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SPOROPOLLINIC BIOSTRATIGRAPHY AND YPRESIAN PALEOENVIRONMENT

by

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(with 5 figures and 2 plates)

ABSTRACT

Through sporopollinic analysis of the Ypresian it is possible to establish biostratigraphic boundaries within the stage's formations. The sporopollinic assemblages of the Mont-Heribu Member, the Orchies Clay, the Roubaix Clay and, in the northern part of the Belgian Basin, the Aalbeke Clay are somewhat similar to those of the continental Landenian. However, they distinguish themselves by the absence of certain typical species of the Landenian and the appearance of new species peculiar to Ypresian.

In the Kortemark Silt, in the Egem Sand an even in the Aalbeke Clay of the type area, new sporopollinic assemblages appear, indicating floristical changes which characterize the Upper Ypresian (formerly "Lower Paniselian"). The variations in palynological associations enable to distinguish the clay-sandy lower part from the sandy upper one.

During the Ypresian, the subtropical flora which characterizes the Late Landenian, progressively undergoes tropical influences emphasized by the appearance of genera with megathermic affinities. During a short period starting with the Kortemark Silt deposit (if not the Aalbeke Clay) and stopping with the "Aalterbrugge Complex", a very hot and wet climate has favoured the expansion of these genera in the Belgian Basin.

Key words: Paleogene — Eocene — Ypresian — Palynostratigraphy — Paleoenvironment — Paleoclimatology.

SAMENVATTING

Door de sporen- en pollenstudie van het Ypresien kan men biostratigrafische grenzen binnen deze tijdlaag bepalen. De sporen- en pollenassociaties van het Lid van de Mont-Héribu, de Klei van Orchies, de Klei van Roubaix en, in het noordelijk deel van het Belgisch Bekken, de Klei van Aalbeke, gelijken tamelijk goed op die van het kontinentaal Landeniaan. Ze worden nochtans gekenmerkt door de afwezigheid van bepaalde typische soorten van het Landeniaan en het verschijnen van nieuwe speciës, eigen aan het Ypresien.

In het Silt van Kortemark, het Zand van Egem en zelfs in de Klei van Aalbeke in het typegebied, verschijnen nieuwe sporen- en pollenassociaties, die wijzen op veranderingen in de flora, die het Boven-Ypresien (vroeger "Onder-Paniselien") kenmerken. De variaties van de palynologische associaties hierin laten toe een onderscheid te maken tussen het onderste kleiig zandige en het bovenste zandige deel.

Gedurende het Ypresien ondergaat de subtropische flora, kenmerkend voor het Laat-Landenien, geleidelijk een tropische invloed, benadrukt door het verschijnen van genera met megatermische affiniteiten. Gedurende een korte periode, vanaf de afzetting van het Silt van Kortemark (misschien reeds van de Klei van Aalbeke) en tot het "Complex van Aalterbrugge" bevorderde een zeer warm en vochtig klimaat de ontwikkeling van deze genera in het Belgische Bekken.

Sleutelwoorden: Paleogeen — Eoceen — Ypresien — Palynostratigrafie — Paleomilieu — Paleoklimaat.

RESUME

L'analyse sporopollinique de l'Yprésien permet d'établir des coupures biostratigraphiques entre les formations qui constituent l'étage. Les assemblages sporopolliniques du Membre du Mont-Héribu, de l'Argile d'Orchies, de l'Argile de Roubaix et, dans le nord du Bassin belge, de l'Argile d'Aalbeke rappellent ceux du Landénien continental; ils s'en distinguent cependant par l'absence de certaines espèces marquantes du Landénien et par la présence de quelques nouvelles espèces propres à l'Yprésien.

Dans le Silt de Kortemark et les Sables d'Egem et même déjà dans l'Argile d'Aalbeke de la région-type, de nouveaux assemblages sporopolliniques apparaissent, annonçant les changements floristiques caractérisant l'Yprésien supérieur (ancien "Paniselien" inférieur). Au sein de celui-ci, les variations des associations palynologiques permettent de différencier la partie inférieure argilo-sableuse de la partie supérieure sableuse.

A l'Yprésien, la flore subtropicale qui caractérisait le Landénien supérieur subit progressivement des influences tropicales soulignées par l'apparition de genres aux affinités mégathermes. Durant une courte période commençant avec le dépôt du Silt de Kortemark (sinon déjà de l'Argile d'Aalbeke) et se terminant par le "Complexe d'Aalterbrugge", un climat au caractère chaud et humide prononcé a favorisé l'extension de ces genres dans le bassin belge.

Mots-clés: Paléogène — Eocène — Yprésien — Palynostratigraphie — Paléoenvironnement — Paléoclimatologie.

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The sporopollinic study of the different formations and layers of the Ypresian was the subject of various publications (E. ROCHE, 1973, 1980, 1982). This paper synthetises the biostratigraphical and paleographical results.

Passage from Continental Landenian to lower Ypresian was studied for the borings of Kallo, Beringen, Loksbergen and Tertre. Lithologically, this passage is as follows in the different sequences examined (M. MERCIER and al., 1985).

Kallo: from black lignitic clay with shells (−377,8 m to −377,35 m) to glauconitic clay-sandy sediments (−377,35 m to −376 m), topped by a finely stratified heavy clay (from −376 m).

Beringen: from grey-black lignitic clay to grey sandy clay.

Loksbergen: from a lignit to black lignitic clay.

Tertre: from a heterogenous black clay to sandy-clay and silty sand.

The Ypresian layers under study are included in the following lithostratigraphic units:

1. Mont-Heribu Member: Kallo boring, Overijse boring;
2. Orchies Clay: Kallo boring, abandonned clay-pit at Lauwe-Knok;
3. Aalbeke Clay: Kallo boring, clay-pit at Aalbeke;
5. Kortemark Silt: Kallo boring;
6. Egem Sand: Kallo boring, Ampe sand-pit at Egem and Kwatrecht Complex: F.DB.11 boring at Melle;
7. Merelbeke Clay: Kallo boring, Woensdrecht boring, F.DB.11 boring at Melle, Torhout and Potte wells.
8. Pittem Clay: Kallo boring, Ampe sand-pit at Egem, F.DB.6 and F.DB.4 borings at Heusden;
9. Vlierzele Sand: Kallo boring, Woensdrecht boring, F.DB.4 and F.DB.2 borings at Heusden;
10. Aalterbrugge Complex: F.DB.1 boring at Heusden.

At Melle and Heusden, in the area of Gent, DE MOOR and GEETS (1974) identified the Upper layers of Ypresian (Kwatrecht Complex, Merelbeke Clay, Pittem Clay, Vlierzele Sand with the Aalter-

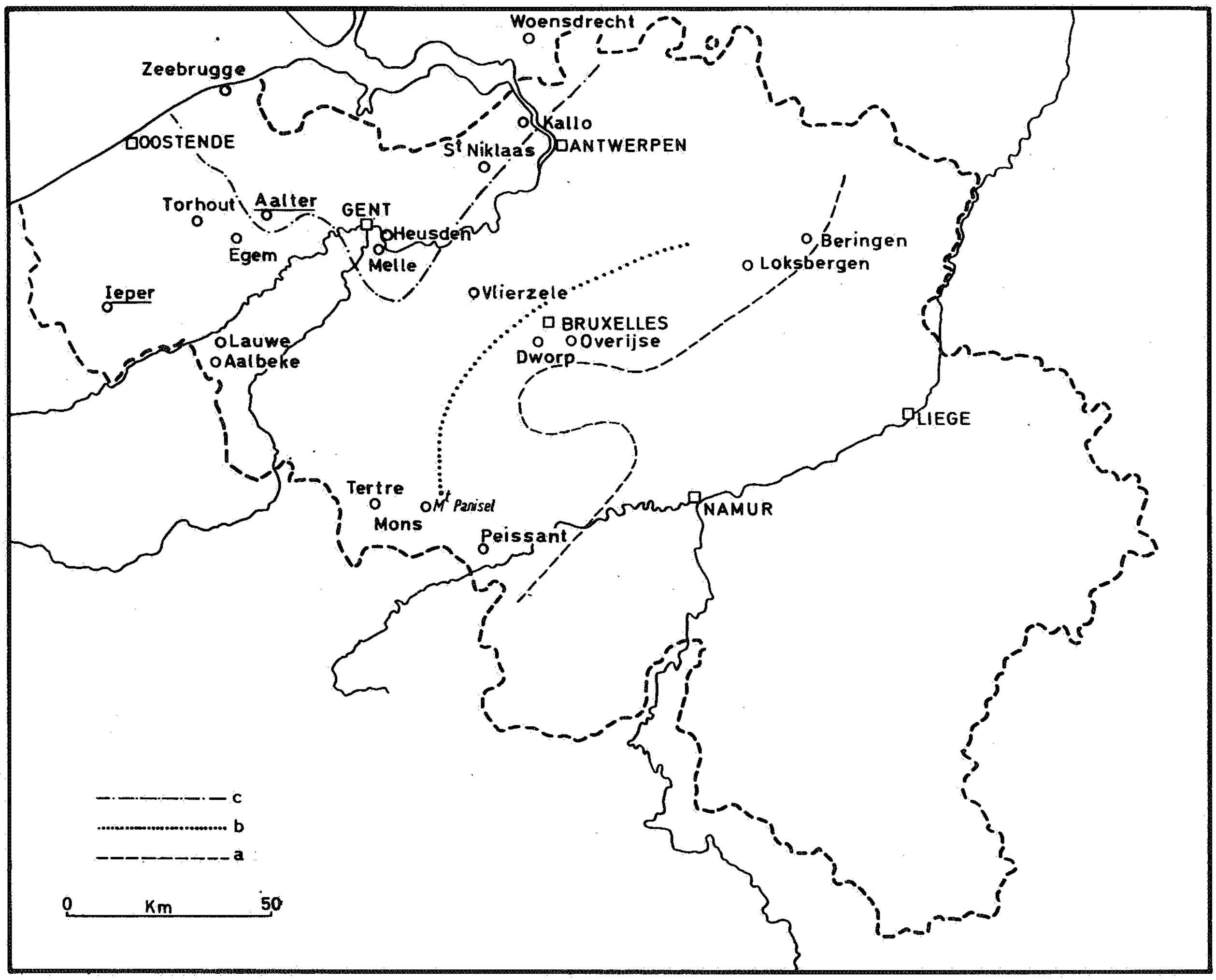

Fig. 1
Extension of the main facies:
a, eastern limit of the Ypresian deposits;
b, southeastern limit of the "lower Paniselian" facies (Pittem Clay, Vlierzele Sand);
c, Aalter Sand.

brugge Complex) covered by Aalter Sands. Sporopollinic analysis of this sedimentary sequence was carried out and compared with the corresponding levels ("paniselian") of the Kallo (−239 m to −200 m) and Woensdrecht (−459 m to −380 m) borings.

The limits of the lower Eocene formations and the examined sites can be found in figure 1.

SPOROPOLLINIC BIOSTRATIGRAPHY

Ypresian formations enclose characteristic markers as well as diversified sporopollinic assemblages which enable to establish accurate biostratigraphic subdivisions in the Belgian Basin. Two major boundaries which mark two main palynological zones in the Ypresian were put forward: the first in the reference Kallo sequence between the Aalbeke Clay and the Kortemark Silt; the second, at the top of the Vlierzele Sand (Aalterbrugge Complex), at the basis of the Aalter Sand.

Both zones can then subdivised into several subzones.

Sporopollinic assemblages observed in the Mont-Heribu Member, the Orchies Clay, the Roubaix Clay and in the Aalbeke Clay (North of the Belgian Basin), if less diversified, are similar to those of the Upper Landenian. The impoverishment of the sporopollinic material is mainly due to the selective sedimentation of small or light pollens in fine granulometry marine deposits: *Triatriopollenites platycarioides* (Platycarya), *Triatriopollenites engelhardtioides* (Engelhardtia), *Psilatricolporopollenites cingulum* (quercoïds asiatic forms) and some disaccites.

Thick-walled subtriporate forms (*Subtriporopollenites spissoexinus*) disappear at the base of the Mont-Heribu Member and are replaced by "modern" forms with thin walls: *Caryapollenites triangulus*, already present in the Upper Landenian and *Caryapollenites circulus*. With the latter another significant form in the first Ypresian clay layers appears: *Clavatricolporites iliacus* (Ilex).

The Normapolles, archaïc pollinic forms from the Cretaceous flora, in regression at the Upper Landenian, are represented by four genus at the lower Ypresian: *Interpollis supplingensis, Nudopollis endangulatus. Pompeckjoidaepollenites suhercynicus* and *Plicapollis pseudoexcelsus*. The first of these forms can be found no further than the top of the Egem Sand.

In the first clay series of the Ypresian deposits, *Spinizonocolpites* (Nipa) is sporadically present in the clay-sandy facies which probably proves a costal environment. *Spinizonocolpites* appear at the beginning of the *Dradodinium simile* zone defined elsewhere in this volume (DE CONINCK). The first appearence projected on the reference sequence (see also J. DE CONINCK in the present volume) of Kallo is situated at about the Orchies Clay-Roubaix Clay transition. The genus will regularly appear later on from the layers which in Kallo, correspond to the Kortemark Silt. In these levels as well as in the Egem Sand the presence of new palynological assemblages prove the existence of floristic changes and perhaps also a larger supply of more pollen and spores arrival.

The floristic change became more evident at the base of the Merelbeke Clay. The assemblages contain (more particulary): *Milfordia incerta* (Restionaceae), *Dicolpopollis luteticus* (Calamus) and new species of *Triatriopollenites: T. myricoïdes, T. plicatus* and *T. sibiricus*.

In the Merelbeke Clay the first *Bombacacidites* and *Diporites iskaszentgyorgii* (Alyxia) and *Araliaceae* of the *Schefflerops*is type appear. At the same time, *Nudopollis endangulatus* disappears.

The most frequent species in the upper members of the Ypresian at the beginning of the Merelbeke Clay are the following: *Milfordia hungarica, Milfordia incerta, Triatriopollenites platycarioïdes, Triatriopollenites plicatus, Triatriopollenites myricoides, Triatriopollenites sibiricus, Caryapollenites triangulus, Caryapollenites circulus, Monocolpopollenites tranquillus, Monocolpopollenites parareolatus, Spinizonocolpites echinatus* and *Dicolpopollis luteticus*. The last four pollinic forms, produced by Palms, are particulary frequent in the lower clay sediments (Merelbeke Clay, Pittem Clay). Diporites in the Merelbeke Clay increase in the Pittem Clay level, while the *Bombacacidites* are more common in the upper sandy deposits (Vlierzele Sand, Aalterbrugge Complex).

The Aalterbrugge Complex is the last layer in which *Spinizonocolpites* and *Diporites* are still found although they are dispersed. One can observed the simultaneous rearefaction of monocolpate pollens. Three of the four *Bombacacidites (Bombacacidites noremii, Bombacacidites europaeus, Bombacacidites egenensis)* are also present at the top of their vertical extension. *Bombacacidites grandis* is the only species of the genus to appear in the Aalter Sand where it disappears at the same time as *Pompeckjoidaepollenites subhercynicus*, one of the two last genus of Normapolles still present at this level.

The comparison of the sporopollinic assemblages of the different "paniselian" layers of the area of Melle-Heusde with the corresponding sequences of Kallo and Woensdrecht enable to establish the following correlations between some levels analysed in the two borings:

	Kallo	Woensdrecht
Aalter Sand	−200 m	−308 m
Aalterbrugge Complex	−203 m	−385 m
Vlierzele Sand	−209 m	−410 m
Pittem Clay	−234 m	−429 m
Merelbeke Clay	−238 m	−459 m

Considering the sporopollinic analysis of the Ypresian layers, a biostratigraphic synthesis can be proposed in fig. 2.

It is possible to determine the following palynologic zones:

— The Zone I including the Mont-Héribu Member, the Orchies Clay, the Roubaix Clay and, in the north of the Belgian Basin, the Aalbeke Clay form subzone b which is part of a unit including Continental Landenian (subzone a);

- The floristic changes occurring at the base of the Kortemark Silt and even in the Aalbeke Clay of the sample area oblige us to group these layers with the upper-laying Egem Sand in the subzone a of the pollinic zone II. The two other subzones b and c correspond respectively to the clay layers (Merelbeke Clay, Pittem Clay) and sandy layers (Vlierzele Sand, Aalterbrugge Complex) of the Upper Ypresian (former Lower Paniselian);
- The Aalter Sand appear as the base (subzone a) of a zone III including the other formations of the Lutetian and the Bartonian till the clay and sand of Asse. By the biozonal position of the Aalter Sands, we may consider them as the basis of the Lutetian (Brusselian) instead of the top of the Ypresian.

PALEOECOLOGY

Since the beginning of the Cenozoïc period, the archaïc little floras of the Upper Cretaceous have been replaced by better structured great floristic units.

For the Paleocene period, KRYSHTOFOVICH (1957) distinguishes, two provinces in the northern hemisphere, situated on each part of a line between 35° and 60° latitude: a Northern Province with a temperate "arctotertiary" flora and a Southern Province with a "laurophylle paleotropical" flora (see fig. 3). Following TAKHTAJAN (1969), the vegetation which grew during that period from the Paris Basin to the Oural country was similar to the evergreen forests which under a subtropical humid climate can be found on the Assam and Yunnan highlands.

Already during Paleocene but mainly during Eocene, great changes appear in the flora of the

CHRONOST.	LITHOSTRATIGRAPHY		PALYNOSTRAT. Subzones	PALYNOSTRAT. Zones
BRUXELLIAN	Aalter Sand	former UPPER "PANISELIAN" p.p.	a	III
YPRESIAN	Aalterbrugge Complex		c	II
	Vlierzele Sand	former LOWER "PANISELIAN"		
	Pittem Clay		b	
	Merelbeke Clay			
	Kwatrecht Complex			
	Egem Sand		a	
	Kortemark Silt			
	Aalbeke Clay			
	Roubaix Clay		b	I
	Orchies Clay			
	Mont-Héribu Member			
LANDENIAN	"Continental Landenian"		a	
	Grandglise Sand			

Fig. 2
Stratigraphical scheme of the Ypresian deposits of the Belgian basin with indications of the palynologic zonation.

English, Belgian and Parisian basins. The "Normapolles", produced by extinct genus adapted to hot climates, progressively fall in the palynologic assemblages and are replaced by a group of more modern genera called by KRUTZSCH (1967) "Eocene paleotropical element". MULLER (1980) however, preferred to use the term "Tethysian element", more neutral and better portraying the absence of real megatherm taxa in the flora of Occidental Europe.

Brackish and fluviatile sediments of Upper Landenian are generally very rich in sporomorphs. The sproropollinic assemblages reveal a flora which is in great mutation and where the archaïc genera are mixed with modern genera of increasing importance. The palynological observations and the study of vegetal macro-remains show the nature of the Upper Landenian flora. In the lagunair zones situated in the North of the Belgian Basin, a vegetation of hot and wet ecology appeared composed of *Schizeaceae, Polypodiaceae, Palmae, Taxodiaceae, Nyssaceae-Taxodiaceae.* On the land, east and west of the Basin, *Juglandaceae (Carya, Engehardia, Platyrarya)* were widely developed. To these Juglandaceae were associated taxa whose ecology varied from tropical trend (*Icacinaceae, Iodes* type; *Leguminoseae, Cassia* type; *Sapotaceae*) to temperate trend (*Betulaceae, Coryplaceae*) proving the existence of a transition flora mostly composed of mesotherm elements: *Aceraceae (Acer), Anacardiaceae* (Rhus), *Araliaceae (Hedera, Oreopanax), Caprifoliaceae (Viburnum), Castaneaceae (Castanea, Castanopsis), Fagaceae (Quercus), Lauraceae (Cinnamomum, Laurus), Leeaceae, Magnioliaceae, Moraceae, Myrtaceae, Myricaceae, Restionaceae, Tiliaceae (Tilia, Grewiae), Ulmaceae (Celtis), Vitaceae (Cissus).*

The type of the Upper Landenian flora is essentially subtropical. After a cold pulsation at the beginning of the period, indicated by a extension of the temperate arctotertiary flora taxa, the climate became progressively warmer announcing the particulary warm and wet phase characterizing the Ypresian.

The flora of the Mont-Héribu Member, the Orchies Clay, the Roubaix Clay and of the Aalbeke Clay is not very different from those of the Continental Landenian. It is generally in the Kortemark silt, in the Egem Sand and even in the Aalbeke Clay of the type-area that an important floristic change begins with the progression of the *Nipa* palm living today in the low Indo-Malaysian countries. The latitudinal expansion of this megatherm genus is the effect of a tropical climate in western Europe during the Cuisian and Lutetian periods. Other genera appeared at the same time as *Nipa* are *Calamus,* a palm tree with an intertropical distribution in Africa and Asia and *Acrostichum,* a mangrove fern of intertropical wet zones.

It is mainly at the Upper Ypresian (Merelbeke Clay to Aalterbrugge Complex) that the climate reached its warm and wet optimum: today most families and genus of the flora of that period grow in the warm countries of the world, for example *Palmae (Sabal, Phoenix, Calamus, Nipa), Araliaceae (Scheffleropsis), Aquifoliaceae (Ilex),*

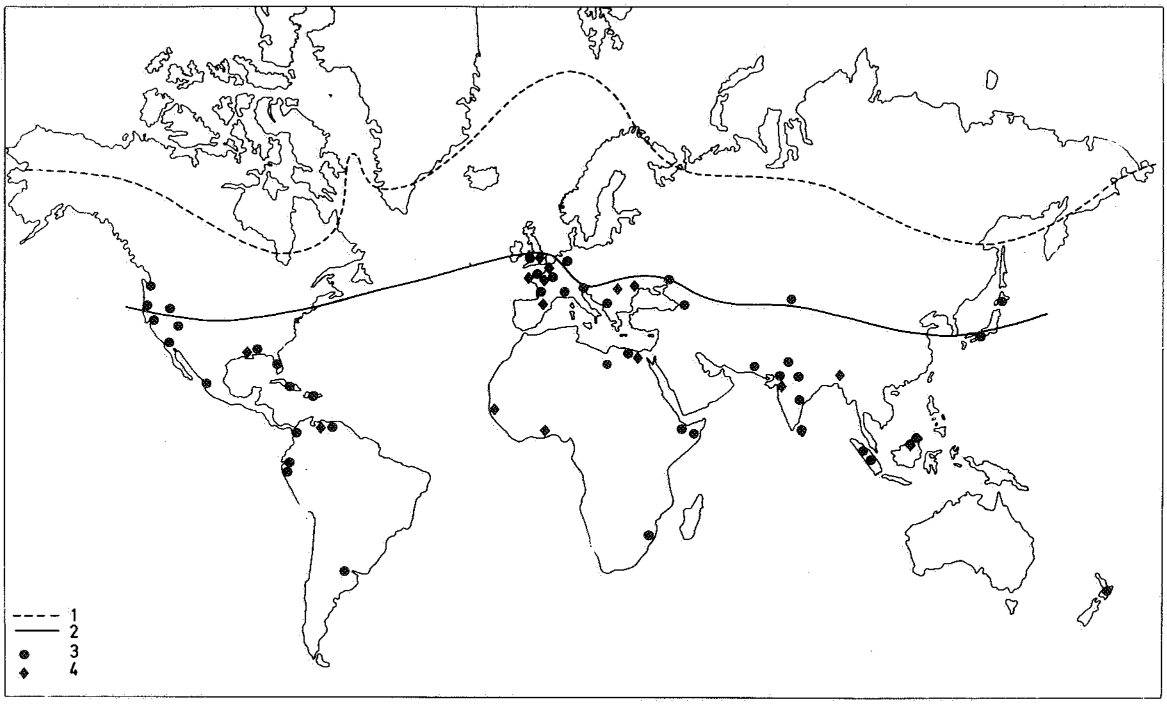

Fig. 3
Distribution of the eocene floras:
1, northern limit of the warm temperate floras;
2, northern limit of the tropical floras;
3, extension of Palmae;
4, extension of the genus Nipa.

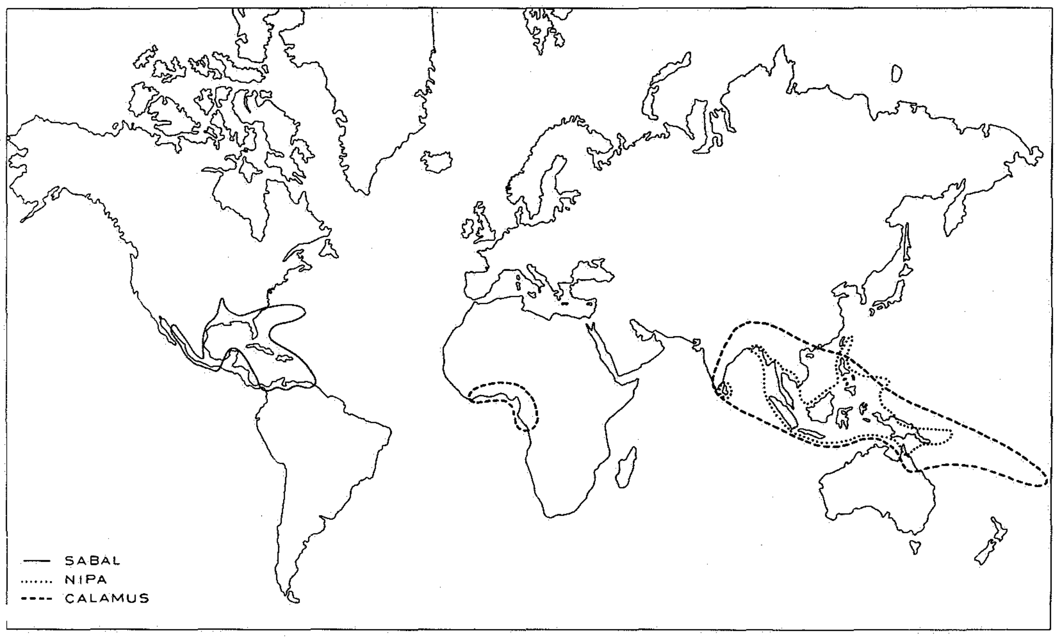

Fig. 4
Recent distribution of the palms Sabal, Nipa and Calamus.

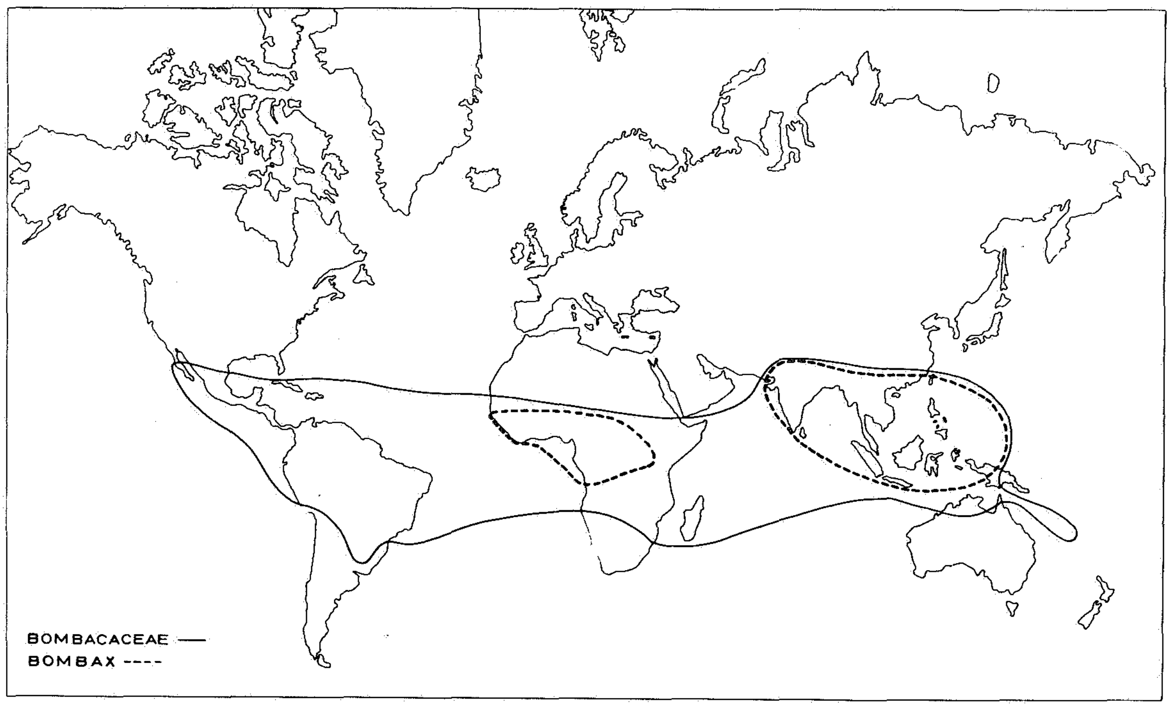

Fig. 5
Recent distribution of the family Bombacaceae *and the genus Bombax.*

Celastraceae (Microtropis), Nyssaceae (Nyssa), Restionaceae, Sapotaceae, Simaroubaceae, Taxodiaceae, Ulmaceae (Celtis).

With *Nipa* and *Calamus* already present in the lower Ypresian, other megatherm taxa are included in the so called "Paniselian" flora (E. ROCHE, 1980-82): *Alyxia*, tropical genus of *Apocynaceae* whose distribution area extends from tropical genus of North Australia, to New Caledonia and Polynesia and *Bombax*, genus with an intertropical distribution in western Africa and in Asia (Fig. 4 and 5). The latter genera are however less submitted to climate fluctuations than *Nipa* in spite of their intertropical tolerate greater temperature variations.

The association *Nipa-Acrostichum* lets us suppose that due to considerable rise in temperature, mangroves developed along the Atlantic coast of Europe at the low Eocene and that the continental flora was submitted to an extremely warm and wet climate. However, it is known that the extension of mangroves is principally due to the temperature of the marine waters where they grow. One must be careful, when taking their sole presence as a basis in drawing hasty conclusions on the climate of continental areas. Nevertheless the pressence of megatherm taxa in the continental "Paniselian" flora enables to put forward the following hypothesis. During a short period of the Eocene, exceptionnal climatic circonstances caused an extension of the tropical zone creating extremely hot and wet conditions which favoured the development of a dense vegetation (coastal swamp forests, evergreen forests in the lowlands, mixed forests in the highlands). This was a good protection of the substratum as proved by the low percentage of kaolinit present in the sedimentary basin during the Upper Ypresian (QUINIF et al., 1983).

If, for the Ypresian in general the climate seems to have been of the subtropical type, it could have been tropical during a given phase of "Paniselian", it cannot be compared to a strict intertropical climate because according to elements in nature today seasonal alternations cannot be excluded even if they were slight.

At the beginning of the Aalter Sand, the flora became mostly subtropical with the disappearence of the megatherm taxa *Nipa, Alyxia* and *Bombax.* The climate remained warm, but evolved into a dryer one. *Nipa* fruit were found in the Brussels Sands, younger than the Aalter Sand. According to F. STOCKMANS (1936), it is allochtonous material brought from the South by marine currents and not elements present in the flora of the Belgian basin during the Brusselian.

CONCLUSIONS

The palynological study of the Ypresian shows that sporopollinic markers and assemblages enable to establish biostratigraphic limits within this geological stage.

As the palynological assemblages of the Mont-Héribu Member, the Orchies Clay, the Roubaix Clay and, in the North of the Belgian Basin, of the Aalbeke Clay, are similar to those of the Upper Landenian, it is at the basis of the Kortemark Silt that the most largest change appears in the Kallo boring. In the Aalbeke-Kortrijk area, it already existed in the Upper part of the Aalbeke Clay, indicated by new species announcing the floristic evolution characteristic of the Upper Ypresian.

The change characterized by a wide extension of sporopollinic species, seems to announce a floristic transformation, even more pronounced in the Upper Ypresian. That sudden floristic change possibly reflected the paleographic overthrow at that time in the Paris Basin. Indeed, continental environments (corresponding to a hiatus in the sedimentation) developed in this basin, accompagned by a rapid expansion of the terrestrial vegetation to the Belgian basin. With the spreading of the vegetation to our countries a greater pollinic dispersion of pollen may have taken place, with a progression of the tropical conditions.

In the Merelbeke Clay, the Pittem Clay, the Vlierzele Sand and the Aalterbrugge Complex, the variations of the palynological associations enable to differenciate the sandy-clay lower part from the sandy upper part.

During the Ypresian, the subtropical flora characterizing the Landenian period progressively underwent modifications due to tropical influences proved by megatherm genera such as *Nipa, Calamus, Alyxia, Bombax...* The optimal expansion of these genera was due to a particulary warm and wet climate in the Belgian basin.

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PLATE 1

Fig. 1 : *Milfordia hungarica* W. KR et VANH. 1970.
Fig. 2 : *Milfordia incerta* W. KR. 1961.
Fig. 3-4 : *Diporites iszkaszentgyorgii* KDS 1965.
Fig. 5 : *Pompeckjoidaepollenites subhercynicus* W. KR. 1967.
Fig. 6 : *Interpollis supplingensis* W. KR. 1967.
Fig. 7 : *Nudopollis endangulatus* PF. 1953.
Fig. 8 : *Plicapollis pseudoexcelsus* W. KR. 1961.
Fig. 9 : *Triatriopollenites sibiricus* KDS. 1974.
Fig. 10-11 : *Triatriopollenites belgicus* ROCHE 1973.
Fig. 12 : *Triatriopollenites myricoïdes* TH. et PF. 1953.
Fig. 13-14 : *Triatriopollenites plicatus* TH. et PF. 1953.
Fig. 15-16 : *Caryapollenites circulus* W. KR. 1961).
Fig. 17 : *Caryapollenites praesimplex* W. KR. et YANH. 1977.
Fig. 18-19 : *Intratriporopollenites microreticulatus* MAI 1961.
Fig. 20 : *Intratriporopollenites pseudinstructus* MAI 1961.
Fig. 21 : *Bombacacidites egelnensis* W. KR. 1970.

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PLATE 1

Fig. 1 : *Milfordia hungarica* W. KR et VANH. 1970.
Fig. 2 : *Milfordia incerta* W. KR. 1961.
Fig. 3-4 : *Diporites iszkaszentgyorgii* KDS 1965.
Fig. 5 : *Pompeckjoidaepollenites subhercynicus* W. KR. 1967.
Fig. 6 : *Interpollis supplingensis* W. KR. 1967.
Fig. 7 : *Nudopollis endangulatus* PF. 1953.
Fig. 8 : *Plicapollis pseudoexcelsus* W. KR. 1961.
Fig. 9 : *Triatriopollenites sibiricus* KDS. 1974.
Fig. 10-11 : *Triatriopollenites belgicus* ROCHE 1973.
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Fig. 15-16 : *Caryapollenites circulus* W. KR. 1961).
Fig. 17 : *Caryapollenites praesimplex* W. KR. et YANH. 1977.
Fig. 18-19 : *Intratriporopollenites microreticulatus* MAI 1961.
Fig. 20 : *Intratriporopollenites pseudinstructus* MAI 1961.
Fig. 21 : *Bombacacidites egelnensis* W. KR. 1970.

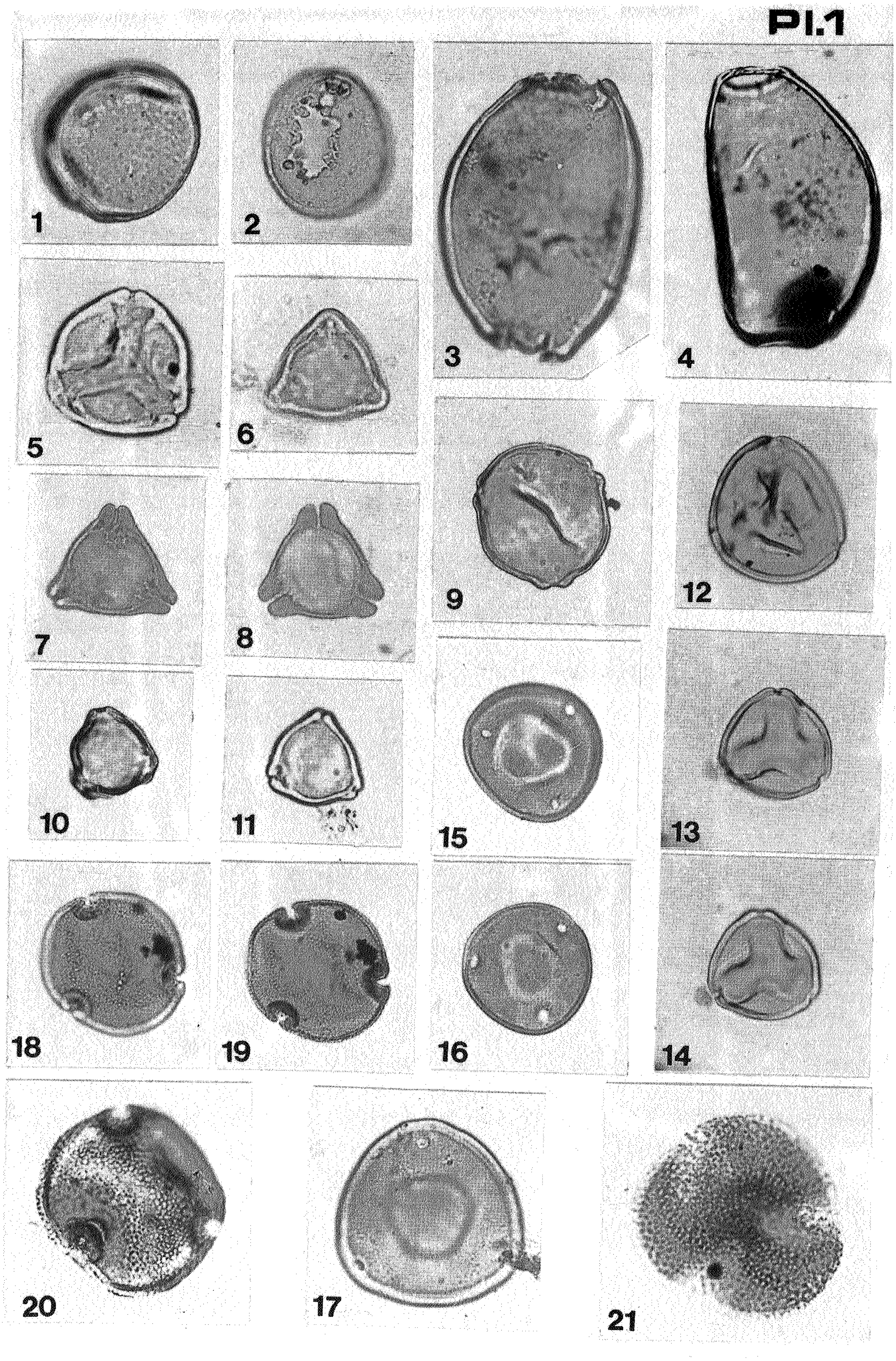
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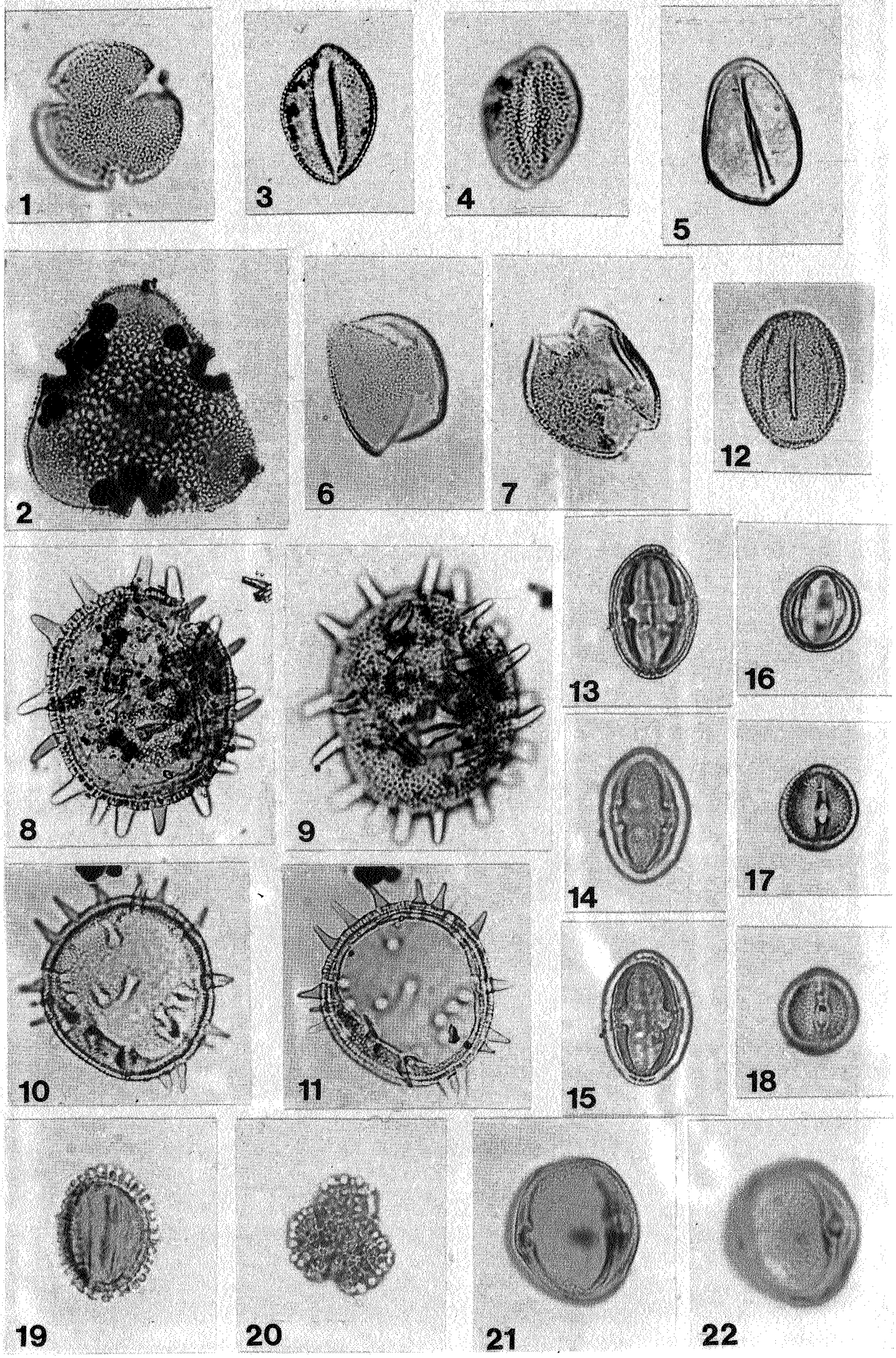
PLATE 2

Fig. 1 : *Bombacacidites europaeus* W. KR. 1970.
Fig. 2 : *Bombacacidites noremii* SALARD 1974.
Fig. 3-4 : *Monocolpopollenites parareolatus* W. KR. 1962.
Fig. 5 : *Monocolpopollenites tranquillus* PF. et TH. 1953.
Fig. 6-7 : *Dicolpopollis luteticus* GR.-CAV. 1976.
Fig. 8-9 : *Spinizonocolpites echinatus* MULLER 1968.
Fig. 10-11 : *Spinizonocolpites baculatus* MULLER 1968.
Fig. 12 : *Bacutricolpites Variabilis* ROCHE 1982.
Fig. 13-14-15 : *Scabratricolporites angki* ROCHE 1982.
Fig. 16-17-18 : *Retitricolporites crassiexinus* ROCHE 1982.
Fig. 19-20 : *Clavatricolporites iliacus* ROCHE et SCHULER 1976.
Fig. 21-22 : *Psilatricolporites kruschi* ROCHE et SCHULER 1976.

Pl. 2



S. A. G R A L E X

Capital : 640 millions

Exploitation de carrières

Production annuelle de granulats de toutes natures : 6 000 000 t

Concassés de porphyre	: Quenast et Lessines
Concassés de calcaire	: Mont-sur-Marchienne, Beez et Soignies
Concassés de grès	: Esneux
Graviers roulés et concassés	: Dilsen, Boorsem et Maasmechelen
Granulats légers Argex	: Kruibeke

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