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CRETACEOUS PALYNOLOGY (SPORES, POLLEN AND DINOFLAGELLATE CYSTS) OF THE SIQEIFA 1-X BOREHOLE, NORTHERN EGYPT

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Abstract. Diverse and well preserved palynofloras were recognized in the Lower Cretaceous succession penetrated by well Siqeifa 1-X in northern Egypt. Dinoflagellate cysts such as *Subtilisphaera senegalensis* was regarded, with the spores *Impardecispora apiverrucata* and *Aequitriradites spinulosus*, as important Berriasian to Barremian species. *Afropollis operculatus/zonatus* pollen and spores such as *Balmeisporites holodictyus*, *Trilobosporites laevigatus* and *Duplexisporites generalis* are diagnostic of Aptian. The lowest occurrences of the pollen *Afropollis jardinus*, the spore *Crybelosporites pannuceus* and elaterates such as *Elaterosporites klaszii, Elaterocolpites castelainii* and *Elateroplicites africaensis* characterize the Albian/lower Cenomanian interval. The palynofloras enabled the recognition of five spore-pollen and four dinoflagellate zones, which are correlated with regional records, mainly from Egypt and Libya. The vertical distribution of terrestrial and marine palynomorphs, along with palynodebris, reflects two regressive marginal marine cycles during Berriasian-Barremian and Albian-lower Cenomanian times whereas the Aptian witnessed a transgressive open marine (inner shelf) environment. A warm humid palaeoclimate was inferred during deposition of the investigated succession of the borehole, in contrast to the known warm arid to semi-arid climate, suggested for the Northern Gondwana Realm during Early Cretaceous times. This is probably due to the palaeogeographic position of Egypt during Early Cretaceous times or, to a local reason. Palynofloras from Siqeifa 1-X borehole, with *Afropollis* pollen and elaterates, are of North African aspect and share the broad characteristics of the "Albian-Cenomanian Elaterates Province" of Herngreen et al. (1996). Abundance of spores and araucariacean pollen are transitional features between those in North Gondwana and Southern Laurasia but, unlikely, typical transitional assemblages contain bisaccates conifers and have Gleicheniaceae spores.

Riassunto. Una palinoflora diversificata e ben conservata è stata ritrovata nella successione del Cretaceo inferiore, perforata dal pozzo Siqeifa 1-X, nell'Egitto settentrionale. Cisti di dinoflagellate come *Subtilisphaera senegalensis*, unitamente alle spore *Impardecispora apiverrucata* and *Aequitriradites spinulosus*, sono state considerate come specie significative del Berriasiano e Barremiano. Il polline *Afropollis operculatus/zonatus* e spore come *Balmeisporites holodictyus*, *Trilobosporites laevigatus* e *Duplexisporites generalis* sono invece diagnostici dell'Aptiano. Il primo ritrovamento del polline *Afropollis jardinus*, della spora *Crybelosporites pannuceus* e degli elaterati come *Elaterosporites klaszii, Elaterocolpites castelainii* e *Elateroplicites africaensis* caratterizzano infine l'intervallo Albiano/Cenomaniano inferiore. Le palinoflore hanno consentito di riconoscere cinque zone a spore/pollini e di quattro zone a dinoflagellati, correlabili con la biostratigrafia regionale soprattutto di Egitto e Libia. La distribuzione verticale di palinomorfi di origine continentale e marina, unitamente ai palinodetriti, riflette due cicli regressivi marini, in posizione marginale, durante il Berriasiano-Barremiano e l'Albiano-Cenomaniano inferiore. Mentre quelli dell'Aptiano testimoniano invece un episodio trasgressivo con ambienti marini di piattaforma interna. Viene ipotizzato che un paleoclima caldo-umido dominasse durante la deposizione dei sedimenti studiati, contrariamente a quello caldo-arido o semi-arido, sinora suggerito per il Regno Gondwaniano settentrionale durante il Cretaceo inferiore. Ciò è probabilmente dovuto alla posizione paleogeografica dell'Egitto durante il Cretaceo inferiore oppure a fattori locali. La palinoflora del pozzo Siqeifa 1-X, con il polline *Afropollis* e gli elaterati, é di aspetto Nordafricano e possiede i caratteri d'insieme della "Provincia Albiano-Cenomaniana ad Elaterati" di Herngreen et al. (1996). L'abbondanza di spore e pollini di araucariacee rappresenta un carattere transizionale tra quelli del Gondwana settentrionale e del Laurasia meridionale, ma a differenza delle tipiche associazioni transizionali, contengono conifere bisaccate e spore di Gleicheniaceae.

Introduction

Mesozoic rocks in northern Egypt are buried beneath younger Neogene sediments. This portion of the African platform is made up of a thick sedimentary sequence, gently sloping northward towards the Mediterranean Sea and comprises a variety of Phanerozoic rocks. It attains a thickness of 8-9 km in the Abu Ghar-

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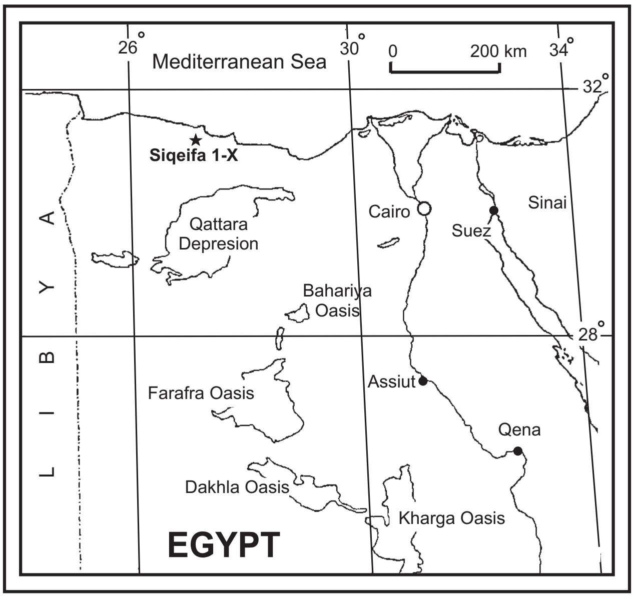


Fig. 1 - Geographic map showing the location of the Siqeifa 1-X borehole.

adig basin at the north of the Qattara Depression. This northern region in general, and the area where the present Siqeifa 1-X borehole (Fig. 1) is drilled in particular, was an area of intensive marine sedimentation during Early Cretaceous. During this time period the change from open to marginal marine conditions could be achieved by the occurrence of shales, limestones and sandstones in the Lower Cretaceous succession of Siqeifa 1-X and the adjacent wells Medeiwar 1, Meleiha 1 and Mersa Matruh 1. This marine oscillation could be seen from the palynological record in Matruh Basin area (Mahmoud et al. 2003, Siqeifa 1-X borehole). The lithostratigraphy in the studied Siqeifa 1-X well is adopted according to modern stratigraphic usage in northern Egypt and correlation with the nearby Mersa Matruh 1 well, only about 12 km to the north (see Penny 1991). Accordingly, in the Siqeifa 1-X well (Fig. 2), the lowermost shale dominated interval, which is not penetrated to its total depth, refers to the Matruh Shale Formation. Relatively thin sandstone and carbonate horizons, named as Umbarka sands and Lower Carbonates (WEPCO 1970), underlie and overlie directly this unit. These two informal rock units, which are included within the Matruh Shale, are no longer in use. A dolomite-dominated interval, which is not recognized in the well Mersa Matruh 1, overlies the Matruh Shale. A thick unit originally indicated as "No Information" interval and an overlying informal unit named as "Cenomanian Carbonates", seem to be counterparts of Kharita Member of the Burg El Arab Formation.

Despite the fact that Mesozoic and Cenozoic strata are exposed in vast areas of Egypt, palynological information came largely from the subsurface. This is due to the intensive arid weathering and the resultant oxidation of organic-walled microfossils in surface outcrops. Since the early sixties until present the Western Desert was a subject of numerous palynological studies, as a result of the intensive hydrocarbon exploration activities in northern Egypt. Earlier palynological investigations from Egyptian rocks were mostly descriptive. From 1990 onward there was a noticeable development in the application of palynomorphs to biostratigraphic problems. However, in Matruh Basin area biostratigraphic results from the Lower Cretaceous interval of the Mersa Matruh 1 borehole are presented in a series of research papers. Penny (1986, 1988, 1991) worked intensively on angiosperm pollen assemblage, with emphasis on their morphological and taxonomical criteria as revealed essentially by scanning electron microscopy. El Beialy (1994) analyzed, from the same well interval, terrestrial pollen and spores and marine dinoflagellates.

The main objective of this paper is to present the palynological content of the Lower Cretaceous succession penetrated by the Siqeifa 1-X borehole (Figs. 1, 2), Lat. 31° 13' 09" N and Long. 27° 17' 16" E. The well was drilled by WEPCO (1970); there is no independent control on the palynostratigraphy presented here. This borehole is drilled for the purpose of hydrocarbon exploration in the northern Western Desert, Egypt. Informal spore/pollen and dinoflagellate zonation is also attempted. Zones are correlated with those established in the regional records in Egypt and the surroundings.

Material and methods

Seventy cutting samples were processed by standard (HCl-HF) palynological preparation techniques, without oxidation or ultrasonic treatments. The palynological residue was sieved through 10 µm nylon sieves. Three to five permanent slides were prepared using glycerin jelly as a mounting medium. From each sample a count of at least 200 grain was established for semi-quantitative estimates. The most significant and well preserved palynomorphs were photographed using a Leica DM LB2 light microscope, equipped with a Leica DFC 280 digital camera. Samples, residues and palynological slides are stored in the Geological Museum, Geology Department, Assiut University.

Major palynoflora characteristics

Terrestrial spores and pollen grains dominate the palynological association (Fig. 3). Dinoflagellate cysts reach up to 20%, but at some horizons near the top of the Berriasian-Barremian interval they exceed 50% of total palynoflora. They are represented essentially by proximate (e.g. *Cribroperidinium, Cyclonephelium*, *Pseudoceratium*) and cavate (e.g. *Subtilisphaera*, *Muderongia*) cysts. Skolochorate cysts such as *Coronifera*, *Florentinia*, *Oligosphaeridium* and *Spiniferites* are also common. Spores, especially ferns such as *Deltoidospora* and *Triplanosporites* and gymnosperm pollen (mainly *Araucariacites*) dominate the spore-pollen association

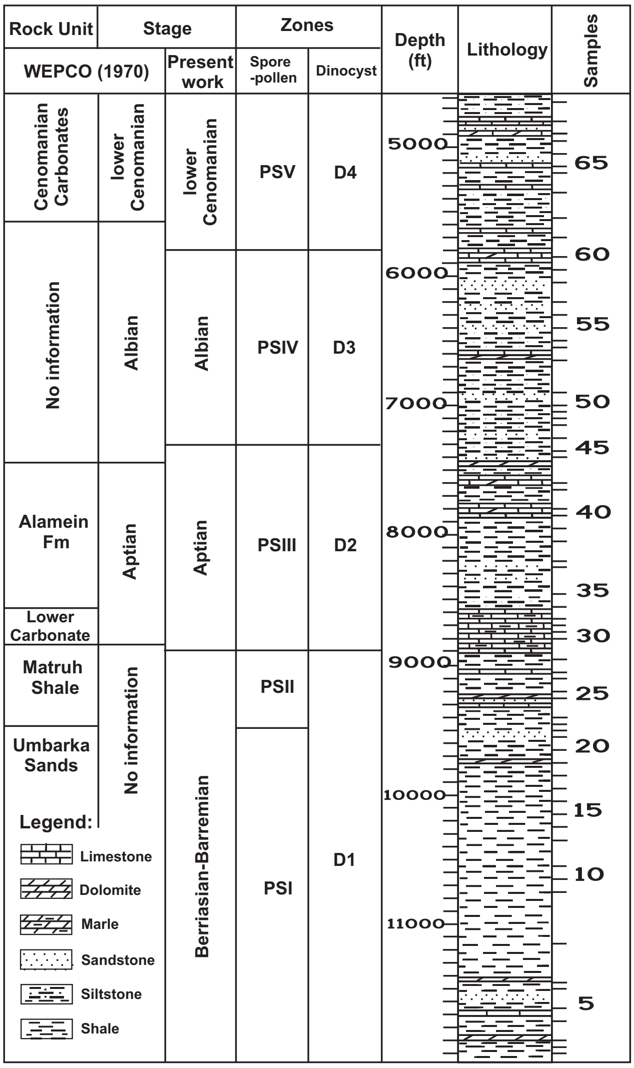


Fig. 2 - Lithological column of the Siqeifa 1-X borehole showing present achieved stratigraphic information. Rock units are designated according to the original lithologic log of the borehole (WEPCO 1970) and on calibration with the nearby well Mersa Matruh 1, only about 12 kilometers south (Penny 1991). Pollen/spores and dinoflagellate cyst zonation are discussed in detail in the text.

but in the lower Cenomanian interval angiosperms reach more than 50%. Xerophytic gymnosperms (*Ephedripites* and *Classopollis*) rarely attain 10% of total sporomorphs. In the Albian-Cenomanian part elaterate pollen became important elements of the palynoflora; at a single horizon in the Albian *Elaterosporites klaszii* reaches an acme (> 40% of spore-pollen content). Spores and pollen are diversified and comprise elements that are well known from the Lower Cretaceous of the northern Gondwanan Realm.

Palynomorph stratigraphy

From a biostratigraphic perspective, spores and pollen seem to be more diversified than dinoflagellate cysts. Therefore age assessment in this work is based primarily on ranges of spores and pollen and partly on dinoflagellate cysts. Reference is made to the position of the taxon, which is used in the present palynostratigraphic investigation, on Appendix.

Neocomian-Barremian (samples S.1-S.29)

Records of *Impardecispora apiverrucata* (no. 88) in Egypt (Schrank 1984, 1987; Mahmoud & Soliman 1994), Libya (Thusu et al. 1988) and Sudan (Kaska 1989; Awad 1994) are Berriasian to early Cenomanian. Schrank & Mahmoud (1998) tentatively dated an *Impardecispora/Aequitriradites* assemblage as early Neocomian, probably Berriasian-Valanginian. *Impardecispora apiverrucata* was found in the Saharan Neocomian subzone 5c (Reyre 1973). The species appeared later as Barremian-Aptian in South America (Archangelsky & Gamerro 1967a, b, Argentina) and upper Albian (Anan-Yorke & Stelck 1978, British Columbia). The dinocysts *Cribroperidinium edwardsii* (no. 37) and *Circulodinium distinctum* (no. 26) did not appear before the Berriasian in Africa (Besems 1982; Below 1984). *Systematophora palmula* (no. 56) has a Hauterivian-Barremian range in Egypt (Omran et al. 1990) and a Berriasian-Valanginian range in SE Spain (Hoedemaeker & Leereveld 1995). *Pseudoceratium anaphrissum* (no. 54) ranges in Libya and Egypt from upper Hauterivian to lower Albian (Uwins & Batten 1988; El-Beialy 1994). *Subtilisphaera senegalensis* (no. 22) ranges in Portugal from the lower Barremian to the upper Albian (e.g. Hasenboehler 1981). But, Hauterivian ranges of *S. senegalensis* are known in Morocco (Below 1981, 1982). The occurrence of *Odontochitina operculata* (no. 15) suggests an age not older than Hauterivian (see Ravn 1998). *Muderongia staurota* (no. 43) is known to range from Valanginian to late Aptian (e.g. Omran et al. 1990; Hoedemaeker & Leereveld 1995). Because typical post-Barremian (Aptian/Albian) palynofloral elements are absent (see subsequent paragraphs) and under consideration of the dinoflagellate evidence cited above, a Berriasian-Barremian age may be plausible for samples S.1 to S.29.

Aptian (samples S.30 to S.45)

Crybelosporites pannuceus (no. 62) occurs in the studied well from samples S. 30 to S. 70. It enters the palynological records during Aptian in Sudan (Kaska 1989). Younger records of *C. pannuceus* in Egypt, as Albian-Cenomanian, are documented by Schrank & Mahmoud (1998). It appeared also later (Albian) in other African localities (Lawal & Moullade 1986, NE Nigeria; Batten & Uwins 1985, NE Libya), in South America (Brenner 1968, Peru) and in the Middle East (El-Beialy & Al-Hitmi 1994, Qatar). *Trilobosporites laevigatus* (no. 66) occurs in lower Aptian rocks of Egypt (El-Beialy 1994). *Balmeisporites holodictyus* (no. 79) is recorded in Egypt (Omran et al. 1990) and Libya (Bat-

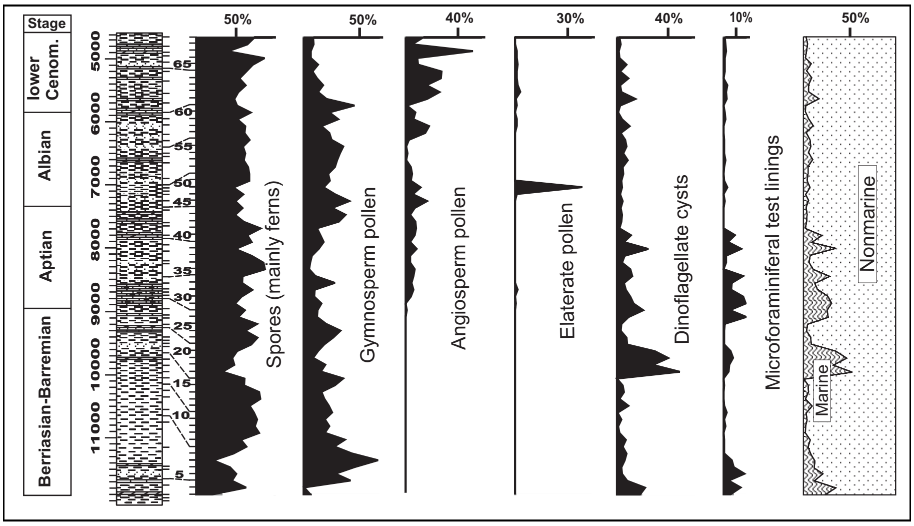


Fig. 3 - Percentage frequency diagram of the palynomorph content and marine/non-marine ratio of the Siqeifa 1-X borehole.

ten & Uwins 1985) from Aptian to Cenomanian strata. *Duplexisporites generalis* (no. 81) is regarded as a potential early Aptian index form in Egypt (Mahmoud & Moawad 1999). *Cicatricosisporites sinuosus* (no. 70) ranges in the local record from Aptian to middle Albian (Omran et al. 1990). Samples S.36 to S.45 witnessed appearance of Aptian zonasulculate heteropolar (*Afropollis operculatus*, no. 113) and zonasulculate isopolar (*Afropollis zonatus*, no. 115) pollen. These two *Afropollis* species are of early Aptian aspect in Africa and South America (see Schrank & Ibrahim 1995). The early angiosperm pollen *Stellatopollis densiornatus* (S. 29 to S. 70, no. 102) first occur at the base of this interval; the single occurrence in the topmost Berriasian-Barremian interval in figure 4 (sample S. 29) might be a contaminant from uphole sediments. *S. densiornatus*, however, is not widely documented in Northern Gondwana; records available in Egypt are Albian-Cenomanian (Schrank & Ibrahim 1995). This implies an older (i.e. Aptian) extension of the localized range of *S. densiornatus* in Egypt.

Albian (samples S.46 to S.60)

Highest occurrence datum (HOD) of *Afropollis operculatus* and *Afropollis zonatus* are used to delineate the top of the preceding Aptian rocks, just above the level of the two species at sample S.46. The non-columellate pollen *Afropollis jardinus* (no. 103) is a potential Albian/Cenomanian marker (see Mahmoud & Moawad 2002 and discussion therein). *Elaterosporites klaszii* (no. 119) and *Elaterocolpites castelainii* (no. 120) first appeared in the middle of the Albian stage (Herngreen et al. 1996). *Elateroplicites africaensis* (no. 121) is largely restricted to the middle Albian and Cenomanian of North Africa (Schrank 1990). *Florentinia laciniata* (no. 9), late Albian (Vraconian) to early Cenomanian (Below 1984) and *Florentinia clavigera* (no. 23), Vraconian to lower Cenomanian (Uwins & Batten 1988) are significant dinocyst species. Hedlund (1966, pp. 11-12) reported *Cyathidites punctatus*, comparable grains of *Concavissimisporites punctatus* (no. 68), from the Cenomanian of the USA, but did not mention Cenomanian records elsewhere. *Concavissimisporites punctatus* may probably be considered a good stratigraphic marker for the topmost Albian, at least in the local record, just above sample S.60.

Lower Cenomanian (samples S.61 to S.70).

Cretacaeiporites densimurus (no. 104) is a significant pollen from a stratigraphic point of view which marks the lower Cenomanian in the local record (Schrank & Ibrahim 1995). Because triporate pollen grains are absent, an early Cenomanian age is suggested for these samples.

Palynological zonation

Five informal spore/pollen and four dinoflagellate cyst zones for the lower Cretaceous interval penetrated by the Siqeifa 1-X borehole are proposed here. HOD of marker palynomorphs are partly used in the definition of zones because infiltrated specimens are expected from uphole sediments, since the used samples in this study are cuttings.

Spore-pollen zonation

- Zone PS I: *Impardecispora apiverrucata-Aequitriradites spinulosus-Cicatricosisporites* spp.
Assemblage Zone.

Samples: S.1 to S.22 (depth 12000 to 9500 ft).

Definition: *Impardecispora apiverrucata* (88) and *Aequitriradites spinulosus* (84) are restricted to this zone.

Age: Berriasian-Barremian.

Correlation: Zone II (Neocomian) of Saad & Ghazaly (1976), Kharga borehole No.1, New Valley area.

- Zone PS II: *Aequitriradites verrucosus-Cicatricosisporites brevilaesuratus-Ephedripites* spp. Assemblage Zone.

Samples: S.23 to S.29 (depth 9450 to 8950 ft).

Definition: from the lowermost occurrence of *Ephedripites* spp. (90) to the horizon underneath the lowermost occurrence of *Murospora* cf. *florida* (80), *Crybelosporites pannuceus* (62), *Trilobosporites laevigatus* (66) and *Cicatricosisporites sinuosus* (70).

Age: Berriasian-Barremian.

Correlation: Sequence XII (Barremian-Aptian) of Jardiné & Magloire (1965), Senegal and Côte d'Ivoire. Zone I (Barremian) of Saad (1978), Umbarka 1X Borehole, northern Western Desert.

- Zone PS III: *Afropollis operculatus-Afropollis zonatus-Crybelosporites pannuceus-Trilobosporites laevigatus-Cicatricosisporites sinuosus-Balmeisporites holodictyus* Interval Zone.

Samples: S.30 to S.45 (depth 7350 to 8800 ft).

Definition: from the lowermost occurrence of *Crybelosporites pannuceus* (62), *Trilobosporites laevigatus* (66), *Murospora* cf. *florida* (80) and *Cicatricosisporites sinuosus* (70), to the uppermost occurrence of *Afropollis operculatus* (113), *Afropollis zonatus* (115) and *Balmeisporites holodictyus* (79).

Age: Aptian.

Important associated taxa: *Duplexisporites generalis* (81), *Stellatopollis densiornatus* (102), *Reyrea polymorphus* (122) and *Retimonocolpites variplicatus* (108).

Correlation: Zone II (Aptian) of Saad (1978), Umbarka 1X Borehole, northern Western Desert. *Afropollis operculatus-Brenneripollis-Tricolpites* spp. Assemblage Zone I (Aptian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert. *Duplexisporites generalis-Murospora florida-Concavissimisporites variverrucatus-Tricolpites* Assemblage Zone I (Aptian) of Mahmoud & Moawad (2002), Sanhur-1X borehole, northern Western Desert.

- Zone PS IV: *Afropollis jardinus*-elaterates-*Concavissimisporites punctatus* Interval Zone.

Samples: S.46 to S.60 (depth 7250 to 5850 ft).

Definition: from the lowermost occurrence of *Afropollis jardinus* (103), *Elaterosporites klaszii* (119), *Elateroplicites africaensis* (121) and *Elaterocolpites castelainii* (120) to the uppermost occurrence of *Concavissimisporites punctatus* (68) which marks the top of this zone.

Age: Albian.

Important associated taxa: *Rousea delicipollis* (112), *Stellatopollis densiornatus* (102) and tetracolpates.

Correlation: Zones III c, b (late Albian) of Aboul Ela & Mahrous (1992), East Tiba-1 well, northern Western Desert. Zones II & III- *Tricolporopollenites-Afropollis jardinus-Crybelosporites pannuceus* and *Elaterosporites klaszi-Afropollis-Tricolporopollenites* (Albian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert. Zone PSII (Albian) of Mahmoud & Moawad (2002), Sanhur-1X borehole, northern Western Desert.

- Zone PS V: *Cretacaeiporites densimurus-Foveotricolpites gigantoreticulatus* Assemblage Zone.

Samples: S.61 to S.70 (depth 5700 to 5650 ft).

Definition: the base of this interval is delineated above the uppermost occurrence of *Concavissimisporites punctatus* (86). The top of this zone is uncertain due to lack of samples.

Age: early Cenomanian.

Important associated taxa: *Cicatricosisporites orbiculatus* (61), *Crybelosporites pannuceus* (62), *Trilobosporites* sp. (63) and *Trilobosporites laevigatus* (66). *Afropollis jardinus* (103), *Retimonocolpites variplicatus* (108) and *Elaterosporites klaszii* (119) are abundant in this zone.

Correlation: Zone III-*Elaterosporites klaszii-Elaterocolpites castelainii* and Zone II-*Afropollis jardinus* (late Albian-early Cenomanian) of Aboul Ela & Mahrous (1992), East Tiba-1 well, northern Western Desert. *Classopollis brasiliensis-Elaterocolpites castelainii-Cretacaeiporites densimurus* Assemblage Zone (early-middle Cenomanian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, northern Western Desert. *Elaterocolpites castelainii* Total Range Zone (early Cenomanian) of Mahmoud & Moawad (2002), Sanhur-1X borehole, northern Western Desert.

Dinoflagellate cyst zonation

- Zone D1: *Systematophora* spp.-*Muderongia* spp.-*Pseudoceratium anaphrissum-Cyclonephelium* cf. *vannophorum* Assemblage Zone.

Samples: S.1 to S.29 (depth 12000 t o 8950 ft).

Definition: *Systematophora valensii* (55), *Systematophora palmula* (56), *Pseudoceratium anaphrissum* (54), *Cyclonephelium* cf. *vannophorum* (50) and *Cribroperidinium edwardsii* (37) are found at the base of this zone. *Muderongia staurota* (43) marks the zone top.

Age: Berriasian-Barremian.

Important associated taxa: *Systematophora complicata* (51), *Systematophora areolata* (52), *Pseudoceratium* cf. *anaphrissum* (45), *Cyclonephelium brevispinatum* (46), *Muderongia* sp. (47) and *Pseudoceratium eisenackii* (48) are restricted to this zone.

Correlation: Association 1A (? late Hauterivian-?middle Barremian) of Uwins & Batten (1988), Well C1-33, Libya. Zone III (late Hauterivian-early Barremian) of Ibrahim & Schrank (1996), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert, Egypt. Zone

D1 (Hauterivian-Barremian) of Omran et al. (1990), Fadda-1 borehole, northern Western Desert, Egypt.

- Zone D2: *Subtilisphaera deformans-Subtilisphaera pirnaensis-Pseudoceratium securigerum* Assemblage Zone.

Samples: S.30 to S.45 (depth 8950 to 7350 ft).

Definition: from the uppermost occurrence of *Muderongia staurota* (43) to the uppermost occurrence of *Circulodinium distinctum* (26).

Age: Aptian.

Important associated taxa: *Palaeoperidinium cretaceum* (39), *Coronifera tubulosa* (2), *Coronifera albertii* (27), *Oligosphaeridium porosum* (28), *Cyclonephelium chabaca* (30), *Achomosphaera* cf. *sagena* (35) and *Achomosphaera verdieri* (40) are restricted to this zone.

Correlation: Zone II (early to late-middle Aptian) of Uwins & Batten (1988), Well B1-36, Well A1-18 and Well F1-2, Libya. Zone D2 (Aptian) of Omran et al. (1990), Fadda-1, Minqar-1X and Sharib-1X wells, northern Western Desert, Egypt. *Pseudoceratium expolitum-Pseudoceratium securigerum-Cribroperidinium edwardsii* Assemblage Zone (Aptian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert, Egypt.

- Zone D3: *Coronifera oceanica-Oligosphaeridium* spp.-*Subtilisphaera senegalensis* Assemblage Zone.

Samples: S.46 to S.60 (depth 7250 to 5850 ft).

Definition: from the lowermost occurrence of *Coronifera oceanica* (11) to below the lowermost occurrence of *Florentinia berran* (5).

Age: Albian.

Important associated taxa: *Florentinia clavigera* (23) and *Oligosphaeridium irregulare* (25) are restricted to this zone. *Downiesphaeridium aciculare* (18), *Oligosphaeridium poculum* (20), *Cribroperidinium orthoceras* (21), *Subtilisphaera senegalensis* (22), *Oligosphaeridium asterigerum* (24) and *Odontochitina operculata* (15) are present in this zone.

Correlation: Zone IIIA (middle to late Albian) of Uwins & Batten (1988), Well A1-28, Well A1-18, Well A1-117, Well B1-33 and Well C1-18, Libya. Zone D3 (Albian/?early Cenomanian) of Omran et al. (1990), Fadda-1, Minqar-1X and Sharib-1X well, northern Western Desert, Egypt. *Subtilisphaera senegalensis-Cyclonephelium vannophorum* Interval Zone (Albian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert, Egypt.

- Zone D4: *Florentinia berran-Florentinia mantellii-Oligosphaeridium totum-Oligosphaeridium verrucosum* Assemblage Zone.

Samples: S.61 to S.70 (depth 5700 to 4650 ft).

Definition: from the lowermost occurrence of *Florentinia berran* (5).

Age: early Cenomanian.

Important associated taxa: *Florentinia berran* (5), *Oligosphaeridium totum* (10) and *Oligosphaeridium verrucosum* (12) occur only in this zone.

Correlation: Zone IVA (Vraconian to early Cenomanian) of Uwins & Batten (1988), well A1-45, Libya. *Senegalinium aenigmaticum-Odontochitina rhakodes-Florentinia berran* Assemblage Zone (late Albian/early Cenomanian) of Schrank & Ibrahim (1995), Kahraman-1 and Abu Gharadiq-18 wells, Western Desert, Egypt.

Palaeoecologic and palaeoclimatic significance of the Siqeifa palynoflora

Palynomorphs from the lower part of the Berriasian to Barremian interval suggest deposition in a marginal marine (deltaic) environment during a regressive phase. This is interpreted by the occurrence of proximate dinoflagellate cysts such as *Systematophora*, *Pseudoceratium*, *Cribroperidinium*, *Subtilisphaera* and *Circulodinium*, large terrestrial influx of palynomorphs along with palynofacies. A transgressive, open marine (inner neritic) phase is thought to have taken place near the top of this interval and continued during Aptian, because skolochorate cysts such as *Oligosphaeridium* became abundant. A second regressive phase and marginal marine environment took place during deposition of Albian to lower Cenomanian sediments because dinocysts and poorly diversified miospores are abundant. In the Albian spiniferate cysts are associated with a noticeable increase in the quantity of land derived organic debris, which are taken to indicate a pronounced sea level fall (Brinkhuis & Zachariasse 1988).

In general, extant sporomorph groups such as pteridophytic families Cyatheaceae and Dicksoniaceae show broad climatic and ecologic preferences, which render them of limited palaeoclimatic importance. All extant species of the polyplicate *Ephedra* are highly adapted to semi-arid or arid climates (Trevisan 1980; Hochuli 1981). Dominating pteridophytic spores (mainly *Deltoidospora*), which are accompanied by relatively low numbers of *Ephedripites* pollen, occur sporadically and rarely in two samples of the Berriasian to Barremian interval, may suggest humid palaeoclimate during deposition of the investigated Lower Cretaceous succession. The striking high percentages of elaterates in a single horizon near the Albian base and the occurrence of *Afropollis* in appreciable amounts may indicate more local temporary short term coastal humidity. This could be established in the Berriasian to Barremian interval where liverworts such as *Aequitriradites* and schizaeaceous spores such as *Cicatricosisporites* are found (Schrank & Mahmoud 1998). Humidity could also be inferred by presence of *Afropollis* (Schrank 2001) and freshwater algae such as *Chomotriletes*, *Ovoidites* and *Schizosporis* in the Aptian/Albian interval and by occurrence of *Crybelosporites* spores, which are produced by hygrophilous plants in swampy conditions of brackish character, along with *Afropollis* in the lower Cenomanian.

Egypt in relation to world Lower Cretaceous palynofloral provinces

Mid-Cretaceous palynofloras from Siqeifa 1-X borehole share the broad characteristics of the "Albian-Cenomanian Elaterates Province" of Herngreen et al. (1996). Important elements in this province are *Afropollis* pollen and elaterates such as *Elaterosporites, Elaterocolpites* and *Elateroplicites*. The *Elaterosporites klaszii* acme in sample S.48 represents a very localized and short-time event in the Albian of North Africa since it was found also by Schrank (2001). However there are also differences: *Ephedripites* and *Classopollis* pollen are common constituents in the Elaterates Province but are minor constituents in the Siqeifa assemblages. More likely, the palynofloras are of North African aspect; spores and araucariacean pollen are abundant, in contrast with contemporaneous assemblages in other parts of Africa and South America such as Congo and Brazil. The Siqeifa assemblages are transitional between those in North Gondwana and Southern Laurasia, but they differ from typical transitional assemblages in lacking bisaccate conifers and having *Afropollis* pollen occurring in appreciable amounts. However, our spore assemblages are made up mainly of smooth trilete forms such as *Deltoidospora*, despite the occurrence of Gleicheniaceae spores, one of the typical Southern Laurasian elements (Hochuli 1981). These characteristics were attributed by Doyle et al. (1982) to a presumed near equatorial position of northeast Africa during Early Cretaceous times. The interpreted humid palaeoclimate for the investigated Berriasian to Aptian part of the Siqeifa 1-X well (see palaeoecologic and palaeoclimatic section) contrasts previously ascertained interpretations for the "Pre-Albian Early Cretaceous *Dicheiropollis etruscus/Afropollis* Province" of Herngreen et al. (1996). In this province warm-arid climate is inferred during Berriasian-Hauterivian, became drier in the Barremian-Aptian. The frequency and diversity of the Siqeifa (fern) spores support previous interpretation of Herngreen et al. that Egypt was in a more marginal and transitional geographic position and was more humid during pre-Albian times. The humid climate witnessed also by the Albian-Cenomanian record in the Siqeifa section, unlike the known warm arid to semi-arid climate in Northern Gondwana Realm during Early Cretaceous times in the "Albian-Cenomanian Elaterates Province" described by Herngreen et al. (1996), was likely responsible for the high diversification of fern spores and araucariacean pollen and the low numbers of *Classopollis* and *Ephedripites*. *Afropollis* and Elaterate pollen parent plants flourished in humid coastal plains (Dino et al. 1999; Schrank 2001). Therefore the presence of *Afropollis* pollen in the samples investigated here suggests that similar conditions were in existence in Egypt during the Albian-Cenomanian time. The coastal position of Egypt during the Early Cretaceous (Parrish 1987) may account for the palynofloral dissimilarities between Egypt and other parts of the Elaterates Province that display warm-arid to semiarid palaeoclimate. De Lima (1983) and Herngreen & Dueñas Jimenez (1990) favoured a wetter climate for the coastal areas of Brazil and Columbia, taking into account the opening of the South Atlantic. We argue in favour that the interpreted humidity in the succession of the Siqeifa borehole may be attributed to the palaeogeographic position of Egypt during Early Cretaceous times, or to a local reason.

Acknowledgments. Thanks go to the Egyptian General Petroleum Corporation for providing the samples and borehole log. The authors are indebted to E. Schrank (TU Berlin) and S. Torricelli (San Donato Milanese) for their critically reading and improving the quality of the manuscript. The equipment donation (Leica DM LB2 microscope, Leica DFC 280 digital camera and an up-to-date IBM computer system) and support of the Alexander von Humboldt Foundation to M.S. Mahmoud are greatly appreciated.

PLATE 1

(Slide number, depth, "England Finder" indices and measure are given).

a, b, i. *Concavissimisporites punctatus*
a. Slide S-39A, depth 7950 ft, V60-4, diameter 68 µm.
b. Slide S-36B, depth 8250 ft, V20, diameter 68 µm.
i. Slide S-41B, depth 7800 ft, W58-3, diameter 63 µm.
c. *Cibotiumspora jurienensis.* Slide S-24A, depth 9400 ft, Y52-4, diameter 40 µm.
d. *Impardecispora apiverrucata* sensu lato. Slide S-01A, depth 12000 ft, H59, diameter 60 µm.
e. *Cicatricosisporites* sp. Slide S-05B, depth 11650 ft, V32-2, diameter 58 µm.
f. *Duplexisporites generalis.* Slide S-32B, depth 8700 ft, F35-4, diameter 55 µm.
g. *Deltoidospora*-type spore. Slide S-33A, depth 8650 ft, S48-4, diameter 55 µm.
h. *Cicatricosisporites sinuosus.* Slide S-32A, depth 8700 ft, W50-1, diameter 43 µm.
j. *Retitriletes*? sp. Slide S-53A, depth 6550 ft, T42, diameter 60 µm.
k. *Aequitriradites spinulosus.* Slide S-67A, depth 4950 ft, V24, diameter 70 µm.
l. *Balmeisporites* cf. *holodictyus.* Slide S-34A, depth 8550 ft, Z43, length 128 µm.
m. *Crybelosporites pannuceus.* Slide S-70A, depth 4650ft, E39, diameter 75 µm.
n. *Triplanosporites* sp. Slide S-33A, depth 8650ft, X12, diameter 50 µm.
o. *Trilobosporites laevigatus.* Slide S-64A, depth 5200 ft, N50, diameter 78 µm.
p. *Ephedripites* sp. Slide S-56B, depth 6300 ft, X20, length 85 µm.
q. *Inaperturopollenites undulates.* Slide S-10A, depth 10650 ft, N27, diameter 70 µm.
r. *Callialasporites trilobatus.* Slide S-16A, depth 10050 ft, X34-1, diameter 50 µm.
s. *Arucariacites australis.* Slide S-41A, depth 7800 ft, Q39-1, diameter 75 µm.

PLATE 2

a, b. *Afropollis jardinus*
a. Slide S-33A, depth 7000 ft, U50-4, diameter 40 µm.
b. Slide S-47A, depth 8650 ft, Y54-2, diameter 38 µm.
c. *Afropollis* sp. (inaperturate/columellate?). Slide S-41A, depth 7800 ft, M57-1, diameter 50 µm.
d. *Afropollis zonatus.* Slide S-36B, depth 8250 ft, C52, diameter 45 µm.
e. *Afropollis* sp. Slide S-41A, depth 7800 ft, T27-2, diameter 35 µm.
f, g, t. *Retimonocolpites variplicatus*
f. Slide S-65A, depth 5150 ft, Q41, length 68 µm.
g. Slide S-67A, depth 4590 ft, E57-1, length 75 µm.
t. Slide S-52A, depth 6650 ft, K22-4, length 68 µm.
h. *Foveotricolpites gigantoreticulatus.* Slide S-62B, depth 5550 ft, H33, diameter 70 µm.
i. *Rousea delicipollis.* Slide S-50A, depth 7000 ft, Q33-4, diameter 38 µm.
j, k, o, r. *Elaterosporites klaszii*
j. Slide S-48C, depth 7100 ft, K23-4, body diameter 48 µm.
k. Slide S-48D, depth 7100 ft, B31-2, body diameter 45 µm.
o. Slide S-48A, depth 7100 ft, X40, body diameter 38 µm.
r. Slide S-48D, depth 7100 ft, A24-4, body diameter 40 µm.
l. *Elateroplicites africaensis.* Slide S-48C, depth 7100 ft, K26-2, body diameter 43 µm.
m. *Elaterocolpites castelainii.* Slide S-48D, depth 7100 ft, F21-3, body diameter 85 µm.
n. *Tricolpites* sp.Slide S-65A, depth 5150 ft, U41-1, diameter 35 µm.
p, s. *Cretacaeiporites densimurus*
p. Slide S-62B, depth 5550 ft, U59, diameter 68 µm.
s. Slide S-68A, depth 4900 ft, L29-3, diameter 50 µm.
q. *Stellatopollis densiornatus.* Slide S-57B, depth 6200 ft, T59-3, diameter 88 µm.

PLATE 3

a. *Circulodinium distinctum.* Slide S-04A, depth 11750 ft, X46-3 body diameter 67 µm.
b. *Cyclonephelium* cf. *vannophorum.* Slide S-5B, depth 11650 ft, Y42, body diameter 80 µm.
c. *Pseudoceratium securigerum.* Slide S-34B, depth 8550 ft, Z21, body diameter 75 µm.
d. *Cyclonephelium vannophorum.* Slide S-26A, depth 9200 ft, M63-1, body diameter 63 µm.
e. *Oligosphaeridium* cf. *totum.* Slide S-66B, depth 5050 ft, Z32-4, body diameter 53 µm.
f. *Cribroperidinium* sp. Slide S-05A, depth 11650 ft, W32-1, width 67 µm.
g. *Subtilisphaera senegalensis.* Slide S-41A, depth 7800 ft, Y34, width 38 µm.
h. *Cribroperidinium edwardsii.* Slide S-35A, depth 8450 ft, Y57-2, width 63 µm.
i. *Oligosphaeridium* cf. *poculum.* Slide S-41A, depth 7800 ft, D31, body diameter 52 µm.
j. *Muderongia staurota.* Slide S-22A, depth 9500 ft, J56-4, body diameter 35 µm.
k. *Odontochitina operculata* (operculum). Slide S-55A, depth 6400 ft, U31-3, width of opercular piece 43 µm.
l. *Coronifera tubulosa.* Slide S-53B, depth 6550 ft, J16-3, body diameter 50 µm.
m. *Oligosphaeridium complex.* Slide S-42A, depth 7650 ft, Y38-3, body diameter 53 µm.
n. *Pseudoceratium* cf. *anaphrissum.* Slide S-26A, depth 9200 ft, C20-3, body diameter 67 µm.
o. *Spiniferites multibrevis.* Slide S-62B, depth 5550 ft, Y33-3, body diameter 50 µm.
p. *Coronifera oceanica.* Slide S-46A, depth 7250 ft, O48, body diameter 57 µm.
q,t. *Florentinia* cf. *laciniata*
q. Slide S-63A, depth 5350 ft, R62, body diameter 55 µm.
t. Slide S-57A, depth 6200 ft, Z53-2, body diameter 57 µm.
r. *Florentinia mantellii.* Slide S-37A, depth 8200 ft, N60-4, body diameter 53 µm.
s. *Florentinia radiculata.* Slide S-57A, depth 6200 ft, V17-3, body diameter 60 µm.

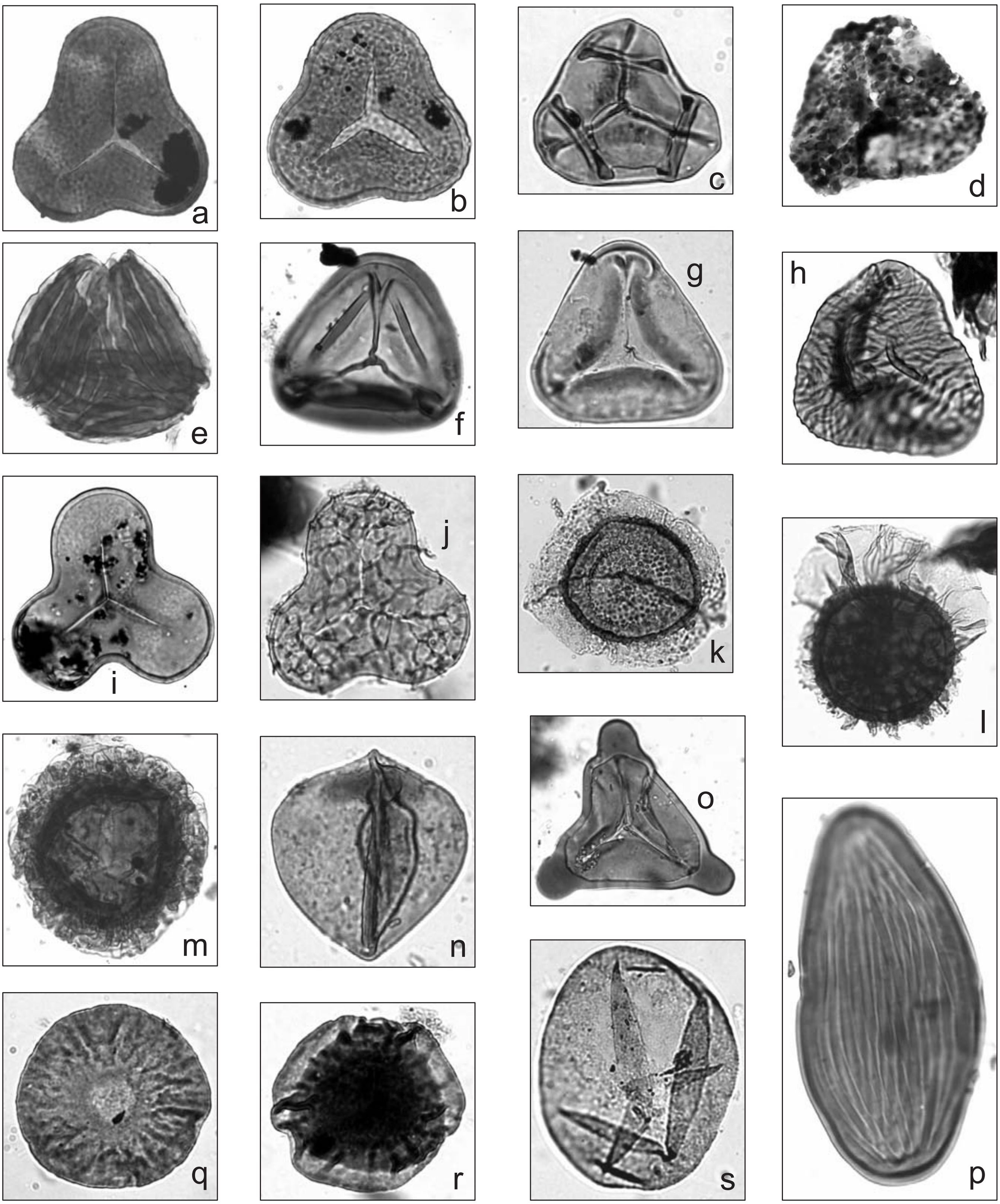


PLATE 1

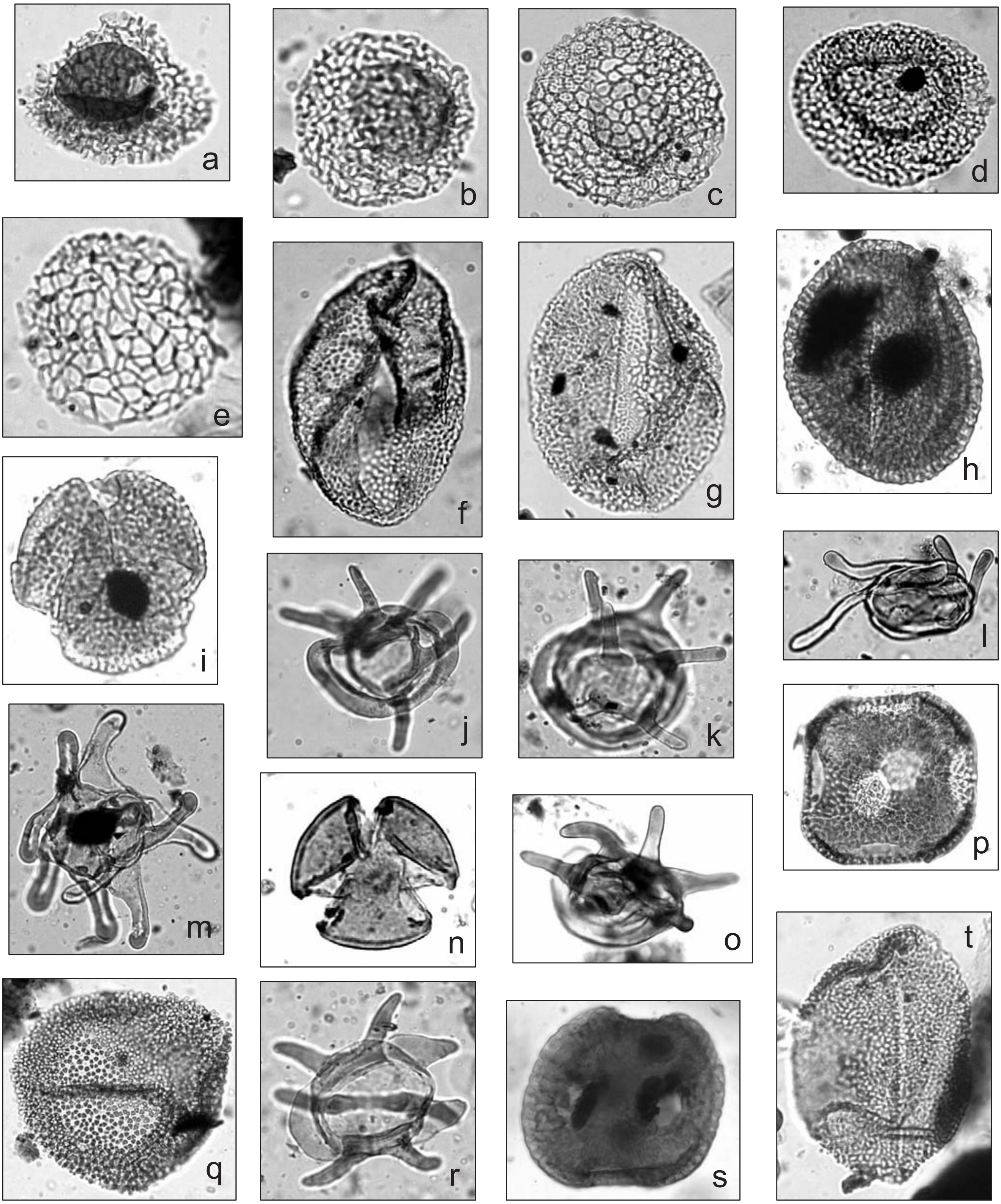


PLATE 2

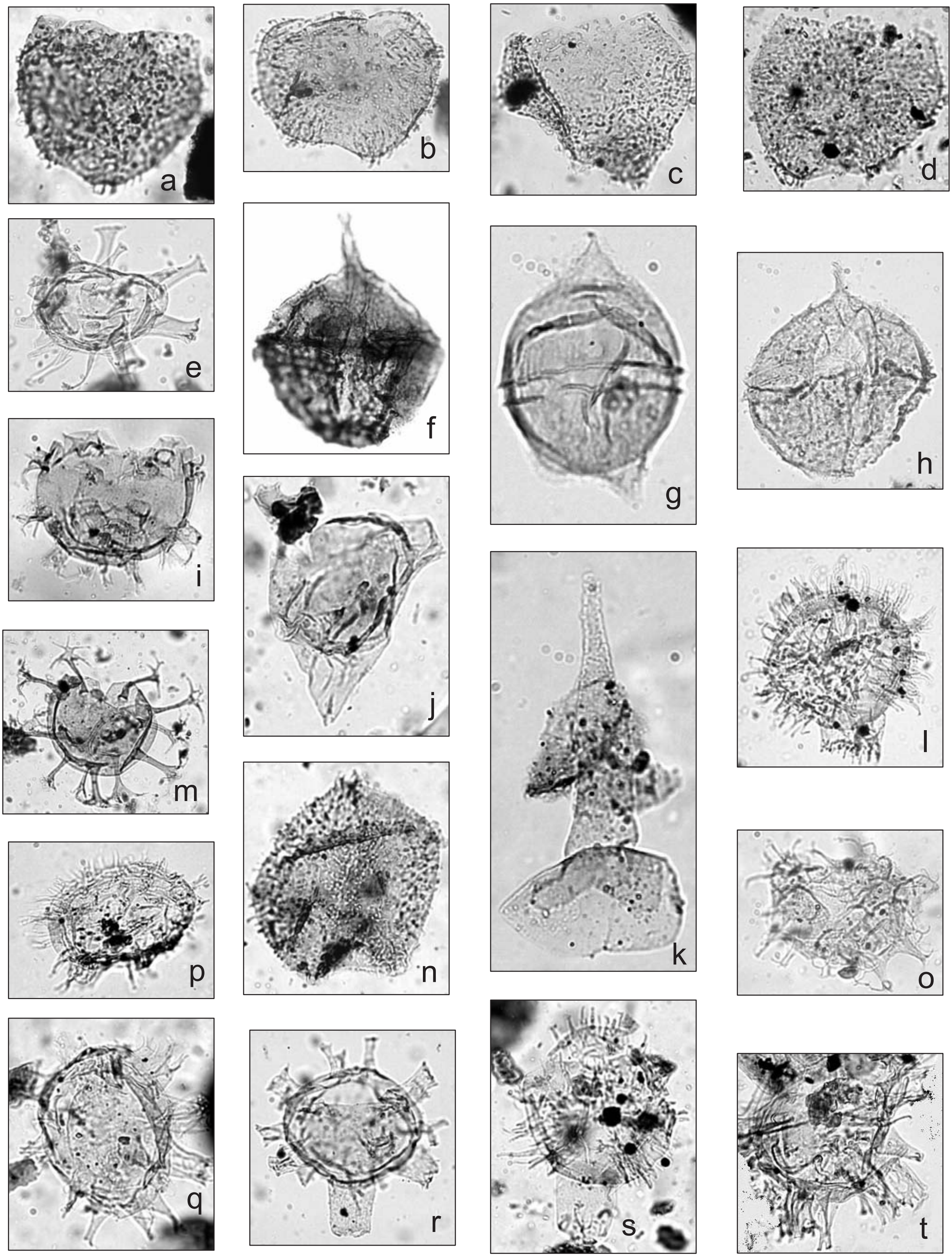


PLATE 3

APPENDIX

Alphabetical listing of identified palynomorphs (numbers in brackets refer to position of taxon in the range chart; Fig. 4)

Spores and pollen

- *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann, 1961, Plate 1k (84).
- *Aequitriradites verrucosus* (Cookson & Dettmann) Cookson & Dettmann, 1961 (85).
- *Afropollis jardinus* (Brenner) Doyle et al., 1982, Plate 2 a,b (103).
- *Afropollis operculatus* Doyle et al., 1982, Plate 2c (113).
- *Afropollis zonatus* Doyle et al., 1982, Plate 2d (115).
- *Afropollis* sp., Plate 2e (105).
- cf. *Afropollis jardinus* (Brenner) Doyle et al., 1982 (116).
- *Appendicisporites tricornitatus* Weyland & Greifeld, 1953 (67).
- *Appendicisporites* sp. (78).
- *Araucariacites australis* Cookson ex Couper, 1953, Plate 1s (89).
- *Arecipites punctatus* Wodehouse, 1933 (118).
- *Balmeiopsis limbatus* (Balme) Archangelsky, 1979 (91).
- *Balmeisporites holodictyus* Cookson & Dettmann, 1958, Plate 1l (*B.* cf. *holodictyus*) (79).
- *Biretisporites potoniaei* Delcourt & Sprumont, 1955 (75).
- *Biretisporites* sp. (65).
- *Brenneripollis* sp. (117).
- *Callialasporites dampieri* (Balme) Sukh Dev, 1961 (92).
- *Callialasporites trilobatus* (Balme) Sukh Dev, 1961, Plate 1r (100).
- *Cibotiumspora jurienensis* (Balme) Filatoff 1975, Plate 1c (60).
- *Cicatricosisporites brevilaesuratus* Couper, 1958 (83).
- *Cicatricosisporites kedvesii* Schrank, 2000 (86).
- *Cicatricosisporites orbiculatus* Singh, 1964 (61).
- *Cicatricosisporites sinuosus* Hunt, 1985, Plate 1h (70).
- *Cicatricosisporites sprumontii* Döring, 1965 (87).
- *Cicatricosisporites* spp., Plate 1e (64).
- *Clavatasporites irregularis* Wilson, 1962 (73).
- *Classopollis classoides* Pflug, 1953 (94).
- *Classopollis torosus* (Reissinger) Balme, 1957 (93).
- *Classopollis* sp. (95).
- *Concavisporites* sp. (69).
- *Concavissimisporites punctatus* (Delcourt & Sprumont) Brenner, 1963, Plate 1 a,b,i (68).
- *Cretacaeiporites densimurus* Schrank & Ibrahim, 1995, Plate 2 p,s (104).
- *Crybelosporites pannuceus* (Brenner) Srivastava, 1977, Plate 1m (62).
- *Cycadopites* sp. (96).
- *Deltoidospora* spp., Plate 1g (*Deltoidospora*-type spore) (58).
- *Duplexisporites generalis* Déak, 1962, Plate 1f (81).
- *Duplexisporites* sp. (82).
- *Elaterocolpites africaensis* Herngreen, 1973, Plate 2l (121).
- *Elaterocolpites castelainii* Jardiné & Magloire, 1965, Plate 2m (120).
- *Elaterosporites klaszii* (Jardiné & Magloire) Jardiné, 1967, Plate 2 j,k,o,r (119).
- *Ephedripites* spp., Plate 1p (90).
- *Eucommiidites troedssonii* (Erdtman) Potonié, 1958 (97).
- *Exesipollenites* sp. (99).
- *Foveotricolpites gigantoreticulatus* (Jardiné & Magloire) Schrank, 1987, Plate 2h (109).
- *Impardecispora apiverrucata* (Couper) Venkatachala et al., 1969 (88).
- *Inaperturopollenites undulatus* Weyland & Greifeld, 1953, Plate 1q (101).
- *Matonisporites cooksonii* Dettmann, 1963 (77).
- *Matonisporites* spp. (71).
- *Monocollpopollenites* sp. (114).
- *Murospora* cf. *florida* (Balme) Pocock, 1961 (80).
- *Retimonocolpites variplicatus* Schrank & Mahmoud, 1998, Plate 2 f,g,t (108).
- *Retimonocolpites* sp. (106).
- *Retitriletes*? sp., Plate 1j (74).
- *Rousea delicipollis* Srivastava, 1975 (112).
- *Spheripollenites* sp. (98).
- Spinate (*Deltoidospora*-like) spores (72).
- *Stellatopollis densiornatus* (Lima) Ward, 1986, Plate 2q (102).
- *Tetracolpites* sp. (110).
- *Tetracolpites* sp. 1 (111).
- *Todisporites minor* Couper, 1958 (76).
- *Tricolpites* spp., Plate 2n (107).
- *Trilobosporites laevigatus* El-Beialy, 1994, Plate 1o (66).
- *Trilobosporites* sp. (63).
- *Triplanosporites* sp., Plate 1n (59).
- Unidentified spore type 1 (74).

Dinoflagellate cysts

List of dinoflagellate cyst species encountered in this study. The generic allocation and species authorship follow Williams, Lentin and Fensome (1998)

- *Achomosphaera* cf. *sagena* Davey & Williams, 1966 (35).
- *Achomosphaera* sp. (42).
- *Achomosphaera verdieri* Below, 1982 (40).
- *Aptea* sp. (57).
- *Coronifera albertii* Millioud, 1969 (27).
- *Coronifera oceanica* Cookson & Eisenack, 1958, Plate 3p (11).
- *Coronifera* sp. (29).
- *Coronifera tubulosa* Cookson & Eisenack, 1974, Plate 3l (2).
- *Circulodinium brevispinatum* (Millioud) Fauconnier in Fauconnier & Masure, 2004 (46).
- *Circulodinium distinctum* (Deflandre & Cookson) Jansonius, 1986, Plate 3a (26).
- *Cribroperidinium edwardsii* (Cookson & Eisenack) Davey, 1969, Plate 3h (37).
- *Cribroperidinium orthoceras* (Eisenack) Davey, 1969 (21).
- *Cribroperidinium* sp., Plate 3f (19).
- *Cyclonephelium chabaca* Below, 1981 (30).
- *Cyclonephelium vannophorum* Davey, 1969, Plate 3b (*C.* cf. *vannophorum*), Plate 3d (31).
- *Cyclonephelium* cf. *vannophorum* Davey, 1969 (50).
- *Downiesphaeridium aciculare* (Davey) Islam, 1993 (18).
- *Florentinia berran* Below, 1982 (5).
- *Florentinia clavigera* (Deflandre) Davey & Verdier, 1973 (23).
- *Florentinia mantellii* (Davey & Williams) Davey & Verdier, 1973, Plate 3r (13).
- *Florentinia laciniata* Davey & Verdier, 1973, Plate 3 q,t (*F.* cf. *laciniata*) (9).
- *Florentinia radiculata* (Davey & Williams) Davey & Verdier, 1973, Plate 3s (4).
- *Florentinia* sp. (14).
- *Impletosphaeridium clavulum* (Davey) Islam, 1993 (7).
- *Muderongia simplex* Alberti, 1961 (44).
- *Muderongia staurota* Sarjeant, 1966, Plate 3j (43).
- *Muderongia* sp. (47).
- *Odontochitina operculata* (O. Wetzel) Deflandre & Cookson, 1955, Plate 3k (15).
- *Oligosphaeridium albertense* (Pocock) Davey & Williams, 1969 (25).
- *Oligosphaeridium asterigerum* (Gocht) Davey & Williams, 1969 (24).
- *Oligosphaeridium complex* (White) Davey & Williams, 1966, Plate 3m (17).

- *Oligosphaeridium poculum* Jain, 1977, Plate 3j (*O.* cf. *poculum*) (20).
- *Oligosphaeridium porosum* Lentin & Williams, 1981 (28).
- *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams, 1966 (6).
- *Oligosphaeridium* sp. (16).
- *Oligosphaeridium totum* Brideaux, 1971 (10).
- *Oligosphaeridium verrucosum* Davey, 1979 (12).
- *Palaeoperidinium cretaceum* (Pocock, 1962 ex Davey, 1970) Lentin & Williams, 1976 (39).
- *Pseudoceratium anaphrissum* (Sarjeant) Bint 1986 (54).
- *Pseudoceratium* cf. *anaphrissum* (Sarjeant) Bint 1986, Plate 3n (45).
- *Pseudoceratium eisenackii* (Davey) Bint, 1986 (48).
- *Pseudoceratium securigerum* (Davey & Verdier) Bint, 1986, Plate 3c (38).
- *Spiniferits multibrevis* (Davey & Williams) Below, 1982, Plate 3o (8).
- *Spiniferits ramosus* (Ehrenberg) Mantell, 1854 (3).
- *Spiniferits* sp. (33).
- *Subtilisphaera deformans* (Davey & Verdier) Stover & Evitt, 1978 (36).
- *Subtilisphaera pirnaensis* (Alberti) Jain & Millepied, 1973 (34).
- *Subtilisphaera senegalensis* Jain & Millepied, 1973, Plate 3g (22).
- *Subtilisphaera* cf. *senegalensis* Jain & Millepied, 1973 (32).
- cf. *Subtilisphaera senegalensis* Jain & Millepied, 1973. (49).
- *Subtilisphaera* sp. (41).
- *Systematophora areolata* Klement, 1960 (52).
- *Systematophora complicata* Neale & Sarjeant, 1962 (51).
- *Systematophora palmula* Davey, 1982 (56).
- *Systematophora silyba* Davey, 1979 (53).
- *Systematophora* sp. (1).
- *Systematophora valensii* (Sarjeant) Sarjeant, 1961 (55).

Incertae Sedis
- *Reyrea polymorphus* Herngreen, 1973 (122).

Freshwater algae
- *Chomotriletes minor* (Kedves) Pocock, 1970 (125).
- *Ovoidites parvus* (Cookson & Dettmann) Nakoman, 1966. (123).
- *Pediastrum* sp. (124).
- *Schizosporis reticulatus* Cooskon & Dettman, 1959 (126).

Miscellaneous
- Microforaminiferal test linings.

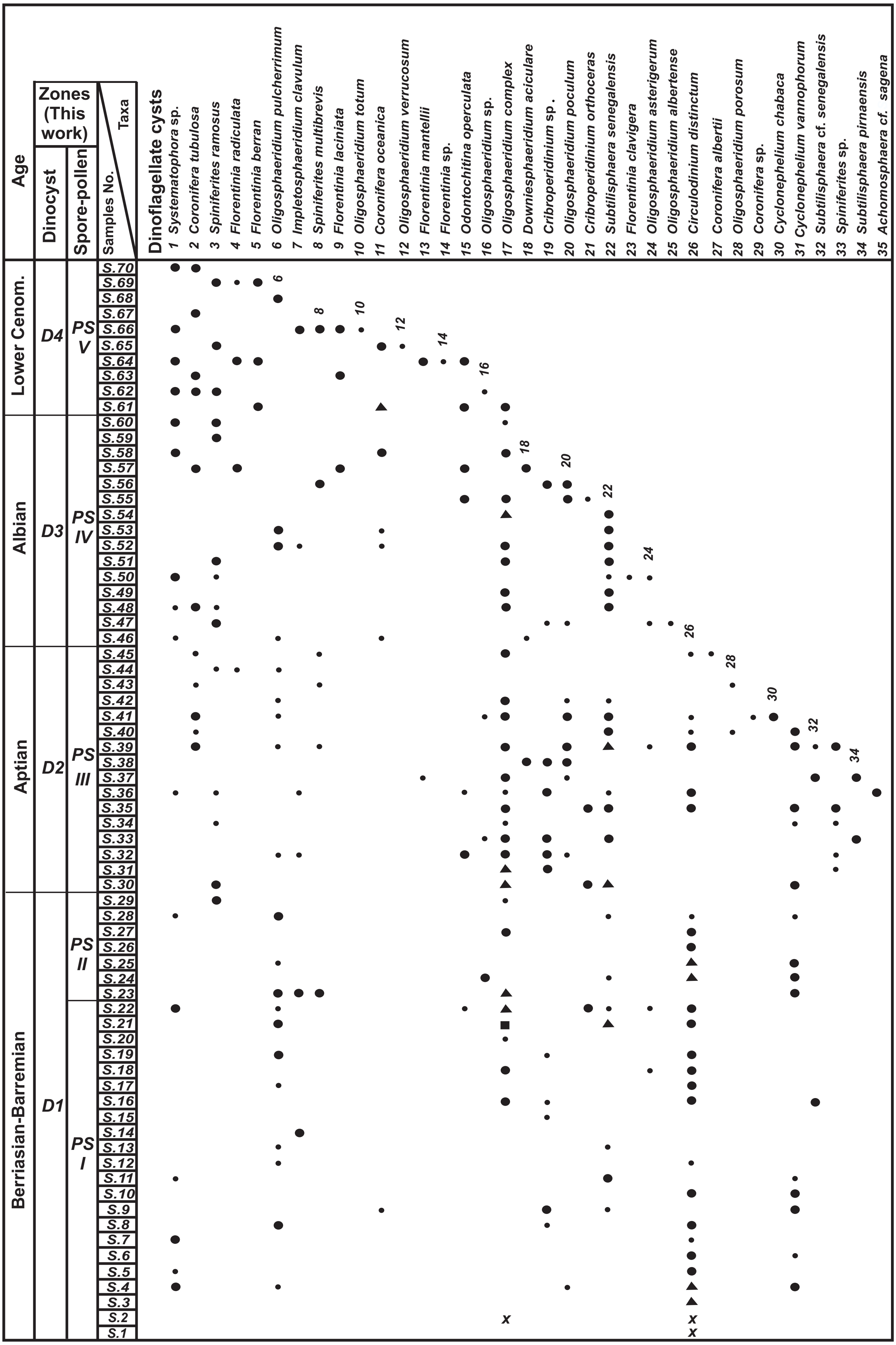
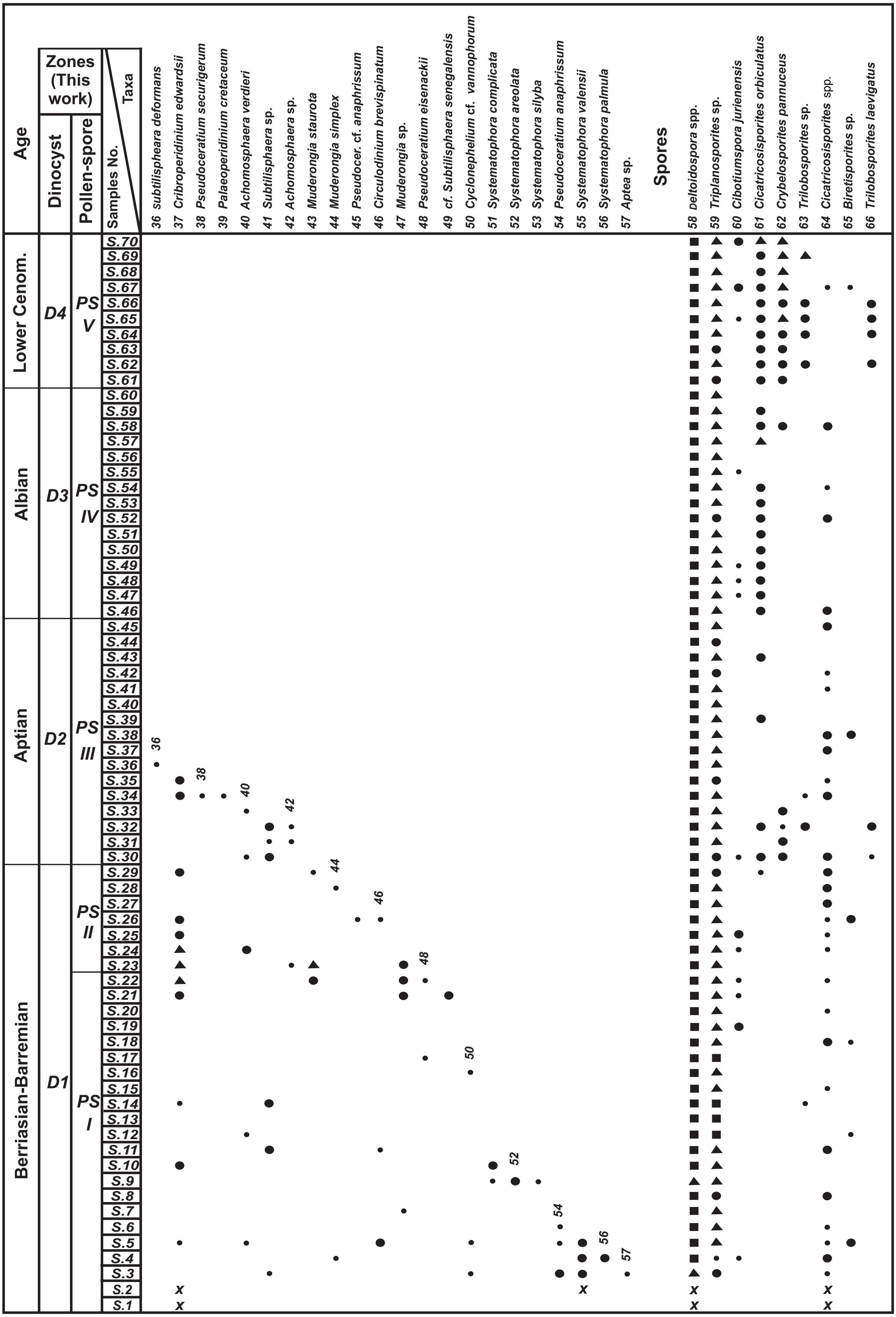
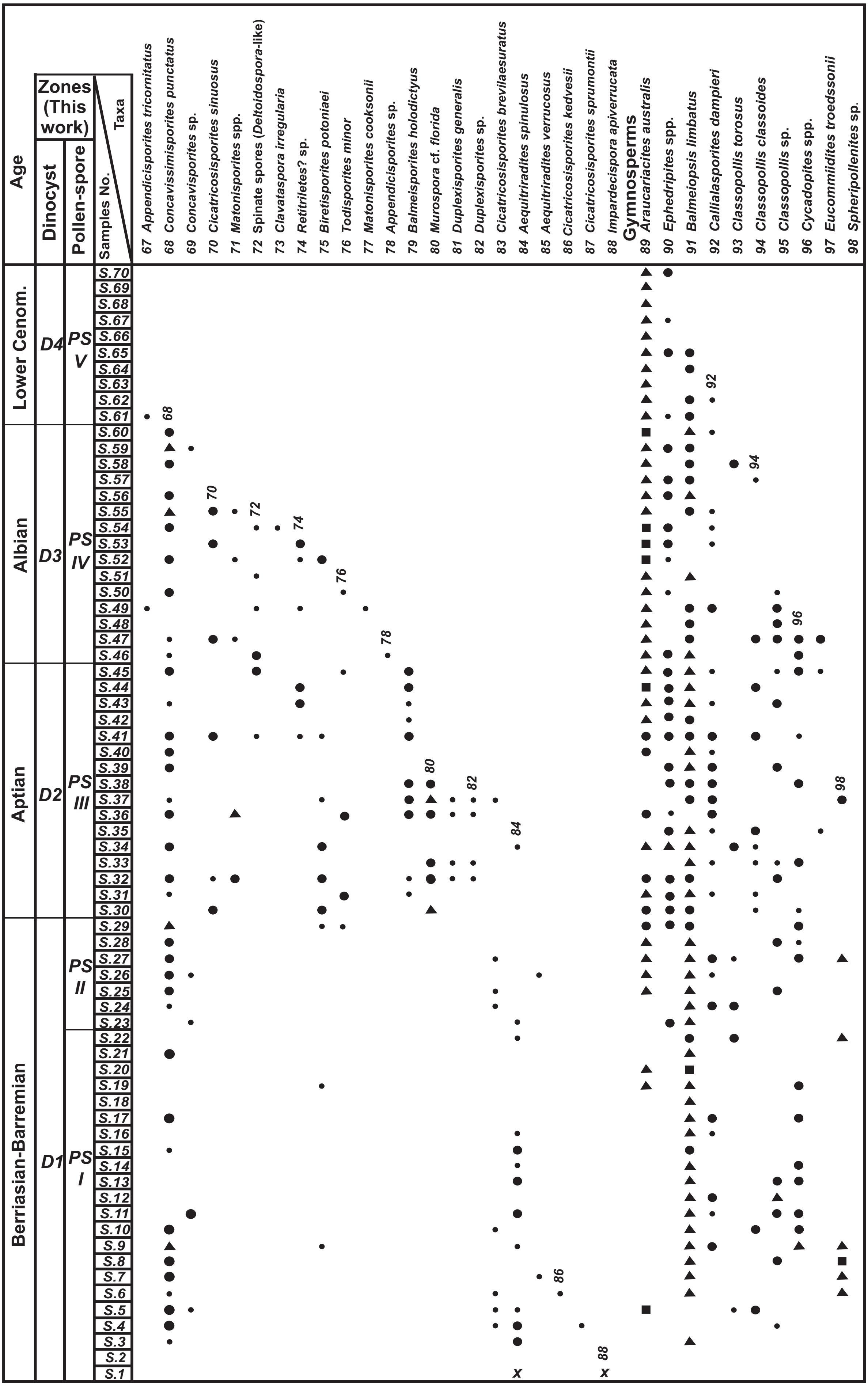
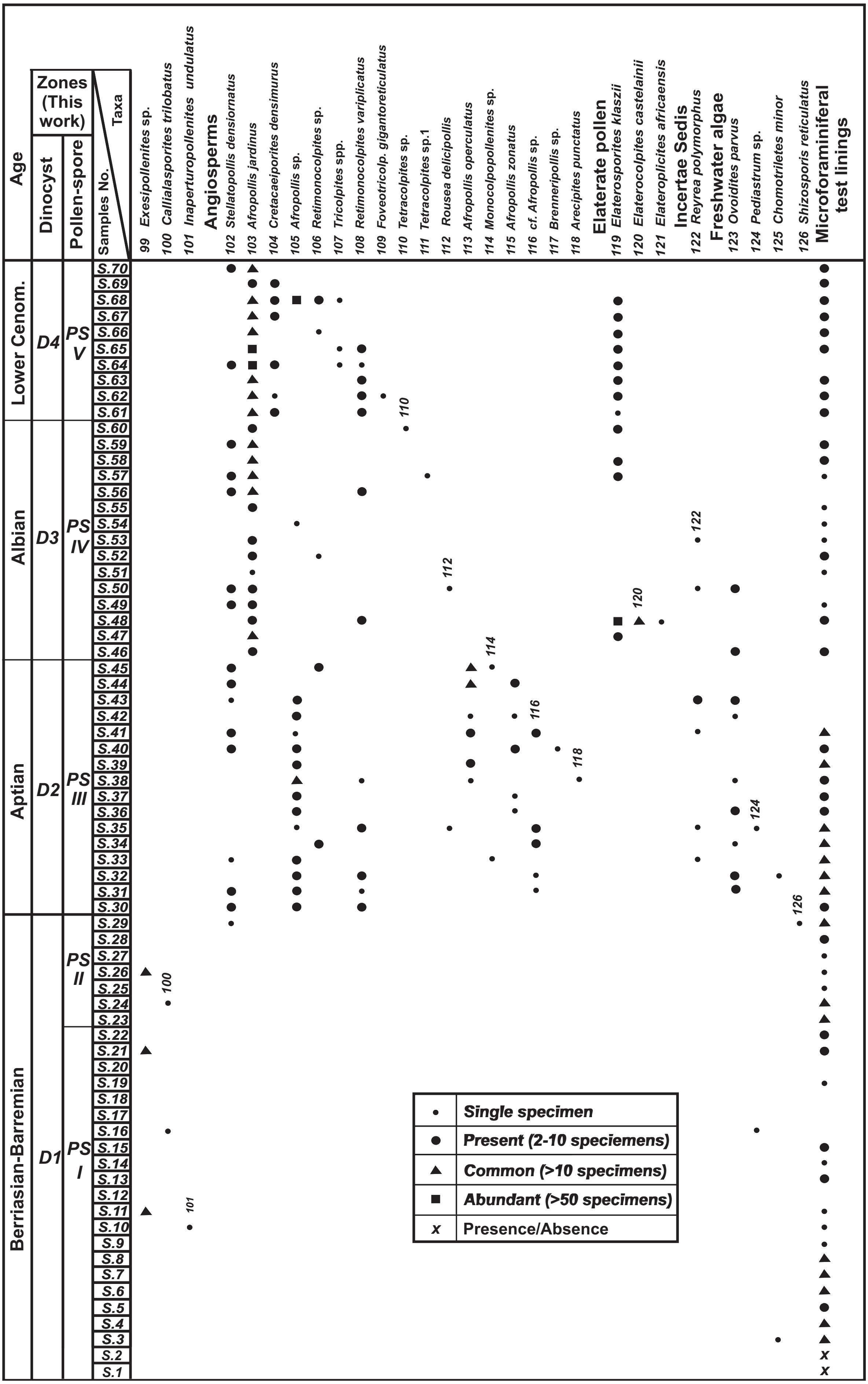


Fig. 4 - Semi-quantitative palynomorph distribution chart (ordered by highest occurrence) of the Siqeifa 1-X borehole. Zones are defined in the present paper. (Single occurrence of questionably referred species is not indicated on this figure).


Age
Zones (This work)
Dinocyst
Pollen-spore
Samples No.
Taxa
Lower Cenom.
Albian
Aptian
Berriasian-Barremian
D4
D3
D2
D1
PS V
PS IV
PS III
PS II
PS I
36 Subtilisphaera deformans
37 Cribroperidinium edwardsii
38 Pseudoceratium securigerum
39 Palaeoperidinium cretaceum
40 Achomosphaera verdieri
41 Subtilisphaera sp.
42 Achomosphaera sp.
43 Muderongia staurota
44 Muderongia simplex
45 Pseudocer. cf. anaphrissum
46 Circulodinium brevispinatum
47 Muderongia sp.
48 Pseudoceratium eisenackii
49 cf. Subtilisphaera senegalensis
50 Cyclonephelium cf. vannophorum
51 Systematophora complicata
52 Systematophora areolata
53 Systematophora silyba
54 Pseudoceratium anaphrissum
55 Systematophora valensii
56 Systematophora palmula
57 Aptea sp.
Spores
58 Deltoidospora spp.
59 Triplanosporites sp.
60 Cibotiumspora jurienensis
61 Cicatricosisporites orbiculatus
62 Crybelosporites pannuceus
63 Trilobosporites sp.
64 Cicatricosisporites spp.
65 Biretisporites sp.
66 Trilobosporites laevigatus


Age
Zones (This work)
Dinocyst
Pollen-spore
Samples No.
Taxa
Lower Cenom.
Albian
Aptian
Berriasian-Barremian
D4
D3
D2
D1
PS V
PS IV
PS III
PS II
PS I
67 Appendicisporites tricornitatus
68 Concavissimisporites punctatus
69 Concavisporites sp.
70 Cicatricosisporites sinuosus
71 Matonisporites spp.
72 Spinate spores (Deltoidospora-like)
73 Clavataspora irregularia
74 Retitriletes? sp.
75 Biretisporites potoniaei
76 Todisporites minor
77 Matonisporites cooksonii
78 Appendicisporites sp.
79 Balmeisporites holodictyus
80 Murospora cf. florida
81 Duplexisporites generalis
82 Duplexisporites sp.
83 Cicatricosisporites brevilaesuratus
84 Aequitriradites spinulosus
85 Aequitriradites verrucosus
86 Cicatricosisporites kedvesii
87 Cicatricosisporites sprumontii
88 Impardecispora apiverrucata
Gymnosperms
89 Araucariacites australis
90 Ephedripites spp.
91 Balmeiopsis limbatus
92 Callialasporites dampieri
93 Classopollis torosus
94 Classopollis classoides
95 Classopollis sp.
96 Cycadopites spp.
97 Eucommiidites troedssonii
98 Spheripollenites sp.


Age
Zones (This work)
Dinocyst
Pollen-spore
Samples No.
Taxa
99 Exesipollenites sp.
100 Callialasporites trilobatus
101 Inaperturopollenites undulatus
Angiosperms
102 Stellatopollis densiornatus
103 Afropollis jardinus
104 Cretacaeiporites densimurus
105 Afropollis sp.
106 Retimonocolpites sp.
107 Tricolpites spp.
108 Retimonocolpites variplicatus
109 Foveotricolp. gigantoreticulatus
110 Tetracolpites sp.
111 Tetracolpites sp.1
112 Rousea delicipollis
113 Afropollis operculatus
114 Monocolpopollenites sp.
115 Afropollis zonatus
116 cf. Afropollis sp.
117 Brenneripollis sp.
118 Arecipites punctatus
Elaterate pollen
119 Elaterosporites klaszii
120 Elaterocolpites castelainii
121 Elateroplicites africaensis
Incertae Sedis
122 Reyrea polymorphus
Freshwater algae
123 Ovoidites parvus
124 Pediastrum sp.
125 Chomotriletes minor
126 Shizosporis reticulatus
Microforaminiferal test linings
Lower Cenom.
Albian
Aptian
Berriasian-Barremian
D4
D3
D2
D1
PS V
PS IV
PS III
PS II
PS I
S.70
S.1
Single specimen
Present (2-10 speciemens)
Common (>10 specimens)
Abundant (>50 specimens)
x Presence/Absence

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