

Reconstruction of Paleovegetation and Paleocology from the Early Cretaceous Sporomorphs of Bougaz-1 well, northeast Sinai, Egypt

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A WELL-preserved, diverse sporomorph assemblage of 62 species belonging to 39 genera has been recorded in two Cretaceous (Aptian/Albian) samples recovered from depths 3105m and 3117m in the Bougaz-1 well, northeast Sinai. The identified 62 species consist of 20 genera and 27 species of pteridophytic fern spores, nine genera and 15 species of gymnosperm pollen, and 10 genera and 20 species of angiosperm pollen. A correlation of the encountered sporomorphs and their parent plant affinities (classes, orders and families) has been attempted in order to give an image of the past vegetation in this part of Egypt. Vegetation reconstruction demonstrates a mixed forest which is represented by a mixture of ferns, gymnosperms and angiosperms. A remarkable abundance of pteridophytic fern spores with other hygrophilous elements such as *Afropollis* pollen seems to indicate paleoclimatic trends towards warm humid conditions during the Aptian/Albian period in the studied area. This climatic preference is also confirmed by the low frequencies of conifer vegetation such as Araucariaceae, Cheirolepidiaceae and genetelean pollen (*Ephedripites*) which were predominant on the topographically higher and relatively xeric environments.

Keywords: Aptian/Albian, Cretaceous, Egypt, Paleocology, Paleovegetation, Sporomorphs.

Introduction

The Cretaceous deposits are widespread in different basins and sub-basins in the surface and subsurface of Egypt and are considered one of the main targets of oil exploration by the drilling companies (Abdel-Kireem et al., 1996). Because of this economic value, these strata are the scope of interest of many researchers mostly with regards to seismic, lithostratigraphy, sedimentology, geochronology and biostratigraphy.

From the botanical point of view, the Cretaceous was an important period in the history of the plant kingdom. Differences between Early Cretaceous and Late Cretaceous floras are much more pronounced than those between Late Jurassic and Early Cretaceous or between Late Cretaceous and Paleocene floras. The Early Cretaceous floras dominated by the ferns and gymnosperms over the angiosperms which started to appear by the end of the Jurassic and the beginning of the Cretaceous. In contrast, all Late Cretaceous floras are dominated by angiosperms, and consisted largely of modern families. Even the ferns, of which many are known, have modern analogy. The majority of the older cycadophytes, ginkgophytes and conifers had disappeared during the Late Cretaceous (Arnold, 1969).

Cretaceous sporomorph assemblages from Egypt and north Africa are of interest. During the Cretaceous period, especially the Early Cretaceous, Egypt and surrounding areas were part of a broad, low latitude belt that played an important role in the initial radiation and diversification of the non-dominant angiosperms (Schrank & Mahmoud, 2002). Many papers have been published on the palynology of the Egyptian Cretaceous strata since the pioneering works by Saad (1963, 1965, 1974 and 1978). Most of these works are more inclined towards biostratigraphy and geochronology, but few tackled how fossil miospores can be used to imagine the distribution, diversification and ecology of our earliest terrestrial floras.

This paper is a continuation of the study of the terrestrial palynomorphs from the Cretaceous sequence in Bougaz-1 well, northeast Sinai (El Noamani & Saleh, 2018). The latter work was restricted to the algal palynomorphs and excluded the diverse pollen and spores assemblage studied in the present work. The main goal of this study is to use the overall composition of the encountered miospore assemblage to configure a tentative picture for the paleovegetation model and more precise interpretation of the Aptian/Albian palaeoclimatic conditions which prevailed in

that part of northeast Sinai. To conduct such interpretations, semi-quantitative analysis of all miospore taxa and their possible parent plant affinities of miospore genera encountered in the present study are made.

Material and Methods

This study is based on the investigation of two cutting samples taken at depths 3105m and 3117m from the Aptian/Albian sequence encountered in Bougaz-1 well (Fig. 1). The samples consist of grey-to brown soft clay. Samples were processed for palynological study as follows: 10g of each crushed sample were treated with 10% HCL, 40 % HF, 39% HCL, Zinc chloride solution (specific gravity: 1.9), 10 % HCL and finally sieving with a nylon filtering screen (15µm mesh). Two permanent slides per sample were prepared using DPX as mounting medium. Using light microscopy, two slides of each sample were completely scanned and the observed miospores were identified to the lowest taxonomic level possible. The semi-quantitative analysis was based on the first 200 miospores (spores and pollen grains) counted on each slide. The specimens of interest were photographed using a Canon PowerShot G12 digital camera attached to a DEL binocular biological compound microscope and illustrated in Plates I, II and III. The locations of the illustrated specimens on the microscope slides are given as England Finder coordinates. The prepared slides and the remaining residues are housed in the palynological collection at the Paleobotany and Palynology Lab, Botany Department, Faculty of Science, Ain Shams University, Egypt.

Results

In the present analyzed material 62 miospore species have been identified including 27 species of ferns, 20 species related to the angiosperm pollen, meanwhile the gymnosperms are the least representative component which are represented by 15 species.

The present study uses a systematic organization of miospore genera that is formalized to suit the botanical affinities of the encountered taxa to reconstruct the paleovegetation based on the available data obtained from Couper (1958), Brenner (1963), Dettmann (1963), Singh (1964, 1971), Felix & Burbridge (1973), Srivastava (1977), Wingate (1980), Kedves (1986), Takahashi & Sugiyama (1990), Srivastava & Binda (1991), Mohr & Gee (1992), Ravn (1995), Dino et al. (1999), Abbink et al. (2004), Mahmoud & Schrank (2007), Narváez & Sabino (2008), Pole & Vajda (2009), Scafati et al. (2009), Krassilov & Schrank (2011), Villalba-Breva et al. (2012) and Ibrahim et al. (2017), as outlined in Table 1.

Paleovegetation reconstruction

The Aptian/Albian palynoflora in Bougaz Basin comprises a variety of plant groups. Information on the botanical affinities of the principal dispersed spore and pollen genera or categories in the studied samples is summarized in Table 1. In general, the vegetation in this interval is interpreted as a mixed forest which is represented by a mixture of ferns, gymnosperms and angiosperms. Their variations in dominance apparently influenced the overall structure of the vegetation.

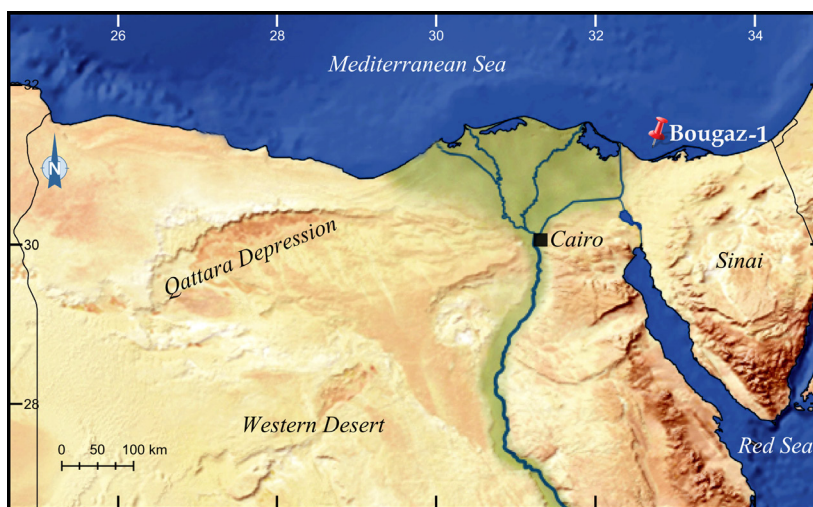


Fig. 1. Location map of Bougaz-1 (B-1) well (after El Noamani & Saleh, 2018).

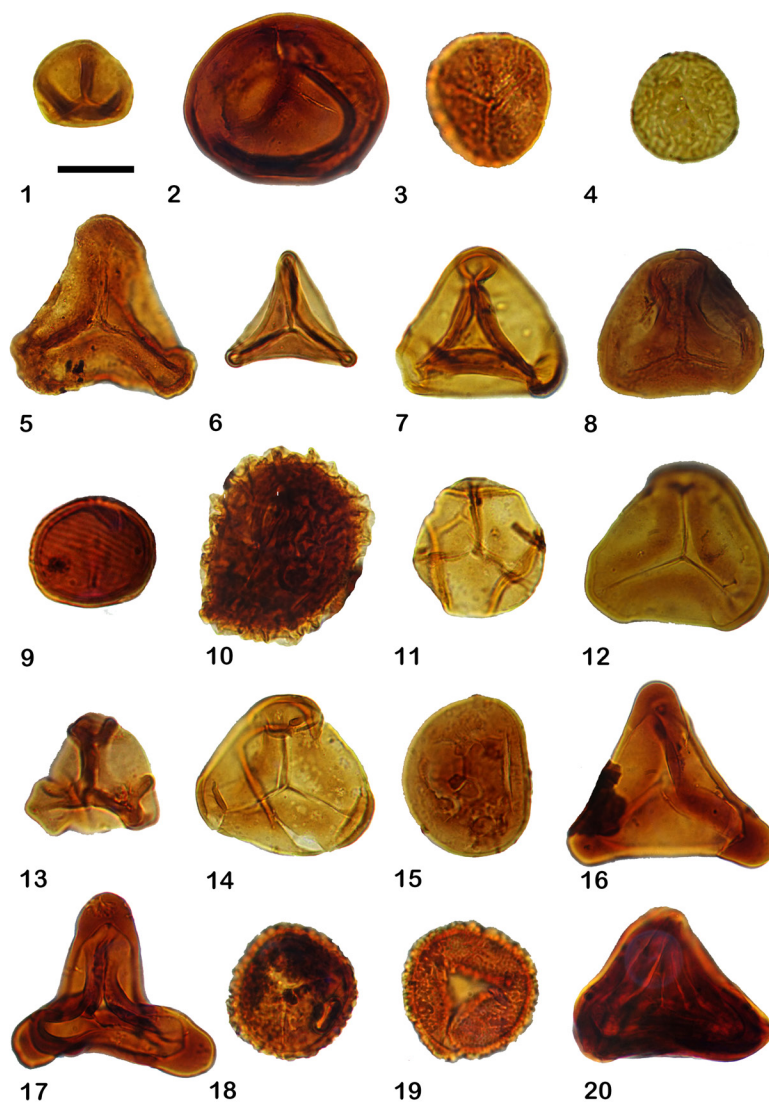


Plate I.

- I.1 *Biretisporites potonieii* Delcourt and Sprumont; B-1 3117/1; M19/2-4; 17 μ m.
 I.2 *Punctatisporites couperi* Ravn; B-1 3117/1; J34/2; 26 μ m.
 I.3 *Punctatisporites globosus* (Leschik) Lund; B-1 3105/1; B55/2-4; 15 μ m.
 I.4 *Rugulatisporites* sp.; B-1 3105/4; T44/3-4; 20 μ m.
 I.5 *Gleicheniidites senonicus* Ross; B-1 3105/1; E16/2; 26 μ m.
 I.6 *Gleicheniidites* sp.; B-1 3117/1; Y14/1-3; 21 μ m.
 I.7 *Dictyophyllidites equixinus* (Cookson) Dettmann; B-1 3117/3; M63/1-2; 21 μ m.
 I.8 *Dictyophyllidites harrisii* Couper; B-1 3105/1; Q20/2-4; 23 μ m.
 I.9 *Cicatricosisporites minutaestriatus* (Bolkhovitina) Pocock; B-1 3105/1; H44/2-4; 20 μ m.
 I.10 *Crybelosporites pannuceus* (Brenner) Srivastava; B-1 3105/2; N53/1-3; 23 μ m.
 I.11 *Cibotiumspora juncta* (Kara-Murza) Singh; B-1 3105/1; L44; 19 μ m.
 I.12 *Deltoidospora australis* (Couper) Pocock; B-1 3105/2; J17/2; 22 μ m.
 I.13 *Cibotiumspora jurienensis* (Balme) Filatoff; B-1 3105/2; P30; 15 μ m.
 I.14 *Deltoidospora* sp.; B-1 3105/2; Q31/1; 22 μ m.
 I.15 *Laevigatosporites* sp.; B-1 3105/2; S22/2; 20 μ m.
 I.16 *Trilobosporites laevigatus* El-Beialy; B-1 3105/2; G19; 24 μ m.
 I.17 *Trilobosporites laevigatus* El-Beialy; B-1 3105/2; R40/3; 22 μ m.
 I.18 *Verrucosisporites rotundus* Singh; B-1 3105/2; B54/1-3; 19 μ m.
 I.19 *Dictyosporites* sp.; B-1 3105/2; L43/1; 20 μ m.
 I.20 *Duplexisporites generalis* Déak; B-1 3117/1; R44/1-3; 20 μ m.

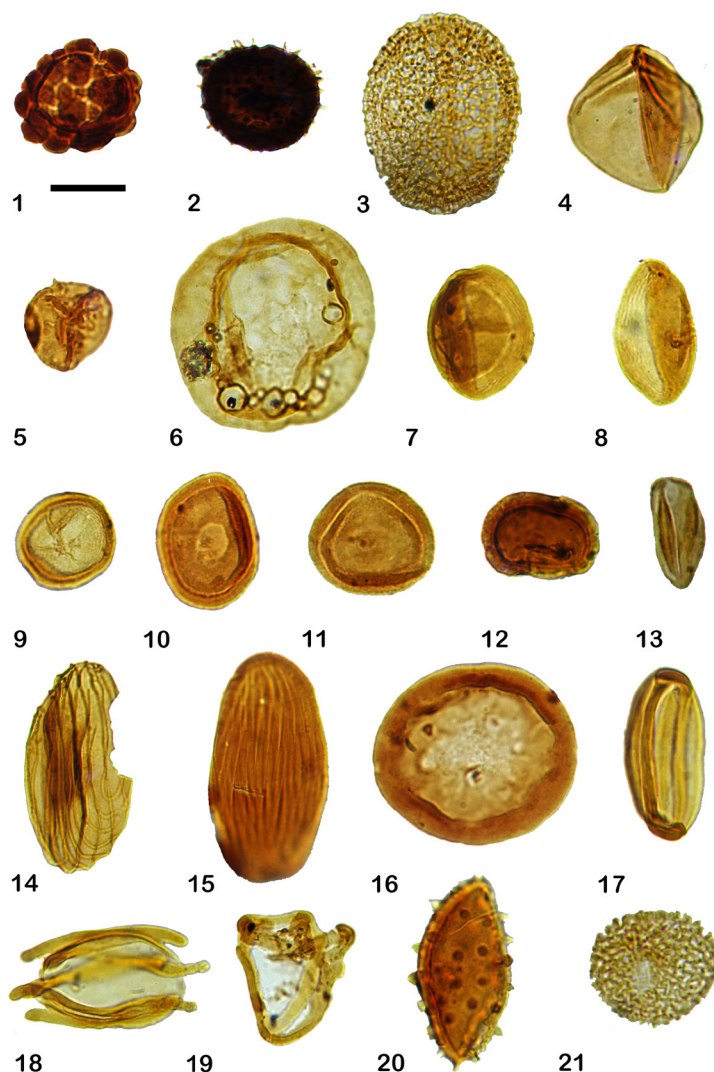


Plate II.

- II.1 *Leptolepidites psarosus* Norris; B-1 3117/1; N39/1-2; 20 μ m.
 II.2 *Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont; B-1 3117/1; R34/3; 19 μ m.
 II.3 *Schizosporites reticulatus* Cookson and Dettmann emend. Pierce; B-1 3105/1; P18/3-4; 21 μ m.
 II.4 *Triplanosporites* sp.; B-1 3105/1; H55; 20 μ m.
 II.5 *Undulatisporites pannuceus* (Brenner) Singh; B-1 3117/3; J67/2-4; 18 μ m.
 II.6 *Araucariacites australis* Cookson ex Couper; B-1 3105/1; P55/2; 23 μ m.
 II.7 *Classopollis brasiliensis* Herngreen; B-1 3105/1; T57/3-4; 15 μ m.
 II.8 *Classopollis brasiliensis* Herngreen; B-1 3117/1; T20/2; 16 μ m.
 II.9 *Classopollis classoides* Pflug emend. Pocock and Jansonius; B-1 3105/1; L53/2-4; 19 μ m.
 II.10 *Classopollis torosus* (Reissinger) Couper; B-1 3105/2; R49/1; 15 μ m.
 II.11 *Classopollis* cf. *triangulus* (Zhang) Lei; B-1 3105/2; F43/1; 16 μ m.
 II.12 *Circulina parva* Brenner; B-1 3117/1; R24/3; 15 μ m.
 II.13 *Eucommiidites troedssonii* (Erdtman) Hughes; B-1 3105/1; M55/3; 13 μ m.
 II.14 *Ephedripites jansonii* (Pocock) Muller; B-1 3117/1; G29/1-3; 23 μ m.
 II.15 *Ephedripites regularis* van Hoeken-Klinkenberg; B-1 3105/1; G15/2-4; 22 μ m.
 II.16 *Balmeiopsis limbata* (Balme) Archangelsky; B-1 3105/1; E16/2; 19 μ m.
 II.17 *Steevesipollenites cupuliformis* Azéma and Boltenhagen; B-1 3105/1; X18; 17 μ m.
 II.18 *Elaterosporites klaszii* (Jardiné and Magloire) Jardiné; B-1 3105/2; F18; 17 μ m.
 II.19 Indetermined elaterate pollen; B-1 3105/2; S51; 20 μ m.
 II.20 *Echinomonocolpites* sp.; B-1 3105/2; P31/1-2; 18 μ m.
 II.21 *Retimonocolpites bueibensis* Ibrahim; B-1 3105/1; W21/3-4; 14 μ m.

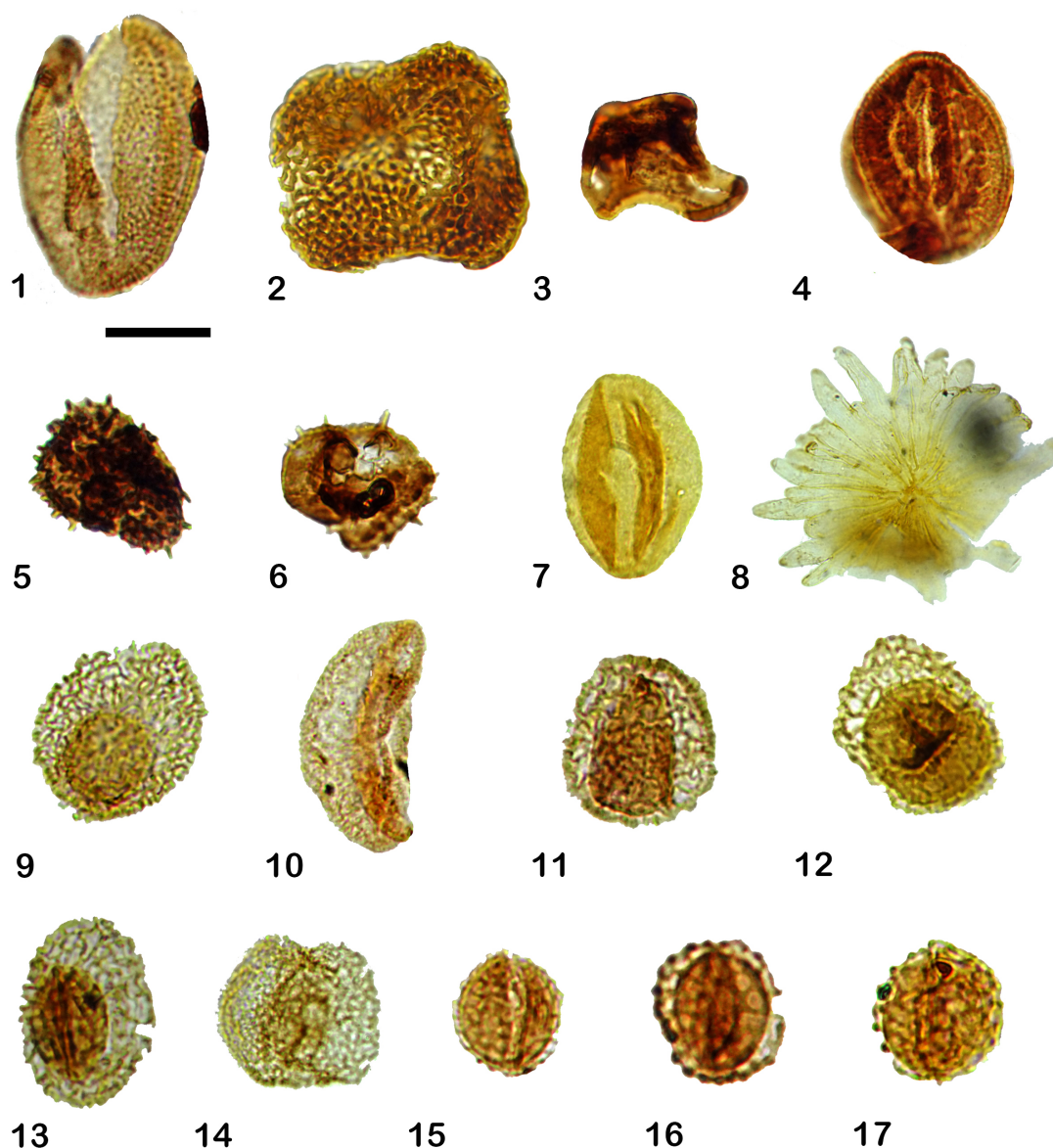


Plate III.

- III.1 *Retimonocolpites variplicatus* Schrank and Mahmoud; B-1 3105/1; E42/3-4; 18 μ m.
 III.2 *Cretacaeiporites densimurus* Schrank and Ibrahim; B-1 3105/1; W36/3-4; 23 μ m.
 III.3 *Cretacaeiporites polygonalis* (Jardiné and Magloire) Herngreen; B-1 3105/1; N50/4; 13 μ m.
 III.4 *Foveotricolpites gigantoreticulatus* (Jardiné and Magloire) Schrank; B-1 3105/2; K44/1-3; 17 μ m.
 III.5 *Droseridites baculatus* Ibrahim; B-1 3117/3; M67/2-4; 15 μ m.
 III.6 *Droseridites senonicus* Jardiné and Magloire; B-1 3105/2; N28/1; 22 μ m.
 III.7 *Tricolpites* sp. (equatorial view); B-1 3105/1; K52/3-4; 18 μ m.
 III.8 Peltate hair of a flowering plant (may be recent contamination); B-1 3105/4; E50/3; 42 μ m.
 III.9 *Afropollis jardinus* (Brenner) Doyle et al.; B-1 3105/1; O47/2-4; 14 μ m.
 III.10 *Afropollis kahramanensis* Ibrahim and Schrank; B-1 3105/1; G49/1-2; 15 μ m.
 III.11 *Afropollis operculatus* Doyle et al.; B-1 3105/1; P31/3-4; 14 μ m.
 III.12 *Afropollis operculatus* Doyle et al.; B-1 3117/1; J30/1-3; 14 μ m.
 III.13 *Afropollis schrankii* Ibrahim; B-1 3105/1; N54/2; 14 μ m.
 III.14 *Afropollis zonatus* Doyle et al.; B-1 3105/1; B44/4; 19 μ m.
 III.15 *Brenneripollis peroreticulatus* (Brenner) Juhász and Góczán; B-1 3117/3; M66/1-3; 12 μ m.
 III.16 *Brenneripollis reticulatus* (Brenner) Juhász and Góczán; B-1 3117/1; J36/3-4; 12 μ m.
 III.17 *Brenneripollis reticulatus* (Brenner) Juhász and Góczán; B-1 3117/1; J21/1; 12 μ m.

TABLE 1. Semi-quantitative distribution of miospores encountered in the Aptian/Albian interval of Bougaz-1 well (○ Single specimen; ● Present (2-10 specimens); □ Common (>10 specimens); ■ Abundant (>30 specimens). The Ecological types after Schrank (2001), Wang et al. (2005), Eiserhardt et al. (2011) and Bowman et al. (2014).

Botanical affinity/ Miospore taxa	Ecological type	Sample		Figure
		B-1 (3105)	B-1 (3117)	
Pterophyta: Filicopsida; Osmundales; Osmundaceae				
<i>Biretisporitespotonitei</i> Delcourt and Sprumont	Hygrophytic	●		Pl. I, Fig. 1
<i>Punctatisporitescouperi</i> Ravn	Hygrophytic	○		Pl. I, Fig. 2
<i>Punctatisporitesglobosus</i> (Leschik) Lund	Hygrophytic	●	●	Pl. I, Fig. 3
<i>Rugulatisporites</i> sp.	Hygrophytic		○	Pl. I, Fig. 4
::; Gleicheniales; Gleicheniaceae				
<i>Gleicheniiditesessenonicus</i> Ross	Hygrophytic	●	●	Pl. I, Fig. 5
<i>Gleicheniidites</i> sp.	Hygrophytic	○	○	Pl. I, Fig. 6
::; Matoniaceae				
<i>Dictyophylliditesequiximus</i> (Cookson) Dettmann	Hygrophytic	○	●	Pl. I, Fig. 7
<i>Dictyophylliditesharrisi</i> Couper	Hygrophytic	○	●	Pl. I, Fig. 8
::; Schizales; Schizaceae				
<i>Cicatricosporitesminutaestriatus</i> (Bolkhovitina) Pocock	Hygrophytic	●		Pl. I, Fig. 9
::; Salviniales; Marsileaceae				
<i>Crybelosporitespannuceus</i> (Brenner) Srivastava	Hygrophytic	○	●	Pl. I, Fig. 10
::; Cyatheales; Cibotiaceae				
<i>Cibotiumsporajuncta</i> (Kara–Murza) Singh	Hygro-/Mesophytic	○	●	Pl. I, Fig. 11
<i>Cibotiumsporajurienensis</i> (Balme) Filatoff	Hygro-/Mesophytic	●	○	Pl. I, Fig. 13
::; Cyatheaceae/Dicksoniaceae				
<i>Deltoidosporaaustralis</i> (Couper) Pocock	Hygro-/Mesophytic	□	□	Pl. I, Fig. 12
<i>Deltoidospora minor</i> (Couper) Pocock	Hygro-/Mesophytic	●	●	Not illustrated
<i>Deltoidosporasp.</i>	Hygro-/Mesophytic	■	■	Pl. I, Fig. 14

TABLE 1. Cont.

Botanical affinity/ Miospore taxa	Ecological type	Sample		Figure
		B-1 (3105)	B-1 (3117)	
;; ?Dicksoniaceae				
<i>Trilobosporiteslaevigatus</i> El-Beialy	Unknown	●	●	Pl. I, Figs. 16, 17
;; Polypodiaceae				
<i>Laevigatosporites</i> ssp.	Hygrophytic	●	●	Pl. I, Fig. 15
<i>Verrucosiporitesrotundus</i> Singh	Hygrophytic		○	Pl. I, Fig. 18
<i>Verrucosiporites</i> ssp.	Hygrophytic	○	●	Not illustrated
Pterophyta– Incertae Sedis				
<i>Concavisporites</i> ssp.	Hygrophytic	○	●	Not illustrated
<i>Dictyotosporites</i> ssp.	Unknown		○	Pl. I, Fig. 19
<i>Duplexisporitesgeneralis</i> Déak	Unknown	○		Pl. I, Fig. 20
<i>Leptolepiditespsarosus</i> Norris	Hygro-/Mesophytic	○	○	Pl. II, Fig. 1
<i>Pilosporitestrichopapillosus</i> (Thiergart) Delcourt and Sprumont	Hygro-/Mesophytic	○	○	Pl. II, Fig. 2
<i>Schizosporisreticulatus</i> Cookson and Dettmann emend. Pierce	Unknown	○	○	Pl. II, Fig. 3
<i>Triplanosporites</i> ssp.	Hygro-/Mesophytic	□	□	Pl. II, Fig. 4
<i>Undulatisporitespannuceus</i> (Brenner) Singh	Hygro-/Mesophytic	○	○	Pl. II, Fig. 5
Gymnospermatophyta: Cycadopsida; Cycadales; Cycadaceae				
<i>Cycadopitesfragilis</i> Singh	Mesophytic		○	Not illustrated
<i>Cycadopites</i> ssp.	Mesophytic	○	●	Not illustrated
: Coniferopsida; Coniferales; Araucariaceae				
<i>Araucariacitesaustralis</i> Cookson ex Couper	Mesophytic	□	●	Pl. II, Fig. 6
<i>Balmetopsislimbata</i> (Balme) Archangelsky	Mesophytic	●	□	Pl. II, Fig. 16

TABLE 1. Cont.

Botanical affinity/ Miospore taxa	Ecological type	Sample		Figure
		B-1 (3105)	B-1 (3117)	
::: Cheirolepidiaceae				
<i>Classopollisbrasiliensis</i> Herntgreen	Thermo-/Xerophytic	●	●	Pl. II, Figs. 7, 8
<i>Classopollisclassoides</i> Pflug emend. Pocock and Jansonius	Thermo-/Xerophytic	●	□	Pl. II, Fig. 9
<i>Classopollistorosus</i> (Reissinger) Couper	Thermo-/Xerophytic	○	○	Pl. II, Fig. 10
<i>Classopollis cf. triangulus</i> (Zhang) Lei	Thermo-/Xerophytic	○	●	Pl. II, Fig. 11
<i>Circulinaparva</i> Brenner	Thermo-/Xerophytic	●	●	Pl. II, Fig. 12
::: Coniferales–Incertae Sedis				
<i>Eucommiiditesstroedssoni</i> (Erdtman) Hughes	Unknown	●	●	Pl. II, Fig. 13
: Gnetopsida; Gnetales; Ephedraceae				
<i>Ephedripitesjansoni</i> (Pocock) Muller	Thermo-/Xerophytic	○		Pl. II, Fig. 14
<i>Ephedripitesregularis</i> van Hoeken–Klinkenberg	Thermo-/Xerophytic	○		Pl. II, Fig. 15
<i>Ephedripites spp.</i>	Thermo-/Xerophytic	●	●	Not illustrated
<i>Steevesipollenitescupuliformis</i> Azéma and Boltenhagen	Thermo-/Xerophytic		○	Pl. II, Fig. 17
::: Gnetales–Incertae Sedis				
<i>Elaterosporitesklaszi</i> (Jardiné and Magloire) Jardiné	Hygro-/Mesophytic		○	Pl. II, Fig. 18
Indeterminedelaterate pollen	Hygro-/Mesophytic		○	Pl. II, Fig. 19
Magnoliophyta: Liliopsida; Arecales; Arecaceae				
<i>Echinomonocolpites</i> sp.	Hygro-/Mesophytic		○	Pl. II, Fig. 20
<i>Retimonocolpitesbueibensis</i> Ibrahim	Hygro-/Mesophytic	○		Pl. II, Fig. 21
<i>Retimonocolpitesvariplicatus</i> Schrank and Mahmoud	Hygro-/Mesophytic	○	○	Pl. III, Fig. 1
<i>Retimonocolpites</i> sp.	Hygro-/Mesophytic	○		Not illustrated

TABLE 1. Cont.

Botanical affinity/ Miospore taxa	Ecological type	Sample		Figure
		B-1 (3105)	B-1 (3117)	
: Liliales; Liliaceae				
<i>Liliacidites/arafaensis</i> Ibrahim and Abdel-Kireem	Thermo-/Xerophytic	○		Not illustrated
: Liliopsida–Incertae Sedis				
<i>Stellatopollis</i> sp.	Unknown	○		Not illustrated
: Magnoliopsida; Caryophyllales; Caryophyllaceae				
<i>Cretacaiporitesdensimurus</i> Schrank and Ibrahim	Mesophytic	○		Pl. III, Fig. 2
<i>Cretacaiporitespolygonalis</i> (Jardiné and Magloire) Hemgreen	Mesophytic	○	○	Pl. III, Fig. 3
Magnoliophyta; Magnoliales; Winteraceae				
<i>Afropollisjardinus</i> (Brenner) Doyle et al.	Hygro-/Mesophytic	■	■	Pl. III, Fig. 9
<i>Afropolliskahramanensis</i> Ibrahim and Schrank	Hygro-/Mesophytic	●		Pl. III, Fig. 10
<i>Afropollisoperculatus</i> Doyle et al.	Hygro-/Mesophytic	■	■	Pl. III, Figs. 11, 12
<i>Afropollisschrankii</i> Ibrahim	Hygro-/Mesophytic	●	●	Pl. III, Fig. 13
<i>Afropollisonatus</i> Doyle et al.	Hygro-/Mesophytic	●	●	Pl. III, Fig. 14
<i>Afropollis</i> sp.	Hygro-/Mesophytic	□	□	Not illustrated
: Magnoliopsida–Incertae Sedis				
<i>Droseriditesbaculatus</i> Ibrahim	Unknown	○		Pl. III, Fig. 5
<i>Droseriditesnonicus</i> Jardiné and Magloire	Unknown		○	Pl. III, Fig. 6
<i>Foveotricolpitesgigantoreticulatus</i> (Jardiné and Magloire) Schrank	Unknown		●	Pl. III, Fig. 4
<i>Tricolpites</i> sp.	Unknown	○	●	Pl. III, Fig. 7
Magnoliophyta–Incertae Sedis				
<i>Brenneripollispororeticulatus</i> (Brenner) Juhász and Góczán	Unknown	●	●	Pl. III, Figs. 15, 16
<i>Brenneripollisreticulatus</i> (Brenner) Juhász and Góczán	Unknown	●	●	Pl. III, Fig. 17

Ferns

The present palynological assemblage shows a predominance of ferns (average 47% of the total sporomorph assemblage). Several subordinate families can be deduced, including Osmundaceae (*Biretisporites*, *Punctatisporites* & *Rugulatisporites*), Gleicheniaceae (*Gleicheniidites*), Matoniaceae (*Dictyophyllidites*), Schizaeaceae (*Cicatricosisporites*), Marsileaceae (*Crybelosporites*), Cibotiaceae (*Cibotiumspora*), Cyatheaceae/Dicksoniaceae (*Deltoidospora*)? Dicksoniaceae (*Trilobosporites*) and Polypodiaceae (*Laevigatosporites* & *Verrucosisporites*). Among them, Cyatheaceae/Dicksoniaceae is dominant, Gleicheniaceae and Matoniaceae occur less frequently. The Osmundaceae, Schizaeaceae, Marsileaceae, Cibotiaceae,? Dicksoniaceae and Polypodiaceae are rare. Besides, other genera (*Concavisporites*, *Dictyotosporites*, *Duplexisporites*, *Leptolepidites*, *Pilososporites*, *Schizosporis*, *Triplanosporites*, *Undulatisporites*) which are related to the early Pterophyta but their botanical position cannot yet be ascertained. The latter genera are rare except *Triplanosporites* which is highly represented (17%), in the present assemblage.

Angiosperms

Angiosperm pollen group generally occurs as a subordinate element in the present assemblage (average 31.5% of the total sporomorph assemblage). It is characterized by abundance of *Afropollis* which is thought to be in the Winteraceae. Other minor contributors are of the Arecaceae (*Echimonocolpites* & *Retimonocolpites*), Liliaceae (*Liliacidites*), Caryophyllaceae (*Cretacaeiporites*), an undifferentiated tetrad and tricolpate monosulcate pollen of unknown angiospermic origin.

Gymnosperms

Gymnosperm pollen occurs as a minor element with average of 21.5% of the total sporomorph assemblage. It is represented by a mixture of conifers, Cycadopsida and Gentopsida. Conifers are the most dominant category of the gymnosperms which are represented by Araucariaceae (*Araucariacites* & *Balmeiopsis*), Cheirolepidiaceae (*Classopollis* & *Circulina*) and undifferentiated aperturate pollen (*Eucommidites*) produced by an unknown family of Coniferales. The Cycadopsida and Gentopsida generally occur less frequently. *Cycadopites* is the only identified genus with affinity to Cycadaceae. The polylicate

pollen (*Ephedripites* & *Steevesipollenites*) and elaterate pollen (*Elaterosporites*), which are botanically related, are thought to be of gnetalean origin.

Palaeoclimatic implications

Terrestrial plants are more climatically sensitive than most marine organisms. They have specific demands of temperature, moisture and soil. Consequently, this makes it possible to interpret the palaeoclimate conditions that were prevailing during their life cycles from their sporomorph assemblages preserved in the sediments (Wang et al., 2005).

The paleoecologic and paleoclimatic interpretation of Cretaceous pollen and spore assemblages often relies on the overall composition of the floras because the nearest living relatives at the specific or generic level are not available (Schrank & Nesterova, 1993).

In the present palynoassemblage many taxa seem to have local palaeoclimate and ecological preferences. In order to track these trends, the relative abundances of the encountered miospores and the hygric types of their modern analogues (hygrophytic, mesophytic, hygro-mesophytic and thermophytic/xerophytic) are summarized in Table 1.

The Aptian/Albian vegetation in Bougaz Basin is characterized by the high relative abundance and diversity of hygrophilous and hygro-mesophilous fern spores belonging to Osmundaceae, Gleicheniaceae, Matoniaceae, Schizaeaceae, Marsileaceae, Cibotiaceae, Cyatheaceae/Dicksoniaceae,? Dicksoniaceae and Polypodiaceae, among others of unknown botanical affinities, which indicates humid conditions comparable with the majority of the extant hygro-mesophilous ferns, which prefer to grow in warm humid lowlands such as riversides or as understory in forests (Pelzer et al., 1992 and Abbink et al., 2004). Similar ecological preferences are also confirmed by the relatively high abundance of *Afropollis* a pollen of winteracean affinity which was proposed to inhabit paleotropical humid coastal plains (Schrank, 2001).

According to Doyle et al. (1982), the relatively low abundances of Mesozoic conifer families such as Araucariaceae which have mesic

preferences and Cheirolepidiaceae which have inhabited relatively dry areas of upland forest are used as palaeo-indicators of hot dry conditions (i.e., thermo-/xerophytic forms). Further support of the prevalence of more humid conditions, agreed with Doyle et al. (1982), Schrank (1990) and Brenner (1996) who suggested relatively wetter paleoclimates for African paleotropics (e.g. Egypt and Sudan), based on the presence of high abundances of fern spores (indicating humidity) and lower frequencies of *Classopollis* and the cooler-temperate coniferous genus *Araucariacites* than seen in the paleosubtropics.

The gymnospermous genetelean pollen *Ephedripites* is another xerophytic genus. Its rarity in the studied interval could also suggest less hot and more humid conditions, as its high abundances are taken to indicate hot and dry conditions (Doyle et al., 1982 and Dino et al., 1999).

The hot and relatively wetter paleoclimate that is suggested to prevail during the Early Cretaceous over the Egyptian land area is also compatible with such a deduction driven from the paleolatitudinal position. During this time, Egypt was continuously located at the paleotropical zone where hot but relatively wetter conditions prevailed due to the highest rainfall rate at or near the paleoequator (Dino et al., 1999).

Conclusion

The sporomorph assemblage recovered from two studied samples of Cretaceous (Aptian/Albian) shales from Bougaz-1 well in northeast Sinai consists of 39 genera and 62 species of miospores. A reconstruction of the vegetation showed a mixed forest of three distinct plant groups. In order of dominance, pteridophytic ferns represent the most abundant group (47%), followed by angiosperms (31.5%) and gymnosperms (21.5%). The distribution of hygrophilous versus xerophytic elements in the present assemblage is used to interpret the paleoclimatic trends in this part of Egypt during Aptian/Albian period. A relatively warm humid climate is proposed based on the high frequency and diversity of pteridophytic fern spores together with relative abundances of *Afropollis* pollen which are usually regarded as indicative of humid conditions. This interpretation is also supported by the low frequency of conifer vegetation such as Araucariaceae, Cheirolepidiaceae and genetelean

pollen (*Ephedripites*) which are indicative of semi-arid/arid conditions.

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إعادة بناء الغطاء النباتي والبيئة القديمة من سيورومورفات عصر الطباشيري المبكر من بئر بوغاز-1، شمال شرق سيناء، مصر

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من دراسة المحتوي الأحفوري (حبوب اللقاح والأبواغ) في تتابع الطباشيري السفلي (الأبتي/الألبي) ببئر بوغاز-1 والمستخلص من عدد إثنين عينة صخرية فتاتية مأخوذة على أعماق 3105 و 3117 متراً، أمكن التعرف على إثنين وستين نوعاً من حبوب اللقاح والأبواغ (منها سبعة وعشرون نوعاً تنتمي لعشرين جنساً من السراخس وخمسة عشر نوعاً تنتمي لتسعة أجناس من عاريات البذور وعشرين نوعاً تنتمي لعشرة أجناس من كاسيات البذور). هذا المحتوي الأحفوري الجيد أمكن بواسطته إعادة بناء الغطاء النباتي القديم بمنطقة الدراسة أثناء عصر الأبتي/الألبي والذي تمثل بغابة كثيفة تسودها السراخس الضخمة وأشجار من عاريات البذور وبعض أنواع من كاسيات البذور. تم إستنتاج الظروف المناخية السائدة بمنطقة الدراسة إعتماًداً على المعلومات المكتسبة من بيئة النباتات الحديثة ذات الصلة بالسيورومورفات المسجلة، حيث تميز المناخ آنذاك بزيادة الحرارة والرطوبة العالية إستناداً على وجود كميات وفيرة ومتنوعة من أبواغ التريديات السرخسية التي تقطن البيئات المائية إلى الرطبة وكذلك وجود ارتفاع ملحوظ في أعداد جنس الأفروبولس التي تقطن المناطق الإستوائية الرطبة. ويعضد هذا المناخ الإستوائي أيضاً قلة تمثيل بعض الأجناس التابعة لبعض عائلات عاريات البذور مثل الأروكارية والشيروليبدياسي والعلندية ذات الدلالة البيئية على الظروف الصحراوية القاحلة.