# PALYNOLOGY AND PALYNOFACIES OF GURA ŞOIMULUI FORMATION FROM BISTRIŢA-RÂŞCA HALF-WINDOW (EASTERN CARPATHIANS, ROMANIA)

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**Abstract** Palynological and palynofacies data described in this paper come from analysis of Gura Şoimului Formation identified in Bistriţa-Râşca Half-window. Among the palynomorphs identified mention species of phytoplankton (*Operculodinium centrocarpum, Deflandrea* sp. a.o.) ferns (*Leiotriletes triangulatoides* Krutzsch 1962, *Laevigatosporites gracilis* Wilson – Webster 1946, *Baculatisporites nanus* (Wolff 1934) Krutzsch 1959), gymnosperms and angiosperms (*Inaperturopollenites concedipites* (Wodehouse 1933) Krutzsch 1971, *Pityosporites minutus* (Zaklinskaja 1957) Krutzsch 1971, *Monocolpopollenites tranquillus* (Potonié 1934) Thomson et Pflug 1953, *Engelhardtioidites microcoryphaeus* (Potonié 1931) Thomson et Thiergart ex Potonié 1960, *Myricipites bituitus* (Potonié 1931) Nagy 1969 a.o.). Mean Annual Temperature deducted on account of continental palynomorphs indicates a value of 18,6 °C. Palynofacies showed a predominance of continental phytoclasts (opaque and black particles, woody tissue, yellow-brown fragments) coming from a continental vegetation.

**Keywords**: Burdigalian, palynomorphs, palynofacies, palaeoenvironment, palaeoclimat.

## INTRODUCTION

Gura Şoimului Formation, characterized by a pelitic-arenitic facies with features of flysch, was separated and described by Stoica (1953). It marks the beginning of the aerobic sedimentation, following the bitumolite accumulation during the Upper Oligocene.

This formation is found in all half-windows of Vrancea Nappe, under that name, except being in Vrancea Half-window where is known as the "Goru Mişina Formation" (Săndulescu et al., 1962).

The area of sampling the analyzed rocks in this paper is between Suha Valley to the north and Tazlăul Sărat Valley in south (Bistriţa-Râşca Half-window).

The present paper provides an analysis of Lower Miocene vegetation - climatic evolution based on the interpretation of palynological data in the Bistriţa-Râşca Half-window using quantitative methods. Palynofacies analysis of samples from studied area was undertaken to determine the origin and depositional environment of organic matter in the sediments.

## BIOSTRATIGRAPHY

Calcareous nannoplankton identified in Gura Şoimului Formation shows that the lower limit of this formation belongs to the lower part of NN2 Biozone (Fig. 1). The middle part of this formation corresponding to NN2 Biozone and upper part belong at the end of NN2 Biozone and possibly the lower part of NN3 Biozone. This interpretation is consistent with the data of Dicea & Dicea (1980) and Ionesi & Mészáros (1995). The NN2 Biozone and the beginning of NN3 Biozone correspond the interval Early Burdigalian – the beginning of Upper Burdigalian.

## MATERIALS AND METHODS

Palynological association described in this paper comes from analysis of 11 samples preserved in Gura Şoimului Formation (Bistriţa-Râşca Half-window) (Fig. 1). Samples have been treated with HCl (37%) to remove the carbonate and HF (48%) to remove the silicate minerals. The separation of palynomorphs from the residue resulting from the chemical reaction above described was performed using $ZnCl_2$ with a density 2.00 $g/cm^3$ as heavy liquid with centrifugal action. Microscopic slide were made using glycerine jelly as a mounting medium. The visualization of the palynomophs was accomplished with a Leica DM1000 microscope, using the amplification of X100, X400.

The method used for palaeoclimatic estimations is „Coexistence Approach" (CA), described by Mosbrugger & Utescher (1997). Determination of the coexistence approach for all taxa, establish for the fossil flora their relative life conditions (NLR - Nearest Living Relative) and climate of tolerance (maximum and minim values), respecting variations of the climatic parameters (Mean annual temperature – MAT; Mean annual precipitation – MAP; Mean temperature of the warmest month – WMT and Mean temperature of the coldest month – CMT). Climatic parameters values were taken after PALAEOFLORA database (Utescher and Mosbrugger, 1990-2010).

Palynofacies analysis involves the identification of palynomorphs, plant debris and amorphous particles, their absolute and relative proportion, size spectra and preservation states (Combaz 1964, 1980). The most commonly used term to describe the Palynological Organic Matter (POM) contained in sedimentary rocks is kerogen. In this paper, three main groups of morphological constituents can be recognised within kerogen assemblages: phytoclasts, palynomorphs (sporomorph and phytoplankton) and Amorphous Organic Matter - AOM (Tyson 1993, 1995).

## RESULTS AND DISCUSSION

1. *Palynological data*. Gura Şoimului Formation was filed in an oxygenated environment occurred due to

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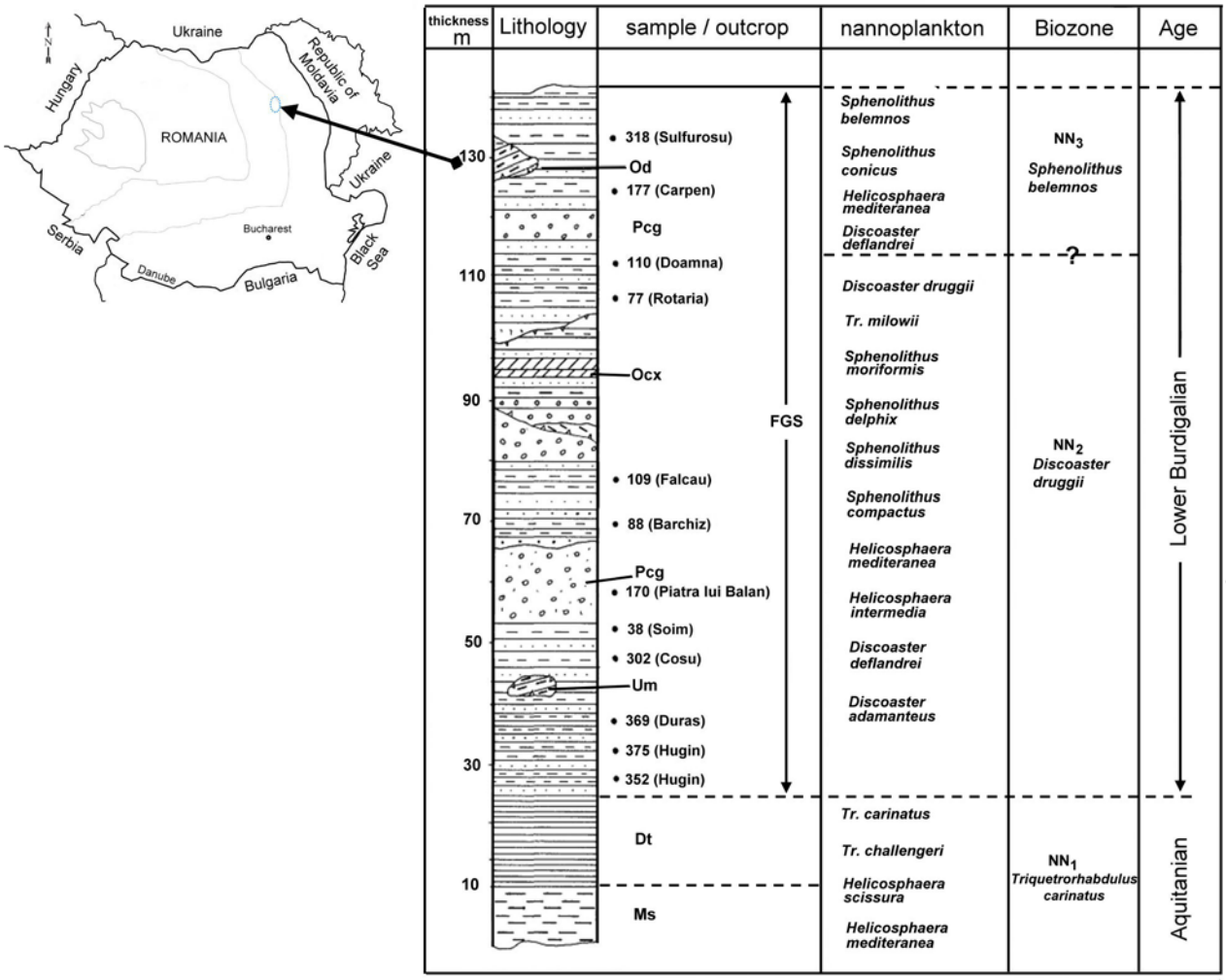


**Fig. 1** Lithostratigraphical column by deposits of Gura Şoimului Formation: Ms-Upper menilites; Dt - Upper dysodilic shale; FGS - Gura Şoimului Formation (Pcg-paraconglomerate, Om - olistolith of menilites, Od -olistolith of dysodilic shale; Ocx - olistolith with different type of rocks).

marine regression in the Eastern Carpathians which began in the late Oligocene. Some palynological data of this formation were presented by Stoicescu (2004) from Slănic-Oituz Half-window. The author notes the ferns are well represented in the palynological assemblage by *Hydrosporis* (abundant), *Baculatisporites* and *Laevigatosporites* genres.

Among Bryophyta are cited species as *Stereisporites megastereis* and *S. involutus*. The gymnosperms occur sporadically and are represented by Cycadale and various species of Pinaceae (*Pityosporites minutus, P. microinsignis* a.o.). Monocotyledonous angiosperms appear in a fairly large proportion (30%) and are represented by various species of *Palmae* (*Arecipites* div. sp., *Monocolpopollenites* div. sp.). Among dicotyledonous angiosperms are mentioned *Liquidambar, Carya, Alnus, Quercus,* Sapotaceae, *Engelhardia* genres which formed a forest along rivers or in higher areas, of hills. Palaeoenvironment revealed by vegetation described above indicate the existence of swamp zone in around which lived many ferns, some hilly areas in which to develop a mixed mesophytic forest and a mountain zone populated by various Pinaceae.

Palynological data obtained by us from Gura Şoimului Formation allows reconstruction the following palaeoenvironment:

- the innermost neritic setting is indicated by *Homotryblium* genre in analyzed samples, this taxon has a low frequency. Most common than genre above mentioned was identified *Operculodinium centrocarpum* from outer neritic setting. This taxa is generally reported as a cosmopolitan species, distributed within a very broad range: temperature of water (-2,1 to 29,6°C) and salinity (16,1 – 36,8 $^{0}/_{00}$) (Marret and Zonneveld, 2003).

- swamp area is demonstrated by the presence in palynological assemblage a numerous species of ferns as *Leiotriletes triangulatoides, Laevigatosporites* div. sp., *Baculatisporites nanus, Neogenisporis* sp., *Polypodiaceoisporites* sp. etc (Table 1). In the same area develop *Taxodium* (well represented in palynological assemblage), *Myrica, Sequoia* and palm trees.

- area of low and medium altitude in which to develop a riparian forest represented by *Engelhardia* and a mixed mesophytic forest with *Quercus* div. sp., *Carya, Betula, Castanopsis*.

- high altitude area was occupied by *Pinus* and *Abies* taxa.

**Table 1.** Taxonomical list of palynomorphs identified in the Gura Şoimului Formation (Bistriţa-Râşca Half-window).

| Taxa | P 38 | P 77 | P 88 | P 109 | P 110 | P 170 | P 177 | P 302 | P 318 | P 352 | P 375 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***PHYTOPLANCTON*** | | | | | | | | | | | |
| *Operculodinium centrocarpum* (Deflandre et Cookson 1955) Wall 1967 | 1 | 1 | | | | | | | | 1 | |
| *Deflandrea* sp. | | | | | | | 1 | | | 3 | |
| *Systematophora placacantha* (Deflandre et Cookson 1955) Davey et al. 1966 | | | | | | | | | 1 | | |
| *Homotryblium* sp. | | | | | | | | | 1 | | |
| *Tytthodiscus* sp. | | | | | | | | | | 3 | |
| *Dapsilidinium pseudocolligerum* (Stover 1977) Bujak et al. 1980 | | | | | | | | | | 1 | |
| *Pterospermella* sp. | | | | | | | | | | 1 | |
| *Algae* | | | | | | | | | | 3 | 1 |
| ***PTERIDOPHYTA*** | | | | | | | | | | | |
| *Leiotriletes triangulatoides* Krutzsch 1962 | | | | | | | | | | | 1 |
| *Leiotriletes* sp. | | | 1 | | | | | | 1 | 2 | |
| *Laevigatosporites nutidus* (Mamczar 1960) subsp. *nutidus* (Krutzsch 1967) | | | | | | | | | | 1 | |
| *Laevigatosporites haardti* (Potonié et Ven. 1934) Thomson et Pflug, 1953 subsp. *haardti* Krutzsch 1967 | | | | | | | | 2 | | | 1 |
| *Laevigatosporites gracilis* Wilson - Webster 1946 | | | | | | 1 | 1 | | | 2 | |
| *Verrucatosporites favus* (Potonié 1931) subsp. *favus* Krutzsch 1967 | | | | | | | | | | 1 | |
| *Verrucatosporites* sp. | | | | | | | | | | 2 | |
| *Toripuctisporis* cf. *granuloides* Krutzsch 1959 | | | | | | | | | | 1 | |
| *Baculatisporites nanus* (Wolff 1934) Krutzsch 1959 | | | | | | | | | | 1 | |
| *Baculatisporites* sp. | | 1 | 1 | | | | | | | | |
| *Neogenisporis* sp. | | | 1 | | | | | 3 | | 1 | |
| *Toroisporis* sp. | | | | | | | | | | 2 | |
| *Extrapunctatosporis* sp. | | | | | | | | | 1 | | |
| *Polypodiaceoisporites* sp. | | | | | | | | | | 3 | 1 |
| *Polypodiidites secundus* (Potonié 1934) Krutzsch 1963 | | | | | | | | 1 | | | |
| *Stereisporites* sp. | 1 | | | | | | | 1 | | 2 | |
| reworked spores | | | | | 11 | | | | | | |
| ***GYMNOSPERMATOPHYTA*** | | | | | | | | | | | |
| *Inaperturopollenites* sp. | 1 | | 1 | | | | 1 | | 1 | 6 | 2 |
| *Inaperturopollenites concedipites* (Wodehouse 1933) Krutzsch 1971 | | | 1 | | | | | | | 1 | |
| *Podocarpidites libellus* (Potonié 1931) Krutzsch 1971 | 1 | | | | | | | | | | |
| *Pityosporites* sp. | | | 4 | 4 | | 1 | | 4 | 4 | 19 | 2 |
| *Pityosporites minutus* (Zaklinskaja 1957) Krutzsch 1971 | | | 1 | | | 1 | | | | | |
| *Pityosporites microalatus* (Potonié 1931) Thomson et Pflug 1953 | | | 1 | 1 | | | | | | 4 | |
| *Pityosporites labdacus* (Potonié 1931) Thomson et Pflug 1953 | | | | | | | | | | 2 | |
| *Pityosporites alatus* (Potonié 1931) Thomson et Pflug 1953 | | | | | | | | | | 1 | |
| *Abiespollenites* sp. | | | | | | | | | 1 | | |
| *Sciadopityspollenites* sp. | | | | | | | | 1 | | 1 | |
| *Sequoiapollenites* sp. | | | | | | | | | 1 | | |
| ***ANGIOSPERMATOPHYTA. MONOCOTYLEDONATAE*** | | | | | | | | | | | |
| *Graminidites* sp. | | | | | | 1 | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Monocolpopollenites tranquillus* (Potonié 1934) Thomson et Pflug 1953 | | | | | | | | | | 1 | |
| ***ANGIOSPERMATOPHYTA. DICOTYLEDONATAE*** | | | | | | | | | | | |
| *Engelhardtioidites microcoryphaeus* (Potonié 1931) Thomson et Thiergart ex POTONIÉ 1960 | 1 | | | 2 | | | 2 | | 1 | 15 | 3 |
| *Myricipites bituitus* (Potonié 1931) NAGY 1969 | | | | | | | | | 1 | 1 | |
| *Myricipites* sp. | 1 | | 1 | | | 1 | | 2 | 2 | 2 | 1 |
| *Quercopollenites granulatus* NAGY 1969 | | | | | | | | | | 1 | |
| *Quercopollenites* sp. | | | 4 | | | | | 1 | | 1 | |
| *Tricolporopollenites henrici* (Potonié 1931) Krutzsch 1960 | | | | | | | | | | 1 | |
| *Tricolporopollenites microhenrici* (Potonié 1930) Krutzsch 1960 | | | 1 | 1 | | | | | | 4 | |
| *Tricolporopollenites cingulum* (Potonié 1931) Thomson et Pflug 1953 subsp. *pusillus* (POTONIE 1934) Thomson et Pflug 1953 | | | | | | | | | | 1 | 1 |
| *Tricolporopollenites* sp. | | | | 2 | | 1 | | | 2 | 3 | |
| *Tricolpopollenites liblarensis* (Thomson 190) Thomson et Pflug 1953 subsp. *liblarensis* | | | | | | 1 | | | | 1 | 1 |
| *Betulaepollenites* sp. | | | | | | | | | 1 | | |
| *Compositoipollenites* sp. | | | | | | | | | | 1 | |
| *Lonicerapollis* sp. | | | | | | | | | | 1 | |
| *Caryapollenites* sp. | | | | | | | | | | 1 | |
| *Magnolipollis* sp. | | | | | | | | | | | 1 |

Palaeoclimatic parameters deducted by the „Coexistence approach" method based on palynological assemblage are:

- MAT: min. 15,6°C *Engelhardia microcoryphaeus*
  max. 21,7°C *Polypodiaceoisporites* sp.
- MAP: min. 823 mm *Engelhardia microcoryphaeus*
  max. 1520 mm *Inaperturopollenites concedipites* and *Sequoiapollenites* sp.
- CMT: min. 5°C *Engelhardia microcoryphaeus*
  max. 14,8°C *Polypodiaceoisporites* sp.
- WMT: min. 24,7°C *Engelhardia microcoryphaeus*
  max. 28,2°C *Polypodiaceoisporites* sp.

Palaeoclimatic data reconstructed, presented above, indicate a warm-temperate climate in the Lower Burdigalian from eastern part of Eastern Carpathians.

2. *Palynofacies analysis*. Visual evaluation of the relative abundances of palynological organic matter was carried out by reference to semiquantitative patterns.

2.1. *Percentage of phytoclasts* (of total kerogens)

In the 11 samples analyzed, the percentage of phytoclasts is between 95 - 98% from the total particles of kerogen viewed under the microscope. Of these, oxidized or carbonized woody tissue (opaque and black particles) are found in high percentage, which are included in inertinitic maceral group (mostly fusinite and inertinite) (Ercegovac and Kostić, 2006). From phytoclasts category found in Gura Şoimului Formation mention also woody tissue (xylem secondary) (Fig. 5B) and yellow-brown fragments from continental vegetation. Generally, large amounts of phytoclast particles are deposited by rivers in estuarine, deltaic and lagoon environments (Carvalho et al., 2006).

2.2. *Percentage of palynomorphs* (of total kerogens)

Palynomorphs identified in the 11 samples analyzed are generally few, these having a frequency of approximately 1 – 2%. This group contains spores and pollen grains (continental bodies) and aquatic algae (Table 1). The highest number of autochthonous palynomorphs was identified in P352. In P110 only reworked exemplars of spores was found, sometimes appearing in agglomeration (Fig. 2O). These allochthonous species have been mentioned from Silurian deposits of Podolia (Zhvanets locality, on the left side of the Dnestr River) (Olaru et al., 2010).

Palaeoenvironment and palaeoclimatical interpretations based on palynological assemblage were presented previously.

2.3. *Percentage of AOM* (of total kerogen)

The amount of AOM in the analyzed samples is small, this not exceeding 1 – 2% from the total organic matter. The low content of AOM is due to the oxic conditions of sedimentation to this formation.

## CONCLUSION

Palynological and palynofacial analysis achieved from the Gura Şoimului Formation revealed the following conclusions:

- palynomorphs identified belonging aquatic and terrestrial environment. Their presence indicates an inner-outer neritic setting of the sedimentary basin, where lived taxa such as *Homotryblium* and *Operculodinium*. Swamp area is argumented by the presence of ferns (*Polypodiaceae*, *Osmunda*), gymnosperms (*Taxodium* and *Sequoia*) and angiosperms (*Myrica*). Riparian assemblage is well represented by *Engelhardia* genus and

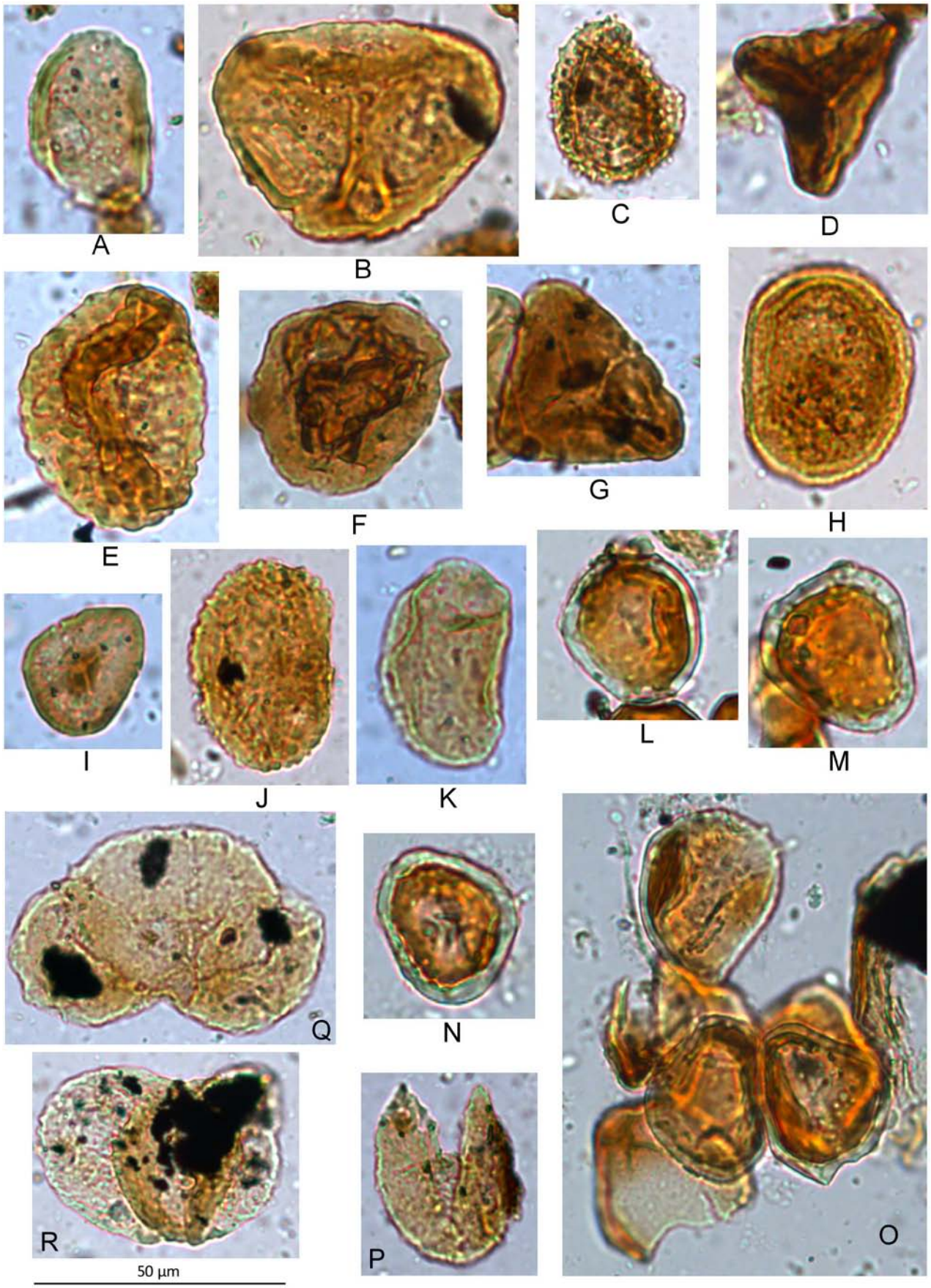


**Fig. 2 – A** *Laevigatosporites gracilis* Wilson - Webster 1946**. B** *Toroisporis* sp. **C** *Baculatisporites nanus* (Wolff 1934) Krutzsch 1959. **D** *Neogenisporis* sp. **E** *Verrucatosporites favus* (Potonié 1931) subsp. *favus* Krutzsch 1967. **F** *Polypodiaceoisporites* sp. **G** *Leiotriletes triangulatoides* Krutzsch 1962. **H** *Extrapunctatosporis* sp. **I** *Stereisporites* sp. **J** *Polypodiidites secundus* (Potonié 1934) Krutzsch 1963. **K** *Laevigatosporites haardti* (Potonié et Ven. 1934) Thomson et Pflug, 1953 subsp. *haardti* Krutzsch 1967. **L - O** reworked spores (Silurian) *Cymbosporites* sp. **P** *Inaperturopollenites concedipites* (Wodehouse 1933) Krutzsch 1971. **Q** *Pityosporites labdacus* (Potonié 1931) Thomson et Pflug 1953. **R** *Pityosporites microalatus* (Potonié 1931) Thomson et Pflug 1953.

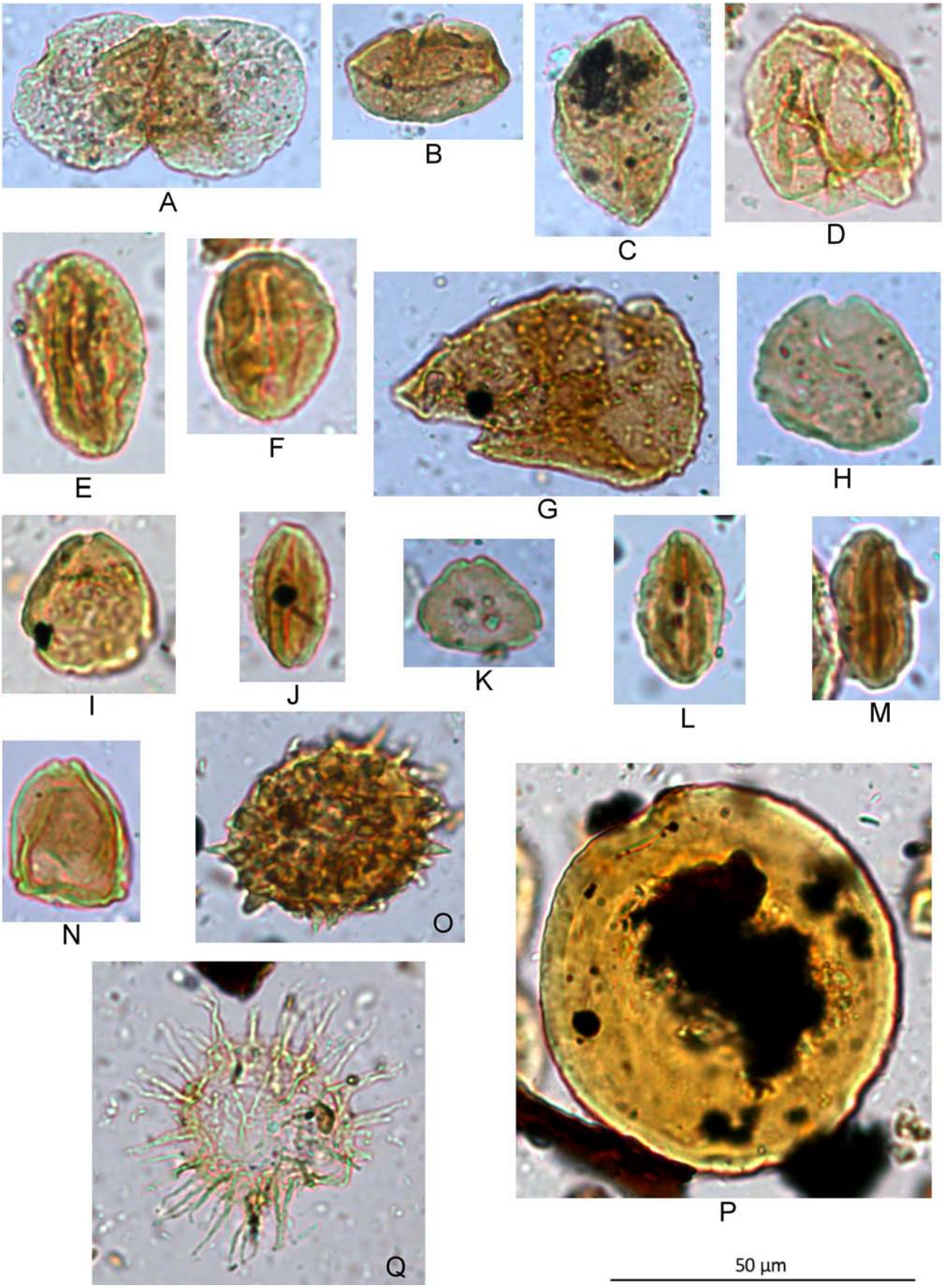


**Fig. 3** - **A** *Podocarpidites libellus* (Potonié 1931) Krutzsch 1971. **B** *Sequoiapollenites* sp. **C** *Monocolpopollenites tranquillus* (Potonié 1934) Thomson et Pflug 1953. **D** *Graminidites* sp. **E**, **F** *Quercopollenites* sp. **G** *Lonicerapollis* sp. **H** *Myricipites* sp. **I** *Myricipites bituitus* (Potonié 1931) NAGY 1969. **J** *Tricolpopollenites liblarensis* (Thomson 1950) Thomson et Pflug 1953 subsp. *Liblarensis*. **K** *Engelhardtioidites microcoryphaeus* (Potonié 1931) Thomson et Thiergart ex POTONIÉ 1960. **L** *Tricolporopollenites microhenrici* (Potonié 1930) Krutzsch 1960. **M** *Tricolporopollenites cingulum* (Potonié 1931) Thomson et Pflug 1953 subsp. *pusillus* (POTONIE 1934) Thomson et Pflug 1953. **N** *Betulaepollenites* sp. **O** *Compositoipollenites* sp. **P** *Tytthodiscus* sp. **Q** *Dapsilidinium pseudocolligerum* (Stover 1977) Bujak et al. 1980.

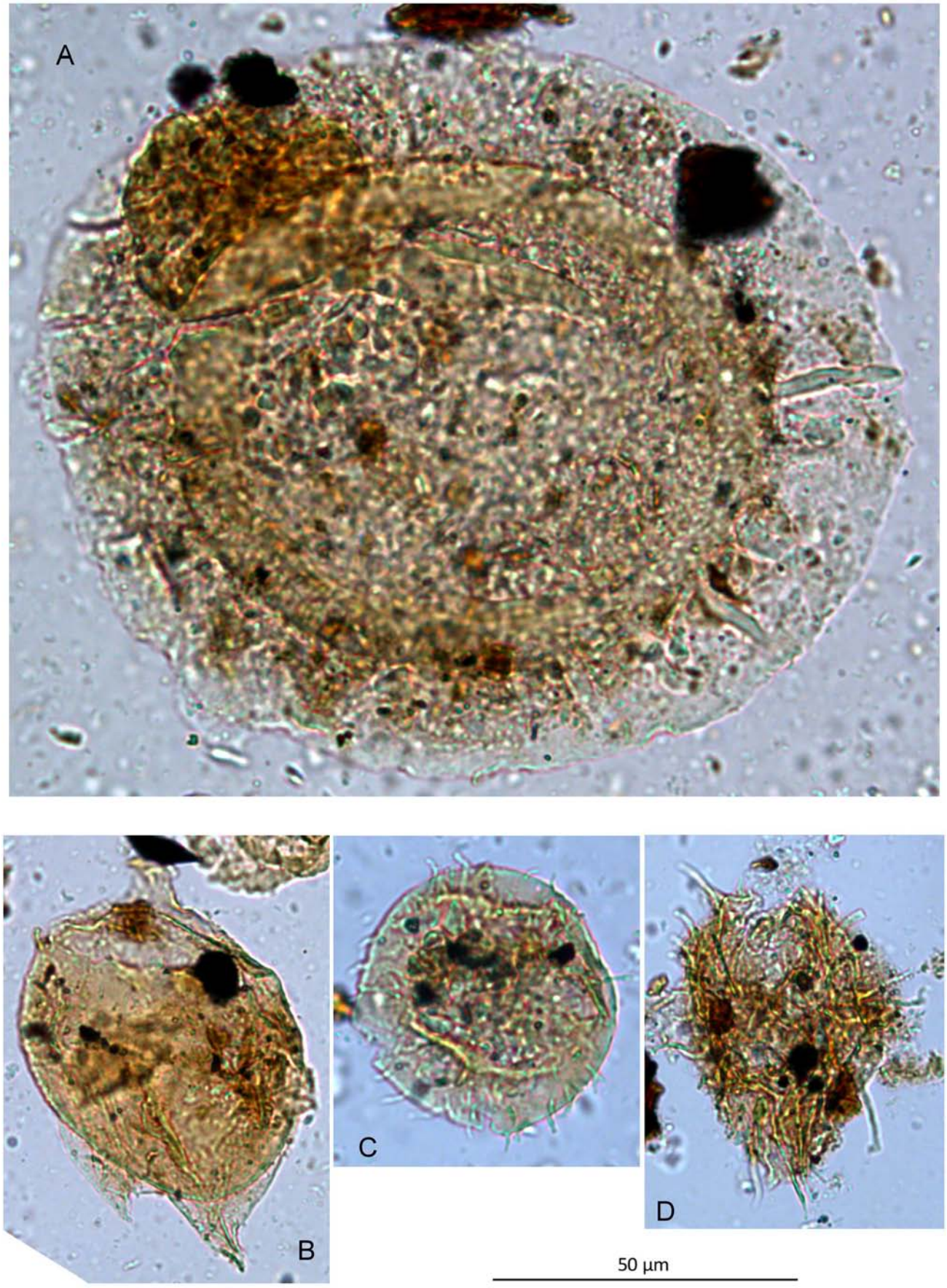


**Fig. 4 - A** *Pterospermella* sp. **B** *Deflandrea* sp. **C** *Operculodinium centrocarpum* (Deflandre et Cookson 1955) Wall 1967. **D** *Systematophora placacantha* (Deflandre et Cookson 1955) Davey et al. 1966.

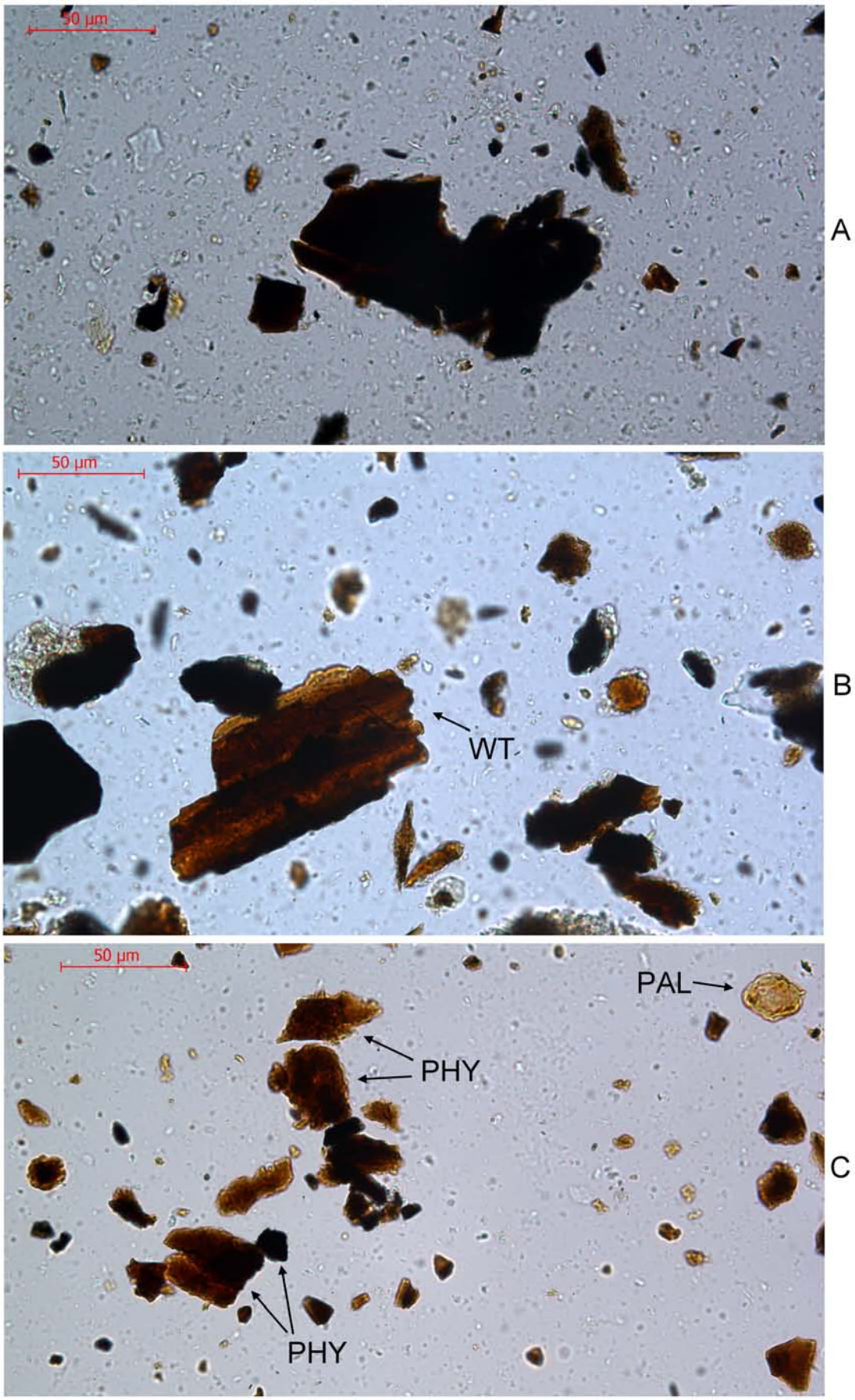


**Fig. 5 - A** In palynological slide under natural light, opaque and black particles (oxidized or carbonized woody tissue) indicating a estuarine and deltaic environments. **B** Structured woody tissue (WT) derived from continental vegetation. **C** Mixed assemblage of brown-black phytoclasts (PHY) and palynomorphs (PAL) (continental organic matter).

mixed mesophytic forest was populated by taxa such as *Quercus* div. sp., *Betula*, *Carya*.

- climatic parameters during the sedimentation of this formation are following: Mean Annual Temperature 15,6 – 21,7°C; Mean Annual Precipitations 823 – 1520 mm; Mean Temperature of the Coldest Month 5 – 14,8°C and Mean Temperature of the Warmest Month 24,7 – 28,2°C.

- palynofacies analysis showed 95-98% to continental phytoclasts from total of kerogene extracted from the rock. This type of palynofacies, abundant in organic particles with continental origin, indicates an environment of estuary, delta or lagoon.

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