

Palynological age Dating and Paleoenvironment of Patti Formation, Bida Basin, North-Central Nigeria

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ABSTRACT

Biostratigraphy study of Patti Formation was carried out in order to refine the Maastrichtian age ascribed to it. Palynological analysis was carried out on eighteen samples retrieved along the Ahobo Lokoja-Abaji-Abuja highway. Standard laboratory processes that involved hydrofluoric acid digestion, sieving and maceral separation through the use of heavy liquid and final mounting of residue on glass slides for petrographic observation were carried out. The paly nomorphs recovered are moderate to poor in terms of abundance and diversity. Stratigraphically important pollen, spores and dinoflagellates were recovered and they constitute one palynozone of *Foveotriletes margaritae* belonging to Early Maastrichtian age. The zone erected is characterized by co-occurrence of rare to moderate abundance of *Milfordia jardinei*, *Longapertites marginatus*, *Proteacidites* sp., *Auriculiidites* sp., *Retidiporites magdalenensis*, *Zlivisporites blanensis*, *Araucariacites* sp. and *Milfordia* sp. Other marker forms present are *Buttinia andreevi*, *Syncolporites* sp., *Cingulatisporites ornatus*, *Trocolporopollenites* sp., *Distaverrusporites* sp. and *Proteacidites sigali*. The paleoenvironment of deposition was indicated to be marginal marine based on preponderance of peridinacean forms such as *Senegalinium* sp., *Histrichosphaeridium turonica*, *Andalusiella polymorpha* and *Oligosphaeridium* sp. The Patti Formation was conveniently dated Early Maastrichtian; stratigraphically equivalent and correlated with Mamu Formation in Anambra Basin based on similarity in paly nomorph assemblages.

Keywords: Palynozone, Early Maastrichtian, Biostratigraphy, Patti Formation, Mamu Formation

INTRODUCTION

Palynological study of Patti Formation is not well documented. The study area is situated in the southern part of Bida Basin, within Kogi State and Abuja, Federal Capital Territory. The study was concentrated along the Ahoko Lokoja-Abaji-Abuja highways (Fig. 1). The Bida Basin has been called several names by earlier workers such as Niger Embayment (Reyment, 1965), Niger Basin (Wright *et al.*, 1985), Middle Niger Basin (Idowu and Enu, 1992), Nupe Basin (Jones *et al.*, 1994; Petters,

1995; Olaniyan and Olabaniyi, 1996; Uden and Osasuwa, 2004). The origin of the basin was described to be as result of rift bounded tensional structure associated with Benue Trough, formed due to separation of African and South American Plates (Kennedy, 1965). However, Ojo (1984) and Adeniyi (1985) strongly advocated wrench-fault tectonic model for the origin of the basin. Other notable researchers on the basin include the works of Obaje *et al.* (2015); Rahaman *et al.* 2019; Ojo *et al.* (2020).

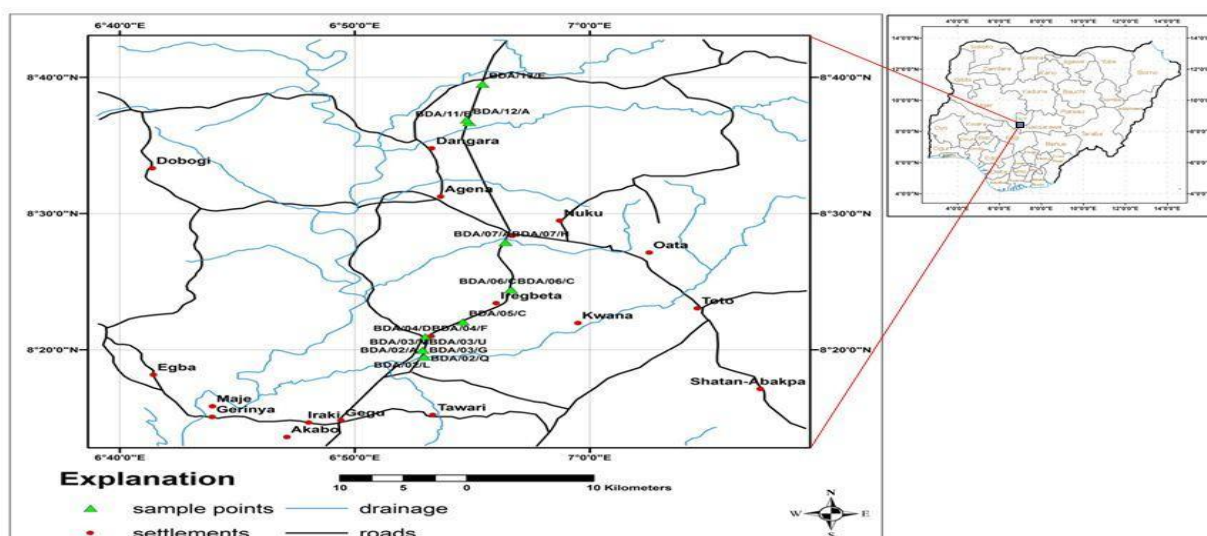


Figure 1: Map showing the locations of the study area

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The stratigraphy of the Bida Basin was documented to contain oldest Lokoja Formation lying unconformably on crystalline basement complex dated Campanian-Maastrichtian age; overlain by Patti Formation at the

middle and capped at the top by Agbaja Ironstone. The former and latter formations were dated Maastrichtian age (Table 1).

Table: Stratigraphy of Bida Basin (modified by Akande *et al.*, 2005)

Age	Southern Bida Basin	Northern Bida Basin
Maastrichtian	Agbaja Ironstone	Batati Ironstone
	Patti Formation	Enagi Siltstone
Campanian-Maastrichtian	Lokoja Formation	Sakpe Ironstone
		Bida Sandstone
		Jima Member Doko Member
Precambrian	Crystalline Basement	Complex

This study was based on Patti Formation with the objectives of determining the relative age and paleoenvironment of deposition of the formation through the application of palynological tool. The essence of the study in particular was to refine the Maastrichtian age given by earlier researchers into epoch and to establish lateral stratigraphic equivalent in adjoining basin or other sedimentary basins in Nigeria based on our knowledge and established facts of the stratigraphy of other basins especially Anambra Basin.

MATERIAL AND METHODS

Eighteen samples composed of claystones and few shales were treated in the laboratory by crushing and pulverizing them because they were highly indurated before chemical treatment was impacted on them. Chemical treatment went through basic standard

laboratory method of preparing palynology slides for observation under the microscope. The samples were subjected to pre-treatment with dilute hydrochloric acid (HCl) in order to remove the carbonate present in the rock samples; further treated with hydrofluoric acid in order to digest the samples. They were thereafter sieved with 10µm sieve in order to eliminate the clay size particles for clean slide analysis. The samples were later subjected to heavy liquid separation whereby zinc chloride was used to separate the macerals from the organic residue. The macerals were rinsed with alcohol and finally mounted on glass slides for palynological analysis.

The collection of samples from the field was carried out by labelling the fresh samples into two groups as presented in Table 2.

Table 2. Grouping of the sample locations

S/N	Group 1 Sample Location	Group 2 Sample Location
1	DN12	DN001A
2	DN23	DN006A
3	DN80	DN007A
4	DN124	DN011A
5	DN182	DN12A
6	DN202	DN020A
7	DN335	DN069A
8		DN078A
9		DN222A
10		DN012B
11		DN254B

RESULT AND DISCUSSION

The analysed samples showed that the abundance and diversity of recovered palynomorphs such as pollen, spores, dinoflagellates, algae and fungal spores vary from one sample to another. Generally, the samples are moderate to poor in terms of palynomorph abundance

and diversity. In most cases the recovered palynomorphs are poorly preserved, they are corroded, probably due to intense weathering processes that had impacted on them or due to oxidation in the environment of deposition. The interpretation for the palynozone and age dating of the Patti Formation was based on comparison of analysed

palynomorphs assemblages with established zones after the works of Germaraad *et al.*, (1968); Evamy *et al.*, 1978; Lawal and Moullade, 1986; Ogala *et al.*, 2009 and Ola-Buraimo, 2013, 2018, 2020). Chronostratigraphy of the samples was established because the samples were collected laterally along the road, not in vertical sequence, therefore, palynozonation of the samples shall be discussed and characterized on per sample basis.

Group 1

Sample No.: DN12

Zone: *Foveotrilites margaritae* Zone

Age: Early Maastrichtian

Description: Sample DN12 is moderately rich in palynomorphs and diversity. Few diagnostic forms recovered include *Milfordia jardinei*, *Proteacidites* sp. and *Inaperturopollenites* sp. (Plate 1). The recovered palynomorphs are dominated by rare occurrence of dinoflagellates such as *Andalusiella polymorpha*, *Cometodinium* sp., *Polysphaeridium* sp. (Plate 2), *Hstrichosphaeridium stellatum* and *Andalusiella laevigata*. Other pollen recovered is *Inaperturopollenites* sp. (Plate 2) and algae form of *Botryococcus braunii*. The palynomorph assemblage is similar to the upper section of Well B, Anambra Basin, Nigeria, dated Lower Maastrichtian (Ola-Buraimo and Yelwa, 2018). Therefore, the sample was conveniently dated Early Maastrichtian due to rare occurrence of *Milfordia jardinei* and *Proteacidites* sp. The paleoenvironment of deposition was inner neritic depicted by relative dominance of *peridinaceans* forms.

Sample No.: DN23

Palynozone: *Foveotrilites margaritae* Zone

Age: Early Maastrichtian

Description: The sample is moderately rich in palynomorphs. The only diagnostic form present is rare occurrence of *Milfordia jardinei* (Plate 1) which suggests Lower Maastrichtian age. The rare occurrence of *Milfordia jardinei* is similar with same characteristics of uppermost section of Asata/Nporo Shale dated Lowermost Maastrichtian age (Ola-Buraimo, 2013; Ola-Buraimo *et al.*, 2012). Thus, the sample is reliably dated Lower Maastrichtian but stratigraphically equivalent laterally to uppermost stratigraphic section of Nkporo Shale. Other forms present are dinoflagellates cysts such as *Andalusiella polymorpha*, dinocyst and *Phelodinium boloniense*, suggestive of shallow marine setting (Oloto, 1987)

Sample No.: DN080

Palynozone: *Foveotrilites margaritae* Zone

Age: Lower Maastrichtian

Description: The sample is relatively rich in palynomorph grains. Few grains of miospores that appeared are stratigraphically important; they include *Longapertites marginatus*, *Foveotrilites margaritae*, *Tricolpites* sp., *Auriculidites* sp., *Monosulcites* sp. and *Tricolpites giganteus* (Plates 1 and 2) The miospores present are depictive of Lower Maastrichtian age deposit, equivalent to Mamu Coal Measure (Ogala *et al.*, 2009), also similar in assemblage with Arimogija-Okelusi Shale, Dahomey Basin, southwestern Nigeria dated Early Maastrichtian (Ola-Buraimo *et al.*, 2012). Recovered dinoflagellates suggest marine environment of deposition.

Sample No.: DN124

Palynozone: *Foveotrilites margaritae* Zone

Age: Maastrichtian

Description: The sample is poor in both miospores and dinoflagellates recovery. However, the appearance of *Retidiporites magdalenensis* (Plate 1) tentatively suggests Maastrichtian age. Dominance of *Phelodinium boloniense* and *Gonyaulacacean* sp. suggest a marginal marine paleoenvironment of deposition Ola-Buraimo, 2020 unpublished PhD thesis).

Sample No.: DN 182

Age: Not Determined

Description: The sample is very poor in palynomorphs. Spore and dinoflagellate retrieved are *Zlavisporites blanensis* and *Subtilisphaera* sp. respectively. The sediment might have been deposited during deltaic progradation at low sea level position. The sample cannot be assigned a particular age because of lack of marker forms, However, the occurrence of *Zlavisporites blanensis* was tentatively dated Maastrichtian age.

Sample No.: DN202

Palynozone: *Foveotrilites margaritae* Zone

Age: Early Maastrichtian

Description: The sample is relatively poor in miospore recovery but moderate in dinoflagellate presence. The few miospores present are stratigraphically important forms such as *Milfordia* sp and *Longapertites marginatus*. (Plates 1 and 2). The co-occurrence of rare *Milfordia* sp. and few occurrences of *Longapertites marginatus* are suggestive of Early Maastrichtian age (Ola-Buraimo and Akaigbobi, 2013). Relative substantial occurrence of dinoflagellates such as *Senegalinium* sp., *Subtilisphaera* sp. and *Michrystidium* sp. are indicative of shallow marine deposit of Patti Formation.

Sample No.: DN335

Palynozone: *Milfordia* spp. Zone

Age: Campanian

Description: The sample is characterized by relative moderate abundance of *Milfordia* sp. Other miospores present are rare occurrence of *Longapertites marginatus*, *Araucariacites* sp., *Cyathidites* sp. and *Tricolpites* sp. (Plate 1 and 2). The relative quantitative abundance of *Milfordia* sp. and rare occurrence of *Longapertites marginatus* are indicative of Campanian age deposit; equivalent stratigraphically to Nkporo Shale, deposited in shallow marine setting (Ola-Buraimo and Akaigbobi, 2013). The sample might belong to Lokoja Formation or represents Campano-Maastrichtian boundary between Lokoja Formation and Patti Formation .

Group 2

Sample No.: DN001A

Age: Maastrichtian

Description: The sample is very poor of preserved fossils. The only pollen recovered is *Retidiporites magdalenensis* suggestive of Maastrichtian age deposit (Plate 1). The sediment has paucity of forms probably due to progradation of the delta, poor climatic condition and low sea level.

Sample No.: DN006A

Palynozone: *Foveotrilites margaritae* Zone

Age: Early Maastrichtian

Description: The sample is relatively poor in taxon frequency but moderate in form diversity. Three diagnostic forms present are *Foveotrilites margaritae*, *Butinia andreevi*, *Tricolporopollenites* sp., *Laevigatosporites* sp. and *Syncolporites* sp. (Plates 1 and 2). The assemblage of palynomorph in the sample is similar with palynological assemblage of Afowo

Formation and partly lower section of Uzeeba Shale deposit, Dahomey Basin, southwestern Nigeria, dated Early Maastrichtian (Ikhane *et al.*, 2012; Ola-Buraimo *et al.*, 2014). Therefore, the sample DN006A belonging to Patti Formation was conveniently dated Early Maastrichtian age. The organic wall microplankton recovered include *Phelodinium bolonienae*, dinoflagellate cysts and *Trichodinium* sp. are depictive of shallow marine depositional setting.

Sample No.: DN007A

Palynozone: *Foveotrilletes margaritae* Zone

Age: Early Maastrichtian

Description: Sample DN007A is defined by the co-occurrence of *Foveotrilletes margaritae*, *Proteacidites* sp., *Proteacidites* sp. 4 (Lawal, 1986), *Cingulatisporites ornatus*, *Periretisyncolpites* sp, *Cyathidites* sp. and *Syncolporites* sp (Plates 1 and 2). This miospore assemblage is similar with palyнологical assemblage of Afowo Formation, Dahomey Basin, Nigeria dated Early Maastrichtian age (Ikhane *et al.*, 2012). Dinoflagellate assemblage of *Batiacasphaera* sp., dinoflagellate cysts and relative moderate frequency of *Histrichosphaeridium turonica* suggest marginal marine paleoenvironment of deposition (Ola-Buraimo and Adeye, 2008; Ojo *et al.*, 2009). The stratigraphic equivalents of this deposit are Mamu Formation in Anambra Basin, southeastern Nigeria and Uzeeba Shale, Dohomey Basin, southwestern Nigeria.

Sample No.: 011A

Palynozone: *Milfordia* spp. Zone

Age: Campanian

Description: The sample is rich in abundance and moderate in diversity of palynomorphs. Here, *Milfordia* sp. shows very high abundance, while *Milfordia jardinei* is moderate in frequency. The acme abundance of the taxa indicates Campanian age equivalent to Nkporo Shale in Anambra Basin (Ola-Buraimo and Akaigbobi, 2012; Ola-Buraimo *et al.*, 2014). Other associate forms are *Auriculiidites* sp., *Distaverrusporites* sp., *Longapertites marginatus*, *Monosulcites* sp. and *Cyathidites* sp (Plates 1 and 2). The recovery of dinoflagellates in the sample suggests marine deposit. The sediment might belong to Lokoja Formation or the Campano-Maastrichtian boundary between Patti and Lokoja Formations.

Sample No.: DN012A

Palynozone: *Milfordia* spp. Zone

Age: Early Maastrichtian

Description: Sample D012A shows decrease in *Milfordia* sp. abundance compared to Sample DN011A (Plate 1), suggestive of Late Campanian to Early Maastrichtian age deposit; similar in assemblage with upper part of Asata /Nkporo Shale dated Late Campanian-Lowermost Maastrichtian age (Ola-Buraimo and Akaigbobi, 2013). The sample is very rich in *Oligosphaeridium* sp., showing maximum abundance in association with other dinoflagellates such as *Subtilisphaera* sp. 6, *Areoligera* sp. and *Cyclonephelium* sp. 3 in rare abundance. The preponderance of gonyaulacacean forms suggest typical marine deposit of middle to outer neritic to setting during sediment starvation, equivalent to flooding surface (FS) (Ola-Buraimo and Ehinola, 2021; in press). This sediment may be the Patti Formation transition contact with underlying older Lokoja Formation.

Sample No.: DN020A

Palynozone: *Foveotrilletes margaritae* Zone

Age: Maastrichtian

Description: The sample is composed of palynomorphs with fair abundance and diversity. The appearance of *Proteacidites sigali*, *Stephanocolpites* sp. and *Laevugatosporites* sp. suggest Maastrichtian age deposit (Plates 1 and 2). *Senegalinium* sp. 4 and *Senegalinium* sp. were recovered in rare quantity; suggested shallow marine environment of deposition.

Sample No.: DN022A

Age: Not determined

Description: Palynomorph recovery is very poor in content; a spore *Laevigatosporites* sp. (Plate 2) and algae (*Botryococcus braunii*) are the only forms present in the analysed slide. The forms present are not age diagnostic while the algae suggest sediment deposition in fluviomarine setting of probably prograding complex

Sample No.: 069A

Age: Not determined

Description: The sample contains only an appearance of dinoflagellate cyst. It is a very poor sample in terms of palynomorph recovery. The presence of the dinoflagellate could suggest a fluviomarine environment of deposition in a prograding deltaic setting.

Sample No.: 078A

Age: Not Determined

Description: It is a very poor sample, containing a grain of *Longapertites* sp. and dinoflagellate cyst. The rare quantitative occurrence of *Longapertites* sp. is not sufficient enough to suggest the age of the sediment. However, the presence of dinoflagellate cyst could suggest a marine deposit.

Sample No.: DN012B

Palynozone: *Foveotrilletes margaritae* Zone

Age: Early Maastrichtian

Description: The sample DN012B consists of palynostratigraphically important forms such as *Echitriporites trainguliformis*, *Cingulatisporites ornatus*, *Auriculiidites reticulatus*, and *Monocolpites marginatus* (Plates 1 and 2). The assemblage is synonymous with Maastrichtian sediments in Nigeria sedimentary basins such as Afowo Formation in Dahomey Basi and Well B, Anambra Basin Nigeria dated Early Maastrichtian age (Ikhane *et al.*, 2012; Ola-Buraimo and Yelwa, 2018). Thus, the Patti Formation was dated Early Maastrichtian age. The only dinocyst present is *Batiacasphaera* sp. suggestive of marine deposit.

Sample No.: DN254B

Palynozone: *Foveotrilletes margaritae* Zone

Age: Maastrichtian

Description: The sample is relatively rich in palynomorph abundance and diversity. A stratigraphically important form useful for age determination is *Proteacidites sigali*, depictive of Maastrichtian age (Jardine and Magloire, 1965). Other miospores present are *Longapertites marginatus*, *Inaperturopollenites* sp., *Longapertites* sp., and *Cyathidites* sp (Plates 1 and 2). The Patti Formation was suggested to have been deposited in a marine environment based on the recovery of dinoflagellates such as *Histrichosphaerina turonica*, *Andalusella polymorpha*, *Cyclonephelium* sp. and dinoflagellate cysts.

Stratigraphy correlation

Patti Formation in Bida Basin is stratigraphically correlatable with adjoining sedimentary basins in Nigeria on the basis of similarity in palynomorph assemblages. Patti Formation is correlatable with Mamu Formation in

Anambra Basin southeastern Nigeria (Ogala *et al.*, 2009; Fig. 4), correlatable with Afowo Formation in Dahomey Embayment, southwestern Nigeria (Ikhane *et al.*, 2012), correlatable with Fika Formation in Tuma-land Murshe-1 wells, Bornu Basin, northeastern Nigeria (Ola-Buraimo, 2012, 2013b). The correlation exercise was a modification on the work of Akande *et al.*, (2005) based on deep knowledge on the latest stratigraphy of Anambra

Basin as detailed in the work of Ola-Buraimo (2020, unpublished PhD thesis). Therefore, due to the palynological data obtained in this research, Patti Formation is conveniently stratigraphically laterally correlated and equivalent to Mamu Formation instead of Ajali Formation suggested by Akande *et al.* (2005) (Fig. 2).

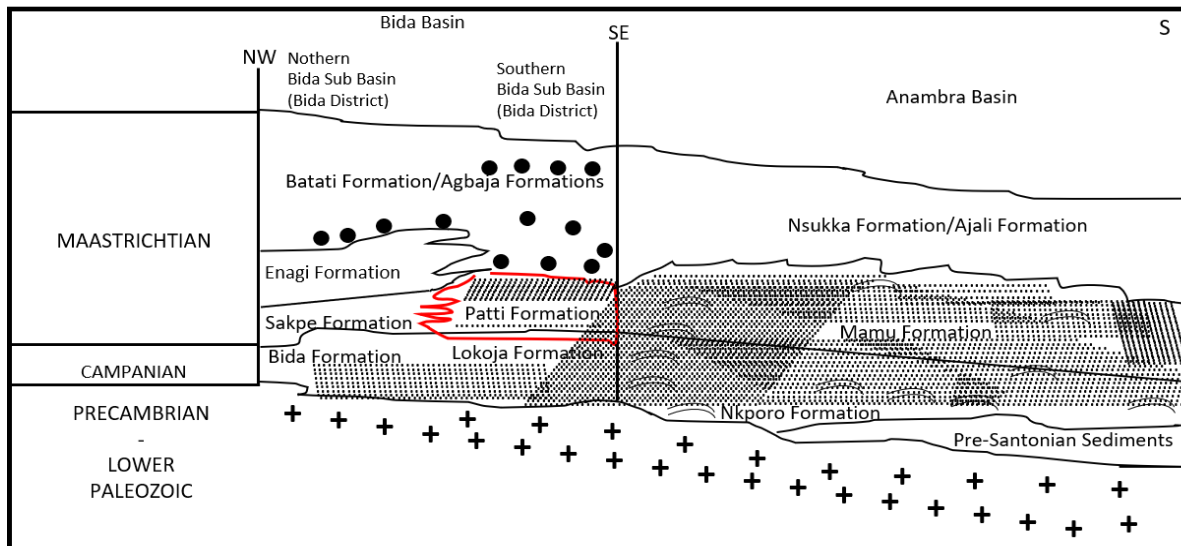


Figure 2: Stratigraphy of Maastrichtian-Campanian formations in the Bida Basin correlated with the Anambra Basin; Patti Formation highlighted (modified after Akande *et al.* 2005).

Magnification $\times 800$

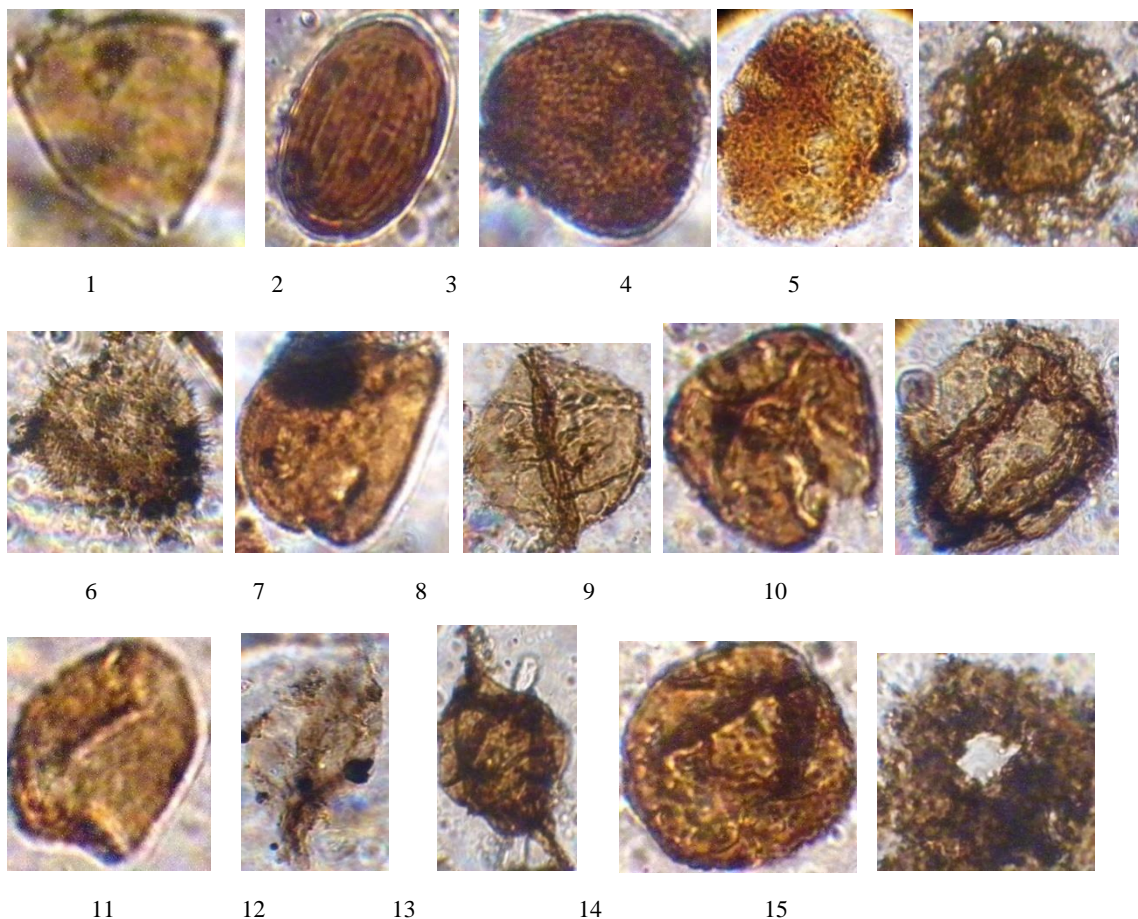


Plate 1. Photographs of recovered palynomorphs

- 1 *Proteacidites* sp.
- 2 *Retistephanocolpites* sp.
- 3 *Foveotriletes margaritae*
- 4 *Periretisyncolpites* sp.
- 5 *Histicosphaeridium turonica*
- 6 *Cometodinium* sp.
- 7 *Longapertites marginatus*

- 8 *Phelodinium bolonienae*
- 9 *Cyathidites* sp.
- 10 *Zlvisporites blanensis*
- 11 *Retidiporites magdalenensis*
- 12 *Auriculiidites* sp.
- 13 *Andalusiella polymorpha*
- 14 *Araucariacites australis*
- 15 *Milfordia jardinei*

Magnification x800

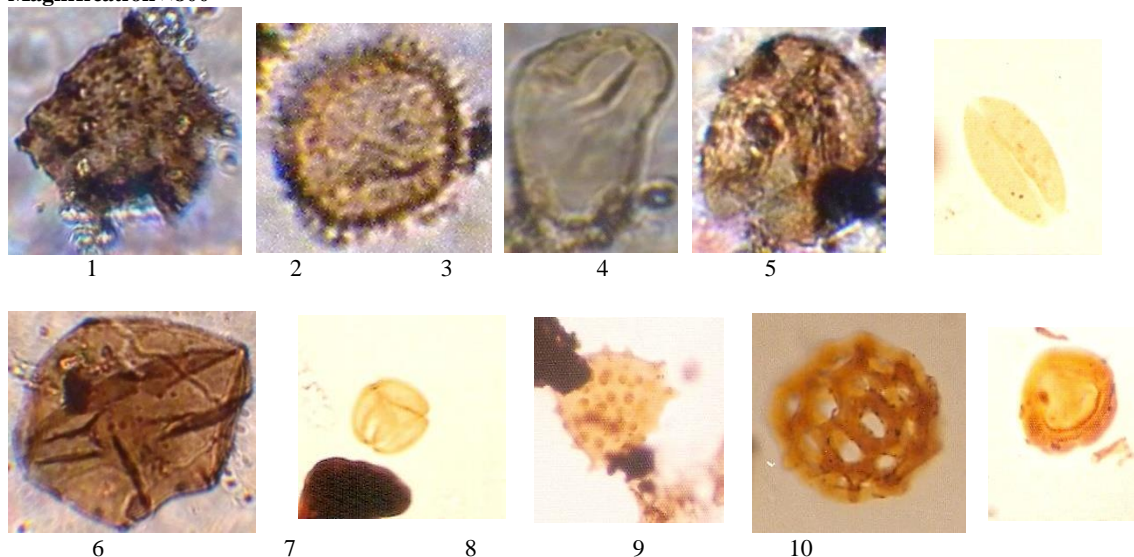


Plate 2. Photographs of recovered palynomorphs

- 1 *Senegalinium* sp.
- 2 *Polysphaeridium* sp.
- 3 *Laevigatosprites* sp.
- 4 *Inaperturopollenites* sp.
- 5 *Monosulcites* sp.
- 6 *Andalusiella laevigata*
- 7 *Syncolporites marginatus*
- 8 *Echitriporites trianguliformis*
- 9 *Buttinia andreevi*
- 10 *Cingulatisporites ornatus*

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