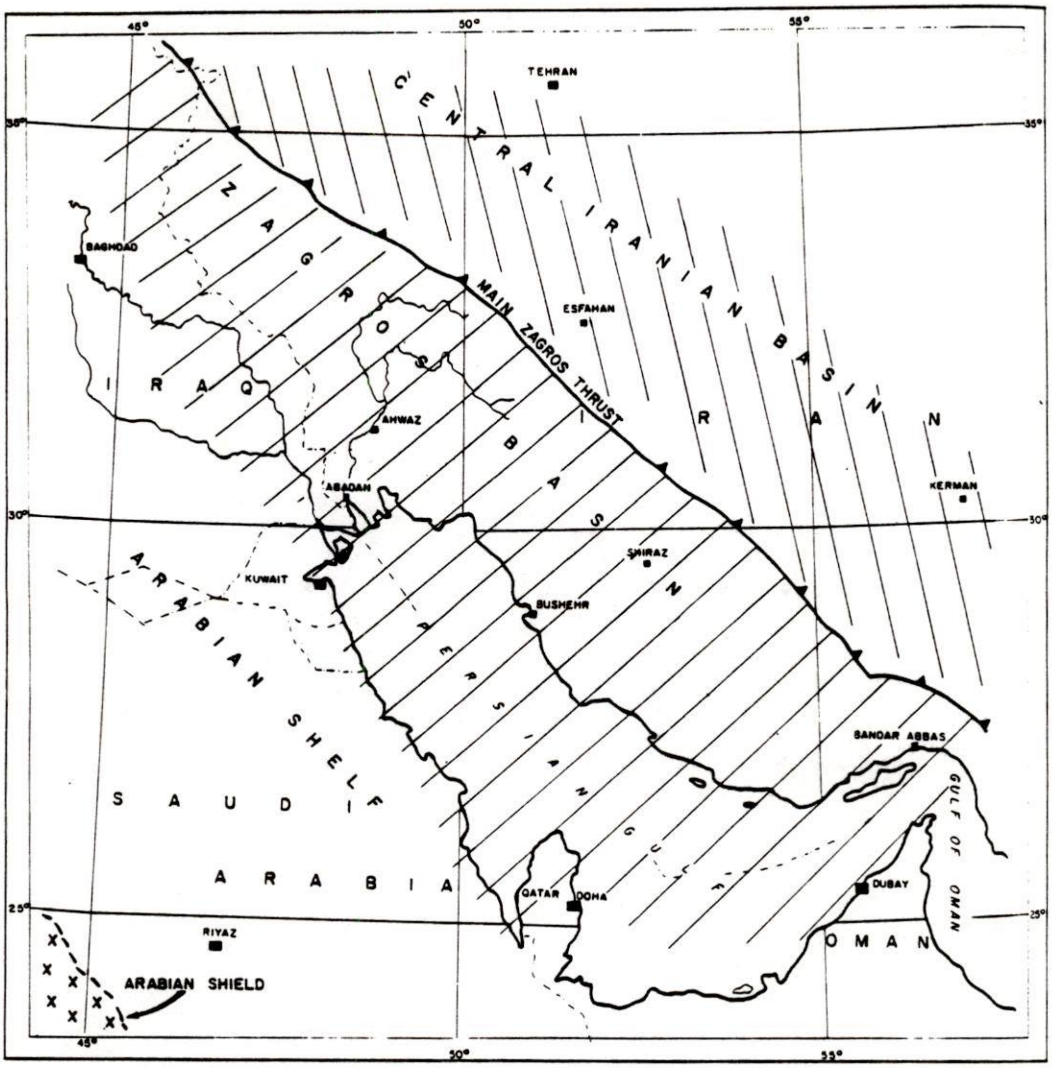


Figure 1. The Zagros Basin and Central Iranian Basin in Relation to the Main Zagros Thrust (from Szabo and Kheradpir, 1978, p. 60, fig. 1).

James and J.G. Wynd in 1965. The paper by James and Wynd includes the lithostratigraphic nomenclature of the Zagros Basin from Triassic to Plio-Pleistocene strata, but the Permian and older strata were excluded from their work. J. Stocklin (1968) summarized the tectonic history of Iran, dealing mostly with the tectonic history of the Central Iranian Basin but he discussed briefly the tectonic history of the Zagros Basin.

Geologic Studies: 1968 to 1976

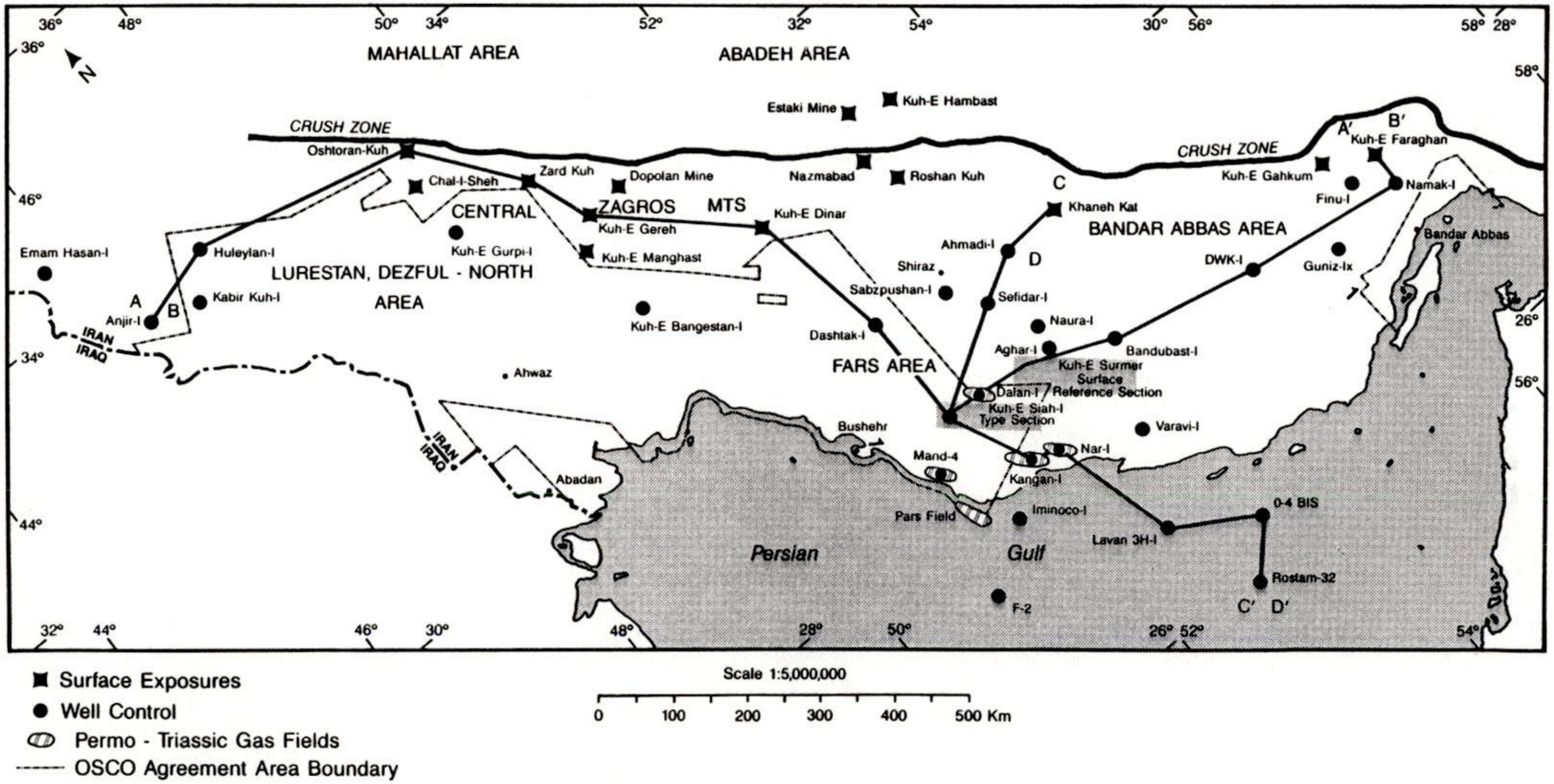
The second phase of geological study of the Zagros Basin, dating from 1968 to 1976, was carried out by the geologists of the Oil Service Company of Iran, a consortium of international petroleum companies under Iranian government contract. During this period, O. Thiele et al. (1968) completed a map of the Golpaygan area near Shiraz. Thiele et al. described the sedimentary strata of the Golpaygan area from infra-Cambrian to recent age. Likewise, H. Taraz studied the sedimentary sequence of the Central Iranian Basin in general and the Permo-Triassic in detail in outcrops near Abadeh in 1971-1974 (Figure 2).

A. Setudehnia (1972-1976) described the Mesozoic and Paleozoic strata in the High Zagros Mountains (Zard-Kuh, Kuh-e-Gereh, and Dinar Mountains, located approximately 200 km south and west of Esfahan). A. Kheradpir, G.A. Nicol and H. McQuillan conducted a stratigraphic field survey in Kuh-e-Faraghan and Kuh-e-Gahkum in 1968-1976. Szabo, Khosravi and Rusk (unpublished company report, 1976) studied the sedimentary sequence of the Chal-i-Sheh area. These comprehensive fieldwork studies resulted in information on the Mesozoic and Paleozoic strata in the Zagros Basin.

The pre-Triassic sedimentary beds were named in the Zagros Basin by Szabo and Kheradpir (1976) and approved by the Iranian Stratigraphic Committee in that year. Szabo presented the new nomenclature at the Second Iranian Geological Symposium in 1977. Szabo and Kheradpir's paper is the most complete documentation of the pre-Triassic units and is also a useful supplement to description of the Mesozoic and Tertiary rock units provided by James and Wynd (1965).

Szabo and Kheradpir (1978) have pointed out that the Paleozoic deposits in the Zagros Basin are underlain by an eastward continuation of the granitic and metamorphosed Precambrian Arabian Shield. They suggested that a marine transgression took place during the Cambrian and continued into the early Carboniferous, depositing clastic sediments. According to Szabo and Kheradpir (1978), tectonic activity, probably associated with the Hercynian Orogeny in the Zagros Basin, resulted in emergence of the Zagros Basin in late Carboniferous-early Permian time. They also pointed out strong erosional activity during this period which is suggested by a major unconformity, especially in the area corresponding to the High Zagros Mountains.

Figure 2: Distribution of the Faraghan Formation in the Zagros Basin and the location of the study area to the Main Zagros Thrust (from Szabo and Kheradpir, 1978).



Renewed marine transgression in the Permian resulted in the deposition of clastics, shallow water carbonates, and evaporites. Szabo and Kheradpir (1978) argue that a minor break in sedimentation between Permian and Triassic is indicated over most of the areas in the Zagros Basin. Following this, a succession of shallow water carbonates with tidal flat evaporites was deposited during the Triassic. In the late Triassic, another tectonic event resulted in complete partition of the Paleozoic sequence such that the two parts experienced different sedimentary and tectonic histories. Szabo and Kheradpir (1978) suggest that these two disjunct areas were rejoined during the Tertiary Alpine tectonic phase.

The period of geological activity in the second phase of geological study resulted in much more geological information in the Zagros Basin than the first phase. The age assignments of the Paleozoic rock units is still incomplete or in a premature stage in the Zagros Basin. Some of the lithostratigraphic units of this basin are lacking in marine fauna (e.g., Faraghan Formation), and most paleontological work has focused on those Paleozoic beds that are gas-bearing and contain well-preserved marine faunas, such as the Dalan Formation, which contains fusilinids, brachiopods, corals, and bryozoans. However, early Paleozoic strata in the Zagros Basin have been studied in more detail than the late Paleozoic beds. Since the early Paleozoic strata are rich in marine fauna, their age assignment has less ambiguity than that of the late Paleozoic beds.

Earlier Palynological Studies

In spite of the fact that applied palynology has been widely used in other countries, especially by oil companies, this aspect of paleontology was not used by either the National Iranian Oil Company or by Oil Service Company of Iran. In 1977, the Oil Service Company of Iran (OSCO) established a palynology section in order to resolve those stratigraphic problems that arose during the second geological survey phase in the Zagros Basin. At that time, I was responsible for research on the Paleozoic beds including the Cambrian, Ordovician, Silurian, and especially of the Faraghan Formation, because it lacks marine invertebrate fossils and has been of controversial age for a long time. Fortunately, my research on the Faraghan Formation yielded well-preserved, abundant, and well-known palynomorphs which made it possible to determine the approximate depositional time of the rock unit. Therefore, one goal of this research is to determine the exact time span of Faraghan Formation deposition based on palynomorphs. Another aspect of this research will deal with relationships between the palynomorphic assemblages of the Faraghan Formation and contemporaneous phytogeographic assemblages in other parts of the world.

GEOLOGY AND LOCATION OF THE STUDY AREA

Location

The study area is located approximately 80 km north of Bandar Abbas in southeastern Iran. This area is called "Kuh-e-Faraghan" and is one of the highest mountains in the Zagros Basin (3200 m). The study area has an east-west tectonic trend (Figures 4 and 5) similar to Kuh-e-Finu, Kuh-e-Gahkum, Khush-Kuh, Kuh-e-Neyse, and other geological structures of the Zagros Basin.

Geologic Structure

The geological sequence exposed in this area ranges from the early Paleozoic to the Miocene (Figure 3). Kuh-e-Faraghan is structurally an anticline, called the Zakin anticline. The Zakin anticline has been cut by two major faults in the northern and southern flanks, and these are respectively referred to as the Faraghan and Khirbin faults. The Faraghan fault is a high angle reverse fault that has thrust Paleozoic strata onto Upper Triassic beds (Khaneh-Kate Formation) at the northern flank. The Khirbin fault has also resulted in displacement of Paleozoic and Triassic strata in the southern flank. Likewise, many other subsidiary faults, in smaller scale, have resulted in

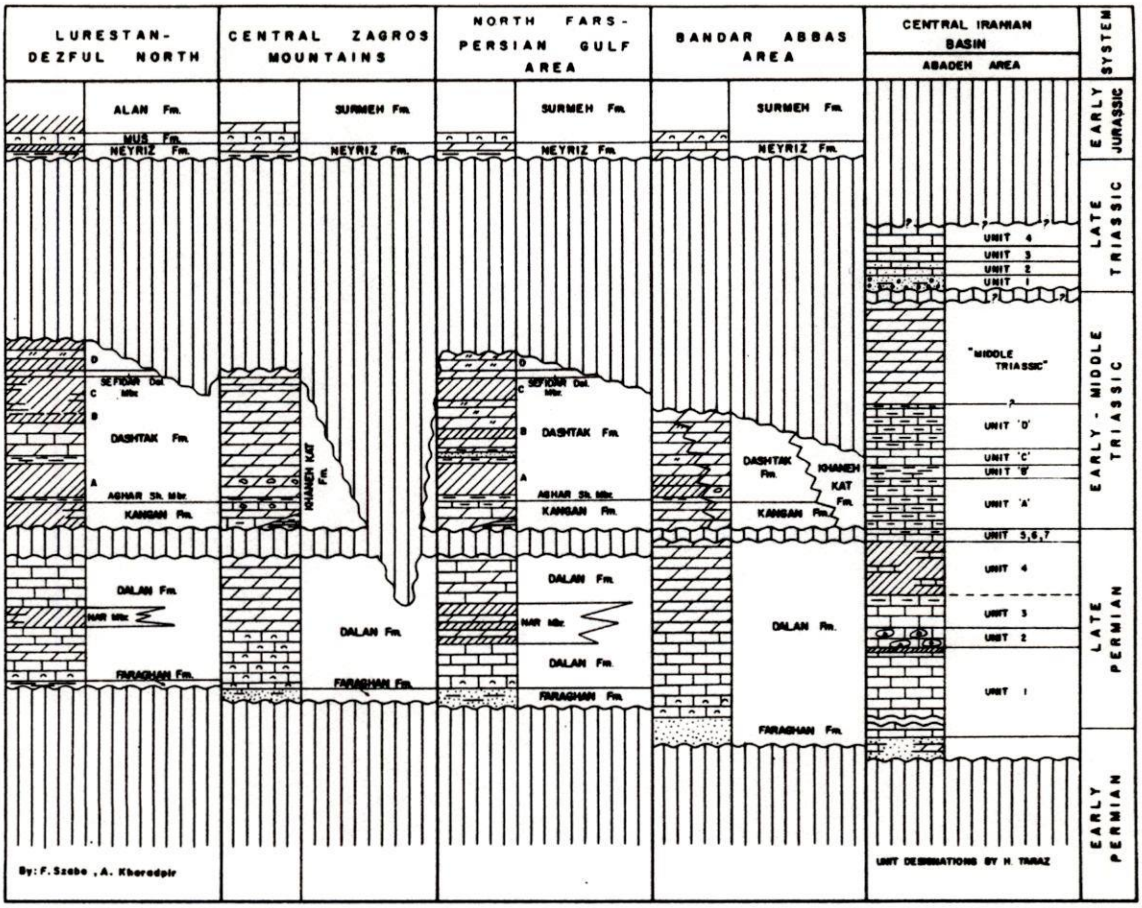


Figure 3. Correlation chart of Faraghan Formation in the Zagros Basin and adjacent areas (after Szabo and Kheradpir, 1978, p. 63 fig. 5). Present palynological data indicate that the Faraghan Formation is of Devonian and Lower Permian age.

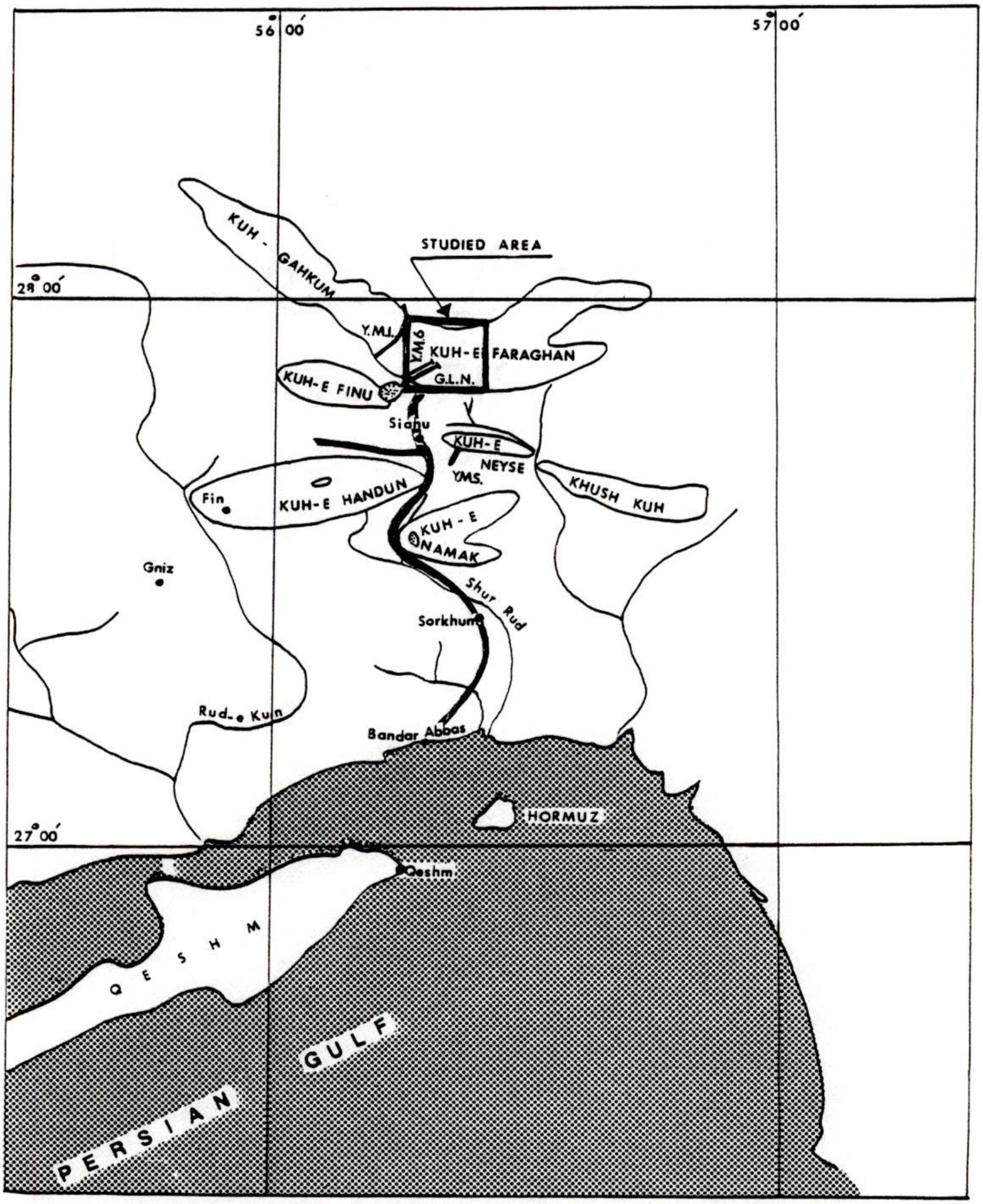


Figure 4· Location of the study area and its position in relation to the Persian Gulf.

- SALT PLUG
- PAVED ROAD
- MEASURED SECTION

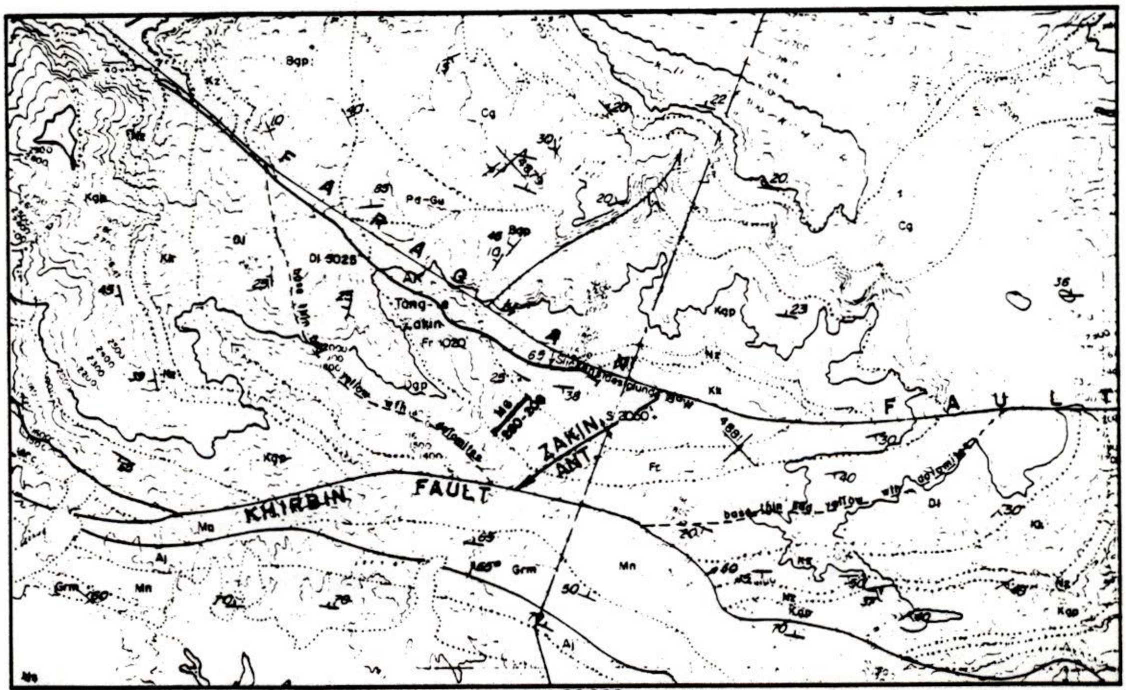
displacement of layers in small scale. The subsidiary faults are mostly strike-slip.

The Paleozoic sequence is exposed at the core of the Zakin anticline and that sequence contains early to late Paleozoic strata. In the Zakin anticline, dips of layers are variable and a consequence of movement of both the Faraghan and Khirbin faults. At the northern flank, dips of beds change from 65 to 85 degrees near the Faraghan fault, and at the southern flank, dips of beds range from 38 to 65 degrees near the Khirbin fault. Only in the core of the Zakin anticline do strata have less pronounced dips in the range of 25 to 40 degrees.

<u>Lower Paleozoic Strata</u>

The base of the Paleozoic sequence in Kuh-e-Faraghan consists of a hundred meters of clastic sediments, mainly red and green shales at the base and white sandstones and conglomerates at the top. The age of this part of the sequence is unknown at the Zakin anticline (Fig. 5) because sediments are barren of fossils. This part of the Paleozoic sequence may be equivalent (in part) to either the Lalun Formation (Cambrian?) or the Zaigun Formation (Infracambrian?) of central and northern Iran. This part of the section is overlain by marine fossiliferous Silurian sediments. The relationship of the base and top of this sequence to underlying and overlying beds is not clear because the Faraghan fault has caused intensive distortion in areas of contact.

Silurian sediments are well-exposed at Kuh-e-Faraghan as well as at Kuh-e-Gahkum. These Silurian sediments are called "Silurian shales" and they are composed of dark gray and green shales with sandstone intercalations. The Silurian shales contain marine fossils such as brachiopods, corals, ammonoids, graptolites, and trilobites. These early Paleozoic sediments have been attributed to the lowermost Silurian. The age assignment has been suggested based on Monograptus, Diplograptus, and Climacograptus by H.de Bockh et al. (unpublished company report, 1929) and J.A. Douglas (1950). Likewise, the Silurian shales contain different types of ichnofossils that characterize successive ichnofacies such as Nereites, Zoophycos, Cruziana, Skolithos, and Scoyenia from bottom to top, respectively. The Silurian shales have a thickness of about 700 meters at Kuh-e-Faraghan and about 120 meters at Kuh-e-Gahkum. At Kuh-e-Faraghan, the Silurian shales are gradational laterally into silty micaceous shales with large concretions (0.5-2.0 meters) near the top. The Silurian sediments grade into purple shales at the top and they are disconformably overlain by the Faraghan Formation. The lithofacies and biofacies changes of the Silurian shales probably reveal their gradual emergence sometime during the Silurian period. On the other hand, the great thickness of these sediments at



Scale: 1:90,000

Figure 5. Location map of study sections in Tang-e-Zakin in Kuh-e-Faraghan.

Contour interval 100 m.

├──┤	Measured Section
──►	Anticline Axis
───	Faults
·······	Boundary of Fm.
▪▪▪▪▪▪	Base of key Triassic dolomite

(Map courtesy of National Iranian Oil Company)

Kuh-e-Faraghan in comparison with Kuh-e-Gahkum possibly suggests continuous subsidence in the sedimentary basin of the Faraghan area during the Silurian period. This continuous subsidence could have been caused by faulting at that time.

The Faraghan Formation

The name Faraghan Formation is given to the clastic sediments that are exposed along all of the high mountain ranges in the Zagros Basin from northwest to southeast Iran. The Faraghan Formation was named from one of the best developed and most accessible outcrop sections at Kuh-e-Faraghan (Szabo and Kheradpir, 1978). Before 1978, the Faraghan Formation was called "Carboniferous sandstones" or "Permo-Carboniferous sandstones". These terms are still used in some unpublished reports of the Anglo-Iranian Oil Company Limited (Harrison, 1931) and the Stratigraphic Lexicon of Iran (Setudehnia, 1976). The Faraghan Formation is exposed along Ushtran-Kuh, Zard-Kuh, Kuh-e-Dina mountain ranges, Kuh-e-Surmeh, Kuh-e-Gahkum, and Kuh-e-Faraghan (Figure 2).

The thickness of the Faraghan Formation varies from place to place and is described as follows.

In Ushtran-Kuh, the Faraghan Formation consists of brownish-red-weathering white, coarse-grained sandstones (Harrison, 1931). Usually, this rock unit is poorly exposed and is 30 meters thick (Harrison, 1931). In the Zard-Kuh area, the Faraghan Formation is exposed with a thickness of 100 meters, and it is composed of white, thin-bedded sandstones. The thickness of sandstone is consistent with Upper Permian carbonates (Kheradpir and Setudehnia, unpublished company report, 1972; Ghavidel-Syooki, 1982b).

In the Chal-i-Sheh area, the Faraghan Formation is approximately 500 meters thick (unpublished company reports, Harrison, 1930s; Szabo et al., 1976; and Ghavidel-Syooki, 1982). The Faraghan Formation contains abundant remains of Sigillaria persica (Seward, 1932) at one horizon in the Chal-i-Sheh area. As Seward suggested, this plant species indicates an age not older than Westphalian for the Faraghan Formation.

In the Kuh-e-Dina mountain ranges, the Faraghan Formation is diminished to a few meters of white sandstones with a dark brown, ferruginous-weathered surface (Setudehnia, 1976). The Faraghan Formation is usually present along the base of the cliffs of Permian carbonate in this area (Setudehnia, 1976).

In Kuh-e-Gahkum, the Faraghan Formation consists of white, current-bedded sandstones approximately 240 meters in thickness (McQuillan, 1962; Szabo, 1977; and Ghavidel-Syooki, 1984b) with 27 meters of thin-bedded black limestones in the middle portion of the section.

In Kuh-e-Surmeh, the Faraghan Formation is composed of approximately 100 meters of white, pebbly, current-bedded, friable, hematitic sandstones. In Kuh-e-Surmeh, only the lower portion of the Faraghan Formation is exposed: its upper portion is obscured. McGugan in 1949 (unpublished company reports), found a number of plant clasts from the middle part of the section that Douglas (1950) has identified as a Carboniferous morphotype of Equisetaceae.

In Kuh-e-Faraghan, the Faraghan Formation is composed of white to dark gray, fine to medium-grained sandstone with dark shale intercalations and minor limestone in the middle part of the section. In Kuh-e-Faraghan, the thickness of the Faraghan Formation has been measured by different geologists and the measurements range from 207.2 meters by McQuillan in 1962, 300 meters by Mollazal in 1963, 311 meters by Nicol and Kheradpir in 1972, and 230 meters by Ghavidel-Syooki in 1984 The discrepancies may be due to a combination of factors such as precise locality of measurement, interpretation of dip, faults, base, top, etc.

The upper contact of the Faraghan Formation is with Upper Permian carbonates (Dalan Formation) at all outcrop sections, except that this upper contact is obscured in Kuh-e-Surmeh. The gradational contact of this formation with the Permian carbonates is shown in two surface sections of Kuh-e-Faraghan (stratigraphic sections concerning this research) by a transition from interbedded sandstone and limestone beds, and by the sandy character of the lowermost carbonates of the Dalan Formation.

The lower contact of the Faraghan Formation is marked by an unconformity with the lowermost beds of the Faraghan

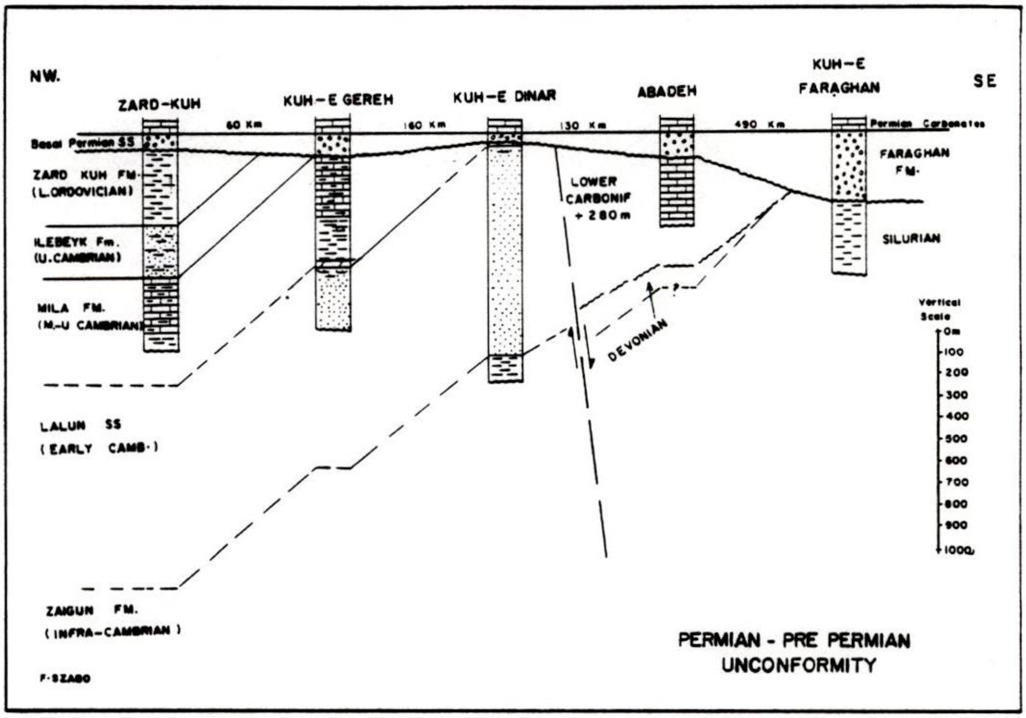


Figure 6. Distribution of the Faraghan Formation from northwest to southeast Iran and its relationship to overlying and underlying formations as interpreted by Szabo and Kheradpir, 1978, p. 62, Fig. 4.

Formation overlying Cambrian- to Silurian-age sediments (Szabo and Kheradpir, 1978). The Faraghan Formation overlies the Middle Cambrian at Kuh-e-Dina, Kuh-e-Gereh; the Lower Ordovician at Zard-Kuh, Chal-i-Sheh, Kuh-e-Surmeh; and the Silurian shales in the Faraghan-Gahkum areas. In Kuh-e-Surmeh, this unconformity is marked by a coarse, quartz conglomerate which lies on a barren, dolomitic, recrystallized limestone with approximately a 10 degree angular unconformity (Szabo and Kheradpir, 1978). However, in Kuh-e-Faraghan and Kuh-e-Gahkum, the lowest contact with the Silurian shales appears to be more a disconformity than an angular unconformity (Figure 6). This well-marked angular unconformity has been associated with erosional activity that removed more than 1100 meters of Ordovician-Cambrian beds at Kuh-e-Dina and Kuh-e-Gereh in the Zagros Basin (Szabo and Kheradpir, 1978). This erosional period might have been simultaneous with the Hercynian orogenic activities at the areas mentioned. Similar observations were suggested in the Galpaygan area by Thiele et al. (1968), who postulated similar movements for the Central Iranian Basin.

The source area for the Faraghan clastics may have been the acidic basement complex of the Arabian Shield (Szabo and Kheradpir, 1978). However, there is another alternative in that much of the sand in the Faraghan Formation could have been derived from Kuh-e-Dina and Kuh-e-Gereh in the Zagros Basin. The latter possibility is based on the Permian subcrop map of the Zagros Basin which has been prepared by Szabo and Kheradpir (1978).

The Faraghan Formation lacks marine fossils. The age of this rock unit has been the subject of controversy for a long time. Most geologists, however, assigned the Faraghan Formation to the Permo-Carboniferous period (Setudehnia, 1976) or Permian period (Szabo and Kheradpir, 1978). The age assignment of the Faraghan Formation has been based on Seward's work (1932) in the Chal-i-Sheh area in the southwestern part of Zagros. Chal-i-Sheh is about 500 kilometers from the Faraghan-Gahkum areas (Figure 2). Seward (1932) identified some plant remains as Sigillaria persica and suggested that the Faraghan Formation might be either lower Permian or Stephanian (Upper Carboniferous).

After the publication of Seward's paper, the geologists accepted his age assignment of Carboniferous for the Faraghan Formation. This proposed age is recorded in the "Stratigraphic Lexicon of Iran" (Stöcklin and Setudehnia, 1972).

During the second phase of geological survey of the Zagros Basin, which established nomenclature of rock units, Szabo and Kheradpir (1978) reviewed Seward's paper and suggested a Lower Permian age for the Faraghan Formation (Figure 5) based on Seward's suggestion that Sigillaria persica "may represent Stephanian or indeed be Lower Permian". On the other hand, they suggested that paleontological and stratigraphic evidence of the Zagros Basin indicates that the oldest dated Permian beds are not older than Artiniskian in age. Hence, if the Faraghan Formation were of unconformity should exist between the Faraghan Formation and Permian carbonates in the Zagros Basin, as continuous sedimentation in this facies over such a time period is unreasonable. Therefore, they suggest that such a break is not known, and the only unconformity that can be seen is at the very base of the Faraghan Formation.

Preliminary Palynologic Dating

The author's preliminary research focused on palynological characteristics of the Faraghan Formation in the Faraghan and Gahkum area in 1980 (Figures 2 and 3). The research was carried out on both surface stratigraphic sections which were measured and sampled in the area by other geologists (Mollazal in 1962, Nicol and Kheradpir in 1972) or cutting samples which were obtained from oil wells (Finu-1, Namak-1, Sefidar-1, Naura-1, Anjir-1, Kuh-E Siah-1, Dalan-1 & 2, 0-4 Bis) (Figure 2).

Fortunately, both surface and cutting samples are rich in palynomorphs which makes it possible to determine the full age span of the Faraghan Formation. The present study demonstrates that 200 out of 300 meters of outcrop section of the Faraghan Formation in both Kuh-e-Faraghan and Kuh-e-Gahkum were deposited during the Devonian period and that the remainder accumulated during Lower Permian time. Thus, the Carboniferous period is apparently unrepresented in southern Iran. These preliminary findings were presented in the Sixth International Conference in Calgary, Canada, in 1984.

It was determined by these preliminary studies that it was desirable to undertake a more detailed palynological study on the Faraghan Formation. Therefore, the author measured and sampled two stratigraphic sections in Tang-e-Zakin of Kuh-e-Faraghan and one section in Tang-e-Abzag of Kuh-e-Gahkum in 1984. The location of this formation is in the critical area of the overthrust of the Iranian Plate onto the Arabian Plate.

FIELDWORK

The study area is located approximately 80 kilometers north of Bandar Abbas in southeastern Iran. The paved road of Bandar-Abbas-Sirjan is the main connection. Sixty kilometers east and north of Bandar Abbas, this road divides. The main road leads to the Siahu village 19 kilometers away, and an unpaved road connects the Siahu village to the study area (Figure 4).

As shown on the topographic map of the study area (Figure 5), the Faraghan Formation is exposed at about 2000 meters elevation in the core of the Zakin anticline in Kuh-e-Faraghan. The two surface stratigraphic sections for this dissertation were measured and sampled at the same places that the other geologists (Mollazal in 1962, Nicol and Kheradpir in 1972) had prepared surface stratigraphic sections of the Faraghan Formation and older and younger Paleozoic beds in Tang-e-Zakin of Kuh-e-Faraghan.

The fieldwork was carried out in the winter season (January to February) in 1984 because winter is the best time for geological fieldwork. Spring and summer are too hot (45-50°C) and in fall, the Faraghan River is flooded. The fieldwork was organized between three geological teams, and each team was concerned with one part of the Paleozoic sequence in the Gahkum-Faraghan areas. These parts included the Silurian shales, the Faraghan Formation, and the Dalan Formation.

Much attention was paid by the team to consider all possibilities that could have resulted in better field observation and measurement of the true thickness of the Faraghan Formation at Kuh-e-Faraghan and Kuh-e-Gahkum. Each bed of the Faraghan Foramation was carefully investigated both horizontally and vertically. Therefore, the field observations resulted in many new findings such as biogenic structures, fish remains and plant remains which are noted on the two surface stratigraphic sections (Figures 7 and 8). Moreover, a small scale tear fault has cut the middle portion of the Faraghan Formation, an observation that was not considered in previous studies (Nicol and Kheradpir in 1972, and Mollozal in 1962). Therefore, the author´s measurement differs by 70 meters in comparison with previous studies.

The Faraghan Formation is a very distinctive sedimentary facies which is easily separable from the underlying and overlying formations, consisting mainly of white sandstone with intercalations of dark-gray shales and a few stringers of limestone. Shale layers become dominant in the middle portion of the Faraghan Formation and contain plant remains (Figure 7, sample number MG-240 to MG-246). The Faraghan Formation grades laterally into the green silty, fissile shale layers which contain abundant hematitic nodules and and plant remains (MG-262 to MG-265).

Ripple marks and cross-bedding are common throughout the Faraghan Formation. Biogenic structures appear in a few meters of strata at the base and near the middle part of the Faraghan Formation and are mostly vertical burrows with some horizontal trails (Figure 7, MG-236 to MG-243A). Deformed sedimentary structures are not common, but they occur in two horizons from which samples MG-253 and MG-258 (Figure 7) were obtained.

A total of 204 composite samples was collected from three surface stratigraphic sections of the Faraghan-Gahkum areas. As indicated on the stratigraphic logs, 130 out of 204 samples were collected from the two surface sections of Kuh-e-Faraghan with the remainder from Kuh-e-Gahkum. Samples were collected from all lithologic units. A greater number of samples were collected in units where lithological changes were obvious (Figures 7 and 8). To obtain less-weathered samples, a trench was made to the depth of about one-half meter. About 3 kilograms of rock chips were picked from this trench for each sample. The samples were placed in plastic bags and then in cloth bags. This was done to prevent any possible contamination of samples during transport from the field to the laboratory.

Figure 7. Stratigraphic Column of Surface Section One of the Faraghan Formation in Tang-e-Zakin at Kuh-e-Faraghan (Palynology Project, Samples MG-208 to MG-280).

NATIONAL IRANIAN OIL COMPANY

EXPLORATION AND PRODUCTION GROUP

EXPLORATION DIVISION-SOUTH

KUH-E FARAGHAN (TANG-E ZAKIN)

Scale: 1:200

SURFACE SECTION

SECTION NO: 1

DRAWING NO: 41513

AREA: BANDAR-ABBAS

LOCATION:

X: 2,613,000 & 2,609,000

Y: 7,065,250 & 7,094,000

GEOGRAPHIC COORDINATES:

E: 56°18′57″ & 56°16′30″

N: 27°50′56″ & 27°52′25″

MAP REFERENCE: 40406

SURVEY: PALEOZOIC PROJECT (PALYNOLOGY)

REPORT(S) OR NOTE(S):

MEASURED BY: M. GHAVIDEL-SYOOKI & D. BAGHBANI

DATE: 63-11-20, 63-12-20

RANGE OF SAMPLE NOS: MG. 208 - 280

TOTAL NUMBER OF SAMPLES: 72

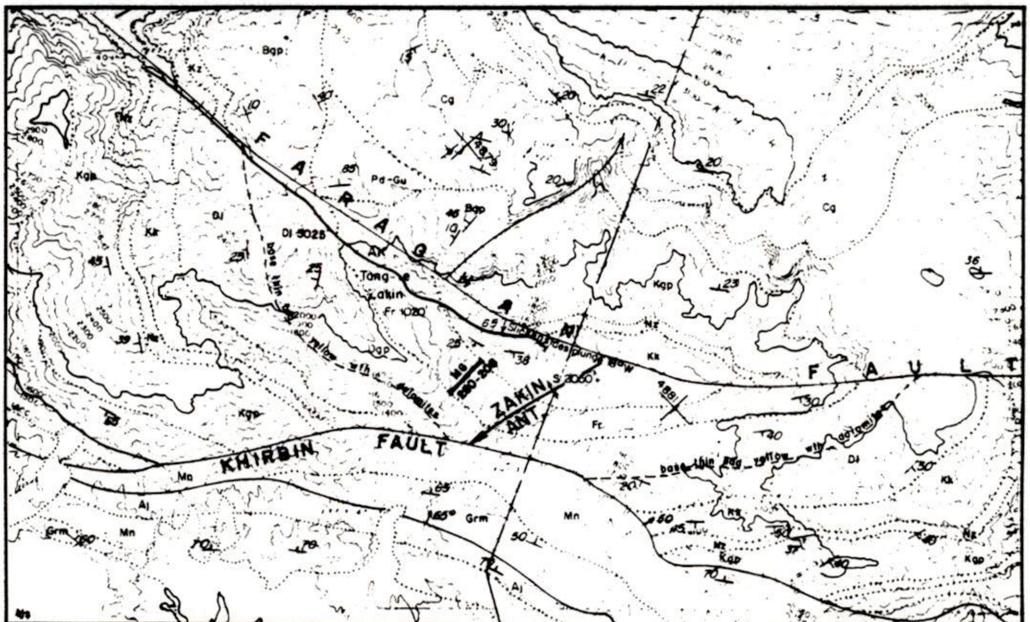
INTERVAL COVERED:

TOTAL THICKNESS: 230 M

AVERAGE SAMPLE INTERVAL: $\frac{220}{72}$

N.I.O.C. Section Name Section No. GRAPHIC LOG

Author: M. Ghavidel-Syooki



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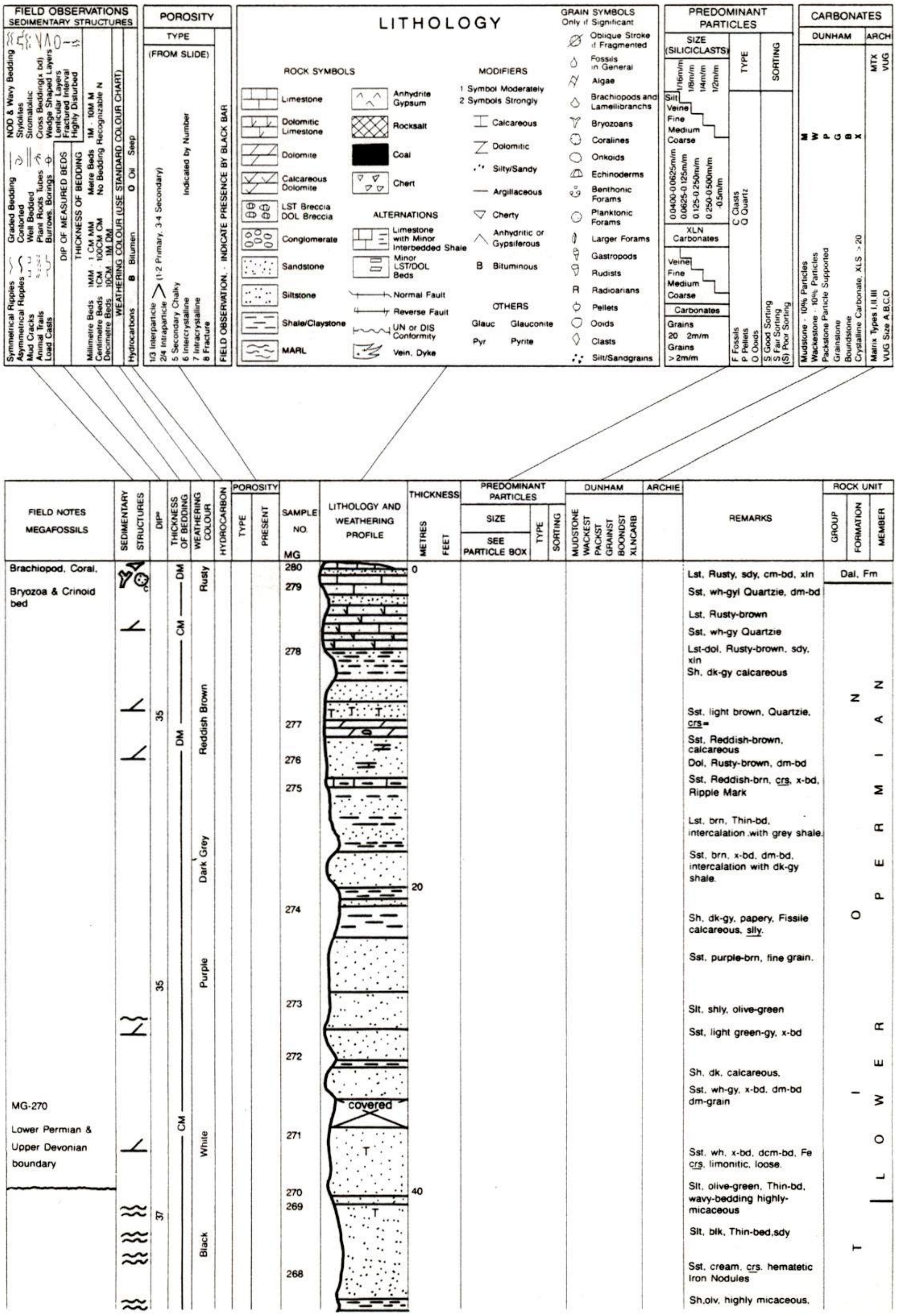

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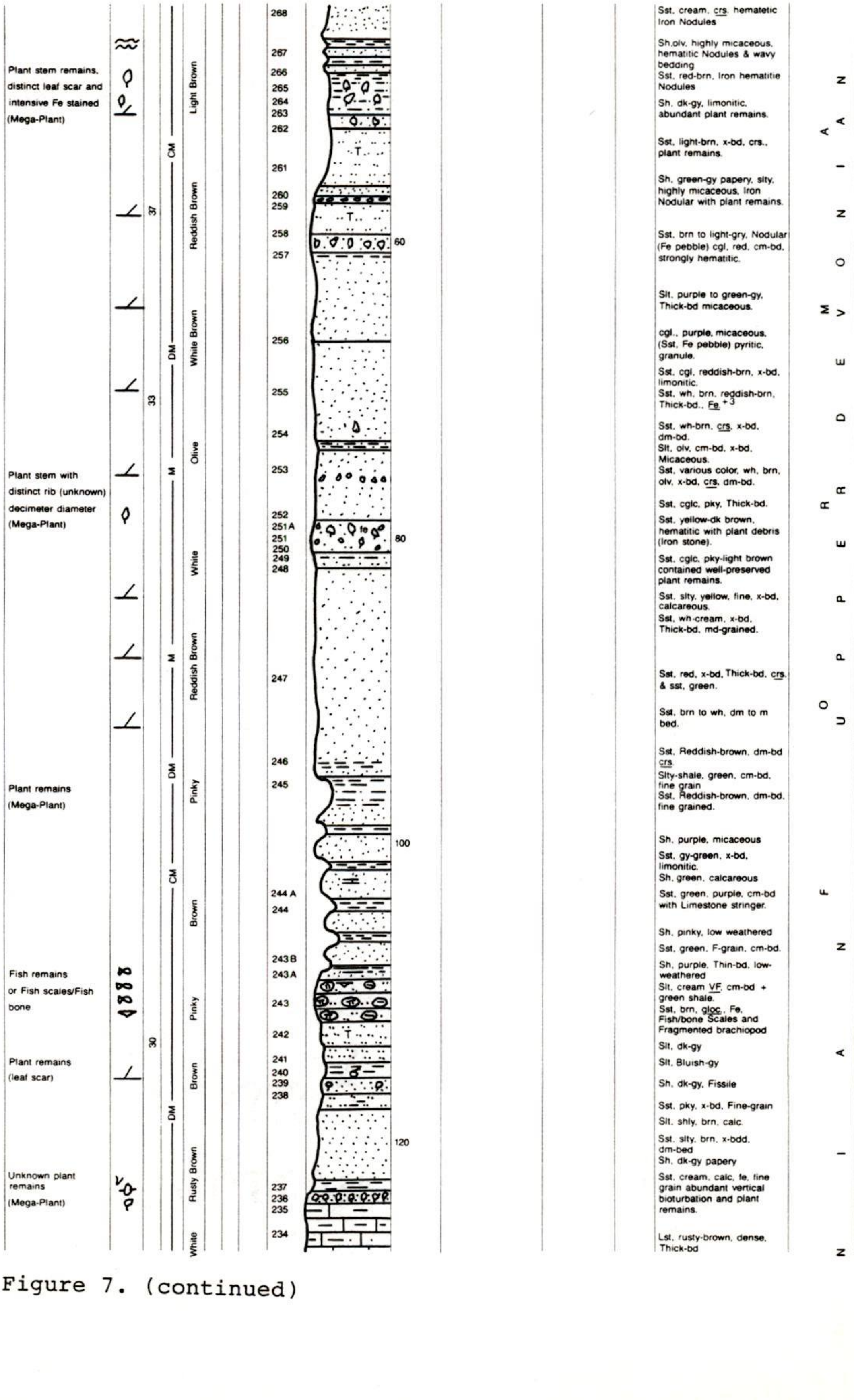

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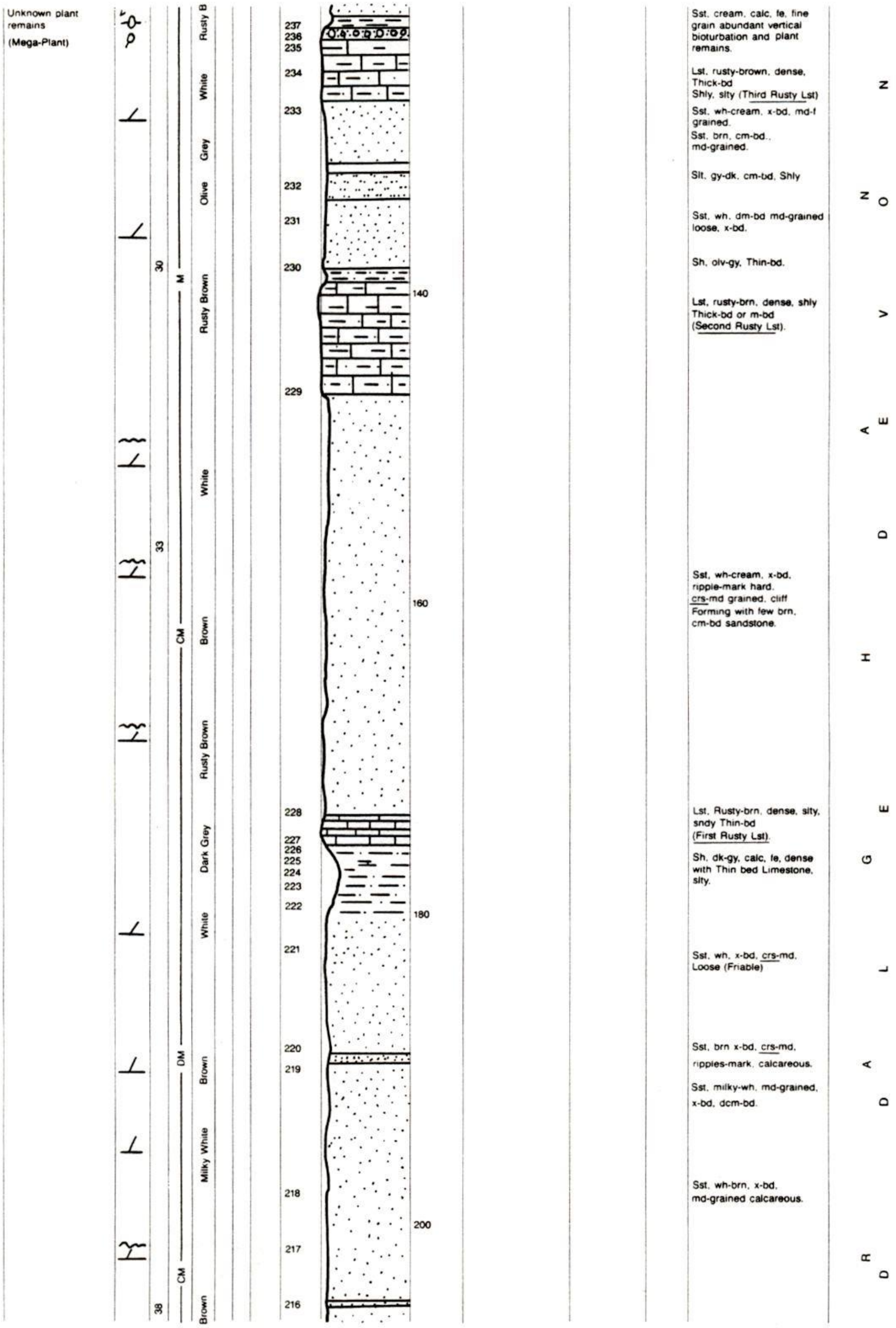

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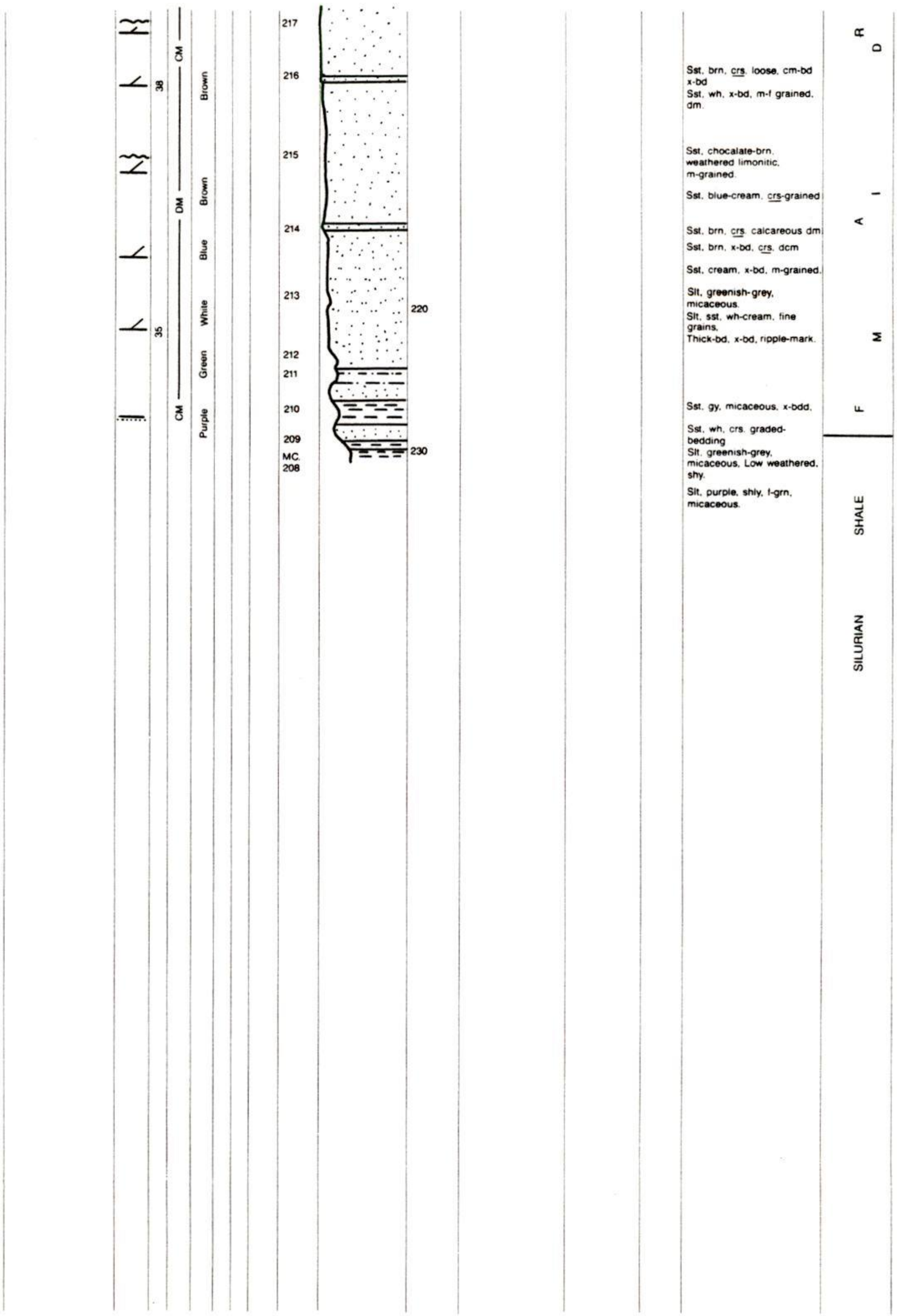


Figure 7. (continued)

Figure 8. Stratigraphic Column of Surface Section Two of the Faraghan Formation in Tang-e-Zakin at Kuh-e-Faraghan (Palynology Project, Samples MG-281 to MG-338).

NATIONAL IRANIAN OIL COMPANY

EXPLORATION AND PRODUCTION GROUP

EXPLORATION DIVISION-SOUTH

KUH-E FARAGHAN (TANG-E ZAKIN)

Scale: 1:200

SECTION NO: 2

SURFACE SECTION

DRAWING NO: 41514

MEASURED BY: M. GHAVIDEL-SYOOKI & M. E. KHOSRAVI

AREA: BANDAR-ABBAS

DATE: 20/11 - 20/12/63

LOCATION:

X: 2,613,000 & 2,609,000

RANGE OF SAMPLE NOS: 281 - 338

Y: 7,065,250 & 7,094,000

GEOGRAPHIC COORDINATES:

E: 56°18′57″ & 56°16′30″

TOTAL NUMBER OF SAMPLES: 57

N: 27°50′56″ & 27°52′25″

INTERVAL COVERED:

MAP REFERENCE: 40406

SURVEY: PALEOZOIC PROJECT (PALYNOLOGY)

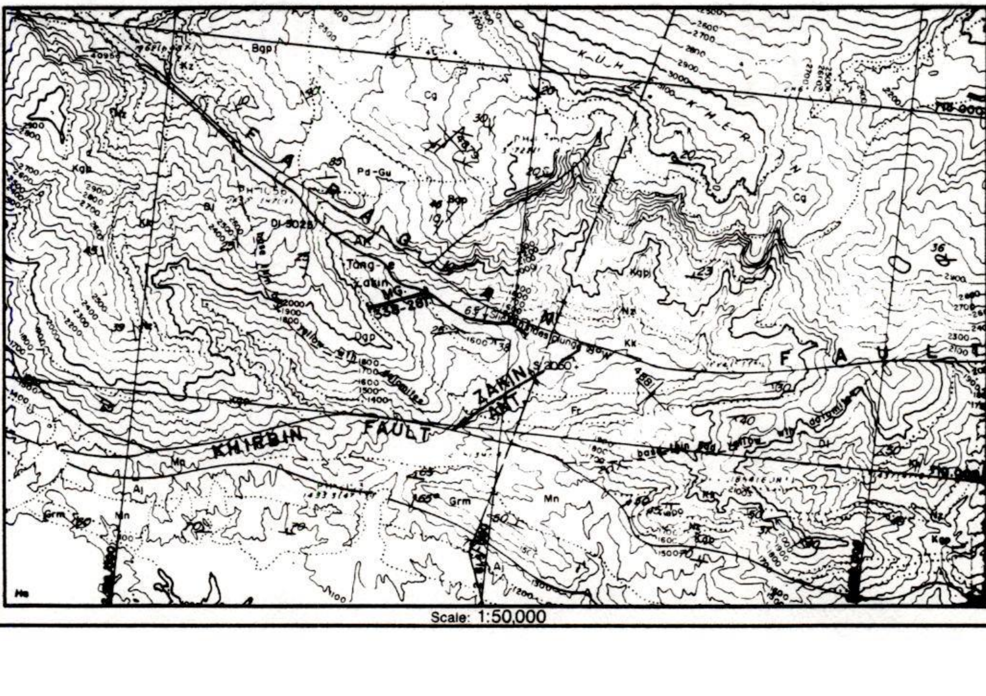
TOTAL THICKNESS: 230 M

REPORT(S) OR NOTE(S):

AVERAGE SAMPLE INTERVAL: 4

N.I.O.C. Section Name Section No. GRAPHIC LOG

Author: M. Ghavidel-Syooki



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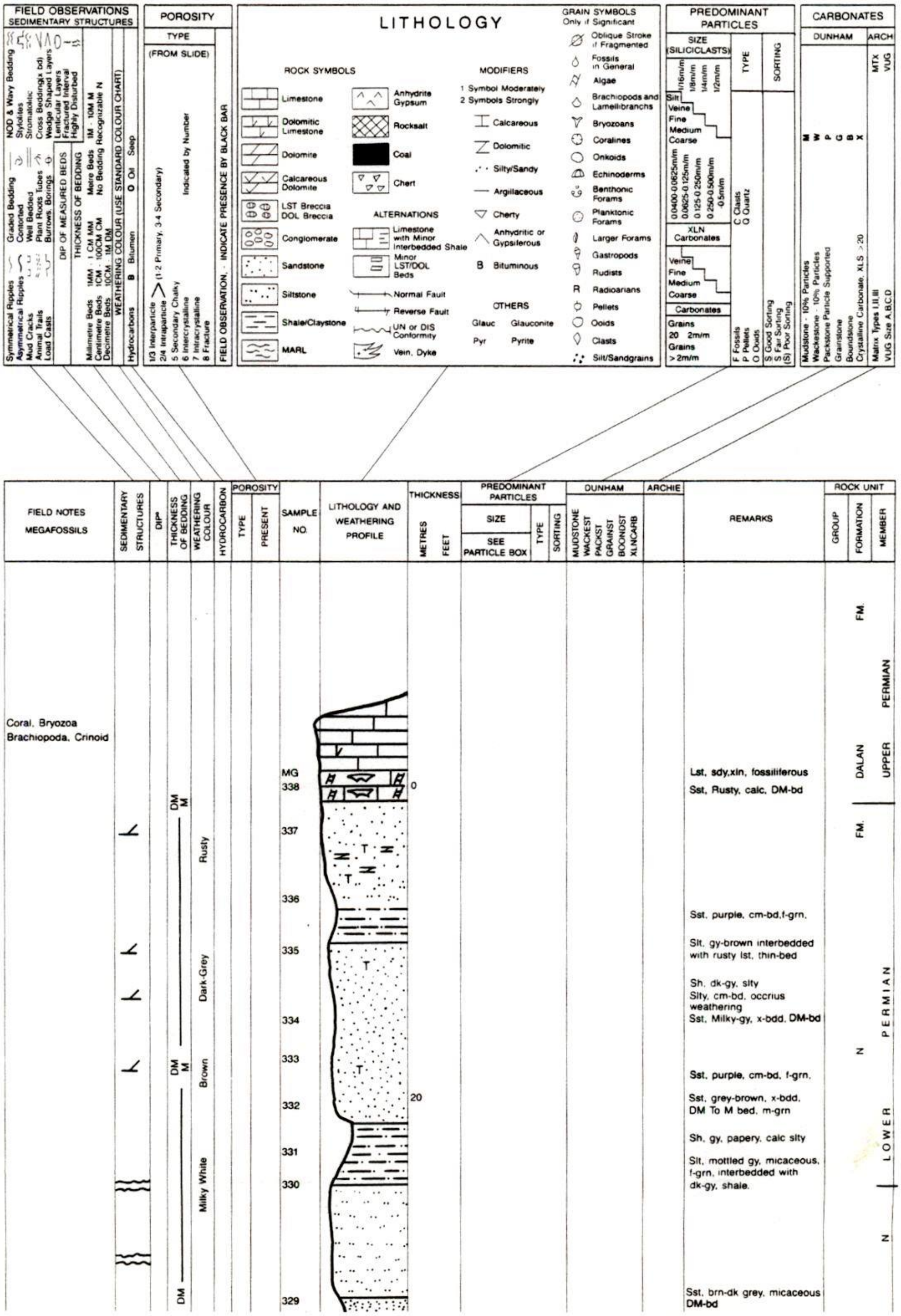

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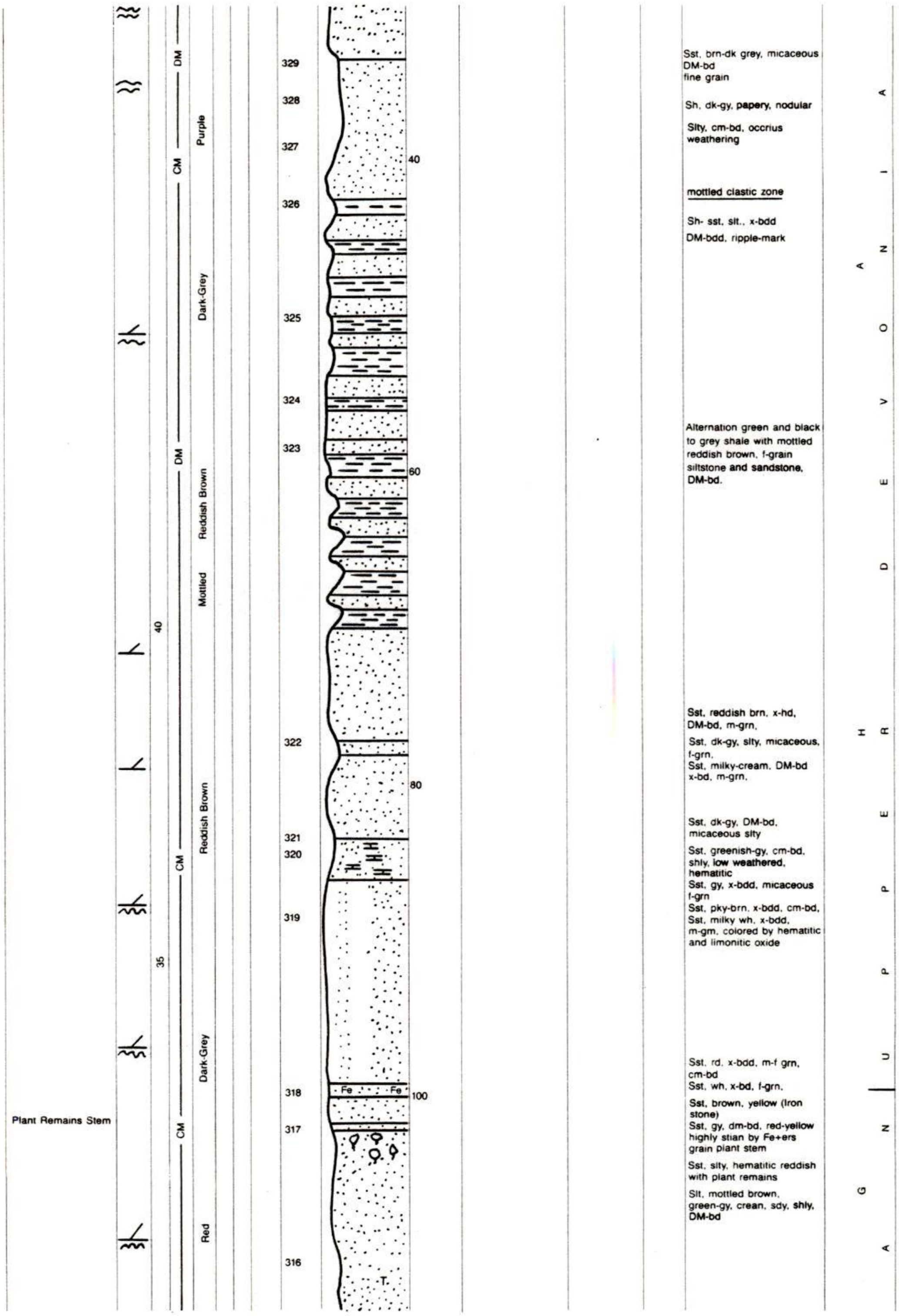

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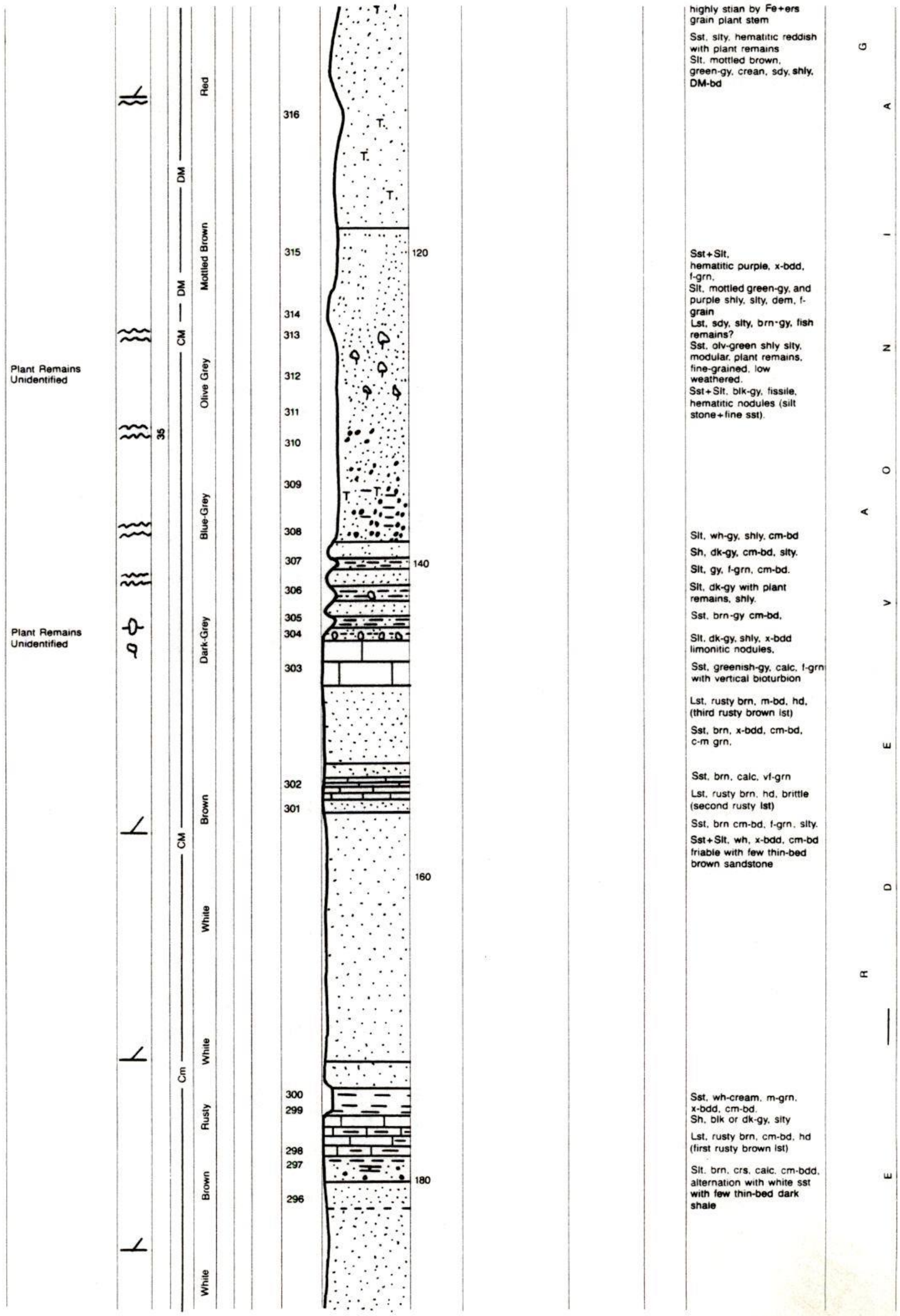


Figure 8. (continued)

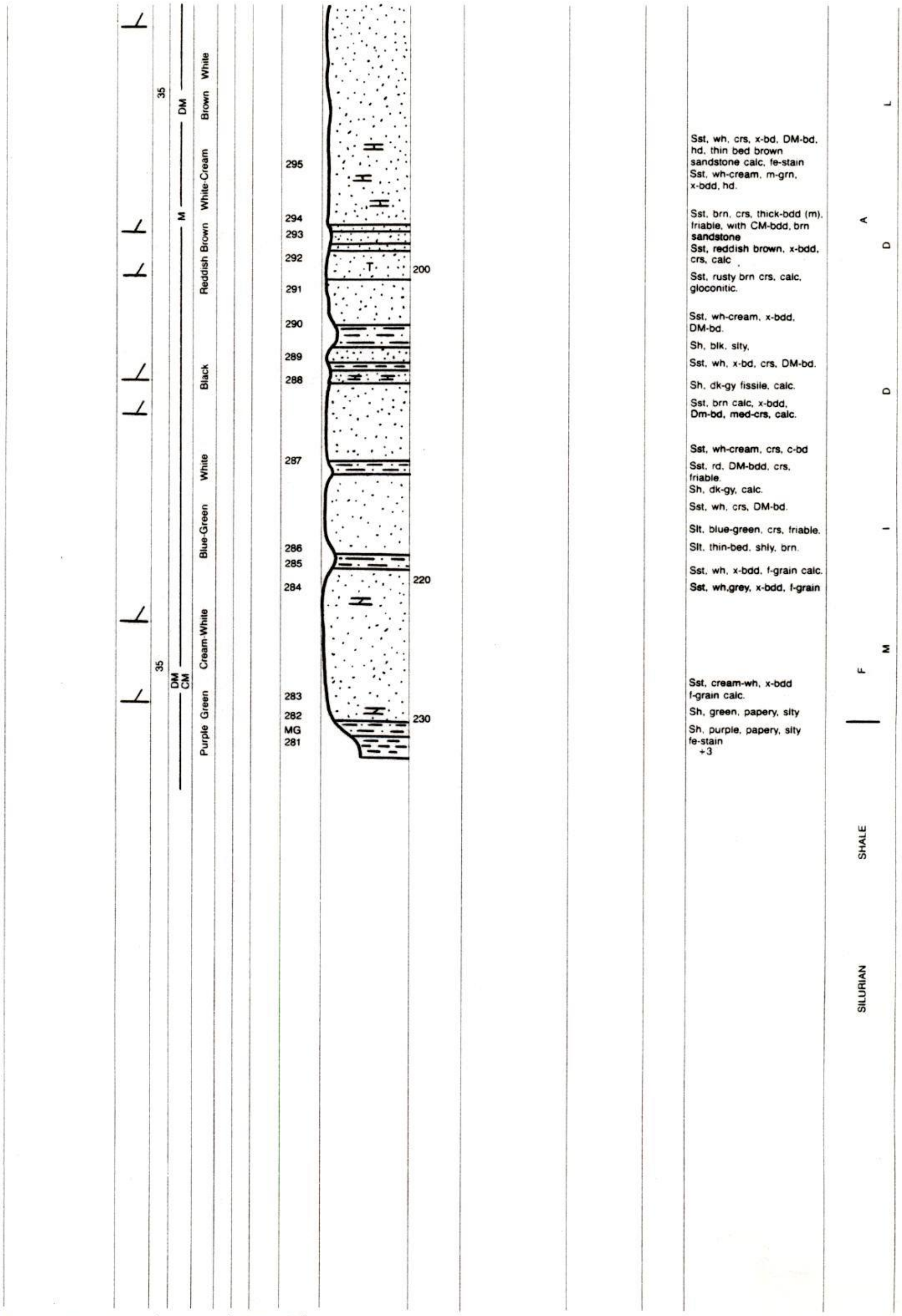


Figure 8. (continued)

TECHNIQUES FOR STUDY

Palynological Preparation Techniques

A total of 137 surface samples from the Faraghan Formation of Kuh-e-Faraghan and Chal-i-Sheh were selected for palynological study by the author. The field and laboratory description of samples have been plotted on the stratigraphic sections of this study (Figures 7 and 8). The code and number of each sample follows the policy of the National Iranian Oil Company.

Seventy-five grams of each sample out of a total of approximately 3000 grams each sample was randomly selected. These samples were processed in the palynology laboratories at both Michigan State University and the National Iranian Oil Company. The disaggregation of the rock samples was carried out using standardized techniques that are employed by both universities and oil companies. The procedure used for this study is as follows:

1. Each sample was washed in running water to remove dust and extraneous material from the surface of the rock sample.
2. Each sample was then crushed in a clean iron mortar until all fragments were less than one cm in maximum

dimension. This step was used for the siltstones and sandstones but not for the shale samples.

3. The crushed sample was placed in a 500 ml glass beaker and 10% hydrochloric acid was added until the sample was covered. Experience indicated that reaction time varies between 12 hours for calcareous samples and 20 to 60 minutes for non-calcareous siltstones and sandstones. The disaggregated sample was repeatedly washed with distilled water, using a centrifuge, to remove any trace of hydrochloric acid.
4. The acid-free sample was placed in a plastic beaker and treated with 48% hydroflouric acid for 24 hours. The reaction time was 12 hours for shales and 24 hours for siltstones and sandstones. A series of distilled water washes was used to remove any trace of hydroflouric acid from the sample. The sample was then sieved using a 20 micrometer screen and examined under the microscope for the presence of palynomorphs. Most palynomorphs were observable in this step. Thus, the next steps followed with more confidence and more care. After sieving, the organic fraction was placed in glass beakers and treated with 10% hot hydrochloric acid for 4 hours or more. The samples were then washed to remove hydrochloric acid from the organic fragments. Experimentation demonstrated that both Schulze´s solution and KOH destroyed the pollen and spores freed

from the matrix in steps 3 and 4 so neither oxidizing agent was used.

5. About 30 ml of saturated zinc bromide solution (ZnBr2 + H_2O) with a specific gravity of 1.95 was added to the sample in a clean centrifuge tube to separate organic residue from inorganic materials. The mixed organic and inorganic materials were suspended in this heavy liquid and the ultrasonic generator was used to homogenize the suspension. The suspended material was centrifuged for 3 minutes at 1000 rpm. After this period of time, the materials separated into three zones in the zinc bromide solution: an upper, middle, and lower zone. Each zone was extracted by pipette in sequence. An aliquot from each zone was mixed with distilled water in a separate centrifuge tube and washed several times to remove any trace of the corrosive zinc bromide solution. After this stage, the residue of each zone was examined for the occurrence of palynomorphs. This procedure revealed that the uppermost zone was typically lacking in palynomorphs and made up of only woody debris, and the bottom zone was made up of minerals and no palynomorphs. The middle aliquot contained a good concentration of palynomorphs with a few plant tracheids, and it was the organic residue of this zone in each sample that was stored in small glass sample vials for study.

6. The residue containing palynomorphs was not stained since the color of the grains, ranging from golden yellow to dark brown or black was adequate for study.
7. The residue in each small glass sample vial was diluted and mixed with distilled water. Immediately, after agitation, three drops were taken by pipette and put on a clean cover slip. The residue of the cover slip was mixed with polyvinyl alcohol (PVA) and was dispersed on the cover slip as uniformly as possible with a tooth pick. The cover slip was placed on a hot plate to dry. After a few minutes, the excess polyvinyl alcohol evaporated, and a thin film of organic residue remained adhering to the cover slip. The cover slip was then inverted and mounted, residue side down, on a clean glass microscopic slide in a drop of Kleermount resin. Three slides were prepared from each sample, and all slides used in this study are on file in the palynology laboratory at Michigan State University.

Analytical Microscopy Techniques

During this study, the Leitz Orthomat microscope (# 591962) in the palynology laboratory of Michigan State University was used for all observations and photography. All of the slides were examined by the author for the occurrence of palynomorphs. The coordinates of the location of each particular palynomorph were recorded using the coordinates from the calibrated mechanical stage. In all cases, the slide was placed in the stage holder with the label to the right of the observer. The different palynomorphs were photographed using the Leitz Orthomat automatic microscope camera system. Kodak Panatomic X film (32 ASA/16 DIN) was used. The developing and printing were done at existing facilities at Michigan State University using standard techniques.

Identification of various palynomorphs was accomplished by comparison of the specimens under study with those described and illustrated in most available literature of the late Paleozoic time. Quantitative evaluation of each productive sample was made based on systematic traverses of the slide. The palynomorphs were counted until a total of 1000 specimens was attained. In order to eliminate size bias from the counts, only grains whose geometric centers were included in the alignment rectangle within the field of view were tallied. Detached, isolated sacci of palynomorphs were not counted whereas the body of such grains was counted as a single grain.

Scolecodonts were counted, but plant tissues (tracheids and stomata) were considered for the qualitative interpretation of the sample. Those palynomorphs which were too poorly preserved to allow either identification or consistent recognition, were tallied as unknown types.

The relative percent for each genus and species was calculated based on the total number of each species or genus to the total grain counts. Bar graphs were made to show the contribution of each palynomorph. The study data appear in Table 1 through Table 13 and are discussed in the chapter on stratigraphy and paleoecology of palynomorphs.

REVIEW OF PALEOZOIC PALYNOLOGIC ASSEMBLAGES

The purpose of reviewing here the worldwide stratigraphical distribution of fossil spores and pollen is to make possible the comparison of key stratigraphic palynomorphs with the distribution of genera and species found in strata of the Zagros Basin. General information about the stratigraphic succession of critical pre-Devonian, Devonian, and post-Devonian taxa will be summarized below.

1. Silurian spore assemblages

According to some palynological studies, the first group of trilete spores appeared in the Lower Silurian (Hoffmeister, 1959; Richardson and Lister, 1969; Richardson et al., 1981). These trilete spores are few in number with smooth exine. They gradually increase in number and variety through the Middle and Upper Silurian strata.

The Silurian trilete spores are mainly azonate, smooth, and retusoid. The paucity of spores and lack of variety within the Silurian spores are in marked contrast to rich assemblages of the Gedinnian strata. However, the parent taxa which attained great diversity in the Gedinnian stage may have emerged during the Silurian period. The Silurian microflora assemblage consists of *Ambitisporites abtivus*, *A. dilutus*; *Archaeozonotriletes chulus*; *Retusotriletes* warringtonii; Emphanisporites neglectus and E. protophanus; Synorisporites verrucatus; and Apiculatisporites synorea.

2. Devonian spore assemblages

A. Gedinnian spore assemblages

Little information is available on the Gedinnian assemblages (Cramer, 1966; Richardson, 1967; McGregor et al., 1970). Available data, however, have been generally based on poorly preserved material with little stratigraphic control.

According to Richardson and Lister (1969), the Gedinnian assemblages collectively have several distinctive features that can be summarized as follows:

1) Spores are very small, on the average, ranging in size from 8 to 62 microns.
2) Well-developed contact areas and "curvaturae perfectae" are constant features among the Gedinnian trilete spores.
3) Sculptures are highly varied compared with the Silurian forms.
   The sculptures of the Gedinnian forms are granulate, spinose, biform, verrucate, murinate, reticulate, and ribbed.
4) Radial spores appeared in relatively more abundance and more variety in the Gedinnian strata than in the Upper Silurian strata.

Richardson and Lister (1969) reason that the increase in number and variety of spores in the Gedinnian assemblages may reflect evolutionary response to environmental conditions such as climatic factors. These differences in assemblages are accentuated in different facies. They also noted that the Gedinnian floodplain deposits contain much more abundant and sculptured forms than the Gedinnian marine facies. Thus, it is probable that facies character is an important factor in the observed diversity of Gedinnian palynomorph assemblages, as it is in all later periods.

B. Siegenian-Emsian spore assmblages

Well-dated Siegenian-Emsian assemblages are rare, but some available data indicate a similar developmental pattern to that observed in the Gedinnian stage (McGregor, 1961; Doubinger, 1963; Allen, 1965; McGregor et al., 1970). However, the important event which took place in the Gedinnian stage is the appearance of several important, characteristic Devonian genera. The Siegenian-Emsian spore types tend to be larger in size and continue to have proximal differentiation as in the Gedinnian spore types.

The radial pattern forms are frequently present, clearly differentiated, and more diversified in the Siegenian-Emsian strata than in the Gedinnian strata. Annulate-erraticus types of the genus Emphanisporites occur in the Siegenian-Emsian strata and continue into the Middle Devonian and the lower part of the uppermost Devonian strata. The appearance of Emphanisporites annulatus is an important Siegenian marker, since it has not been recorded from pre-Siegenian strata.

The genus Emphanisporites ranges from Silurian to the Lower Carboniferous age and reached to maximum number of species in the Emsian-Eifelian stages. After the Emsian-Eifelian stages, the frequency of Emphanisporites begins to decline gradually without significant morphological change through the rest of the Devonian period.

The strong proximal sculpture is an unusual feature among the Devonian genera. Emphanisporites is a distinctive and common genus of this type. However, there are some exceptions. Emphanisporites has not been reported from the Siegenian-Emsian rocks in some places (e.g., Ajou, France). On the other hand, several reports indicate that Emphanisporites species have been found from Lower and Middle Devonian strata (Naumova, 1953; Allen, 1965; Riegel, 1973). Likewise, Richardson (1974) reports E. rotatus and E. annulatus-erraticus in the Famennian and Lower Carboniferous strata of New York State, yet he emphasizes that Emphanisporites spore types are mainly characteristic of Lower and Middle Devonian strata and the presence of Emphanisporites in the Carboniferous strata may be due to recycling (Winslow, 1962; Eames, 1974).

Well-developed pseudosaccate spores are present in Siegenian-Emsian strata. Elaboration of this type continues through the Siegenian-Emsian and later becomes prominent in

Eifelian and Givetian assemblages. The records of pre-Middle Devonian spore types with anchor-shaped spines are rare. According to Allen (1965), this type of spore emerged in the Emsian stage. The age of spores with anchor-shaped spines in the Emsian is verified by their presence in Emsian strata dated by marine faunas. They are not abundant in the Emsian, but they are important in the Middle-Upper Devonian strata. Furthermore, the palynological records reveal that the appearance of these genera (Ancyrospora and Hystricosporites) may not have been simultaneous in different parts of the world.

Spores of megaspore size have been recorded from Siegenian strata by Allen (1965) and Richardson (1967). The size of megaspores varies from about 185 to 530 microns. These megaspores have a stratigraphic range from the Siegenian to the Givetian suggesting that heterosporous plants appeared in the Siegenian stage.

C. Eifelian-Givetian spore assemblages

Unlike the situation in the Siegenian-Emsian, there are many more stratigraphic occurrences of Eifelian-Givetian assemblages. In general, the microfloras from these two stages represent a continuation and limited diversification of the Emsian microfloras. The Middle Devonian assemblages are characterized by significant numbers of large zonate, pseudosaccate spores and by distinctive spores with anchor-shaped processes (Richardson, 1960, 1962; Allen, 1965;

McGregor and Owens, 1966; Lele and Streel, 1969; Riegel, 1973; Loboziak and Streel, 1981; McGregor, 1981; McGregor and Camfield, 1982).

The principal problem in the interpretation of the data from these two stages is related to variable facies and ecological interpretations. The examination of palynological assemblages from a wide range of facies leads to problems of interpretation. Such problems may also be due to ecological controls which may have been exerted on the assemblages. These problems have made it difficult to establish an accurate macropaleontological correlation among fish, plant, coral, brachiopod and bivalve assemblages of the marine deposits.

At the present time, it cannot be determined whether the absence of particular generic groups in some areas of the world is due to regional differences or the ecological conditions which have operated on assemblages in stratigraphic sequences that include a wide variety of facies changes.

Another problem is assessment of the results obtained from palynological studies of Devonian strata in Iran and the systematic and taxonomic interpretations of Soviet palynologists. The Soviet palynologists use a different taxonomic approach and a different nomenclatural system, making direct comparisons difficult.

Review of the available data from the Eifelian-Givetian strata reveals a broad similarity between the Middle

Devonian assemblages from North America, the Soviet Union, and some other European countries. Yet, it is not easy to draw reliable correlation lines between the assemblages of the Middle Devonian strata in various parts of the world. According to Richardson (1974) there are several significant spore assemblages of Middle Devonian strata. Some characteristic species are Acinosporites acanthomammillatus, Densosporites devonicus, Rhabdosporites langi, Ancyrospora grandispinosa, Calyptosporites velatus, and Samarisporites orcadensis. He states that Calyptosporites velatus is restricted to Middle Devonian strata, but it has also been reported from Lower Tournaisian strata in northern Africa (Lanzoni and Magloire, 1969). Richardson (1974) suggests that the presence of Calyptosporites in Lower Tournaisian strata is due to recycling because this species has not been recorded elsewhere in the Tournaisian. It is important to mention that Rhabdosporites langi has not been recorded below the Eifelian. Therefore, the appearance of Rhabdosporites langi is a good indicator of the Emsian.

D. Frasnian spore-pollen assemblages

The general pattern of morphological diversification of the Givetian assemblages continues into the Frasnian with no major changes in composition of the assemblages at the boundary between the two stages. Although the palynofloras of Frasnian age contain extensive populations of zonate and pseudosaccate spores similar to those of Givetian strata, the Frasnian strata can be distinguished from the Givetian below and the Famennian above (Kedo, 1957; Winslow, 1962; Owens and Streel, 1967; Clayton and Graham, 1974; Van der Zwan, 1980; Loboziak and Streel, 1981; Van Veen, 1981). The assemblages of the Frasnian are characterized by a degree of diversification that can be summarized as follows:

1) The first taxa with multifurcate termination processes appeared in the Frasnian with maximum diversification in the processes of bifurcate genera such as Hystricosporites and Ancyrospora.

2) Occurrence of the genus Archaeoperisaccus is limited to the Frasnian. Owens and Richardson (1972) point out that the genus Archaeoperisaccus is restricted to Frasnian strata at some localities in the Soviet Union and Canada. The paleogeographic distribution of Archaeoperisaccus was also be extended to the Frasnian of northern and southern Iran by Ghavidel-Syooki (1977).

3) Appearance of Chomotriletes vedugensis has so far been recorded from the Frasnian of Australia, the Soviet Union, the United States, Saudi Arabia, and in Devonian strata in northern and southern Iran.

This species is associated with other distinctive Frasnian palynomorphs such as Geminospora spp., Ancyrospora sp., and Hystricosporites sp.. Chomotriletes vedugensis has not yet been recorded below the Frasnian or in Carboniferous strata above. Although there are some records of the presence of this species in the Permian deposits in India

(Tiwari et al., 1980) and Cretaceous deposits in the United States. The presence of representatives of this genus in Permian and Cretaceous deposits may be due to recycling since the frequency of Chomotriletes in these deposits is very low in comparison to its abundance and diversity in the Frasnian. These later occurrences may also represent a taxon of similar morphology but without relationship to Devonian taxa.

4) Continuation of the Middle Devonian pseudosaccate forms in the Frasnian strata is characterized by a decrease in size and abundance and appearance of new taxa such as Contagisporites optivus. According to Owens and Richardson (1972) the Geminispora types comprise a high percentage of Frasnian assemblages.

E. Famennian spore-pollen assemblages

In general, many genera that were distinctive in Eifelian-Givetian-Frasnian strata begin to decrease in frequency and significance in the Famennian. Many genera become extinct and are replaced by a new series of spore types that become significant in Lower Carboniferous assemblages. Genera such as Retusotriletes, Hystrichosporites, and Ancyrospora are all known from the Famennian strata, but they disappeared early in the Lower Carboniferous.

Significant research on spore distribution in the Famennian type section in Belgium was carried out by Streel

(1970). An important feature of Streel´s work is that his study was carried out as part of a coordinated project, involving the analysis of the stratigraphical distribution of brachiopods, cephalopods, conodonts, and foraminifera. Consequently, his study is amplified by a reliable series of biostratigraphic zones that can be used as a standard succession for this stage. Many projects have been carried out by McGregor and Owens (1966) on the Famennian strata of Canada. The results show similarities to the succession of assemblages that Streel reported from the Famennian of Belgium.

The assemblages of the Famennian are composed of a wide variety of genera that have greater affinities to the Lower Carboniferous than to the Devonian. The Famennian assemblages do not contain spores with bifurcate spines nor any representatives of the characteristic Middle Devonian and Frasnian pseudosaccate genera. Recently, considerable attention has been given to the distribution of spores in the uppermost Famennian and lowermost Tournaisian deposits in various parts of the world. This particular interval was the subject of a special symposium organized by C.I.M.P. in 1969. Results of that symposium reveal that the uppermost Famennian and basal Tournaisian strata are characterized by the presence of Retispora lepidophytus complex associated with Vallatisporites pusillites, Knoxisporites literatus, Lophozonotriletes cristifer, Spinozonotriletes uncatus, and Verrucosisporites nitidus.

3. Summary of Pertinent Devonian Microplankton

The name "acritarch" was suggested by Evitt (1963) to encompass that group of microfossils previously known as the "Hystrichospheres". Downie, Evitt, and Sarjeant (1963) defined the group as follows:

> Unicellular, or apparently unicellular, microfossils consisting of a test composed of organic substances and enclosing a central cavity. Shape of the test is spherical, ellipsoidal, discoidal, elongate, or polygonal; test surface is smooth, granular, punctate, or perforate. Spines, raised ridges, flanges, wings, or other overgrowths are present or absent; where present, they are distributed regularly or irregularly. The shell opens by rupture, splitting, or formation of a simple pylome. Rarely are tests loosely associated in a chain.

They also subdivided the acritarchs on the basis of morphology into subgroups, such as acanthomorphs, sphaeromorphs, etc. The acritarchs were thought to be a polyphyletic group of planktonic marine organisms of diverse affinities, and it was suggested that, as more became known about them, they would be transferred to appropriate classes.

The acritarch group was therefore conceived as an informal category for a varied collection of "*incertae sedis*" microfossils. Above the generic level, the nomenclature was deliberately informal so as to avoid difficulties such as those encountered when the formal and legally established predecessor to the acritarch, the order Hystrichosphaeridea, had to be broken up. Some workers, notably in the United States, prefer to refer to the acritarchs as organic-walled microplankton *incertae sedis*.

Not many of these problems of relationship have been solved to date. It is generally agreed that the acritarchs are marine planktonic algae (Downie, 1973; Tappan, 1980). A considerable number of them show little resemblance to any extinct or extant groups, and many are too simple to be confidently assigned anywhere. One major group shows similarity to dinoflagellate cysts, but these similarities are not thought to be sufficient justification to transfer them. Another large group is placed by a number of authors (e.g., Tappan, 1980) with the Prasinophycae, a class of planktonic algae that includes the living *Pachysphaera* and *Pterospermopsis* as well as the fossil *Tasmanites*. However, this group is here retained in the acritarchs.

The subgroups of Downie, Evitt, and Sarjeant (1963) include the following types:

A. Sphaeromorphs are more or less spherical, smooth forms that dominate the Precambrian assemblages. Their systematic treatment is confused and obscure, and treatments vary greatly. There is a marked difference in approach between morphological and biological schools. They probably include blue-green algae, green-algae, and prasinophycid algae.

B. Acanthomorphs and polygonomorphs are round or more or less spine-bearing polygonal forms. These dominate the Paleozoic assemblages and probably were the dominant

Paleozoic phytoplankton. Some resemblance to dinoflagellate cysts has been noted but they are probably polyphyletic and are classified on the basis of gross morphology.

C. Pteromorphs and herkomorphs are round forms, the latter with the ellipsoidal test that shows polygonal subdivisions on the surface, with raised veils, crests, or alae. These have been present since the Cambrian and are mainly represented by the genera *Pterospermopsis* and *Cymatiosphaera*. Except in euxinic deposits, their numbers are not large. Many species, especially in the late Paleozoic and Mesozoic, strongly resemble *Pterosperma*; consequently, some authors classify them with prasinophycean algae (Tappan, 1980).

D. Diacromorphs, Netromorphs, and Oomorphs are round or elongate bodies with polar differentiation. These are variously shaped. Some can be linked to the acanthomorphs and polymorphs. They are heterogeneous with no clear affinities.

In spite of the fact that acritarchs are of uncertain biological affinity, they are widely used to date Paleozoic sequences. In order to explain what acritarchs are like and what they contribute in biostratigraphy, charts have been presented by Downie (1984) illustrating a very substantial sample of worldwide Paleozoic acritarchs to show the stratigraphic range of each species. One can obtain from these charts a good idea of appearance of these forms and their biostratigraphic ranges. According to Downie´s chart (1984), throughout the periods succeeding the Cambrian, a rich and changing flora of acritarchs is present in the Ordovician, Silurian, and Devonian in most marine sediments. Downie has indicated that during the Paleozoic, the assemblages of acritarchs from offshore marine sediments comprise 40 to 60 species. Palynological preparations from Cambrian marine sedimentary strata of Iran are dominated entirely by acritarchs (Ghavidel-Syooki, unpublished data). Ordovician samples are similar but also contain some chitinozoans and scolecodonts. The Silurian marine sediments also provide similar assemblages but with the addition of a few microspores in the younger Silurian strata. Miospores become very common in the Devonian and may even dominate in some coastal marine sediments with their proportion tending to decrease with increasing distance from the paleoshoreline. According to Downie (1984) acritarchs are less significant after the Devonian. The few scattered records from the Carboniferous to the Triassic show the persistence of spiny forms belonging to the Veryhachium/Micrhystridium complex. This group continues through to the Neogene but after the Triassic, marine microplankton are usually dominated by the dinoflagellates.

In respect to geographic distribution of acritarchs, temperature, water depth, and salinity may be major factors.

It is probable that their distribution is controlled by mass water movements. The best evidence comes from the Silurian where Cramer and Diez (1972; 1977) have studied acritarch distribution in North and South America, Europe, Africa, and parts of Asia. Their study reveals the presence of distinctive assemblages that appear to be temperature-controlled since their distribution approximates paleolatitudes. Patterns from the Ordovician show similar tendencies, and Vavrdova (1974) noted marked differences between the Baltic and the Mediterranean provinces during this period.

Apart from the obvious fact that Paleozoic acritarchs are confined to marine strata, there is little evidence to indicate a salinity control. Dorning (1981) showed that in the Ludlow of England and Wales, sphaeromorphs are not only dominant inshore but also in the distal (deep water) sediments. The greatest diversity of acritarchs is asociated with offshore shelf sediments, and probably middle latitudes. However, Upshaw (1964) has proposed that the acritarchs seem to thrive at intermediate depths on the continental shelf and diminish in numbers in shallower and deeper waters. He also argues that the acritarchs are not found in sediments known to have been deposited in waters whose salinities were significantly below that of open marine environments.

The presence of microplankton in association with spores and pollen grains indicates near-shore or shelf conditions, whereas an assemblage consisting exclusively of spores and pollen grains is interpreted as being representative of terrestrial depositional environments. Determination of abundance ratios between acritarchs and spores/pollen provides a quantitative means of estimating the relative distance of the sedimentary environment from the paleoshoreline. Such ratios have the advantage of minimizing the effect of varying rates of sedimentation of the organic constituents in the sample (Staplin, 1961).

According to the Devonian literature, the Devonian acritarchs are commonly accompanied in palynological preparations by chitinozoa and scolecodonts, and, in proximity to land, miospores may also be abundant (Staplin, 1961). There are some index acritarchs in the Devonian period that have not been found in the pre- and post-Devonian periods. These include: Chomotriletes vedugensis and C. bistchoensis; Deltotosoma intonsum; Duvernaysphaera spp.; Diexallophasis remota; Gorgonisphaeridium spp.; Navifusa bacillum; Papulogabata annulata; Polyedryxium spp.; Pterospermella onondaegensis; and Stellinium micropolygonale (Becker et al., 1974).

The Devonian acritarchs of Iran have been little studied. Because of the inadequate information about Devonian acritarchs of Iran, descriptions and illustrations of selected species from better-studied sections in other countries, the United States, Europe, and Australia have been used in this study. In doing this, use has been made of the works of Stockmans and Williere (1974), Martin (1981), Vanguestaine (1978) in Belgium; Deunff (1978) in France; Cramer and Diez (1976) in Spain; Playford (1977) in Canada; Wicander (1974), Wicander and Loeblich (1977), and Wicander and Wood (1981) in the United States; Playford and Dring (1981) in Australia; and Downie (1984) in England.

There are few records of Carboniferous acritarchs. This may be explained by the unsuitable environments of deposition in those areas where palynological studies have been conducted. The Carboniferous limestones and coal measures, for instance, are virtually barren. Such records as do exist indicate a continued but diminished presence of the late Devonian types and the demise of the chitinozoans. However, some studies have shown relatively diverse assemblages in the Lower Limestone Shales of England (Dorning, 1981) and the Tournaisian Shales of Belgium (Stockmans and Williere, 1966, 1967). Fifteen acritarch species have been recorded by Wicander (1974, 1975) from the Lower Mississippian marine Bedford Shale in Ohio (United States). These seem to represent the waning of the Devonian forms and subsequently only simple Veryhachium/Micrhystridium forms appear to be present.

Because of the predominantly terrestrial sedimentary strata, and wide spread arid conditions of the Permian, it might be expected that reports of acritarchs would be limited in occurrence and diversity. However, a limited range of acritarch morphologies was widespread (Sarjeant,

1973) and was mainly confined to the Veryhachium/ Micrhystridium group as documented by Wall and Downie (1963).

4. Summary of Pertinent Carboniferous and Permian Literature

The available palynological literature of the Carboniferous and Permian periods was examined to identify major floristic events and fossils characteristic of these periods. The study was useful for comparison of Iranian Permian palynomorphs with those of western Europe, Pakistan, India, Africa, Australia, and North America. Considerable palynological data have been added in the past 20 years from the continents of the Gondwana landmass and the Middle East.

Almost all of these have been oriented towards basic taxonomic description and organization of stratigraphic data. For Africa, data are available from the Congo (Bose and Kar, 1967) and from South Africa (Anderson and Anderson, 1970; Anderson, 1977). From Antarctica, data from the Transantarctic Mountains have been presented by Askin and Schopf (1978). Wilson (1976) demonstrated the clear similarity of Late Permian assemblages of Australia and New Zealand. Taxonomic and biostratigraphic work in Australia between 1970 and 1976 has been summarized by Kemp et al. (1977). Data from the Indian peninsula were synthesized by Bharadwaj (1975).

New information should make possible the evaluation of provincialism within Gondwanaland itself. There are hints that distinct phytogeographic units existed. For instance, the morphologically distinct spore genus *Dulhuntyispora*, which is a common and stratigraphically valuable fossil in the late Permian in Australia, appears to be confined to the Australian continent. However, there was a report of a limited occurrence of *Dulhuntyispora* in southern Africa (Anderson, 1977).

From the Middle East, Horowitz (1973) reported late Permian assemblages in Israel; Akyol (1975) reported on early Permian palynological assemblages of Turkey; Balme (1970) described the Permian palynological assemblages from the Salt Range of western Pakistan in detail; Ghavidel-Syooki (1984a) reported palynological assemblages belonging to early Permian time from southeastern Iran; and, from the Arabian peninsula, Besems and Schuurman (1987) described the late Paleozoic assemblages. Jerzykiewicz (1987) reported on early Permian palynoflora assemblages of Poland.

According to worldwide literature, there are some index plant microfossils in the Permian period that have not been found in the pre- and post-Permian periods. These include: *Hamiapollenites perisporites* and *H. tractiferinus*; *Costapollenites ellipticus*; *Corisaccites alutas*; *Striomonosaccites ovatus*; *Vittatina subsaccata*, *V. verrucosa*, *V. ovalis*, and *V. costabilis*; *Leuckisporites* spp.; *Quadrisporites horridus*; *Nuskoisporites rotatus*; *Potonieisporites granulatus*, and *P. neglectus*.

In summary, the literature review of the Permian period reveals that the microfloras of this period are distinctly different from those of the Carboniferous and succeeding periods. Hart (1964) divided the Permian palynoflora assemblages into Camerati, Cingulati, Zonati, and Striatiti groups, but only the Striatiti group underwent an evolutionary diversification, possibly related to the Gondwanian glaciation, at the beginning of the Permian period. Unlike the Striatiti group, the other Permian groups did not reach maximum diversity until the Mesozoic Era.

SYSTEMATIC DESCRIPTION OF DEVONIAN SPORES

In this study, the palynomorphs (spores, pollen, acritarchs) are classified alphabetically by genera and species. This classification scheme is particularly useful for applied stratigraphic palynology and permits ready placement of each morphotype within the frame-work of the system. Suprageneric categories, that may, in some cases, reflect natural relationships among genera are not employed. This is appropriate because the Palaeozoic plants, which produced the pollen and spores reported in this study, largely disappeared at the end of the Palaeozoic Era. Hence, any relationship to extant taxa can usually only be expressed in the most general terms.

In the systematic section that follows, "cf." is used in some cases to indicate a similarity to published material which can not be confirmed because of inadequate knowledge of the type material. "sp." is used to define morphotypes within a genus that appear to be distinct from the described species known to the author. With additional study, such morphotypes may ultimately be assigned to existing taxa or serve for the description of new palynospecies.

Descriptions are provided in the case of morphotypes which cannot be matched to published taxa. If a species is essentially identical to material cited, the description is omitted.

Quantitative terminology for abundance is as follows. Very rare < 1%, rare 1-3%, common 3-7%, and abundant > 7.

Genus Ancyrospora (Richardson) emend. Richardson, 1962.

Ancyrospora ampulla Owens, 1971

(Plate 1, Fig.1)

Occurrence: This species is very rare and confined to samples of the upper portion of the Devonian in section two of the Faraghan Formation at Tang-e-Zakin, Kuh-e-Faraghan.

Age: From the Frasnian of Arctic Canada (Whiteley, 1980), the Givetian of South Africa (Stapleton, 1977b), and the Frasnian of Canada (Owens, 1971).

Ancyrospora ancyrea (Eisenack) Richardson, 1962

(Plate 1, Figs. 3&5)

Occurrence: This species is rare and restricted to samples from the upper portion of the Devonian in section two of the Faraghan Formation.

Age: From the Emsian-Eifelian of Eastern Gaspé, Canada (McGregor, 1973), the Middle Devonian of Britain (Richardson, 1960, 1962), the Givetian of France (Lobozaik and Streel, 1980), the Givetian of South Africa (Stapleton, 1977b), the Upper Devonian of the United States (Von Almen, 1970; Eames, 1974; Wood, 1978) and the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967).

Ancyrospora grandispinosa Richardson, 1960
(Plate 1, Fig. 7)

Occurrence: This species is very rare, and, like other species of the genus *Ancyrospora*, is confined to the samples from the upper portion of the Devonian in section two of the Faraghan Formation.

Age: From the Middle Devonian of Britain (Richardson, 1962), and the Emsian-Early Eifelian of Canada (McGregor and Owens, 1966).

<u>Ancyrospora</u> <u>longispinosa</u> Richardson, 1962

(Plate 1, Fig. 4)

<u>Occurrence</u>: This species is rare and confined to the samples of upper portion of the Devonian in section two of the Faraghan Formation.

<u>Age</u>: From the Middle Devonian of Britain (Richardson, 1960, 1962) and the Middle Devonian of Canada (McGregor and Camfield, 1982).

<u>Ancyrospora</u> <u>magnifica</u> Owens, 1971

(Plate 1, Fig. 2)

<u>Occurrence</u>: The species is very rare and restricted to samples from the upper portion of the Devonian in section two of the Faraghan Formation.

<u>Age</u>: The Frasnian of Canada (Owens, 1971).

<u>Ancyrospora</u> sp.

(Plate 1, Fig. 6)

<u>Description</u>: Outline and central body of specimens are triangular to roundly triangular; laesurae distinct, straight, length equals spore radius; exine two-layered; intexine 5-3 μm thick and appressed to the exoexine; exoexine

granulate and sculptured with different types of spines; spines ornamented by microechinae or grana; diameter 130 μm, outline (excluding spines) 80 μm, spines 30-20 μm length, 5-3 μm wide.

Occurrence: Specimens are rare and confined to the samples of upper portion of the Devonian in section two of the Faraghan Formation.

Genus *Ambitisporites* Hoffmeister, 1959

Ambitisporites avitus Hoffmeister, 1959

(Plate 2, Fig. 4)

Occurrence: This species is rare and occurs in four samples (MG-287 to MG-297) from section two of the study area.

Age: From the Lower Devonian of the Welsh borderland (Edwards and Richardson, 1974), the Silurian-Lower Devonian of South Wales (Richardson and Lister, 1969), and the Silurian of Libya (Hoffmeister, 1959; Richardson and Ioannides, 1973).

Genus _Acinosporites_ Richardson, 1965

Acinosporites _acanthomammillatus_ Richardson, 1965

(Plate 2, Fig. 3)

Occurrence: This species is rare in section one and common in section two of the Faraghan Formation.

Age: From the Eifelian-Givetian of north-east Scotland (Richardson, 1965), the Emsian-Eifelian of West Germany (Riegel, 1973), the Givetian of South Africa (Stapleton, 1977b), the Middle Devonian of China (Lianda, 1981), the Givetian of Canada (Owens, 1971) and the Middle Devonian of Canada (McGregor, 1981).

Genus _Apiculiretusispora_ (Streel) emend. Streel, 1967

Apiculiretusispora _granulata_ Owens, 1971

(Plate 2, Figs. 1-2)

Occurrence: This species occurs in both sections of the Faraghan Formation, but it is rare in section one and abundant in section two.

Age: From the Upper Devonian of Canada (Owens, 1971).

Genus Auroraspora (Hoffmeister, Staplin and Malloy)
emend. Richardson, 1960

Auroraspora macromanifestus (Hacquebard)
emend. Richardson, 1960
(Plate 2, Fig. 5)

Occurrence: This species is very rare and restricted to a few samples of section one of the study area.

Age: From the Eifelian-Givetian of north-east Scotland (Richardson, 1960), the Givetian and Frasnian of Arctic Canada (Whiteley, 1980), and the Givetian to Famennian of Canada (Chi and Hills, 1976).

Auroraspora aurora Richardson, 1960
(Plate 2, Fig. 6)

Occurrence: This species is very rare and confined to a few samples in section one of the Faraghan Formation.

Age: From the Eifelian-Givetian of north-east Scotland (Richardson, 1960).

Genus Bullatisporites Allen, 1965

Bullatisporites bullatus, Allen 1965

(Plate 2, Fig. 7)

Occurrence: This species occurs in middle portion of the Devonian in both sections but it is very rare in section one and rare in section two.

Age: From the Siegenian-Eifelian of north and central Vestspitsbergen (Allen, 1965), the Woodford Formation of the United States (Von Almen, 1970), the Givetian of South Africa (Stapleton, 1977), the Emsian-Eifelian of West Germany (Riegel, 1973) and the Givetian-Lower Frasnian of France (Loboziak and Streel, 1980).

Genus Calyptosporites Richardson, 1962

Calyptosporites velatus (Eisenack) Richardson, 1962

(Plate 3, Figs. 4&10-11)

Occurrence: This species is common throughout both sections of the Faraghan formation.

Age: From the Middle Devonian of Britain (Richardson, 1962, 1964), the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967), the Emsian-Early Eifelian of Canada (McGregor and Owens, 1966), the Middle Devonian of Canada

(Owens, 1971), the late Middle Devonian of eastern New York State (Streel, 1972).

Genus Calamospora Schopf, Wilson, and Bentall, 1944

Calamospora pannucea Richardson, 1964

Occurrence: This species is common throughout the Devonian portion of both sections of the Faraghan Formation, in Tang-e-Zakin, Kuh-e-Faraghan.

Age: From the Middle Devonian of Britain (Richardson, 1964), the Emsian-Eifelian of eastern Gaspé, Canada (McGregor, 1973), and the Upper Devonian and Lower Carboniferous of the United States (Eames, 1974).

Calamospora sp.

(Plate 3, Fig. 5)

Description: Meiospores oval to subcircular in outline; trilete mark simple, 2/3 the spore radius in length; dark triangular area present in angles of the rays at the poles, merging with lighter part of wall with distinct contact; Exine thin and usually folded. Calamospora sp. differs from Calamospora pannucea in size and length of trilete rays.

Occurrence: This species is rare and cooccurs with *Calamospora pannucea* in Devonian samples from both sections.

Genus *Chelinospora* Allen, 1965

Chelinospora concinna Allen, 1965

(Plate 3, Fig 8)

Occurrence: This species is rare in both sections of the Faraghan Formation and its occurrence is confined to the lower portion of the Devonian in the study sections.

Age: From the Givetian of Spitsbergen (Allen, 1965), the Givetian-Frasnian Boulonnias of France (Loboziak and Streel, 1980, 1981).

Chelinospora sp.

(Plate 3, Fig 6&9)

Description: Specimens circular; exine two-layered; intexine thick and homogeneous; Exoexine thin, homogeneous, thin pseudosaccate (patinate); pseudosaccus irregularly developed on proximal surface, disappearing on some specimens (Plate 3, Fig. 9); trilete mark obscure in this species because of enclosing large polygonal to irregular lumina.

<u>Occurrence</u>: This species is very rare and has a stratigraphic range similar to <u>Chelinospora concinna</u>.

Genus <u>Cyclogranisporites</u> Potonie and Kremp, 1954

<u>Cyclogranisporites</u> <u>rotundus</u> (Naumova) Allen, 1965

(Plate 3, Fig 7)

<u>Occurrence</u>: This species is very rare and its occurrence confined to a few samples from the Devonian portion of the Faraghan Formation.

<u>Age</u>: From the Givetian of Spitsbergen (Allen, 1965).

Genus <u>Cymbosporites</u> Allen, 1965

<u>Cymbosporites</u> <u>cyathus</u> Allen, 1965

(Plate 3, Fig. 2)

<u>Occurrence</u>: This species is abundant in section one and very rare in section two of the Faraghan Formation.

<u>Age</u>: From the Givetian of Spitsbergen (Allen, 1965), the Givetian-Lower Frasnian Boulonnais of France (Loboziak and Streel, 1980), and the Middle Devonian of China (Lianda, 1981).

<u>Cymbosporites</u> <u>catillus</u> Allen, 1965

(Plate 3, Fig 3)

<u>Occurrence</u>: This species is rare in section one and very rare in section two of the Faraghan Formation.

<u>Age</u>: From the Givetian Spitsbergen (Allen, 1965), the Gedinnian of Scotland (Richardson, et al., 1984) and the Givetian-Lower Frasnian Boulonnais of France (Loboziak and Streel, 1980).

Genus <u>Densosporites</u> (Berry 1937) Potonie and Kremp, 1954

<u>Densosporites</u> <u>devonicus</u> Richardson, 1960

(Plate 4, Fig. 2)

<u>Occurrence</u>: This species is very rare in both sections and confined to few samples in the Devonian portion of the Faraghan Formation.

<u>Age</u>: From the Middle Devonian of Britain (Richardson, 1960, 1965), the Emsian-Eifelian of West Germany (Riegel, 1973), the Lower-Middle Devonian of Vestspitsbergen (Allen, 1965) and the Middle Devonian of Canada (McGregor and Camfield, 1982).

Genus <u>Dibolisporites</u> Richardson, 1965

<u>Dibolisporites</u> <u>eifeliensis</u> (Lanninger) McGregor, 1973

(Plate 4, Fig. 1; Plate 5, Fig. 1)

<u>Occurrence</u>: This species is common in section one and abundant in section two of the Faraghan Formation.

<u>Age</u>: From the Emsian-Eifelian of eastern Gaspé of Canada (McGregor, 1973), the Lower-Middle Devonian of Poland (Turnau, 1986) and the Early Devonian of central Ellesmere Island, Canadian Arctic (McGregor, 1974).

Genus <u>Emphanisporties</u> McGregor, 1961

<u>Emphanisporites</u> <u>annulatus</u> McGregor, 1961

(Plate 4, Figs. 6&9)

<u>Occurrence</u>: The species is very rare and confined to a few samples of the Devonian portion of both sections of the Faraghan Formation, in Tang-e-Zakin, Kuh-e-Faraghan.

<u>Age</u>: From the Emsian-Eifelian of eastern Gaspé of Canada (McGregor and Owens, 1966; McGregor, 1973), Eifelian of West Germany (Riegel, 1973), the Lower-Middle Devonian of Poland (Turnau, 1986), the Lower Devonian of Belgium (Streel, 1967), the Late Devonian -Early

Carboniferous of the Irish Republic (Clayton and Higgs, 1977) and the Siegennian-Emsian of Canada (McGregor, 1970).

Emphanisporites erraticus (Eisenack) McGregor, 1961
(Plate 4, Figs. 5, 8&11)

Occurrence: The species is common in a few samples of the Devonian portion of the Faraghan Formation, in Kuh-e-Faraghan.

Age: From the Emsian-Eifelian of eastern Gaspé Canada (McGregor, 1973), the Lower-Middle Devonian of Poland (Turnau, 1986), and the Emsian of eastern and north Canada (McGregor and Owens, 1966).

Emphanisporites rotatus McGregor, 1961
(Plate 4, Figs. 3&7)
(Plate 5, Figs. 2&3)

Occurrence: This species is common throughout the Devonian portion of both sections of the Faraghan Formation in Tang-e-Zakin, Kuh-e-Faraghan.

Age: From the Emsian-Eifelian of eastern Gaspé Canada (McGregor and Owens, 1966; McGregor, 1973), the Lower-Middle Devonian of Canada

(McGregor, 1961), the Lower-Upper Devonian of the United States (Von Almen, 1970), the Lower-Middle Devonian of Poland (Turnau, 1986), the Lower Devonian of Belgium (Streel, 1967), the Silurian of Libya (Richardson and Ioannides, 1973), the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967), the Lower Devonian of Antarctica (Kemp, 1972), the Lower-Middle Devonian Vestspitsbergen (Allen, 1965), the Upper Devonian of Ohio, U.S.A. (Molyneux, et al., 1984), Upper Devonian-Lower Carboniferous of the Algerian Sahara (Lanzoni and Magloire, 1969), the Late Devonian, and the Early Carboniferous of the Irish Republic (Clayton et al., 1977).

Emphanisporites orbicularis Turnau, 1986

(Plate 4, Fig. 4)

Occurrence: This species is very rare in both sections and appears at higher stratigraphic levels (younger sediments) in comparison with other species of the genus Emphanisporites.

Age: From the Lower-Middle Devonian of Poland (Turnau, 1986).

<u>Emphanisporites</u> sp.

(Plate 4, Fig. 10)

<u>Description</u>: Trilete spores with proximal ridges aligned parallel to one another; ridges extend from equator to the margin of commissure and form a "herring-bone" pattern; trilete mark distinct, equal to the radius of the spore; diameter 48-50 μm. Forms similar to this morphotype have been reported from the Devonian of Canada (McGregor, 1961, Plate 1, Fig. 10).

<u>Occurrence</u>: This morphotype is very rare in both sections of the Devonian portion of Faraghan Formation (See, Table 2, 5).

Genus <u>Geminospora</u> Balme, 1962

<u>Geminospora antaxios</u> (Chibrikova) Owens, 1971

(Plate 5, Fig. 4, 8&9)

<u>Occurrence</u>: This species is very rare in both study sections and confined to few samples from the Devonian portion of the Faraghan Formation.

<u>Age</u>: From the Middle and early Upper Devonian of Canada (Owens, 1971).

Geminospora lemurata Balme, 1962

(Plate 5, Fig. 3)

Occurrence: Abuntant in section one and common in section two.

Age: From the Middle and early Upper Devonian of Canada (Owens, 1971), the Frasnian of western Australia (Balme, 1962), the Frasnian of Poland (Turnau, 1986), the Frasnian-Famennian of France (Loboziak and Streel, 1980, 1981), the Frasnian of the United States (von Almen, 1970), the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967), and the Frasnian of Canada (McGregor and Owens, 1966).

Geminospora micropaxilla (Owens) McGregor and Camfield, 1982

(Plate 5, Figs. 6&10)

Occurrence: This species is rare in both study sections of the Faraghan Formation.

Age: From the Middle Devonian of Canada (McGregor, 1982).

Geminospora punctata Owens, 1971

(Plate 5, Fig. 7)

Occurrence: This species is very rare in section one and rare in section two.

<u>Age</u>: From the Middle and early Upper Devonian of Canada (Owens, 1971).

Genus <u>Grandispora</u> (Hoffmeister, Staplin and Molly) Neves and Owens, 1966

<u>Grandispora</u> <u>douglastownense</u> McGregor, 1973

(Plate 6, Fig. 5)

<u>Occurrence</u>: The species is rare in section one, and very rare in section two.

<u>Age</u>: From the Lower and Middle Devonian of eastern Gaspé, Canada (McGregor, 1973), the Middle Devonian of Canada (McGregor, 1982), the Givetian-Frasnian of France (Loboziak and Streel, 1980), and the late Early Middle Devonian (Van der Zwan, 1980).

<u>Grandispora</u> <u>longus</u> Chi and Hills, 1976

(Plate 6, Fig. 6)

<u>Occurrence</u>: The species is rare in section one (1.9%), and very rare (0.7%) in section two.

<u>Age</u>: From the Middle Devonian of Canada (McGregor, 1982), and the Middle Devonian of Arctic Canada (Chi and Hills, 1976).

Grandispora macrotuberculata McGregor, 1973

(Plate 6, Fig. 1-2)

Occurrence: This species is rare in section one and very rare in section two.

Age: From the Lower-Middle Devonian of eastern Gaspé, Canada (McGregor, 1973).

Grandispora mammillata Owens, 1971

(Plate 6, Figs. 3-4)

Occurrence: This species is common in section one and abundant in section two.

Age: From the Middle-early Upper Devonian of Canada (Owens, 1971), and the Middle Devonian of Canada (McGregor, 1982).

Genus Hystricosporites McGregor, 1960

Hystricosporites corystus, Richardson, 1962

(Plate 7, Figs. 1&3)

Occurrence: This species is rare and confined to the upper portion of the Devonian of section two of the Faraghan Formation.

Age: From the Givetian-Frasnian of Britain (Richardson, 1962), the Givetian-Lower Frasnian Boulonnais of France (Loboziak &

Streel, 1980, 1981), the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967), and the Lower-Middle Devonian of Vestspitsbergen (Allen, 1965).

Genus Retusotriletes (Naumova) Richardson, 1965

Retusotriletes distinctus Richardson, 1965

Occurrence: This species is common throughout of both study sections.

Age: From the Middle and early Upper Devonian of Canada (Owens, 1971), the Early Devonian of Canada (McGregor, 1974), and the Middle Devonian of Britain (Richardson, 1965).

Retusotriletes dittonensis Richardson and Lister, 1969

(Plate 7, Figs. 7&9-10)

Occurrence: This species is rare and confined to a few samples in section two of the Faraghan Formation.

Age: From the Siegenian-Emsian of Canada (McGregor, 1970), and the Gedinnian of Britain (Richardson and Lister, 1969).

Retusotriletes dubiosus McGregor, 1973

(Plate 7, Figs. 4-5)

Occurrence: This species is rare in both study sections and confined to many samples of section one and few samples of section two.

Age: From the Middle Devonian of Canada (McGregor and Camfield, 1982), the late Early Middle Devonian of Southwest Ireland (Van der Zwan, 1980), and the Lower-Middle Devonian of Canada (McGregor, 1973).

Retusotriletes rotundus (Streel) Streel, 1967

(Plate 7, Fig. 6)

Occurrence: This species is very rare in both sections and restricted to the Devonian portion of the Faraghan Formation.

Age: From the Lower Emsian - Lower Givetian of Belgium (Streel 1964, 1967), the Gedinian-Early Givetian of the United States (Von Almen, 1970), the Middle Devonian of Canada (McGregor and Camfield, 1982), the late Early Devonian - Middle Devonian of southwest Ireland (Van der Zwan, 1980), the Early Devonian of Canada (McGregor, 1974), and the

Lower-Middle Devonian of Canada (McGregor, 1973)

Retusotriletes rugulatus Riegel, 1973

(Plate 7, Fig. 8)

Description: The specimens closely resemble the description of Riegel (1973), but the Faraghan form is more similar to Turnau´s (1986) illustration.

Occurrence: This species is very rare and confined to a few samples in the upper portion of the Devonian of the Faraghan Formation.

Age: From the Middle Devonian of Canada (McGregor and Camfield, 1982), the Givetian-Lower Frasnian of France (Loboziak and Streel,1980, 1981), the Lower-Middle Devonian of Poland (Turnau, 1986), and the Emsian-Eifelian of West Germany (Riegel, 1973).

Genus *Raistrickia* (Schopf, Wilson, and Bentall) Potonie and Kremp, 1954

Raistrickia aratra Allen, 1965

(Plate 8, Fig. 6)

Occurrence: This species is abundant in section one and rare in section two, and it is confined to upper portion of the Devonian of the Faraghan Formation.

Age: From the Upper Givetian of Vestspitsbergen (Allen, 1965).

Genus Retispora Staplin, 1960

Retispora lepidophyta (Kedo) Playford, 1976

(Plate 8, Figs. 1-3)

Occurrence: This species is rare in section one and very rare in section two, and restricted to few upper samples of the Devonian portion of the Faraghan Formation.

Age: From the Upper Devonian and the Lower Carboniferous of the Irish Republic (Van Veen, 1981), the Upper Devonian and Lower Carboniferous of northeastern Iran (Coquel et al., 1977), the Upper Devonian and Lower Carboniferous of Algeria (Lanzoni and Magloire, 1969), and the Upper Devonian of Canada (McGregor, 1970).

Genus Rhabdosporites Richardson, 1960

Rhabdosporites langi (Eisenack, 1944) Richardson, 1960

Occurrence: This species is common throughout both study sections.

<u>Age</u>: From the Givetian of France (Loboziak and Streel, 1980, 1981), the Middle Devonian-early Upper Devonian of Canada (Owens, 1971), the Middle Devonian of Poland (Turnau, 1986), the Middle Devonian of Britain (Richardson, 1965), the Givetian of Canada (McGregor, et al., 1970), the late Middle Devonian of the United States (Streel, 1972), the Middle Devonian of Canada (McGregor, and Camfield, 1982), the Lower Givetian of Britain (Richardson, 1960), the Givetian (McGregor and Owens, 1965), and the Middle Devonian of Belgium (Lele and Streel, 1969).

Genus <u>Rugospora</u> Neves and Owens, 1966

<u>Rugospora</u> <u>flexuosa</u> (Juschko) Streel, 1974

(Plate 8, Fig. 7)

<u>Occurrence</u>: This species is very rare and confined to a few samples in section one of the Faraghan Formation.

<u>Age</u>: From the Upper Devonian and basal Dinantian of Belgium (Becker et al., 1974), the Late Devonian and Early Carboniferous of the Irish Republic (Van der Zwan, 1980), and Late Devonian and Early Carboniferous of the Irish Republic (Van Veen, 1981).

Genus Samarisporites Richardson, 1960

Samarisporites triangulatus Allen, 1965

(Plate 8, Fig. 9)

Occurrence: This species is common in a few samples of both studied sections.

Age: From the Upper Givetian-Frasnian of France (Loboziak and Streel 1980, 1981), and the Upper Devonian and basal Dinantian of Belgium (Becker, et al., 1974).

Genus Spelaeotriletes Neves and Owens, 1966

Spelaeotriletes crustatus Higgs, 1975

(Plate 8, Fig. 5)

Occurrence: This species is very rare and confined to few samples of section one of the Faraghan Formation.

Age: From the Upper Devonian and Early Carboniferous of the Irish Republic (Van der Zwan, 1980) and the Upper Devonian-Lower Carboniferous of the Irish Republic (Higgs, 1975).

Genus <u>Spinozonotriletes</u> (Hacquebard, 1957)

emend. Neves and Owens, 1966

<u>Spinozonotriletes</u> <u>naumovii</u> (Kedo) Richardson, 1965

(Plate 8, Fig. 8)

<u>Occurrence</u>: This species is very rare in both sections from Tang-e-Zakin, Kuh-e-Faraghan.

<u>Age</u>: From the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967), the Middle Devonian of Britain (Richardson, 1965), the Givetian of Canada (McGregor, et al., 1970), and the late Middle Devonian of the United States (Streel, 1972)

SYSTEMATIC DESCRIPTION OF DEVONIAN ACRITARCHS

Group *Acritarcha* Evitt, 1963

Genus *Chomotriletes* Naumova, 1953

Chomotriletes bistchoensis Staplin, 1961

(Plate 9, Fig. 1)

Occurrence: This species is rare in both sections of the Faraghan Formation (14 specimens in section one, and 24 specimens in Section Two).

Age: Frasnian (Staplin, 1961).

Chomotriletes vedugensis Naumova, 1953

(Plate 9, Fig. 2)

Occurrence This species appears in the upper portion of the Devonian part of the Faraghan Formation. It is rare in section one (7 specimens) and common in section two of the Faraghan Formation (69 specimens).

Age: The lower Frasnian Gneudna Formation of Western Australia (Balme 1962; Playford and Dring, 1981), and the Frasnian of Saudi Arabia (Hemer and Nygreen, 1967).

Genus Cymatiosphaera (O. Wetzel) ex. Deflandre, 1954

Cymatiosphaera perimembrana Staplin, 1961

(Plate 9, Fig. 5)

Occurrence: This species is rare in both sections of the Faraghan Formation.

Age: Frasnian deposits of the United States (Wicander and Playford, 1985), Givetian-Frasnian of Canada (Wicander, 1983), Frasnian of western Australian (Playford and Dring 1981), and Upper Devonian-Lower Carboniferous of northern Iran (Coquel et al., 1977).

Genus Deltotosoma Playford, 1981

Deltotosoma intonsum Playford, 1981

(Plate 9, Figs. 3&7)

(Plate 10, Fig 10)

Occurrence: This species is rare, and confined to the upper portion of the Devonian part of section two.

Age: The Frasnian (Gneudna Formation) of western Australia (Playford and Dring, 1981).

Genus Dictyotidium (Eisenack) emend. Staplin, 1961

Dictyotidium granulatum Playford, 1981

(Plate 9, Fig. 8)

Occurrence: This species is very rare, and restricted to the upper part of the Devonian portion of section two.

Age: The Frasnian (Gneudna Formation) of western Australia (Playford and Dring, 1981).

Genus Diexallophasis Loeblich, 1970

Diexallophasis remota (Deunff) Playford, 1977

(Plate 9, Fig. 4)

Occurrence: This species is rare in both sections.

Age: Middle Devonian of Ontario, Canada (Playford, 1977), the Lower Devonian (Gedinnian) of Oklahoma (Wicander, 1986).

Diexallophasis sp.

(Plate 9, Fig. 6)

Description: Vesicle polygonal, one layered relatively thin and granulate; processes few, hollow, unsculptured, and freely connected with the vesicle. Diexallophasis sp. differs from Diexallophasis remota in its lack of sculptural elements on the vesicle and processes. The processes have a tendency to be completely closed at their distal ends.

Occurrence: This morphotype is very rare (11 specimens, 0.8%) in section one.

Genus Duvernaysphaera (Staplin) emend. Deunff, 1964

Duvernaysphaera tessella Deunff, 1964

(Plate 9, Fig. 10)

Occurrence: This species is very rare (2 specimens) and confined to the upper portion of the Devonian part of section two.

Age: The Devonian of Tunisia (Deunff, 1964), the Lower to Middle Devonian of Brazil (Brito, 1976a), the Givetian-Frasnian of Tennessee (Reaugh, 1978), probable middle Devonian and Frasnian of Ghana (Bar and Riegel, 1974), and the Frasnian of western Australia (Playford and Dring, 1981).

Genus Evittia Brito, 1967

Evittia geometrica Playford, 1981

(Plate 9, Fig. 2)

Occurrence: This species is rare, and confined to upper portion of the Devonian part of the Faraghan Formation.

Age: The Frasnian of western Australia (Playford and Dring, 1981).

Genus Gorgonisphaeridium Staplin, Jansonius, and Pocock, 1965

Gorgonisphaeridium abstrusum Playford, 1981

(Plate 10, Fig. 8)

Description: The specimens conform to the description of Playford 1981, but the average size of the Faraghan species is larger than Playford´s morphotype.

Occurrence: This species is common throughout section one, but it is rare in section two.

Age: The Frasnian of Western Australia (Playford and Dring, 1981)

Gorgonisphaeridium discissum Playford, 1981

(Plate 10, Figs. 1-3)

Occurrence: This species is present in both sections of the Faraghan Formation, but it is rare in section one and abundant in section two.

Age: The Frasnian of western Australia (Playford and Dring, 1981).

<u>Gorgonisphacridium</u> sp. A

(Plate 10, Fig 4)

<u>Description</u>: Vesicle elliptical, thin-walled, densely covered by simple, solid homomorphic, psilate processes; processes are straight to curved with circular bases and slightly expanded apices; excystment structure not visible.

<u>Occurrence</u>: This species is rare throughout the section one of the Faraghan Formation.

<u>Gorgonisphaeridium</u> sp. B

(Plate 10, Fig. 5)

<u>Description</u>: Vesicle spherical, thin walled, covered by discretely solid homomorphic processes; processes straight with circular bases and truncate, or slightly expanded apices; excystment structure a simple split in the vesicle wall.

<u>Occurrence</u>: This species is common in the lower portion of section one of the Faraghan Formation.

<u>Gorgonisphaeridium</u> sp. C

(Plate 10, Fig. 7)

<u>Description</u>: Vesicle circular, wall thickened and densely covered by solid, heteromorphic processes;

processes straight or bent with slightly expanded apices; vesicle with numerous folds, obscuring details of any excystment structure.

Occurrence: This species is rare and confined to the lower portion of section one of the Faraghan Formation.

Gorgonisphaeridium sp. D

(Plate 10, Fig. 12)

Description: Vesicle circular, thin walled, covered by discrete solid homomorphic processes; processes straight or rarely curved; excystment structure is clear but irregular.

Occurrence: This species is rare and restricted to the lower portion of section one of the Faraghan Formation.

Genus Leiosphaeridia Eisenack, 1958

Leiosphaeridia sp.

(Plate 10, Fig. 11)

Description: Vesicle circular, 110μ in diameter, thick, psilate wall; excystment structure a median split observable in most specimens. Specimens encountered in this study are similar to those reported from the Middle Devonian Boyle Dolomite of Kentucky, U.S.A. (Wood and Clendening, 1985).

Occurrence: This species is abundant throughout the section two.

Genus *Lophosphaeridium* (Timofeev) ex. Downie, 1963

Lophosphaeridium segregum Playford, 1981

(Plate 10, Fig. 5)

Occurrence: This Faraghan species is abundant throughout both sections.

Age: The Frasnian of western Australia (Playford and Dring, 1981) and the Frasnian of Iowa, U.S.A., (Wicander and Playford, 1985).

Genus *Melikeriopalla* Tappan and Loeblich, 1971

Melikeriopalla venulosa Playford, 1981

(Plate 10, Fig. 9)

Occurrence: This species is rare and confined to the upper portion of the Devonian part of section one.

Age: The Frasnian of western Australia (Playford and Dring, 1981).

Genus Navifusa Combaz, Lange, and Pansart, 1967

Navifusa excilis Playford and Dring, 1981

(Plate 11, Fig. 2)

Description: The specimens conform to the description of Playford, 1981.

Occurrence: This species appears in the upper portion of Devonian zone in both sections of the Faraghan Formation. It is very rare in section one and abundant in section two.

Age: The Frasnian of Western Australia (Playford and Dring, 1981).

Genus Papulogabata Playford, 1981

Papulogabata annulata Playford, 1981

(Plate 11, Figs. 1&3-4)

Description: The specimens conform to the original description of Playford, 1981. Some of specimens of this species are altered and show pseudoconcentric rings (Plate 11, Figs. 3-4).

Occurrence: This species is abundant and confined to the Devonian part of the upper portion of section two.

<u>Age</u>: The Frasnian of Western Australia (Playford, 1981).

Genus <u>Polyedryxium</u> (Deunff) ex. Deunff, 1961

<u>Polyedryxium</u> <u>decorum</u> Deunff, 1955

(Plate 11, Fig. 5)

<u>Occurrence</u>: This species is common in both sections of the Faraghan Formation.

<u>Age</u>: Middle-Upper Devonian (Wicander, 1983).

Genus <u>Somphophragma</u> Playford, 1981

<u>Somphophragma</u> <u>miscellum</u> Playford, 1981

(Plate 11, Fig 7)

<u>Occurrence</u>: This species is very rare in the Faraghan Formation and is confined to the upper portion of the Devonian portion of section two.

<u>Age</u>: The Frasnian of Western Australia (Playford and Dring, 1981).

Genus Stellinium Jardine et al., 1972

Stellinium micropolygonale (Stockmans and Williere) Playford, 1977.

(Plate 11, Fig. 6)

Occurrence: This species is very rare and confined to upper portion of the Devonian part of section two.

Age: Early-Upper Devonian of Canada (Playford 1977; Playford and Dring, 1981).

Genus Veryhachium Deunff ex. Downie, 1959

Veryhachium trispinosum (Eisenack) Deunff, 1954

(Plate 11, Fig. 8)

Occurrence: This species is rare throughout the Devonian part of both Faraghan sections.

Age: Givetian-Famennian (Wicander, 1983), Upper Devonian - Lower Carboniferous of northern Iran (Coquel, et al., 1977).

Acritarch sp. A

(Plate 11, Figs. 9-10)

Description: Vesicle circular to subcircular, 45μm in diameter double-layered with a granulate surface; size 70μm (including processes);

Processes hollow, slightly taped at their ends, ornamented by fine microechinae or grana, 8-10μm long, 4-3μm wide at base, do not communicate with the interior of the vesicle; excystment structure were not observed. This form is similar to Acritarch sp. B of Wicander and Wood (1981), but the Faraghan specimens are larger than those of the Silica Formation of Ohio, U.S.A. This morphotype is figured here and left in open nomenclature.

occurrence: Acritarch type A is very rare and confined to upper portion the Devonian of section two of the Faraghan Formation.

Scolecodonts

(Plate 12, Figs. 1-3&5)

Scolecodonts are the chitinous jaws of marine polychaete annelid worms. They are of considerable biological interest in that they represent the only part of these organisms, normally capable of fossilization (Ertdman, 1969).

Studies have shown that some species of scolecodonts have ranges sufficiently limited as to give them potential value as zonal indicators. Scolecodonts have recorded from the Ordovician of Canada (Eller, 1933), the Silurian of the Soviet Union (Pander, 1956), the Devonian of the United

States (Eller, 1933; Von Almen, 1970; Eames, 1974; Wood, 1978); the Devonian of Brazil (Kielan-Jaworowska, 1960); the Carboniferous of Britain (Hindle, 1896); the Triassic of Germany (Seidel, 1959); the Jurassic of northeastern Italy (Van Erve, 1981); the Cretaceous Lebanon (Roger, 1946) and the Tertiary of northeast Brazil (Regali, M. da S. P. 1981). In this study, no attempt was made to treat them taxonomically, but they are a group that may be useful for palaeoecological interpretation of the Faraghan Formation.

Occurrence: Scolecodonts are rare (1-2%) in both Faraghan sections. They tend to be more abundant in samples where acritarchs are more numerous. Scolecodonts are also present in the Permian part of the Faraghan Formation in Tang-e-Zakin but their morphology differs from the Devonian forms (Plate 12, Fig. 2). In the permian samples of Chal-i-sheh, there is a higher percentage of scolecodonts (4.64%) in comparison with the Permian part of the two study sections in the Faraghan area.

Chitinozoa

Chitinozoan were named, described and illustrated by Eisenack (1931). They are an enigmatic group of hollow, bottle-shaped, organic walled microfossils of unknown biological affinities. Classification is based on gross morphology and internal and external elaborations of the test. In this study, no attempt was made to treat them taxonomically, but they are a group that may be useful for palaeoenvironment interpretation. Chitinozoan are rare (2%) and tend to be poorly preserved. Only a few well-preserved specimens were found in the Devonian portion of section one of the Faraghan Formation (Plate 12, Fig. 4).

SYSTEMATIC DESCRIPTION OF PERMIAN ACRITARCHS

Group *Acritarch* Evitt, 1963

Genus *Veryhachium* Deunff ex. Downie, 1959

Veryhachium riburgense Brosius and Bitterli, 1961

(Plate 13, Fig. 12)

Description: The specimens are in agreement with those reported from the Permian of West-Pakistan (Sarjeant, 1970, plate 1, Figs. 18-19, p. 285).

Occurrence: This species is very rare (two specimens) and it appears in one sample of the Faraghan Formation from the Chal-i-Sheh area. In this study acritarchs were not observed in the sections of the Faraghan Formation, in Tang-e-Zakin, Kuh-e-Faraghan.

Age: The Permian of Britain (Wall and Downie, 1962) and the Permian of West Pakistan (Sarjeant, 1970).

SYSTEMATIC DESCRIPTION OF PERMIAN SPORES

Genus Calamospora, Schopf, Wilson and Bentall, 1944

Calamospora microrugosa (Ibrahim)

Schopf, Wilson and Bentall, 1944

(Plate 13, Fig. 5)

Occurrence: This species is very rare and it was only found in the Permian of the Chal-i-Sheh area.

Age: The Lower-Upper Permian of Australia (Segroves, 1970), the Uppermost Carboniferous-Lower Permian of Germany (Helby, 1966), and the Early Permian of Turkey (Akyol, 1975).

Genus Grandispora Hoffmeister, Staplin and Malloy, 1955

Grandispora sp.

(Plate 13, Fig. 1)

Description: Subcircular to rounded triangular; exine is cavate with exoexine enclosing a fairly thin intexine; trilete mark distinct, extending to the margin of the intexine. This species is similar to Grandispora sp. A of Segroves (1970), but the Faraghan specimens have straight laesura arms and smaller size than Australian forms.

<u>Occurrence</u>: This species is very rare and confined to the Early Permian of the Chal-i-Sheh area.

Genus <u>Gulisporites</u> Imgrund, 1960

<u>Gulisporites</u> <u>cochlearius</u> Imgrund, 1960

(Plate 13, Fig. 2)

<u>Description</u>: The specimens are similar to interval described by Akyol (1975).

<u>Occurrence</u>: This species is very rare (3 specimens) and it is confined to the Early Permian of Chal-i-Sheh area.

<u>Age</u>: The Early Permian of Turkey (Akyol, 1975) and the Upper Carboniferous of Germany and Illinois (Imgrund, 1960).

Genus <u>Horriditriletes</u> Bharadwaj and Salujha, 1964

<u>Horriditriletes</u> <u>ramosus</u> (Balme and Hennelly)

Bharadwaj and Salujha, 1964

(Plate 13, Figs. 7 & 8-9)

<u>Description</u>: The specimens are in agreement with those described and illustrated from both Australia and India. However, some of specimens of Faraghan Formation have larger spines.

<u>Occurrence</u>: This species is rare in the Early Permian of both Faraghan and Chal-i-Sheh area.

Age: From the Lower Permian of the Congo (Maheshwari, 1969), the Middle-Upper Permian of Australia (Segroves, 1970), and the Early Permian of Southwest of Africa (Stapleton, 1977).

Genus Kraeuselisporites Leschik, emend. Jonsonius, 1962

Kraeuselisporites splendens (Balme and Hennelly) Segroves, 1970

(Plate 13, Fig. 4)

Occurrence: This species is abundant and confined to the Faraghan Formation of the Chal-i-Sheh area.

Age: From the Lower Permian of Australia (Segroves, 1970), and the Early Permian of Bolivia (Cousminer, 1965).

Genus Laevigatosporites Ibrahim emended Schopf, Wilson & Bentall, 1944

Laevigatosporites vulgaris Ibrahim, 1933

(Plate 13, Fig. 11)

Description: The specimens conform to description of Ibrahim (1933), and their morphology is similar to Laevigatosporites vulgaris reported from Turkey (Akyol, 1975).

Occurrence: This species is common in the early Permian of Chal-i-Sheh and it is rare in the Permian of Faraghan Formation in Tang-e-Zakin.

Age: The Early Permian of Turkey (Akyol, 1975), Upper Permian of the United States (Wilson, 1962), the Upper Permian of West Pakistan (Balme, 1970), the Lower Permian of Australia (Segroves, 1970), and the Barakar stage of Badam, India (Venkatchala and Kar, 1968).

Genus *Leiotriletes* Naumova, 1937 emend.

Potonie and Kremp, 1954

Leiotriletes sp.

(Plate 13, Fig. 10)

Description: Rounded triangular, 40-45μm, convex interapical; trilete mark distinct, 2/3 spore radius in length, never reaching apices; exine thin, infrapunctate. This species is similar to *Leiotriletes* sp. of the Early Permian of Southwest Africa (Stapleton, 1977, Plate 1, Fig. 5).

Occurrence: This species is found in both the Faraghan and Chal-i-Sheh areas, but it is common in the Chal-i-Sheh and very rare in the Faraghan area.

Genus Punctatisporites Ibrahim 1933,

emend. Potonie and Kremp, 1954

Punctatisporites gretensis Balme and Hennelly 1956b

(Plate 13, Fig. 6)

Occurrence: This species is common in samples of Faraghan Formation in the Chal-i-Sheh area, but it is rare and poorly preserved in the Permian part of the Faraghan study sections.

Age: From the Early Permian of Turkey (Akyol, 1975), the Early Permian of Southwest Africa (Stapleton, 1977), the Early Permian Perth basin of Australia (Segroves, 1970), the Early Permian of Gabon (Jardine, 1974), the Permian of Australia (Balme and Hennelly, 1954, 1955), the Lower Permian of Tanganyika (Hart, 1963), the Lower Permian of Congo (Bose and Maheshwari, 1968), the Lower Permian of Brazil (Tiwari and Navale, 1967), the Lower Permian of India (Tiwari, 1967) and the Lower-Upper Permian of northeastern Iran (Chataeuneuf and Stampfli, 1979).

Genus <u>Thymospora</u> wilson and Venkatachala, 1963

<u>Thymospora</u> <u>perverrucosa</u> (Alpern 1959)

(Plate 13, Fig. 3)

<u>Occurrence</u>: This species is common and confined to the Faraghan Formation in Chal-i-Sheh area.

<u>Age</u>: The Early Permian of Turkey (Akyol, 1975). Wilson and Venkatachala (1963).

Genus <u>Tiwariasporis</u> Maheshwari and Kar, 1967

<u>Tiwariasporis</u> <u>flavatus</u> Maheshwari and Kar, 1967

(Plate 20, Figs. 9&12)

<u>Description</u>: The specimens conform to the description of Maheshwari and Kar, 1967 except that a monolete mark was not observed in the Faraghan specimens.

<u>Occurrence</u>: This species is very rare and restricted to the Lower Permian portion of Faraghan sections.

<u>Age</u>: The Lower Permian of the Congo (Maheshwari and Kar, 1967).

Tiwariasporis gondwanensis (Tiwari) Maheshwari and Kar, 1967

(Plate 20, Fig. 7)

Description: The specimens conforms to the description of (Tiwari) Maheshwari and Kar, 1967. The miospores reported here are the same size as Indian forms, but they are smaller than the specimens from the Congo.

Occurrence: This species is rare and confined to the Lower Permian portion of the Faraghan Formation in Faraghan area.

Age: From the Lower Permian of the Congo (Maheshwari and Kar, 1967) and the Lower Permian of India (Tiwari, 1967).

SYSTEMATIC DESCRIPTIONS PERMIAN POLLEN

Genus Boutakoffites Bose and Kar, 1966

Boutakoffites elongatus Bose and Kar, 1966

(Plate 14, Fig. 14)

Description: The specimens conform to the description of Bose and Kar 1966. Central body specimens of Faraghan Formation appears leathery. 6-12 Grooves on the central body with minor foldings.

Occurrence: This species is rare and confined to the Permian samples of Faraghan Formation in Tang-e-Zakin, Kuh-e-Faraghan.

Age: From the Lower Permian of the Congo (Bose and Kar, 1966; Bose and Maheshwari, 1968).

Boutakoffites quibus Bose and Kar, 1966

(Plate 14, Fig. 13)

Description: The specimens conform to the description of Bose and Kar, 1966 except that the central body of Faraghan specimens is denser than the monosaccus and the number horizontal grooves vary from 10-20.

<u>Occurrence</u>: This species is very rare and restricted to the Permian samples of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Lower Permian of the Congo (Bose and Kar, 1966; Maheshwari, 1969).

Genus <u>Caheniasaccites</u> Bose and Kar, 1966

<u>Caheniasaccites</u> <u>ellipticus</u> Bose and Kar, 1966

(Plate 14, Figs. 7&10)

<u>Occurrence</u>: This species is rare and confined to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Lower Permian of the Congo (Bose and Kar, 1966; Bose and Maheshwari, 1968; Maheshwari and Bose, 1969) and the Lower Permian of Gabon (Jardine, 1974).

<u>Caheniasaccites</u> <u>ovatus</u> Bose and Kar, 1966

(Plate 14, Fig. 12)

<u>Occurrence</u>: This species is rare and confined to the Lower Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Lower Permian of the Congo (Bose and Kar, 1966; Bose and Maheshwari, 1968;

Maheshwari and Bose, 1969) and the Lower Permian of Gabon (Jardine, 1974).

Genus Complexisporites Jizba, 1962

Complexisporites polymorphus Jizba, 1962

(Plate 14, Figs. 1&4)

Occurrence: This species is abundant in the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Early Permian of Texas, U.S.A. (Tshudy and Kosanke, 1962), and the Lower Permian of the United States (Jizba, 1962).

Genus Corisaccites Venkatachala and Kar, 1966

Corisaccites alutas Venkatachala and Kar, 1966

(Plate 14, Fig. 3)

Occurrence: This species is very rare throughout Permian part of the Faraghan Formation and is confined to Kuh-e-Faraghan.

Age: The Lower Permian of Pakistan (Balme, 1970), the Lower Permian West Pakistan (Venkatachala and Kar, 1967, 1966), the Lower Permian of India (Lele and Chandra, 1966), and the Lower Permian of Australia (Segroves, 1969) and the Lower Permian of Rhodesia (Chandra, Kar and Lacey, 1977)

Genus Costapollenites Tschudy and Kosanke, 1966

Costapollenites ellipticus Tschudy and Kosanke, 1966

(Plate 14, Figs. 6&9)

Occurrence: This species is rare and confined to the Permian portion of Faraghan Formation in Kuh-e-Faraghan.

Age: From the Early Permian of Texas, U.S.A. (Tschudy and Kosanke, 1966) and the Lower Permian of Gabon (Jardine, 1974).

Genus Crustaesporites Leschik, 1956

Crustaesporites globosus Leschik, 1956 emend. Jansonius, 1962

(Plate 14, Fig. 5)

Description: The specimens conform to the description of Leschik, 1956 emend. Jansonius, 1962. The specimen illustrated here is similar to those has been reported from Congo by Maheshwari, 1962. The description and illustration of Maheshwari suggest Crustaesporites globosus, but he named it Trochosporites sp.

Occurrence: This species is very rare and confined to the Permian portion of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Upper Permian of Germany (leschik, 1956), the Permian-Triassic of Canada (Jansonius, 1962), the Lower Permian of the Congo (Maheshwari, 1969), the Early Permian of Poland (Jerzykiewicz, 1988), the Early-Upper Permian of Britain (Clarke, 1965) and the Lower Triassic of Australia (Balme, 1963).

<u>Crustaesporites</u> sp. A

(Plate 14, Figs. 2 & 8)

<u>Description</u>: Pollen grain monosaccate, oval to circular in outline, 50-70 μm; central body distinct, thick, multistriate (10-18 taeniae), 40-45 μm, with secondary fold; saccus thin, intrareticulate, diameter 8-15 μm. Some specimens show symmetrical constriction on saccus face that might suggest evolution of multisaccate forms from monosaccate morphotypes. This species is very close to <u>Crustaesporites</u> <u>hessii</u> Cousminer (1965), but the Faraghan specimens have fewer taeniae and have four primary sacci.

<u>Occurrence</u>: This species is very rare and confined to the Permian portion of the Faraghan Formation in Kuh-e-Faraghan.

Crustaeisporites sp. B

(Plate 14, Fig. 11)

Description: Pollen grain, four imperfect sacci, cresent-shaped, diameter 50 μm; central body circular to rectangular, thick, multistriate, 30 μm with secondary fold; sacci intrareticulate typically different in size. This species has not reported from other parts of world. However, Cousminer (1965) has discussed diagnosis of genus Crustaesporites and he concluded that monosaccate to polysaccate pollen may have been produced by a single source plant.

Occurrence: This species is very rare and confined to the Permian portion of Faraghan Formation in Faraghan area.

Genus Decussatisporites Leschik, 1955

Decussatisporites sp.

(Plate 14, Fig. 15)

Description: Pollen grain monocolplate, elliptical to Spindle-shaped, and 70-75 μm in diameter; Exine thick, appearing granulose in some specimens; Horizontal and vertical striations are well-developed; Colpus typically well-defined athough margins occassionally overlap, partially obscuring the colpus; Horizontal striations 15-20, extending from one margin to other; Vertical striations 10-15, straight or slightly oblique, extending from end to end. This species is similar to Decussatisporites magmus Bose and Kar (1966), but has fewer vertical and horizontal striations.

Occurrence: This species is very rare and confined to the Permian portion of the Faraghan Formation in Kuh-e-Faraghan.

Age: The genus Decussatisporites has been reported from the Early Permian of the Congo (Bose and Kar, 1966) and the Barakar stage of India (Bharadwaj and Salujha, 1964), the Lower Permian of Congo (Maheshwari, 1969), the Barakar stage of Badam, India (Venkatachala and Kar, 1968), the Lower Permian of Gabon (Jardine, 1974) and the Lower Permian of India (Tiwari, 1967).

Genus _Ephedripites_ Bolkhovitina ex. Potonie, 1958

Ephedripites _ellipticus_ Kar, 1967

(Plate 15, Figs. 1-2)

Occurrence: Permian, very rare in the Chal-i-Sheh area and rare in the Faraghan area.

Age: From the Lower-Upper Permian of India (Kar, 1967).

Ephedripites sp.

(Plate 15, Fig. 3)

Description: Pollen grain bilateral, fusiform, 85 μm long; grooves distinct, 8 in number converging at one end; exine thin, minutely punctate; germinal furrow obscure.

Occurrence: This species is very rare and restricted to the Permian part of Faraghan Formation in Kuh-e-Faraghan.

Genus _Fusacolpites_ Bose and Kar, 1966

Fusacolpites _fusus_ Bose and Kar, 1966

(Plate 15, Figs. 5&9)

Description: The specimens conform to the description of Bose and Kar, 1966.

Occurrence: This species is rare and confined to the Permian of the Faraghan Formation in Kuh-e-Faraghan.

Age: The Lower Permian of Gabon (Jardine, 1974), the Lower Permian of the Congo (Bose and Kar, 1966, 1968), the Lower-Upper Permian of India (Kar, 1967), the Early Permian of southwestern Africa (Stapleton, 1977), and the Early Permian of the Congo (Kar and Bose, 1967).

Fusacolpites ovatus Bose and Kar, 1966

(Plate 15, Fig. 12)

Description: The specimens conform to the description of Bose and Kar, 1966.

Occurrence: This species is very rare in the Permian portion of the Faraghan Formation both in Kuh-e-Faraghan and Chal-i-Sheh area.

Age: From the Lower Permian of Gabon (Jardine, 1974) and the Lower Permian of Congo (Bose and Kar, 1966, 1967, 1968).

Genus Ginkgocycadophytus Samoilovich, 1953

Ginkgocycadophytus cymbatus (Balme and Hennelly) Potonie and Lele, 1959

(Plate 15, Figs. 7&10)

Occurrence: This species is restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan and the productive samples of the Faraghan Formation of the Chal-i-Sheh area. It is rare in Kuh-e-Faraghan and very rare in Chal-i-Sheh area.

Age: From the Early Permian of India (Potonie and Lele, 1959), the Early permian of Gabon (Jardine, 1974), the Barakar stage (Lower Permian) at Badam of India (Bharadwaj and Kar, 1968), the Lower Permian of the Congo (Bose and Maheshwari, 1968), the Late Palaeozoic of Arabian Peninsula (Besems and Schuurman, 1988), the Lower Permian of West-Pakistan (Venkatachala and Kar, 1967, 1968), and the Early Permian of India (Kar, 1966).

Genus Høegiasaccites Bose and Kar, 1966

Høegiasaccites transitus Bose and Kar, 1966

(Plate 15, Fig. 6)

Occurrence: This species is very rare and confined to the Permian of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower Permian of the Congo (Bose and Kar, 1966) and the Lower Permian of Gabon (Jardine, 1974).

Genus Hamiapollenites (Wilson) Tschudy and Kosanke, 1966

Hamiapollenites karrooensis (Samoilovich) Hart, 1964

Occurrence: This species is rare and confined to the Permian part of Faraghan Formation in Tang-e-Zakin, Kuh-e-Faraghan.

Age: From the Early Permian of Gabon (Jardine, 1974), the Lower Permian of Tanzania (Hart, 1963, 1964, 1965), and the Upper Permian of the U.S.A. (Clapham, 1970).

<u>Hamiapollenites</u> <u>perisporites</u> (Jizba)

Tschudy and Kosanke, 1966

(Plate 17, Figs. 1, 4, 5, 7&8)

<u>Occurrence</u>: This species is common in the Permian part of the Faraghan Formation in the Faraghan area and abundant in the Chal-i-Sheh area.

<u>Age</u>: From the Early Permian of southwestern Africa (Stapleton, 1977), and the Early Permian of Texas, U.S.A. (Tschudy and Kosanke, 1966).

<u>Hamiapollenites</u> <u>saccatus</u> Wilson, 1962

(Plate 17, Figs. 2&3)

<u>Occurrence</u>: This species is abundant and confined to the early Permian of the Faraghan Formation in the Chal-i-Sheh area.

<u>Age</u>: From the Early Permian of Turkey (Akyol, 1975), the Upper Permian of the United States (Wilson, 1962; Clapham, 1970), the Lower Permian of West-Pakistan (Venkatachala and Kar, 1967).

<u>Hamiapollenites</u> <u>tractiferinus</u> (Samoilovich) Hart, 1964

(plate 17, Fig. 6)

<u>Occurrence</u>: This species is rare (2%) and restricted to the productive samples of the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Permian of the U.S.S.R. (Samoilovich, 1953), the Lower Permian Saudi Arabia (Hemer, 1965), the Upper Permian of northern Iran (Chataeuneuf, et al., 1979), the Upper Permian of the U.S.A. (Clapham, 1970) and the Late Pennsylvanian-Early Permian of U.S.A. (Jizba), 1960.

Genus <u>Kosankeisporites</u> Bharadwaj, 1955

<u>Kosankeisporites</u> <u>elegans</u> (Kosanke) Bharadwaj, 1962

(Plate 15, Fig. 4)

<u>Occurrence</u>: This species is very rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Late Palaeozoic of the United States (Jizba, 1962).

Genus Lueckisporites (Potonie and Klaus, 1954)

emend. Potonie, 1958

Lueckisporites sp.

(Plate 15, Fig. 11)

Description: Disaccate striatiti, diploxylonoid; central body circular or slightly elongate with a proximal cap with one longitudinal rib in polar view; sacci semi-circular in outline, infra-reticulate. This species differs from Taeniaesporites in number of ribs.

Occurrence: This species is very rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Genus Mabuitasaccites Bose and Kar, 1966

Mabuitasaccites ovatus Bose and Kar, 1966

(Plate 15, Fig. 8)

(Plate 16, Fig. 9)

Occurrence: This species is very rare (0.1%) and confined to a few productive samples of the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Early Permian of Gabon (Jardine, 1974) and the Early Permian of the Congo (Bose and Kar, 1966).

Genus Nuskoisporites Potonie and Klaus, 1954

Nuskoisporites rotatus Balme and Hennelly, 1956

(Plate 15, Fig. 13)

Occurrence: This species is rare in the Permian of the Faraghan Formation and the Chal-i-Sheh area.

Age: From the Early Permian of India (Potonie and Lele, 1959), the Permian Australia (Balme and Hennelly, 1956), the Late Permian of Prince Charles Mountains, Antarchtica (Playford, 1967; Balme and Playford, 1967), Early Permian of Tanzania (Hart, 1963).

Nuskoisporites triangularis (Mehta) Potonie and Lele, 1959

(Plate 16, Figs. 1&2)

Occurrence: This species is rare in the Permian of both Faraghan and Chal-i-Sheh areas.

Age: From the Early Permian of India (Potonie and Lele, 1959).

Genus <u>Pityosporites</u> (Seward) Manum, 1960

<u>Pityosporites</u> <u>giganteus</u> Balme and Hennelly, 1955

(Plate 16, Figs. 3&5)

<u>Occurrence</u>: This species is rare in the Permian part of the Faraghan Formation in Kuh-e-Faraghan, but it is common in the Chal-i-Sheh area.

<u>Age</u>: From the Early Permian Australia (Balme and Hennelly, 1955), the Early Permian of Bolivia (Cousminer, 1965) and the Lower Permian of the Congo (Maheshwari and Bose, 1969).

Genus <u>Plicatipollenites</u> Lele, 1964

<u>Plicatipollenites</u> <u>indicus</u> Lele, 1964

(Plate 126, Figs. 4&6)

<u>Occurrence</u>: This species is rare in both Faraghan and Chal-i-Sheh areas.

<u>Age</u>: From the Lower Permian of northern Iran (Chateauneuf, et al., 1979), the Lower Permian West-Pakistan (Balme, 1970), the Lower Permian of Congo (Kar and Bose, 1967; Bose and Maheshwari, 1968), the Lower Permian of Arabian Peninsula (Besems and Schuurman, 1988) and the Lower Permian of India (Kar, 1967).

Genus <u>Platysaccaus</u> (Naumova) ex. Potonie and Klaus, 1954

<u>Platysaccus</u> <u>papilionis</u> Potonie and Klaus, 1954

(Plate 18, Fig. 1)

<u>Occurrence</u>: This species is very rare and found in the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Permian of Canada (Jansonius, 1962), the Upper Permian of the United States (Wilson, 1962), the Permian of the U.S.A. (Clapham, 1970) and the Lower Permian of Rhodesia (Chandra, Kar and Lacey, 1977).

<u>Platysaccus</u> <u>densus</u> Kar, 1967

(Plate 18, Fig. 3)

<u>Occurrence</u>: This species is very rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Lower Permian of India (Kar, 1967).

Genus <u>Potonieisporites</u> Bharadwaj, 1954

<u>Potonieisporites</u> <u>granulatus</u> Bose and Kar, 1966

(Plate 16, Figs. 8&10)

<u>Occurrence</u>: This species is rare in Kuh-e-Faraghan and common in the Chal-i-Sheh area.

<u>Age</u>: From the Early Permian of Gabon (Jardine, 1974) and the Early Permian of Congo (Bose and Kar, 1966).

<u>Potonieisporites</u> <u>neglectus</u> Potonie and Lele, 1959

(Plate 16, Fig. 7)

(Plate 18, Fig. 5)

<u>Occurrence</u>: This species is very rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Early Permian of India (Potonie and Lele, 1959; Lele, 1973), the Early Permian Gabon (Jardine, 1974), the Lower Permian of northern Iran (Chataeuneuf, et al., 1979), and the Lower Permian of the Congo (Bose and Maheshwari, 1968).

Genus <u>Protohaploxypinus</u> samoilovich emend. Hart, 1964

<u>Protohaploxypinus</u> <u>diagonalis</u> Balme, 1970

(Plate 18, Fig. 2)

<u>Occurrence</u>: This species is abundant in the Permian part of the Faraghan Formation at Tang-e-Zakin and rare in the Faraghan Formation of the Chal-i-Sheh area.

Age: From the Lower-Upper Permian of West-Pakistan (Balme, 1970) and the Early Permian of Southwest of Africa (Stapleton, 1977).

Protohaploxypinus goraiensis (Potonie and Lele) Hart, 1964
(Plate 18, Fig. 6)

Occurrence: This species is common in the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower-Upper Permian of West-Pakistan (Balme, 1970), the Lower Permian of India (Potonie and Lele, 1959; Bharadwaj, 1966).

Protohaploxypinus sp.
(Plate 18, Fig. 4)

Description: Pollen grain disaccate, multistriate, diploxyloniod to haploxynoid, and 45-50 μm; central body subcircular to ovoid, thick wall, disected by 8-10 longitudinal striae; striae parallel to subparallel, non symmetric in pattern, reaching of the central body; Sacci hemispherical to cresent-shaped reticulate, united by narrow subequatorial strip. A groove, approxoimately 10 μm wide, is present between the sacci and is defined by two folds perperdicular to the striae.

<u>Occurrence</u>: This species is rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Genus *Rhizomaspora* Wilson, 1962

Rhizomaspora radiata Wilson, 1962

(Plate 18, Figs. 7&8)

<u>Occurrence</u>: This species is rare and restricted to the productive samples of Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Upper Permian of the United States (Wilson, 1962), the Lower Permian of the Congo (Bose and Maheshwari, 1968), the Lower Permian of West Pakistan (Venkatachala and Kar, 1967), the Lower Permian of Gabon (Jardine, 1974), and the Lower Permian of India (Tiwari, 1968).

Genus *Schizaeoisporites* (Potonie) Potonie, 1960

Schizaeoisporites microrugosus Tschudy and Kosanke, 1966

(Plate 19, Fig. 1)

<u>Occurrence</u>: This species is rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Early Permian of the United States (Tschudy and Kosanke, 1966).

Genus <u>Schizopollis</u> Venkatachala and Kar, 1964

<u>Schizopollis</u> sp.

(Plate 19, Figs. 2-3)

<u>Description</u>: Pollen grain monosaccate (lobed saccus may appears polysaccate); central body dense, oval, 60-70 μm, disected by more than 12 striae; Exine, exclusive of striae, is intramicroreticulate. The Faraghan specimens are similar to those reported from the Congo (Bose and Maheshwari, 1968).

<u>Occurrence</u>: This species is very rare and restricted to the Permian part of Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Lower Permian of India (Venkatachala and Kar, 1964), the Lower Permian of Congo (Bose and Maheshwari, 1968), and the Lower Permian of northern Iran (Chataeuneuf, et al., 1979), and the Barakar stage of Badam Basin of Bihar, India (Venkatachala and Kar, 1968).

Genus Striatoabietites (Sedova) Polukhina ex. Hart, 1964

Striatoabietites multistriatus (Balme and Hennelly) Hart, 1964

(Plate 19, Fig. 3)

Occurrence: This species is rare and confined to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower Permian (Sakmarian-Kungurian) of western Australia (Segroves, 1969), and the Lower Permian of Gabon (Jardine, 1974).

Genus Striatopodocarpites Zoricheva and Sedova ex. Sedova emend. Hart, 1964

Striatopodocarpites cancellatus (Balme and Hennelly) Hart, 1964

(Plate 19, Figs. 10-11&13)

Occurrence: This species is rare in the Permian part of the Faraghan Formation of Kuh-e-Faraghan and very rare in the Lower Permian of Chal-i-Sheh area.

Age: From the Lower-Upper Permian of West Pakistan (Balme, 1970), the Lower-Upper Permian of Gabon (Jardine, 1974), the Lower to Upper permian of western Australia (Segroves, 1969), the Lower Permian Tanzania (Hart, 1963), and the Upper Permian of Britain (clarke, 1965).

Striatopodocarpites rarus (Bharadwaj and Salujha) Balme, 1970
(Plate 19, Fig. 2)

Occurrence: This species is abundant in the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower-Upper Permian of West Pakistan (Balme, 1970), and the Lower Permian of Gabon (Jardine, 1974).

Genus Striomonosaccites Bharadwaj, 1962

Striomonosaccites ovatus Bharadwaj, 1962
(Plate 19, Fig. 4)

Occurrence: This species is very rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Upper Permian of India (Bharadwaj, 1962) and the Early Permian of Southwest Africa (Stapleton, 1977).

<u>Striomonosaccites</u> <u>triangularis</u> Bose and Kar, 1966

(Plate 19, Fig. 6)

<u>Occurrence</u>: This species is rare and confined to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Early Permian of Gabon (Jardine, 1974), the Lower Permian of the Congo (Maheshwari, 1969; Bose and Kar, 1966).

Genus <u>Sulcatisporites</u> Leschik, 1956

<u>Sulcatisporites</u> <u>splendens</u> Leschik, 1956

(Plate 19, Figs. 7&9)

<u>Occurrence</u>: This species is abundant in the Faraghan Formation of Chal-i-Sheh and rare in the Permian part of the Faraghan Formation of Kuh-e-Faraghan.

<u>Age</u>: From the Lower permian of Western Australia (Segroves, 1969), and the Early Permian of the United States (Tschudy and Kosanke, 1966).

Genus <u>Vittatina</u> Luber ex. Wilson, 1962

<u>Vittatina</u> <u>costabilis</u> (Wilson) emend.

Tschudy and Kosanke, 1966

(Plate 20, Fig. 3)

<u>Occurrence</u>: This species is common in the productive of samples of the Faraghan Formation of Chal-i-Sheh area and rare in the Permian part of Faraghan Formation in Faraghan area.

<u>Age</u>: From the Early Permian of the United States (Tschudy and Kosanke, 1966), the Upper Permian of the U.S.A. (Clapham, 1970), the Upper Permian of Poland (Jerzykiewicz, 1988), and Early Permian of Southwest of Africa (Stapleton, 1977).

<u>Vittina</u> <u>lata</u> Wilson, 1962

(Plate 20, Figs. 2&5)

<u>Description</u>: The specimens conform to the description of Wilson 1962, except that the Faraghan specimens have two secondary folds.

<u>Occurrence</u>: This species is rare and restricted to the Permian portion of the Faraghan Formation in Kuh-e-Faraghan.

<u>Age</u>: From the Upper Permian of the United States (Wilson, 1962), the Barakar of stage in the

Badam Basin of Bihar, India (Venkatachala and Kar, 1968).

Vittatina subsaccata Samiolovich, 1953
(Plate 20, Figs. 1&4)

Occurrence: This species is abundant in the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower Permian of Russia (Samoilovich, 1953), the Lower Permian of Gabon (Jardine, 1974), the Lower Permian of the Congo (Bose and Kar, 1966, 1967), the Lower Permian of Tanzania (Maheshwari, 1969), and the Early Permian of southwestern Africa (Stapleton, 1977).

Genus *Walikalesaccites* Bose and Kar, 1966
Walikalesaccites ellipticus Bose and Kar, 1966
(Plate 20, Fig. 6)

Occurrence: This species is very rare and confined to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Age: From the Lower Permian of the Congo (Bose and Kar, 1966), and the Early Permian of Gabon (Jardine, 1974).

Pollen type A.

(Plate 20, Fig. 11)

Description: Pollen grain monosaccate, oval, 90-100 µm; central body thick walled, intrapunctate, 80-70 µm in size; central body with a monolete mark, surrounded by a fold; saccus translucent, 4-5 µm beyond central body and enclosing it. This morphotype is similar to Cordaitina (Balme, 1970), but the Faraghan specimens have a dense central body that distinguishes them from Cordaitina.

Occurrence: This morphotype is rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Pollen Type B.

(Plate 20, Fig. 8)

Description: Pollen grain disaccate, multistriate, 70 µm long and 35 µm wide; central body thick walled and disected by 7-8 striae; striations confined to the proximal face. Sacci hemispherical, uniformly reticulate, overlaping the central body. This morphotype maybe related to genus Hamiapollenites, but it differs in its lack of vertical striations and the fact that striae are confined to the proximal face.

Occurrence: This morphotype is rare and restricted to the Permian part of the Faraghan Formation in Kuh-e-Faraghan.

Pollen Type C.

(Plate 20, Fig. 10)

Description: Pollen grain disaccate, multistriate, circular to oval, 50-60 μm.; central body thick walled, circular, intrareticulate, disected by 6-7 striae which are confined to the proximal face. This morphotype is similar to morphotype B differing only in size.

Occurrence: This morphotype is very rare and restricted to the Permian part of the Faraghan Formation Kuh-e-Faraghan.

ANALYSIS OF PALYNOLOGIC DATA AND DISCUSSION

Composition and Age of Pollen/Spores Assemblage Zones

It is common practice to use both individual taxa and assemblages of taxa of spores and pollen for correlating late Palaeozoic stratigraphic sequences. Individual taxa probably should be used with caution because their local stratigraphic ranges are controlled to some extent by depositional conditions or local changes in plant distribution. The various species that make up an assemblage each responds somewhat differently during the depositional processes due to differences in size, shape, and structure. As a result, some winnowing occurs and certain taxa that are abundant in one depositional environment, may be less common or even absent in another. For purposes zonation and correlation, it would seem best to employ assemblages of taxa, each characterized by several relatively distinct forms. The presence of a substantial number of the characteristic taxa would be sufficient to identify a zone. Based on this method, palynologists have recognized spore assemblage zones such as those in the Boulonais region of France (Lobozaik & Streel, 1980, 1981), the Canadian Arctic Islands (McGregor, 1981), Great Britain (Richardson, 1960, 1962, 1965, 1974), Belgium (Becker, et al., 1974; Allen, 1965), Central Poland (Turnau, 1986) and the Arabian Peninsula (Hemer & Nygreen, 1967).

One of the objectives of this study is to summarize the known stratigraphic range of assemblages and species that occur in the Faraghan Formation and compare these data with zonal assemblages that have been suggested by other palynologists. In this study, 136 morphotype species (pollen, spores and acritarchs) representing 84 morphotype genera have been identified from the Faraghan Formation. The distribution of these forms has been plotted on Figures 15, 16, and 19. Five successive pollen/spore assemblages have been recognized and will be discussed in the sections which follow.

Spore Assemblage Zone I

This zone begins at the base of the Faraghan Formation and is about 100 meters thick in both study sections in the Faraghan area. This zone is characterized by Retusotriletes dittonensis, Ambitisporites avitus and Chelinospora sp. Longer ranging spore species also occur in this zone and continue into the succeeding zones, including Retusotriletes rotundus, R. dubiosus, and R. distinctus; Cymbosporites cyathus, and C. catillus; and Cyclogranulatisporites rotundus. Within the top 15 m of this zone, the genus Emphanisporites appears (E. annulatus, E. erraticus and E. rotatus).

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

In terms of relative abundance, the dominant species are Retusotriletes dittonensis, Ambitisporites avitus, Chelinospora spp., Gorgonisphaeridium spp., Lophosphaeridium segregum and Leiosphaeridia spp. (Tables 1, 2, 3, 4). Based on the presence of Retusotriletes dittonensis, Ambitisporites avitus, Emphanisporites annulatus and Emphanisporites erraticus, this assemblage zone is considered to be Lower Devonian, probably Gedinnian to Emsian. In general, this assemblage zone is characterized by:

a) low number of spore and acritarch species

b) small (30-50 μm), smooth, simple spores and acritarchs.

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. The interval is characterized by occurrence of Densosporites devonicus; Bullatisporites bullatus; Acinosporites acanthomammillatus; Dibolisporites eifeliensis; Cymbosporites cyathus and C. catillus; Calyptosporites velatus; Grandisporites longus, G. mammillata, G. douglastownense and G. macrotuberculata; Auroraspora aurora,

A. macromanifestus; Emphanisporites rotatus and E. orbicularis; Rhabdosporites langi; and Apiculiretusispora granulata. Several longer-ranging spore and acritarch species which also occur in Zone I are present, including Calamospora pannucea; Retusotriletes distinctus, R. dubiosus and R. rotundus; Veryhachium trispinosum; Polyedryxium decorum; Gorgonisphaeridium abstrusum and G. discussum; Cymatiosphaera perimembrana; and Leiosphaeridia sp. Moreover, a few typical Lower Devonian forms occur at the base of this zone, such as Emphanisporites annulatus and E. erraticus. The dominant genera are Acinosporites, Bullatisporites, Retusotriletes, Emphanisporites, Densosporites, Dibolisporites, Calyptosporites, Calamospora, Apiculiretusispora and Leiosphaeridia (Tables 1, 2, 3 and 4).

This assemblage zone is considered to be Middle Devonian and is correlatable with those from the Middle Devonian of France (Loboziak & Streel, 1981), the Federal Republic of Germany (Regiel, 1973), the Canadian Arctic Islands (McGregor, 1973, 1981), Great Britain (Richardson, 1960, 1962, 1965), Belgium (Allen, 1965), Saudi Arabia (Hemer & Nygreen, 1967), and Poland (Turnau, 1986). 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 (Regiel, 1973; Richardson, 1960, 1962, 1965; Allen, 1965; McGregor, 1973). The Faraghan zone is quite similar to Zones III and IV of the Arabian Peninsula (Hemer & Nygreen, 1967).

Assemblage Zone III

This zone comprises 50.7m in Section One and 20 meters in Section Two. It is marked by appearance of Geminospora punctata, G. antaxios, G. micropaxilla and G. lemurata; Raistrickia arata; 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 Grandispora longus and G. mammillata; Calyptosporites velatus; Rhabdosporites langi; Dibolisporites eifeliensis and Emphanisporites rotatus. A few Acritarch taxa that occur in the underlying zones persist but none are well-represented.

Considering relative abundance, dominant species are Emphanisporites rotatus; Geminospora antaxios, G. micropaxilla, and G. punctata; Rhabdosporites langi; Raistrickia aratra; Grandispora mammillata; Retusotriletes distinctus, and R. rugulatus; Geminospora lemurata; Lophosphaeridium segregum and Leiosphaeridia sp. (see Tables 1, 2, 3 and 4).

This zone is considered to be upper Givetian in age and includes some genera and species that become dominants 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

(Loboziak & Streel, 1981), Germany (Regiel, 1973), and the Canadian Arctic Islands (McGregor, 1973; Owens, 1971).

Assemblage Zone IV

This zone marks the youngest Devonian unit of the Faraghan Formation in Kuh-e-Faraghan. The zone is 20 meters thick in Section One and 30 meter in Section Two and is marked by complete disappearance of taxa from underlying zones and the appearance of new spore species such as *Hystrichosporites corystus*; *Ancyrospora ampulla*, *A. magnifica*, *A. ancyrea*, *A. longispinosa*, *A. grandispinosa*, and *A.* sp.; *Spinozonotriletes naumovii*; *Samarisporites triangulatus*; *Rugospora flexuosa*; *Spelaeotriletes crustus*; *Retispora lepidophyta* and *Geminospora lemurata*. In addition to spore species, several new acritarchs appear in this assemblage, including *Chomotriletes vedugensis*, and *C. bistchoensis*; *Duvernaysphaera tessella*; *Deltotosoma intonsum*; *Dictyotidium granulatum*; *Papulogabata annulata*; *Somphophragma miscellum*; *Stellinium micropolygonale*; *Navifusa excilis* and Acritarch type A.

In terms of relative abundance, the dominant spore and Acritarch species are *Samarisporites triangulatus*; *Geminospora lemurata*; *Ancyrospora ancyrea*, *A. ampulla*, *A. magnifica*, and *A. grandispinosa*; *Spinozonotriletes naumovii*; *Hystricosporites corystus*; *Chomotriletes vedugensis* and *C. bistchoensis*; *Deltotosoma intonsum*, *Navifusa exilis*, 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 and C. bistchoensis; Deltotosoma intonsum and Papulogabata annulata. This zone is equivalent to those which have recorded from the Frasnian of Belgium (Becker et al., 1974), the Canadian Arctic Islands (McGregor, 1981), China (Lianda, 1981), Australia (Balme, 1962; Playford & Dring, 1981), and the Lower Frasnian of France (Loboziak & Streel, 1980) and the Arabian Peninsula (Hemer & Nygreen, 1967).

One of the most marked aspects of this zone is the occurrence of bifurcating spinous spores, such as Hystricosporites and Ancyrospora. Species of these two genera have been recorded elsewhere from Middle Devonian sediments, suggesting the possibility of a Middle Devonian age assignment for this zone. The numerous Upper Devonian index spore and acritarch species which are present mandate a Frasnian assignment and 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 the Arabian Peninsula. The similarity of spore assemblage zones 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 appeciably in the relative importance of the acritarch assemblage. This would suggest a high degree of diversity in source plant environments within the Devonian 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 the presence of Chomotriletes vedugenis (U.S.S.R.) and Chomotriletes bistchoensis (the Woodbed Formation of Alberta). It is quite similar to the assemblage recorded from the Frasnian of Australia (Playford & Dring). 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 possibility of marine continuity between Australia 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 begins just above the uppermost Devonian unit (zone IV) and extends to the top of the Faraghan Formation, a thickness of approximately 40 m. This zone is characterized by the appearance of many gymnospermous pollen species. The various pollen types of this zone contrast strongly with the spore-dominated Devonian zones. Significant pollen groups in zone V include:

1) Disaccate-striatiti pollen including genera such as Hamiapollenites, Vittatina, Corisaccites, Complexisporites, Protohaploxypinus, Striatopodocarpites, Striatoabietites, Lueckisporites, Rhizomaspora, Kosankeisporites, unknown pollen type B and unknown pollen type C.
2) Disaccate non-striatiti pollen such as Sulcatisporites, Platysaccus, Pityosporites, Høegiasaccita and Walikalesaccites.
3) Monosaccate non-striatiti pollen including Plicatipollenites, Nuskoisporites, Potonieisporites, Caheniasaccites and unknown pollen type A.
4) Monosaccate striatiti pollen group representing of genera, such as Striomonosaccites, Costapollenites, Boutakoffites, Decussatisporites and Mabuitasaccites.
5) Polysaccate striatiti pollen as Schizopollis and Crustaesporites.
6) Monosulcate pollen represented by genera such as Fusacolpites and Ginkgocycadophytus.
7) Polycolpate (polyplicate) pollen represented by genera such as Schizaeoisporites and Ephedripites.

In addition to pollen, zone V is characterized by spores of "lower" vascular plant groups, represented by genera such as Punctatisporites, Leiotriletes, Horriditriletes, Laevigatosporites and Tiwariasporis.

In terms of relative abundance, the dominant pollen groups are Disaccate striatiti, Monosaccate striatiti, Monosaccate non-striatiti, Monosulcate, Disaccate non-striatiti polycolpate and polysaccates, respectively (see Table 5).

A detailed microscopic study of palynological samples reveal that the base of this zone coincides with the appearance of pollen species, such as Vittatina costabillis; Cosptapollenites ellipticus; Corisaccites alutas; Striomonosaccites triangularis; Hamiapollenites perisporites; Potonieisporites neglectus; Nuskoisporites triangularis and N. rotatus; Sulcatisporites splendens; and Ginkgocycadophytus cymbatus. Diversity within the zone rapidly increases with the appearance of other pollen and spore species: Boutakoffites elogatus and B. quibus; Caheniasaccites ellipticus and C. ovatus; Mabuitasaccites ovatus; Striomonosaccites ovatus; Fusacolpites fusus and F. ovatus; Walikalesaccites ellipticus; Hoegiasaccites transitus; Plicatipollenites indicus; Potonieisporites granulatus; Vittatina subsaccata; Pityosporites giganteus; Complexisporites polymorphus; Crustaesporites globosus; Kosankeisporites elegans; Protohaploxypinus diagonalis and P. goraiensis; Hamiapollenites saccatus, H. karrooensis and

Table 7. Quantitative Representation of the Devonian Plant Microfossils from the Faraghan Formation, Section One. Numbers for each genus are used in Figure 9.

MS	212	213	222	224	225	226	227	230	232	236	237	238	240	241	242	243A	245	249	250	251A	252	254	258	259	261	262	264	266	267	268	269	SUM	%
1 Acinosporites acanthomammillathus													19	2	10							21										52	1.47
2 Apiculiretusispora granulata														8	5			1		3	5			10	1	17	6	18	0	22	7	103	2.91
3 Auroraspora																																65	1.84
A. aurora											5	3	6	10	3																		
A. macromanifestus											2	5	6	15	10																		
4 Bullatisporites bullatus										1	2	8	1		2																	14	.40
5 Caiamaspora pannucea			1		5	9	45	12	17			20		21	25				2			15		19	4	21	2	9	0	6	2	235	6.64
6 Calyptosporites velatus											7	25	15	6	30		1	2			6	4	14	8	3	16	1	0	13	6	1	158	4.47
7 Cheilinospora spp.			2	3	18	13		1	7				1		2																	47	1.33
8 Cymbosporites																																352	9.95
C. catillus																								1	3	2	5	24	2	28	3		
C. cyathus																								4	5	4	13	112	12	117	17		
9 Densosporites devonicus											5	11	2	2	1																	21	.59
10 Dibolisporites eifeliensis											45	42	4	13	14	2				8	17	19	15									179	5.06
11 Emphanisporites																																285	8.06
E. annulatus								1		1	5																						
E. erraticus								2		1	20	3		3	2									5									
E. orbicularis																				2	3			0	0	0	1						
E. rotatus								4		3	12	21		14	31	1	1	1	2	7	2	25	6	50	4	23	7	1	0	9	3		
Emphanisporites sp.																									3	2	1	2	0	0	1		
12 Geminospora																																367	10.38
G. antaxios																				2	1		3	4	3	6	5						
G. lemurata																				15	12	39	3	40	14	26	4	21	2	40	42		
G. micropaxilla																				1	2	5	3	8	9	23	10						
G. punctata																				2		5		8	2	4	3						
13 Grandispora																																381	10.77
G. douglastownense											2	7		1	23		1					5											
G. longa											3	10		24	10		7					8	6										
G. macrotuberculata											3	20		2	30		5																
G. mammillata											14	32		6	5		11					15	2	9	7	68	0	9	0	10	26		
14 Raistrickia aratra																									47	116	10	73	0	35	7	288	8.14
15 Retusotriletes																																355	10.04
R. dubiosus					8	3	22	2	5	1	9	5	3	9	4					1	4	6		18	2	3							
R. distinctus					2	1	31	5	10	9	7	6	5	11	19			1		1	7	15	1	28	1	18	2	11	0	14	3		
R. rotundus					1	4	15	3	3		3	2	1																				
R. rugulatus																							8	0	0	0	0	1	0	0	1		
16 Retispora lepidophyta																								6	1	9	0	7	1	19	57	100	2.83
17 Rhabdosporites langi											3	7	1	32	45							54	51	19	2	20	1	7	0	5		247	6.98
18 Rugospora flexuosa																									1	2	0	0	3	9	11	26	.74
19 Samarisporites triangulatus																								4	0	4	0	120	21	49	35	233	6.59
20 Spelaeotriletes cf. crustatus																									2	0	0	1	2	3	4	12	.34
21 Spinozonotriletes naumovii																										11	2	0	0	3	1	17	.48

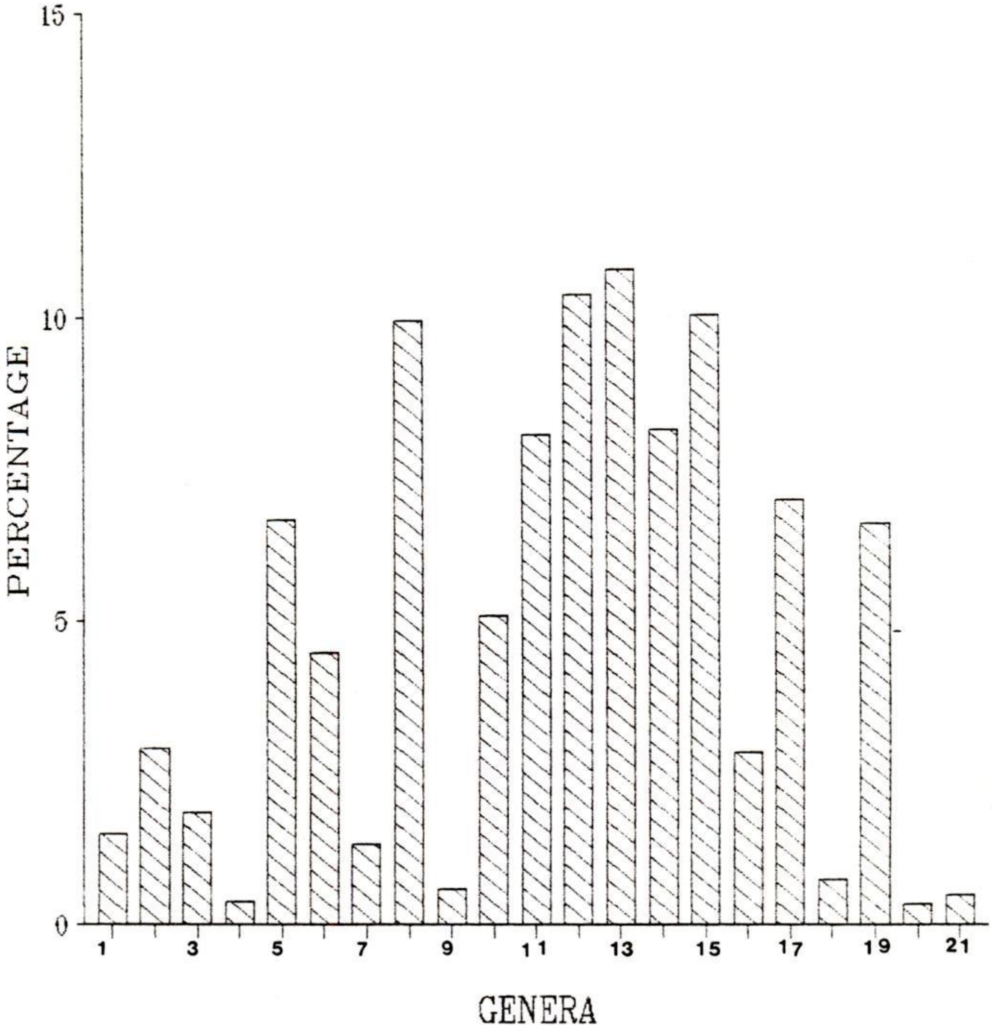


Figure 9. Relative Frequency of the Devonian Miospores from Section One of the Faraghan Formation at Kuh-e-Faraghan.

Table 2. Quantitative Representation of the Devonian Acritarchs from the Faraghan Formation at Kuh-e-Faraghan, Section One. Numbers for each genus are used in Figure 10.

MG	211	212	213	222	224	225	226	227	230	232	236	237	238	240	241	242	243A	245	249	250	251A	252	254	258	259	261	262	264	266	267	268	269	SUM	%
1 Chomotriletes																																	21	1.69
C. bistchoense																										2	5	4	0	1	0	2		
C. vedugensis																										1	3	2	0	0	0	1		
2 Cymatiosphaera perimembrana					5	11		2							1	3																	22	1.77
3 Diexallophasis																																	23	1.85
D. remota					2	1						3		1											1	2	2							
Diexallophasis sp.					1	5						1														3	1							
4 Gorgonisphaeridium																																	191	15.34
G. abstrusum						7		5	2	3	1		2	1	3		1						3	2		5	1	4	2	0	1			
G. discissum																							1		1	2	3	2	0	0	1			
Gorgonisphaeridium sp. A			1		3	20	3		1	3						2																		
Gorgonisphaeridium sp. B			3	1	5	35	7		2																									
Gorgonisphaeridium sp. C			1		2	18	1		3		1																							
Gorgonisphaeridium sp. D			2		2	11	3				2		1	3		2																		
5 Lophosphaeridium segregum			21	45	63	380	67	274			1		4	2	1	5	3	4		1	2			7	11	5	2	1	0	0	8	3	910	73.09
6 Navifusa excilis																								3	1		0	0	0	0	2	1	7	.56
7 Polyedryxium decorum					1	5	2	15			2			1	3	2					1	3		2	5		1						43	3.45
8 Veryhachium trispinosum		5	1	10	7	2		3																									28	2.25

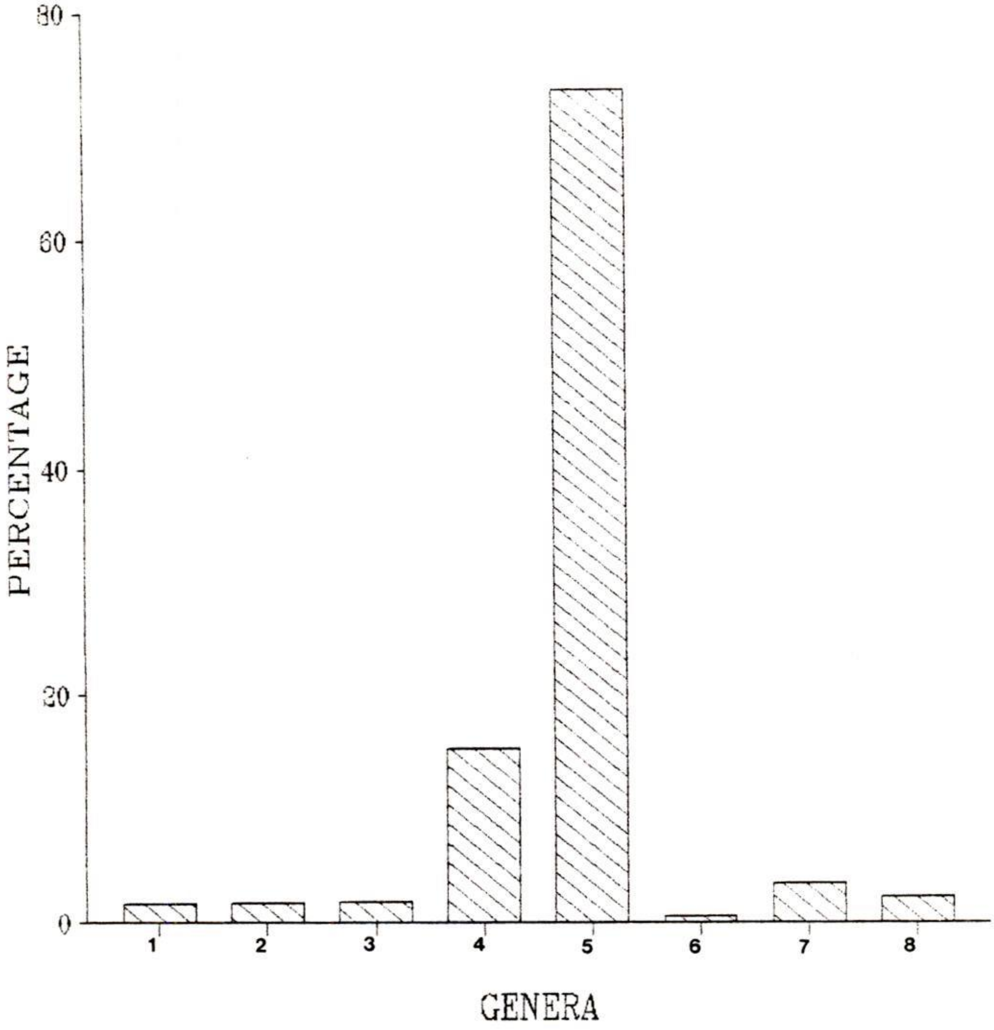


Figure 10. Relative Frequency of the Devonian Acritarchs in Section One of the Faraghan Formation at Kuh-e-Faraghan.

Table 3·1 Quantitative Representation of the Devonian Miospores from the Faraghan Formation at Kuh-e-Faraghan, Section Two. Numbers for each genus are used in Figure 11.

MG	281	282	285	287	289	290	297	300	301	304	305	306	307	308	309	310	316	318	320	323	325	327	328	329	SUM	%
1 Acinosporites acanthomammillatus											145	130	3	9	11	7									305	6.21
2 Ambitisporites cf. avitus				2	5	60	3																		70	1.43
3 Ancyrospora																										4.91
A. ancyrea																				8	2	30	25	60	125	
A. ampulla																				2		5	2	10	19	
A. grandispinosa																				3	1	5	4	2	15	
A. longispinosa																				4	1	9	14	25	53	
A. magnifica																				1	1	8	5	3	18	
Ancyrospora sp.																				2		4	1	4	11	
4 Apiculiretusispora granulata											22	11	98	69	56	62	18	2	30	22	15	6	12	13	436	8.88
5 Bullatisporites bullatus										1	15	8	1	25											50	1.02
6 Calamaspora pannucea			4			21	2	2		3	10	22	53	3	2	15	13	6	3	4	7	3	5	12	190	3.87
7 Calyptosporites velatus										16	4	5	30	15	24	32	24	6	6	11	6	2	5		186	3.79
8 Chelinospora spp.		1	2	1	3	11	2																		20	.41
9 Cyclogranulatisporites sp.						5	1											8	6						20	.41
10 Cymbosporites																										1.47
C. cyathus									1	4	1	2			6			6	1		25	3			49	
C. catillus									1	1	6							2			12	1			23	
11 Densosporites devonicus											2	3		2	1	3									11	.22
12 Dibolisporites eifeliensis										13	94	53	68	71	42	43	32								416	8.47
13 Emphanisporites																										9.96
E. annulatus										3	9	7													19	
E. erraticus										2	40	50	3	15		4									114	
E. orbicularis														4	1						1				6	
E. rotatus										1	47	88	3	68	18	15	30	35	1	25	8	3	2		·344	
Emphanisporites sp.											1	4			1										6	
14 Geminospora																										10.14
G. antaxios																	1	5	17	21	3	1	3	1	52	
G. lemurata																	8	13	23	18	40	34	30	60	226	
G. micropaxilla																	3	2	3	90	21	8	12	7	146	
G. punctata																	2	1	7	50	8	3	1	2	74	
15 Grandispora																										16.05
G. douglastownense											2	1	13	3	1	3	2								25	
G. longa											2	1	18	1	9	4	1								36	
G. macrotuberculata											3		2	5	20	14	5								49	
G. mammillata											10	9	180	126	174	86	33	9	6	8	24		4	9	678	
16 Hystricosporites corystus																				2	5	12	3	13	35	.71
17 Raistrickia aratra																			1	1	32	10	10	4	58	1.18
18 Retusotriletes																										11.46
R. distinctus						1		2		2	20	20	15	48	15	9	8	18	35	20	31	17	12	6	279	
R. dittonensis			9	5	4	80	1	2	3																104	
R. dubiosus						30		1		1	9	16	10	5	2			3	17	13	10	10	4		131	
R. rotundus						28					2	2	8	2	1										43	
R. rugulatus																			3	2				1	6	
19 Retispora lepidophyta																			4					1	5	.10
20 Rhabdosporites langi											49	37	3	24	30	18	49	14	12	10	3	3	4	2	258	5.25
21 Samaisporites triangulatus																				106	30	11	21	16	184	3.75
22 Spinozonotriletes naumovii																				4	6	1	3	2	16	.33

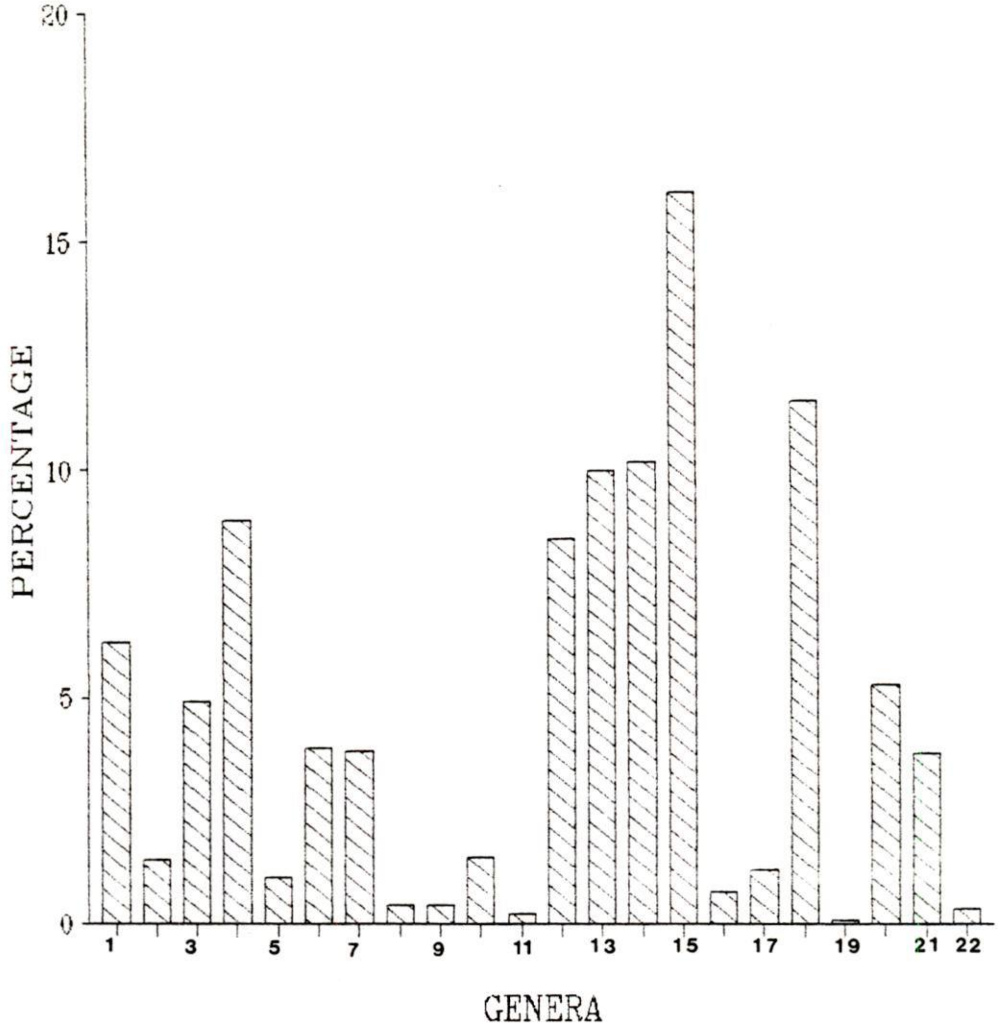


Figure 11. Relative Frequency of the Devonian Miospores from Section Two of the Faraghan Formation at Kuh-e-Faraghan.

Table 4 · Quantitative Representation of the Devonian Acritarchs in Section Two of the Faraghan Formation at Kuh-e-Faraghan. Numbers for each genus are used in Figure 12.

	MG	281	282	285	287	289	290	297	300	301	304	305	306	307	308	309	310	316	318	320	323	325	327	328	329	SUM	%
1 Acritarch type A.																							1	2	2	5	.37
2 Chomotriletes																											6.91
C. bistchoense																					1	2	6	4	11	24	
C. vedugensis																					6	4	12	17	30	69	
3 Cymatiosphaera perimembrana					1	3	12																			16	1.19
4 Dictyotidium granulatum																					3	2	1		5	11	.82
5 Diexallophasis remota																					1	2		3	1	7	.52
6 Deltotosoma intonsum																							3	12	22	37	2.75
7 Duvernaysphaera tessella																								1		1	.07
8 Evittia geometrica																								2	5	7	.52
9 Gorgonisphaeridium																											10.63
G. abstrusum							5		1								3					1			6	16	
G. discissum							18	2	23	4							27			2	1	5			45	127	
10 Leiosphaeridia sp.							11	2	176	10	15	11	20		32		50	60	10	5		2	48	72	26	550	40.86
11 Lophosphaeridium segregum																				3	4	7	20	25	36	95	7.06
12 Melikeriopalla venulosa																							3	2	10	15	1.11
13 Navifusa excilis																			5	10	15		20	35	49	134	9.96
14 Papulogabata annulata																					2	5	75	61	18	161	11.96
15 Polyedryxium decorum			2	4	4	1	5	3								1	6					1		2		29	2.15
16 Somphophragma miscellum																					2	3	1	4		10	.74
17 Stellinium micropolygonale																					1		2	5		8	.59
18 Veryhachium trispinosum		1	1	2		3	1											2		1	2	2	3	5	1	24	1.78

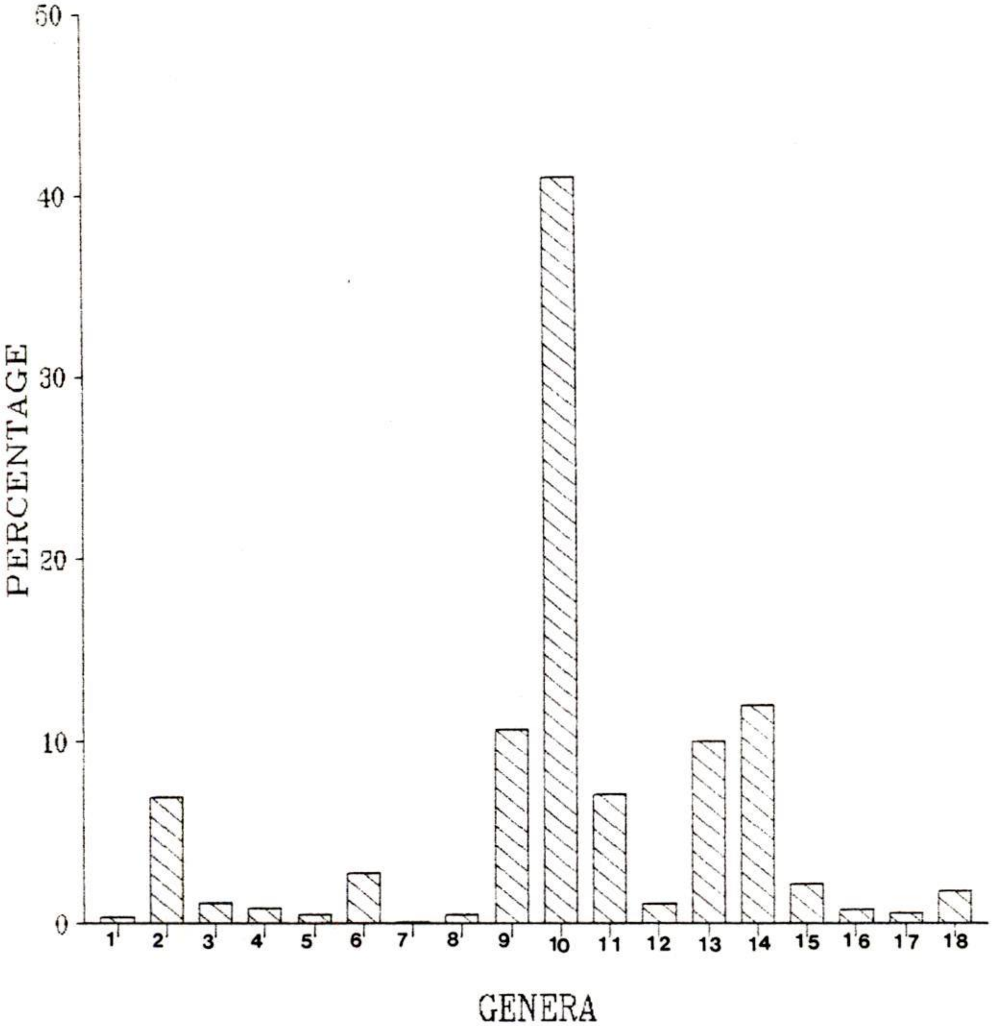


Figure 12. Relative Frequency of the Devonian Acritarchs in Section Two of the Faraghan Formation at Kuh-e-Faraghan.

H. tractiferinus; Striatoabietites multistriatus; Schizaeoisporites microrugosus; Rhizomasporites radiata; Platysaccus papilionis and P. densus; Striatopodocarpites rarus and S. cancellatus; Vittatina lata; Ephedripites ellipticus; Tiwariasporis gondwanensis and T. flavatus; Horriditriletes ramosus; Laevigatosporites vulgaris; Schizopollis sp.; Decussatisporites sp.; Lueckisporites sp.; Protohaploxypinus sp.; Crustaesporites sp.; Leiotriletes sp.; unknown pollen type A; unknown pollen type B, and unknown pollen type C.

The relative percentage of each genus and species was calculated based on counts of one thousand grains per sample for each study section (see Tables 6 and 7). The base of this zone is not very rich in pollen and data here are limited to four samples (MG-274, MG-275, MG-331, MG-332) which yielded a diverse, well-preserved assemblage.

Table 5. Spectrum of different palynomorph groups and their percentages in the Permian part of the Faraghan Formatin in Tang-e-Zakin, Kuh-e-Faraghan. Numbers of each group are used in figure 13.

No.	Group	Rel. %
1	Disaccate striatiti	60.05
2	Monosaccate non-striatiti	9.15
3	Monosaccate striatiti	10.00
4	Monocolplate	5.5
5	Spores	5.35
6	Disaccate non-striatiti	5.1
7	Polycolpate	2.85
8	Polysaccate	1.8

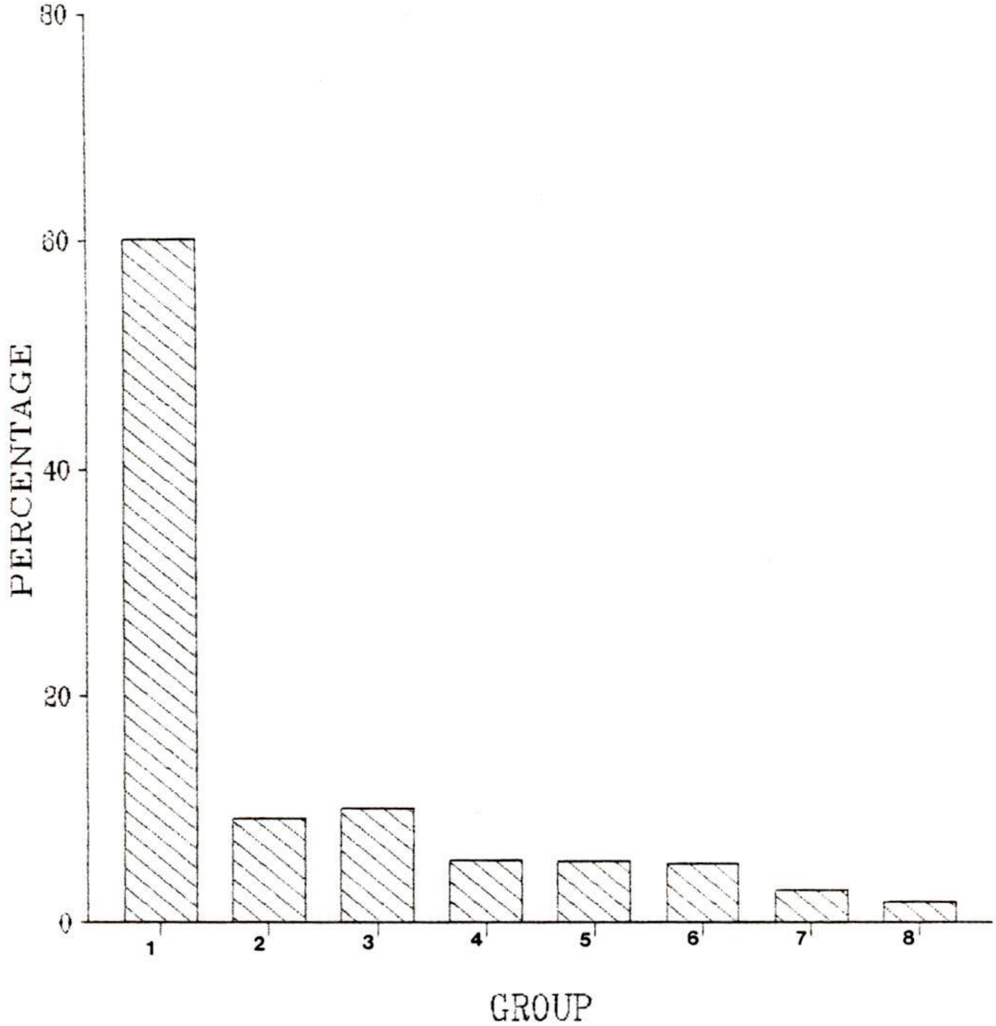


Figure 13. Relative Frequency of the Palynomorph Groups from the Permian Part of the Faraghan Formation at Kuh-e-Faraghan.

Table 6. Relative frequency and percentages of genera throughout the Permian part of the Faraghan Formation in Kuh-e-Faraghan. Number for each genus correspond to those of figure 14.

#	List of Genera	%
1	Protohaploxypinus	13.6
2	Vittatina	11.45
3	Hamiapollenites	10.00
4	Striatopodocarpites	9.5
5	Complexisporites	7.4
6	Costapollenites	4.2
7	Fusacolpites	3.3
8	Potonieisporites	2.80
9	unknown pollen type B	2.75
10	Boutakoffites	2.60
11	Caheniasaccites	2.40
12	Laevigatosporites*	2.30
13	Tiwariasporis*	2.25
14	Ginkgocycadophytus	2.2
15	Striomonosaccites	2.2
16	Ephedripites	1.75
17	Nuskoisporites	1.55
18	Crustaesporites	1.5
19	Sulcatisporites	1.5
20	Pityosporites	1.5
21	Corisaccites	1.35
22	Plicatipollenites	1.25
23	unknown type A	1.15
24	Rhizomaspora	1.15
25	Schizaeoisporites	1.1
26	Striatoabietites	1
27	unknown type C	0.9
28	Walikalesaccites	0.85
29	Høegiasaccites	0.75
30	Horriditriletes*	0.65
31	Kosankeisporites	0.6
32	Mabuitasaccites	0.6
33	Decussatisporites	0.6
34	Platysaccus	0.5
35	Lueckisporites	0.35
36	Schizopollis	0.30
37	Leiotriletes*	0.15

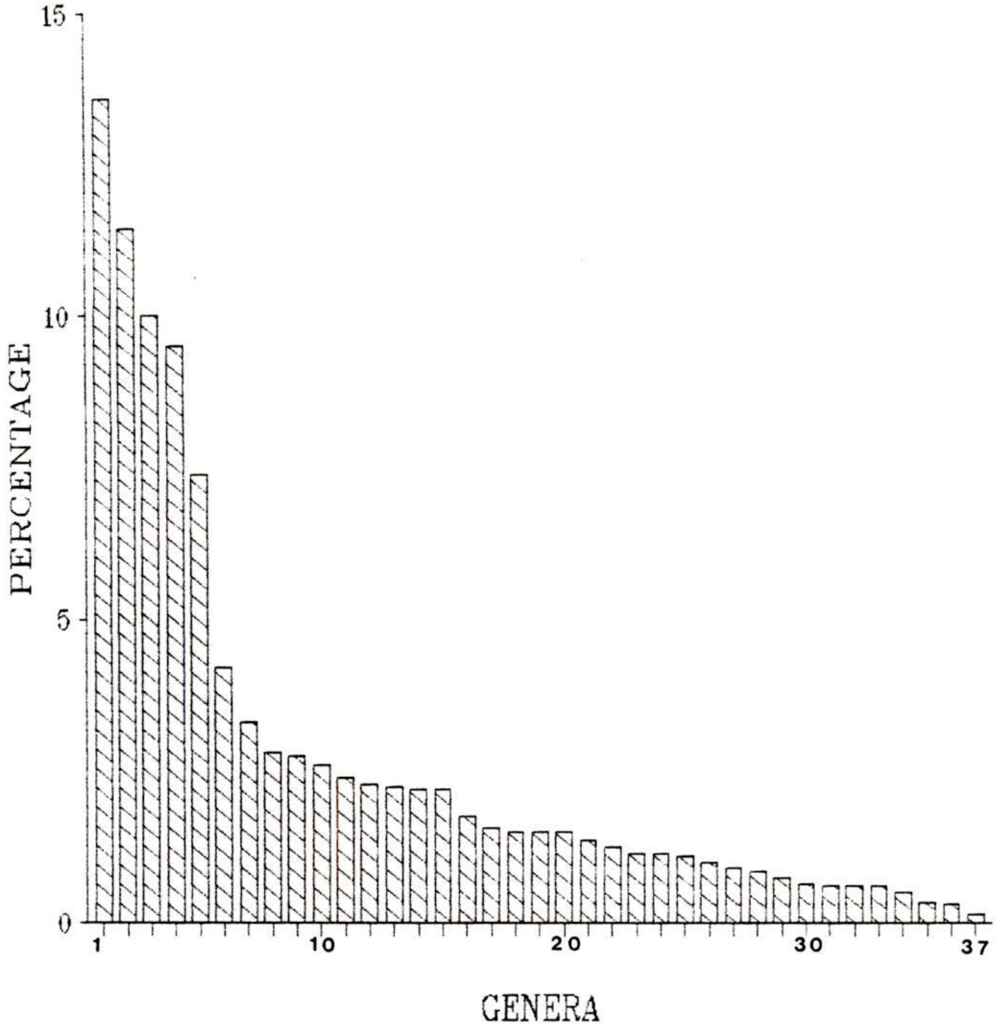


Figure 14. Relative Frequency of the Permian Palynomorph Genera from the Faraghan Formation at Kuh-e-Faraghan.

Table 7. Total counts and reltive percentages of individual palynospecies in the Permian portion of the Faraghan Formation at Kuh-e-Faraghan (n = 2000).

#	List of species	# grains	%
1	Boutakoffites quibus	15	0.75
2	B. elongatus	37	1.85
3	Caheniasaccites ovatus	18	0.9
4	C. ellipticus	30	1.5
	Complexisporites polymorphus	148	7.4
	Costapollenites ellipticus	84	4.2
5	Corisaccites alutas	27	1.35
6	Crustaesporites globosus	10	0.5
7	C. spp.	20	1
8	Decussatisporites sp.	12	0.6
9	Ephedripites ellipticus	35	1.75
10	Fusacolpites ovatus	24	1.2
11	F. fusus	48	2.4
12	Ginkgocycadophytus cymbatus	42	2.1
13	Hamiapollenites perisporites	130	6.5
14	H. karrooensis	50	2.50
15	H. tractiferinus	20	1.00
16	Horriditriletes ramosus*	13	0.65
17	Høegiasaccites transitus	15	0.75
18	Kosankeisporites elegans	12	0.60
19	Laevigatosporites vulgaris*	46	2.3
20	Leiotriletes sp.*	3	0.15
21	Lueckisporites sp.	7	0.35
22	Mabuitasaccites ovatus	12	0.6
23	Nuskoisporites triangularis	17	0.85
24	N. rotatus	14	0.70

Table 7 (continued)

#	List of species	# grains	%
25	Pityosporites giganteus	30	1.5
26	Platysaccus papilionis	6	0.3
27	P. densus	4	0.2
28	Plicatipollenites indicus	25	1.25
29	Potonieisporites granulatus	41	2.05
30	P. neglectus	15	0.75
31	Protohaploxypinus diagonalis	172	8.5
32	P. goraiensis	100	5.0
33	P. sp.	20	1
34	Rhizomaspora radiata	23	1.15
36	Schizaeoisporites microrugosus	14	0.7
37	S. sp.	8	0.4
38	Schizopollis sp.	6	0.3
39	Striatopodocarpites rarus	160	8.0
40	S. cancellatus	30	1.5
41	Striomonosaccites ovatus	15	0.75
42	S. triangularis	29	1.45
43	Sulcatisporites splendens	30	1.5
44	Tiwariasporis flavatus	19	0.95
45	T. gondwanensis	26	1.3
46	Vittatina lata	40	2.0
47	V. costabilis	59	2.95
48	V. subsaccata	130	6.50
49	Walikalesaccites ellipticus	17	0.85
50	unknown pollen type A	23	1.15
51	unknown pollen type B	55	2.75
52	unknown pollen type C	18	0.9

Figure 15. Stratigraphic distribution of palynomorphs in Section One of the Faraghan Formation at Tang-e-Zakin, Kuh-e-Faraghan.

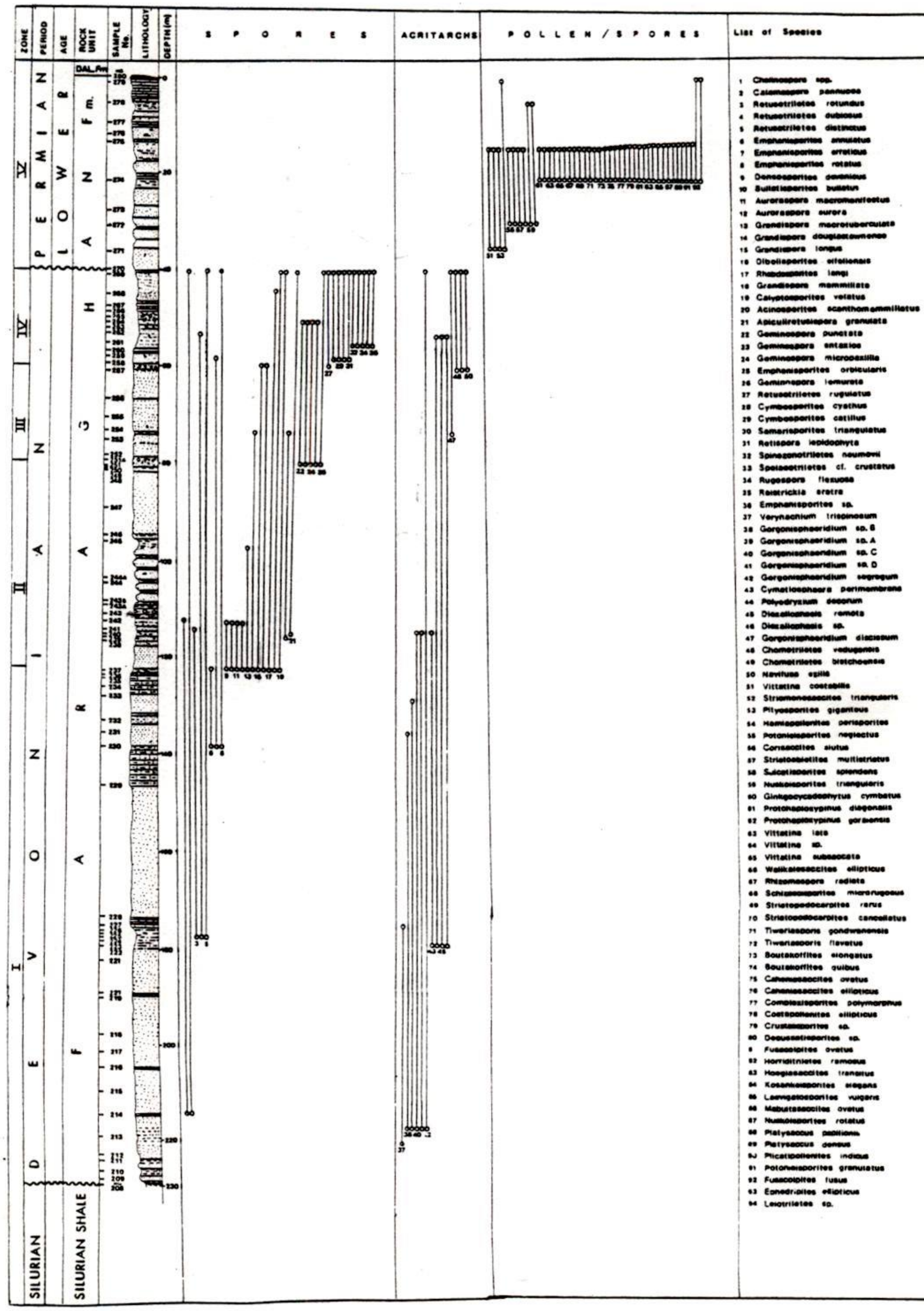
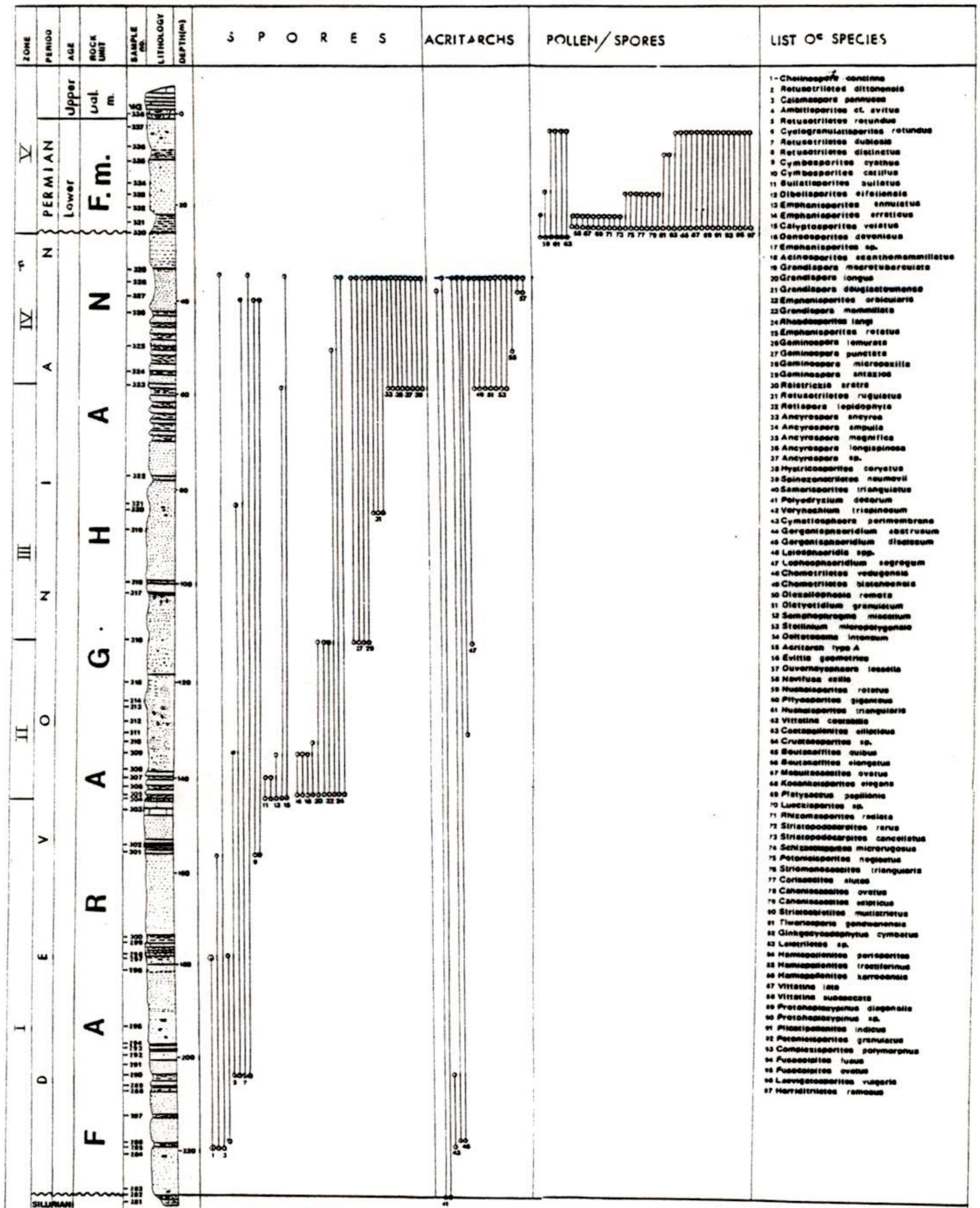

ZONE
PERIOD
AGE
ROCK UNIT
SAMPLE No.
LITHOLOGY
DEPTH (m)
S P O R E S
ACRITARCHS
P O L L E N / S P O R E S
List of Species
PERMIAN
LOWER
NAWAR Fm.
DAL_Fm
VI
V
IV
III
II
I
DEVONIAN
AWAYNAT WANIN
SILURIAN
SILURIAN SHALE
1 Chelinospora spp.
2 Calamospora pannucea
3 Retusotriletes rotundus
4 Retusotriletes dubiosus
5 Retusotriletes distinctus
6 Emphanisporites annulatus
7 Emphanisporites erraticus
8 Emphanisporites rotatus
9 Densosporites devonicus
10 Bullatisporites bullatus
11 Aurorospora macromanifestus
12 Aurorospora aurora
13 Grandispora macrotuberculata
14 Grandispora douglastownense
15 Grandispora longus
16 Diboliisporites eifeliensis
17 Rhabdosporites langi
18 Grandispora mammillata
19 Calyptosporites velatus
20 Acinosporites acanthomammillatus
21 Apiculiretusispora granulata
22 Geminospora punctata
23 Geminospora antaxios
24 Geminospora micropaxillis
25 Emphanisporites orbicularis
26 Geminospora lemurata
27 Retusotriletes rugulatus
28 Cymbosporites cyathus
29 Cymbosporites catillus
30 Samarisporites triangulatus
31 Retispora lepidophyta
32 Spinozonotriletes naumovii
33 Spelaeotriletes cf. crustatus
34 Rugospora flexuosa
35 Raistrickia aratra
36 Emphanisporites sp.
37 Verynachium trispinosum
38 Gorgonisphaeridium sp. B
39 Gorgonisphaeridium sp. A
40 Gorgonisphaeridium sp. C
41 Gorgonisphaeridium sp. D
42 Gorgonisphaeridium segregum
43 Cymatiosphaera perimembrana
44 Polyedryxium decorum
45 Diexallophasis remota
46 Diexallophasis sp.
47 Gorgonisphaeridium disciseum
48 Chomotriletes vedugensis
49 Chomotriletes bistchoensis
50 Navifusa exilis
51 Vittatina costabilis
52 Striomonosaccites triangularis
53 Pityosporites gigantous
54 Hamiapollenites perisporites
55 Potonieisporites neglectus
56 Corisaccites alutus
57 Strialoabietites multistriatus
58 Sulcatisporites splendens
59 Nuskoisporites triangularis
60 Ginkgocycadophytus cymbatus
61 Protohaploxypinus diagonalis
62 Protohaploxypinus gorisensis
63 Vittatina lata
64 Vittatina sp.
65 Vittatina subsaccata
66 Walikalesaccites ellipticus
67 Rhizomaspora radiata
68 Schizosaccisporites microrugosus
69 Striatopodocarpites rarus
70 Striatopodocarpites cancellatus
71 Tiwariasporis gondwanensis
72 Tiwariasporis flavatus
73 Bouteakoffites elongatus
74 Bouteakoffites guibus
75 Cahenisaccites ovatus
76 Cahenisaccites ellipticus
77 Complexisporites polymorphus
78 Costapollenites ellipticus
79 Crustaesporites sp.
80 Decussatisporites sp.
8 Fusacolpites ovatus
82 Horriditriletes ramosus
83 Hoegisaccites tranatus
84 Kosankeisporites elegans
85 Laevigatosporites vulgaris
86 Mabuitasaccites ovatus
87 Nuskoisporites rotatus
88 Platysaccus papilionis
89 Platysaccus densus
9J Plicatipollenites indicus
91 Potonieisporites granulatus
92 Fusacolpites fusus
93 Ephedripites ellipticus
94 Leiotriletes sp.

Figure 16. Stratigraphic distribution of pollen/spore and acritarchs in Section Two of the Faraghan Formation at Tang-e-Zakin, Kuh-e-Faraghan.


ZONE
PERIOD
AGE
ROCK UNIT
SAMPLE no.
LITHOLOGY
DEPTH(m)
SPORES
ACRITARCHS
POLLEN/SPORES
LIST OF SPECIES
PERMIAN
Upper
Lower
F.m.
FARAGHAN F.
DEVONIAN
SILURIAN
I
II
III
IV
V
1 - Chelinospora concinna
2 Retusotriletes dittonensis
3 Calamospora pannucea
4 Ambitisporites cf. avitus
5 Retusotriletes rotundus
6 Cyclogranulatisporites rotundus
7 Retusotriletes dubiosus
8 Retusotriletes distinctus
9 Cymbosporites cyathus
10 Cymbosporites catillus
11 Bullatisporites bullatus
12 Dibolisporites eifeliensis
13 Emphanisporites annulatus
14 Emphanisporites erraticus
15 Calyptosporites velatus
16 Densosporites devonicus
17 Emphanisporites sp.
18 Acinosporites acanthomammillatus
19 Grandispora macrotuberculata
20 Grandispora longus
21 Grandispora douglastownense
22 Emphanisporites orbicularis
23 Grandispora mammillata
24 Rhabdosporites langi
25 Emphanisporites rotatus
26 Geminospora lemurata
27 Geminospora punctata
28 Geminospora micropaxilla
29 Geminospora antaxios
30 Raistrickia aratra
31 Retusotriletes rugulatus
32 Retispora lepidophyta
33 Ancyrospora ancyrea
34 Ancyrospora ampulla
35 Ancyrospora magnifica
36 Ancyrospora longispinosa
37 Ancyrospora sp.
38 Hystricosporites corystus
39 Spinozonotriletes naumovii
40 Samarisporites triangulatus
41 Polyedryxium decorum
42 Veryhachium trispinosum
43 Cymatiosphaera perimembrana
44 Gorgonisphaeridium absitum
45 Gorgonisphaeridium discissum
46 Leiosphaeridia spp.
47 Lophosphaeridium segregum
48 Chomotriletes vedugensis
49 Chomotriletes bistchoensis
50 Diexallophasis remota
51 Dictyotidium granulatum
52 Saminophragma mieczum
53 Stellinium micropolygonale
54 Deltotosoma intonsum
55 Acritarch type A
56 Evittia geometrica
57 Duvernaysphaera tessella
58 Navifusa exilis
59 Nuskoisporites rotatus
60 Pityosporites giganteus
61 Nuskoisporites triangularis
62 Vittatina costabilis
63 Costapollenites ellipticus
64 Crucisaccites sp.
65 Boutakoffites quibus
66 Boutakoffites elongatus
67 Mabuitasaccites ovatus
68 Kosankeisporites elegans
69 Platysaccus papilionis
70 Lueckisporites sp.
71 Rhizomaspora radiata
72 Striatopodocarpites rarus
73 Striatopodocarpites cancellatus
74 Schizopollis microrugosus
75 Potonieisporites neglectus
76 Striomonosaccites triangularis
77 Corisaccites alutas
78 Caheniasaccites ovatus
79 Caheniasaccites ellipticus
80 Striatoabieites multistriatus
81 Tiwariaspora gondwanensis
82 Ginkgocycadophytus cymbatus
83 Leiotriletes sp.
84 Hamiapollenites perisaccites
85 Hamiapollenites tractiferinus
86 Hamiapollenites karrooensis
87 Vittatina lata
88 Vittatina subsaccata
89 Protohaploxypinus diagonalis
90 Protohaploxypinus sp.
91 Plicatipollenites indicus
92 Potonieisporites granulatus
93 Complexisporites polymorphus
94 Fusacolpites fusus
95 Fusacolpites ovatus
96 Laevigatosporites vulgaris
97 Horriditriletes ramosus

This zone is considered to be Lower Permian in age ranging from part of the Sakmarian to the Kungurian. In general, this zone is correlatable with the Vittatina costabillis (VS) and Disaccate Striatiti zones (DS) of western Europe (Clayton, et al., 1977). Some of the components of this zone are similar to those from, the Lower Permian of northern Iran (Chataeuneuf, et al., 1979), the United States (Tschudy & Kosanke, 1966), Turkey (Akyol, 1975), the Arabian Peninsula (Hemer, 1965), Tiwari, 1967), Bolivia (Cousminer, 1965), Australia (Balme & Hennelly, 1955; Segroves, 1970), West-Pakistan (Venkatachala & Kar, 1967; Balme, 1970) and Africa (Jardine, 1974; Bose & Kar, 1966; Bose & Maheshwari, 1968; Hart, 1963a, 1964; and Stapleton, 1977), and the Barakar stage of India (Potonie & Lele, 1959; Bharadwaj, 1962).

Characteristic Lower Permian taxa include Hamiapollenites perisporites and H. karrooensis; Vittatina subsaccata and V. costabillis; Costapollenites ellipticus; Plicatipollenites indicus; Boutakoffites elongatus and B. quibus; Caheniasaccites ellipticus and C. ovatus; Mabuitasaccites ovatus; Nuskoisporites triangularis; Høegiasaccites transitus; Walikalesaccites ellipticus; Potonieisporites neglectus and P. granulatus; Protohaploxypinus diagonalis; Schizaeoisporites microrugosus; Striomonosaccites triangularis and S. ovatus; Sulcatisporites splendens; Tiwariasporis gondwanensis and T. flavatus; Horriditriletes ramosus; Fusacolpites ovatus and

F. fusus; Corisaccites alutas; Ginkgocycadophytus cymbatus and Schizopollis sp.

Except for Laevigatosporites vulgaris, which is a Carboniferous relict form, other species (see Table 7) associated with these Lower Permian index species are long-ranging Permian forms, some with ranges extending to the early Mesozoic. The palynological slides from this assemblage zone were examined for reworked palynomorphs. A few reworked specimens were noted in the lowermost part of the Lower Permian zone (MG-270, MG-330), including Emphanisporites rotatus, Geminospora lemurata and Ancyrospora sp. All reworked forms have been extensively altered and they are quite rare in contrast to their abundance and excellent preservation in the uppermost Devonian samples. The palynological data document an extensive hiatus in the Faraghan area that lasted from at least the Famennian stage to the end of the Carboniferous period.

Parts of this diastem may represent non-depositional intervals or the extensive erosion of Upper Devonian and Carboniferous sediments, perhaps in conjunction with the Hercynian orogeny at the end of the Devonian. This latter possibility is consistent with data from the Arabian peninsula and Oman (Hughes Clark, 1988; Besems & Schuurman, 1987).

In addition to the palynological study of two stratigraphic sections from the Faraghan area, seven samples were also studied from the Chal-i-Sheh area (Fig. 19) in order to determine the age of the Faraghan Formation in the Chal-i-Sheh area. The Carboniferous age determination of the Chal-i-Sheh area, based on the occurrence of Sigillaria Persica Seward (1931), has been a source of controversy for the age assignment of Faraghan Formation in the Zagros basin. The samples were selected from below, within and above of Sigillaria persica zone (see Fig. 19). A total 22 genera and 24 species of spores, pollen and microphytoplankton were identified.

The Chal-i-Sheh assemblage consists of 12 pollen genera (14 species), 9 spore genera (9 species), a single species of marine phytoplankton, and scolecodont remains (Tables 8 and 9).

The palynofloral composition suggests a Early Permian age for the Faraghan Formation in the Chal-i-Sheh area and is consistent with the Early Permian assemblage in the Faraghan area.

Carboniferous spore species are somewhat more common at Chal-i-Sheh, while pollen taxa are somewhat less diverse than at Faraghan. In general, the Chal-i-Sheh palynomorph assemblage is somewhat similar to that recorded by Akyol (1975) from the Lower Permian of Turkey. The majority of

Table 8 . 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
Laevigatosporites 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

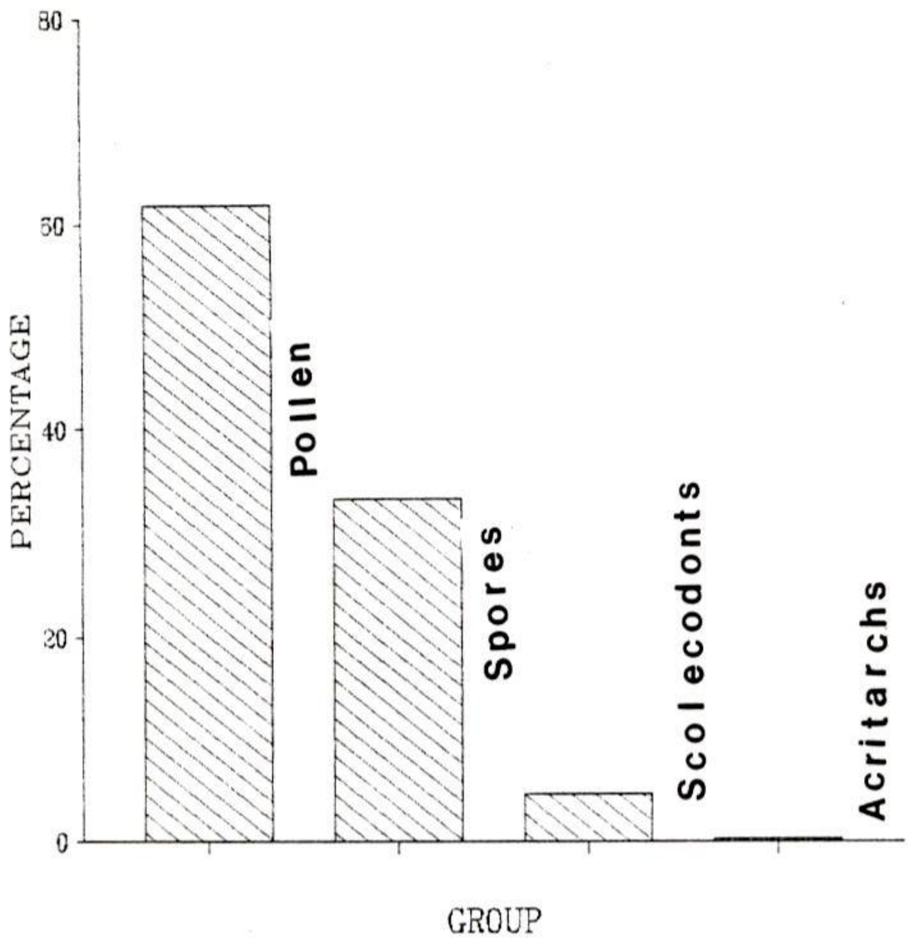


Figure 17. Relative Frequency of Permian Pollen, Spores, Scolecodonts, and Acritarchs from the Faraghan Formation at Chal-i-Sheh Area, Northwestern Zagros Basin.

Table 9. Relative percentages of palynomorphs (spores, pollen, and acritarchs) and Scolecodonts from seven samples from the Chal-i-Sheh area. Numbers for each genus are used in Figure 18.

#	List of Genera	# of grains	%
1	Hamiapollenites	299	32.5
2	Kraeuselisporites*	123	13.37
3	Sulcatisporites	86	9.35
4	Potonieisporites	53	5.76
5	Punctatisporites*	50	5.43
6	Pityosporites	48	5.22
7	Scolecodonts**	43	4.67
8	Thymospora*	35	3.8
9	Laevigatosporites*	34	3.7
10	Leiotriletes*	34	3.7
11	Vittatina	33	3.6
12	Nuskoisporites	29	3.15
13	Ginkgocycadophytus	13	1.4
14	Protohaploxypinus	12	1.3
15	Gulisporites*	5	0.54
16	Horriditriletes*	5	0.54
17	Striatopodocarpites	4	0.4
18	Fusacolpites	4	0.4
19	Plicatipollenites	2	0.22
20	Ephedripites	2	0.22
21	Calamospora*	2	0.22
22	Grandispora*	2	0.22
23	Veryhachium***	2	0.22

* spore species
** Jaw of Permian worms
*** Acritarch species

without star, pollen grains

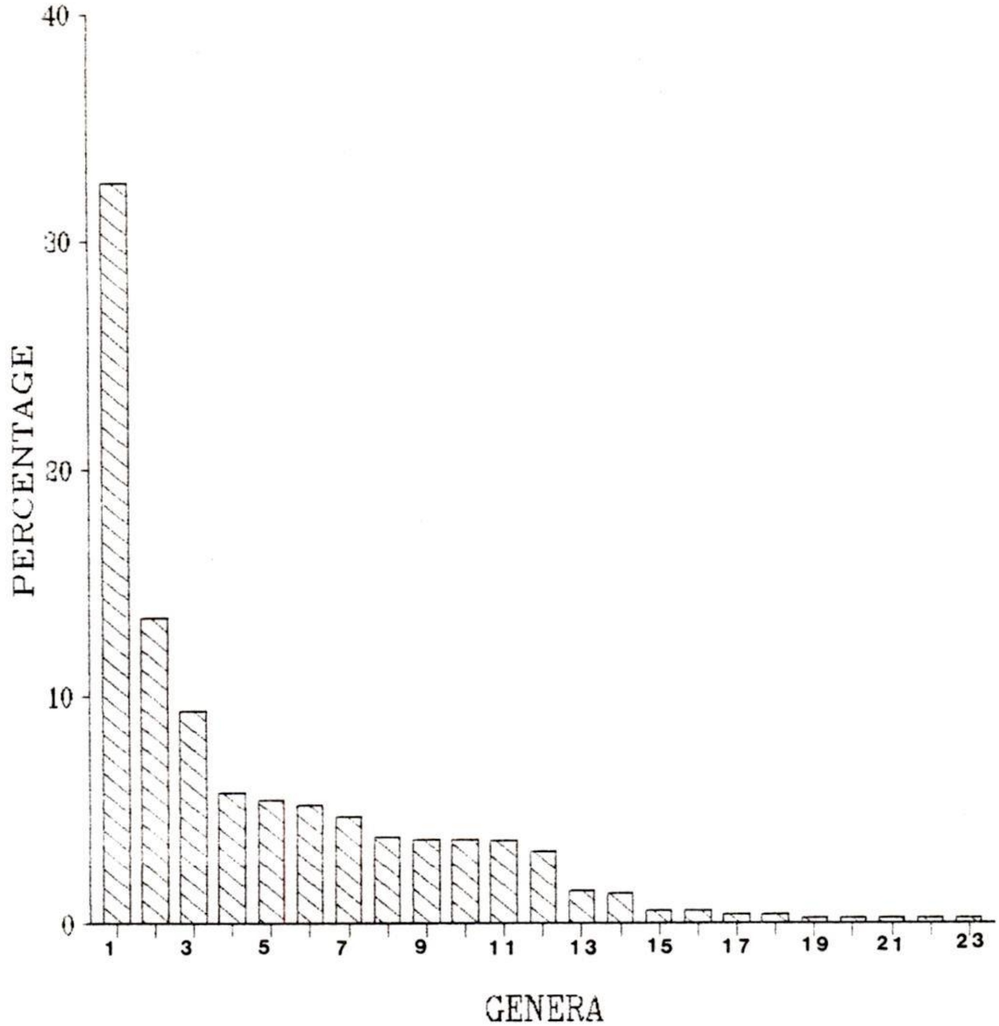


Figure 18. Relative Frequency of the Permian Genera from the Faraghan Formation at Chal-i-Sheh Area.

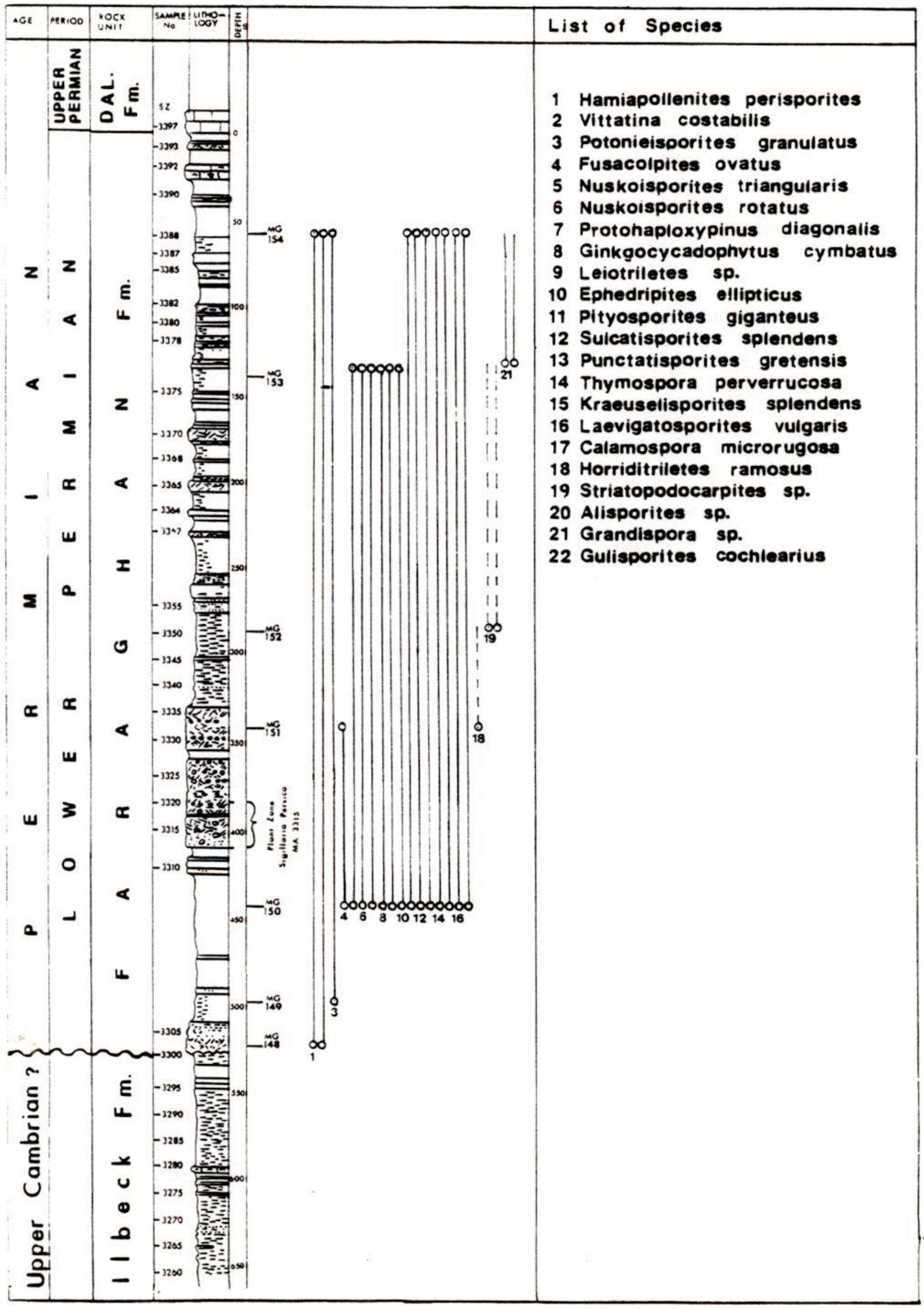


Figure 19. Stratigraphic distribution of pollen and spores of the Faraghan Formation in Chal-i-Sheh area (After Szabo, Rush, and Khosravi, 1977)

the Chal-i-Sheh taxa consist of Lower Permian species and the remainder are species that range from the Carboniferous through the Permian. There are no species diagnostic of the Upper Carboniferous nor are there taxa indicative of an exclusively Late Permian assignment.

Paleogeography of The Devonian

The records of plant microfossil and megafossil floras both demonstrate that the earliest land plant evolution goes back to the Silurian or perhaps slightly 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. Banks (1975) suggested that both plant megafossil remains and spore microfossils suggest broad cosmopolitanism through much of the Devonian period. However, Edwards (1973) argues that there are distinctions between northern and southern hemisphere megafossils through the Early and Middle Devonian. Although the Australian floras show a high portion of northern hemisphere types, distinction between southern microfossil floras is becoming increasingly apparent. A palynologically-based distinction between Euramerican and Gondwanic provinces has been suggested by Bar and Riegel (1974). They claim that the distinction is most pronounced during the Middle Devonian. They also claim that provincialism diminished in the Late Devonian, resulting from the formation of Pangaea.

The past decade has seen a proliferation of papers which describe Devonian spore assemblages. Most of these papers have been concerned with descriptive taxonomy and with the refinement of stratigraphic information. There is little comment in these papers as to whether these assemblages constituted a single phytogeographic province, or numerous provinces. However, the possibility of regional differences and also similarities have been suggested by some authors. Richardson (1969) suggested that there is sufficient data for intercontinental correlation between two sides of the present Atlantic by using microfloras at the generic level but that species differences indicate clear regional provincialism that prevents species-level intercontinental correlation.

McGregor (1977) recorded 89 taxa from the Devonian Gaspé sequence of eastern Canada where 30 of these had not previously been recorded and 21 species appear in the coeval strata of the Eifel region. Streel (1974) suggests that the global distribution of Retispora lepidophyta indicates a cosmopolitan terrestrial vegetation during that interval. According to Streel (Ibid) and the palaeogeographic maps 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 southern shore of the Tethys sea. Streel (1974) discerned no close relationship between circum-Atlantic palynofloras and those of Australia, apart from the presence of Retispora lepidophyta.

Playford (1976) described an assemblage from the Devonian of northern Australia and emphasized the strongly endemic character of the Australian suites. Based on that study, Playford (1976) suggested that there is no phytogeographic link between North America and Europe. He suggests that the Australian spore assemblages may have been linked with southern Tethyan localities such as Libya but the latter are too poorly documented for detailed comparison.

An important general survey of world distribution patterns of the Devonian spores was recently presented by McGregor (1979, 1981). He stresses that the relative paucity of data outside the Old Red Sandstone continent makes it premature to define spore provinces outside that region. However, McGregor (1979) did make some very general points. These include comments on the cosmopolitanism of some species such as Retispora lepidophyta that suggest a wider equatorial zone of distribution than proposed by Streel (1974). Also McGregor suggested that the genus Archaeoperisaccus has been confined to paleoequatorial regions of the present Northern Hemisphere, extending in a SW-NE direction through Hudson Bay, southern Greenland and southern Scandinavia (McGregor, 1979, p. 182, Fig. 3).

As documented in the earlier sections, the Devonian spore assemblage zone of the Faraghan area shares certain genera and species in common with those of the Old Red Sandstone continent, especially in the Early and Middle Devonian, but that the most precise comparisons are to 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 in the Old Red Sandstone continent but appear to be confined to the Upper Devonian (Frasnian) of the Faraghan area, Saudi Arabia and western Australia. Moreover, the marine microphytoplankton taxa of the Devonian of the Faraghan area are quite similar to those of western Australia (Playford & Dring, 1981). These marine palynomorph species include *Deltotosoma intonsum*, *Papulogabata annulata*, *Lophosphaeridium segregum*, *Dictyotidium granulatum*, *Evittia geometrica*, *Gorgonisphaeridium discissum*, *Navifusa exilis*, *Somphophragma miscellum*, and *Melikeriopalla venulosa*. Based on these palynological data, it would be reasonable to consider that this part of the Zagros basin of Iran, Saudi Arabia and western Australia were at similar palaeolatitudes along located the southern shore of Tethys Sea. Such a reconstruction based on palynomorph data is supported by Devonian palaeogeographic maps of Heckel and Witzke (1979).

Palaeogeography of Permian

Correspondence between the well-defined plant megafossil floral provinces and those derived from palynology is clearer in the Permian than any other late Palaeozoic period. The palynological characteristics of four major provinces (Euramerican, Angaran, Caythaysian and Gondwonian) of classical palaeobotany are summarized by Hart (1964). Consequently, Hart (1964) proposed finer subdivisions of these provinces, particularly in Eurasia, suggesting a complex of latitudinally controlled plant geographic zones for the Permian.

Hart (1969) suggests that the Siberian association of the Angaran flora approximates a northern polar element. Other subdivisions of this flora represent concentrically arranged belts in the north temperate zone and an equatorial belt and comprise floras of the Middle East, the Salt Range of Pakistan, and southern Indo-China.

An equatorial position for part of southeast Asia in the Permian has also been suggested by Kremp (1974, 1975). He restated earlier palaeobotanical 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 suggests that both Chinese and North America assemblages reflect a tropical flora. In Asia, this flora is found in Korea, eastern China, Indochina, Malaysia and Sumatra. According to Kremp, this region formed a single "China plate", which was located at the equator in the late Palaeozoic and subsequently moved northwards.

The biogeographic relationships of floras from the southern coastal region of the Permian Tethys has been the subject of speculation with regard both to the palynoflora and plant megafossils. Palynological assemblages from the Salt Range (Pakistan) have been described in detail by Balme (1970). Waterhouse (1976) described the assemblages of Chhidruan age (probably Middle Permian) that show similarities to those from the Urals and Gondwana.

There is also an endemic element present, in addition to taxa recorded previously from Europe and the Middle East. The Middle East palynofloras suggest that the position of this landmass lay between India and the east coast of Africa. Chateauneuf and Stampfli (1979) have recorded palynofloras from Permian sequences in northern part of Iran (Elburz Mountain) that they believe are intermediate in composition between those of the Salt Range of Pakistan and Iraq.

Akyol (1975) has documented assemblages from coal seams of Early Permian age in Turkey which contain genera and species in common with assemblages from southeastern China. Palynological data presented here thus suggest that the southwestern and western regions of Iran show a southeast Asian influence. A similar mixture of Cathaysian elements has long been recognized in megafossil floras from Hazro in

Turkey (Wagner, 1962), 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. A wealth of palynological data are available from the Congo (Bose & Kar, 1966, 1968, 1969, 1976), southeast Africa (Anderson, 1977), the Arabian Peninsula (Hemer, 1965), and from the United States (Tschudy and Kosanke, 1966; Wilson, 1962; Jizba, 1962). These data provide a sound basis for comparison with the Iranian assemblages of the present study.

53 spore and pollen species occur in the Lower Permian part of the two study sections from the Faraghan area and 25 spore, pollen and one acritarch species are present in the Chal-i-Sheh area. These species are considered to be sufficiently distinct to have potential value in defining floral regions of the Early Permian of the Zagros Basin in Iran. These species are listed in Table 10 for the Faraghan area and in Table 11 for the Chal-i-Sheh area. These data document the occurrence of similar forms from coeval strata in other parts of the world.

Table 10. Comparison 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	-	-	+	-	-	-	-
Høegiasaccites transitus	-	-	+	-	-	-	-
Costapollenites ellipticus	-	-	+	-	-	-	+

Table 10. (continued)

Encountered taxa of Faraghan area	Turkey N. Iran	Saudi Arabia	Gabon Congo S. Africa	India	West Pakistan	Australia	N. America U.S.A. Canada
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	-	+	+	+	+	-	+
Striatoabietites multistriatus	-	+	+	-	-	+	+
Rhizomaspora radiata	-	-	+	+	+	-	+
Ephedripites ellipticus	-	-	+	+	+	-	+

Table 11. Comparison 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	+	+	+	+	+	+	-
Potonieisporites granulatus	-	-	+	-	-	-	-
Protohaploxypinus diagonalis		+	+	+	+	-	-
Sulcatisporites splendens	+	-	+	+	+	+	+
Vittatina costabilis	+	+	+	-	-	-	+
Kraeuselisporites splendens	+	+	-	-	-	+	-
Calamospora microrugosa*	+	-	-	-	-	-	-
Laevigatosporites vulgaris*	+	-	-	+	+	+	+
Gulisporites cochlearius	+	-	-	-	-	-	-
Harriditriletes ramosus		-	+	-	-	+	-
Thymospora perrerrucosa	+	-	-	-	-	-	-
Puctatisporites gretensis	+	+	+	+	+	+	-

In general, the Lower Permian assemblage of the Faraghan area is similar to those recorded from Gondwanic assemblages: *Fusacolpites fusus* and *F. ovatus*; *Plicatipollenites indicus*; *Striomonosaccites triangularis* and *S. ovatus*; *Walikalesaccites ellipticus*; *Høegiasaccites transitus*; *Mabuitasaccites ovatus*; *Boutakoffites quibus* and *B. elongatus*; *Corisaccites alutas*; *Tiwariasporis gondwanensis* and *T. flavatus*; *Caheniasaccites ovatus* and *C. ellipticus*; *Potonieisporites neglectus* and *P. granulatus*; *Nuskoisporites triangularis* and *N. rotatus*; *Decussatisporites* sp. and *Schizopollis* sp. The palynological associations of the Faraghan area are most similar to those of Africa. As documented in Table 10, certain species have been recorded only from the Africa, including: *Fusacolpitus fusus* and *F. ovatus*; *Caheniasaccites ovatus* and *C. ellipticus*, *Walikalesaccites ellipticus*; *Høegiasaccites transitus*; *Mabuitasaccites ovatus*; *Boutakoffites quibus* and *B. elongatus*; *Vittatina subsaccata* and *Decussatisporites* sp. These occurrences suggest that the Zagros basin and portions of the African Plate were not very distant from one another and that they may have been at about the same latitude along the southern shore of the Tethys sea.

Gondwanic elements are present in the Chal-i-Sheh area but they are less diverse than at Faraghan or in the Durod Formation (Chateuneuf and Stampfli, 1979) of northern Iran. This contrast may reflect the relative proximity of the

Faraghan area to the Gondwanic land mass and a relatively more distant position of Chal-i-Sheh toward a Cathaysian source area.

Such a geographic reconstruction would imply that portions of Iran were geographically disjunct in the Permian, a suggestion which has not previously been made on the basis of other geological data. An alternative interpretation of the differences in palynological assemblages from Faraghan and Chal-i-Sheh is that the Chal-i-Sheh material may be somewhat older (earlier in the Permian) than the Faraghan samples. Such a determination is consistant with the higher spore diversity and lower pollen diversity noted at Chal-i-Sheh in comparison with the study sections from the Faraghan area and is the most probable explanation given our present understanding of the tectonic history of Iran.

In Chal-i-Sheh, the Limnic condition, which was the predominant condition of the sediment in Turkey, had the same effect on the vegetation as at Kuh-e-Gareh and Zard-Kuh. This is indicated by the remnants of Carboniferous forests (including Sigillaria persica) at Chal-i-Sheh and coalseams at Kuh-e-Gareh and in Turkey. Due to the similarity of the Lower Permian assemblage of Chal-i-Sheh with those of the early Permian of Turkey, it might be suggested that the vegetation in the northwestern Zagros Basin had similarities to that of the Cathaysian province. Consequently they may represent similar palaeolatitudes.

Based on abundance and diversity of conifer pollen, a mesic temperate condition is suggested for the Early Permian assemblage, consistent with a geographic position between 30 to 40 degrees of palaeolatitude. The palynological results of this study are consistent with palaeogeographic world maps of Smith, et al. (1983) and palaeobiogeographic maps of Hart (1969). These maps have placed Iran, Saudi Arabia and Africa between 30 to 60 degrees palaeolatitude during the Lower Permian.

Palaeoecology

One of the principal ecological goals of the Faraghan study was the reconstruction of the position of the depositional sites, through time, in relation to nearby land and sea features. The relative proportions of spores, pollen, marine phytoplankton (primarily acritarchs), chitinozoans, and scolecodonts provides one approach to such a reconstruction.

Spores and pollen grains are produced as a result of the reproductive processes of terrestrial plants. In Paleozoic deposits, wind can be assumed to be the primary dispersal vector. The relative aerodynamic qualities of the individual palynomorphs and prevailing winds determine, to a large extent, the pattern of winnowing that serves to alter the relative composition of the wind-born assemblage at progressively greater distances from the source plant communities. Some of the wind-born assemblage will be deposited directly into sedimentary environments on the coastal margin, nearshore marine, and off-shore marine sites. Other terrestrial palynomorphs will be deposited in streams and rivers to be borne by water to a variety on on-shore and off-shore depositional sites. Relative hydrodynamic qualities, resistance to mechanical and chemical degradation (both biological and non-biological), distribution of distributaries on the paleocoastline, longshore currents, and turbidity flow patterns are all factors that control the differential composition of water transported palynomorph assemblages. All other factors being equal, the absolute abundance of terrestrial palynomorphs can be expected to decline with increasing distance from the paleoshoreline with patterns of winnowing and sorting being taxon-specific (Woods, 1955; Upshaw, 1964; Cross et al., 1964).

Acritarchs, scolecodonts, and chitinozoans are the remains of marine organisms. Their representation in marine environments is a function of environmental parameters (including depth, salinity, temperature, and insolation) as well as marine current patterns that may effect the distribution of these palynomorphs both in life and after death.

Sarmiento (1957) made the following generalizations regarding acritarch (marine phytoplankton) distribution:

(1) They are most abundant at intermediate depths on the continental margin, decreasing in abundance in shallower and deeper water.

(2) They require salinity levels equivalent to the open ocean and tend not to be found in environments influenced by freshwater input. This appears to also to be the case with chitinozoans and may be true of scolecodonts (marine annelids) as well.

Staplin (1961), in a study of the paleoenvironments suggested by various acritarchs, suggests the following pattern for prominent genera:

(1) Acritarch genera with simple processes or where processes are lacking (*Leiosphaeridia*, *Lophosphaeridium*, and *Dictyotidium*) are commonly found in shales interbedded with reef carbonates and distribution becomes increasingly variable with increased distance from reef facies.

(2) Thin-spined genera (*Gorgonosphaeridium* and *Veryhachium*) are widespread at some distance beyond reefs but are seldom found within a mile of reef deposits.

(3) Thick-spined, polyhedral forms (*Multisphaeridium* and *Baltisphaeridium*) which appear to characterize off-reef deposits, seldom occur within 4 miles of reef deposits.

The ratio of terrestrial/marine palynomorphs (primarily acritarchs) provides one approach to assessing the degree of marine influence and the relative distance from the paleoshoreline. Upshaw (1964) used this approach to document transgressive and regressive sequences in the Wyoming Cretaceous. Similar success has been realized in the study of a number of Cretaceous sequences from the western interior of North America (Thompson, 1969).

Quantitative tabulation of the Faraghan samples included acritarchs, chitinozoans, and scolecodonts in order to obtain ecological data on the marine depositional environment and to permit estimates of the relative proximity of terrestrial communities. These data are summarized in Tables 12, and 13.

The data from the Devonian portion of the section indicate marine influence with 18 genera (25 species) of acritarchs and 25 genera (48 species) of terrestrial spores. The relatively higher diversity of terrestrial taxa (see Tables 1, 2, 3, and 4) suggest the presence of diverse, proximal terrestrial communities. Conditions may have been somewhat harsh for optimum development of marine phytoplankton based on the low diversity of such taxa. This may reflect the nearby influx of freshwater from coastal distributaries, creating brackish or periodically brackish water conditions. The dominant acritarch genera and species (Table 2, and 4) generally have morphologies similar to Staplin's (1961) groups 1 and 2, suggesting the possibility of a nearshore reef complex with relatively high energy water conditions.

Based on the ratios of miospores/acritarchs, four sedimentary intervals are recognizable from the base to the top of the Faraghan Formation. Three occur in the Devonian part and the fourth occurs in the Lower Permian part of the Faraghan Formation.

The first interval coincides with a transgressive period during which about 100 meters of sediment were deposited. These sediments consist of mainly calcareous, white, thin cross-bedded sandstones which are interbedded with calcareous, black to gray shales and dense, gray limestone beds. Other well-marked characteristics of the interval are:

Table 12. Point Count Data of the Devonian Miospores, Acritarchs, Chitinozoans, and Scolecodonts from Section One of the Faraghan Formation at Kuh-e-Faraghan. Number of each genus are used in Figure 20.

Sample # MG	# Grains ACRITARCHS	# Grains MIOSPORES	# Grains CHITINOZOANS	# Grains SCOLECODONTS	Ratio MIOSPORE/ ACRITARCH
208	2		4		.00
209					
210					
211	9		6		.00
212	15	5	8		.33
213	21	6	24		.29
214					
215					
216					
217					
218					
219					
220					
221					
222	48	16	15		.33
223	50	13	20		.26
224	62	10	13		.16
225	475	69	14		.15
226	69	35	4		.51
227	274	226	16		.82
228					
229					
230	63	37			.59
231	63	37			.59
232	13	48			3.69
233					
234					
235					
236	10	30			3.00
237	1	265			265.00
238	1	200			200.00
239					
240	1	39			39.00
241	1	222			222.00
242	1	242			242.00
243A		3			
244					
245		12			
246					
247					
248					

Table 12. (Continued)

Sample # MG	# Grains ACRITARCHS	# Grains MIOSPORES	# Grains CHITINOZOANS	# Grains SCOLECODONTS	Ratio MIOSPORE/ ACRITARCH
249		18			
250		2			
251A		100			
252		95			
253					
254	5	300		7	60.00
255					
256					
257					
258		112			
259	2	410			205.00
260					
261	2	67			33.5
262	2	498			249.00
263					
264		90			
265					
266		500			
267		40			
268	3	497			165.67
269	4	496			124.00
Sum	1197	4740	124	7	
Percentage	20	78	2	0	
Grains Counted		6068			

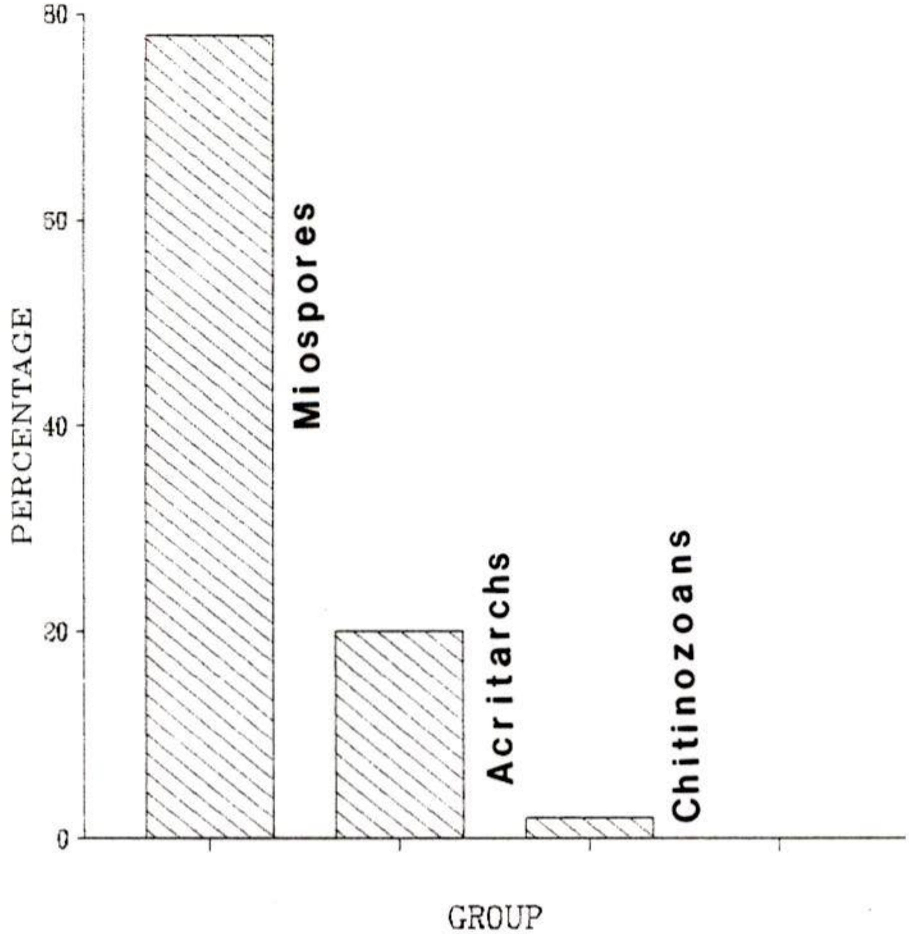


Figure 20. Relative Percentages of Devonian Palynomorphs (Miospores, Acritarchs, Chitinozoans, and Scolecodonts) in Section One of the Faraghan Formation at Kuh-e-Faraghan.

Table 13. Point Count Data of the Devonian Miospores, Acritarchs, Chitinozoans, and Scolecodonts from Section Two of the Faraghan Formation at Kuh-e-Faraghan.

Sample # MG	# Grains ACRITARCHS	# Grains MIOSPORES	# Grains CHITINOZOANS	# Grains SCOLECODONTS	Ratio MIOSPORE/ ACRITARCH
281	34				.00
282	10				.00
283					
284					
285	8	16			2.00
286					
287	3	3			1.00
288					
289	12	16			1.33
290	60	340			5.67
291					
292					
293					
294					
295					
296					
297	1	9			9.00
298					
299					
300	176	2			.01
301	11	7			.64
302					
303					
304	46	49			1.07
305	50	532			10.64
306	26	474		11	18.23
307	2	507		4	253.50
308	32	470		3	14.69
309	95	406			4.27
310	190	315			1.66
311					
312					
313					
314					
315					
316	60	223			3.72
317					
318	36	166			4.61
319					
320	53	453			8.55

Table 13. (Continued)

Sample # MG	# Grains ACRITARCHS	# Grains MIOSPORES	# Grains CHITINOZOANS	# Grains SCOLECODONTS	Ratio MIOSPORE/ ACRITARCH
321					
322					
323	21	503			23.95
325	51	449		9	8.80
327	325	203		2	.62
328	310	217		9	.70
329	275	250		4	.91
Sum	1887	5610	0	42	
Percentage	25	74	0	1	
Grains Counted		7539			

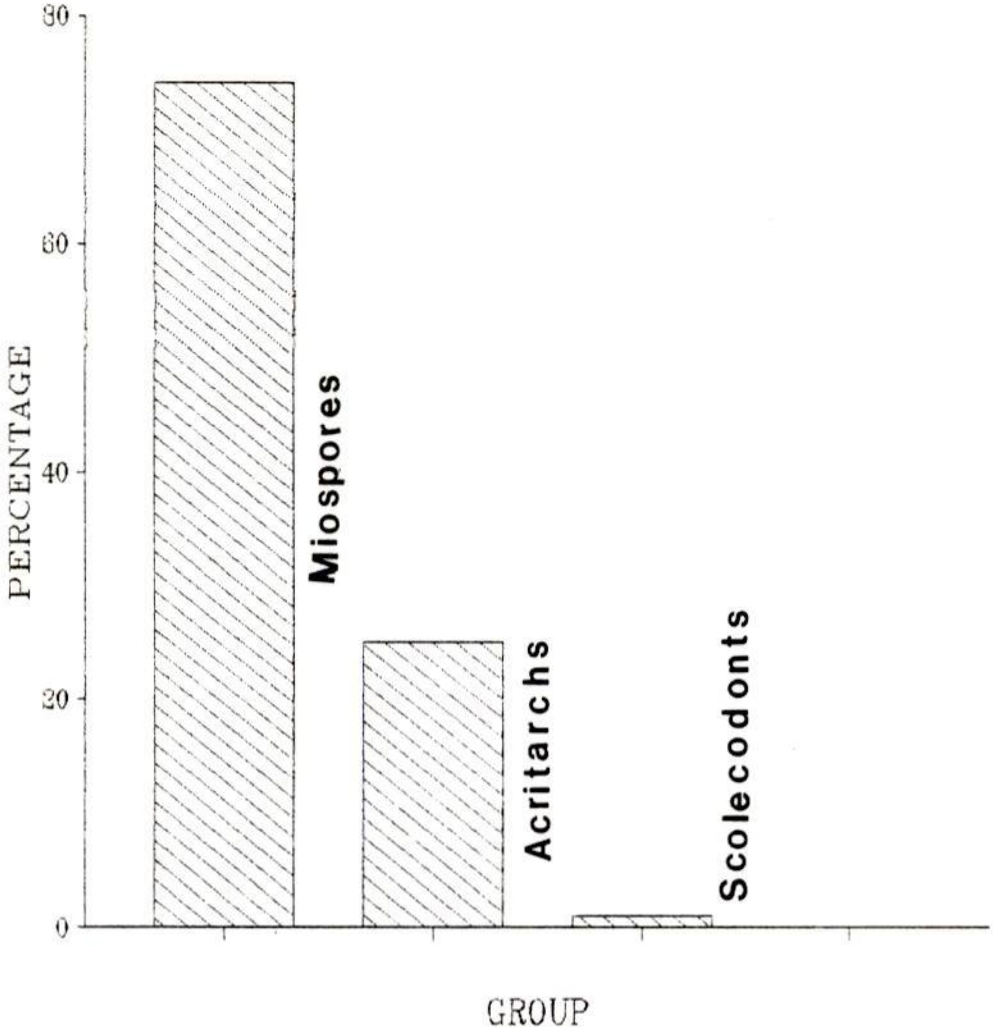


Figure 21. Relative Percentages of Devonian Palynomorphs (Miospores, Acritarchs, Scolecodonts, and Chitinozoans) in Section Two of the Faraghan Formation at Kuh-e-Faraghan.

1) It is bounded at the base by a few meters of purple shale, representing the uppermost part of the Silurian. At the top, the interval is overlain by conglomeratic beds (See Figs. 7-8).
2) High relative abundance of marine palynomorphs and low abundance of terrestrial spores; the dominant marine palynomorph genera are represented by *Gorgonisphaeridium*, *Polyedryxium*, *Cymatiosphaera*, *Veryhachium*, and *Diexallophasis*. The dominant spore genera which are associated with marine acritarchs of this interval are: *Chelinospora*, *Calamospora*, *Retusotriletes* and *Emphanisporites*.

The second interval represents a gradual marine regression, indicated by an increase in the ratios of miospores/acritarchs (see Tables 12 and 13). Sediments are fine-medium grained and the rate of influx was moderate with a significant degree of bioturbation. Plant debris (largely stems) was gradually supplied to the depositional sites as the basin shallowed. Accumulation of fish debris (fish scales and bone) and sedimentary structures such as current ripple marks and cross stratification are present in this unit. This unit coincides with the Middle Devonian (Eifelian-Givetian) in the Faraghan basin and is characterized by a high diversity of terrestrial plant taxa and a decrease in marine phytoplankton (See Figures, 15 and 16).

The third interval represents a marine transgression which continued until the end of the Devonian component of the Faraghan Formation. It is characterized by a decrease in the ratios of miospores/acritarchs (see Table 13). The interval begins with the appearance of new marine phytoplankton and terrestrial taxa. Sediments of this interval in Section One are characterized by conglomerates grading upward into coarse-medium grained sandstones and olive-gray, micaceous, shale layers with some invertebrate fossils. The shale layers contain abundant plant debris and hematitic iron nodules in the uppermost layer. In contrast, sediments in this interval in Section Two, are represented primarily by gray shale layers interbedding with fine to medium grained sandstone which grade upward into a fine sandstone layer. This fine grained standstone is highly bioturbated and contains numerous nodules.

As documented in Tables 1, 2, 3 and 4, the change in lithofacies in this interval corresponds to major changes in palynofloral assemblages. Significant palynomorphs in Section Two include Ancyrospora, Hystricosporites, Deltotosoma and Papulogabata. There are no palynological data to suggest the presence of Famennian or Carboniferous sediments in the Faraghan area. Any events in the Famennian-Permian hiatus are beyond the scope of this study.

The fourth interval begins near the onset of the Permian period. The interval is characterized by miospores and pollen and no marine phytoplankton were noted. The only marine elements are scolecodonts. In addition, the presence of recycled Devonian elements at the base of the lower Permian sediments indicates that active erosion was occuring early in this interval.

The depositional environment of the spores and pollen may have been a shallow marine environment during the Early Permian. Since scolecodonts are jaw parts of marine polychaete worms, these worms are mainly shallow water sand and mud-burrowing animals. This shallow depositional environment deepened by Dalan Formation time (Upper Permian), based on the occurrence of brachiopods, corals, crinoids and fusulinids in the Dalan Formation immediately above the Faraghan Formation.

As documented on Table 6-7, the palynoflora of this part of the Faraghan Formation consists of 33 pollen genera (52 species) and 4 spore genera (5 species). Saccate pollen forms dominate the assemblage in terms of diversity and frequency (94.63%).

Source plant communities were clearly dominated by saccate pollen producers. Spore-bearing plants played a minor role. Pollen of this type characterizes seed plants and is most similar in morphology to modern coniferalean pollen. By Lower Permian time the vegetation proximal to the Faraghan Basin was clearly dominated by seed plants including many conifer taxa. This pattern of dominance suggests the possibility that limited water availability may have been a factor controlling vegetation development the

Faraghan area. The degree of water stress is difficult to quantify but a semi-arid regime may have pertained, a reconstruction supported by the occurrence of gnetalean pollen types such as Ephedripites, Vittatina, Fusacolpites, Costapollenites, Boutakoffites, and Mabuitasaccites.

In contrast, the association of saccate pollen with spore genera such as Laevigatosporites, Leiotriletes, Horriditriletes and possibly Tiwariasporis indicate mesic to wet lowland communities, possibly equivalent to modern coastal swamps. Such coastal swamps, probably of limited extent, represent the probable habitat of Sigillaria persica Seward (1932), recovered from the Lower Permian sediments of the Chal-i-Sheh area.

The Chal-i-Sheh assemblage is similar to that of the Lower Permian of the Faraghan area except that diversity of saccate pollen types at Faraghan is significantly greater than that in the Chal-i-Sheh area. The presence of Sigillaria persica and the greater role of spore-bearing species in the Chal-i-Sheh area suggest that that region may have supported more mesic vegetation types or that coastal swamps were more extensive. Whether this difference reflects temporal or phytogeographic variation between the two areas cannot be determined.

SUMMARY

The Faraghan Formation is constituted of clastic sediments exposed along the high mountain range in the Zagros Basin from the northwest to southeast of Iran. the type section at Kuh-e-Faraghan is one of the most complete and accessible sections in southeastern Iran, approximately 80 km north of Bandar Abbas. The Formation is composed of principally sandstone intercalated with shale and limestone layers, in the Faraghan area. It has disconformable contact with the Silurian Shales below and is graditional upward into the Upper Permian Dalan Formation. Because this rock unit lacks marine invertebrate fossils, the age of the Faraghan Formation has been the subject of controversy. Most geologists have assigned a Permo-Carboniferous age to the Formation based on Seward´s work on plant megafossils of the Chal-i-Sheh area in the northwestern part of the Zagros Basin.

This study was undertaken to determine more precisely the geological age of the Formation, to make interpretation of the depositional sites and to reconstruct the palaeogeographic relationships of the Zagros Basin to Gondwana and Laurasia during the Upper Palaeozoic time represented by these strata.

136 pollen, spore and acritarch species are described in this study that include 59 spores (36 genera), 52 pollen types (33 genera), and 26 acritarchs (19 genera). These have been arranged in five ascending stratigraphic assemblage zones and the distribution patterns of all species have been plotted.

Zone I is characterized by Lower Devonian index spore species Retusotriletes dittonensis, Ambitisporites avitus, Emphanisporites annulatus and E. erraticus. Several longer ranging Devonian spore and acritarch species also appeared in this zone including Lophosphaeridium segregum; Polyedryxium decorum; Veryhachium trispinosum; Leiosphaeridia sp.; Gorgonisphaeridium spp.; Retusotriletes dubiosus, R. rotundus, and R. distinctus; Cymbosporites cyathus, and C. catillus; and Cyclogranisporites rotundus.

Zone II is marked by the presence of Middle Devonian index spore species consisting of Densosporites devonicus; Acinosporites acanthomammillatus; Dibolisporites eifelensis; Calyptosporites velatus; Rhadosporites langi; Grandispora longus, G. douglastownense, G. mammillata, and G. macrotuberculata; Auroraspora aurora and A. macromanifestus; and Bullatisporites bullatus. This zone is considered to be Middle Devonian and is correlated with Middle Devonian fossils reported from Europe, Canada, and Saudi Arabia.

Zone III is characterized by the occurrence of diagnostic spore species including Geminospora punctata, G. antaxios, and G. lemurata; Retusotriletes rugulatus; and

Retispora lepidophyta. This zone is also marked by reduction in numbers of several species which had already appeared in zone II, such as Grandispora longus, G. mammillata, Rhabdosporites langi, Calyptosporites velatus, Dibolisporites eifeliensis, Emphanisporites rotatus, and Calamospora pannucea. This reduction in numbers is also true for longer ranging acritarch species. This zone is considered to be Upper Givetian in age. In general, this zone is correlatable with the Middle Devonian of Europe and the Canadian Arctic Islands. The palynomorphs of this zone are also quite similar to those recorded from the Middle Devonian of Saudi Arabia.

Zone IV is the youngest Devonian unit of the Faraghan Formation in the Faraghan area and characterized by appearance of new spore species consisting of Ancyrospora ancyrea, A. ampulla, A. grandispinosa, and A. longispinosa; Spinozonotriletes naumovii; and Samarisporites triangulatus. In addition to spore species, several new acritarchs appear in this zone including Chomotriletes vedugensis and C. bistchoensis; Deltotosoma intonsum; Papulogabata annulata; Dictyotidium granulatum; Somphophragma miscellum; Stellinium micropolygonale; Duveraysphaera tessella; Navifusa exilis and Acritarch type A.

This zone is considered to be Frasnian in age based on diagnostic taxa such as Samarisporites triangulatus, Geminospora lemurata, Chomotriletes vedugensis, Chomotriletes bistchoensis, Deltotosoma intonsum and Papulogabata annulata.

Zone V is marked by complete absence of Devonian morphotype species and occurrence of many gymonspermous pollen species. This zone is considered to be Lower Permian based on diagostic pollen species including Corisaccites alutas; Costapollenites ellipticus; Vittatina costabillis and V. subsaccata; Hamiapollenites perisporites; Sulcatisporites splendens; Plicatipollenites indicus; Mabuitasaccites ovatus; Fusacolpites fusus and F. ovatus; Boutakoffites elongatus and B. quibus; Caheniasaccites ovatus and C. ellipticus; Walikalesaccites ellipticus, Høegiasaccites transitus; and Striomonosaccites triangularis. In addition to pollen species, several spore species appear in this zone, such as Punctatisporites gretensis, Tiwariasporis gondwanensis, Tiwariasporis flavatus and Horriditriletes ramosus. These spore species are also characteristic of the Lower Permian.

Based on these assemblage zones, there is a "hiatus" within the Faraghan Formation extending from the Famennian through the Carboniferous period into the Lower Permian. This "hiatus" possibly coincides with the Hercynian Orogney that resulted in the emergence of this part of the Zagros Basin producing extensive erosion of part of the Late Devonian and the whole of the Carboniferous sequence, or the combination of lack of deposition and erosion.

Diverse acritarchs (25 species) in the Devonian strata of the Faraghan sections indicate a marine environment. However, the presence of 25 genera (48 species) of terrestrial spores suggests that a source for the land plants, probably a delta or coastal plain, was not at too great a distance from this area. Some of the acritarchs identified from the Faraghan Formation have also been recorded from Europe and North America including Chomtriletes vedugensis and C. bistchoensis; Cymatiosphaera perimembrana; Veryhachium trispinosum; and Polyedryxium decorum. However, 10 species found in the Faraghan have been recorded from Frasnian sediments of the Gneuda Formation of western Australia: Deltotosoma intonsum, Papulogabata annulata, Navifusa exilis, Lophosphaeridium segregum, Dictyotidium granulatum, Evittia geometrica, Gorgonisphaeridium discissum, Somphophragma miscellum, and Melikeriopalla venulosa. Based on these palynological data, it would be reasonable to consider that this part of the Zagros Basin of Iran, Saudi Arabia and western Australia were at similar palaeolatitudes along the southern shore of the Tethys Sea during the Upper Devonian.

As documented on Table 5 through Table 13, the spore and pollen species occurring in the Lower Permian of the study sections of the Faraghan and Chal-i-Sheh areas have potential value in defining floral regions of the Zagros Basin of Iran during the Early Permian.

The Early Permian morphotypes derived from the Faraghan area are similar to those recorded from the gondwanian countries. This is based on index gondwanic elements including Fusacolpites fusus and F. ovatus; Plicatipollenites indicus; Striomonosaccites triangularis and S. ovatus; Walikalesaccites ellipticus; Hoegiasaccites transitus; Mabuitasaccites ovatus; Boutakoffites quibus and B. elongatus; Corisaccites alutas; Tiwariasporis gondwanensis and T. flavatus; Caheniasaccites ovatus and C. ellipticus; Potonieisporites neglectus and P. granulatus; Decussatisporites sp.; and Schizopollis sp.

The palynological associations of the Faraghan area appear most similar to paleofloras of African countries because certain Lower Permian pollen species have been recorded only from African countries including Fusacolpites fusus and F. ovatus; Caheniasaccites ovatus and C. ellipticus; Walikalesaccites ellipticus; Hoegiasaccites transitus; Mabuitasaccites ovatus; Boutakoffites quibus and B. elongatus; Vittatina subsaccata and Decussatisporites sp. The occurrence of these species suggests that the Zagros Basin and portions of the African plate were not very distant from one another and that they were at about the same latitude along the southern shore of the Tethys sea.

Gondwanic elements are also present in the Lower Permian sediment of the Chal-i-Sheh area in the northwestern Zagros Basin. However, they are less diverse than in the Faraghan area. This contrast may reflect the relative proximity of the Faraghan area to the Gondwanic landmass and relative displacement of Chal-i-Sheh toward a more Cathaysian source area.

In Chal-i-Sheh, limnic condition had the same effect on vegetation as at Kuh-e-Gareh and Zard-Kuh. This is indicated by the remnants of Carboniferous forests (including Sigillaria persica) in Chal-i-Sheh and coal seams in Kuh-e-Gareh and similar deposits in Turkey.

Due to the similarity of the Early Permian assemblages of Chal-i-Sheh with those of the Early Permian of Turkey, it can be suggested that the vegetation in the northwestern part of the Zagros Basin has some relationship to Cathysian source areas.

Based on the abundance and diversity of conifer pollen, a mesic temperate condition is suggested for the Lower Permian assemblage. This condition could have existed between 30°-40° S palaeolatitude.

APPENDIX

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Plate 1

Fig. 1. <u>Ancyrospora</u> <u>ampulla</u> Owens, 1971.

Fig. 2. <u>Ancyrospora</u> <u>magnifica</u> Owens, 1971.

Fig. 3. <u>Ancyrospora</u> <u>ancyrea</u> Richardson, 1962.

Fig. 4. <u>Ancyrospora</u> <u>longispinosa</u> Richardson, 1962.

Fig. 5. <u>Ancyrospora</u> <u>ancyrea</u> Richardson, 1962.

Fig. 6. <u>Ancyrospora</u> sp.

Fig. 7. <u>Ancyrospora</u> <u>grandispinosa</u> Richardson, 1960.

Scale bar is 10 micrometers.

PLATE 1

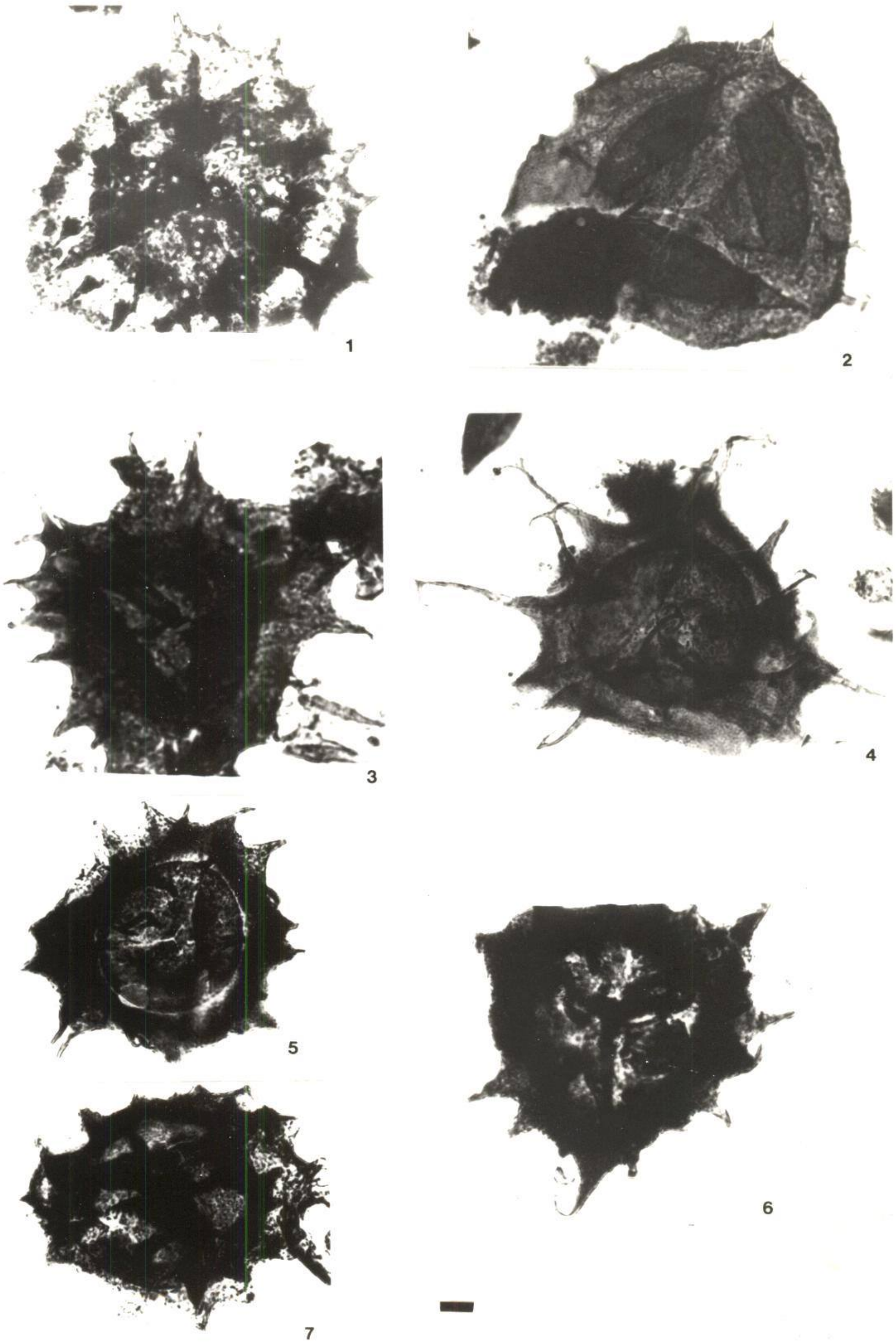

Plate 2

Fig. 1. Apiculiretusispora granulata Owens, 1971.

Fig. 2. Apiculiretusispora granulata Owens, 1971.

Fig. 3. Acinosporites acanthomammillatus Richardson, 1965.

Fig. 4. Ambitisporites avitus Hoffmeister, 1959.

Fig. 5. Auroraspora macromanifestus (Hacquebard) Richardson, 1960.

Fig. 6. Auroraspora aurora Richardson, 1960.

Fig. 7. Bullatisporites bullatus Allen, 1965.

Scale bar is 10 micrometers.

PLATE 2

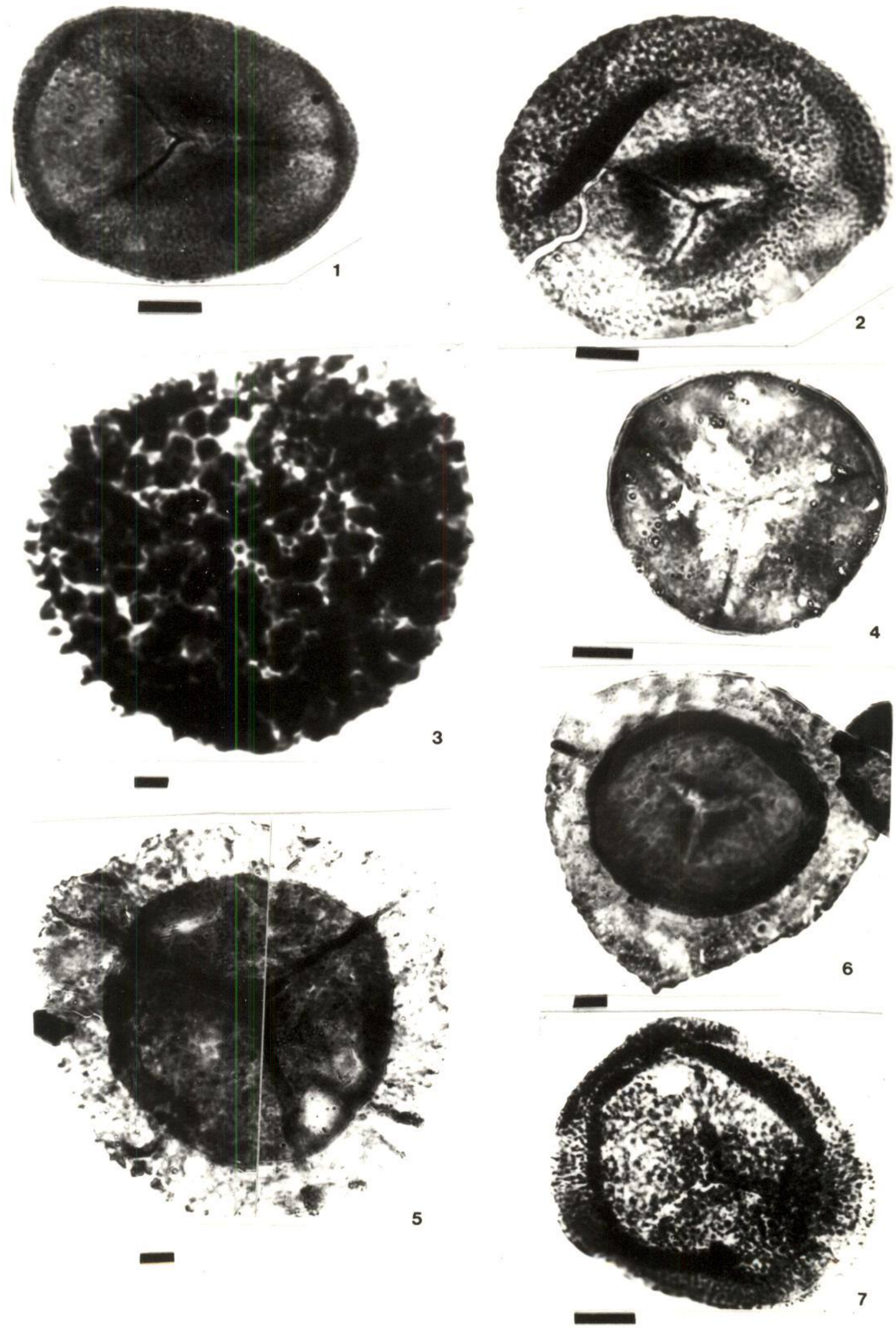

Plate 3

Fig.1. <u>Calamospora pannucea</u> Richardson, 1965.

Fig.2. <u>Cymbosporites cyathus</u> Allen, 1965.

Fig.3. <u>Cymbosporites catillus</u> Allen, 1965.

Fig.4. <u>Calyptosporites velatus</u> (Eisenack) Richardson, 1962.

Fig.5. <u>Calamospora</u> sp.

Fig.6&9. <u>Chelinospora</u> sp.

Fig.7. <u>Cyclogranisporites rotundus</u> Allen, 1965.

Fig.8. <u>Chelinospora concinna</u> Allen, 1965.

Fig.10. <u>Calyptosporites velatus</u> (Eisenack) Richardson, 1962.

Fig.11. <u>Calyptosporites velatus</u> (Eisenack) Richardson, 1962.

Scale bar is 10 micrometers.

PLATE 3

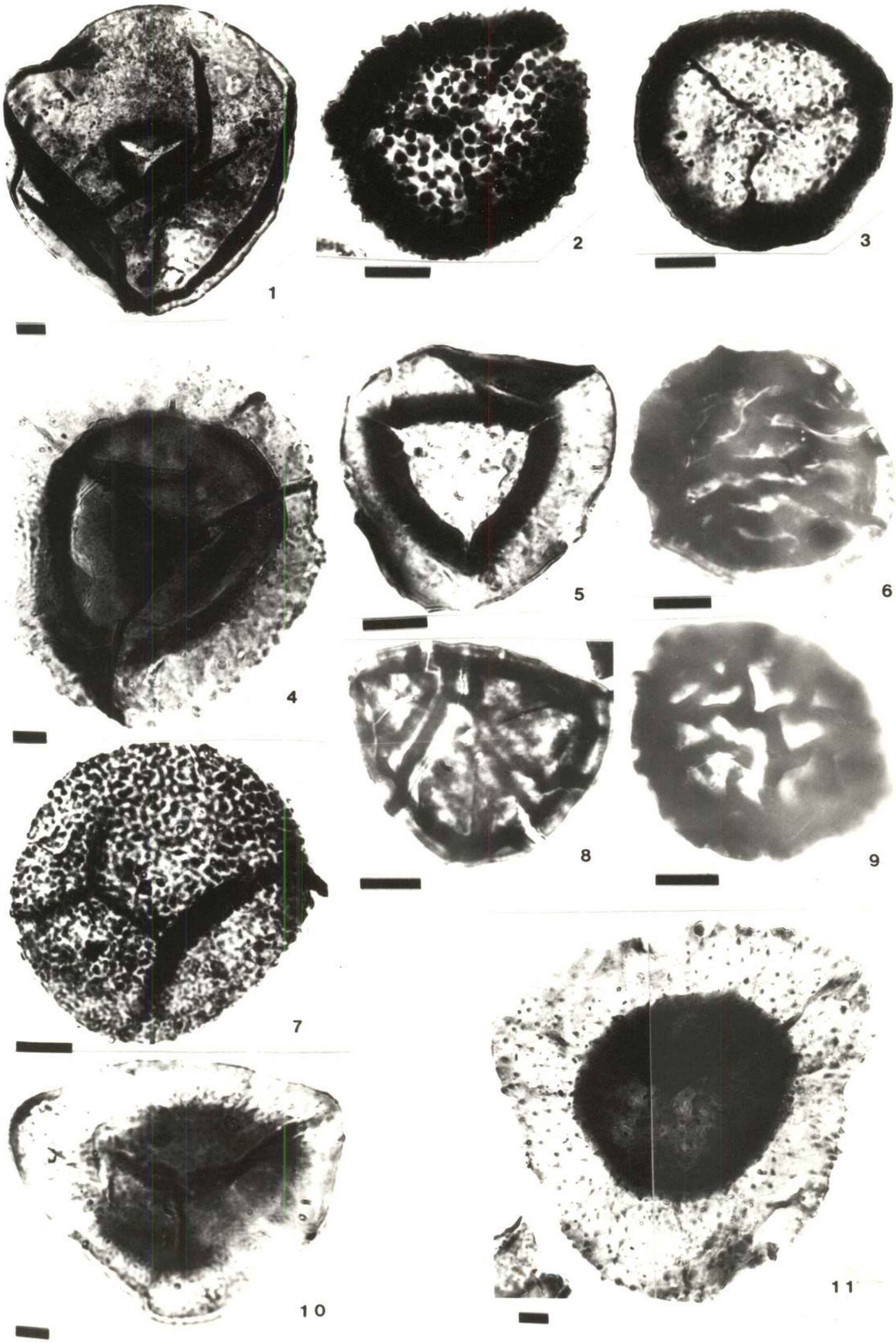

Plate 4

Fig.1. *Dibolisporites eifeliensis* (Lanninger) McGregor, 1971.

Fig.2. *Densosporites devonicus* Richardson, 1960.

Fig.3. *Emphanisporites rotatus* McGregor, 1961.

Fig.4. *Emphanisporites orbicularis* Turnau, 1986.

Fig.5. *Emphanisporites erraticus* (Eisenack) McGregor, 1961.

Fig.6. *Emphanisporites annulatus* McGregor, 1960.

Fig.7. *Emphanisporites rotatus* McGregor, 1961.

Fig.8. *Emphanisporites erraticus* (Eisenack) McGregor, 1961.

Fig.9. *Emphanisporites annulatus* McGregor, 1960.

Fig.10. *Emphanisporites* sp.

Fig.11. *Emphanisporites erraticus* (Eisenack) McGregor, 1961.

Scale bar is 10 micrometers.

PLATE 4

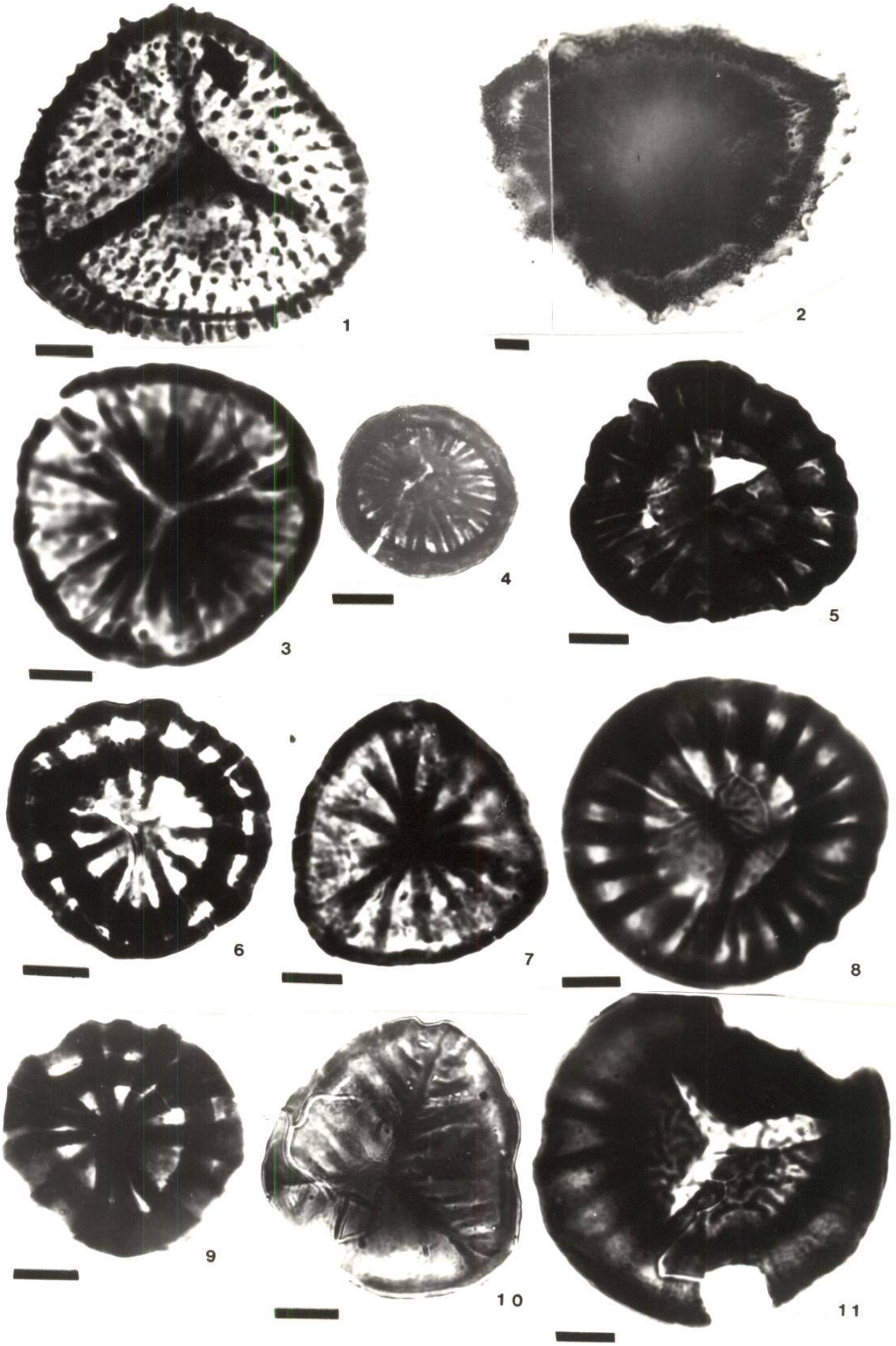

Plate 5

Fig.1. <u>Dibolisporites</u> <u>eifeliensis</u> (Lanninger) McGregor, 1961.

Fig.2. <u>Emphanisporites</u> <u>rotatus</u> McGregor, 1961.

Fig.3. <u>Geminospora</u> <u>lemurata</u> Balme, 1962.

Fig.4. <u>Geminospora</u> <u>antaxios</u> (Chibrikova) Owens, 1971.

Fig.5. <u>Emphanisporites</u> <u>rotatus</u> McGregor, 1961.

Fig.6. <u>Geminospora</u> <u>micropaxilla</u> McGregor, 1982.

Fig.7. <u>Geminospora</u> <u>punctata</u> Owens, 1971.

Fig.8. <u>Geminospora</u> <u>antaxios</u> (Chibrikova) Owens, 1971.

Fig.9. <u>Geminospora</u> <u>antaxios</u> (Chibrikova) Owens, 1971.

Fig.10. <u>Geminospora</u> <u>micropaxilla</u> McGregor, 1982.

Scale bar is 10 micrometers.

PLATE 5

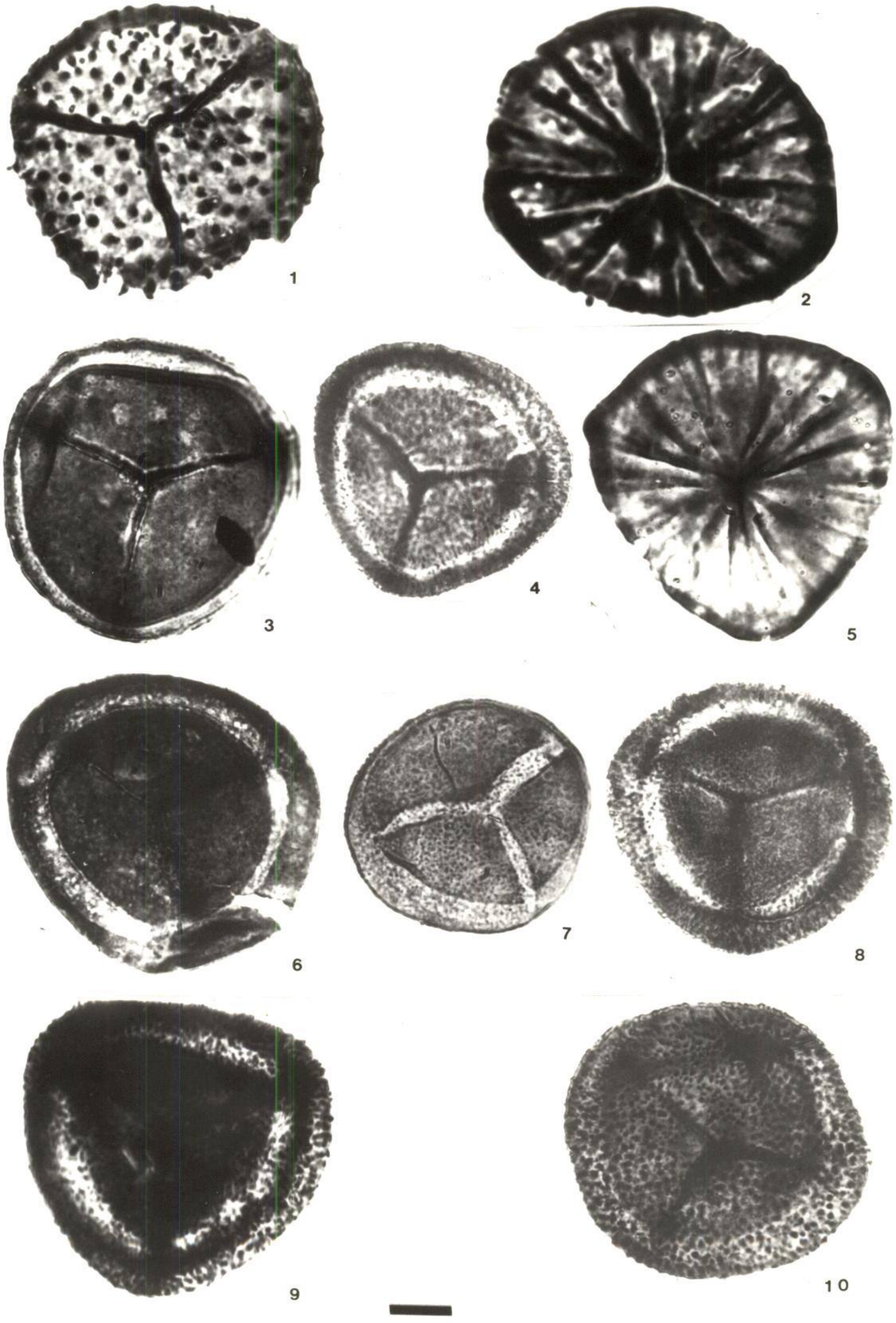

Plate 6

Fig.1. <u>Grandispora</u> <u>macrotuberculata</u> (Arkhangelskaya) McGregor, 1973.

Fig.2. <u>Grandispora</u> <u>macrotuberculata</u> (Arkhangelskaya) McGregor, 1973.

Fig.3. <u>Grandispora</u> <u>mammillata</u> Owens, 1971.

Fig.4. <u>Grandispora</u> <u>mammillata</u> Owens, 1971.

Fig.5. <u>Grandispora</u> <u>douglastownense</u> McGregor, 1973.

Fig.6. <u>Grandispora</u> <u>longus</u> Chi & Hills, 1976.

Scale bar is 10 micrometers.

PLATE 6

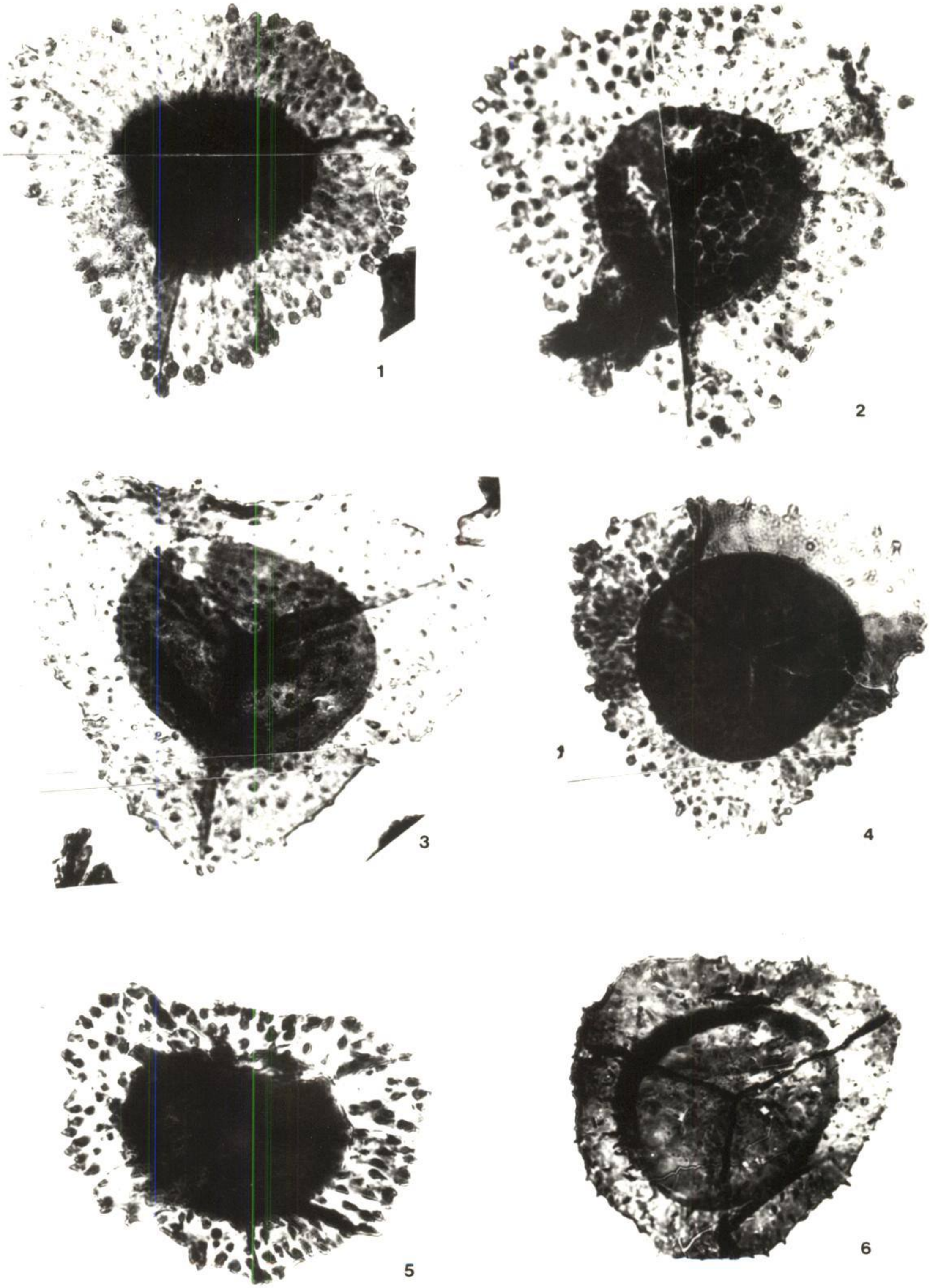

Plate 7

Fig.1. *Hystricosporita corystus* Richardson, 1962.

Fig.2. *Retusotriletes distinctus* Richardson, 1965.

Fig.3. *Hystricosporita corystus* Richardson, 1962.

Fig.4. *Retusotriletes dubiosus* McGregor, 1971.

Fig.5. *Retusotriletes dubiosus* McGregor, 1971.

Fig.6. *Retusotriletes rotundus* Streel, 1964.

Fig.7. *Retusotriletes dittonensis* Richardson & Lister, 1969.

Fig.8. *Retusotriletes rugulatus* Reigel, 1973.

Fig.9. *Retusotriletes dittonensis* Richardson & Lister, 1969.

Fig.10. *Retusotriletes* cf. *dittonensis* Richardson & Lister 1969.

Scale bar is 10 micrometers.

PLATE 7

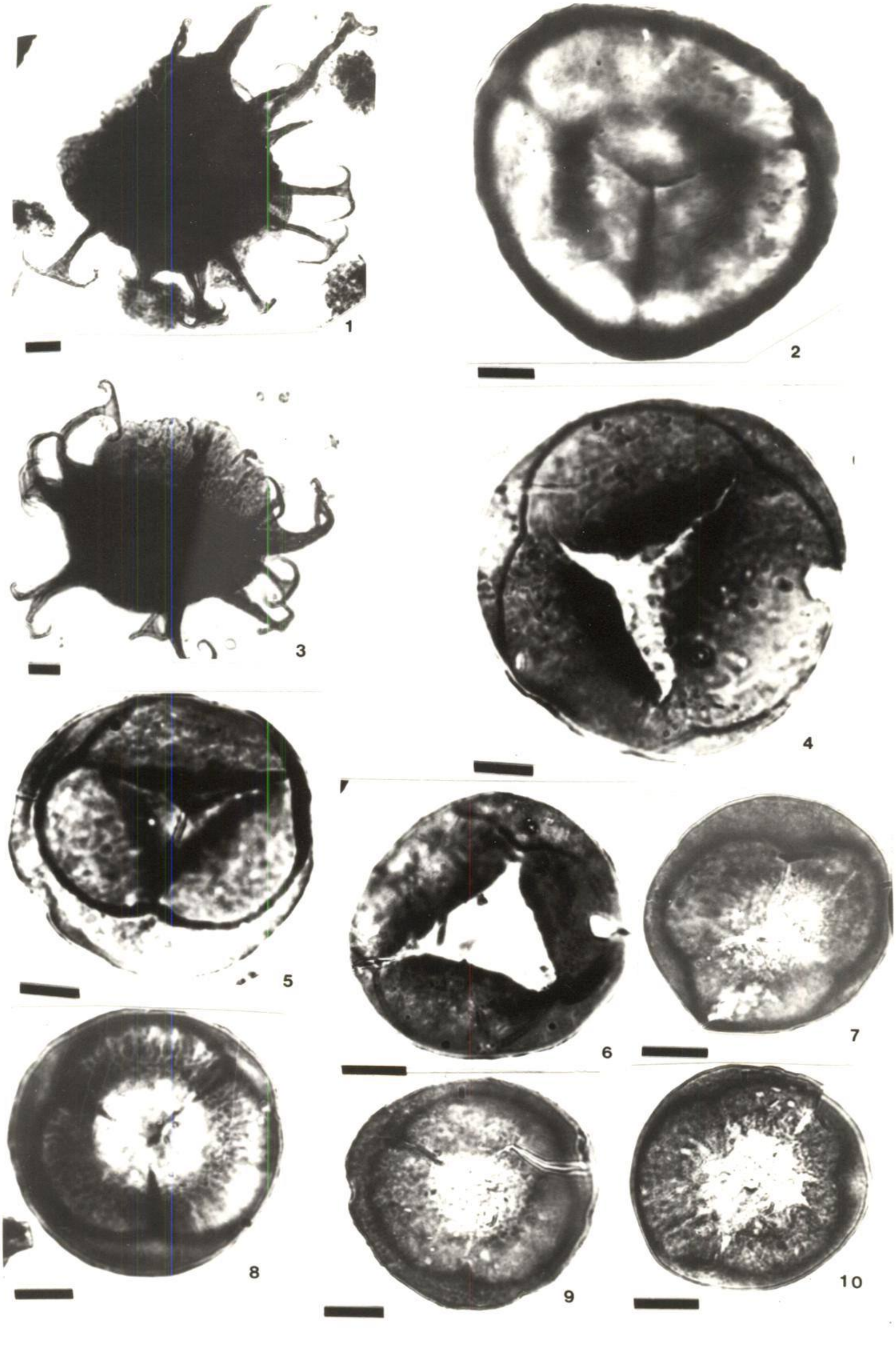

Plate 8

Fig.1. <u>Retispora</u> <u>lepidophyta</u> (Kedo) Playford, 1976.

Fig.2. <u>Retispora</u> <u>lepidophyta</u> (Kedo) Playford, 1976.

Fig.3. <u>Retispora</u> <u>lepidophyta</u> (Kedo) Playford, 1976.

Fig.4. <u>Rhabdosporita</u> <u>langi</u> (Eisenack) Richardson, 1960.

Fig.5. <u>Spelaeotriletes</u> cf. <u>crustatus</u> Higgs, 1975.

Fig.6. <u>Raistrickia</u> <u>aratra</u> Allen, 1965.

Fig.7. <u>Rugospora</u> <u>flexuosa</u> (Juschko) Streel, 1974.

Fig.8. <u>Spinozonetriletes</u> <u>naumovii</u> (Kedo), Richardson, 1965.

Fig.9. <u>Samarisporites</u> <u>triangulatus</u> Allen, 1965.

Scale bar is 10 micrometers.

PIATE 8

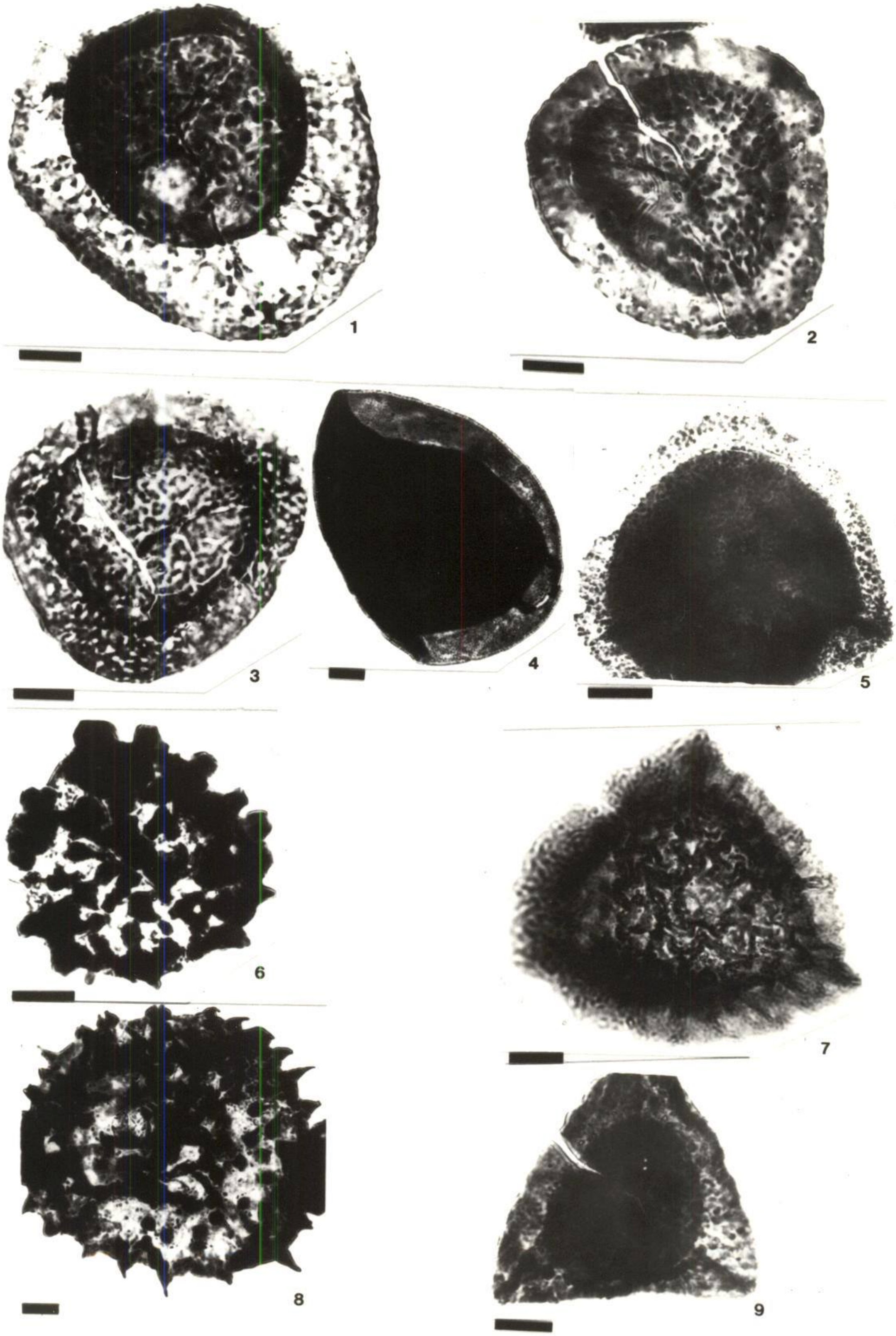

Plate 9

Fig.1. Chomotriletes bistchoensis Staplin, 1961.

Fig.2. Chomotriletes vedugensis Naumova, 1953.

Fig.3. Deltotosoma intonsum Playford, 1981.

Fig.4. Diexallophasis remota (Deunff) Playford, 1977.

Fig.5. Cymatiosphaera perimembrana Staplin, 1961.

Fig.6. Diexallophasis sp.

Fig.7. Deltotosoma intosum Playford, 1981.

Fig.8. Dictyotidium granulatum Playford, 1981.

Fig.9. Evittia geometrica Playford, 1981.

Fig.10. Duvernaysphaera tessella Deunff, 1964.

Scale bar is 10 micrometers.

PLATE 9

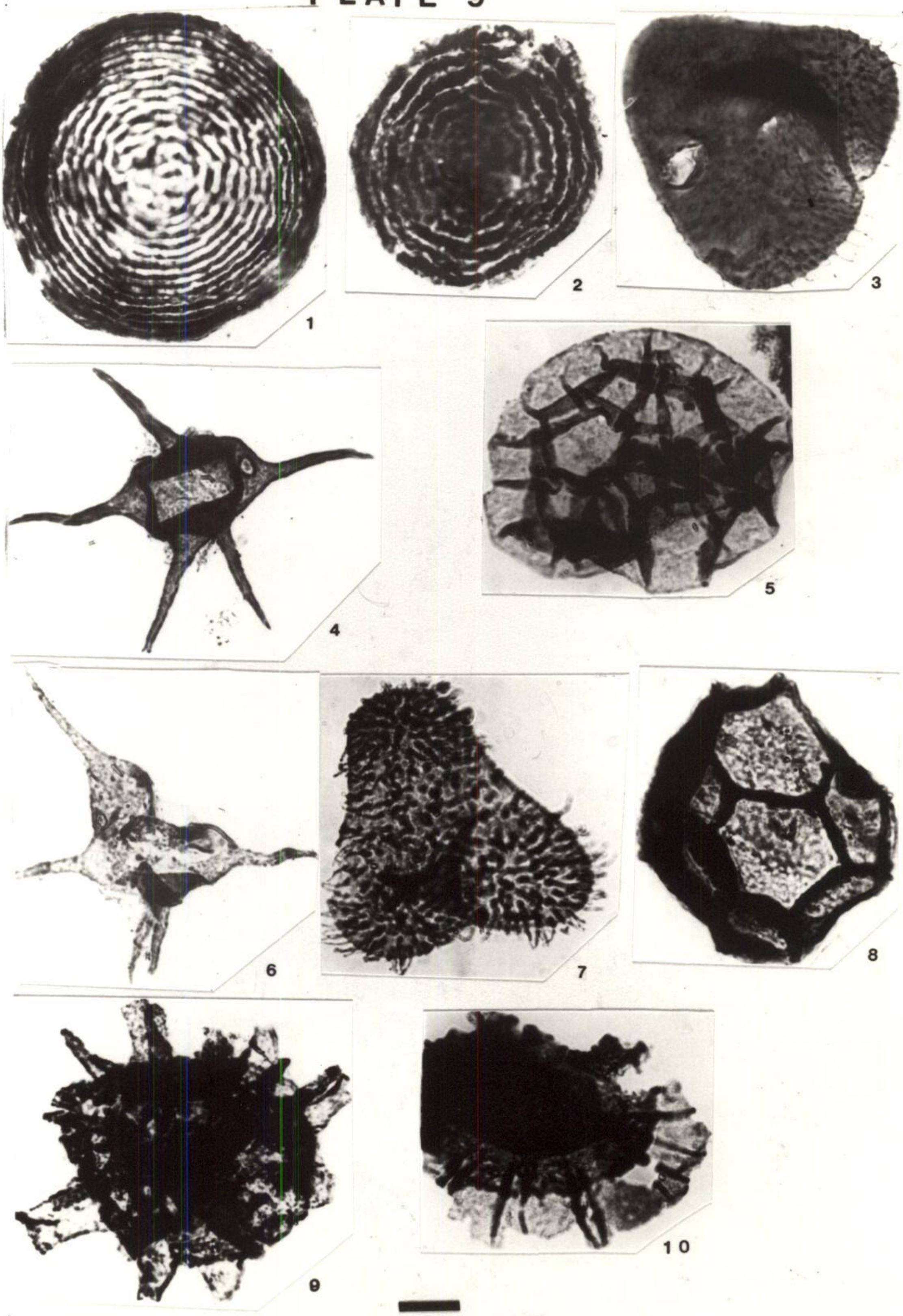

Plate 10

Fig.1. Gorgonisphaeridium discissum Playford, 1981.

Fig.2. Gorgonisphaeridium discissum Playford, 1981.

Fig.3. Gorgonisphaeridium discissum Playford, 1981.

Fig.4. Gorgonisphaeridium sp. A.

Fig.5. Lophosphaeridium segregum Playford, 1981.

Fig.6. Gorgonisphaeridium sp. B.

Fig.7. Gorgonisphaeridium sp. C.

Fig.8. Gorgonisphaeridium abstrusum Playford, 1981.

Fig.9. Melikeriopalla venulosa Playford, 1981.

Fig.10. Deltotosoma cf. intonsum Playford, 1981.

Fig.11. Leiosphaeridia sp.

Fig.12. Gorgonisphaeridium sp. D.

Scale bar is 10 micrometers.

PLATE 10

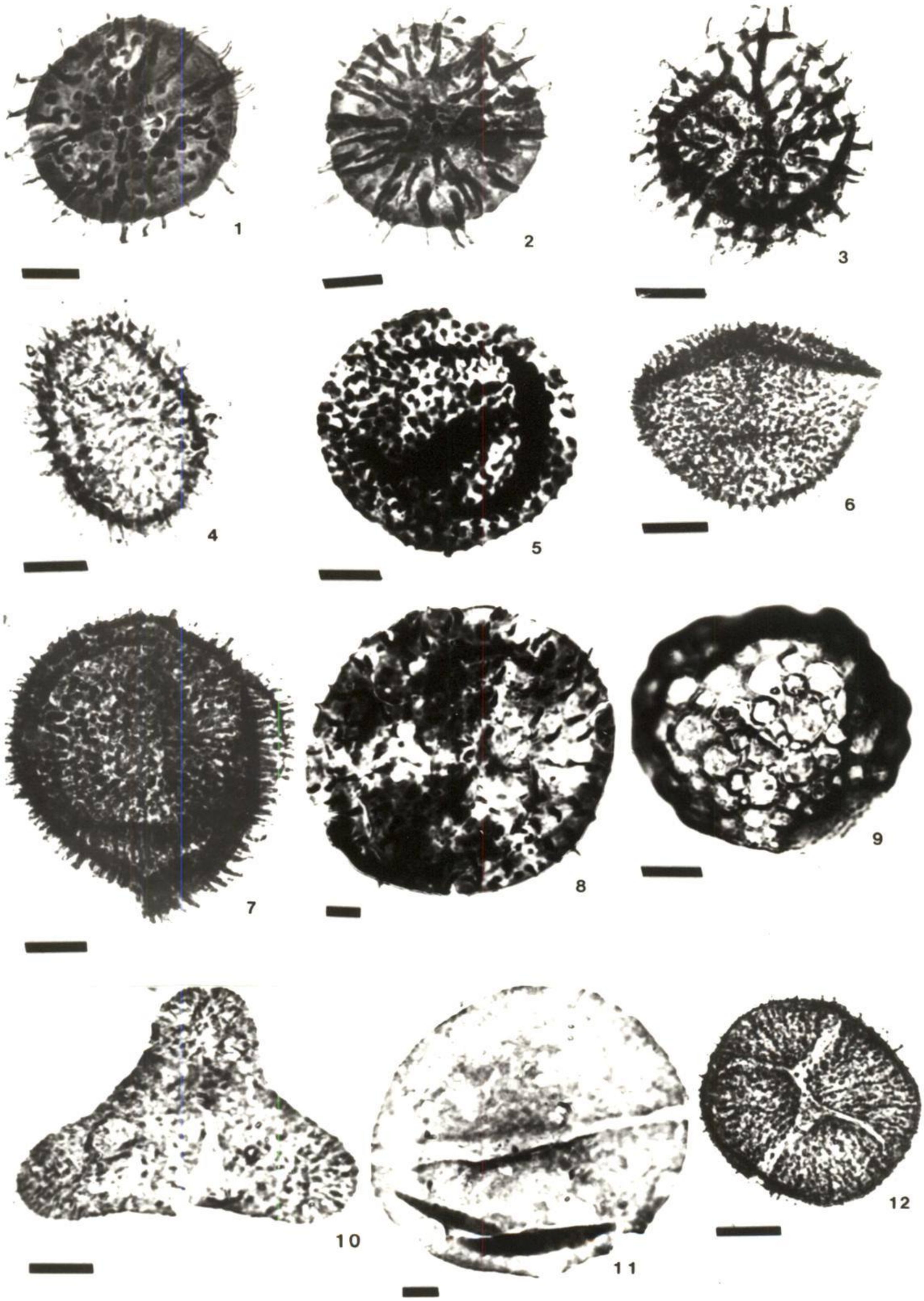

Plate 11

Fig.1. Papulogabata annulata Playford, 1981.

Fig.2. Navifusa excilis Playford, 1981.

Fig.3. Papulogabata annulata Playford, 1981.

Fig.4. Papulogabata annulata Playford, 1981.

Fig.5. Polyedryxium decorum Deunff, 1955.

Fig.6. Stellinium micropolygonale (Stockmans and Williere) Playford, 1977.

Fig.7. Somphophragma miscellum Playford, 1981.

Fog.8. Veryhachium trispinosum (Eisenack) Deunff, 1954.

Fig.9. Acritarch type A.

Fig.10. Acritarch type A.

Scale bar is 10 micrometers.

PLATE 11

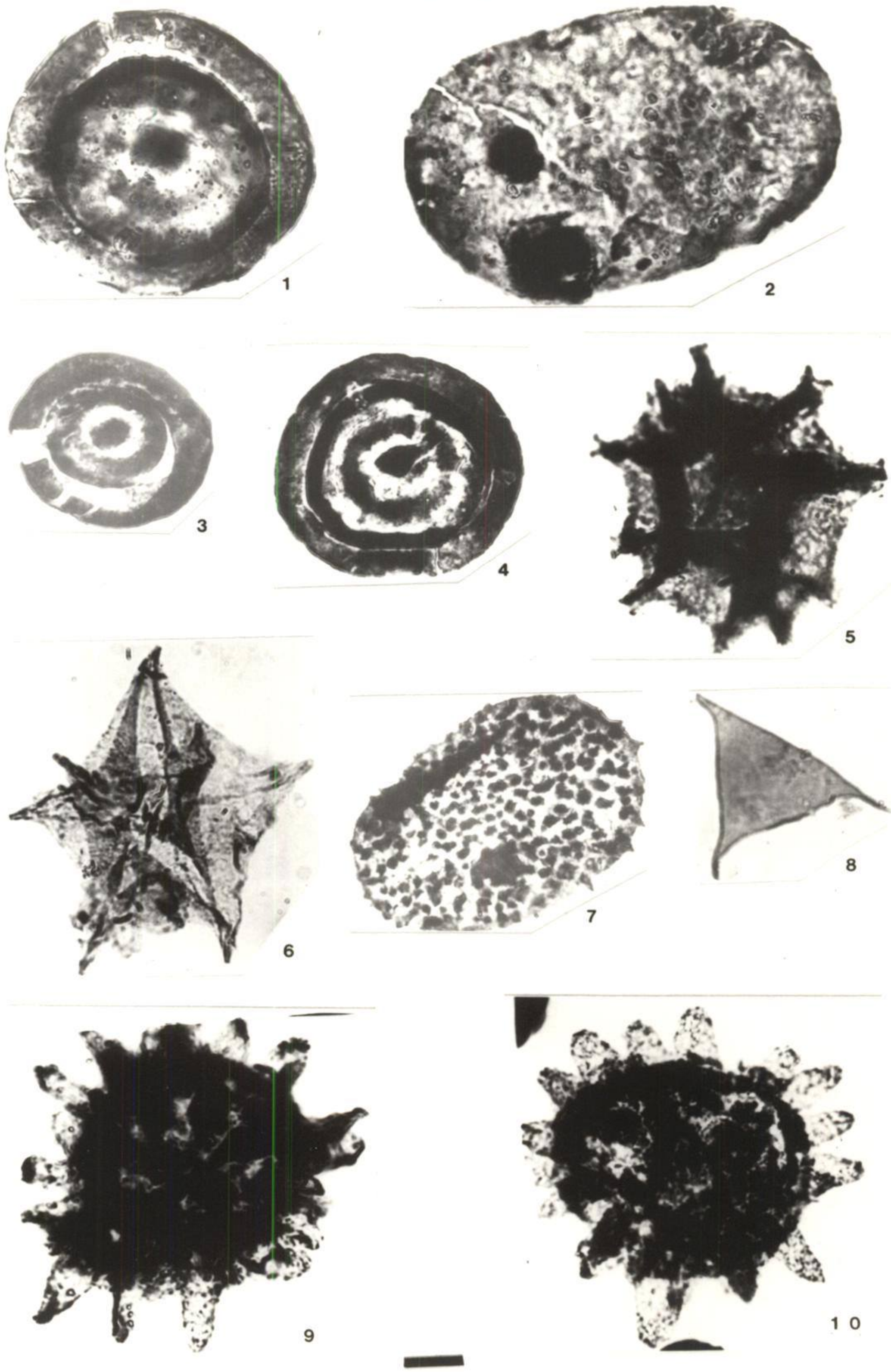

Plate 12

Fig.1. *Scolecodont* type A.

Fig.2. *Scolecodont* type B.

Fig.3. *Scolecodont* type A.

Fig.4. *Ancyrochitina* sp.

Fig.5. *Scolecodont* type C.

Fig.6. A typical gymnosperm tracheid, with the Permian palynomorphs of the Faraghan Formation.

Scale bar is 10 micrometers.

PLATE 12

Plate 13

Fig.1. Grandispora sp.

Fig.2. Gulisporites cochlearius Imgrand, 1960.

Fig.3. Thymospora perverrucosa (Alpern) Wilson & Venkatachala, 1963.

Fig.4. Kraeuselisporites splendens (Balme & Hennelly) Segroves, 1970.

Fig.5. Calamospora microrugosa (Ibrahim) Schopf, Wilson & Bentall, 1944.

Fig.6. Punctatisporites gretensis Balme & Hennelly, 1956b.

Fig.7. Horriditriletes ramosus (Balme & Hennelly) Bharadwaj & Salujha, 1964.

Fig.8. Horriditriletes cf. ramosus (Balme & Hennelly) Bharadwaj & Salujha, 1964.

Fig.9. Horriditriletes ramosus (Balme & Hennelly) Bharadwaj & Salujha, 1964.

Fig.10 Leiotriletes sp.

Fig.11. Laevigatosporites vulgaris Ibrahim, 1933.

Fig.12. Veryhachium riburgense Brosius & Bitterli, 1961.

Scale bar is 10 micrometers.

PLATE 13

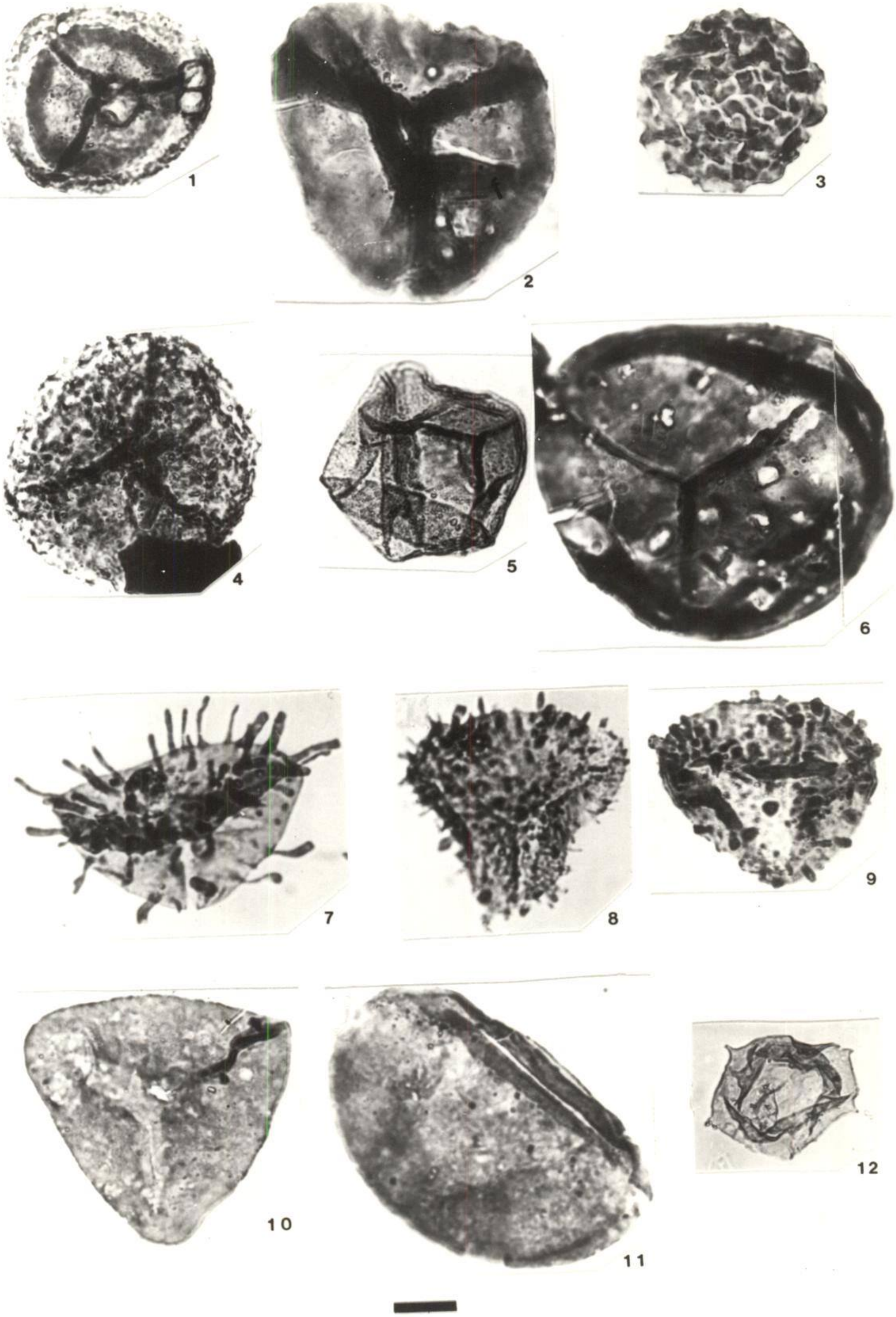

Plate 14

Fig.1. Complexisporites polymorphus Jizba, 1962.

Fig.2. Crustaesporites sp. A.

Fig.3. Corisaccites alutas Venkatachala & Kar, 1966.

Fig.4. Complexisporites polymorphus Jizba, 1962.

Fig.5. Crustaesporites globosus Leschik, 1956.

Fig.6 Costapollenites ellipticus Tschudy & Kosanke, 1966.

Fig.7. Caheniasaccites ellipticus Bose & Maheshwari, 1968.

Fig.8. Crustaesporites sp. B.

Fig.9. Costapollenites ellipticus Tschudy & Kosanke, 1966.

Fig.10. Caheniasaccites ellipticus Bose & Maheshwari, 1968.

Fig.11. Crustaesporites sp. C.

Fig.12. Caheniasaccites ovatus Bose & Kar, 1966.

Fig.13 Boutakoffites quibus Bose & Kar, 1968.

Fig.14. Boutakoffites elongatus Bose & Kar, 1966.

Fig.15. Decussatisporites sp.

Scale bar is 10 micrometers.

PLATE 14

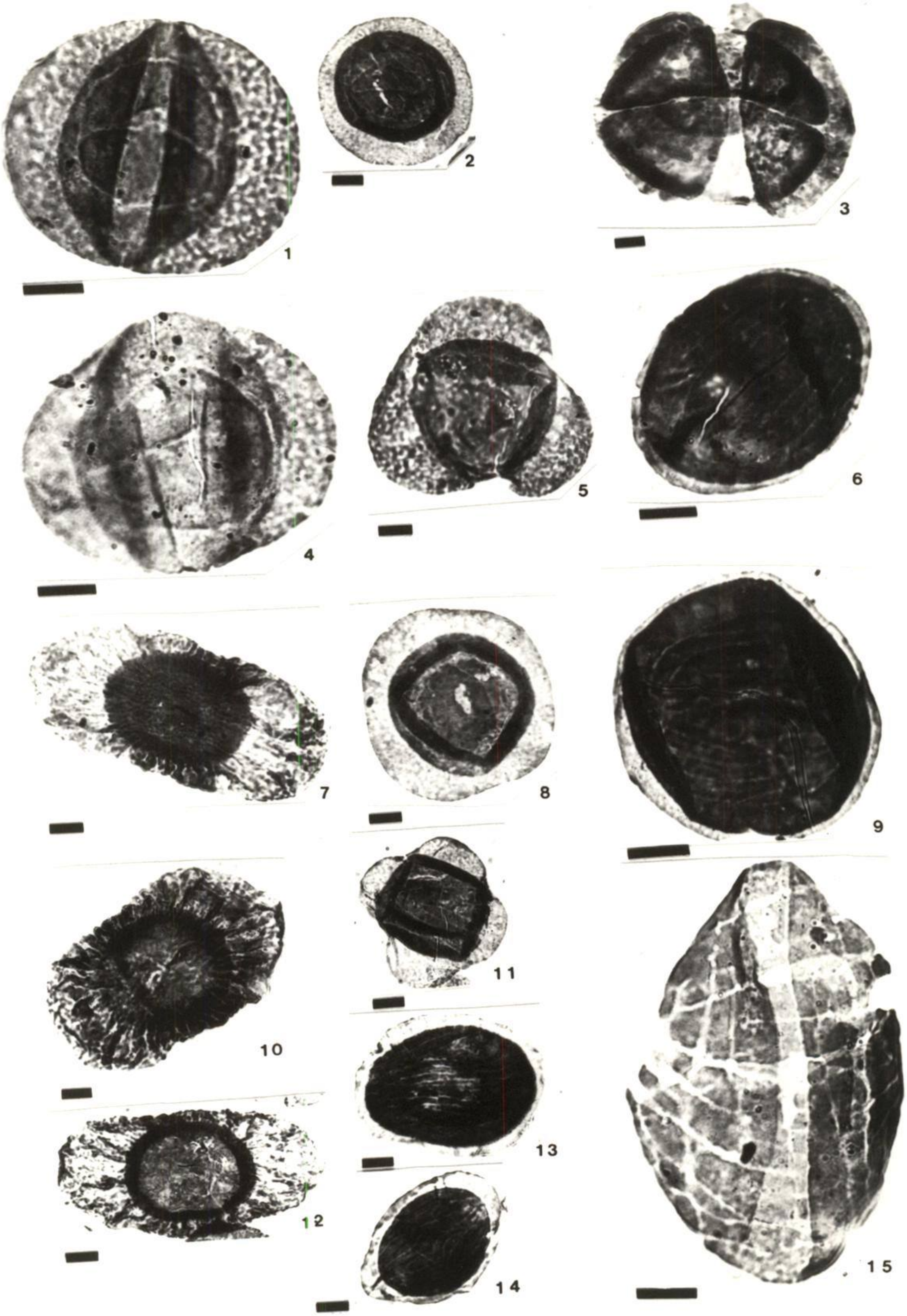

Plate 15

Fig.1. Ephedripites ellipticus Kar. 1967.

Fig.2. Ephedripites ellipticus Kar. 1967.

Fig.3. Ephedripites sp.

Fig.4. Kosankeisporties elegans (Kosanke) Bharadwaj, 1962.

Fig.5. Fusacolpites fusus Bose & Kar, 1966.

Fig.6. Høeigiasaccites transitus Bose & Kar, 1966.

Fig.7. Ginkgocycadophytus cymbatus (Balme & Hennelly) Potonie & Lele, 1961.

Fig.8. Mabuitasaccites ovatus Bose & Kar, 1966.

Fig.9. Fusacolpites fusus Bose & Kar, 1966.

Fig.10. Ginkgocycadophytus cymbatus (Balme & Hennelly) Potonie & Lele, 1961.

Fig.11. Lueckisporites sp.

Fig.12. Fusacolpites ovatus Bose & Kar, 1966.

Fig.13. Nuskoisporites rotatus Balme & Hennelly, 1965.

Scale bar is 10 micrometers.

PLATE 15

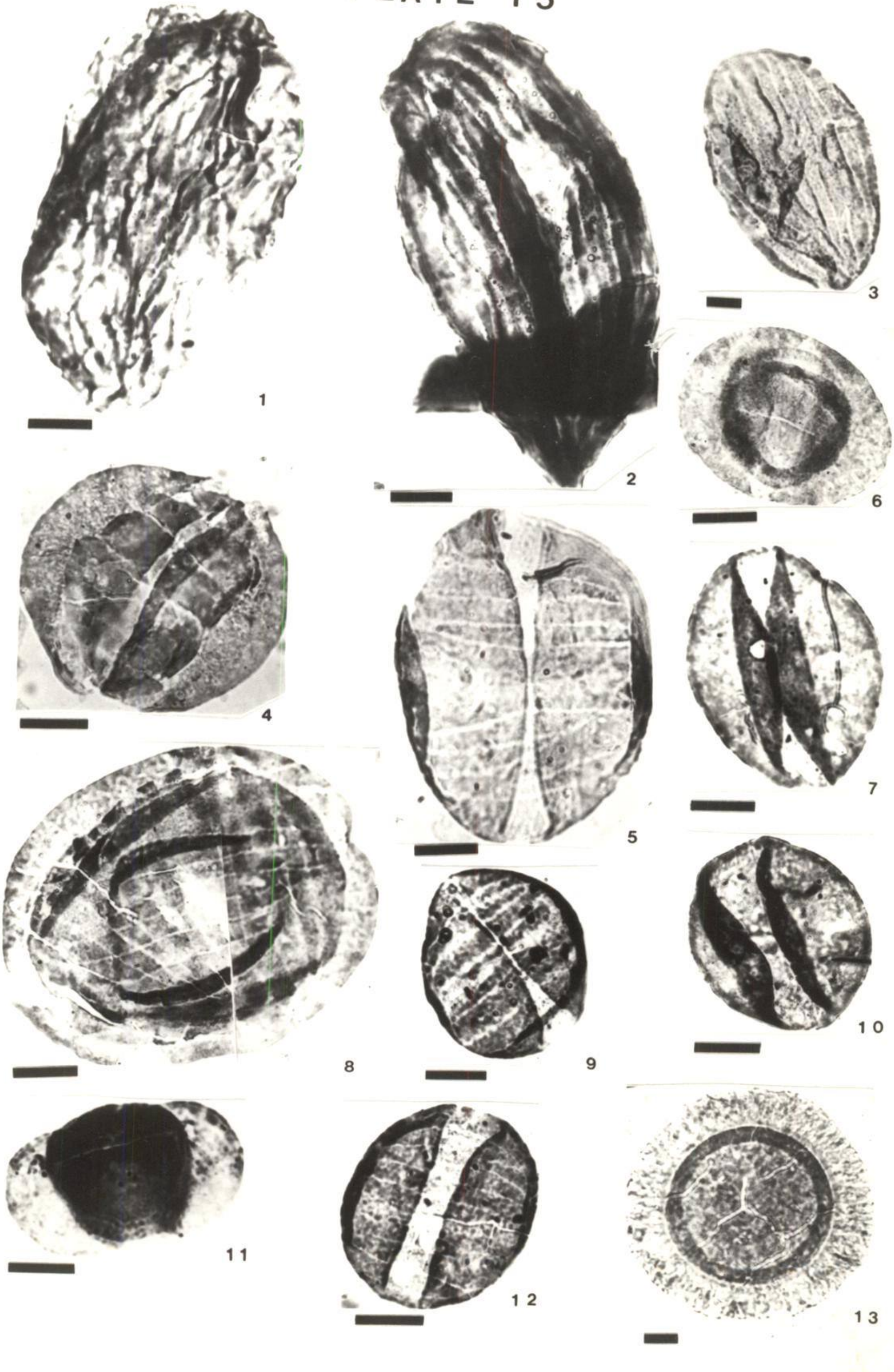

Plate 16

Fig.1 Nuskoisporites triangularis Potonie & Lele, 1959.

Fig.2. Nuskoisporites rotatus Balme & Hennelly, 1965.

Fig.3. Pityosporites giganteus Balme & Hennelly, 1955.

Fig.4. Plicatipollenites indicus Lele, 1964.

Fig.5. Pityosporites giganteus Balme & Hennelly, 1955.

Fig.6. Plicatipollenites indicus Lele, 1964.

Fig.7. Potonieisporites neglectus Potonie & Lele 1965.

Fig.8. Potonieisporites granulatus Bose & Kar, 1966.

Fig.9. Mabuitasaccites ovatus Bose & Kar, 1966.

Fig.10. Potonieisporites granulatus Bose & Kar, 1966.

Scale bar is 10 micrometers.

PLATE 16

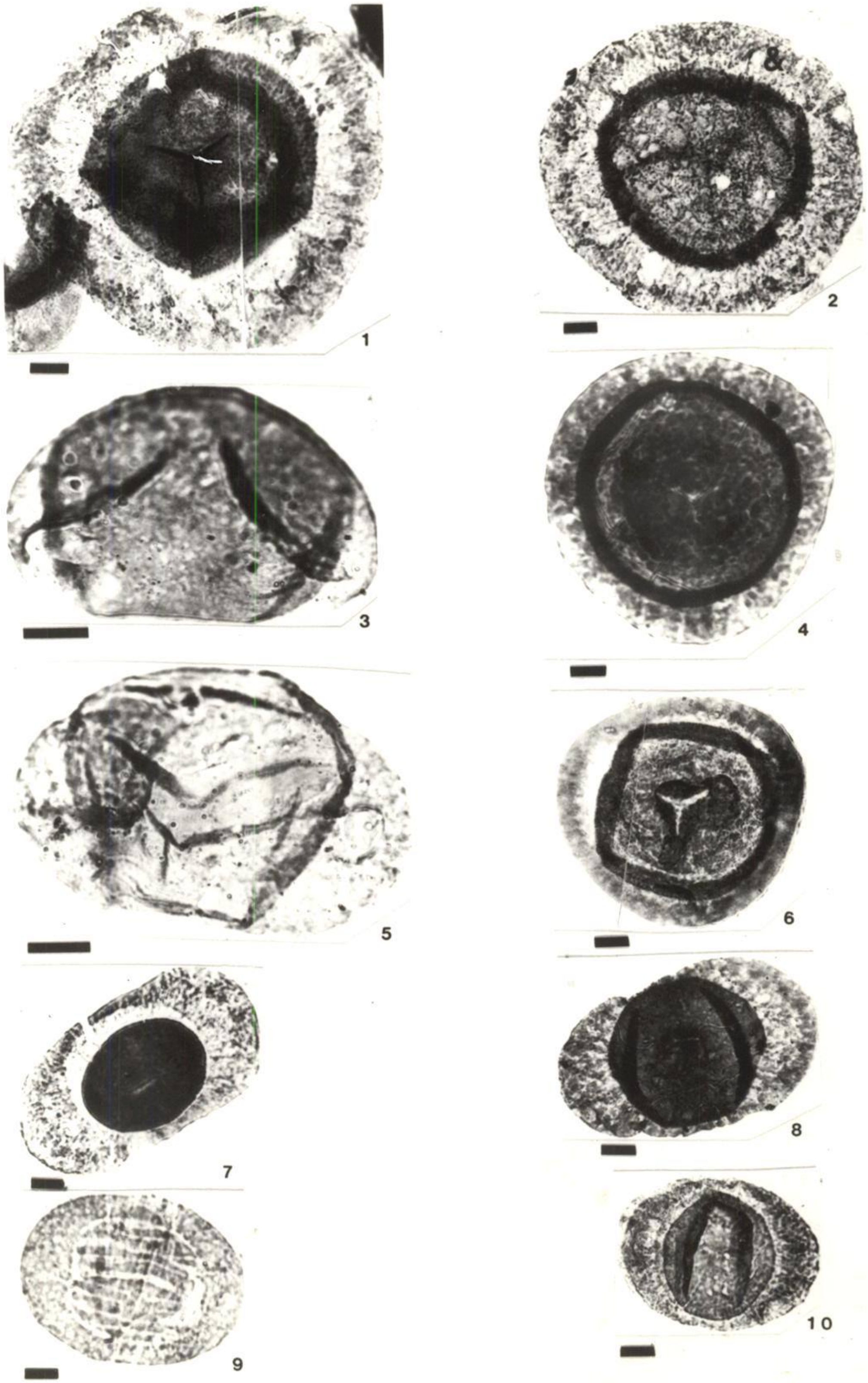

Plate 17

Fig.1. Hamiapollenites perisporites (Jizba) Tschudy & Kosanke, 1966.

Fig.2. Hamiapollenites saccatus Wilson, 1962.

Fig.3. Hamiapollenites saccatus, Wilson, 1962.

Fig.4. Hamiapollenites perisporites (Jizba) Tschudy & Kosanke, 1966.

Fig.5. Hamiapollenites perisporites (Jizba) Tschudy & Kosanke, 1966.

Fig.6. Hamiapollenites tractiferinus (Samoilovich) Hart, 1964.

Fig.7. Hamiapollenites perisporites (Jizba) Tschudy & Kosanke, 1966.

Fig.8. Hamiapollenites perisporites (Jizba) Tschudy & Kosanke, 1966.

Fig.9. Hamiapollenites karrooensis (Hart) Hart, 1964.

Scale bar is 10 micrometers.

PLATE 17

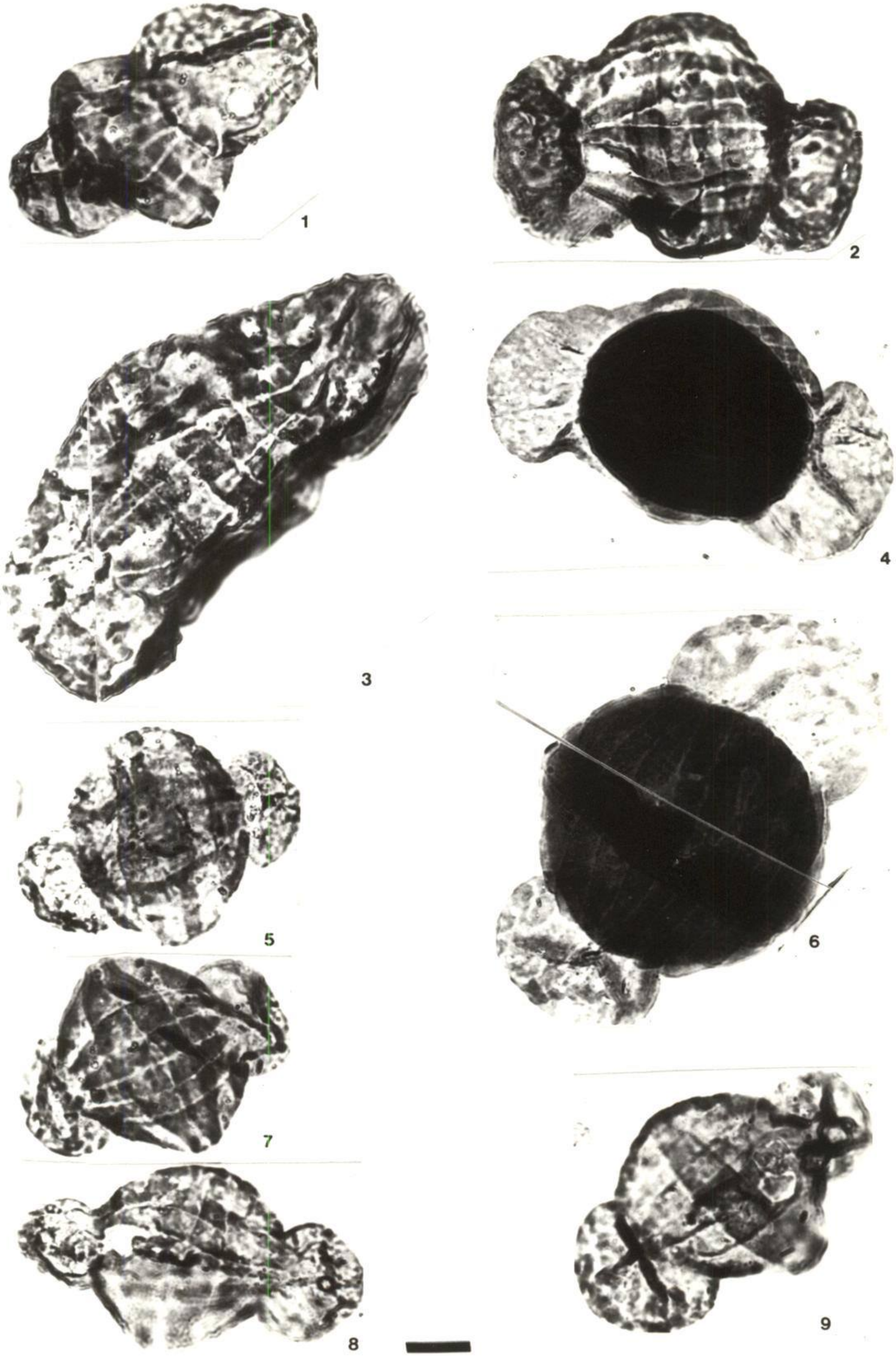

Plate 18

Fig.1. Platysaccus papilionis Potonie & Klaus, 1954.

Fig.2. Protohaploxypinus diagonalis Balme, 1970.

Fig.3. Platysaccus densus Kar, 1967.

Fig.4. Protohaploxypinus sp.

Fig.5. Potonieisporites neglectus Potonie & Lele, 1962.

Fig.6. Protohaploxypinus goraiensis (Potonie & Lele) Hart, 1964.

Fig.7. Rhizomaspora radiata Wilson, 1962.

Fig.8. Rhizomaspora radiata Wilson, 1962.

Scale bar is 10 micrometers.

PLATE 18

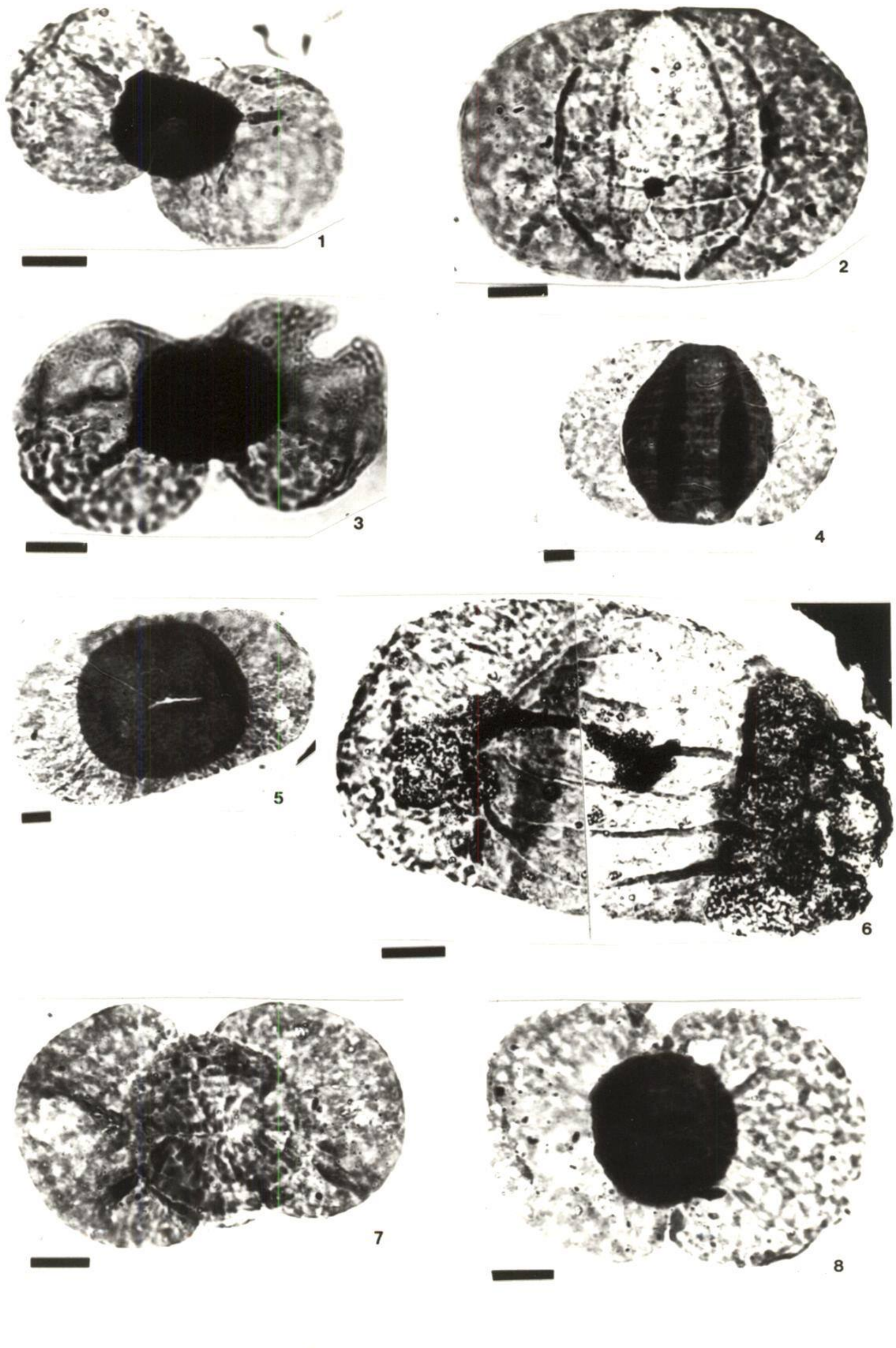

Plate 19

Fig.1. Schizaeoisporites microrugosus Tschudy & Kosanke, 1966.

Fig.2. Schizopollis sp.

Fig.3. Striatoabietites multistriatus (Balme & Hennelly) Hart, 1964.

Fig.4. Striomonosaccites ovatus Bharadwaj, 1962.

Fig.5. Schizopollis sp.

Fig.6. Striomonosaccites triangularis Bose & Kar, 1966.

Fig.7. Sulcatisporites splendens Leschik, 1966.

Fig.8. Tracheid showing arrangement of Pit groups.

Fig.9. Sulcatisporites splendens Leschik, 1966.

Fig.10. Striatopodocarpites cancellatus (Balme & Hennelly) Hart, 1964.

Fig.11. Striatopodocarpites cancellatus (Balme & Hennelly) Hart, 1964.

Fig.12. Striatopodocarpites rarus (Bharadwaj & Salujha) Balme, 1970.

Fig.13. Striatopodocarpites cancellatus (Bharadwaj & Salujha) Balme, 1970.

Scale bar is 10 micrometers.

PLATE 19

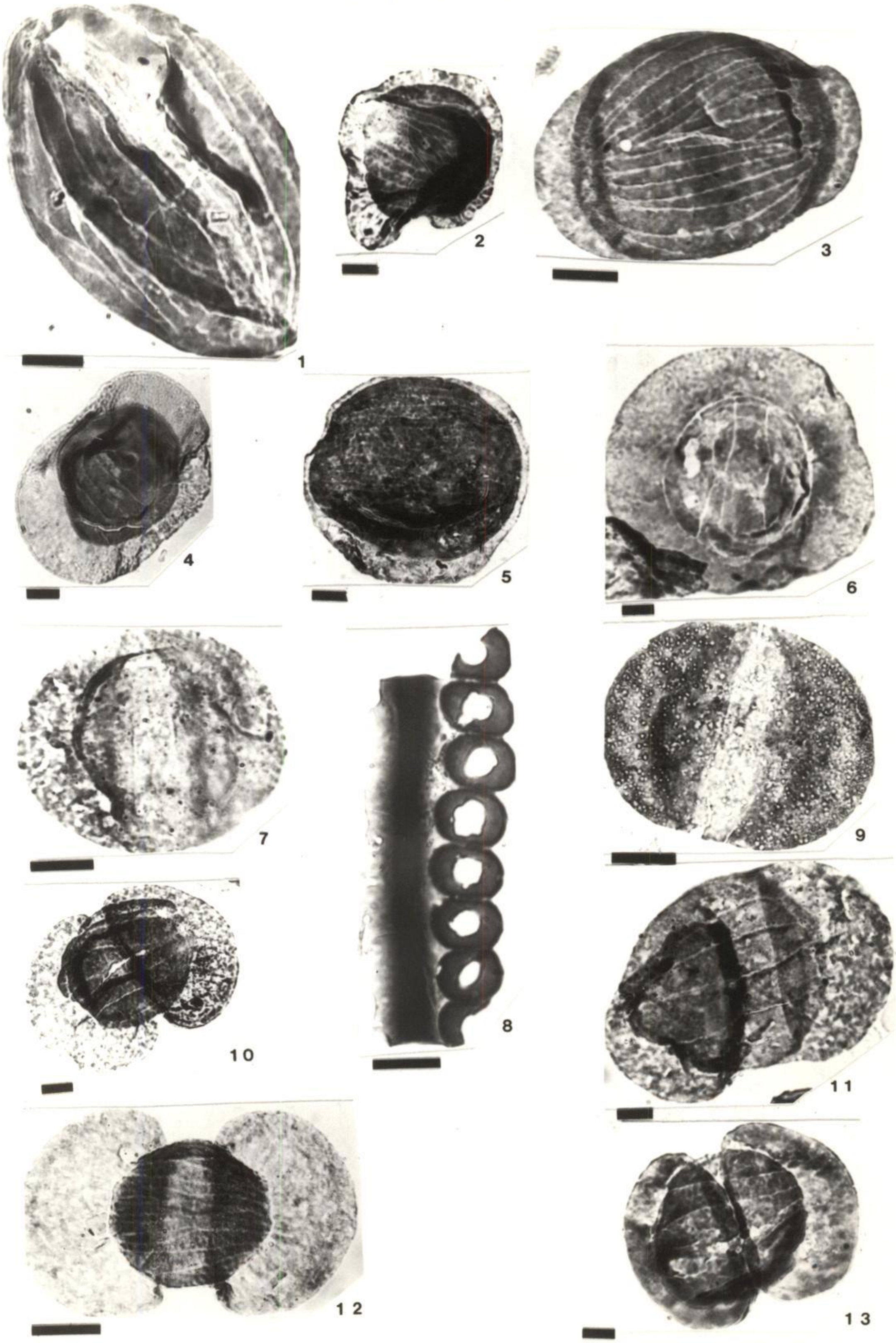

Plate 20

Fig.1. *Vittatina subsaccata* Samoilovitch, 1953.

Fig.2. *Vittatina lata* Wilson, 1962.

Fig.3. *Vittatina costabilis* (Wilson) Tschudy & Kosanke, 1966.

Fig.4. *Vittatina subsaccata* Samoilovitch, 1953.

Fig.5. *Vittatina lata* Wilson, 1962.

Fig.6. *Walikalesaccites ellipticus* Bose & Kar, 1966.

Fig.7. *Tiwariasporis gondwanensis* (Tiwari) Maheshwari & Kar, 1967.

Fig.8. Unknown type B.

Fig.9. *Tiwariasporis flavatus* Maheshwari & Kar, 1967.

Fig.10. Unknown pollen type C.

Fig.11. Unknown pollen type A.

Fig.12. *Tiwariasporis flavatus* Maheshwari & Kar, 1967.

Fig.13. Typical permian preparation at low magnification.

Scale bar is 10 micrometers.

PLATE 20