ACTA PALAEONTOLOGICA ROMANIAE V. 2 (1999), P. 361-368

PALEOCLIMATIC AND ENVIRONMENTAL CONDITIONS DURING GENESIS OF EVAPORITIC FORMATION FROM TURDA-CHEIA AREA (WESTERN TRANSYLVANIAN BASIN, ROMANIA) BASED ON PALYNOLOGICAL INVESTIGATIONS

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Abstract. On the western border of the Transylvanian Basin, on a relatively restricted area, the equivalent of the main Middle Badenian salt deposits is represented by evaporitic-sulfatic facies. Several samples of salt and gypsum from the Turda-Cheia area were analysed from a palynological point of view.The identified microflora from these evaporites is well preserved and significant as quantity and quality are concerned. The investigation of this microflora allowed the identification of an important number of species (100 taxa) which document the paleoclimatic and environmental conditions during genesis of the evaporitic deposits.

Keywords: Palynology, Middle Badenian, Transylvanian Basin, evaporites.

GEOLOGICAL SETTING

Turda-Cheia area is located on the western border of the Transylvanian Depression (Fig.1).

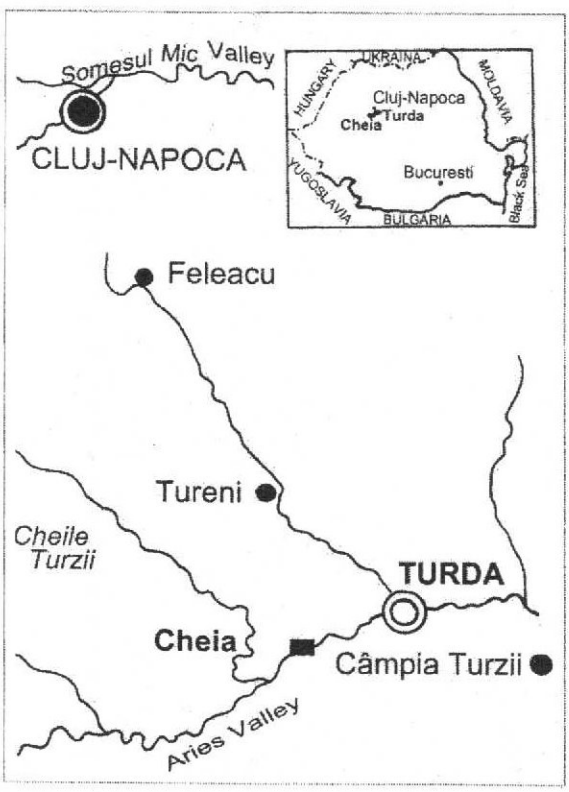

Figure 1 - Location of the studied area

The Neogene sedimentary formations consist of Badenian, Sarmatian and Pannonian deposits just like on the entire western basin border.

Within the Badenian deposits, salt and gypsum make up the evaporitic formation from this area.

The gypsum deposits outcrop on a relatively restricted area. These deposits were separated as Cheia Formation (Filipescu, 1996).

The salt occurs in diapiric structures, being located in the eastern part of the basin border (Filipescu, 1996). In this area it is associated with the Măhăceni – Ploscoş anticline and belongs to the Ocna Dejului Formation (Mészáros, 1991).

The Cheia Formation is an equivalent of the Ocna Dejului Formation (Mészáros, 1991) defined for the deeper salt facies.

PALYNOLOGICAL APPROACH

Ten samples of salt with clayey material were collected from the shaft – Franz Josef, Rudolf and Ghizela chambers in theTurda mine.

The sampling points are located at two distinctive stratigraphical levels: samples labeled 4, 5, 6, 7, 8, 9, 19 and 20 belong to the upper level situated about 26 m under Sarmatian marls; samples labeled 7' and 17 belong to the lower lever situated about 65 m below the previously mentioned marls level. The extraction of palynological material was done after salt dissolution and treatment of the remaining clayey samples with $ZnCl_2$ (d = 2).

The preservation of the palynological material in the above mentioned samples is less homogeneous.

In some of them (samples labeled 6, 9, 17) the sporo-pollinic material is exceptionally preserved.

It is worth mentioning that certain pollen-spore grains are impregnated with bituminous material that overprints a peculiar character to the fossilization process. It is possible that *Botryococcus* colonies have genetical links with these bitumens.

In some of the samples with bituminous material, the fossilization process led to the "mummification" of many pollen grains thus preserving the specific morpho-structural features but decreasing the grain size.

This "mummification" with loss in the size of polleno-spores was also pointed out for polleno-spores from Oligocene amber in Romania (Petrescu et al., 1989).

The study of 38 microscopic slides allowed the identification of 100 taxa presented in table 1.

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Table 1 - List of pollen-spores taxa identified in the evaporitic formation from Turda-Cheia area and their frequency.

TAXA	FREQUENCY
CHLOROPHYTA	
1. *Botryococcus brouni* Kutz. 1949	•
PTERIDOPHYTA. FILICOPSIDA	
1. *Leiotriletes maxoides maxoides* asp. *triplan* W. Kr. 1962	•
2. *Leiotriletes* gr. *maxoides* W. Kr. 1962	•
3. *Leiotriletes wolffi* W. Kr. 1962	•
4. *Toroiosporis* (T.) *lusaticus* W. Kr. 1962	•
5. *Foveotriletes verrucatoides* W. Kr. 1962	•
6. *Laevigatisporites haardti* (Pot. et Ven. 1934) Th. et Pf. 1953	••
7. *Laevigatisporites gracilis* Wilson et Webster 1946	•
8. *Polypodiidites secundus parasecundus* W. Kr. 1959	•
9. *Verrucatosporites alienus* (Pot. 1931) Th. et Pf. 1953	•
10. *Verrucatosporites favus* (Pot. 1931) Th. et Pf. 1953	•
11. *Verrucatosporites balticus* (W. Kr. 1962) W. Kr. 1967 *major* W. Kr. 1967	•
12. *Verrucatosporites* sp.	•
13. *Hydrosporis azollaensis* W. Kr. 1962	•
14. *Polypodiaceoisporites cyclocingulatus* W. Kr. 1967	•
15. *Polypodiaceoisporites* gr. *gracillimus* Nagy 1963	•
16. *Polypodiaceoisporites lusaticus* W. Kr. 1967	•
17. *Polypodiaceoisporites pulchellus* Nagy 1963	•
GYMNOSPERMATOPHYTA. CONIFEROPSIDA	
1. *Abiespollenites absolutus* Thg. 1937	••
2. *Abiespollenites cedroides* (Thomson 1953) W. Kr. 1971	•••
3. *Abiespollenites dubius* (Chlonova 1960) W. Kr. 1971	•
4. *Abiespollenites latisaccatus* (Trevisan 1967) W. Kr. 1971	••
5. *Abiespollenites crassus* Nagy 1969	•
6. *Pityosporites microalatus* (Pot. 1931) Th. et Pf. 1953	•••
7. *Pityosporites alatus* (Pot. 1931) Th. et Pf. 1953	•
8. *Pityosporites pacltovae* W. Kr. 1971	•
9. *Pityosporites cedrisaciformis* W. Kr. 1971	•
10. *Pityosporites insignis* (Naum ex. Bolch. 1953) W. Kr. 1971	••
11. *Pityosporites macroinsignis* W. Kr. 1971	•
12. *Pityosporites labdacus* (Pot. 1931) Th. et Pf. 1953	•••
13. *Pityosporites scopulipites* (Wdh. 1933) W. Kr. 1971	•
14. *Pityosporites pristinipollinius* (Trav. 1955) W. Kr. 1971	•
15. *Piceapollis praemarianus* W. Kr. 1971	•
16. *Piceapollis tobolicus* (Panova 1966) W. Kr. 1971	•
17. *Piceapollis sacculiferoides* W. Kr. 1971	•
18. *Cedripites minutus* (Stelmak 1960) W. Kr. 1971	•
19. *Cedripites lusaticus* W. Kr. 1971	••
20. *Cedripites miocaenicus* W. Kr. 1971	•
21. *Cedripites deodaraesimilis* (Nagy 1969) Nagy 1985	•
22. *Cedripites hidasensis* Nagy 1885	•
23. *Podocarpidites libellus* (Pot. 1931) W. Kr.1971	•
24. *Podocarpidites podocarpoides* (Thg. 1958) W. Kr. 1971	•
25. *Zonalapollenites igniculus* (Pot. 1931) Th. et Pf. 1953	•
26. *Zonalapollenites maximus* (Raatz 1937) W. Kr. 1971	•
27. *Sciadopityspollenites serratus* (Pot. et Ven. 1934) Thg. 1937	•
28. *Sciadopityspollenites verticillatiformis* (Zauer 1960) W. Kr. 1971	•
29. *Cupressacites insulipapillatus* (Trevisan 1967) W. Kr. 1971	•
30. *Cupressacites bockwitzensis* W. Kr. 1971	•
31. *Inaperturopollenites concedipites* (Wodeh. 1933) W. Kr. 1971	•
32. *Inaperturopollenites verrupapillatus* Trevisan 1967	•
33. *Sequoiapollenites polyformosus* Thg. 1937	••
34. *Sequoiapollenites gracilis* W. Kr. 1971	••
35. *Sequoiapollenites megaligulus* W. Kr. 1971	•
ANGIOSPERMATOPHYTA. MONOCOTYLEDONATAE	
1. *Graminidites subtiliglobosus* (Trevisan 1967) W. Kr. 1970	•
2. *Sparganiaceaepollenites polygonalis* Thg. 1937	•
3. *Monocolpopollenites tranquillus* (Pot 1934) Th. et Pf. 1953	•
4. *Monocolpopollenites* n. sp.	•
5. *Arecipites convexus* (Thg. 1937) W. Kr. 1970	•
6. *Arecipites trachycarpoides* Nagy 1969	•
7. *Dicolpopollis kuckeli* Pfanzl. *1956*	•

Table 1 (continued)

ANGIOSPERMATOPHYTA. DICOTYLEDONATAE	
1. *Slowakipollis cechowici* (Pacltova 1958) W. Kr. 1962	•
2. *Slowakipollis elaeagnoides* W. Kr. 1962	•
3. *Triatriopollenites myricoides* (Kremp 1950) Th. et Pf. 1953	•••
4. *Triatriopollenites bituitus* (Pot. 1931) Th. et Pf. 1953	•
5. *Triatriopollenites rurensis* Th. et Pf. 1953	•
6. *Engelhardtioidites microcoryphaeus* (Pot. 1931) Thom. et Thg. ex Pot. 1960	•
7. *Momipites punctatus* (Pot. 1931) Nagy 1969	••
8. *Platycaryapollenites miocaenicus* Nagy 1969	•
9. *Plicatopollis plicatus* (Pot. 1931) W. Kr. 1962	•
10. *Caryapollenites simplex* (Pot. 1931) W. Kr. 1960	•••
11. *Pterocaryapollnites stellatus* (Pot. 1931) Thg. 1937	•••
12. *Multiporopollenites maculosus* (Pot. 1931) Th. et Pf. 1953	•
13. *Ulmipollenites undulosus* Wolff 1934	••
14. *Zelkovaepollenites thiergarti* Nagy 1969	•
15. *Trivestibulopollenites betuloides* Pflug 1953	•••
16. *Alnipollenites verus* (Pot. 1931) Pot. 1934	•••
17. *Carpinipites carpinoides* (Pf. 1953) Nagy 1985	••
18. *Intratriporopollenites insculptus* Mai 1961	•
19. *Intratriporopollenites instructus* (Pot. 1931) Th. et Pf. 1953	••
20. *Porocolpopollenites vestibulum* (Pot. 1931) Th. et Pf. 1953	•
21. *Periporopollenites stigmosus* (Pot. 1931) Th. et Pf. 1953	••
22. *Chenopodipollis multiplex* (Weyl. et Pf. 1957) W. Kr. 1966	•
23. *Eucommiopollis eucommi* (Planderova 1990) n. comb.	••
24. *Tricolpopollenites liblarensis* (Th. 1950) Th. et Pf. 1953	••
25. *Tricolporopollenites microhenrici* (Pot. 1930) W. Kr. 1960	••
26. *Tricolporopollenites cingulum* (Pot. 1931) Th. et Pf. 1953	•••
27. *Tricolporopollenites pseudocingulum* (Pot. 1931) Th. et Pf. 1953	•
28. *Tricolporopollenites marcodurensis* Pf. et Th. 1953	•
29. *Araliaceoispollenites edmundi* (R. Pot. 1931) R. Pot. 1953	••
30. *Nyssapollenites kruschi* (Pot. 1931) Nagy 1969	••
31. *Faguspollenites verus* Raatz 1937	•
32. *Cyrillaceaepollenites exactus* (Pot. 1931) R. Pot. 1960	••
33. *Ilexpollenites iliacus* (Pot. 1931) Thg. 1937	•
34. *Ilexpollenites margaritatus* (Pot. 1931) Pot. 1953	•
35. *Caprifoliipites andreansky* Nagy 1969	••
36. *Caprifoliipites gracilis* Nagy 1969	••
37. *Caprifoliipites sambucoides* Nagy 1969	•
38. *Reevesiapollis triangulus* (Mamczar 1960) W. Kr. 1970	•
39. *Myrtaceidites* sp.	•
40. *Tetracolporopollenites obscurus* Pf. et Th. 1953	•
41. *Ericipites baculatus* Nagy 1969	•••
42. *Ericipites callidus* (Pot. 1931) W. Kr. 1970	••
43. *Ericipites ericius* (Pot. 1931) Pot. 1960	••

Frequency: ••• - frequent (10 - 20 grains); •• - rare (3 - 9 grains); • - very rare (1 - 2 grains); species determinated after Krutzsch (1962, 1963, 1967, 1970, 1971) and Nagy (1985)

Algae (Chlorophyta) are represented by colonies of *Botryococcus* (*Botryococcus braunii* (Pl. I, Fig. 1). The sporadic incidence in some samples reveals that they were transported into the basin by watercourses from the surroundings of the sedimentary basin.

Ferns, even if they have a low frequency (little more than 2%) show an important qualitative diversity. Forms of *Schizeaceae* (*Leiotriletes maxoides*) are present but the *Polypodiaceae* (*Laevigatisporites haardti* (Pl. I, Fig. 2), *Verrucatosporites alienus* (Pl. I, Fig. 3), *Verrucatosporites favus* (Pl. I, Fig. 4), *Polypodiaceoisporites cyclocingulatus* (Pl. I, Fig. 6), etc.) prevail. The other forms with subordinate frequency in the spectrum are *Toroiosporis* (T.) *lusaticus* (Pl. I, Fig. 5), *Foveotriletes verrucatoides* (Pl. I, Fig. 8).

Sporadically, water ferns (*Hydrosporis azollaensis* (Pl. I, Fig. 7)) could be noticed, transported into the sedimentary basin by the seasonal high floods.

Conifers (about 35%) are represented by *Taxodiaceae* + *Cupressaceae* (about 3%) (*Sciadopityspollenites verticillatiformis* (Pl. I, Fig. 9), *Sequoiapollenites polyformosus* (Pl. I, Fig. 11), *Sequoiapollenites megaligulus* (Pl. I, Fig. 12), *Cupressacites bockwitzensis* (Pl. I, Fig. 13), etc.) and mainly by *Pinaceae* (about 32%) (Fig.2).

The pollen of *Podocarpaceae* (*Podocarpidites libellus* (Pl. I, Fig. 10)) occurs only sporadically.

The trees belonging to *Cupressaceae* and *Sequoia* probably preferred sunnier environments, located at altitudes, from inside the land.

The *Pinaceae* family with an extraordinary diversity, is represented by a rich variety of *Abies*, *Cedrus* and *Pinus*. Most of them proceed from alpine forest of warm temperate (especially *Cedrus*) to temperate (*Picea*, *Tsuga*) climate. Among the representative species of this family are: *Abiespollenites cedroides* (Pl. II, Fig. 2,3), *Abiespollenites latisaccatus* (Pl. II, Fig. 8), *Abiespollenites absolutus* (Pl. II, Fig. 9), *Abiespollenites crassus* (Pl. I, Fig. 16), *Pityosporites microalatus* (Pl. II, Fig. 4), *Pityosporites labdacus* (Pl. II, Fig. 5),

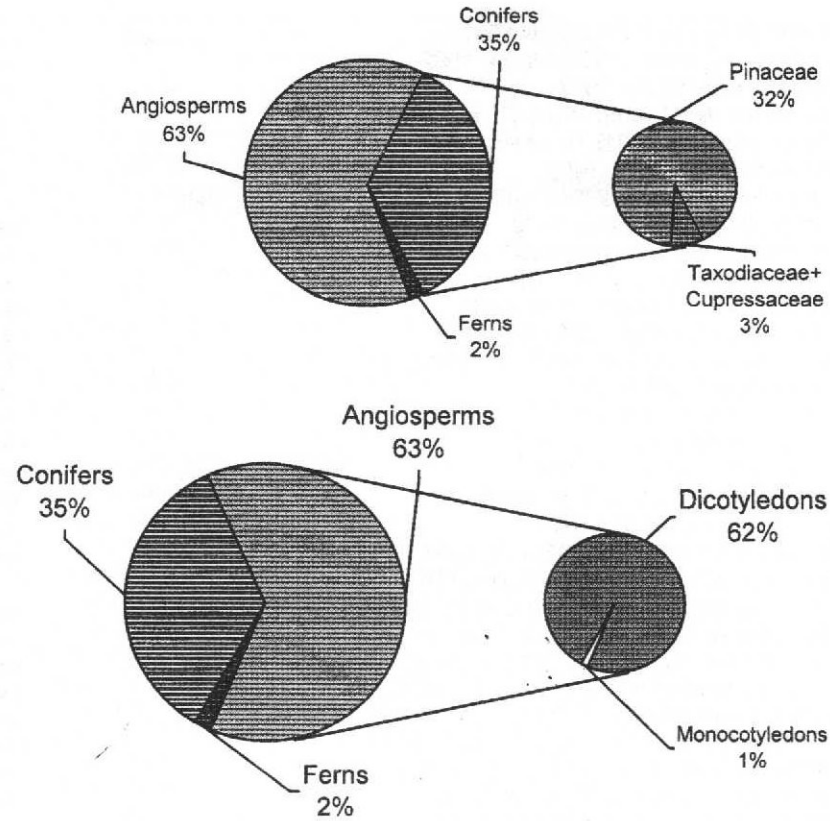

Fig. 2. The percentage diagrams of the most important botanical groups (samples 17)

Pityosporites cedrisaciformis (Pl. I, Fig. 15), *Pityosporites pacltovae* (Pl. II, Fig. 1), *Cedripites lusaticus* (Pl. II, Fig. 6), *Cedripites hidasensis* (Pl. II, Fig. 7), *Zonalapollenites igniculus* (Pl. I, Fig. 14).

Monocotyledonous angiosperms are scarce (less than 1%) and are represented mainly by monocolpate pollen of palm trees (*Monocolpo-pollenites tranquillus* (Pl. II, Fig. 13), *Arecipites convexus* (Pl. II, Fig. 14), *Arecipites trachycarpoides* (Pl. II, Fig. 15)). The monoporate pollen of *Gramineae* (*Graminiidites subtiliglobosus*) and *Sparganiaceae* (*Sparganiaceaepollenites polygonalis* (Pl. II, Fig. 17)) is also present.

The paleoclimatic significance of the palm trees is obvious. It seems that this is the last occurrence of dicolpate pollen of *Calamus* (*Dicolpopollenites kuckeli* (Pl. II, Fig. 16)).

Dicotyledonous angiosperms (more than 60%) are of a great diversity (almost 40 morphological types identified by now).

The more important botanic families belong to *Myricaceae*, *Juglandaceae*, *Betulaceae*, *Fagaceae*, *Ericaceae*, etc. but other families (Tiliaceae, Eleagnaceae, etc.) are represented too, by specific forms (*Intratriporopollenites instructus* (Pl. II, Fig. 10) *Slowakipollis cechowici* (Pl. II, Fig. 11), *Slowakipollis elaeagnoides* (Pl. II, Fig. 12)).

From a paleoclimatic point of view it can be noticed that macrotherm pollen, well individualized is present in the spectrum represented by *Engelhardtioidites*, *Momipites*, *Platycaryapollenites*, *Plicatopillis*, *Cyrillaceaepol-lenites*, *Porocolpopollenites*, etc.

The microtherm pollen of dicotyledons is well represented (*Ulmipollenites*, *Carpinipites*, *Faguspol-lenites*, etc.) but it can not quantitatively compete with the Pinaceae microtherm pollen (*Picea*, *Tsuga*, etc).

The gypsum sample (labeled 10) collected nearby Cheia village (about 500 m from the entrance of CheileTurzii) preserved to a lesser extent a palynologic archive. The statistical analysis highlights a striking resemblance to the microflora from the Turda salt. Some differences are assigned to a more precarious process of preservation in the case of the gypsum sample.

REMARKS ON THE MICROFLORA-TYPE IN THE BADENIAN DEPOSITS FROM THE TURDA-CHEIA AREA AND PALEOCLIMATIC APPROACHES.

In the present stage of knowledge, in Romania the Badenian is known from many stratigraphic sequences.

The **Lower Badenian** has been studied from a palynological point of view at Lăpugiu de Sus (Hunedoara County) (Petrescu et al., 1990). In that study, the dominance of thermophile elements (40%) in the pollinic spectrum is underlined.

On the other hand, at the level of the **Upper Badenian** studied from a palynological point of view at Beia and Buneşti (Braşov County) (Petrescu et al., 1988), the prevalence of temperate elements (very well represented at the level of the microterme Pinaceae) is established.

The microflora from the Turda-Cheia area belonging to the **Middle Badenian** presented in this paper shows a transitional character, still bearing many macrotherm elements together with expending microtherme (arctotertiary) microflora. The same transitional character is valid also for the Middle Badenian microflora from Ocna Dej (Petrescu et al., 1993).

As concerns paleoclimatical conditions, the Middle Badenian microflora from the Turda-Cheia area, proves a dominance of thermophile and intermediate elements developing in the neighborhood of the sedimentary basin.

Inwards the land, there was at least one warm season, with obvious dryness characteristics sustained by the *Cupressaceae*, *Chenopodiaceae* pollen, some of the monocolpate palm trees, etc.

The facies pollen-spores (*Myricaceae*, *Cyrillaceae*, *Nyssaceae*, *Symplocaceae*, *Calamus*) as well as the spores of many ferns prove that in the close proximity of the sedimentary basin there might have been vegetal communities, encouraged in their development by local wet conditions.

On the other hand, some dicotyledons (*Quercus*, *Fagus*, etc.) and especially *Pinaceae* (*Pinus* pr. p., *Abies*, *Cedrus*, *Tsuga*, *Picea*) prove the existence of an evident distribution of the forest vegetation according to altitude, related to the orogenetic stages of the Carpathians (Styrian phase). This distribution proves an evident evolution to a "Neogene"-type of the coniferous forests at the end of the Middle Badenian in our country, which will continue more relevant in the Upper Badenian.

CONCLUSIONS

Ten samples of the Turda salt have been studied as well as a sample of the Cheia area gypsum, all of them assigned to the Middle Badenian (Wieliczian). The samples consist of salt and gypsum with clayey material and the microflora is certainly syngenetic within the salt deposits.

The existence of some rich microfloristic assemblages in the salt deposits of the Turda - Cheia area prove that the sedimentation of these evaporites was possible in specific paleogeographical conditions. The climate, possibly showing dryness features towards the land, had a subordinate role.

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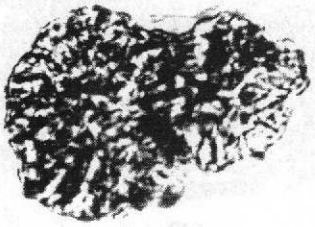
PLATES

Plate I

Fig. 1 *Botryococcus braunii* Kutz. 1949, 1000 x
Fig. 2 *Laevigatisporites haardti* (Pot. et Ven. 1934) Th. et Pf. 1953, 1000 x
Fig. 3 *Verrucatosporites alienus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 4 *Verrucatosporites favus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 5 *Toroiosporis* (T.) *lusaticus* W. Kr. 1962, 1000 x
Fig. 6 *Polypodiaceoisporites cyclocingulatus* W. Kr. 1967, 1000 x
Fig. 7 *Hydrosporis azollaensis* W. Kr. 1962, 1000 x
Fig. 8 *Foveotriletes verrucatoides* W. Kr. 1962, 1000 x
Fig. 9 *Sciadopityspollenites verticillatiformis* (Zauer 1960) W. Kr. 1971
Fig. 10 *Podocarpidites libellus* (Pot. 1931) W. Kr.1971, 1000 x
Fig. 11 *Sequoiapollenites polyformosus* Thg. 1937, 1000 x
Fig. 12 *Sequoiapollenites megaligulus* W. Kr. 1971, 1000 x
Fig. 13 *Cupressacites bockwitzensis* W. Kr. 1971, 1000 x
Fig. 14 *Zonalapollenites igniculus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 15 *Pityosporites cedrisaciformis* W. Kr. 1971, 1000 x
Fig. 16 *Abiespollenites crassus* Nagy 1969, 1000 x

Plate II

Fig. 1 *Pityosporites pacltovae* W. Kr. 1971, 1000 x
Fig. 2 *Abiespollenites cedroides* (Thomson 1953) W. Kr. 1971, 1000 x
Fig. 3 *Abiespollenites cedroides* (Thomson 1953) W. Kr. 1971, 1000 x
Fig. 4 *Pityosporites microalatus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 5 *Pityosporites labdacus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 6 *Cedripites lusaticus* W. Kr. 1971, 1000 x
Fig. 7 *Cedripites hidasensis* Nagy 1985, 1000 x
Fig. 8 *Abiespollenites latisaccatus* (Trevisan 1967) W. Kr. 1971, 800 x
Fig. 9 *Abiespollenites absolutus* Thg. 1937, 800 x
Fig. 10 *Intratriporopollenites instructus* (Pot. 1931) Th. et Pf. 1953, 1000 x
Fig. 11 *Slowakipollis cechowici* (Pacltova 1958) W. Kr. 1962, 1000 x
Fig. 12 *Slowakipollis elaeagnoides* W. Kr. 1962, 1000 x
Fig. 13 *Monocolpopollenites tranquillus* (Pot 1934) Th. et Pf. 1953, 1000 x
Fig. 14 *Arecipites convexus* (Thg. 1937) W. Kr. 1970, 1000 x
Fig. 15 *Arecipites trachycarpoides* Nagy 1969, 1000 x
Fig. 16 *Dicolpopollis kuckeli* Pfanzl. 1956, 1000 x
Fig. 17 *Sparganiaceaepollenites polygonalis* Thg. 1937, 1000 x



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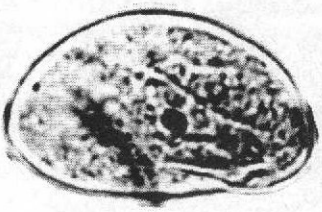

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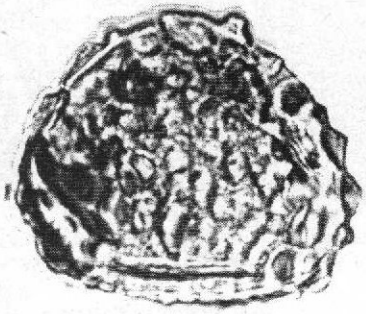

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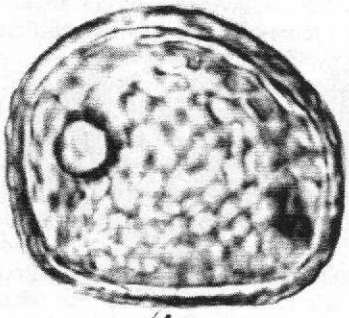

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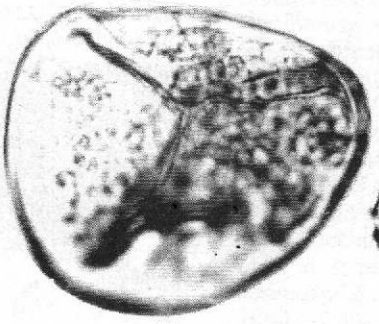

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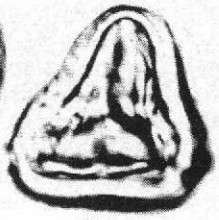

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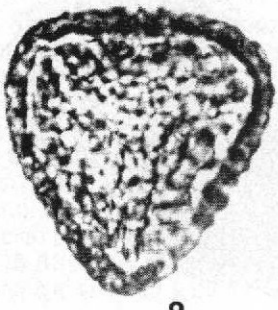

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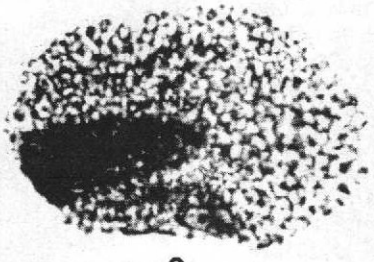

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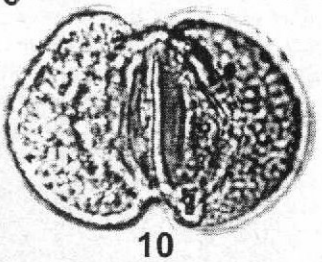

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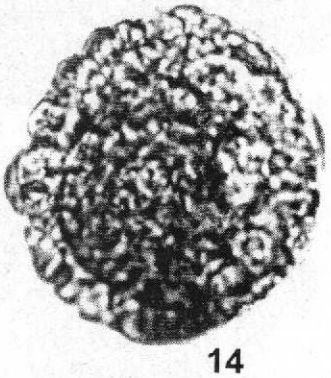

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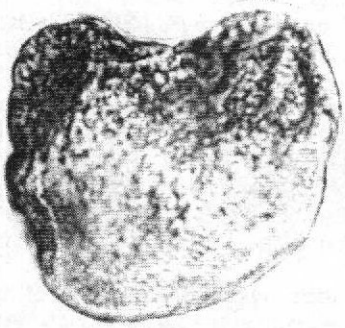

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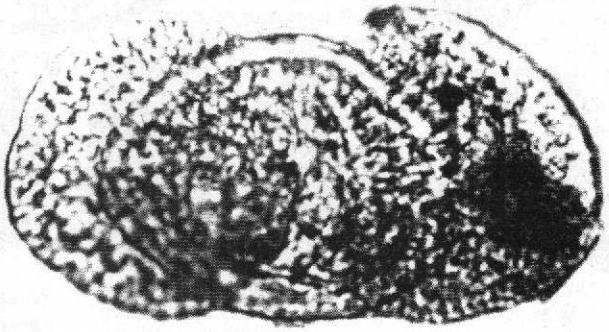

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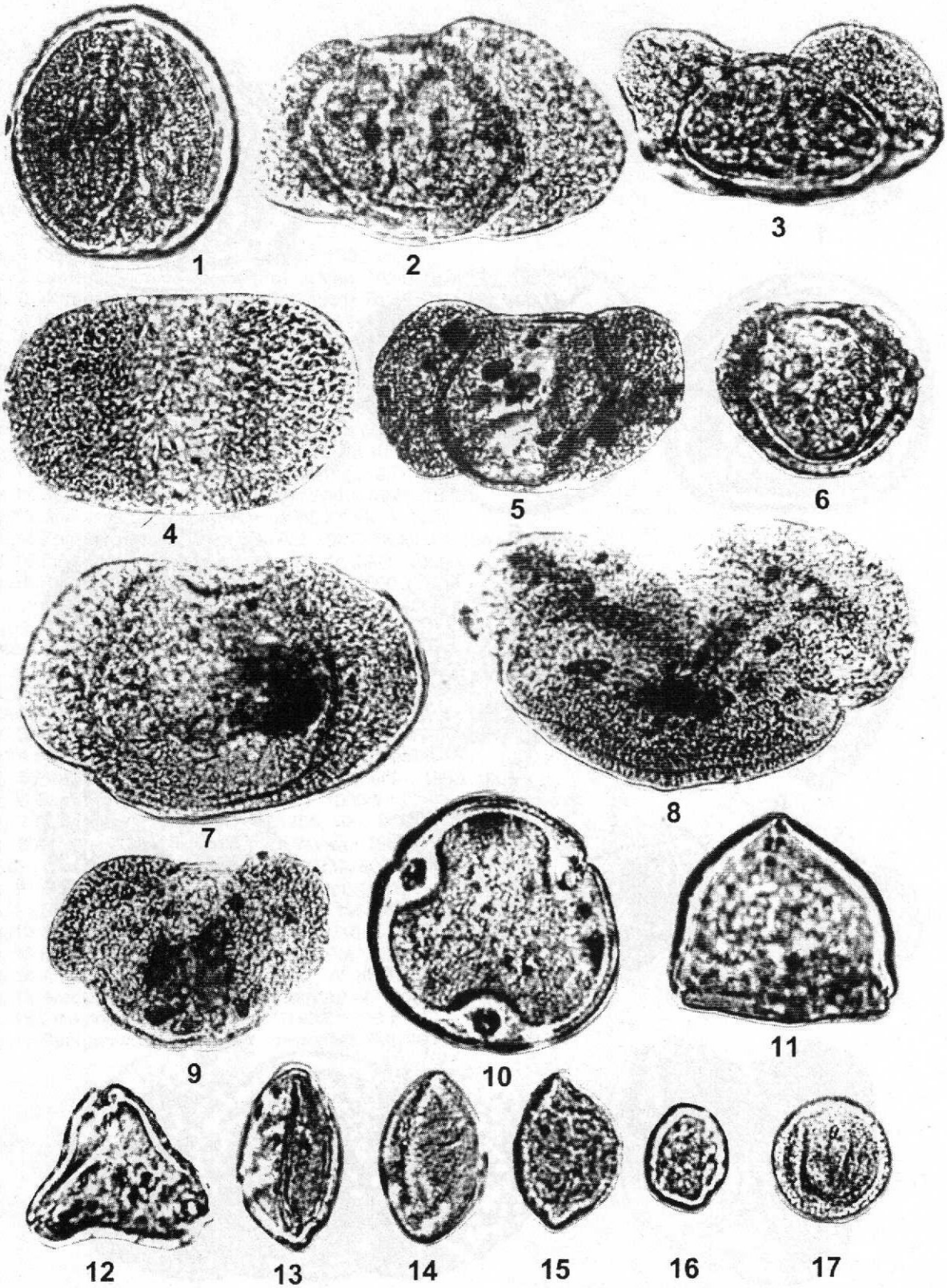
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