Palynological Evidence of a Campanian-Maastrichtian age of Shendi Formation, Central Sudan

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Abstract

This paper presents for the first time, palynological results from the subsurface part of the Shendi Formation, in central Sudan. The study is based on eight samples of grey mudstones collected from three shallow water wells drilled in Shendi Formation. The recovered material is characterized by well preserved and fairly diversified miospores in which angiosperm pollen form the major constituent; gymnosperms and bryophyte/ptridophyte spores are relatively fewer. The coexistence of marker species such as Monocolpopollenites spheroidites Zlivisporis blanensis, Longapertites sp. 3, Proteacidites sigalii, Echitriporites trianguliformis, Syncolporites schrankii, Retidiporites magdalenensis indicates a Campanian-Maastrichtian age for the subsurface part of the Shendi Formation. The palynomorph assemblage encountered herein, is characteristic of the Senonian Palmae province.

Keywords: Palynostratigraphy; spore/pollen; Campanian-Maastrichtian; Shendi Formation; Central Sudan.

1. Introduction

The study area lies within Shendi Basin in the River Nile State, it covers a strip that extends along the eastern side of the Nile between Shendi and Umm Ali village (Fig. 1). The Shendi-Atbara Basin is now considered as an important target for hydrocarbon exploration in central Sudan. In the last decades, the increasing demand for energy resources boosts the search for additional hydrocarbon reserves in intra-cratonic basins. Among other tools needed to achieve this goal, palynology has been proved indispensable for age determination and correlation of subsurface units. Moreover, important conclusions on paleoecologic and paleoclimatic developments can be drawn using sporomorph taxa that can be compared to extant plants of known botanical affinity. Such information is essential for the prediction of depositional environment and source rock potentiality.

Although several geological studies have been carried out in the study area (e.g. Khairalla, 1966; Whiteman, 1971; Bussert, 1993; Wycisk, 1990) the stratigraphic position of Shendi Formation remains debatable. Hitherto the Shendi Formation is correlated with the Albian-Cenomanian Omdurman and Wadi Milk Formations (Wycisk, 1990; Bussert, 1993). This correlation was primarily based on lithological similarities and on few, long-range macroflora elements from the outcrops. The presumed Albian-Cenomanian age of the Wadi Milk Formation was made based on spores/pollen assemblages recovered from a number of wells between Wadi Muqadam and Dongola area (Schrank, 1990). Therefore, the present study aims at providing a more reliable and accurate age assignment for Shendi Formation using palynology.
2. Material and palynological methods

In this study, eight cutting samples from three shallow water wells, north of Shendi town have been analyzed for their palynological content (Fig. 1). The studied successions are dominated by mudstones of variable colours and thin sandstone interbeds indicating lacustrine to fluvio-lacustrine depositional settings.

A routine palynological preparation scheme, which involves washing of sample, treatment with hydrochloric acid (35%) and hydrofluoric acid (40%), was followed. Oxidation was not employed for any of the analyzed material. A target of 150 specimens count has been set, but most of the samples were proved practically far less productive, therefore, absolute count has to be made. Processing of palynological samples was carried out at the Petroleum Laboratories, Researches and Studies (PLRS) in Khartoum.

3. Palynostratigraphy

The analyzed material from Shendi Basin is dominated by angiosperm pollen; gymnosperms and spores are relatively less represented. Palynodebris are dominated by dark brown to black woods, cuticles, membranous tissues and very little amorphous matter. Characteristic elements of the Palmae province e.g. *Zlivisporis blanensis, Longapertites* sp.3, *Retidiporites magdalenensis* and *Echitripites trianguliformis* form the bulk of the recovered sporomorphs. The stratigraphic ranges of these forms in relevant basins of Northern South America, North and West Africa are depicted in Figure 2 and discussed in the following paragraphs.

Previous records of *Zlivisporis blanensis* has been made from the Coniacian-Maastrichtian of West Africa basins (Boltenhagen, 1976; Jan du Chêne et al., 1978 and Salard-Cheboldaeff, 1990). It has also been reported from the Maastrichtian of Somalia (Schrank, 1994a), Late Cretaceous of Nigeria (Beilstein, 1994) and from the Campanian-Maastrichtian of Sudan (Awad, 1994; Eisawi and Schrank, 2008). The first record of *Longapertites* sp.3 has been made from the Campanian-Maastrichtian of Nigeria (Lawal and Moullade, 1986). Schrank (1994b) considered the coexistence of *Echitripites, Retitripites*, and *Longapertites* sp.3 to indicate a Campanian-Maastrichtian age for the sediments in northern Kordofan, Sudan. *Cristaeocolpites echinaceus* has been reported for the first time from the Maastrichtian of Somalia and later from the Campanian-Maastrichtian of the Sudan (Schrank, 1994a; Eisawi and Schrank, 2008). African records of *Foveomonocolpites bauchiensis* range from the Maastrichtian of Somalia and Sudan (Schrank, 1994a; Eisawi and Schrank, 2009) to the Paleocene of West Africa (Adegoke et al., 1978; Salard-Cheboldaeff, 1990) and Sudan (Stead and Awad, 2005; Eisawi and Schrank, 2008). Previous African records of *Monocolpites marginatus* range from the Campanian-Maastrichtian of Nigeria and Sudan (Lawal and Moullade, 1986; Awad, 1994; Eisawi and Schrank, 2009) to the Paleocene and Eocene of Nigeria (Adegoke et al., 1978). *Periretisyncolpites giganteus* is known from the Maastrichtian of Nigeria (Kieser and Jan Du Chêne, 1979; Edet and Nyong, 1994 and Somalia (Schrank, 1994a), the Campanian-Maastrichtian of West Africa and Egypt (Salard-Cheboldaeff, 199; Schrank, 1987) respectively and the Campanian-Paleocene of Sudan (Kaska, 1989; Eisawi and Schrank, 2008). The marker species *Proteacidites sigalii* was originally described from the Senonian (Coniacian to
Maastrichtian) of Gabon (Boltenhagen, 1978) and later reported from the Coniacian to Maastrichtian of a number of West African basins (Salard-Cheboldaeff, 1990). Additional records are from the Campanian–Maastrichtian of Egypt (El Beialy, 1995; Mahmoud and Schrank, 2007) and the Maastrichtian of Nigeria (Salard-Cheboldaeff, 1979; Lawal and Moullade, 1986), Egypt (Sultan, 1985; Schrank, 1987) and Sudan (Awad, 1994; Eisawi and Schrank, 2008; Eisawi and Schrank, 2009). Previous records of Retidiporites magdalenensis are from the Maastrichtian of Nigeria (Lawal and Moullade, 1986), Egypt and Somalia (Schrank, 1987; Schrank, 1994a), respectively, the Maastrichtian to Paleocene of Nigeria (Germeraad et al., 1968; Jan du Chêne et al., 1978) and Sudan (Awad, 1994; Eisawi and Schrank, 2009) and the interval Maastrichtian to Eocene of the Caribbean (Germeraad et al., 1968), Colombia (Jaramillo et al., 2007) and several West African basins (Salard-Cheboldaeff, 1990). The species was also reported from the Campanian-Maastrichtian of Nigeria (Salami, 1990) and the late Campanian-Maastrichtian of Sudan (Schrank, 1994b). Scabratriporites samoilovitchii was recorded from the Coniacian-Maastrichtian (Senonian) of Gabon (Boltenhagen, 1976) and the Maastrichtian of Nigeria and Sudan (Beilstein, 1994; Eisawi and Schrank, 2009), respectively. The most abundant and biostratigraphically important among angiosperm taxa encountered herein is the Echitriporites trianguliformis which is restricted to the Campanian-Maastrichtian to Eocene of Sudan (Awad, 1994; Eisawi and Schrank, 2008), Campanian-Maastrichtian of Nigeria (Edet, 1992) and Egypt (Schrank, 1987). African records of Ctenolphonidites costatus range from Maastrichtian of Somalia (Schrank, 1994a) to the Eocene-Miocene of Cameroon (Salard-Cheboldaeff, 1979).

The combined stratigraphic ranges of the aforementioned palynomorphs in Africa and northern South America (Fig. 2) and the absence of earliest Late Cretaceous forms such as Droseridites senonicus Cretacaeiporites spp., Foveotricolpites spp., support a Campanian-Maastrichtian age for the subsurface part of the Shendi Formation.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Cretaceous</th>
<th>Paleogene</th>
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<tbody>
<tr>
<td></td>
<td>Turonian</td>
<td>Coniacian</td>
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<tr>
<td>Cristaeolpites echinaceous</td>
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<td>Echitriporites trianguliformis</td>
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<td>Longapertites sp.3</td>
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<td>Monocolpice marginatus</td>
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<td>Periretisyncolpites giganteus</td>
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<td>Proteacidites sigalii</td>
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<td>Retidiporites magdalenensis</td>
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<td>Ctenolphonidites costatus</td>
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<td>Scabratriporites samoilovitchii</td>
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<td>Syncolporites schrankii</td>
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<td>Slivisporis blanensis</td>
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**Fig. 2.** The stratigraphic ranges of selected marker species outside the study area.
4. Comparison of Shendi material with neighboring areas

The spores/pollen assemblages encountered herein are comparable with those recovered from the Maastrichtian Gedaref Formation (Eisawi and Schrank, 2009) and the youngest zone (Campanian-Maastrichtian) of North Kordofan (Schrank, 1994b). They are all dominated by angiosperm pollen of the palmae group. However, some older forms such as *Longapertites* sp. 3, which is indicative of the Campanian are lacking in the Gedaref Formation but are reported in the North Kordofan material. The pre Campanian form *Droseridites senonicus*, characteristic of the Turonian-Santonian (Coniacian) of Kosti Basin Awad (1994) has not been encountered herein.

5. Conclusions

Well preserved and fairly diversified miospores from the subsurface strata of Shendi Formation have been encountered in two shallow wells. The assemblage is dominated by angiosperm pollen, with minor representatives of gymnosperm pollen and spores.

Age determination of the studied interval has been made by comparison of the stratigraphic ranges of the recovered taxa with their previous records in contemporaneous African and north South American basins. Accordingly, a Campanian-Maastrichtian age has been assigned for the subsurface part of the Shendi Formation. The central Sudan was part of the Senonian Palmae province as indicated by the occurrence of characteristic taxa such as *Longapertites*, *Retidiporites*, *Echitriporites*, *Proteacidites* within the studied material.

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References


Mahmoud, M.S., Schrank, E., 2007. Late Cretaceous spores, pollen and dinoflagellates from two boreholes (Nuqra-1 and 3) in the Aswan area, southeast Egypt. Revue de Paléobiologie 26, 593-613.


Plate 1.

Campanian-Maastrichtian Spores and pollen

Fig. 1. *Zlivisporis blanensis* Pacltova 1961.
   Well No. 1, sample 2

Fig. 2. *Foveomonocolpites bauchiensis* Adegoke & Jan du Chêne 1979.
   Well No. 2, sample 1

Fig. 3. *Monocolpopollenites spheroidites* Jardiné & Magloire 1965 sensu Awad 1994.
   Well No. 1, sample 1

Fig. 4. *Retimonocolpites retifossulatus* Lorente 1986.
   Well No. 1, sample 1

Fig. 5. *Spinizonocolpites kostinensis* Awad 1994.
   Well No. 3, sample 1

Fig. 6. *Spinizonocolpites baculatus* Muller 1968.
   Well No. 1, sample 3

Fig. 7. *Tubistephanocolpites cylindricus* Salami 1984.
   Well No. 3, sample 3

   Well No. 3, sample 2

Fig. 9. *Scabratriporites Samoilovitchii* Boltenhagen 1976.
   Well No. 2, sample 1

Fig. 10. *Proxapertites operculatus* Van der Hammen 1956.
   Well No. 3, sample 2

Fig. 11. *Retidiporites magdalensis* Van Der Hammen & Garcia De Mutis 1966.
   Well No. 3, sample 3

Fig. 12. *Ladakhipollenites lehmani* (Boltenhagen) Schrank 1994a.
   Well No. 3, sample 3

Fig. 13. *Gemmatricolpites cf. pergemmatus* Muller 1968.
   Well No. 3, sample 3

Fig. 14. *Gabonisporis vigourouxii* Boltenhagen 1967.
   Well No. 1, sample 2

Fig. 15. *Periretisyncolpites cf. giganteus* Kieser & Jan du Chêne 1979.
   Well No. 1, sample 2

Fig. 16. *Cristaeocolpites echinaceus* Schrank 1994.
   Well No. 2, sample 1

Fig. 17. *Monocolpites marginatus* Van der Hammen 1954.
   Well No. 3, sample 2

Fig. 18. *Echitriporites trianguliformis* Van Hoeken-Klinkenberg 1964.
   Well No. 2, sample 1

Fig. 19. *Syncolporites schrankii* Awad 1994.
   Well No. 2, sample 1

Fig. 21. *Gliechenidites senonicus* Ross 1949.
   Well No. 1, sample 2

Fig. 23. *Longapertites microfoveolatus* Jan Du Chêne and Adegoke in Adegoke et al. 1978.
   Well No. 3, sample 3

Fig. 24. *Ctenolophonidites costatus* (Van Hocken-Klinkenberg1964) Van Hocken-Klinkenberg1966.
   Well No. 3, sample 1

Fig. 25. *Longapertites sp.3*.
   Well No. 3, sample 3.
Plate 1

Scale bar = 20 μm