Occurrences of elaterate pollen from the Lower Cretaceous of Ghana: Implications for biostratigraphy and palaeoclimatology

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ABSTRACT

Elaterate pollen with elater-like protruberances including Elaterocolpites castelaini, Elaterosporites klaszii, E. protensus, E. verrucatus, Elateropollenites jardinei, Gaiaecocornea causea, G. clavis, Sofrepites legouxae, have been recovered from the 1S-3AX well in the offshore Tano Basin. The assemblage has been interpreted as Albian - Cenomanian age, and is indicative of an arid to semi-arid palaeoclimatic conditions for these periods in the Tano Basin. Similar species have been interpreted as Albian – Cenomanian in other localities within the Africa-South America (ASA) province and thus allows for a palynostratigraphic correlation with these localities in the ASA province.

Keywords: Elater-bearing pollen; palaeoclimate; Albian; Cenomanian; Tano Basin

1. INTRODUCTION

A total of 39 cutting samples have been obtained and analysed from the offshore Tano 1S-3AX well in the Tano Basin (Fig. 1). The Mesozoic to tertiary rocks of the basin occur on the eastern side of a crescent-shaped basin which is located along the coast of the Atlantic Ocean. The basin extends to the southeastern corners of Cote I’voire and continues into the Gulf of Guinea. The Tano Basin began its tectonic-sedimentary life as an extensional rift basin modified by wrench tectonism. This rifting was initiated by complex movements due to the separation of the continents of South America and Africa. This was most likely initiated in the Barremian and Aptian times. It is thought that movement along a series of transform faults including faults in the Romanche Fault Zone during this continental separation led to the development of the large rift basin in the Tano area (Davies, 1989). As a result of these movements, by Aptian - early Albian time, a large rift basin had developed in the Tano Basin area. This was followed in middle - late Albian times by widespread deposition of shallow marine sandstones and shales with minor limestone in the area. General evidence suggests that final separation on the continents took place in latest Albian (Davies 1989). It is speculated that, a thermal anomaly with subsequent uplift occurred at the margin of the newly created African and Brazilian continental plates in the Tano area. This uplift occurred in late Albian time and may be the plate tectonic model for the development of the Tano structural trend. This paper presents the occurrences of elater-bearing species including Elaterocolpites...
castelaini, Elaterosporites klaszii, E. protensus, E. verrucatus, Elateropollenites jardinei, Galaeocornea causea, G. clavis, Soperites legouxae, in the Tano basin and also provides updated information on their occurrence in some parts of the Africa-South America (ASA) province (Fig. 2).

**Fig. 1.** Map of Tano Basin showing the offshore 1X-3AX well (Modified after GNPC Offshore Activity Map, 1994).
Fig. 2. Comparison between Ghanaian elater-bearing species and those of other localities within the palynofloral province (Modified after Abubakar et al., 2006). Information on Venezuela (Muller et al., 1987), Morocco (Bettar and Meon, 2006), Egypt (Mahmoud, 1998; Aboul Ela and Mahrous, 1992), Ecuador (Dino et al., 1999) has been added.
2. MATERIALS AND METHODS

The specimens studied have been obtained from the Albian – Cenomanian section of well 1S-3AX in the Tano Basin. The samples were mainly shales, sandstones and some limestones. Samples were processed using standard laboratory techniques for the extraction of palynomorphs from sediments (Phipps and Playford, 1984). This involved the use of hydrochloric (HCl) (10 %) and hydrofluoric (HF) (40 %) acids to digest and remove the carbonates and silicates from the rock samples respectively. The residue was then sieved through a 10 μm nylon sieve, and the organic matter separated using zinc bromide solution. Slides were then prepared from shrew mounts of organic matter in polyvinyl alcohol (PVA) and cured in ultra violet light for light microscopy and photomicrography.

![Distribution chart of elater-bearing forms](image)

Fig. 3. Distribution chart of elater-bearing forms (Modified after Herngreen, 1975 with added contributions from Ecuador, Venezuela, Colombia, Morocco, Nigeria, Sudan, and Ghana.

3. RESULTS

3.1. Pollen fossil

The distribution of the elater-bearing pollen species recovered from the stratigraphic column from well have been shown in Fig 4. They include *Elaterosporites protensus*, *E. verrucatus*, *E. klaszii*, *Elaterocolpites castelaini*, *Elateropollenites jardinei*, *Galeacornea causea*, *Sofrepites legouxae*. 

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| AGE        | LITHOLOGY | SAMPLE DEPTH (FT) | Palynomorphs                  |
|------------|-----------|-------------------|-------------------------------|
| ALBIAN - CENOMANIAN | LIMESTONE | 6300              | Araucaricites australis       |
|            |           | 6350              | Classopollis classoides       |
|            |           | 6650              | Ephedripites jansonii         |
|            |           | 7000              | Elateropollenites protensus   |
|            |           | 7190              | Galaecornea causea            |
|            |           | 7310              | Reyrea polyporus              |
|            |           | 7490              | Elaterocolpites castelaini    |
|            |           | 7670              | Sofrepites legouxae           |
|            |           | 7730              | E. braziliensis               |
|            |           | 7800              | Elaterosporites verrucatus    |
|            |           | 7920              | Afropollis jardinus           |
|            |           | 7980              | Reyrea polyphora              |
|            |           | 8000              | Reyrea polyphora              |
|            |           | 8040              | Reyrea polyphora              |
|            |           | 8100              | Reyrea polyphora              |
|            |           | 8160              | Reyrea polyphora              |
|            |           | 8220              | Reyrea polyphora              |
|            |           | 8280              | Reyrea polyphora              |
|            |           | 8340              | Reyrea polyphora              |
|            |           | 8400              | Reyrea polyphora              |
|            |           | 8460              | Reyrea polyphora              |
|            |           | 8540              | Reyrea polyphora              |
|            |           | 8660              | Reyrea polyphora              |
|            |           | 8720              | Reyrea polyphora              |
|            |           | 8780              | Reyrea polyphora              |
|            |           | 8840              | Reyrea polyphora              |
|            |           | 8900              | Reyrea polyphora              |
|            |           | 9000              | Reyrea polyphora              |

Fig. 4. Stratigraphic column of 1S-3AX well showing the distribution of elater-bearing pollen and other stratigraphically relevant palynomorphs.
Explanation to Plate 1

All figures X 660 unless otherwise stated.

Figure.

A, B, C, D. Elaterosporites klaszii (Jardiné and Magloire) Jardiné, 1967
E, F, G, H. Elaterosporites verrucatus (Jardiné and Magloire) Jardiné, 1967
I, J, K, N. Elaterosporites protensus (Jardiné and Magloire) Jardiné, 1967
L, P. Elaterocolpites castelaini forma B Jardiné, 1967
S. Elaterocolpites castelaini forma A Jardiné, 1967
M. Elateropollenites jardinei Herngreen, 1973
O, R. Galaeocornea causea Stover, 1963
T, U. Galaeocornea clavis Stover, 1963
Q. Sofrepites legouxae Jardiné, 1967

Selected Systematics

For nomenclature and rules on priority and typification, the International Code of Botanical Nomenclature ([ICBN] Stafleu et al., 1978) is followed.

Genus Elateropollenites Herngreen, 1973
Elateropollenites jardinei Herngreen, 1973
Plate 1, Figure M.

Dimensions: (34-36) x (43-45) µ, mean 35 x 44 µ. (5 specimens measured)
Length of appendages 5-12 µ, mean 8 µ.
Width at base 3-6 µ, mean 5 µ.

Remarks: Specimen has three appendages which give the body a lobate habitus. It is also ornamented with thin striae more or less parallel to the body. Elateropollenites differs from Elaterocolpites which possesses 10 appendages and also from Elaterosporites which has 3 pairs of U-shaped appendages. It has not been recorded from post-Middle Albian sediments.

Genus Elaterocolpites Jardiné and Magloire, 1965
Elaterocolpites castelaini Jardiné and Magloire, 1965, forma B Jardiné 1967
Plate 1, Figure L, P.

Dimensions: (30-34) x (37-42) µ, mean 32 x 40 µ. (8 species measured)
Length of appendages 15-30 µ, mean 22 µ.
Width at base 7-12 µ, mean 10 µ.

Remarks: Specimens bear 10 short cylindrical, simple appendages with more or less parallel sides and terminating in free, blunt rounded apices. In some cases vestiges of annular band surround the spore body. Most of the specimens observed are similar to Elaterocolpites castelaini, forma B of Jardiné (1967). It differs from the forma A (Pl. 1, Fig. S) by its longer parallel sided appendages. Appendages of forma A are either clavate or gemmate.

Genus Elaterosporites Jardiné, 1967
Elaterosporites protensus (Jardiné and Magloire) Jardiné, 1967
Plate 1, Figure I, J, K, N.

Dimensions: (42-55) x (30-45) µ, mean 50 x 38 µ. (12 specimens measured)
Length of appendages 22-50 µ, mean 35 µ.
Width at base 5-8 µ, mean 7 µ.

Remarks: Specimen has elliptical to subspherical central body with a strongly convex distal face, thick exine and ornamented with spines (5-7 µ long, 2.5 µ wide at base). It also bears 3 pairs of U-shaped cylindrical appendages of almost equal lengths.
**Elaterosporites verrucatus** (Jardiné and Magloire) Jardiné, 1967
Plate 1, Figure E, F, G, H
Dimension: (37-50) x (50-57) µ, mean 42 x 54 µ (15 specimens measured)
Length of appendages 25-37 µ, mean 31 µ
Width at base 5-8 µ, mean 7 µ.
Remarks: This species differs from *E. protensus* only by ornamentation. *E. verrucatus* has verrucate ornamentation, much lower in height (2.5-3) µ and also loosely packed on distal face as well as bigger appendages.

**Elaterosporites klaszii** (Jardiné and Magloire) Jardiné, 1967
Plate 1, Figure A, B, C, D
Dimension: (30-48) x (50-60) µ, mean 40 x 55 µ. (12 specimens measured)
Length of appendages 25-37 µ, mean 32 µ
Width at base 5-9 µ, mean 7 µ.
Remarks: This species differs from other forms of *Elaterosporites* by its smooth or punctate membrane, and the frequent expansion and detachment from the central body of an annular band similar to the appendages of the distal face.

**Galeacornea Stover, 1963**
**Galeacornea clavis** Stover, 1963
Plate 1, Figure T, U
Dimension: (37-42) x (25-30) µ, mean 40 x 28 µ. (4 specimens measured)
Length of appendages 12-25 µ, mean 20 µ
Width at base 4-6 µ, mean 5 µ.
Remarks: This specimen is characterised by a Y-shaped horn on the distal surface. A single stem supports the “V” of the “Y”. This attribute of the specimen is similar to the original description of the species by Stover (1963). It differs from *G. causea* in possessing a distal horn or appendage, a zona of uniform width that is concentric to the equatorial outline of the body and that lies in a plane.

**Galeacornea causea** Stover, 1963
Plate 1, Figure O, R
Dimension: (35-48) x (25-35) µ, mean 42 x 30 µ. (10 specimens measured)
Length of appendages 25-40 µ, mean 35 µ.
Width of appendages 3-6 µ, mean 5 µ.
Remarks: *G. causea* differs from other forms of *G. clavis* in possessing zona of variable width, long axis of the zona oblique to that of the body and possessing a distal flap instead of a horn or appendage.

**Sofrepites Jardiné, 1967**
**Sofrepites legouxae** Jardiné, 1967
Plate 1, Figure Q
Dimensions (25-42) x (18-34) µ, mean 35-26 µ (5 specimen measured)
Length of appendage 10-18 µ, mean 15 µ
Width at base 5-8 µ, mean 6 µ.
Remarks: *S. legouxae* possesses ellipsoidal body with elliptical to subcircular outline with 2 or 3 appendages of somewhat equal lengths. Exine is psilate to granulate.

**Reported Occurrences**

*Elaterocolpites castalainii* has been reported from middle Albian–middle Cenomanian in Brazil (Herngreen, 1973, 1975, Dino et al., 1990); late Albian–early Cenomanian in Dongola
region in northern Sudan (Schrank, 1990), Gabon and Senegal (Jardiné, 1967), Colombia (Herngreen & Jiminez, 1990), Egypt (Zobaa et al., 2013), late Albian – late Cenomanian in Senegal (Jardine & Magloire, 1965), Albian in Gabon (Boltenhagen, 1965), Albian in Libya (Thusu and Van der Eem, 1985), late Albian – middle Cenomanian in Nigeria (Abubakar et al., 2006, 2011).

_Elateropollenites jardinei_ has been recorded in early Albian – middle Albian in Brazil (Regali and Viana, 1989; Herngreen, 1973, 1975; Dino et al., 1999), Venezuela (Muller et al., 1987), middle Albian in Ivory Coast (Jardiné and Magloire, 1965)

_Elaterosporites klazii_ has been recorded from has been reported from Albian – Cenomanian of Senegal and Cote d’Ivoire (Jardiné and Magloire, 1965), middle Albian (Jardiné, 1967), late Albian of Gabon (Doukaga, 1980) and Senegal (Jardiné, 1967). Herngreen and Dueñas-Jimenez (1990) have reported _E. klazii_ from the late Albian – early Cenomanian in Peru and Colombia.

_Elaterosporites protensus_ has been reported from the Albian of Morocco (Bettar & Meon, 2006), late Albian of Nigeria (Abubakar et al., 2006, 2011), middle – late Albian of Senegal (Jardiné, 1967), middle Albian in Gabon (Doukaga, 1980), late Albian – early Cenomanian of Brazil (Herngreen, 1973, 1975), Peru (Herngreen and Dueñas-Jimenez, 1990) and Venezuela (Muller et al., 1987), middle Albian – early Cenomanian of Cote d’Ivoire (Jardiné, 1967).

_Elaterosporites verrucatus_ occurs in the Albian of Morocco (Bettar & Meon, 2006), late Albian – early Cenomanian of Brazil (Herngreen, 1973, 1975), Senegal and Cote d’Ivoire (Jardiné et Magloire, 1965), and Venezuela (Muller et al., 1987), Egypt (Shrank and Ibrahim, 1995).

_Elateropollenites jardinei_ has been reported from early to middle Albian rocks of Brazil (Herngreen, 1973, 1975; Regali and Viana, 1989), Senegal and Cote d’Ivoire (Jardiné et Magloire, 1965), Venezuela (Muller et al., 1987).

_Galaecornea causea_ has been reported from late Albian – early Cenomanian of Brazil (Herngreen, 1973, 1975), Albian – Turonian of Guinea Bissau and Senegal (Stover, 1964), late – early Cenomanian of Senegal and Gabon (Jardiné and Magloire, 1965; Jardiné, 1967), Albian – Cenomanian of Peru (Brenner, 1968), late Albian – early Cenomanian of Egypt (Mahmoud, 1998; Shrank and Ibrahim, 1995; Aboul Ela and Mahrous, 1992; Zobaa et al., 2013), late Cenomanian of Nigeria (2011).

_Sofreites legouxae_ has been recorded from late Albian – early Cenomanian rocks of Brazil (Herngreen, 1973, 1975; Herngreen et al., 1996), Gabon (Jardiné, 1967), Egypt (Mahmoud, 1998; Mahmoud and Moawad 1999; Aboul Ela and Mahrous, 1992), late Albian of Senegal (Jardiné, 1967).
4. DISCUSSIONS AND CONCLUSIONS

The elater-bearing pollen have been attributed to the Albian-Cenomanian Elaterate Province of Africa South America (ASA). This concept was introduced by Herngreen (1975) and has been also referred to as Northern Gondwana Province (Brenner, 1976) and Elaterosporites phytoprovince (Srivastava, 1981).

Their unique morphology with protuberances characterise this otherwise heterogeneous group of pollen grains with a short stratigraphic range. They appeared in the lower Albian sediments of the low latitude region, diversified, became numerically important in the upper Albian-Cenomanian and died out at the end of Cenomanian, which saw rapid diversification and rise to dominance of the angiosperms (Herngreen et al. 1996; Vallati, 2013). The elater pollen have attracted the attention of palynologists and has contributed to their application in palynostratigraphy and paleobiogeography (Schrank, 2001). According to Vallati (2013), the morphological characteristics of these grains are unknown from extant pollen grains and up to now in situ specimens have not found. A probable ephedroid affinity for the elaterates has been proposed (Shrank, 2001; Dino et al.1999; Crane, 1988). The ranges of other associated palynomorphs in the assemblage point to an Albian-Cenomanian age. These include; Afropollis jardinus (Aptian-lower Cenomanian) (Herngreen 1973, 1975; Doyle et al., 1982), Reyea polymorphus (lower Albian-Middle Albian) (Herngreen 1973, 1975; Masure et al., 1998), Perotriletes pannuceus (Albian-Cenomanian) (Brenner, 1968), Classopollis spp. (early Aptian-late Cenomanian) (Schrank and Ibrahim, 1995).

The distribution of the characteristic elements of this province paralleled the palaeolatitude and the axis of the Elaterate Province approximates the palaeoequator (Herngreen, 1998; Dino et al., 1999). The province is recognized in ASA region, Middle East, (Fig 3) and recently Bahamas islands, China and Papua New Guinea (Herngreen, 1996, 1998; Dueñas-Jimenez, 1990). According to Herngreen (1998), their presence suggests that climate was the main controlling factor of the geographical extent of the province. This phytogeographic belt is characterized by the presence of elater-bearing species and related forms which are restricted to the province, variety of polyplicate forms (ephe-droids, etc), absence of bia and trisaccate gymnosperous pollen, scarcity of fern spores and the presence of angiospermous pollen.

The presence of elaterate pollen have been interpreted as indicating arid-semi arid palaeoclimatic conditions (Herngreen and Dueñas-Jimenez, 1990; Herngreen et al., 1996; Schrank, 2001). But because of the unknown botanical affinities, and taking into account wall stratification and ultrastructural compatibility of the elaterates (Sophrepites, Elateroplicites, Elaterosporites) with that of Ephetdrpites and other Cretaceous polyplacites, Dino et al., (1999) suggested that elatereal and polyplacites are botanically related. Dino et al., (1990) thus intimated that palaeoclimatic factor controlling the distribution of the elater pollen may be obtained from knowledge of associated vegetation and the types of environment they inhabited. They also opined that associated plant fossil provided a perspective of the vegetation and the enclosing sediments reflect the interaction of physiographic/biotic processes in the region.

The associated plant fossils (Classopollis, ephedroids) with the elaterates in our materials are similar to that of Dino et al., (1990) and Schrank (2001), which suggests that a hot-arid to semi-arid climatic condition must have prevailed during deposition of the Albian-Cenomanian sediments in the Tano Basin. Mahmoud and Deaf (2007), Dino et al., (1999) and Schrank (2001) have reported that Afropollis and Elaterate pollen parent plants flourished in humid coastal plains. The presence therefore of the Afropollis pollen in the samples...
investigated here suggests that similar conditions prevailed in Ghana during the Albian – Cenomanian time.

The continental breakup, drift and initiation of new oceans worldwide were experienced during the Cretaceous period. The opening of the South Atlantic Ocean, which separated South America from Africa, was initiated by crustal thinning and thermodynamic uplifts during the Late Jurassic. According to Dino et al., (1999), which is reiterated by Abubakar et al., (2006), the elater-bearing plants were found in dry zones under warm climates, and that their diversification and abundance were the response to climatic changes associated with the opening and enlargement of the northern parts of the South Atlantic ocean in the latest Aptian to early Albian, which came to a close during the late Albian – Cenomanian time. Dino et al., (1990) also opined that, the widening and deepening of the South Atlantic Ocean at the close of Cenomanian, resulting in temperature drop, culminated in the disappearance of the elater pollen from the stratigraphic record.

Contrary to the Brazilian and Equadorian basins, where Dino et al., (1990) have reported that the earliest appearance and highest diversity and frequency levels of the elateres seem to coincide with the transgressive event during the late Albian – Cenomanian time, the elateres in this study, reached their maximum diversity and frequency levels in fluvial and lacustrine continental facies. This observation supports Abubakar’s (2006) suggestion that the appearance and subsequent abundance of the elateres is evolutionary and palaeoclimatic in nature and that the palaeoclimatic influence may not necessarily be related to the opening of the northern part of the southern Atlantic Ocean, as suggested by Dino et al., (1990).

Overlying the Cenomanian fluvial/lacustrine facies are the limestones which is as a result of deposition in open marine waters which is devoid of the elater pollen. This supports the suggestion of Dino et al., (1990) that the elater pollen disappeared as a result of climatic fluctuations or perturbations during the onset of deeper and more marine conditions as the South American Atlantic Ocean widened at the close of the Cenomanian.

References

[1] Abubakar M. B., Obaje N. G., Luterbacher H .P., Dike E. F. C., Ashraf A. R., *Journal of African Earth Sciences* 45 (2006) 347-354.

[2] Abubakar M. B., Luterbacher H. P., Ashraf A. R., Ziedner R., Maigari A. S., *Journal of African Earth Sciences* 60 (2011) 19-27.

[3] Aboul Ela N. M., Mahrous H. A. R., *Neues Jahrbuch für Geologie und Paläontologie Monatschfte* 10(1) (1992) 595-613.

[4] Batten D. J, Uwins P. J. R. (1985). *Early Cretaceous - Late Cretaceous (Aptian – Cenomanian) palynomorphs.* In Thusu B, Owens B (Eds): Palynology of northeast Libya. *Journal of Micropaleontology* 4, 131-150.

[5] Bettar I., Meon H., *Revue de Paléobiologie,* Geneve 25(2) (2006) 593-631.

[6] Boltenhagen E., *Mem. Bur. Rech. Géol. Miniere* 32 (1965) 305-327.

[7] Brenner G. J., *Pollen et Spore* 10 (2) (1968) 341-383.
Brenner G. J. (1976). Middle Cretaceous floral provinces and early migration of angiosperms. In Beck, C. B., (Ed); Origin and early evolution of angiosperms. Columbia Univ. Press, New York, p. 23-47.

Crane P. R. (1988). Major clades and relationships in the ‘higher’ gymnosperms. In Beck, C. B. (Eds): Origin and Evolution of the Gymnosperms. Columbia Univ. Press, New York, NY, 218-272.

Davies, G (1989). Geological and tectonic framework of the Republic of Ghana, and petroleum geology of the Tano Basin, Southwestern Ghana. Unpublished consultancy report prepared for Petro-Canada International Corporation on behalf of GNPC. 24pp

Dino R., Pocknall D. T., Dettman M. E. Rev. Palaeobot. Palynol. 105 (1999) 201-235.

Doukaga A. M. (1980). Etude palyno-planctologique dans le Crétace moyen du bassin sédimentaire du Gabon. Thèses. Univ. Sci. Tech., Lille, 174 pp.

Doyle J. A., Jardine S., Doerenkamp A., Bulletin du Centre de Recherches Exploration Production Elf-Aquitaine 6(1) (1982) 39-117.

Herngreen G. F. W., Pollen et Spores 15(3-4) (1973) 515-555.

Herngreen G. F. W., Mededelingen Rijks Geologische Dienst N. S. 26(3) (1975) 39-91.

Herngreen G. F. W., Zbl. Geol. Paläontol., Teil 1, (11/12) (1998) 1313-1323.

Herngreen G. F. W., Dueñas-Jimenez H., Rev. Paleobot. Palynol. 66 (1990) 345-359.

Herngreen G. F. W., Kedves M., Rovnina L.V., Smirnova S. B. (1996). Cretaceous palynofloral provinces: a review. In Jansonius, J., and McGregor, D. C., (Eds): Palynology: principles and applications. Amer. Assoc. Strat. Palynol. Found., 3: 1157-1188.

Jardiné S., Magloire L., Mem. Bur. Rech. Geol. Minières. 32 (1965) 187-245.

Jardiné S., Rev. Paleobot Palynol. 1(1-4) (1967) 235-258.

Mahmoud M. S., Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen, 209(1) (1998) 79-104.

Mahmoud M. S., Moawad A-R.M. M., Revista Espanola de Micropaleontologia 34(2) (2002) 129-143

Mahmoud M. S., Deaf Amr S., Rivista Italiana di Paleontologia e Stratigrafia. 113(2) (2007) 203-221.

Masure E., Rausher R., Dejax J., Schuler M., Ferre B., (1998). Cretaceous - Paleocene palynology from the Côte d’Ivoire - Ghana transform margin, sites 959, 960, 961, and 962. In Mascl, J., Lohmann, G. P., and Moullade, M., (Eds): Proc. Ocean Drill. Prog. Sci. Results, 159: 253-276.

Muller J., de Di Giacomo E., van Erve A. W., Amer. Assoc. Strat. Palynol. Contrib. Ser. 19 (1987) 7-76.

Phipps D., Playford G., Pap. Dept. Geol. Univ. Queensland. 11(1) (1984) 1-23.
[27] Regali M. S. P., Viana C. F. (1989). *Late Jurassic - Early Cretaceous in Brazilian sedimentary basins: correlation with the international standard scale*. Petrobras, Rio de Janeiro, 95 pp.

[28] Schrank, E., *Berl. Geowiss. Abh. A* 120(1) (1990) 149-168.

[29] Schrank E., Ibrahim M. I. A., *Berl. Geowiss. Abh. A* 177 (1995) 1-44.

[30] Schrank E. (2001). *Palaeoecological aspects of Afropollis /Elaterates peaks (Albian – Cenomanian pollen) in the Cretaceous of Northern Sudan and Egypt*. In Goodman, D. K., Clarke, R. T., (Eds): Proceedings of the IX Inter. Palynol. Congr., Houston, Texas, USA., 1996. Amer. Assoc. Strat. Palynol. Found. 201-210.

[31] Srivastava S. K., *Rev. Paleobot. Palynol*. 35 (1981) 155-173.

[32] Stafleu L. E. (1998). *International Code of Botanical Nomenclature*. Bohn, Skeltema and Holkema. Utrecht, 457 pp.

[33] Stover L. E. *Micropaleontology* 9(1) (1963) 85-94.

[34] Thusu B., Van der Eem J. G. L., *Journal of Micropaleontology* 4(1) (1985) 131-150.

[35] Vallati P. (2013). *Paleotropical pollen grains from Neuquen Group, Patagonia, Argentina*. Carnets de Geologie [Notebooks on Geology], Brest, Letter 2013/05 (CG2013_L05), 273-279.

[36] Zobaa, M., El- Beialy, S. Y., El- Sheikh, H. A., El Beshtawy, M. K., *Journal of African Earth Sciences* 78 (2013) 51-65.

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