INTRODUCTION

Jurassic palynomorph assemblages have been recovered in numerous wells in northeast Libya. Jurassic rocks reflect changing sedimentary environments which have greatly influenced the composition of the palynological assemblages.

In the northernmost area, Jurassic sediments unconformably overlie the Palaeozoic or Triassic and show a mixed marine and continental influence. In the northeastern part of the area thicker and deeper water marine sediments are known, while shallow marine sediments overlie the platform facies immediately to the south. Pollen and miospores are fairly well preserved and are dominant in most samples. Dinoflagellate cysts are richly represented especially in the deposits of the north and northeast. Most samples contain abundant variably sorted cuticular debris and structured wood fragments. This significant influx of terrestrial debris together with the associated palynomorph assemblages indicate deposition in a shallow marine environment in close proximity to the shoreline for most of the Jurassic deposits in the northern area.

In the central and southern region, sandstone, silt stone and red shale deposited in non-marine fluvial to lacustrine or lagoonal environment, unconformably overlie the metamorphic or igneous Precambrian Basement. These sediments show a general lack of well preserved palynomorphs. Miospores, though present are generally long ranging and terrestrially derived detrital kerogen dominate the assemblages.

MICROFLORAL SUCCESSION

Miospore assemblages present in most of the samples investigated are dominated by small gymnosperm pollen. Classopollis spp., Exesipollenites spp., Sphaeripollenites spp., and nonaperturate pollen assigned to Araucariacites spp. Saccate pollen assigned to Concentriskopites spp., Perinopollenites spp., Callialaspores spp., and Inaperturopollenites spp., are often common components of the assemblages. Spores are mainly represented by smooth, trilete forms. Sculptured forms are rare but in cutting samples they may be present as a result of contamination by caving.

The miospores present in this interval are long ranging and extend throughout the Jurassic sequence. The variable distribution observed within the sequence has been attributed to sedimentary control, mainly arising from the effect of transport and sorting of palynomorphs from the land vegetation area to the site of deposition.

The illustrated assemblages are similar to those reported by Reyre (1973) from Sahara who found that bisaccate pollen were common only up to zone 12B, and are replaced in Liassic and younger Mesozoic by the group of “large pollen”. This group is again reduced during the later part of the Callovian and Late Jurassic. Our observations indicate a similar development in Northeast Libya. Based on assemblage characters and individual spore and pollen taxa, correlation of the Libyan assemblages can be confidently established with palynozones 5a and b of Reyre (1973). Thus, a Middle to Late Jurassic age is suggested for the Libyan miospore assemblages. No diagnostic miospores of Early Jurassic age were found in the samples examined. Classopollis is represented by sculptured and “smooth” forms that require study by the scanning electron microscope in order to ascertain their stratigraphical significance.

The Libyan assemblages show significant differences from those of European Jurassic deposits. Bisaccates are absent to rare in the Libyan assemblages, but are generally very common in Middle and Late Jurassic assemblages from Northern latitudes. Similarly, Araucariacites, Classopollis and Sphaeripollenites together with Callialasporites and Inaperturopollenites generally abundant in the Libyan assemblage, are relatively less abundant in the northern assemblages. There are thus strong similarities between the miospore assemblages of the Sahara and northeast Libya and marked differences from the European and Arctic microfloral assemblages as reported by Norris (1970), Herngreen & De Boer (1975), Vigran & Thusu (1975) and Pocock, (1970).

Dinoflagellate cysts, mainly restricted to the north and northeast, are present in low numbers and show low diversity. Nevertheless, unlike the miospores, they offer stage level age determinations. No dinoflagellate cysts of Early Jurassic age were found in the borehole material examined. The oldest Jurassic assemblage is of Late Bathonian-Early Callovian age. Systematophora penicillata, Adnatosphaeridium caulleryi, Sensusidinium echinatum, Escharisphaeridia...
pocockii, Pareodinia ceratophora, Ellipsoidictyum gochtii, Ellipsoidictyum sp. A, Dimidiadinium dangeardii, Korystocysta cf. kettonensis/gochtii, Ctenidodinium cf. tenellum and Bradleyella (Dichadogonyaulax) sp., Gonyaulacysta filapicata are some of the most frequently encountered species. Ellipsoidictyum gochtii, Ellipsoidictyum sp. A, Bradleyella sp., Gonyaulacysta filapicata, Ctenidodinium cf. tenellum, Korystocysta cf. kettonensis/gochtii group, Adnatosphaeridium caulleryi, and Systematophora penicillata (orbifera) are considered stratigraphically diagnostic species for the oldest Jurassic assemblage recorded in the area.

Dinoflagellate cyst assemblages of Late Callovian–Early Oxfordian age are characterised by the appearance of Wanea digitata, Energlynia acollaris, Cribroperidinium granulatum, Korystocysta pachyderma and Gonyaulacysta scarburghensis. Energlynia acollaris is common in some samples and also occurs rarely in the older assemblage. Ellipsoidictyum spp., Gonyaulacysta filapicata, and several morphotypes of Sentusidinium disappear in this assemblage.

The youngest assemblage is characterised by the appearance of palynomorphs of Late Kimmeridgian to Tithonian age, and is dominated by Millioudodinium globatum, and a few typical Late Jurassic species, such as Muderongia sp. A Davey, Ctenidodinium panneum, Leptodinium cf. aceras (Eisenack, 1958) Sensu Gitmez & Sarjeant 1972 and Lithodinia cf. jurassica Eisenack, 1935 Sensu Ioannides et. al., 1976. Korystocysta kettonensis which is present in this assemblage may be reworked from the older assemblage.

In summary, the majority of the samples analysed in the northern and northeastern region contain Bathonian to Early Oxfordian dinoflagellate cysts. A limited number of wells (AI-36, AI-NC92, Cl-2 and El-2) contain a sparse Late Jurassic microflora. Many typical Oxfordian and Early Kimmeridgian dinoflagellate cyst species known in the boreal areas were not encountered. This might suggest a possible microfloral provincialism but this suggestion must await the results of further studies, currently in progress.

In the south central and southern area, where deposition of sandstone, siltstone and red shale took place in a fluvial, lacustrine or lagoonal environment, probably under dry climatic conditions, a general lack of well preserved palynomorphs is evident. The most commonly encountered species include Cerebropollenites mesozoicus, Concavisporites sp., Classopollis spp., Araucariacites sp. and Deltoidospora sp. Many of the forms encountered also occur in the overlying sandstone of Early Cretaceous age (see later contribution). Sediments of Jurassic age are frequently difficult to distinguish from those of Early Cretaceous.

Explanation of Plate 45
All figures are × 500

Fig. 1. Exesipollenites scabraus (Couper) Pocock, 1970. C 1–2, 7200–7250 ft., Slide 3, E32/4, AGC 486.

Fig. 2. Spheripollenites sp. C 1–2, 7200–7250 ft., Slide 3, E33/1, AGC 487.

Fig. 3. Classopollis torosus (Reissinger) Balme, 1957. C 1–2, 8350–8390 ft., Slide 2, P31/1, AGC 488.

Fig. 4. Classopollis sp. C 1–2, 7100–7150 ft., Slide 1, M32/3, AGC 489.

Fig. 5. Classopollis sp. cf. C. vignollensis Reyre, Kieser & Pujol, 1970. C 1–2, 7000–7050 ft., Slide 1, O31, AGC 490.

Fig. 6. Classopollis sp. cf. C. vignollensis Reyre, Kieser & Pujol, 1970. C 1–2, 7200–7250 ft., Slide 3, H29/2, AGC 491.

Fig. 7. Classopollis sp. cf. C. torosus (Reissinger) Balme, 1957. C 1–2, 6940–7000 ft., Slide 2, K30/2, AGC 492.

Fig. 8. Fungal fruiting body. C 1–2, 7350–7400 ft., Slide 2, R29/4, AGC 493.

Fig. 9. Scolecospore Fungal multicellate spore Pl. 1, fig. 16, Elsik, 1983. C 1–2, 7300–7350 ft., Slide 2, Q34, AGC 494.

Fig. 10. Classopollis sp. cf. C. noeli Reyre, 1970. C 1–2, 7050–7100 ft., Slide 1, M27/4 – M28/3, AGC 495.

Fig. 11. Cycadopitys nitidus (Balme) Norris, 1969. C 1–2, 8450–8500 ft., Slide 4, F38/1, AGC 496.

Fig. 12. cf. Eucommiidites sp. C 1–2, 8250–8300 ft., Slide 2, J35/4, AGC 497.

Fig. 13. Eucommiidites sp. C 1–2, 8380–8390 ft., Slide 1, J37/3, AGC 498.

Fig. 14. Eucommiidites sp. cf. E. troedsonii Erdtmann, 1948. AI-NC 92, 6650–6660 ft., Slide 6, K39/2, AGC 499.
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Plate 45
age, and are therefore collectively referred to as the Sarir or Nubian Sandstone of Late Jurassic/Early Cretaceous age in the study area. With the exception of a very few wells, where definite Neocomian-Barremian palynomorphs have been encountered, there is at present no palynological evidence to allow the separation of Jurassic and Early Cretaceous sequences in the south-central and southern areas.

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Explanation of Plate 46

All figures are × 500

Fig. 1. Callialasporites dampieri (Balme) Sukh Dev, 1961. C 1–2, 7200–7250 ft., Slide 3, N36/3, AGC 500.

Fig. 2. Callialasporites trilobatus (Balme) Sukh Dev, 1961. C 1–2, 8250–8300 ft., Slide 2, T31/4, AGC 501.

Fig. 3. Callialasporites sp. cf. C. trilobatus (Balme) Sukh Dev, 1961. C 1–2, 8380–8390 ft., Slide 1, R–S/35, AGC 502.

Fig. 4. Callialasporites sp. cf. C. obtratus Norris, 1969. C 1–2, 7250–7300 ft., Slide 1, T36/2, AGC 503.

Fig. 5. Callialasporites sp. cf. C. trilobatus (Balme) Sukh Dev, 1961. C 1–2, 8250–8300 ft., Slide 2, T42/4, AGC 504.

Fig. 6. Inaperturopollenites sp. cf. I. turbatus Balme, 1957. C 1–2, 8250–8300 ft., Slide 2, R36/1, AGC 505.

Fig. 7. Inaperturopollenites turbatus Balme, 1957. C 1–2, 8200–8250 ft., Slide 4, T42/4, AGC 506.

Fig. 8. Araucaricites australis Cookson, 1947. C 1–2, 6940–7000 ft., Slide 2, T36/2, AGC 507.

Fig. 9. Perinopollenites elatoides Couper, 1958. C 1–2, 8350–8390 ft., Slide 2, R26/2, AGC 508.

Fig. 10. Araucaricities sp. cf. A. australis Cookson, 1947. C 1–2, 6940–7000 ft., Slide 2, T37, AGC 509.

Fig. 11. Perotrilites sp. A. J1-81 A., 6740–6780 ft., Slide 3, C44/3, AGC 510.

Fig. 12. Concentrisporites pseudosulcatus (Briche, Danzé–Corsin & Laveine) Pocock, 1970. C 1–2, 8380–8390 ft., Slide 1, N42/2–N42, AGC 511.
Explanation of Plate 47
All figures are × 500

Fig. 1. Deltoidospora psilostoma Rouse, 1959. C 1–2, 8450–8500 ft., Slide 4, U29/1, AGC 512.

Fig. 2. Todisporites sp. C 1–2, 8200–8250 ft., Slide 4, V31, AGC 513.

Fig. 3. Dictyophyllidites sp. C 1–2, 8250–8300 ft., Slide 2, M36/2, AGC 514.

Fig. 4. Converrucosisporites variverrucatus (Couper) Norris, 1969. C 1–2, 8390–8400 ft., Slide 2, X–Y31/3, AGC 515.

Fig. 5. Cyathidites australis Couper, 1953. C 1–2, 7200–7250 ft., Slide 3, U43, AGC 516.

Fig. 6. Cyathidites australis Couper, 1953. C1–2, 8400–8450 ft., Slide 4, D37/3, AGC 517.

Fig. 7. Pilosisporites sp. cf. P. trichopapillosus (Thiergart) Delcourt & Sprumont, 1955. C1–2, 8300–8350 ft., Slide 3, O36/1, AGC 518.

Fig. 8. Concavissimisporites variverrucatus (Couper) Singh, 1964. J1-81A, 6740–80 ft., Slide 3, M31, AGC 519.

Fig. 9. Cyathidites sp. C 1–2, 7000–7050 ft., Slide 1 W35/4, AGC 520.

Fig. 10. Microreticulatisporites sp. C 1–2, 8350–8390 ft., Slide 2, U43/2, AGC 521.

Fig. 11. Concavissipores jurienensis Balme, 1957. C 1–2, 8380–8390 ft., Slide 1, J41/3, AGC 522.

Fig. 12. Cyathidites minor Couper, 1953. J1-81A, 6700–6710 ft., Slide 3, G44, AGC 523.
Explanation of Plate 48
All figures are × 500

Fig. 1. Coronatisporites valdensis (Couper) Dettmann, 1963. C 1–2, 8450–8500 ft., Slide 4, M31/2, AGC 524.
Fig. 2. Leptolepidites sp. C 1–2, 8250–8300 ft., Slide 2, P41/42, AGC 525.
Fig. 3. Cicatricosisporites avnimelechi Horowitz, 1970. J1–81A, 5290–5320 ft., Slide 3, K36/2, AGC 526.
Fig. 4. Todisporites minor Couper, 1958. C 1–2, 8200–8250 ft., Slide 4, V31, AGC 527.
Fig. 5. Trilobosporites apiverrucatus Couper, 1958. C 1–2, 7350–7400 ft., Slide 2, K39/2, AGC 528.
Fig. 6. Dictyophyllidites equiexinus (Couper) Dettmann, 1963. J1–81A, 5290–5320 ft., Slide 3, F29/1, AGC 529.
Fig. 7. Cicatricosisporites australiensis (Cookson) Potonie, 1956. J1–81A, 5290–5320 ft., Slide 3, K25/1, AGC 530.
Fig. 8. cf. Densoisporites sp. ? caved. C 1–2, 7200–7250 ft., Slide 3, M44/3, AGC 531.
Fig. 9. Cicatricosisporites sp. cf. C. purbeckensis Norris, 1969. C 1–2, 8300–8350 ft., Slide 3, T35, AGC 532.
Fig. 10. Cretaceous spore, ? caved. C 1–2, 6940–7000 ft., Slide 2, H34, AGC 533.
Fig. 11. Couperisporites sp. cf. C. complexus (Couper) Pocock, 1962. C 1–2, 8400–8450 ft., Slide 4, M35/1, AGC 534.
Fig. 12. Sestrosporites pseudoalveolatus (Couper) Dettmann, 1963. C 1–2, 8450–8500 ft., Slide 4, M-N41/42, AGC 535.
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Plate 48
Explanation of Plate 49
All figures are \( \times 500 \)

Figs. 1, 12 *Systematophora penicillata* (Ehrenberg, 1943) Sarjeant, 1980. 1. C1-2, 800–8050 ft., W 45/0, AGC 536. 12. A1-NC 92, 6650–6660 ft., Slide 3, S38/0, AGC 537.

Fig. 2. *Pareodinia* cf. *mutabilis* Riley *in* Fisher & Riley, 1980. A1-36, 11344–11346 ft., Slide 4, Z30/0, AGC 538.

Fig. 3. *Adnatosphaeridium caulleryi* (Deflandre, 1938) Williams & Downie, 1969. A1-NC 92, 6650–6660 ft., Slide 3, Q 43/2, AGC 539.

Figs. 4-6. *Pareodinia ceratophora* Deflandre, 1947. 4. A1-NC 92, 6640–6650 ft., Slide 6, E30/1, AGC 540. 5. C1-33, 8153–8155 ft., Slide 2, P42/0, AGC 541. 6. A1-NC 92, 9700–9710 ft., Slide 5, R26/2, AGC 542.

Fig. 7. *Pareodinia* sp. E. *Sensu* Wiggins, 1975. A1-NC 92, 6640–6650 ft., Slide 6, G32/1, AGC 543.

Fig. 8. *Escharisphaeridia pocockii* (Sarjeant, 1968) Erkmen & Sarjeant, 1980. C1-2, 8550–8600 ft., Slide 3, X27/0, AGC 544.

Figs. 9, 10 *Ellipsoidictyum gochtii* Fensome, 1979. 9. C1-2, 8550–8600 ft., Slide 3, R37/3, AGC 545. 10. C1-2, 8550–8600 ft., Slide 3, O36/0, AGC 546.

Fig. 11. *Systematophora* sp. A. C1-2, 8000–8050 ft., Slide 4, S33/4, AGC 547.

Figs. 13, 14. *Sentusidinium echinatum* (Gitmez & Sarjeant, 1972) Sarjeant & Stover, 1978. 13. A1-NC 92, 7170–7180 ft., Slide 4, U43/1, AGC 548. 14. C1-2, 8200–8250 ft., Slide 2, V36/4, AGC 549.
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Explanation of Plate 50

All figures are $\times 500$

Fig. 1. *Ellipsoidictyum* sp. A. C1-2, 8550–8600 ft., Slide 2, H32/3, AGC 550.

Fig. 2. *Spiniferites ramosus* (Ehrenberg, 1938) Loeblich & Loeblich, 1966. A1-45, 9450 ft., Slide 1, V36/4, AGC 551. (Caved specimen from Cretaceous sediments).

Fig. 3. *Dimidiadinium dangeardii* (Sarjeant, 1968) Brideaux, 1977. C1-2, 8550–8600 ft., Slide 3, N35/0, AGC 552.

Fig. 4. *Ellipsoidictyum gochtii* Fensome, 1979. C1-33, 8153–8155 ft., Slide 2, M51/3, AGC 553.

Fig. 5. *Exiguisphaera phragma* Duxbury, 1979. A1-36, 11314–11346 ft., Slide 4, M42/2, AGC 554. (Probably caved specimen).

Fig. 6. *Leptodinium aceras* Eisenack, 1958. *Sensus* Gitmez & Sarjeant, 1972. A1-36, 11751–11759 ft., Slide 2/2, E34/4, AGC 555.

Fig. 7. *Ctenidodinium* cf. *tenellum* Deflandre, 1938. C1-33, 8157–8159 ft., Slide 2, J52/0, AGC 556.

Fig. 8. *Sentusidinium* sp. A. A1-NC 92, 6700–6710 ft., Slide 6, T33/1, AGC 557.

Figs. 9, 12. *Chytroeisphaeridia granulata* Courtinant & Gaillard, 1980. 9. A1-36, 11751–11759 ft., Slide 2, Y33/0, AGC 558. 12. C1-2, 8200–8250 ft., Slide 2, M34/0, AGC 559.

Figs. 10, 13. *Chytroeisphaeridia chytroeides* (Sarjeant, 1962) Downie & Sarjeant, 1965 emend. Davey, 1979. 10. C1-2, 8000–8050 ft., Slide 4, W45/0, AGC 560. 13. C1-2, 8100–8150 ft., Slide 1, R29/4, AGC 561.

Fig. 11. *Bradleyella (Dichadogonyaulax)* sp. A1-NC 92, 6650–6660 ft., Slide 4, V39/1, AGC 562.
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Plate 50
Explanation of Plate 51
All figures are × 500

Fig. 1. Wanaea digitata Cookson & Eisenack, 1958. A1-NC 92, 6650–6660 ft., Slide 3, P35/0, AGC 563.

Fig. 2. Millioudodinium sp. A. A1-36, 11341–11346 ft. Slide 4, S34/4, AGC 564.

Figs. 3,4,6. Energlynia acollaris (Dodekova, 1975) Sarjeant, 1978 emend. Lentin & Williams, 1981. 3. C1-33, 8162 ft., Slide 2, 041/0, AGC 565. 4. B1-33, 12502–12507 ft., Slide 2, L45/3, AGC 566. 6. C1-33, 8157–8159 ft., Slide 2, F49/2, AGC 567.

Figs. 5,10. Gonyaulacysta sp. A. 5. A1-36, 11751–11759 ft., Slide 1, T42/0, AGC 568. 10. C1-2, 8200–8250 ft., Slide 2, K35/0, AGC 569.

Fig. 7. Gonyaulacysta jurassica (Deflandre, 1938) Norris & Sarjeant, 1965. C1-33, 8153–8155 ft., Slide 2, O36/1, AGC 570.

Fig. 8. Cribroperidinium granulatum (Klement, 1960) Stover & Evitt, 1978. A1-36, 12070-12160 ft., Slide 3, K35/0, AGC 571.

Fig. 9. Korystocysta pachyderma (Deflandre, 1938) Woollam, 1983. C1-33, 8150 ft., Slide 2, U49/3, AGC 572.

Fig. 11. Gonyaulacysta scarburghensis Sarjeant, 1964. B1-33, 12602 ft., Slide 2, H49/4, AGC 573.
Explanation of Plate 52
All figures are × 500

Fig. 1. *Meiourogyaulax callomonii* Sarjeant, 1972. A1-NC92, 6800–6810 ft., Slide 1, Q 32/4, AGC 574.

Figs. 2-4. *Millioudodinium globatum* (Gitmez & Sarjeant, 1972) Stover and Evitt, 1978. 2. C1-2, 8100–8150 ft., Slide 1, P 40/2, AGC 575. 3. C1-2, 8250–8300 ft., Slide 1, R 33/4, AGC 576. 4. A1-36, 11751–11759 ft., Slide 2/2, X 26/0, AGC 577.

Fig. 5. *Muderongia* sp. A. *Sensu* Davey, 1979. A1-36, 11751–11759 ft., Slide 2/1, S 31/4, AGC 578.

Fig. 6. *Leptodinium* cf. *acerus* (Eisenack, 1958) *Sensu* Gitmez & Sarjeant, 1972. C1-2, 8450–8500 ft., Slide 3, S 34/4, AGC 579.

Fig. 7. *Ctenidodinium panneum* (Norris, 1965) Lentin & Williams, 1973. A1-NC92, 6700–6710 ft., Slide 6, M 43/4, AGC 580.

Fig. 8. *Systematophora* sp. B. A1-NC92, 6650–6660 ft., Slide 3, N 37/4, AGC 581.

Figs. 9, 12. *Lithodinia* cf. *jurassica* Eisenack, 1935. Sensu Ioannides, Stavrinos & Downie, 1976. 9. A1-NC92, 6700–6710 ft., Slide 6, U 44/0, AGC 582. 12. C1-2, 8500–8550 ft., Slide 2, S 26/1, AGC 583.

Fig. 10. *Korystocysta kettonensis* (Sarjeant, 1976) Woollam, 1983. B1-33, 12603 ft., Slide 2, O 44/0, AGC 584.

Fig. 11. Gen. et. sp. indet. A1-NC92, 6950–6960 ft., Slide 5, P 32/3, AGC 585.
Middle-Late Jurassic Palynomorphs

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Plate 52