INTRODUCTION

The Koppeh Dagh (a.k.a. Kopet Dagh) Basin comprises a substantial sedimentary succession east of the Caspian Sea, stretching from Turkmenistan across Iran into Afghanistan. In the three states, huge gas reserves are known to occur in Jurassic-Cretaceous sediments of the basin. The Iranian sector (Koppeh Dagh Range), with an aerial extent of about 55000 km², is a mountainous area located in the northeast of the country. A thick pile (up to 6000m) of predominantly marine sedimentary rocks mostly of Mesozoic and Cenozoic age constitutes the rock succession that was gently folded during the late Alpine Orogeny (Stöcklin 1968). The Middle Jurassic marine siliciclastic strata of Koppeh Dagh (Kashafrud Formation) are characterized chiefly by alternating grey to black sandstones and shales attributed to the Middle Jurassic (Bajocian-Bathonian), hitherto on the basis of faunal evidence. The appearance of a key miospore species, Contignisporites burgeri, within the succession has been used to attribute a late Bajocian age and early Bathonian age to the lower and upper parts of the studied interval, respectively.

Inferred natural relationships of the miospores imply derivation from a diverse parental flora of Pterophyta and gymnosperms, such as Coniferophyta, Cycadophyta, and Ginkgophyta, growing under warm, humid conditions during the Bajocian-Bathonian. The associated marine fauna (ammonites), marine palynomorphs (proximate dinoflagellate cysts, and acritarchs such as Micrhystridium), and foraminiferal test linings, along with terrestrial palynomorphs (spores and pollen) collectively indicate an open marine, nearshore depositional setting for the Kashafrud Formation at the section studied.

GEOLOGICAL SETTING AND STRATIGRAPHY

Of the major tectonostratigraphic entities recognized in Iran by Stöcklin (1968), the Koppeh Dagh Basin, located in northeastern Iran (text-fig. 1), consists of a notably thick and conformable Mesozoic-Tertiary succession. Steady subsidence of the Koppeh Dagh Trough began in Late Triassic time and marine sedimentation commenced shortly thereafter in the Jurassic and continued, albeit with some breaks, until the Oligocene. The base of the Koppeh Dagh succession is exposed only in the eastern part of the basin in Iran where the Kashafrud River erodes gently domed beds down to the pre-Jurassic basement. The basement is exposed over an area known as the erosional window of Aghdarband (ESE of Mashhad) with an aerial extent of ca. 300km². In this area, Goldschmidt (1956) recognized the prominent angular unconformity separating the pre-Jurassic basement from the overlying predominantly marine deposits. He introduced the name Kashafrud Formation for the lowermost Jurassic unit of the Koppeh Dagh succession. However, due to notable lateral lithofacies variations (Poursoltani et al. 2007), the name is best restricted to eastern parts of the Koppeh Dagh Basin (Afshar Harb 1979).

Diverse and moderately well-preserved palynofloras occur in Middle Jurassic sediments of the Kashafrud Formation at the Senjedak section, southeast of Mashhad, northeastern Iran, Trilete and monolete spores and pollen dominate the assemblages, whereas dinoflagellate cysts, foraminiferal test linings, and fungal spores are minor components. Forty-seven species of spores (30 genera) and 15 species of pollen (eight genera) are identified. Representatives of Dictyophyllidites and Klukisporites are particularly abundant.

Based on the stratigraphic distribution of miospores, three distinctive stratigraphically successive palynofloras informally termed in ascending order, Assemblages A, B, and C are identified within the Kashafrud Formation. These are compared with palynozones known from Iran and elsewhere. Based on the presence of certain miospore species, the Kashafrud palynofloras are collectively dated as Middle Jurassic (Bajocian-Bathonian), thus corroborating the faunal (ammonoid) evidence. The appearance of a key miospore species, Contignisporites burgeri, within the succession has been used to attribute a late Bajocian age and early Bathonian age to the lower and upper parts of the studied interval, respectively.

Inferred natural relationships of the miospores imply derivation from a diverse parental flora of Pterophyta and gymnosperms, such as Coniferophyta, Cycadophyta, and Ginkgophyta, growing under warm, humid conditions during the Bajocian-Bathonian. The associated marine fauna (ammonites), marine palynomorphs (proximate dinoflagellate cysts, and acritarchs such as Micrhystridium), and foraminiferal test linings, along with terrestrial palynomorphs (spores and pollen) collectively indicate an open marine, nearshore depositional setting for the Kashafrud Formation at the section studied.

ABSTRACT: Diverse and moderately well-preserved palynofloras occur in Middle Jurassic sediments of the Kashafrud Formation at the Senjedak section, southeast of Mashhad, northeastern Iran, Trilete and monolete spores and pollen dominate the assemblages, whereas dinoflagellate cysts, foraminiferal test linings, and fungal spores are minor components. Forty-seven species of spores (30 genera) and 15 species of pollen (eight genera) are identified. Representatives of Dictyophyllidites and Klukisporites are particularly abundant.

Based on the stratigraphic distribution of miospores, three distinctive stratigraphically successive palynofloras informally termed in ascending order, Assemblages A, B, and C are identified within the Kashafrud Formation. These are compared with palynozones known from Iran and elsewhere. Based on the presence of certain miospore species, the Kashafrud palynofloras are collectively dated as Middle Jurassic (Bajocian-Bathonian), thus corroborating the faunal (ammonoid) evidence. The appearance of a key miospore species, Contignisporites burgeri, within the succession has been used to attribute a late Bajocian age and early Bathonian age to the lower and upper parts of the studied interval, respectively.

Inferred natural relationships of the miospores imply derivation from a diverse parental flora of Pterophyta and gymnosperms, such as Coniferophyta, Cycadophyta, and Ginkgophyta, growing under warm, humid conditions during the Bajocian-Bathonian. The associated marine fauna (ammonites), marine palynomorphs (proximate dinoflagellate cysts, and acritarchs such as Micrhystridium), and foraminiferal test linings, along with terrestrial palynomorphs (spores and pollen) collectively indicate an open marine, nearshore depositional setting for the Kashafrud Formation at the section studied.

INTRODUCTION

The Koppeh Dagh (a.k.a. Kopet Dagh) Basin comprises a substantial sedimentary succession east of the Caspian Sea, stretching from Turkmenistan across Iran into Afghanistan. In the three states, huge gas reserves are known to occur in Jurassic-Cretaceous sediments of the basin. The Iranian sector (Koppeh Dagh Range), with an aerial extent of about 55000 km², is a mountainous area located in the northeast of the country. A thick pile (up to 6000m) of predominantly marine sedimentary rocks mostly of Mesozoic and Cenozoic age constitutes the rock succession that was gently folded during the latest Alpine Orogeny (Stöcklin 1968). The Middle Jurassic marine siliciclastic strata of Koppeh Dagh (Kashafrud Formation) are characterized chiefly by alternating grey to black sandstones and shales attributed to the Middle Jurassic (Bajocian-Bathonian), hitherto on the basis of faunal evidence. This includes foraminifera (Kalantari in Afshar Harb 1979) and ammonites (Madani 1977, Seyed-Emami et al. 1994, 1996). The latter are enclosed in calcareous nodules found abundantly at various horizons of the Kashafrud Formation (Madani 1977).

Striking superficial similarities have already been noted (e.g., Stöcklin 1972, Afshar Harb 1979) between the Kashafrud Formation and the coal-bearing sediments of north and central Iran generally known as the Shemshak Formation (upper Upper Triassic-Middle Jurassic). The latter or its correlatives in north and central Iran have already been studied palynologically (Arjang 1975, Kimyai 1975, 1977, Achilles et al. 1984, Bharadwaj and Kumar 1986, 1988). However, despite of its potential palynologically. Madani (1977) incidentally recorded some Middle Jurassic miospores from the Kashafrud Formation at the Baghbaghou section, southeast of Mashhad. This contribution is the first detailed palynological investigation of the Middle Jurassic of northeastern Iran. The purpose of this study is to document the palynological content of the Kashafrud Formation at the section studied and to assess its stratigraphic and palaeoecological significance.
The Kashafrud Formation, representing the transgressive upper Bajocian sediments in northeastern Iran (Seyed-Emami and Alavi-Naini 1990), is a relatively thick, partly turbiditic succession developed at the southeastern margin of the Koppeh Dagh Basin (Madani 1977, Afshar Harb 1979, Poursoltani et al. 2007). It represents rapid infilling of an apparently deep and narrow sedimentary basin formed as the result of transform and rotational movements at the conjunction of the Alborz and east-central Iran microplates with the southern margin of the Turan Plate (Seyed-Emami et al. 1994, Poursoltani et al. 2007) along the northern Iran Suture (Davoudzadeh and Schmidt 1982).

At the Baghbaghou type section, the Kashafrud Formation comprises ca. 1800m of clastic sediments that unconformably (Madani 1977) overlie the Triassic Aghdarband Group (Ruttner 1991) and is unconformably underlain by Upper Jurassic carbonates of the Mozduran Formation. Madani (1977) divided the Kashafrud Formation into eight lithostratigraphic units.

Diverse and moderately well-preserved biota, including some allochthonous forms, is known from the formation (Madani 1977). The invertebrate fauna comprises brachiopods, corals, echinoderms, molluscs, and sponges; other fossils include foraminifers, plant mega- and microfossils, woody debris, and ichnofossils. The last-named suggest that the turbidites of the Kashafrud Formation accumulated in a marine setting up to ca. 1000m deep (Madani 1977).

In the section investigated, southeast of Mashhad and southeast of Senjedak (text-fig. 1), the formation is more than 1600m thick and consists of a thick basal conglomerate followed by alternating green-grey sandstones and shales. It succeeds with distinct non-conformity the Permian Mashhad Ophiolites and alternating green-grey sandstones and shales. It succeeds with distinct non-conformity the Permian Mashhad Ophiolites and unconformably underlies red clastics associated with minor limestone and gypsum intercalations of the Upper Jurassic-Lower Cretaceous Shurijeh Formation (text-fig. 2).

**MATERIAL AND METHODS OF STUDY**

Seventy-four samples were collected from the Kashafrud Formation exposure at the Senjedak section, southeast of Mashhad, northeastern Iran (text-fig. 2). The palynologically more productive samples are mainly from the upper part of the formation (ca. 450m thick). The data presented herein about relative abundance of some taxa is based on semiquantitative assessment of microscope slides of the productive samples. Standard palynological procedures (e.g., Phipps and Playford 1984, Wood et al. 1996) were utilized for extraction and concentration of the palynomorphs. Promising samples were initially disaggregated into pea-sized lumps (1-2mm in diameter) and treated with 10-50% HCl to remove carbonates. The residue was then washed to neutrality and remaining inorganic matter dissolved in boiling HF (ca. 40%); fluoride precipitants formed during this step were removed using hot 50% HCl followed by washing the residue to neutrality. No oxidation was necessary as the palynomorphs were of low thermal maturity (T.A.I. = 2 to 3, according to the scheme of Traverse 1988). The organic residue was sieved via a 20µm mesh. Unwanted fine debris was separated by use of heavy-liquid solution (ZnCl₂) at appropriate specific gravity. At least three permanent strew slides per sample were prepared using Canada balsam as the mounting medium and polyvinyl alcohol to facilitate dispersion of the residue. An Olympus BH-2 microscope of the School of Geology, College of Science, University of Tehran, equipped with mechanical stage and automatic Leitz camera facility, was employed for light microscopy and 35mm photography. All rock samples, residues, and strew slides used in this investigation are permanently housed in the Palynology Collection (UPTC) at the School of Geology, College of Science, University of Tehran. Slide locations of all figured specimens are specified in the plate explanations as follows: rock sample field number (e.g., AD-55), preparation- letter-designated slide (e.g., Ad-63f), mechanical stage coordinates per standard “England Finder” slide (e.g., P37/4), and registered specimen number.

**REVIEW OF PREVIOUS PALYNOLOGICAL STUDIES ON THE JURASSIC OF IRAN**

Much potential exists for palynological studies of Mesozoic sequences in Iran (Hashemi and Playford 1998, p. 118), especially for the Triassic and Jurassic strata. Palynological investigations of Jurassic sediments have already been accomplished (e.g., Kimyai 1968, 1974, Arjang 1975, Achilles et al. 1984, Bharadwaj and Kumar 1986, 1988) in various parts of the country. Jurassic palynomorphs, particularly miospores, from north and central Iran are comparatively better documented. In central Iran, investigations have focused exclusively on the coal-bearing Jurassic strata around Kerman, east-central Iran.

In a pioneering study of Iranian Mesozoic strata, Kimyai (1968, 1974) described relatively diverse terrestrial palynofloras from coal-bearing Lower and Middle Jurassic sediments of northwestern Kerman. The palynofloras were considered to share certain elements with those reported from England, Australia, and India (cf. Bharadwaj and Kumar 1986, p. 169). It was further concluded that the assemblages were produced mainly by Pterophyta (ferns), Cycadophyta, and Ginkgophyta, occupying the vicinity of non-marine shallow water settings and thriving under a warm-temperate climate. Tabibian (1974) sampled the coal-bearing deposits of northeastern Kerman over a wider area and obtained more diverse palynofloras extending the lower boundary of this rock succession down to the latest Triassic (Rhaetian). He suggested that a semi-arid to warm-temperate climate prevailed during the latest Triassic-Middle Jurassic in the area studied.

Arjang (1975) extensively sampled the coal-bearing deposits of Kerman through several stratigraphic sections dated as Rhaetian, Liassic, and Dogger. The palynofloras comprised some 100 miospore species; their vertical distributions led to the designation of two miospore assemblage zones within the host strata. In ascending order, these are the Concavisporites assemblage-zone, dated as Rhaetian-Liassic (subdivided into the C. kermanense and C. kaiseri subzones, dated respectively as Rhaetian and Liassic); and the Klukisporites variegatus assemblage-zone attributed to the Dogger. He advocated that the boundary between the two zones coincided with proliferation of the fern Klukiella exilis (Phillips) Raciborski 1890.


Palynological investigation in the Alborz Mountains in the northern part of the country has been conducted on near-coeval and mostly coal-bearing sediments similar to those in central Iran.
In an unpublished MSc thesis, Jameossanaie (1973) reported terrestrial palynofloras in Lower-Middle Jurassic coal-bearing sediments of Shahrud in the eastern Alborz Mountains. He concluded that the flora, dominated by Pterophyta, Cycadophyta, Ginkgophyta, and Coniferophyta, flourished in a warm-temperate climate around a non-marine shallow-water situation. Kimyai (1975), however, envisaged a Late Triassic-Middle Jurassic age for the same interval on the basis of combined palynological and lithological resemblances with ±coeval strata (Shemshak Formation) in northern Iran.

Achilles et al. (1984) described miospores from the Mesozoic (Norian-Dogger) strata of Zangerud (a.k.a. Sangerud; in the western Alborz Mountains), Zirab (northern central Alborz), and Tazareh (eastern Alborz) and introduced several miospore zones.

Bharadwaj and Kumar (1988) reported Early Jurassic miospores from the Alasht Series, Zirab area, in the central Alborz Mountains. They concluded that the palynoflora correlated with Assemblage A of Bharadwaj and Kumar (1986) from upper Lower Jurassic deposits of Hojedk, north of Kerman. This was supported by the fact that Pterophyta, Cycadophyta (Bennettitales), and Ginkgophyta (Ginkgoales) dominated the vegetation in both regions (Bharadwaj and Kumar 1986, p. 169).

Wheeler and Sarjeant (1990) sampled several Mesozoic successions in northern and western Iran and recorded palynofloras.
dominated by dinoflagellate cysts of Jurassic and Late Cretaceous age from one section in the central Alborz Mountains.

Palynological potential exists in the Mesozoic of Zagros and Koppeh Dagh areas of southwestern and northeastern Iran, respectively. However, no publications are as yet available on the Jurassic strata of either area. In an unpublished account, Madani (1977) recorded a few Jurassic miospores from the Kashafrud Formation at its type section, southeast of Mashhad, northeastern Iran. The present study is, therefore, the first detailed palynological investigation on the Jurassic deposits of the Koppeh Dagh Basin.

COMPOSITION AND STRATIGRAPHIC SIGNIFICANCE OF THE KASHAFRUD PALYNOFLORA

A general summary of the qualitative and quantitative features of the palynofloral assemblages retrieved mostly from the upper part of the Kashafrud Formation is given henceforth. This is followed by comparisons with approximately coeval palynofloras reported from within and beyond Iran, and finally a discussion of the age of the formation based on the palynological data herein.

PALYNOFLORAL COMPOSITION

Palynologically productive samples are generally confined to the upper part of the Kashafrud Formation at the section studied, few palynomorphs (mostly miospores and acritarchs) from the lower part of the formation. Most of the palyniferous samples contain miospores and marine palynomorphs (acritarchs and foraminiferal test linings) in moderate to good states of preservation; less diverse dinoflagellate cysts also occur intermittently in some of the productive samples but these are rather poorly preserved and identifiable only at generic level. In quantitative terms, the samples are dominated by land-derived palynomorphs, in common with other Iranian Jurassic assemblages. However, the Kashafrud Formation assemblage is distinct in containing the marine elements.

The Kashafrud samples contain 47 species of spores (30 genera) and 15 species of pollen (eight genera) (Appendix). Relative abundances of miospore species vary considerably; however, species of Dictyophyllidites and Klukisporites are particularly abundant. Text-fig. 3 shows the stratigraphic distribution of certain miospore species of known stratigraphic value and/or persistence throughout the section studied.

TEXT-FIGURE 2 →
Lithostratigraphic column of the Kashafrud Formation, Senjedak section, southeast of Mashhad.
TEXT-Figure 3
Distribution of miospore species through the succession sampled and proposed palynostratigraphic units of the Kashafrud Formation at the Senjedak section.
The spores are predominantly radiosymmetrical and trilete. They are dominantly laevigate taxa attributable to either *Cyathidites* or *Dictyophyllidites* and the foveo-reticulate species *Klukisporites variegatus* (here and elsewhere in the ensuing text an asterisk denotes the first citation of taxa illustrated in Plates 1 and 2). Only one monolete spore (*Laevigatosporites ovatus*) has been encountered. The pollen comprise saccate (mono-, di-, and trisaccate), alete, and monosulcate taxa.

Marine palynomorphs in the Kashafrud assemblage embrace sparse, poorly preserved, proximate dinoflagellate cysts, a morphologically simple, long-ranging acritarch (*sensu stricto*) species (Appendix), and foraminiferal test linings indicating the phytoliths are associated with *Callialasporites trilobatus*. Following the same rationale, *Dictyophyllidites mortonii* and the foveo-reticulate species enable identification of three informal, successive and are associated with *Callialasporites trilobatus* and *Punctatosporites scabratius*, both of which appear higher in the succession. The lower and upper stratigraphic limits of Assemblage A occur, respectively, at 103 and 1170m above the base of the section studied, i.e., the assemblage extends through 1067m of the Kashafrud Formation. Text-fig. 3 shows that only *Callialasporites trilobatus* is virtually exclusive to Assemblage A, whereas the other species extend into the overlying assemblages. The sole representative of acritarchs in the palynofloras studied, *Micrhystridium* sp. first appears near the lower limit of Assemblage A and then persists intermittently upward throughout the Kashafrud Formation.

**Assemblage B**

This assemblage, occurring through 261m of the section studied, is defined by the co-occurrence of the following species: *Alisporites similis*, *Apiculatisporis* sp., *Araucariacites australis*, *Callialasporites dampieri*, *Convolutispora prisca*, *Cyathidites australis*, *Cycadopites follicularis*, *Dictyophyllidites harrissii*, *Limbosporites* sp. cf. *L. lundbladiae*, *Neoraistrickia truncata*, *Platsaccus queenslandi*, *Podocarpidites astrictus*, and *Striatella seebergensis*. Except for *Convolutispora prisca*, all these species make their first appearance concomitantly at the lower stratigraphic boundary of Assemblage B. As evident from text-fig. 3, *Apiculatisporis* sp. and *Neoraistrickia truncata* are the only two species solely occurring in Assemblage B, whereas the other species extend into the succeeding Assemblage C. It should also be noted that *Callialasporites trilobatus* disappears slightly above the lower limit of Assemblage B. This assemblage is also characterized by more persistent occurrence of poorly preserved, proximate dinoflagellate cysts occurring close to the stratigraphic base of Assemblage B and ranging, in association with *Micrhystridium* sp., into the overlying Assemblage C.

**Assemblage C**

Introduction and proliferation of distinctively sculptured (murornate, cingulate, and apiculate) spores (e.g., *Retitriletes* Van der Hammen ex Pierce emend. Döring et al. 1963, *Murospora* Somers 1952, and *Concavissimispories* Delcourt and Sprumont emend. Delcourt et al. 1963) within the section studied mark the lower limit of this assemblage. Moreover, circum- and polysaccate pollen (*Corollina Maljavkina* emend. Cornet and Traverse 1975 and *Microcachryidites* Cookson ex Couper 1953) appear somewhat above the base of Assemblage C. The stratigraphic top of Assemblage C corresponds with the uppermost sample of the section studied. That is, Assemblage C extends through 220m of the Kashafrud Formation. This assemblage is distinguished by the incoming of miospores such as: *Alisporites grandis*, *A. lowoodensis*, *Anapiculatisporis* sp. A, *Biretisporis* sp. B, *Callialasporites segmentatus*, *Concavissimispories verrucosus*, *Corollina* sp., *Cyathidites mi-
nor, C. rafaelii, Cycadopites crassimarginis*, Microcachryidites antarcticus, Murospora florida, Neoraistrickia equalis, Osmundacidae senectus*, Retitriletes clavatoides*, Retitriletes sp. cf. R. austroclavatidites, Retitriletes sp. cf. R. singhii*, Stereisporites sp. cf. S. psilatus, Stereisporites sp., Todisporites major, and Trilobosporites antiquus. These species first appear at, or slightly above, the assemblage base. Additionally, the following species occur in Assemblage C:


The associated dinoflagellate cysts (Appendix) occurring in Assemblage C are poorly diversified and indifferently preserved and the majority of taxa are identifiable only at generic level. These include three shared genera, viz. Nannoceratopsis, Gonyaulacysta, and Pareodinia, with dinoflagellate cysts reported from the Middle Jurassic of northern Iran (Wheeler and Sarjeant 1990).

CORRELATION AND AGE OF THE KASHAFRUD ASSEMBLAGES

Palynological investigations undertaken in Iran have so far been concerned largely with relative age determination. Of these, few (Arjang 1975, Achilles et al. 1984, Bharadwaj and Kumar 1986) have attempted miospore subdivision of the Jurassic strata in either north or central Iran. Arjang (1975) advocated that the range top of Concavissimisporites (Dictyophyllidites) and the inception of Klukisporites (Klukisporites assemblage zone and Klukisporites variegatus assemblage subzone) signifies the Early-Middle Jurassic (Liassic-Dogger) boundary (text-fig. 4) in the coal-bearing sediments of the Kerman Basin, southeastern Iran. Such apparent distinction in the stratigraphic distribution of these genera is not supported herein because they co-occur almost at the base of the section studied (see text-fig. 3).

Assemblage A can be compared with the Klukisporites variegatus assemblage subzone of Arjang (1975). The two have three genera, namely Klukisporites, Callialasporites Sukh Dev 1961, and Dictyophyllidites (Concavissimisporites) and only one species (Klukisporites variegatus) in common. It should also be noted that several species of the Klukisporites variegatus assemblage subzone appear higher in the section investigated and are included in either Assemblage B or Assemblage C herein. These, co-occurring with Klukisporites variegatus in the study material, include Cyathidites australis, C. minor, Neoraistrickia...
truncata, Osmundacidites wellmanii, Retiritiletes (Lycopepodiumsporites) clavatoideis, and Todisporites minor (see text-fig. 3).

The Lower-Middle Jurassic strata of the Kerman Basin have been subdivided on the basis of their miospore content (Bharadwaj and Kumar 1986). They introduced, within the uppermost Liassic-Dogger coal-bearing sediments of northeastern Kerman, three miospore assemblage zones (A-C) primarily on the respective abundances of Dictyophyllidites, Cyathidites, and Klukisporites (text-fig. 5). Klukisporites variegatus was specified as being confined to their Assemblage C (Bharadwaj and Kumar 1986, p. 168). The Kashafrud palynofloras of the present study are generally comparable with Assemblage C of Bharadwaj and Kumar (1986). It should be noted, however, that Gleicheniidites senonicus (Iranicus), which appears exclusively in the uppermost part of the section investigated, occurs in the Bharadwaj and Kumar (1986) Assemblage B. Contrary to Arjang’s (1975) biostratigraphic scheme (text-fig. 4), Bharadwaj and Kumar (1986) did not consider Klukisporites variegatus as a useful index fossil for locating the Lower-Middle Jurassic boundary in the Kerman Basin.

Achilles et al. (1984) introduced several miospore zones covering the Upper Triassic-Middle Jurassic succession of northern Iran. Following Arjang (1975) and Ashraf (1977), they (p. 73) located the Lower-Middle Jurassic boundary based on the inception of Klukisporites (Ischysporites) variegatus and the range top of Concavispores Pflug in Thomson and Pflug 1953. Their Duplexisporites problematicus-Klukisporites (Ischyosporites) variegatus-Leptolepidites argenteaformis Zone is broadly comparable with the present Assemblage C, with three shared species, viz., Klukisporites (Ischysporites) variegatus, Alisporites grandis, and Contigniisporites burgeri (cooksioniæ). Beyond Iran, a number of miospore zonation schemes have subdivided Jurassic strata in Afghanistan, Australia, and northwest Europe. Of these, only a few are consistently applicable to correlation over a wide area (Batten 1996, p. 752).

Ashraf (1977) introduced five miospore zones in the terrestrial Rhaetian-Jurassic sediments of northern Afghanistan. He adopted a sudden compositional change, i.e., the range top of Concavispores, and first appearance of Klukisporites (Ischysporites) variegatus, to locate the Liassic-Dogger boundary. His Klukisporites (Ischysporites) variegatus-Contigniisporites verrucosus (Duplicisporites problematicus) Zone is closely comparable with the Kashafrud palynofloras discussed herein, as both key species of the former have been positively identified within the material studied.

Of miospore zonal subdivisions of the Jurassic strata in northwest Europe (summarized by Koppelhus and Batten 1996, p. 788, text-fig. 7), some (e.g., Schweitzer et al. 1987) are either inadequately defined for stratigraphic purposes or have only local application; the zones are indicative of short time intervals (Batten 1996). Provincialism, latitudinal zonation, diachronous ranges, and different taxonomic approaches are thought to impede long-distance correlation of most of the European Jurassic spore zones (Batten 1996, Batten and Koppelhus 1996).

The Callialasporites-Perinopollenites Zone was introduced to designate the Middle Jurassic strata of northwestern Europe (Dybkaer 1991). The Kashafrud palynofloras share Callialasporites (four species) and Corollina with the Callialasporites-Perinopollenites Zone. Other key elements of the latter, however, have not been recorded in the material studied. However, Perinopollenites elatoides Couper 1958 is known from the Middle Jurassic strata of southeastern Iran, Kerman (Kimyai 1968) and the Alborz Mountains, northern Iran (Achilles et al. 1984).

Several predominantly miospore-stratigraphic schemes (summarized by McKellar 1998, pp. 312-316, fig. 10, Sajjadi and Playford 2002, p. 141, text-fig. 2) have been established in various Australian basins containing predominantly terrestrial Jurassic deposits. Comparison of the Kashafrud palynofloras with the Australian Jurassic zones is possible only in broad terms. Assemblages B and C combined are comparable with Microflora II of Balme (1957), the Dampieri Assemblage of Balme (1964), the Callialasporites dampieri Assemblage zone of Filatoff (1975), and the Callialasporites dampieri Superzone of Helby et al. (1987) and McKellar (1998). These broad scale palynozones embracing much of the Australian Jurassic have been further subdivided; however, dissimilar miospore content of the Australian and Iranian Jurassic strata disallows more detailed comparison. Shared species in the Middle Jurassic of the two regions include: Callialasporites dampieri, Camparozono-spores ramosus, Concaavissimispores verrucosus, Contignisporites burgeri, Converrucosissporites pricei, Dictyophyllidites harrisii, Murospora florida, Osmundacidites senectus, Phlebopterisporites equileanus, Retiritiletes facetus, Sellaspore asperata, Striatella seebergensis, and Tuberculatosporites westbournensis. The material studied thus shares certain miospore species with Middle Jurassic palynofloras reported from elsewhere. Accordingly, a Middle Jurassic age can be proposed for the section studied. This dating is supported by the ammonite evidence (Madani 1977, p. 85, Seyed-Emami et al. 1994, Hosseinioo 2005). For instance, Seyed-Emami et al. (1994) reported from the Senjedak section upper Bajocian ammonites including Cadomites sp., Calliphylloceras sp., Sphaeroceras bromniarti (Sowerby), and Leptosphinctes kitiae (Kakhadze and Zesashvili); the last two taxa are indicative of the Garantiana Zone.

Filatoff and Price (1988, fig. 1) appear to have defined the boundary between the Bajocian and Bathonian in Australian Middle Jurassic strata based on the introduction of Contignisporites burgeri. Applying the same criterion to the current material, the Bajocian-Bathonian boundary appears to occur 1513m above the base of the section investigated.

As indicated previously, the land-derived palynofloras discussed here are associated with a stratigraphically persistent but quantitatively and qualitatively far less significant aquatic palynomorphs including acritarchs and dinoflagellate cysts. However, the generally poor preservation of these marine elements frequently impedes confident identification at specific level; therefore, not pertinent to age determination and/or correlation of the present material.

PALAEOBOTANICAL AND PALAEOECOLOGICAL IMPLICATIONS

Palaeoenvironmental elucidation of the Middle Jurassic is based upon the palaeoecological and phytogeographic significance of the palynofloras identified and on the associated faunal and sedimentological evidence. However, some doubts regarding botanical affinity of dispersed miospores inhibit precise syntheses.

The natural alliances of the dispersed miospores are inferred on the basis of morphological similarities with those of extant

<table>
<thead>
<tr>
<th>Spores</th>
<th>Suggested affinity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Division Bryophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Stereisporites</td>
<td>Sphagnaceae</td>
</tr>
<tr>
<td><strong>Division Lycopodophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Apiculatisporis</td>
<td>Lycopodiaceae, Selaginellaceae</td>
</tr>
<tr>
<td>Neoraistrickia</td>
<td>Lycopodiaceae, Selaginellaceae</td>
</tr>
<tr>
<td>Retitrilettes</td>
<td>Lycopodiaceae, Selaginellaceae</td>
</tr>
<tr>
<td><strong>Division Pterophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Anapiculatisporites</td>
<td>Pterophyta/ Pteridophyta, incertae sedis</td>
</tr>
<tr>
<td>Bireisporites</td>
<td>Pterophyta/ Pteridophyta, incertae sedis</td>
</tr>
<tr>
<td>Camarozonosporites</td>
<td>Lycopodiaceae, Selaginellaceae</td>
</tr>
<tr>
<td>Concavissimisporites</td>
<td>Dicksoniaceae</td>
</tr>
<tr>
<td>Converrucosisporites</td>
<td>Dicksoniaceae</td>
</tr>
<tr>
<td>Coniognisporites</td>
<td>Pteridaceae</td>
</tr>
<tr>
<td>Convoluitispora</td>
<td>Botryopieridaceae, Zygopteridaceae, Marattiaceae</td>
</tr>
<tr>
<td>Cyathidites</td>
<td>Dipteridaceae, Dicksoniaceae, Cyatheaceae, Matoniaceae</td>
</tr>
<tr>
<td>Dictyophyllidites</td>
<td>Dipteridaceae, Dicksoniaceae, Cyatheaceae, Matoniaceae</td>
</tr>
<tr>
<td>Gleichenidites</td>
<td>Gleicheniaceae</td>
</tr>
<tr>
<td>Impardecispora</td>
<td>Dicksoniaceae</td>
</tr>
<tr>
<td>Klukisporites</td>
<td>Schizaceae</td>
</tr>
<tr>
<td>Laeavigatosporites</td>
<td>Pterophyta/Pteridophyta, incertae sedis</td>
</tr>
<tr>
<td>Murospora</td>
<td>Matoniaceae/Dipteridaceae</td>
</tr>
<tr>
<td>Osmundacidites</td>
<td>Osmundaceae</td>
</tr>
<tr>
<td>Sellasspora</td>
<td>Pterophyta/Pteridophyta, incertae sedis</td>
</tr>
<tr>
<td>Streitella</td>
<td>Pteridaceae</td>
</tr>
<tr>
<td>Todusporites</td>
<td>Osmundaceae</td>
</tr>
<tr>
<td>Trillicies</td>
<td>Schizaceae</td>
</tr>
<tr>
<td>Trilobosporites</td>
<td>cf. Pteridaceae</td>
</tr>
<tr>
<td>Tuberculatisporites</td>
<td>Pterophyta/Pteridophyta, incertae sedis</td>
</tr>
<tr>
<td><strong>Pollen</strong></td>
<td><strong>Suggested affinity</strong></td>
</tr>
<tr>
<td><strong>Division Coniferophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Araucariacies</td>
<td>Araucariaceae</td>
</tr>
<tr>
<td>Callialasporites</td>
<td>Araucariaceae</td>
</tr>
<tr>
<td>Corollina</td>
<td>Cheirolepidiaceae</td>
</tr>
<tr>
<td>Microcachyridites</td>
<td>Podocarpaceae</td>
</tr>
<tr>
<td>Podocarpidites</td>
<td>Podocarpaceae</td>
</tr>
<tr>
<td><strong>Division Cycadophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Cycadopities</td>
<td>Bennettiales, Cycadales</td>
</tr>
<tr>
<td><strong>Division Ginkgophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Cycadopisies</td>
<td>Ginkgoales</td>
</tr>
<tr>
<td><strong>Division Pteridospermophyta</strong></td>
<td></td>
</tr>
<tr>
<td>Alisporites</td>
<td>Corystospermaceae</td>
</tr>
<tr>
<td>Cycadopities</td>
<td>Peltaspermaceae</td>
</tr>
</tbody>
</table>
plants and/or the known contents of fossil fructifications of established natural affinities. The plant classification adopted herein is that of Scagel et al. (1965) and Meyen (1987). Botanical affinities of some taxa have been assigned with varying degrees of confidence; some to more than one major natural group (e.g., *Cycadopites* Wodehouse ex Wilson and Webster 1946), and others are more doubtfully assigned. Inferred botanical affinities have been obtained from several sources; e.g., Potonié (1962, 1967), Filatoff (1975), Dettmann (1986, 1994), Filatoff and Price (1988), de Jersey and Raine (1990), and Balme (1995).

Inferred relationships of the Kashafrud Formation’s palynofloras (text-fig. 6) imply contributions from a diverse land vegetation, notably, Pterophyta (particularly), Bryophyta, Lycopodophyta, and gymnosperms such as Coniferosphyta, Cycadophyta, Ginkgophyta, and Pteridospermophyta, that grew under humid, warm-temperate conditions during the Bajocian-Bathonian. Affinities of the dispersed conifer pollen appear to be with the Araucariaceae (*Callialaspores, Araucariacites* Cookson ex Couper 1953), Cheirolepidaeae (*Corollina*), and Podocarpaceae (*Podocarpidites* Cookson ex Couper 1953, *Microcachrydites*). Araucariacites and Microcachrydites are relatively minor components of the Kashafrud palynofloras.

The predominant pterophytes are represented by such families as the Dicksoniaceae, Gleicheniaceae, Matoniaceae, Osmunda-ceae, and Schizaceae. Three of the most common species are *Cyathidites australis*, *Dictyophyllidites mortoni* (with diverse fern affinities), and *Klukisporites variagatus*. At present, ferns are most widely developed in the tropics, but many also thrive in temperate regions. Cyatheaceae, Dicksoniaceae, Gleicheniaceae, Matoniaceae, and Schizaceae, for instance, flourish in both tropical and subtropical habitats (Tryon and Tryon 1982); Marattiaceae grow in wet tropical environments (Scagel et al. 1965, Tryon and Tryon 1982).

Lycopodophyta contributed few spores to the Kashafrud palynofloras. These include species of *Neorustrichia* Potonié 1956 and *Retiritiles*, which are morphologically compatible with extant *Lycopodium*. L. 1753 and *Selaginella* P. Beauv. 1804. *Lycopodium* flourishes mainly in the tropics (Tryon and Tryon 1982) and *Selaginella* lives in mesic environments (Balme 1995).

Bryophyta (mosses, hornworts, and liverworts) comprise a minor component of the studied assemblages. At present, bryophytes are most abundant in moist terrestrial conditions (Taylor and Taylor 1993). Pteridospermophyta are represented palynologically by two families (Corystospermaceae and Peltaspermaeaceae) which produced monosulcate and bisaccate pollen. *Cycadopites* has not only been attributed to the Pteridospermophyta but also to the Cycadophyta and Ginkgophyta (Balme 1995). Comparison of relative abundances of marine palynomorphs vs terrestrial microfossils (spores and pollen) is a conventional approach for inferring palaeoshoreline proximity (Sarmiento 1957, Upshaw 1964, Gray and Boucot 1972). Normally, abundance and diversity of land-derived palynomorphs, in contrast to microphytoplankton, demonstrate shallow, nearshore environment.

In the current material, the land-derived palynomorphs (spores and pollen) are associated with a subordinate but palaeoecologically important aquatic component (acritarchs such as *Mierhystridium* Deflandre 1937, proximate dinoflagellate cysts, and foraminiferal test linings); collectively indicating an open marine, nearshore depositional setting for the Kashafrud Formation at the section studied (text-fig. 7). Dinoflagellate cysts occur sporadically in the alternating sandstones and shales of the Kashafrud Formation, southeast of Senjedak.

Various factors including light, temperature, salinity, nutrient supply, feeding strategy, upwelling, tidal influence, pollution, and grazing appear to control dinoflagellate cysts growth and distribution (Taylor 1987). The rather poor state of preservation of dinoflagellate cysts and their low diversity and concentration obviously hinders the meaningful application of this biostratigraphically and palaeoecologically significant palynomorphs (Stover and Williams 1982) in the current study. Therefore, the relative effects of the above variants is difficult to ascertain and only generalized deductions are possible regarding the palaeoenvironment in which the sediments of the Kashafrud Formation were deposited. Dinoflagellate cysts are most abundant in rocks deposited in middle neritic to upper bathyal environments and decrease in abundance landward and seaward (Stover and Williams 1982). Furthermore, the ratio of terrestrial to marine palynomorphs including dinoflagellate cysts has been correlated with distance from palaeoshoreline (e.g., Smelror and Leereveld 1989). The ratio of non-marine palynomorphs (spores and pollen) to marine palynomorphs (dinoflagellate cysts, acritarchs, and foraminiferal linings) in the material studied might indicate deposition in an upper neritic environment. Moreover, presence in the Kashafrud Formation of abundant plant debris, coarse sands, and extrabasinal pebbles suggests propinquity to terrestrial sources (Poursoltani et al. 2007). A marginal marine setting in which the sediments of the Kashafrud Formation were accumulated could also be ascertained from low diversity and percentage of dinoflagellate cysts (e.g., Hunt 1987). Marine dinoflagellate cysts occur in all climatic regimes, but are most diverse in the tropics and are particularly abundant in neritic temperate waters (Stover et al. 1996). Few dinoflagellate cysts recorded in this study are poorly preserved and are identifiable mostly at generic level (Appendix). Of these, *Namoceratopsis* was considered by Riding (1983) to be a euryhaline genus and *Gonyaulacysta helicoidea* (Eisenack and Cookson) Sarjeant 1966 by Riding and Hubbard (1999) an indicator of warm marine waters. Hence, humid, warm-temperate conditions suggested by terrestrial palynomorphs is evidently supported by the associated microphytoplankton components. Abundant Upper Triassic-Middle Jurassic coals in the Alborz Mountains (Lyberis and Manby 1999) would seem to advocate similar climatic regime for this time interval in northern Iran. This is in essential agreement with palaeoclimatic reconstructions previously envisioned for the Middle Jurassic; i.e., gradual increase of temperature and humidity from a pre-Bajocian cooler climatic regime (e.g., Hubbard and Boulter 1997). It is worthy of mention that the presence of ammonites generally corroborates the palynologically based palaeoenvironmental inferences presented here.

Madani (1977, pp. 89-90; pl. 10) recorded reworked fossils (including a few poorly preserved miospores) of Triassic age in association with *in situ* Middle Jurassic biota from turbidites of the Kashafrud Formation at its type section. Accordingly, she concluded that the Triassic uplift to the southeast of the basin was a main source of material that was transported northward during the Middle Jurassic; that conclusion has been supported by palaeocurrent and mineralogical evidence (Madani 1977, p. 84; Poursoltani et al. 2007). Although the Kashafrud Formation at the section studied unconformably overlies the Permian
Mashhad Ophiolites, no such allochthonous miospores have been retrieved from the material examined.

CONCLUSIONS

The upper part of the Kashafrud Formation at the Senjedak section contains moderately well-preserved and relatively diverse miospore-dominated palynofloras.

In most samples, dinoflagellate cysts, foraminiferal test linings, and fungal spores, albeit palaeoenvironmentally significant elements, occur only sporadically in comparison with overwhelming abundances of terrestrial palynomorphs.

The Kashafrud palynofloras include 47 species of spores (distributed among 30 genera) and 15 species of pollen (assigned to eight genera). Relative abundances of miospore species vary considerably among samples; however, representatives of *Klukisporites* and *Dictyophyllidites* are particularly abundant.

The spores are predominantly radiosymmetrical and trilete and are mainly laevigate species attributable to *Dictyophyllidites* or *Cyathidites*, and a foveo-reticulate species (*Klukisporites variegatus*). Only one monolete spore (*Laevigatosporites ovatus*) was identified. The pollen embrace saccate (mono-, di-, and trisaccate), alete, and monosulcate taxa.

Marine palynomorphs in the Kashafrud assemblages, uncommon and sporadic in occurrence, consist of poorly preserved proximate dinoflagellate cysts, a morphologically simple, long-ranging acritarch species and foraminiferal test linings indicating the presence of multichambered, coiled foraminifera. These palynomorphs are indicative of an open marine, nearshore depositional setting for at least the bulk of the studied Kashafrud Formation.

Vertical distribution of certain spore and pollen species enable recognition of three stratigraphically successive palynofloral associations, here informally termed Assemblages A, B, and C. The presence of *Concavissimisporites verrucosus*, *Converrucosisporites pricei*, *Contignisporites burgeri*, *Murospora florida*, *Osmundacites senectus*, *Retitriletes facetus*, *Sellaspora asperata*, and *Tuberculatosporites westbournensis* collectively indicates a Middle Jurassic (Bajocian-Bathonian) age. The introduction of *Contignisporites burgeri* serves to locate the Bajocian-Bathonian boundary at 1513m above the base of the section investigated.

Inferred natural relationships of the dispersed spores and pollen constituting the three assemblages, imply derivation from a diverse flora, comprising Coniferophyta, Cycadophyta, Ginkgophyta, Pteridospermophyta, and Pterophyta, that grew under warm, humid conditions during the Middle Jurassic.

ACKNOWLEDGMENTS

The authors are thankful to Professor Dr Geoffrey Playford, Department of Earth Sciences, The University of Queensland, Brisbane, Australia; Professor Dr Reed Wicander, Department of Geology, Central Michigan University, Mount Pleasant, 401
Michigan, USA, and Dr John Filatoff, Saudi Arabian Oil Company, Dhahran, Saudi Arabia, for critically reviewing the first draft of the manuscript and providing many useful advice. Grateful acknowledgement is made to the Micropalaeontology reviewers, Dr James Riding, British Geological Survey, Nottingham, UK and Dr Recep Sancay, Turkish Petroleum Corporation, Ankara, Turkey, for their thorough review of the manuscript and offering invaluable comments and suggestions. Mrs M. Hosseinioon, Geological and Mining Exploration Survey of Iran, Northeastern Branch, Mashhad, kindly assisted with the fieldwork and sampling.

REFERENCES


ACHILLES, H., KAISER, H., SCHWEITZER, H-J. and HUSH-\ABBINK, O.A., 1998. Palynological investigations in the Jurassic of the Northeastern Branch, Mashhad, kindly assisted with the fieldwork and sampling.

REFERENCES


PLATE 1


PLATE 2

7. Cycadopites crassimarginis (de Jersey) de Jersey 1964. Distal focus, ×670. AD-51, Ad-51g, E46/1, S.333.
16. Pareodinia sp. ×400. AD-55, Ad-55a, L41/1, S.344.


______, 1977. Further information on the palynological stratigraphy of the Mesozoic coaly sediments from Kerman, Iran. Iranian Petroleum Institute, Proceeding of the 2nd Geological Symposium of Iran, Tehran, pp. 191-217. (in Persian)


Manuscript accepted October 21, 2007

APPENDIX 1

LIST OF PALYNOMORPH TAXA RECORDED

Plate and figure numbers pertain to specimens illustrated in Plates 1 and 2. Only taxa with known stratigraphic value and/or persistence throughout the section studied (or parts therein) are illustrated in Plates 1 and 2.

MIOSPores

Alisporites grandis (Cookson) Dettmann 1963 [Plate 2, fig. 13]
Alisporites lowoodensis de Jersey 1963 [Plate 2, fig. 12]
Alisporites similis (Balme) Dettmann 1963 [Plate 2, fig. 11]
Anapaticulatisporites sp. A
Anapaticulatisporites sp. B
Apaticulatisporites sp.
Araucariacites australis Cookson ex Couper 1953 [Plate 2, fig. 8]
Biretisporites sp. A
Biretisporites sp. B
Callialasporites dampieri (Balme) Sukh Dev 1961 [Plate 2, figs. 2-5]
Callialasporites microvelatus Schulz 1966
Callialasporites segmentatus (Balme) Srivastava 1963 [Plate 2, fig. 7]
Callialasporites trilobatus (Balme) Sukh Dev 1961 [Plate 2, fig. 6]
Camarozonosporites ramosus (de Jersey) McKellar 1974 [Plate 1, fig. 27]
Concavissimisporites punctatus (Delcourt and Sprumont) Brenner 1963
Concavissimisporites verrucosus Delcourt and Sprumont emend. McKellar 1998 [Plate 1, fig. 11]
Converrucosisporites pricei McKellar 1998 [Plate 1, fig. 12]
Contignisporites burgeri Filatoff, McKellar, and Price in Filatoff and Price 1988 [Plate 1, figs. 10, 14, 17]
Convolutaspora prisa (McKellar) Sajjadi and Playford 2002 Corollina sp.
Cyathidites australis Couper 1953 [Plate 1, fig. 15]
Cyathidites minor Couper 1953
Cyathidites rafaelii (Burger) Burger 1980
Cycadopites crassimarginis (de Jersey) de Jersey 1964 [Plate 2, fig. 10]
Cycadopites granulatus (de Jersey) Wilson and Webster 1946
Cycadopites follicularis Wilson and Webster 1946 [Plate 2, fig. 1]
Deltoidospora sp.
Densoisporites sp.
Dictyophyllidites harrisii Couper 1958 [Plate 1, fig. 6]
Dictyophyllidites mortonii (de Jersey) Playford and Dettmann 1965 [Plate 1, figs. 1-5]
Gleicheniidites senonicus Ross emend. Skarby 1964 [Plate 1, fig. 24]
Impardecispora apiverrucata (Couper) Venkatachal, Kar, and Raza 1969 [Plate 1, fig. 8]
Klukisporites variegatus Couper 1958 [Plate 1, figs. 9, 18]
Laevigatosporites ovatus Wilson and Webster 1946 [Plate 2, fig. 9]
Limbsporites sp. cf. L. lundbladiae Nilsson 1958
Microcachryidites antarcticus Cookson 1974
Murospora florida (Balme) Pocock 1961
Neoraistrickia equalis (Cookson and Dettmann) Backhouse 1988
Neoraistrickia trigonata (Cookson) Potonié 1956 [Plate 1, fig. 23]
Osmundacidites senectus Balme 1963 [Plate 1, fig. 7]
Osmundacidites verrucatus Sajjadi and Playford 2002
Osmundacidites wellmani Couper 1953
Phlebopterisporites equitatus (Couper) Juhász 1979
Platysaccus queenslandi de Jersey 1962
Podocarpidites astrictus Haskell 1968 [Plate 2, figs. 14-15]
Punctatosporites scabratas (Couper) Norris 1965
Retitriletes clavatoides (Couper) Döring, Krutzsch, Mai, and Schulz 1963 [Plate 1, fig. 25]
Retitriletes facetus (Dettmann) Srivastava 1975
Retitriletes rosewoodensis (de Jersey) McKellar 1974 [Plate 1, fig. 22]
Retitriletes sp. cf. R. austroclavatidites (Cookson) Döring, Krutzsch, Mai, and Schulz 1963
Retitriletes sp. cf. R. singihii (Singh) Srivastava 1972 [Plate 1, figs. 26a, b]
Sellaspora asperata (Dettmann) emend. McKellar 1998 [Plate 1, fig. 16]
Stereisporites sp. cf. S. psilatus (Ross) Pflug 1953
Stereisporites sp.
Striatella seebergensis Mädler 1964 [Plate 1, figs. 20, 21]
Striatella sp. cf. S. balmei Filatoff and Price 1988 [Plate 1, fig. 13]
Striatella sp. cf. S. scanica (Nilsson) Filatoff and Price 1988
Todisporites major Couper 1958
Todisporites minor Couper 1958
Trilites sp. cf. T. wolfgangii Sajjadi and Playford 2003
Trilobosporites antiquus Reiser and Williams 1969
Tuberculatosporites westbournensis McKellar 1998 [Plate 1, fig. 19]

DINOFLAGELLATE CYSTS
Ctenidodinium sp.
Gonyaulacysta helicoidea (Eisenack and Cookson) Sarjeant 1966 [Plate 2, fig. 20]
Leptodinium sp.
Meiourogonyaulax valensi Sarjeant 1966 [Plate 2, fig. 19]
Nannoceratopsis sp. [Plate 2, fig. 18]
Pareodinia sp. [Plate 2, fig. 21]

ACRITARCHA
Micrhystridium sp. [Plate 2, fig. 17]

FORAMINIFERAL TEST LINING [Plate 2, fig. 16]