PALYNOSTRATIGRAPHY AND PALEOGEOGRAPHY OF THE LATE DEVONIAN IN NORTHEASTERN ESFAHAN CITY, CENTRAL IRAN

Mohammad Ghavidel-Syooki

Abstract

A palynological study of the Padeha and Bahram formations of the Chah-e-Riseh area, in northeastern Esfahan city, was initiated to more precisely determine the stratigraphic age of these rock units. These formations yield 44 diagnostic palynomorphs (23 miospore and 21 acritarch species) which are used to define five stratigraphic zones. Zone I is Early Frasnian and occurs in the Padeha Formation and the basal part of Bahram Formation. The Zones II through V are present in the Bahram Formation and palynomorphs suggest a Late Devonian (Middle Frasnian–Late Famennian) age. A hiatus between the Bahram Formation and overlying Jamal Formation spans essentially the entire Carboniferous and Early Permian, possibly time equivalent with the Hercynian Orogeny.

Few palynomorph taxa recorded in northeastern Esfahan city (Chah-e-Riseh area) are present in Europe and North America. However, many species, such as *Navifusa exilis, Deltotosoma intonsum, Papulogabata annulata, Melikeriopalla venulosa, Horologinella quadrispina, Crassiangulina tesselita, Somphophragma miscellum, Dictyotidium granulatum, Lophosphaeridium deminutum, Helosphaeridium microclavatum, Grandispora fibrilata, Cyclogranisporites isostictus, Dibolisporites turriculatus* and *Lophozonotriletes somphus* have been reported only from Late Devonian strata of western Australia, southern and northern Iran, and Algeria

Based on the mutual occurrence of palynomorph taxa it is reasonable to assume that the Iranian Platform, western Australia and Algeria were at a similar paleolatitude, along the southern shore of the Paleo-Tethys Ocean, during the Late Devonian. The presence of abundant acritarch taxa in the Padeha and Bahram formations suggests a shallow marine environment occupied the Central Iranian Basin during the Late Devonian. Moreover, the occurrence of abundant miospore taxa in these two formations indicates that a fairly robust terrestrial plant community existed in close proximity to the basin.

INTRODUCTION

A 644.0 m thick Devonian sequence is well-exposed at northeastern Esfahan city in central Iran (Text-Figure 1). This section has been divided into the Padeha and Bahram formations (Djafarian, 1977). These formations have received minimal interest for chronostratigraphy since the Padeha Formation lacks marine fauna.

The objectives of this paper is to demonstrate the biostratigraphic, paleoecologic and paleogeographic significance of the acritarchs and miospores in the Devonian of Iran. The paleogeography of the Devonian strata in northeastern Esfahan city is important in relation to the Iranian Alborz and Zagros mountain ranges and other regions of the world.

PREVIOUS STUDIES

The study locality, called the Chah-e-Riseh area, is approximately 55 km northeast of Esfahan city. The paved road from Esfahan to Ardestan city is the main connection to the Chah-e-Riseh area (Text-Figure 1). The Upper Paleozoic sequence in the study area has been divided, in ascending order, into the Padeha, Bahram and Jamal formations (Text-Figure 2). In this paper only the palynomorphs from the Padeha and Bahram formations are discussed since the Jamal Formation consists mainly of fusulinid bearing limestones that are not usually conducive to the preservation of spores and acritarchs.

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The field work was carried out in 1993. The measured and sampled stratigraphic section was chosen near the Chah-e-Riseh area where the thickness of Padeha and Bahram formations is 644.0 m. The Padeha Formation is 236.0 m thick (Text-Figure 2) and consists mainly of dolomite, limestone, sandstone, gypsum and some dark-gray shale horizons. Although the formation lacks fauna, it has been assigned to the Lower Devonian based on stratigraphic position.

The Bahram Formation is 408.0 m thick and is composed of alternating fossiliferous limestones, sandstones and dark-gray shales. Djafarian and Brice (1973) and Djafarian (1977) have studied the brachiopods of Bahram Formation and assigned a Late Famennian–Lower Carboniferous age.

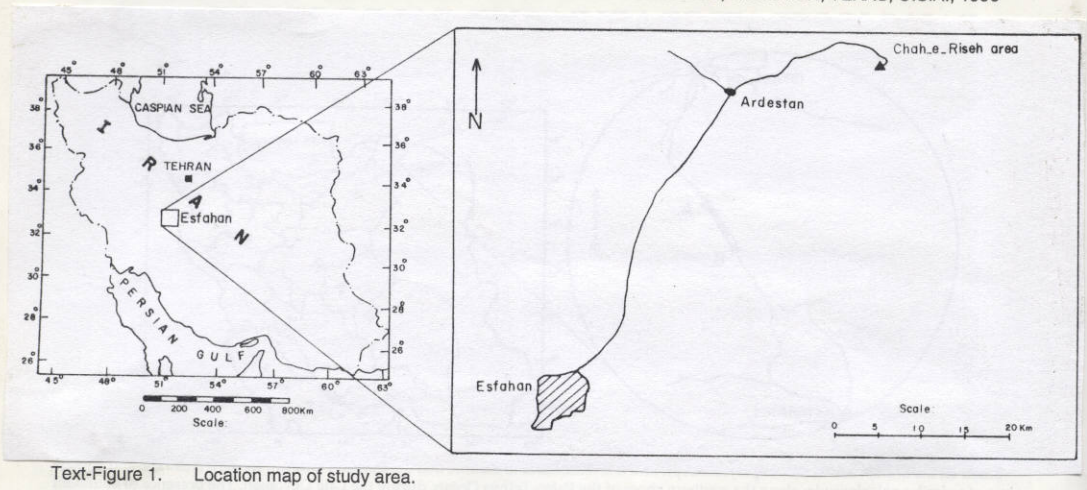
LABORATORY TECHNIQUES

A total of 100 surface samples from the Padeha and Bahram formations were selected for palynological study. The field and laboratory description of the samples are shown in Text-Figure 2. The code and number of each sample follow the policy of National Iranian Oil Company.

Thirty grams of sediments were randomly selected from each sample and processed in the palynology laboratory of the Exploration Department of the National Iranian Oil Company. Disaggregation of the rock samples was carried out using standard palynological procedures. All slides used in this study are on file in the Palaeontology Section of the Exploration Department of the National Iranian Oil Company.

STRATIGRAPHICAL PALYNOLOGY

In this study, a total of 44 palynomorph species (miospores and acritarchs) have been identified. Their distribution is plotted in Text-Figure 2 and selected



Text-Figure 1. Location map of study area.

palynomorphs are illustrated in Plates I-VI. Five palynomorph assemblages zones have been established and are discussed below in ascending stratigraphical order.

Miospore and Acritarch Assemblage Zone I

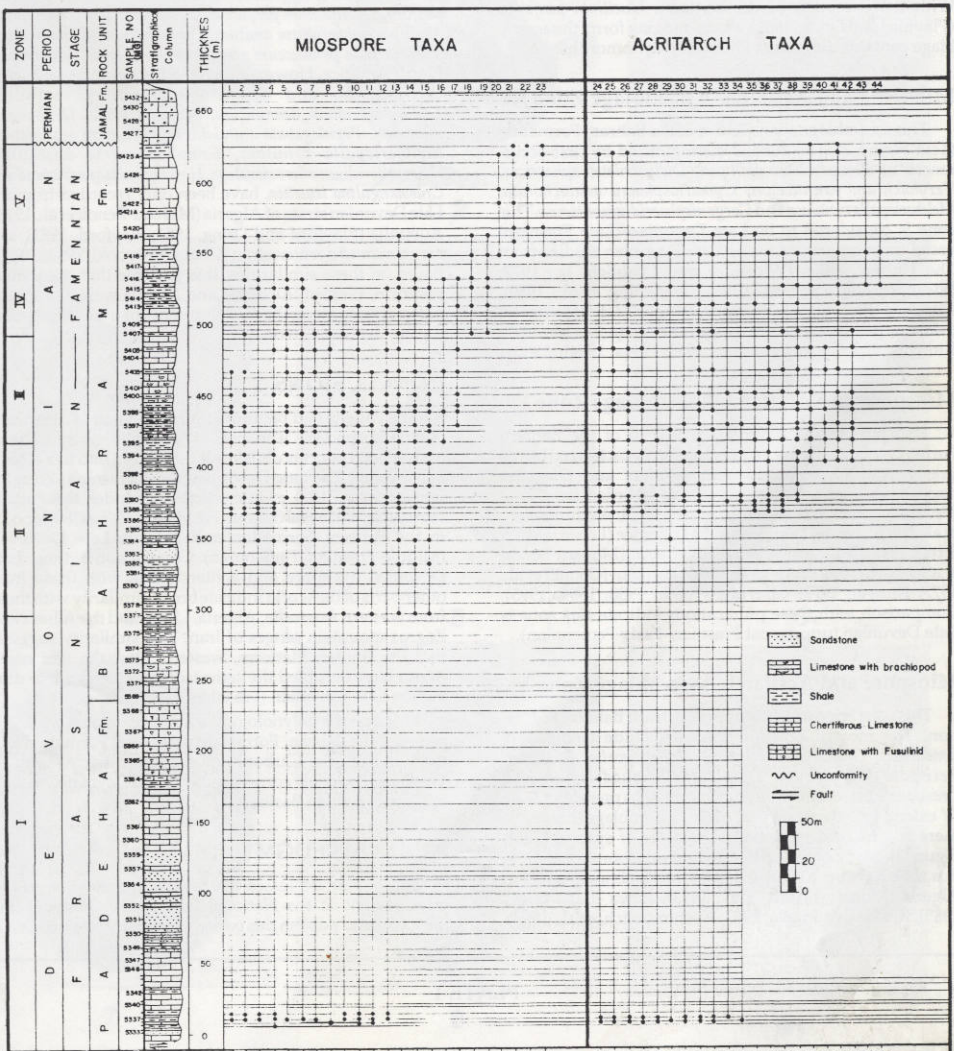
This assemblage zone occurs in a 310.0 m interval of the Padeha Formation and basal part of the Bahram Formation (Text-Figure 2). This assemblage is marked by presence of miospore taxa including *Retusotriletes distinctus, Retusotriletes rotundus, Emphanisporites rotatus, Archaeoperisaccus scabratus, Verrucosisporites scurrus, Samarisporites triangulatus, Grandispora fibrilata, Stenozonotriletes formosus, Cyclogranisporites isostictus, Retusotriletes pychovii, Lophozonotriletes somphus* and *Dibolisporites turriculatus*. Acritarchs occurring in this zone include *Stellinium micropolygonale, Stellinium comptum, Deltotosoma intonsum, Helosphaeridium microclavatum, Polyedryxium pharaonae, Chomotriletes vedugensis, Lophosphaeridium deminutum, Papulogabata annulata, Navifusa exilis, Somphophragma miscellum* and *Dictyotidium granulatum*. The miospore and acritarch species of this assemblage were compared to published information from the Devonian of Australia (Balme, 1960, 1988; Playford, 1981; Playford and Dring, 1981), Canada (Deunff, 1954; Owens, 1971; McGregor, 1961; McGregor and Camfield, 1982), the United States (Clendening et al., 1980; Wicander and Wood, 1981; Wicander, 1974; Wicander and Loeblich, Jr., 1977; Wicander and Playford, 1985), Argentina (Ottone, 1996), Russia (Naumova, 1953; Avchimovitch et al., 1993), France (Loboziak and Streel, 1980,1981; Rauscher, 1969), Belgium (Streel, 1967, 1986), Germany (Hartkopf-Fröder and Streel, 1994), Libya (Paris et al., 1985), Algeria (Jardiné et al., 1972; Moreau-Benoit et al., 1993) and Iran (Kimyai, 1972, 1979; Coquél et al., 1977; Ghavidel-syooki, 1988, 1994b, 1995). The presence of the miospores and acritarchs *Archaeoperisaccus*

Text-Figure 2 (opposite page). Stratigraphic distribution of acritarch and miospore taxa in the Padeha and Bahram formations in Chah-e-Riseh area, northeastern Esfahan city, central Iran (numbers correspond to the columns in Text-Figure 2). 1–*Retusotriletes distinctus* Richardson 1965; 2–*Retusotriletes rotundus* (Streel) Streel 1967; 3–*Emphanisporites rotatus* McGregor 1961; 4–*Archaeoperisaccus scabratus* Owens 1972; 5–*Verrucosisporites scurrus* McGregor & Camfield 1982; 6–*Samarisporites triangulatus* Allen 1965; 7–*Grandispora fibrilata* Balme 1988; 8–*Stenozonotriletes formosus* Naumova 1953; 9–*Cyclogranisporites isostictus* Balme 1988; 10–*Retusotriletes pychovii* Naumova 1953; 11–*Lophozonotriletes somphus* Balme 1988; 12–*Dibolisporites turriculatus* Balme 1988; 13–*Geminospora lemurata* Balme 1962; 14–*Verrucosisporites confertus* Owens 1971; 15–*Contagnisporites optivus* (Chibrikova) Owens 1971; 16–*Retusotriletes phillipsii* Clendening, Eames & Wood 1980; 17–*Dictyotriletes sphaericus* Kimyai 1979; 18–*Hymenozonotriletes perplexa* Balme & Hassel 1962; 19–*Diducites macronatus* (Kedo) emend. Van Veen 1981; 20–*Grandispora echinata* Hacquebard 1957; 21–*Grandispora famenensis* (Naumova) Streel 1986; 22–*Vallatisporites pusillites* (Kedo) Dolby & Neves 1970; 23–*Retispora lepidophyta* (Kedo) Playford 1976; 24–*Stellinium micropolygonale* (Stockmans & Williéré) Playford 1977; 25–*Stellinium comptum* Wicander & Loeblich, Jr., 1977; 26–*Deltotosoma intonsum* Playford 1981; 27–*Helosphaeridium microclavatum* Playford 1981; 28–*Polyedryxium pharaonae* Deunff 1954; 29–*Chomotriletes vedugensis* Naumova 1953; 30–*Lophosphaeridium deminutum* Playford 1981; 31–*Papulogabata annulata* Playford 1981; 32–*Navifusa exilis* Playford 1981; 33–*Somphophragma miscellum* Playford 1981; 34–*Dictyotidium granulatum* Playford 1981; 35–*Unellium piriforme* Rauscher 1969; 36–*Maranhites perplexus* Wicander & Playford 1985; 37–*Multiplicisphaeridium amitum*; 38–*Ammonidium loriferum* (Deunff, 1965) Lister 1970; 39–*Veryhachium pannuceum* Wicander & Loeblich, Jr., 1974; 40–*Cymatiosphaera adaiochorata* Wicander 1974; 41–*Gorgonisphaeridium ohioense* (Winslow) Wicander 1974; 42–*Melikeriopalla venulosa* (Staplin) Jardiné et al. 1972; 43–*Crassiangulina tesselita* Jardiné et al. 1972; 44–*Horologinella quadrispina* Jardiné et al., 1972.

scabratus, Dibolisporites turriculatus, Cyclogranisporites isostictus, Lophozonotriletes somphus, Grandispora fibrilata, Chomotriletes vedugensis, Deltotosoma intonsum, Navifusa exilis, Helosphaeridium microclavatum, Papulogobata annulata, Somphophragma miscellum and *Dictyotidium granulatum* suggests an Early Frasnian age for this section in the Padeha Formation.

Miospore and Acritarch Assemblage Zone II

This assemblage comprises 122.0 m of the Bahram Formation (Text-Figure 2). This zone characterized by appearance of *Geminospora lemurata, Verrucosisporites confertus, Contagnisporites optivus, Maranhites perplexus, Multiplicisphaeridium amitum, Ammonidium loriferum* and



Text-Figure. 2. Stratigraphic distribution of miospore and acritarch taxa in the Padeha and Bahram formations in Chah-e-Riseh area, northeastern Esfahan city, Central Iran.

Unellium piriforme. The palynomorphs of this assemblage were compared to pertinent Late Devonian occurrences in the United States (Wicander and Loeblich, Jr., 1977; Wicander and Playford, 1985), Canada (Owens, 1971), Russia (Naumova, 1953; Avchimovitch et al., 1993), France (Loboziak and Streel, 1980, 1981), Libya (Paris et al., 1985), Algeria (Moreau-Benoit et al., 1993), Iran (Coquél et al., 1977; Kimyai, 1979; Ghavidel-syooki, 1988, 1994a, 1995). With the exception of the acritarch *Unellium piriforme* (Playford and Dring, 1981), a long-ranging form, the assemblage contains diagnostic Frasnian palynomorphs.

Miospore and Acritarch Assemblage Zone III

This assemblage spans 76.0 m of the Bahram Formation (Text-Figure 2). The zone is distinguished by first occurrences of *Retusotriletes phillipsii, Dictyotriletes sphaericus, Veryhachium pannuceum, Cymatiosphaera adaiochorata, Melikeriopalla venulosa* and *Gorgonisphaeridium ohioense*. This zone is considered to be Late Devonian (Late Frasnian) based on comparisons to the Late Devonian studies from The United States (Wicander and Loeblich, Jr., 1977; Wicander and Playford, 1985; Clendening et al., 1980), Australia (Balme, 1988; Playford, 1976, 1977, 1981), Algeria (Moreau-Benoit et al., 1993) and Iran (Coquél et al., 1977; Kimyai, 1979; Ghavidel-syooki, 1988, 1994a, 1994b, 1995).

Miospore and Acritarch Assemblage Zone IV

This assemblage is found in 54.0 m of the Bahram Formation (Text-Figure 2). This zone is characterized by the presence of *Hymenozonotriletes perplexa* and *Diducites macronatus*. These species have been recorded from Late Devonian strata in Russia (Naumova, 1953; Avchimovitch et al., 1993), Ireland (Van Veen, 1981), France (Loboziak and Streel, 1981), Belgium (Streel, 1986), Algeria (Moreau-Benoit et al., 1993), Libya (Paris et al., 1985) and Iran (Coquél et al., 1977; Kimyai, 1979; Ghavidel-syooki, 1988, 1994a,1995). Comparison with these publications indicate this zone is Late Devonian (uppermost Frasnian–Early Famennian).

Miospore and Acritarch Assemblage Zone V

This zone appears in the upper 82.0 m of Bahram Formation. The most diagnostic species include *Grandispora famenensis, Grandispora echinata, Vallatisporites pusillites, Retispora lepidophyta, Horologinella quadrispina* and *Crassiangulina tesselita*. Some palynomorphs present in Zone IV extend into the basal part of this assemblage, however, there is a marked reduction in number of species (Text-Figure 2). Many of the acritarchs and miospores present in this zone have been recorded from the Famennian strata in Algeria (Moreau-Benoit et al., 1993), Libya (Paris et al., 1985), Russia (Naumova, 1953; Avchimovitch, et al., 1993), Belgium (Streel, 1986), Germany (Hartkopf-Fröder and Streel, 1994), France (Loboziak and Streel, 1981), Ireland (Van Veen, 1981), the United States (Wicander, 1974) and Iran (Coquel et al., 1977; Ghavidel-syooki, 1994a).

This comparison indicates that most of miospore taxa and some of acritarch species, such as *Chomotriletes vedugensis, Gorgonisphaeridium ohioense, Stellinium comptum, Stellinium micropolygonale, Ammonidium loriferum, Unellium piriforme, Maranhites perplexus, Cymatiosphaera adaiochorata, Multiplicisphaeridium amitum, Polyedryxium pharaonae* and *Veryhachium pannuceum* are also known from Europe and North America. However, many other acritarch species of the Padeha and Bahram formations including *Lophosphaeridium deminutum, Navifusa exilis, Deltotosoma intonsum, Papulogabata annulata, Dictyotidium granulatum, Melikeriopalla venulosa, Somphophragma miscellum, Helosphaeridium microclavatum, Horologinella quadrispina* and *Crassiangulina tesselita*, have been only recorded from the Late Devonian strata of Algeria (Moreau-Benoit et al., 1993), Australia (Playford and Dring, 1981; Playford, 1981), and southern and northern Iran (Ghavidel-syooki, 1994a, 1995). Based on these similarities, it is possible that the Iranian platform, Western Australia and Algeria were at a similar paleolatitude along the southern shore of the Tethys Ocean during the Late Devonian.

CONCLUSIONS

The Padeha and Bahram formations yield 44 diagnostic palynomorph taxa. The local stratigraphic distribution of each species permits division of the section into five assemblage zones. The Late Devonian (Early Frasnian) Zone I is present in a 310.0 m interval that includes the Padeha Formation and basal Bahram Formation. Zones II to V occur in the Bahram Formation and indicate Late Devonian (Middle Frasnian–Famennian). Comparison of these Late Devonian miospore and acritarch taxa with those from other parts of the world indicate broad similarity with those from western Australia, Algeria, Libya, and the Alborz and Zagros mountain ranges of Iran. This similarity suggests that the Iranian Platform, western Australia and north Africa have occupied the same tropical paleolatitude during the Late Devonian (Frasnian–Famennian).

Based on the palynological evidence, a hiatus is present between the Bahram Formation and Jamal Formation and extends from the Carboniferous through Early Permian. This hiatus possibly corresponds to the Hercynian Orogeny in Central Iranian Basin.

ACKNOWLEDGMENTS

The author expresses his sincere appreciation to the management of the National Iranian Oil Company for permission to publish this paper. I am also grateful to Dr. G.

PLATE 1

All figures x1000.

1, 2, *Crassiangulina tesselita* Jardiné et al. 1972.

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4 *Horologinella quadrispina* Jardiné et al. 1972.

5 *Deltotosoma intonsum* Playford 1981.

7, 8 *Chomotriletes vedugensis* Naumova 1953.

9 *Navifusa exilis* Playford 1981.

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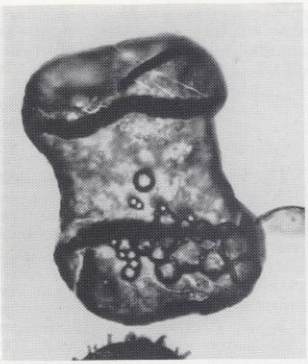

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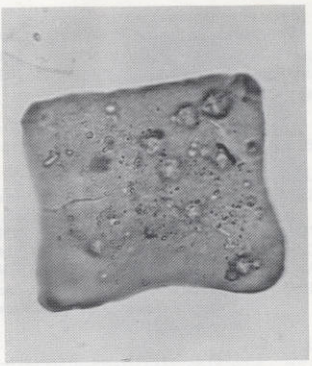

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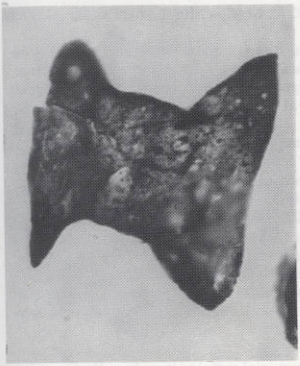

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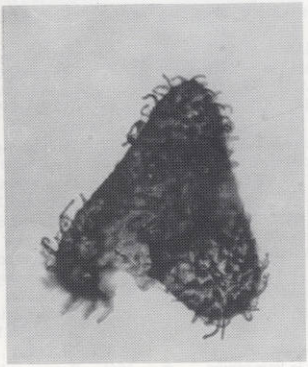

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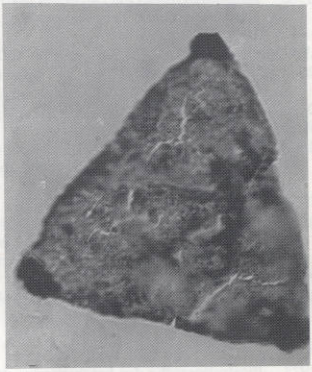

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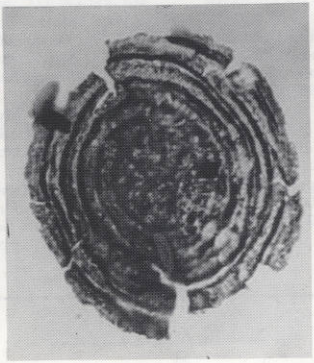

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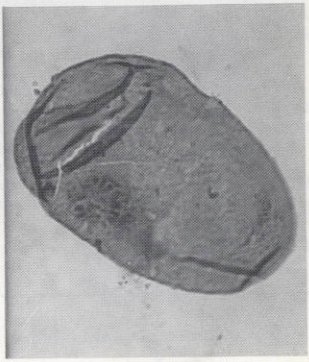

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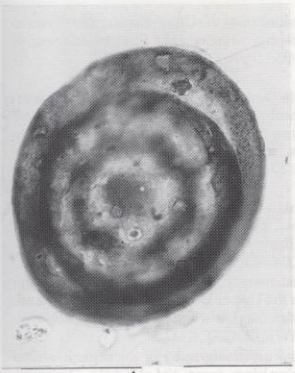
PLATE 2

All figures x1000.

1, 4 *Papulogabata annulata* Playford 1981.
2 *Somphophragma miscellum* Playford 1981.
3 *Dictyotidium granulatum* Playford 1981.
5 *Helosphaeridium microclavatum* Playford 1981.
6 *Melikeriopalla venulosa* Playford 1981.
7 *Maranhites perplexus* Wicander & Playford 1985.
8 *Unellium piriforme* Rauscher 1969.
9 *Cymatiosphaera adaiochorata* Wicander 1974.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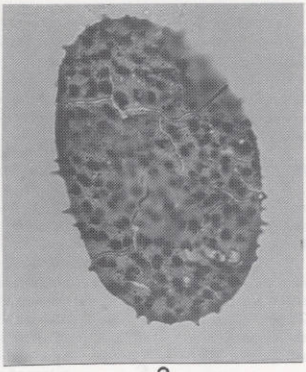
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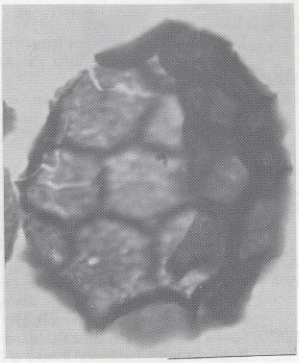
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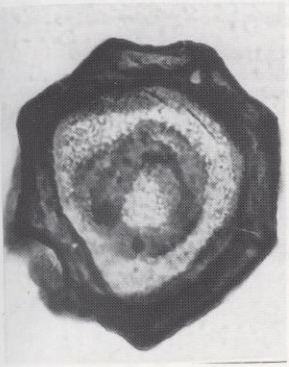
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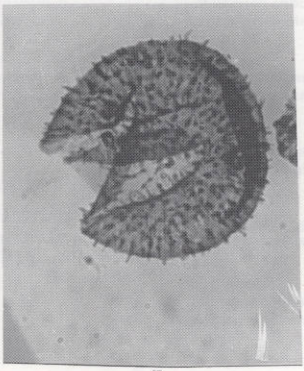
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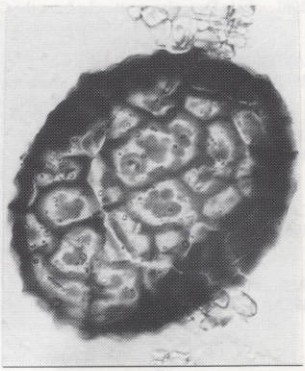
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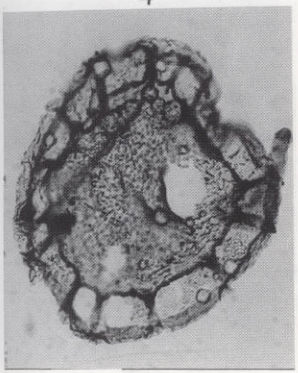
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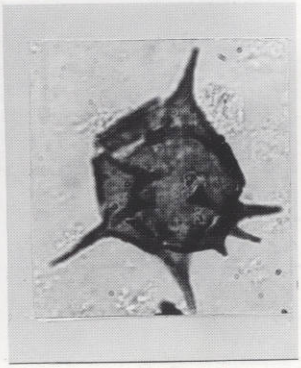
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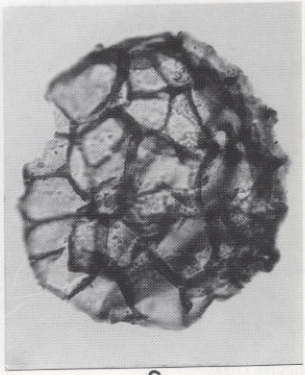
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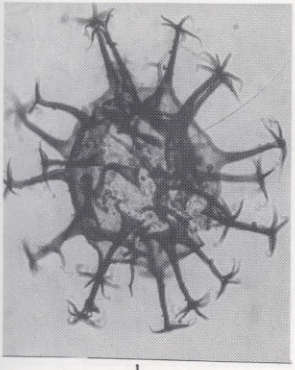
PLATE 3

All figures x1000.

1 *Ammonidium loriferum* (Deunff 1965) Lister 1970.
2 *Lophosphaeridium deminutum* Playford 1981.
3 *Stellinium micropolygonale* (Stockmans & Williéré 1960) Playford 1977.
4 *Gorgonisphaeridium ohioense* Winslow 1962.
5 *Unellium piriforme* Rauscher 1969.
6 *Polyedryxium pharaonae* Deunff 1954.
7 *Stellinium comptum* Wicander & Loeblich, Jr. 1977.
8 *Veryhachium pannuceum* Wicander & Loeblich, Jr. 1977.
9 *Multiplicisphaeridium amitum* Wicander & Loeblich, Jr. 1977.



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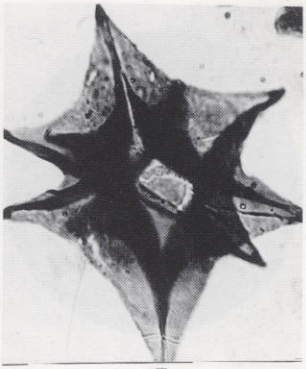

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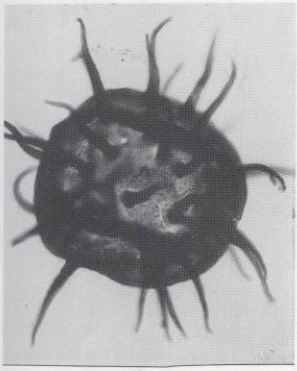

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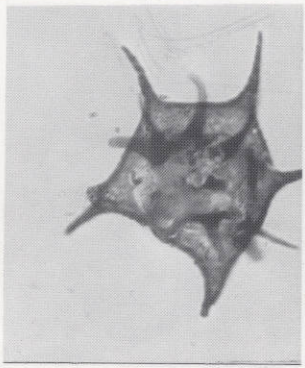

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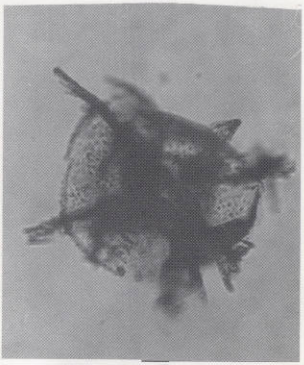

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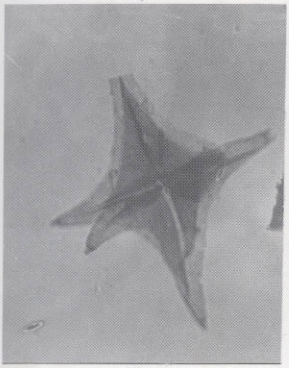

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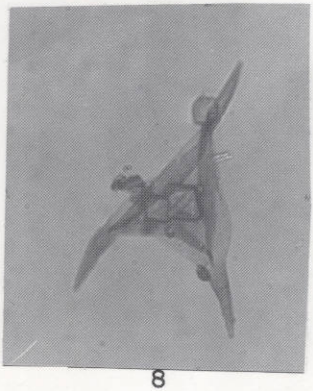

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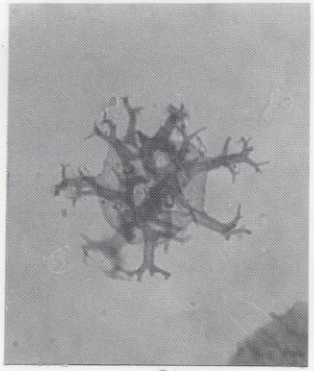

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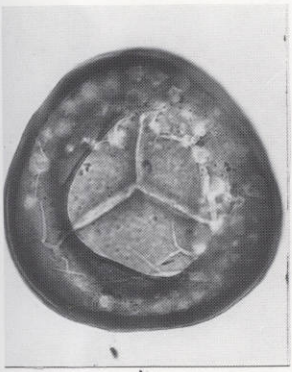
PLATE 4

All figures x1000.

1 *Retusotriletes distinctus* Richardson 1965.
2 *Geminospora lemurata* Balme 1962.
3 *Cyclogranisporites isostictus* Balme 1988.
4, 7 *Retusotriletes phillipsii* Clendening et al. 1980.
5 *Retusotriletes rotundus* Streel 1967.
6 *Dibolisporites turriculatus* Balme 1988.
8 *Geminospora lemurata* Balme 1962.
9 *Retusotriletes pychovii* Naumova 1953.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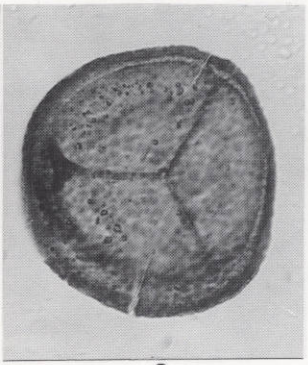
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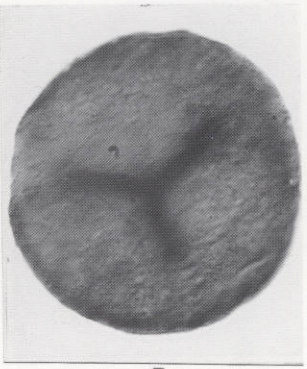
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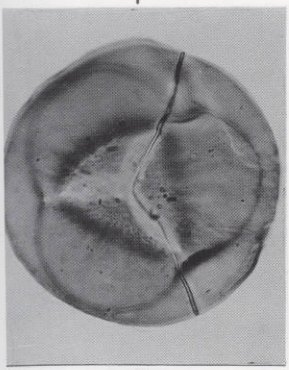
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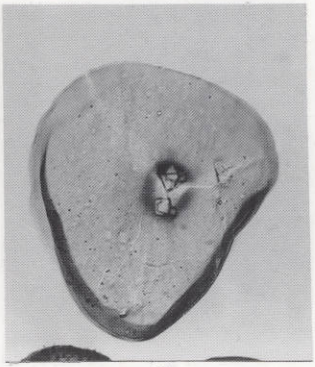
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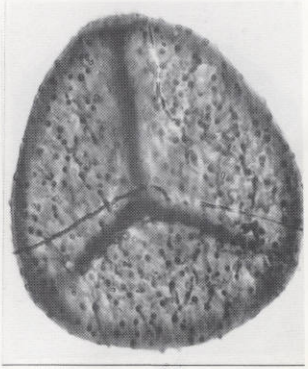
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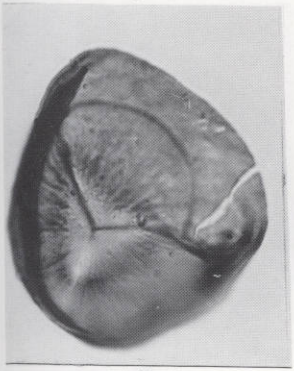
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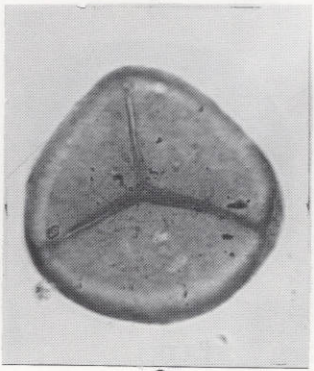
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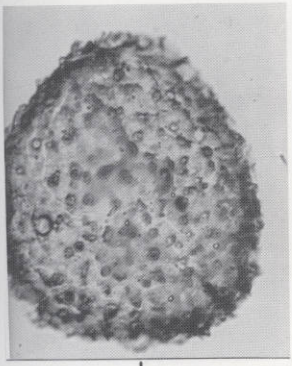
PLATE 5

All figures x1000.

1 *Lophozonotriletes somphus* Balme 1988.
2 *Grandispora famenensis* (Naumova 1953) Streel 1986.
3 *errucosisporites confertus* Owens 1971.
4 *Dictyotriletes sphaericus* Kimyai 1979.
5, 6 *Verrucosisporites scurrus* (Naumova 1953) McGregor & Camfield 1982.
7 *Stenozonotriletes formosus* Naumova 1953.
8 *Emphanisporites rotatus* McGregor 1961.
9 *Grandispora fibrilata* Balme 1988.



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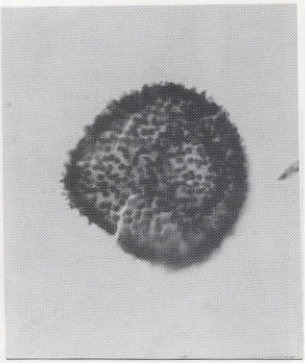

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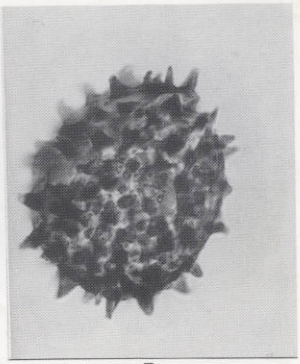

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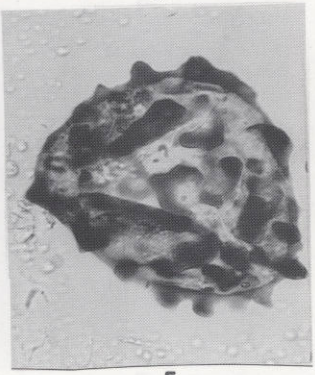

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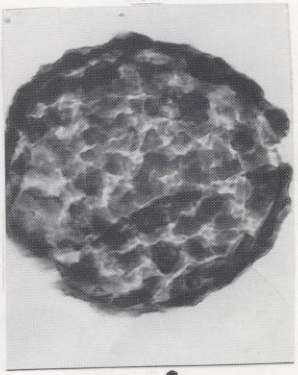

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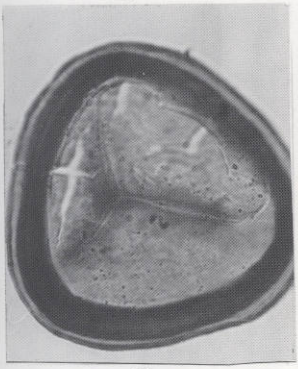

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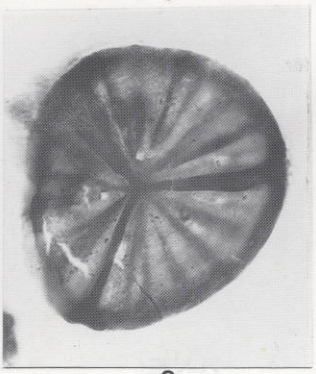

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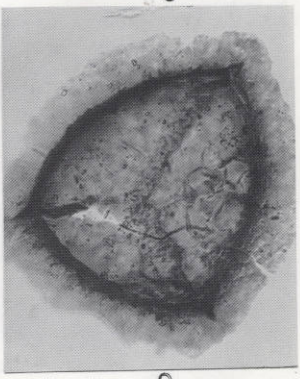

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PLATE 6

All figures x1000.

1 *Grandispora echinata* Hacquebard 1957.
2 *Vallatisporites pusillites* (Kedo 1963) Dolby & Neves 1970.
3 *Hymenozonotriletes perplexa* Balme & Hassel 1962.
4 *Diducites macronatus* (Kedo 1963) emend. Van Veen 1981.
5, 7 *Archaeoperisaccus scabratus* Owens 1971.
6 *Retispora lepidophyta* (Kedo 1963) Playford 1976.
8 *Contagnisporites optivus* (Chibrikova) Owens 1971.
9 *Samarisporites triangulatus* Allen 1965.


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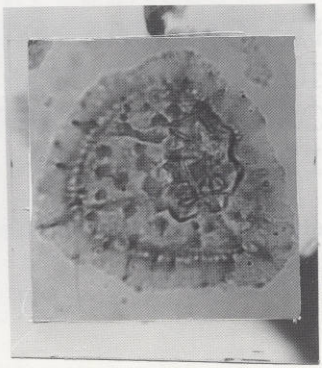
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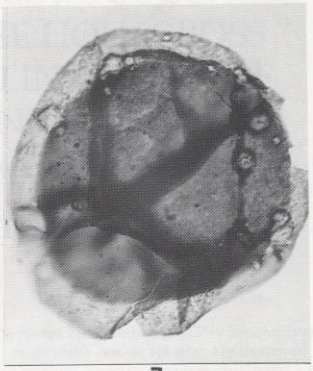
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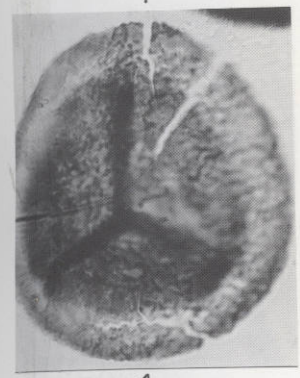
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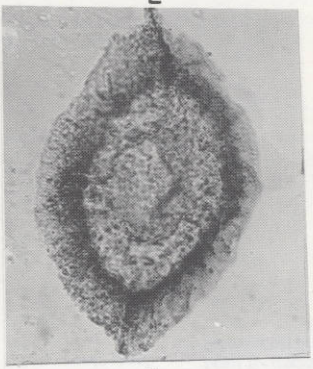
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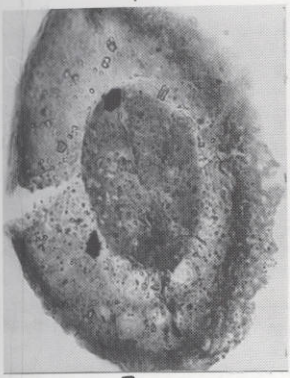
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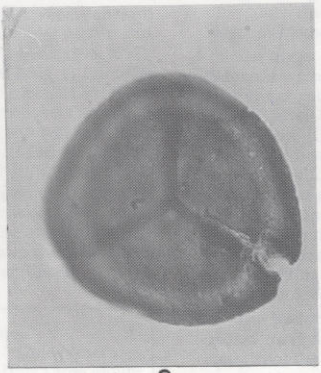
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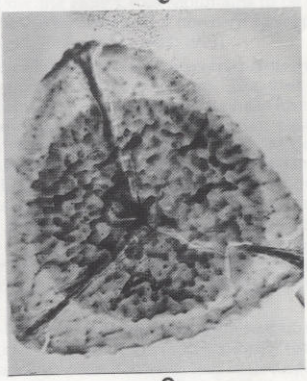
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