

## *Contribution to the Upper Pannonian flora from Visonta, northern Hungary*

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**ABSTRACT:** The first brown coal mine at Visonta in the southern piedmont area of the Mátra Mts. in NE Hungary, was opened in 1969. The mine yielded very interesting flora remains the leaf material of which was studied by I. PÁLFALVY and L. RÁKOSI (1979) while the leaf and fruit remains were described by J. LÁSZLÓ (1989a, b., 1991a, b). In this paper the authors give the presentational discussion of seed and fruit remains. The development of the series with brown coal seams belonging to the Bükkalja Brown Coal Formation may be put into the Dacian and Roumanian periods of the (s.l.) Pannonian. During the studies made on the seed and fruit remains numerous taxa had been recorded and determined which were not recognized in the leaf material because they were not fossilized. Thus we had a chance to make floristic and environmental reconstruction of the flora of a *Glyptostrobus* swamp with considerably richer and more complex plant remains than before.

The first large-scale open-cast brown-coal mine (Thorez mine) of the Mátra Piedmont area (N. Hungary) was opened in 1969 near Visonta (Fig. 1.). First paleobotanical collections at this locality were made in 1977. PÁLFALVY, I. and RÁKOSI, L. had studied the leaf material of these collections (1979). Till 1983, when the mine had been closed down continuous collections yielded very interesting flora remains the study of which has been already started by LÁSZLÓ, J. (1989) and BŮŽEK, C. and LÁSZLÓ, J. (in print).

According to JÁMBOR, Á. et al. (1988) the geological position of brown-coal bearing series at the southern Piedmont areas of the Mátra and Bükk Mountains within the (s.l.) Pannonian formations in Hungary is the following: The formations summarized under the name Bükkalja Brown-Coal Formation are a part of the Heves Formation Group of the Transdanubian Main formation Group. They have been developed during the Dacian and Roumanian phases of the (s.l.) Pannonian. The results of geological researches and mining operations are summarized by RADÓCZ, Gy. (1985).

Technological and geological investigations in the Thorez mine (Fig. 2.) demonstrated the presence of three main brown-coal layers. In the geological profile made in 1979 (LÁSZLÓ, J. 1989a), already a divergence of the lowermost (III.) layer can be observed (Fig. 3.). Clayey layers below the II. brown-coal layer yielded only leaf remains while the clayey layers above this brown-coal seam yielded macrofloral, palynofloral remains and also some fruits, seeds, needles and other remains of reproductive and vegetative organs. The remains were segregated from the emuls by washing and then cleared by HF (40 %) and HCl (30 %). After drying they were handpicked and separated under a binocular preparation microscope according to morphotypes. Their identification is based on the morphological and anatomical comparison with fossil and recent material and respective literature.

The material is inventorized in the Paleobotanical collection of the Hungarian Geological Survey under Inv. Nos. BK.-5449 - BK.-5595.

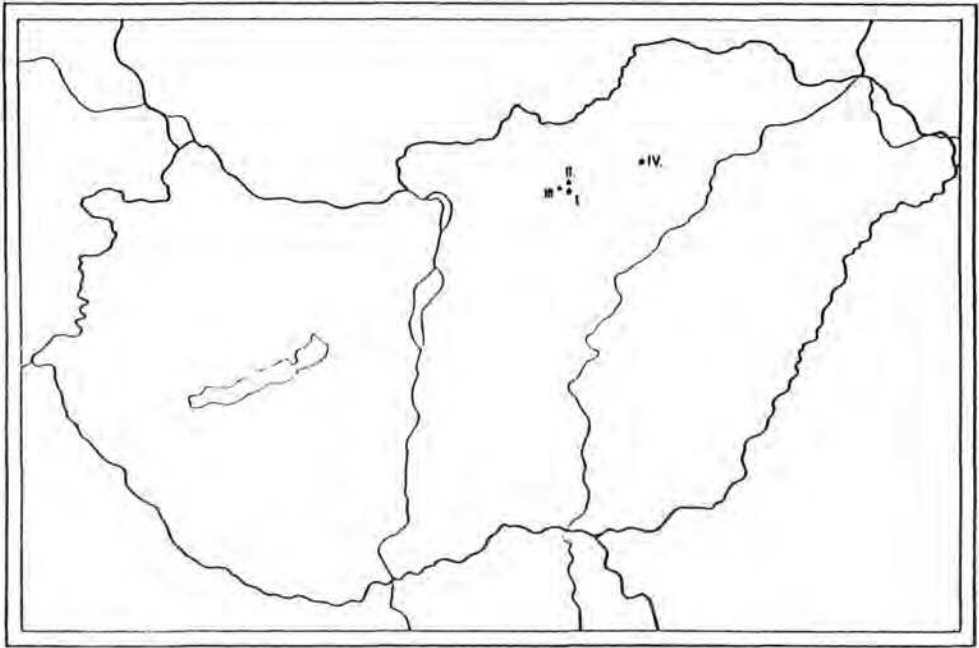


Fig. 1. Map of the localities with flora I. Visonta, Thorez open-cast mine II. Visonta, Eastern open-cast mine III. Visonta, Western open-cast mine IV. Bükk-ábrány, open-cast mine

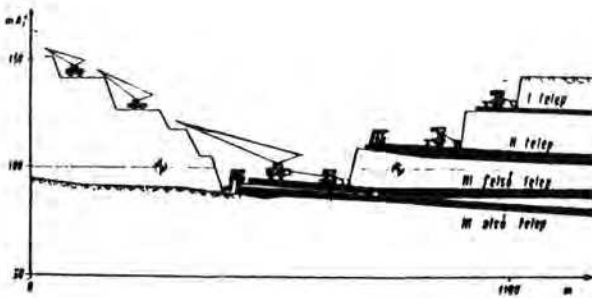


Fig. 2. Technological section of the eastern mine field of the Thorez pit at Visonta (GY. RADÓCZ 1985)

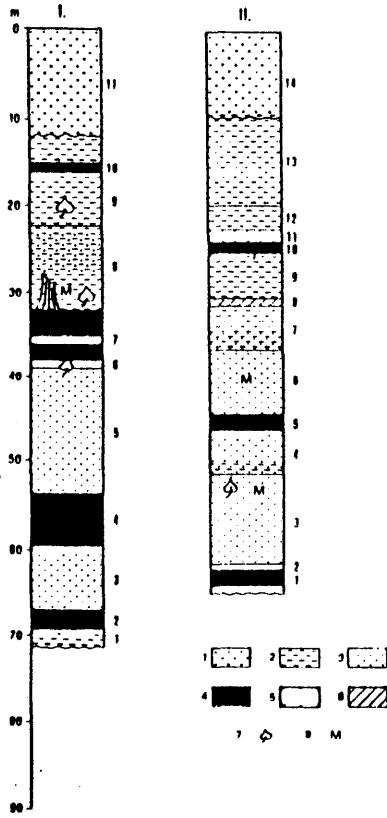


Fig. 3. Geological profile of the localities I. Visonta, Thorez open-cast mine II. Visonta, Western open-cast mine

## HISTORY OF PALEOBOTANICAL RESEARCHES

The first fossil plants known from the Mátra piedmont area are the *Pinus* needle remains mentioned by NOSZKY, J. sen. (1927). HARASZTY, Á. (1933) studied 31 lignite samples from Rózsaszentmárton describing all of them as belonging to the species *Taxodium distichum* Rich.

First large-scale collections at Rózsaszentmárton were made by PÁLFALVY, I. (1952). According to him "the more humid, milder character of the climate is well documented by the presence of the species *Cinnamomum polymorphum* (A. BR.) FRENTZ., *Engelhardtia brongniartii* SAP., *Glyptostrobus europaeus* (BRGT.) HEER etc.". HARASZTY, Á. (1953) made xylotomic studies on the lignites from Rózsaszentmárton. In this material he found only pine trunks, the remains of deciduous trees are absent. An overwhelming majority of the finds proved to be *Taxodioxylon gypsaceum*, *Taxodioxylon taxodii*, *Cupressinoxylon* and also a trunk of *Juniperoxylon* type were found in addition to some *Ginkgo* trunk remains.

The paleobotanical material of Rózsaszentmárton, Petőfibánya was studied also by VÖRÖS, I. (1955). He and PÁLFALVY, I. had published 33 species of 23 genera altogether. According to VÖRÖS, I. "The composition of the Rózsaszentmárton flora roughly corresponds to the composition of floras of the same age at more western areas, yet with a greater ratio of tropical species."

Mrs. L. NAGY summarized her palynological studies made on the brown-coal layers of the Mátra piedmont area in 1958. Her paper comprises detailed paleoclimatological discussion and includes also the detailed description of some paleobotanical problems.

During his recent collections PÁLFALVY, I. (1965) had found leaf impressions of *Ginkgo adiantoides* (UNG.) HEER at Rózsaszentmárton, Petőfibánya, corresponding well with HARASZTY's xylotomical results.

The results of palynological studies made on the material of recent lignite exploration drillings are published by BÓNA, I. - M. RUMLI-SZENTAI (1966). According to their opinion the drillings in the vicinity of Gyöngyös give evidence of the presence of three palynological zones which provide a solid basis for correlation.

The material collected from the lignite mines in the Mátra and Bükk piedmont areas in the summer of 1977 were evaluated by PÁLFALVY, I. - RÁKOSI, L. (1979). According to them "the vegetation of the series with lignite seams of the Mátra and Bükk piedmont areas was similar to that living now at the boundary between warm temperate and temperate zones". The summary of studies made on the leaf and seed finds of the material collected after 1977 was published by LÁSZLÓ, J. (1989a). His more recent papers deal with the leaves of *Ginkgo adiantoides* (UNGER) HEER and with the seed and fruit remains of *Spirematospermum wetzleri* (HEER) Chandler (LÁSZLÓ, J. 1989/b, 1991a/b).

## SYSTEMATIC PART

### SELAGINELLACEAE

*Selaginella* sp. (Pl. III, Figs. 1, 2):

Description: Megaspore flattened, ovate in outline, 1.045 mm long and 0.910 mm wide, proximal side with round structure, Y-mark not clearly visible, surface with low but well developed ornamentation.

Remarks: There is certain similarity with some fossil species in surface structure; however, for specific determination further specimens are necessary. KNOBLOCH (1986) reviewed fossil records of the genus from Moravia and Slovakia and described a series of new species as well.

Material: 1 specimen., inventorized under No. BK-5542.

## EQUISETACEAE

### *Equisetum* sp.

Description: A single stalk fragment of 1.6 cm's length and of 0.6 cm's width. The stalk is divided into parts of more or less of the same size by 4 nodes. The suture lines of the nodes are well developed. The ribs running parallel to the longitudinal axis of the stalk are also well discernible yet there are only a few of them. The traces of leaves in verticillate position are uncertain, hardly discernible.

Remarks: Palynological studies made on the material of the Thorez open-cast mine at Visonta (Mrs. NAGY, L. 1958. PÁLFALVY, I. - RÁKOSI, L. 1979) mentioned the presence of *Equisetum* sp. spores. Its macrofossil remains of Pannonian age has been unknown from Hungary so far.

Material: 1 stalk fragment, the material is in the Paleobotanical collection of the Hungarian Geological Survey, under the inventorized No BK-5492.

## SALVINIACEAE

### *Salvinia* cf. *intermedia* NIKITIN ex DOROFEEV (Pl. II. Figs. 1-4):

Description: Megaspore (sporocarp) mostly more or less compressed and deformed, generally ovate in outline, with acute and shortly mucronate distal end and broad-rounded or truncate proximal end, usually covered by thin sporocarp wall (indusium) with longitudinal vascular bundles well seen: megaspore rather varying in size, length 1 to 1.590 mm, width 1 to 1.360 mm; one complete megaspore contained 11 megasporangia, each of them consisting of single megaspore, in some cases with traces of thin sporangium wall in the form of netlet on the surface. Megaspores 0.500 to 0.610 mm long and 0.350 to 0.420 mm wide, elongate-ovate, rounded at the end and somewhat narrowed at the proximal one; proximal part not separated from the rest of megaspore body, with trilete mark which is usually closed and almost not visible (they are most probably immature megaspores); the surface of this proximal part is more structured than that of the rest of the megaspore body where characteristic folds and starshaped depressions are seen.

Remarks: The species has clearly differentiated sori in male and female ones. In our material, however, only megaspore are present. Morphologically, megaspores seem to be intermediate forms between those of fossil *Salvinia intermedia* NIKITIN ex DOROFEEV and recent *S. natans* (L.) AUBL. which belong to young sect. *Salvinia*. From the Pannonian and Pontian of southern Moravia and from the Upper Miocene of northern Moravia megaspores of *Salvinia cerebrata* NIKITIN ex DOROFEEV (sub *Salvinia reussii* ETT.) have usually been described (KNOBLOCH 1981a, GABRIEL et al. 1982). The common occurrence of *S. intermedia* and *S. cerebrata* has clearly been evidenced in the Meotian of southern Ukraine and both species were probably present in the Upper Miocene of Poland as well (LANCUCKA-SRODONIOWA 1958). Besides, the former species has also been found in the Sarmatian of Lower Don, Ukraine and in the Pliocene of Lower Don (DOROFEEV 1955a, b).

Material: About 30 megaspore and a few isolated megaspores., inventorized under Nos. BK-5457, BK-5530.

## TAXODIACEAE

### *Taxodium* sp. (pl. VIII, Fig. 12):

Description: Seed approx. triangular, with winged and undulate convex margin, 9 mm in length and 4 mm in max. width; surface with a few longitudinal ribs, somewhat winged as well.

Remark: The fossil is comparable in some respect with seeds of *Taxodium*, however, it does not well agree with them in the surface morphology. Nevertheless, the seeds of *Taxodium* are very variable (see BŮŽEK and HOLÝ 1964).

Material: 1 specimen., inventorized under No. BK-5534.

*Glyptostrobus europaeus* (BRONGNIART) UNGER (Pl. III, Figs. 3-5. Pl. X, Figs. 5-12):

Description: Twigs or fragments of twigs with helically arranged, appressed leaves, hardly 2 mm long; leaves have amphistomatic, adaxial epidermis with two triangular stomatal bands including amphicyclic closely spaced stomata, mostly obliquely orientated and abaxial groups of stomata of the same sort; stomata amphicyclic, stomatal pit chagrenate, broadly quadrangular-elliptic, about  $12 \times 30 \mu\text{m}$  large, surrounded by 4 (-6) narrow subsidiary cells, not differentiated, and a ring of encircling cells; cells of non-stomatal areas quadrangular, partly elongated, about  $10-15 \mu\text{m}$  wide, with straight anticlinal walls; somewhat smaller cones and cone-scales, distal part of scales of about 5 mm long and 3 mm wide, with rounded and notched margin at the distal end and with radial furrows on the abaxial side; seeds has an incomplete wing or they are wingless, flat, up to 5.9 mm long and up to 1.2 mm wide, slightly bent, in some cases almost straight.

Remarks: All the remains can be well identified with common *Glyptostrobus europaeus*. In the leaf anatomy the above described remains do not differ from the other Miocene records. According to seed morphology and anatomy, however, a few additional species of *Glyptostrobus* were established (DOROFEEV 1974). In the morphology the present seeds generally agree with those of *G. pannonica* DOROFEEV. The relation between both species has not been studied in details and *G. pannonica* may be only synonym of our species.

Material: Very large number of twigs and their fragments, cones cone-scales and more than 100 seeds. The material is inventorized under Nos. BK-5452, BK-5453, BK5456, BK-5458, BK-5471-73, BK-5475, BK-5478, BK-5482, BK-5494-96, BK-5533, BK-5546-5595.

#### PINACEAE

*Pinus* (*Pinus*) sp. (Pl. III, Figs. 11, 12):

Description: Fragments of brachyblasts with remains of needleleaves: leaves are triangular (?) in cross section, surrounded by a short, transversely wrinkled sheath.

Remark: Anatomical characters due to the bad preservation are not discernible.  
Material: 4 brachyblasts and a few fragments of leaves. The material is inventorized under Nos BK-5489, BK-5499, BK-5536.

*Pinus* (*Strobus*) sp. (Pl. III, Fig. 10):

Description: Fragments of short brachyblasts without a sheath and pieces of separated triangular needle-leaves; leaves entire-margined, epistomatic; stomata monocyclic, longitudinally arranged in 2 to 3 closely disposed rows on either side of the keel.

Remark: Highly fragmentary remains of both pines, which do not allow more specific determination.

Material: 1 brachyblast and a few fragments of leaves. The material is inventorized under Nos BK-5474, BK-5488, BK-5532.

*Tsuga* sp. (Pl. III, Figs. 6-8):

Description: Leaves shortly petiolate, 1 to 1.5 mm wide, 5 and more mm long, bifacial, hypostomatic, with one medial resin canal; upper epidermis consisting of narrow linear cells 8 to  $15 \mu\text{m}$  wide with straight walls; cells of the lower epidermis outside stomatal areas of similar size and shape; two stomatal bands, on either side of the midrib, dense and wide, including up to 8 stomatal rows; stomata longitudinally arranged, incompletely bicyclic, partly sharing polar subsidiary and lateral encircling cells; stomatal pit quadrangular-elongate,  $7 \times 17$  to  $25 \mu\text{m}$ , only slightly thickened margin, surrounded by 2 polar and 2 to 3 lateral subsidiary cells; guard cells deeply sunkened, broadly elliptic, 30 to  $40 \mu\text{m}$  long.

Remark: Petiolate leaves and their stomatal topography refer to the alliance with the genus *Tsuga* CARR. sect. *TSUGA*.

Material: 4 specimens., inventorized under Nos BK-5455, BK-5525.

*Picea* sp. (Pl. III, Figs. 21, 22):

Description: Needle-leaves truncated, linear, in fragments only, 1 to 1.8 mm wide, quadrangular in cross section, bluntly pointed, amphistomatic; cells of

non-stomatal areas narrow linear, up to 23  $\mu\text{m}$  wide, with undulating walls; two stomatal bands, adaxial ones are wider and include 8 widely spaced stomatal rows, and two abaxial ones, the latter are narrow, include usually 2 to 3 rows of stomata; stomata completely bicyclic, longitudinally arranged, stomatal pit broadly elliptic, 12 to 17 x up to 28  $\mu\text{m}$  large, with thickened margin, surrounded by 2 polar and 3 to 4 lateral narrow subsidiary cells and 1 (to 2) rings of broader encircling cells; guard cells sunkened, roundish, 50 to 60  $\mu\text{m}$  long.

Remarks: The morphology of the leaves (truncate quadrangular needles) suffices to prove their affinity to *Picea* A. DIEHR. The stomatal topography is characteristic of the sect. *Picea*.

Material: 6 specimens., inventorized under Nos BK-5467, BK-5500, BK-5528

*Abies* sp. (Pl. III, Figs. 15-20):

Description: Leaves are linear, about 1.5 mm wide and more than 10 mm long, bifacial, slightly emarginate at the apex, shortly petiolate with enlarged petiole base, hypostomatic; cells of non-stomatal areas linear, narrow, up to 18  $\mu\text{m}$  wide, with finely undulating walls; two stomatal bands, on either side of the midrib, dense, consisting of up to 10 stomatal rows; stomata completely bicyclic, partly sharing encircling cells; stomatal pit rectangular-elongate, about 10x25  $\mu\text{m}$  large, less distinct, chagrenata, surrounded by two polar and 3 to 4 lateral narrow and thickened subsidiary cells and 1 ring of large encircling cells; guard cells deeply sunkened, roundish, about 50  $\mu\text{m}$  long.

Remarks: Among the species of *Abies* MILL. with hypostomatic leaves and undulating anticlines the above described fragments match with e.g. *A. nordmanniana* (STEV.) SPACH. and some Asiatic species.

Material: 7 specimens., inventorized under Nos BK-5480, BK-5506, BK-5535

#### MAGNOLIACEAE

*Liriodendron* sp. (Pl. II, Fig. 13):

Description: Seeds-pair (from the same fruit locule) compressed together, drop-like in form, about 5.4 mm long and 3 mm wide, original warty surface structure is mostly covered by impressions of the quartz grains.

Remark: Isolated seeds have been found in the Pontian of southern Moravia (KNOBLOCH 1981a). The present seeds are similar to those of *L. geminata* KIRCHHEIMER which is well known from the Miocene and Pliocene of Eurasia (see Van der BURG 1978).

Material: 2 specimens (seeds-pairs)., inventorized under Nos BK-5476, BK-5519

#### RANUNCULACEAE

*Ranunculus* sp. (Pl. III, Fig. 9):

Description: Fruit approx. 2.2 mm long and 1.8 mm wide, of asymmetric form, with ventrally apical (broken) style and rapidly narrowed base (fruit stalk only indicated); the surface very finely pitted.

Remark: Morphologically very similar fruits may be found in *Ranunculus*, e.g. in *R. polyanthemus* L., *R. repens* L. and others. More precise determination is not possible without some further specimens.

Material: 1 specimen., inventorized under No BK-5531

#### NYMPHAEACEAE

*Nymphaea szaferei* KNOBLOCH (Pl. IV, Fig. 7):

Description: Seed flattened, ovate in outline, about 2.6 mm long and 1.7 mm wide, relatively thin-walled (testa about 0.045 mm thick); surface cells not much visible (under binocular), arranged in the more than 15 longitudinal rows or one side of flattened seed.

Remarks: Present specimen can be identified as belonging to the species named above but the comprehensive studies and revision of the fossil seeds *Nymphaea* L. are necessary. The species based on the seeds from the Miocene of Southern Moravia (KNOBLOCH 1978) has also been recorded from the Pontian in this region (KNOBLOCH 1981a).

Material: 1 seed. Inventorized under No BK-5540

*Nuphar palfalvyi* BŰZEK et LÁSZLÓ sp. n. (Pl. IV, Figs. 1-5, Pl. X, Figs. 3,4):

Diagnosis: Seeds up to 3.5 mm long and up to 3 mm wide, raphe ridge unclear, testa 50 to 80  $\mu$ m thick, surface cells slightly elongated, 20 to 25  $\mu$ m large, sigmoidal, very regularly developed, arranged in 20 to 25 rows at a distance of 0.5 mm, with thick, elevated lateral walls.

Description: Seeds relatively thin-walled (testa about 50 to 80  $\mu$ m thick), quite compressed, ovate to oval in outline, up to 3.5 mm long and up to 3 mm wide, surface cells on the average about 20 to 25  $\mu$ m large, in the form of horizontal quadrangles or polygons, arranged in the more or less distinct, fine longitudinal rows (in number of about 20 to 25 at a distance of 0.5 mm), but their arrangement seems to be sometimes not much regular; SEM shows slightly elongated surface cells, somewhat sigmoidal in form and with thick, elevated lateral walls; raphe ridge not much clearly visible externally; small apical cap appears to be circular, about 0.50 mm in diameter, with central micropyle; de facto cap (and aperture) oval, because the hilum (in the form of "a piece of attached debris") transgressing the margin of the cap is pushed off together as a complex cap; therefore the hilar end of the cap (aperture) is usually wedge-tailed and general length of such cap is up to about 1 mm.

Remarks: The seeds show clear relations to those of *Nuphar* SMITH (in relative position of the micropyle and hilum to apical cap). Seeds of *N. canaliculatum* C. et E.M. Reid are rather similar in this respect but their surface cells seem to be not so wide as those of present material. Seed surface documented by SEM (Pl. X, Figs. 3, 4) is well comparable with that of *Nuphar adeniformis* DOROFEEV (WIELICZKOWICZ 1990) but cellular structure is much more regular in our material. Therefore it cannot be referred to these representatives of *Nuphar* and was described as a new species.

Material: 15 specimens., inventorized under Nos BK-5485, BK-5539

*Pseudoeuryale* cf. *dravertii* DOROFEEV (Pl. IV, Figs. 11-15, Pl. X, Figs. 1,2):

Description: Seeds strongly flattened and deformed, relatively thick-walled (testa 0.270 to 0.360 mm in thickness), generally obovate to ovate-oval in outline, about 5.9 to 6.3 mm long and 4 mm wide; small circular apical cap (or germination aperture), about 0.6 to 1 mm in diameter, probably with central micropyle (the cap is present in only one specimen and is damaged); adjacent and evidently touching this cap (or aperture) light oval scar (hilum) with central depression; cap and scar are surrounded by dark and lustrous hem which is between the both structures slightly contracted; raphe ridge not visible externally; very damaged and secondarily wrinkled external surface covered by many imprints of quartz grains, rarely shows very fine pitting which represents an original cellular structure of the testal surface; cells hexagonal or polygonal, about 0.005 in diameter, without a central papilla.

Remarks: In general, fossil Nymphaeaceae seeds may be barely identified without morphological and anatomical details of their surface structures. According to the relative position of the micropyle and hilum to cap present material is well comparable with the genera of the Euryale group, namely genus *Pseudoeuryale* DOROFEEV (for generic differences - see Dorofeev 1972, in TAKHTAJAN 1974). In the light microscopy the character of the epidermal cells has not been clearly recognized, however, according to informative SEM observations it appears to be rather smooth as in *Pseudoeuryale* than papillate as in *Palaeoeuryale* DOROFEEV.

Present material differs from the species *Pseudoeuryale limburgensis* (C. et E.M. REID) DOROFEEV, for instance, by the smaller seed size and presence of hem around the cap and scar. In this respect it resembles seeds of the species *P. dravertii* described from the Upper Miocene of Siberia. However, it differs from our species in the thicker seed-wall and larger epidermal cells. *Euryale lissa* C. et E.M. REID (1915) from the Brunsumian of the Netherlands, which is considered to represent not fully developed seeds of *Euryale limburgensis* (KIRCHHEIMER 1957), is rather similar to our material.

One isolated cap published as *Euryale* sp. from the Panonian of southern Moravia (KNOBLOCH 1976) might belong to our species but the others from the Pannonian and Pontian of Slovakia (KNOBLOCH 1981c), which are clearly oval in form, cannot be probably connected with *Pseudoeuryale*.

Material: 5 seeds and 1 seed broken into fragments. Inventorized under Nos BK-5511, BK-5524

## CERATOPHYLLACEAE

*Ceratophyllum dubium* (LUDWIG) KIRCHHEIMER (Pl. II, Figs. 5-11):

Description: Fruits (with or without exocarp) and their dehiscent halves, usually flattened, oval to long-oval in outline, 2.730 to 4.230 mm long and 1.455 to 2.270 mm wide, in some cases somewhat obliquely truncated at the base and with short slopping prickle bent dorsally, in apical or slightly subapical position; if prickles missing, usually not broken off, one specimen with stump of stronger apical prickle and with slight indication of basal (lateral) prickles; surface sculpture of exocarp smooth with or without dispersed minute warty-papillae, surface of endocarp smooth to finely granulated or papillated, as well; inner side of some fruit halves with adhered remnant of the seed testa showing a conspicuous "mark" of the vascular bundles which is as characteristic for *Ceratophyllum* as the fruit vascularisation well seen in the plane of dehiscence.

Remarks: Fruit remains well agree in all respects with those of the species *Ceratophyllum dubium* known from the Miocene of Europe, which is matched with the living species *C. submersum* L. According to characters of the material studied fossil species seems to be closely related to *C. submersum* subsp. *submersum* var. *submersum*. Similar material but without apical prickles (if not broken off) was described from the Pannonian and Pontian of southern Moravia as *C. dubium* (CTYROKÝ and KNOBLOCH 1976) and *C. protanaiticum* (NIKITIN) DOROFEEV (KNOBLOCH 1981a). The relation between this material and tuberculated or pricked specimens described as *C. cf. tanaiticum* SAPEGIN from the same stratigraphical level and region is not clear. But it must be noted here, that the fruit ornamentation in *Ceratophyllum* is very complex and variable (WILMOT-DEAR 1985). The living species *C. tanaiticum* was recently banished to the synonymy of *C. submersum* ssp. *muricatum* (Cham.) WILMOT-DEAR var. *echinatum* (A. GRAY) WILMOT-DEAR. Nevertheless, a few species of the *submersum* group cannot be excluded in the Neogene of Europe.

Material: About 30 specimens and fragments. Inventorized under Nos BK-5465, BK-5469, BK-5523

## LAMIAEAE

*Lycopus cf. europaeus* L. (Pl. II, Fig. 16)

Description: Fruits with marginal rim of spongy tissue, obovate in outline, about 1 mm long and 0.80 mm wide, marginal rim up to 0.18 mm wide around apical part of the fruit; hilum basal, large; fruit body with fine longitudinal surface structure.

Remarks: One specimen found without a marginal rim. The fruit remains of *Lycopus* L. have been recorded from the Pliocene and Quaternary (see Van der BURGH 1983, BUZEK et al. 1985), the findings in the Miocene are rare (Van der BURGH 1987).

Material: 3 specimens. Inventorized under No BK-5464

## LYTHRACEAE

*Decodon gibbosus* (E.M. REID) E.M. REID (Pl. II, Fig. 12):

Description: Seeds are very thick-walled, shortly wedge-like form, small, about 1 mm high and 0.9 to 1.1 mm wide (deep); dehiscent valve in one of the specimens is indistinct (in the other one it is missing), with surface structure hardly visible; seed surface smooth.

Remarks: The species is well known from the Pannonian and Pontian of southern Moravia (KNOBLOCH 1981a). There is a great need of taxonomic revision of the fossil seeds of *Decodon* GMELIN because a few rather similar species with the uncertain delimitation were described.

Material: 2 seeds. Inventorized under Nos BK-5503, BK-5538

## ACTINIDIACEAE

*Actinidia faveolata* C. et E.M. REID (Pl. IV, Fig. 6):

Description: Seed oval in outline, somewhat narrowed at the hilar end, flat, 2.23 mm long and 1.32 mm wide, with surface finely pitted; pits polygonal, 0.06 to 0.10 mm in diameter in the middle part of the seed, becoming somewhat smaller towards the seed ends; very small hilum elliptical, situated asymmetrically.

Remarks: In Europe, the seeds have been recorded from the Miocene (SZAFFER 1961, BUZEK and HOLY 1964, ŁANCUCKA-SRODONIOWA 1979, KNOBLOCH 1981b, Van der BURG 1987), Pliocene (REID and REID 1915, REID 1923, SZAFFER 1938, 1947, KIRCHHEIMER 1957, GEISSERT 1961, Van der BURG 1983) and Pleistocene (REID and REID 1907, SZAFFER 1954). The seeds of *Actinidia* were also described from the Pannonian (KNOBLOCH 1976) and Pontian (KNOBLOCH 1981a) of southern Moravia. The present seed is very similar to some specimens described from Brunssum (e.g. by KIRCHHEIMER 1957).

Material: 1 specimen. Inventorized under No BK-5515

#### APIACEAE

*Denanthe* sp. (Pl. II, Figs. 14, 15):

Description: Incomplete fruits, flattened, oval in outline, about 2 mm long, with 4 dark longitudinal stripes on the dorsal side.

Remark: The Tertiary fruits in question are usually identified with recent *O. aquatica* LINK. and *O. lachenalii* GMEL. (SZAFFER 1954, MAI 1965). They were also described from the Pontian of southern Moravia (KNOBLOCH 1981a).

Material: 1 incomplete fruit and 1 specimen fallen into 3 pieces. Inventorized under No BK-5508.

#### ROSACEAE

cf. *Prunus* (Pl. VI, Fig. 5):

Description: Dehiscent valve of evidently 2-valved, one-loculed, one-seeded endocarp (stone), either not or only less flattened, spindle-shaped, somewhat narrowed to the apex, about 4.5 mm long and 3 mm wide; external surface ornamented by the incomplete longitudinal ribs; surface of locule is smooth.

Remarks: Such diagnostic features as the course of the funicular canal, the position of the styler projection and attachment, however, not visible; remain of the thickened sutural line seems to be preserved at the margin and indicates the funicular margin of valve. Endocarp is tentatively assigned to *Prunus*. Endocarps of *Prunus padus* L. have been described from the Pontian of southern Moravia (KNOBLOCH 1981a) which, however, have no common features with the present one.

Material: 1 valve. Inventorized under No BK-5516

#### BETULACEAE

*Alnus* sp. (Pl. III, Fig. 13, Pl. V, Figs. 1-17, Pl. VIII, Fig. 10):

Description: Fragments of leaves, hypostomatic, very thinly cutinized; upper cuticle showing outlines of polygonal straight-walled cells is about 15 to 20  $\mu$ m across; lower cuticle is very thin, bearing 4 to 5-celled thick basal parts of glands, cell walls hardly discernible; stomata anomocytic (?), elliptic, 10 to 15  $\mu$ m broad and 18 (to 20)  $\mu$ m long, showing slightly thickened outer ledges of guard cells recching the stomatal poles and forming spindle-like pore; female cones in different stages of development, usually very destroyed; torsos of mature cones with a few scales on the cone axis; cone remains indicate a size about 1.5 cm and show woody, compound, spirally inserted scales usually damaged or destroyed and preserved just as stups or even scars; cone scales up to 5 mm long and 5 mm wide at the distal end; inner surface of scales striated with a few coarse ribs on the abaxial side; male catkins (preserved only as fragments) in the compressed and deformed state, up to 5 mm wide, consisting of large rounded-triangular catkin scales, spirally arranged (their parastiches very well seen); each cover scale rimmed by 4 (2 pairs) small fused bracts and bracteoles at the margin; in the cross section (break) of compressed catkins and their fragments large number of anthers or pollen sacs with tetraporate (which are dominated) and pentaporate pollen grains were clearly recognizable.

Remarks: The reproductive organs may belong to the leaf remains of *Alnus cecropiaefolia* (EIT.) BERGER and *A. ducalis* (GAUDIN) KNOBLOCH (= *A. hoernesii* STUR) known from the Pannonian and Pontian of southern Moravia (KNOBLOCH 1969). Some leaf fragments found in washing were anatomically identified by Z. KVAČEK. The epidermal structure of the fragments matches well with the remains of *A. cecropiaefolia* from the Pannonian and Pontian of southern Moravia and Slovakia. Otherwise very similar *A. julianiformis* (STERNB.) HOLÝ et KVAČEK differs in slightly and finely undulating anticlines and poorly cutinized glandular bases. Complex catkin-scales with 5 lappets are characteristic of *Alnus* L., and the pollen grains of this genus were really evidenced by M. KONZALOVÁ during microscopical study of the present material.  
Material: Many parts of cones in different stages of ripening and preservation, more than 40 detached cone scales and 3 parts and about 15 small fragments of catkins. Inventorized under Nos BK-5449-BK-5451, BK-5486, BK-5490, BK-5491, BK-5498, BK-5509

*Carpinus* sp. ex gr. *betulus* L. (Pl. VI. Figs. 1-4):

Description: Fruits (nuts) often secondarily flattened and deformed, 1.5 to 3.5 mm long, 2.5 to 3 mm wide, ovate to broad-ovate in outline, narrowed to shortly mucronate at the apex, rounded to truncate at the base, with 1 to 3 (mostly 2) distinct ridges on the usually abraded surface.

Remarks: As it was already pointed out by Polish authors almost all fossil material of this character must be accepted as a small fruited form of *C. betulus* which together with *C. caroliniana* WALT. are the only species with distinct ridges (see also Van der BURG 1983). Such carpological material was described from the Pliocene (SZAFER 1947, Van der BURG 1978). Present material well agrees with that in every respect as well. Similar material from the Pontian of southern Moravia (KNOBLOCH 1981a) was identified as *C. europaea* NEGRU and further probably Pannonian, material from northern Slovakia (KNOBLOCH 1980) was considered as *C. cf. betulus*. For any further identification and explanation of affinity in *Carpinus* detailed morphological and anatomical studies are necessary.

Material: About 50 specimens., inventorized under Nos BK-5463, BK-5481, BK-5527

#### SALICACEAE

*Salix* sp. (Pl. VI. Figs. 8-11):

Description: Bud-scales detached (only a few buds inserted to the fragment of twig), generally broad-conical, flattened very variable in size, 1.5 to 5 mm long and 1.5 to 3 mm wide, blunt at the apex and narrowed into circular basal rim of insertion, surface lustrous, wrinkled and irregularly crumpled; they are usually open (empty), with overlapping edges (on the adaxial side in the inserted bud), in some cases with remnants in their interiors (buds). Fruit (capsule) ovoid-conic, relatively small (incomplete length 2 mm), short-stalked, 2-valved, widely open after dehiscence, at the base asymmetrically developed, obtuse, slowly narrowed into the apexes of the valves (their apical parts are broken off), smooth on the surface.

Remarks: Such one-membered bud-scales agree with those of *Salix* (composed of two fused individual scales). They are also found in the Pontian of southern Moravia (C. BOŽEK, unpublished) where occurred together with the leaf and stipule remains of *Salix*. The fruit agrees in all respects with that of *Salix* as well but it has somewhat smaller size.

Material: More than 50 bud-scales or buds and 1 fruit. Inventorized under Nos BK-5454, BK-5468, BK-5479, BK-5502, BK-5514

#### FAGACEAE

*Fagus decurrens* C. et E.M. REID (Pl. VII. Figs. 1-12, 13, 14, Pl. VIII, Figs. 1-9):

Description: Cupules woody, nevertheless rather compressed, 4-lobed (valved), evidently in different stages of development, relatively very small, about 6 to 12 mm long and 3.5 to 12 mm wide (but one fragment of cupule indicates even larger dimensions), sometimes shortly stalked, asymmetric stalk up to 2 mm long, stout; one of the largest cupules with two overlapping fruits inside; lobes prolonged apically, free from about one half of the cupule length in

smaller (younger) specimens and from about one third of the length in larger (ripe or almost ripe) specimens, in the latter case lobes seem to be relatively flat (most probably due to the secondary compression); outer surface of cupules is coarse, in some cases with longitudinal ribs (remnants of prickles after abrasion) on the distal parts of lobes, or without any special sculpture including keel; inner side rather smooth or granulate; when the cupule is not compressed we can see two trigonal scars on the base of interior (after attachment of the fruits). Fruits (achenes) two in cupule (they had been released during chemical clearing of the above - mentioned specimen), strongly compressed and damaged, obovate in outline, about 7 mm long and 5 mm wide, well developed but probably not fully ripe, evidently thin-walled, smooth, stylar region partly or not preserved; they were originally trigonous as indicated by these fruits and the above-mentioned scars in the cupules, as well.

Remarks: Although the material in question is very abraded and damaged it is well comparable with the cupules and fruits obtained from the same stratigraphic level of Nyugati (West) mine at Visonta (see Pl. VIII, Figs. 1-9) where much more complete and better preserved specimens have been found. In spite of their rather small size they may be identified with *Fagus decurrens*, as it is now considered by Van der BURG (1983).

Very small and thick-walled cupules found in our material (Pl. VII, Figs. 10-12) were at first identified by us with those of *Trigonobalanopsis* KVÁČEK et WALTHER (1989). This type of cupules, generally well-known in the Lower Miocene of Europe under the name of *Trigonobalanus exacantha* Mai, was recently recorded from the Upper Miocene of West Europe (Van der BURG 1987). However, it seems that they are only juvenile and strongly abraded cupules, if not only their basal parts, of our species *Fagus decurrens*.

Material: 10 cupules and their fragments, 2 fruits in one cupule; besides, material from the Nyugati (West) mine (see above). Inventorized under Nos BK-5543-BK-5545

#### JUGLANDACEAE

*Pterocarya* sp. (Pl. VI, Figs. 6, 7):

Description: Endocarps, one lesser deformed, about 2 mm high and 4 mm wide, sharply ridged, the other compressed, up to 5 mm wide, ridges only indicated.

Remark: The endocarps of *Pterocarya* have been recorded from the Miocene to lowermost Pleistocene of Europe (see e.g. REID and REID 1915, Van der BURG 1970). Present material seems to be conspecific with the specimens described as *Pterocarya* sp. from the Pannonian of northern Slovakia (KNOBLOCH 1980). Taxonomic revision of the European fossil material is necessary.

Material: 2 specimens. Inventorized under Nos BK-5487, BK-5522

#### NYSSACEAE

*Nyssa disseminata* (LUDWIG) KIRCHHEIMER (Pl. IV, Figs. 8, 9):

Description: Endocarp (stone) flattened, oval in outline, somewhat narrowed towards the ends, 8 mm long and 4.5 mm wide, with only triangular germination aperture (after valve) and bearing about 7 shallow longitudinal grooves with vascular bundles.

Remarks: The specimen shows much more similarity with endocarps of *Nyssa disseminata* than with those of *N. ornithobroma* UNGER. However, material described as *Nyssa disseminata* from the Pontian of Pošterná, southern Moravia (BŮŽEK 1962), is now considered to be *N. ornithobroma* (for differences see e.g. Mai 1973).

Material: 1 specimen. Inventorized under No BK-5526

#### SABIACEAE

*Meliosma* cf. *wetteraviensis* (LUDWIG) MAI (Pl. VII, Figs. 15, 16):

Description: Endocarp laterally compressed, round - triangular in outline, about 5 mm long and 4.5 mm wide, with a large ventral furrow and distinct median keel; surface smooth (with irregular ridges which are most probably secondary ones due to the deformation).

Remark: Endocarp generally agree with specimens described from the lower Villafranchian of Wetterau (Mai 1973) and from the upper Miocene of the lower Rhine basin (Van der BURG 1987).

Material: 1 specimen. Inventorized under No BK-5517

#### CORNACEAE

*Cornus* cf. *gorbunovii* DOROFEEV (Pl. VI, Figs 12-14):

Description: Endocarps (stones) relatively hard, secondarily rather compressed, in general ovate to broad-ovate in outline, shortly pointed at the apex, about 6x5 mm large, 2-locular; surface smooth but with a few irregular longitudinally oriented ridges bearing vascular bundles in their highest parts; the vascular bundles, if preserved also in meridional groove running around the endocarp.

Remarks: Endocarps agree with those described by KNOBLOCH (1976, 1981a) under the name *Swida gorbunovii* (DOROFEEV) NEGRU from the Pannonian and Pontian of southern Moravia. However, their identification with species *C. gorbunovii* DOROFEEV (1963) or *S. gorbunovii* (NEGRU 1972) is uncertain because both Moravian and Hungarian materials do not well correspond with those from Siberia and Moldavia in the form and surface structure of endocarps. In every case all the fossil endocarps in question must be identified with the so called blue line of *Cornus* in the broad sense (EYDE 1988).

Material: 7 specimens. Inventorized under Nos BK-5470, BK-5507

#### LONICERACEAE

*Sambucus pulchella* C. et E.M. REID (Pl. III, Fig. 14, Pl. IV, Fig. 10):

Description: Seeds obovate to oblongly ovate in outline, compressed, 1.5 to 3.5 mm long and 1.2 to 1.6 mm wide, with typical surface structure and terminal hilum on the ventral face.

Remark: The present species is rather common from the Eocene to Pliocene in Europe, and must be considered as a cumulative taxon which cannot be divided at present. It has also been found in the Pannonian and Pontian of southern Moravia (KNOBLOCH 1981a, b).

Material: 3 specimens. Inventorized under Nos BK-5504, BK-5541

#### ? ONAGRACEAE

*Hartziella miocenica* SZAFER (Pl. II, Fig. 17):

Description: Fruits, somewhat rough, with rather low and round ribs and furrows in the basic number 3, but also further interspaced ones are indicated; not deformed specimen, 2 mm long and 1.5 mm wide, deformed specimen, somewhat smaller, with small apical depression (scar of attachment) probably of triangular form, single dehiscent valve situated over the main rib and therefore it is clearly keeled. Besides, somewhat larger, rather abraded specimen with more distinct ribs has been found, which may belong to some other species of the genus *Hartziella*.

Remark: Fossil species of this interesting extinct genus were reviewed by KNOBLOCH (1982). Relations of the above-mentioned larger specimen are not clear at present.

Material: 2 specimens. Inventorized under Nos BK-5466, BK-5512

#### AQUIFOLIACEAE

*Ilex* sp. (Pl. VI, Fig. 15):

Description: Endocarp, in lateral view narrowly sickle-like, dorsally slightly convex, about 5 mm long and 2 mm wide, the angle between the lateral sides seems to be rather acute (the surface structure is somewhat fallen in), dorsal side with two complete longitudinal and a few short sharp up to wing-like ridges, one lateral side more ridged than the other.

Remark: Endocarp does not well agree with any fossil species known from the Upper Miocene or Pliocene. Similar endocarps of *I. fortunensis* Van der Burg (1983) are smooth on the lateral sides.

Material: 1 specimen. Inventorized under No BK-5513

## THEACEAE

cf. *Stuartia beckerana* (LUDWIG) KIRCHHEIMER (Pl. VII, Figs. 17,18):

Description: Fruit (capsule) without stalk, slightly laterally compressed, about 7 mm long and 3.5 mm wide, pentamerous, pentagonal with distinct edges and convex fruit wall between them, the outer surface is rough.

Remark: Relatively small-sized, probably immature fruit which shows some similarities with capsules known as *Stuartia beckerana*. This species is well known from the Miocene and Pliocene of Europe (see KIRCHHEIMER 1957, Mal 1971, Van der BURG 1978, 1983, 1987), but generally, it is rather rare.

Material: 1 capsule. Inventorized under No BK-5520

## POTAMOGETONACEAE

*Potamogeton* sp. div. (Pl. IX, Fig. 6):

Description: Fruits (endocarps), relatively small, slightly flat laterally, thick-walled, with short style, 1.5 to 2 mm long, 1 to 1.5 mm wide, truncated at the base, contracted to the apex, dorsal side strongly convex, ventral side almost straight; keel reaching almost to the apex, rather robust; central depression relatively large, oblong, surface secondarily (imprints of quartz grains) pitted. Somewhat smaller and thin-walled endocarp and further half showing interior may represent some immature specimens of the same type, or other species.

Remark: Clear endocarps of *Potamogeton* which have not been closely determined for the poor material.

Material: 5 specimens. Inventorized under Nos BK-5459, BK-5505, BK-5537

## ALISMATACEAE

*Caldesia* cf. *cylindrica* (E.M. REID) DOROFFEV (Pl. IX., Fig. 5):

Description: Fruits (endocarps), obovate in outline, 2 to 2.3 mm long and 1 to 1.5 mm wide, with ventral-apical style, about 0.22 mm long, dorsal side of endocarps is more convex than ventral side; surface with 2 to 4 longitudinal edges, finely pitted; pits arranged in the same longitudinal rows.

Remark: Specimens well agree with some endocarps described from the Pannonian and Pontian of southern Moravia (ČTYROKÝ and KNOBLOCH 1976, KNOBLOCH 1981a) and from the Pannonian of northern Slovakia (KNOBLOCH 1980). The species is known from the Lower and Upper Miocene of Germany (GREGOR 1982, Van der BURG 1988).

Material: 2 specimens. Inventorized under Nos BK-5497, BK-5518

## HYDROCHARITACEAE

*Stratiotes tuberculatus* C. et E.M. REID (Pl. VIII, Figs. 13-15, Pl. IX, Figs. 7-12):

Description: Seeds or seed halves of slender form, about 6 to 7 mm and 2.5 to 3 mm wide (but usually somewhat compressed and deformed); sculpture elements arranged in apparent and interrupted rows, in some case strongly corroded, keel usually well developed; micropylar collar relatively small, tiny or absent; micropylar canal often ventral, directed at right angle of locule; neck indistinct, raphe is not visible in the whole course but a hilum basal or subbasal.

Remarks: The sculpture of the seed is very variable even in the living species *S. aloides* L. (see COOK and URMI-KÖNIG 1983) therefore it may hardly be used as a reliable diagnostic feature in the fossil material. Generally, our material agrees with that of the species *S. tuberculatus* which has rather indefinite specific concept and may also be conspecific with *S. kaltännordheimensis* (ZENK.) KEILH. In every case, both fossil species are evidently closely related and their demarcation in morphological features is not clear (see KNOBLOCH 1989).

Material: 9 specimens including seed halves and numerous fragments, further comparative material from the Nyugat (West/Mine/see Pl. VIII, Figs. 13-15). Inventorized under Nos BK-5461, BK-5462, BK-5521

## CYPERACEAE

*Carex* sp. (Pl. IX, Figs. 1-4):

Description: Utricles, thin, rather elongated, more than 6 mm long and about 2 mm wide with many longitudinal striae (vascular bundles), gradually narrowed to the base, stalked; a few utricles show nut inside nuts are small, regularly spindle-like, with rather long (incomplete) style, triangular. long-stalked (stalk incompletely preserved), about 2 mm long (with cut stalk and style) and 1.5 mm wide; surface with very fine pits arranged longitudinally.

Remark: We have been unable to identify this material with any extant or fossil species of *Carex*.

Material: 5 utriculi with nuts, 4 isolated nuts, 3 incomplete utriculi and their fragments. Inventorized under Nos BK-5460, BK-5483, BK-5529

## ZINGIBERACEAE

*Spirematospermum wetzleri* (HEER) CHANDLER (Pl. VIII, Fig. 11):

Description: 5 to 8 cm long, 1.2 to 1.8 cm wide capsular fruit, with elongated, oval shape with the bottom and attenuated into a stem, and the top part rounded. On the edges blunt ribs are found which become smooth when reaching the stem. In longitudinal direction a fine fibrous arrangement can be observed on the external surface. The light setting of aligned seeds can be observed in the form of undulations and elevations visible on the capsule surface. Fruit finds were rather frequently damaged when embedded.

Seeds are 0.9 to 1 cm long, 3 to 4 mm wide, dark brown and have bright seed-coat. The bottom part ends with an oval germgate with a diameter of 0.5 mm, whereas the upper part ends with a spiked tip. They are characterized by a twisting of 45° along the longitudinal axis, which represents a mark excellent for identification.

Remark: The seeds with characteristic surface structure are rather common in the Pontian of southern Moravia (BUZEK 1962). From the Visonta region (Thorez, Keleti and Nyugati mines) they were already described by LASZLÓ 1991b).

Material: 5 seeds. Inventorized under Nos BK-5477, BK-5510

## ECOLOGICAL INTERPRETATION

The plant association is very complex and influenced by many biotic and abiotic factors. Some species are restricted in area and adapted to certain ecological conditions while the others have much wider ecological range and easily penetrate from their typical vegetation units into the transitional communities. In addition, fossil evidence from the studied washings is rather limited by a small number of preserved and/or determinable plant remains. Therefore, reconstruction of vegetation in the Visonta region may be now given only in general terms.

Generally, the plant assemblages obtained from washings of this region represent wetland forest including open water vegetation only with some influence of mesophytic forest, which may be explained by certain drift from outside into the basin. Such inset must be considered as allochthonous component in the studied more or less autochthonous assemblages.

The vegetation of wetland forest was rather diverse and differentiated horizontally in the landscape of different physiognomy. That is why almost all found assemblages reflect all 3 main types of the wetland vegetation - marginal riparian, swamp and open water vegetation.

In the Visonta region, coal-forming swamps are evidenced by *Glyptostrobus europaeus* which is very common and present in large numbers of twigs, cone-scales and seeds. Swampy plants as *Taxodium* sp., *Nyssa disseminata* and *Hellisoma* aff. *wetteraviensis* also occurred, however, they are rare in our material. *Spirematospermum wetzleri* belongs together with the latter to the low tree and shrub zone of the swamp forest. Hydrophyte herbs are represented here by *Caldesia* aff. *cylindrica* and *Oenanthe* sp.

Marginal riparian including periodically flooded forest is usually present and seems to be even dominated in the assemblages. This vegetation type was probably widespread in the region of the brown-coal basin at Visonta. In the tree zone of this unit *Alnus* sp. (cone remains, isolated cone - scales, catkin and leaf fragments) is dominating, associated with such taxa as *Carpinus* sp. ex gr. *betulus*, *Salix* sp., *Cornus* cf. *gorbunovii*, *Liriodendron* sp. and *Pterocarya* sp. In the shrub zone *Sambucus pulchella*, *Actinidia faveolata* and *Ilex* sp. occurred, with *Carex* sp., *Ranunculus* sp. and *Selaginella* sp. in the herbaceous undergrowth. Streamside vegetation of this community is represented by herbs as *Decodon gibbosus* and *Lycopus* cf. *europaeus*.

Representatives of the aquatic vegetation are regularly present in the studied assemblages. Beside surface floating types as *Nymphaea szaferi*, *Pseudoeurolia* cf. *dravertii*, *Nuphar palfalvyi*, *Salvinia* cf. *intermedia* and *Potamogeton* sp. div., such emerged water plant as *Stratiotes tuberculatus* and submerged type as *Ceratophyllum dubium* also occurred. Extinct *Hartziella miocenica* was probably subaquatic plant and can be associated with the last zone of the water vegetation.

This autochthonous flora is slightly influenced by the allochthonous elements transported by the streams or rivers into the basin. They are represented by cupules of *Fagus decurrens* and most probably by the remains identified as cf. *Stuartia beckerana* and cf. *Prunus* sp. which might occupy wider periphery of the basin. In general, some members of *Pinaceae* in the assemblages may be also considered as an allochthonous element.

However, the ecology of *Pinaceae* is rather varied. *Abies* is more often a component of the beach forests on moist and fertile soils. *Isuga* apparently represents the same moist forest vegetation. Compared with it, *Picea* usually grows on somewhat drier soils of elevated sites. Likewise the representatives of section *Pinus*, but some taxa of section *Strobus* may also grow in the moist communities.

#### CHARACTER OF CLIMATE AND STRATIGRAPHICAL RELATIONS

The materials from washings are characterized by the presence of the large number of swampy and aquatic plants. Regarding the climate only little can usually be deduced from such indifferent plants which are growing in the rather stable conditions of swamps. In spite of this fact, *Salvinia* is already represented by the evolutionarily younger section of genus, and the *Nymphaeaceae* include new types which then partly became extinct in the Pliocene. These changes may reflect local ecological factors or some climatic variation during the Upper Miocene and Pliocene time. However, such widespread Upper Miocene plant as *Caldesia* continuously persists in the Pliocene of Central Europe.

In this regard, the occurrence of *Fagus* attracted our attention for its clear record in a certain stratigraphical level of the Pannonian s.l. (e.g. in the uppermost Dacian to the lowermost Romanian) in this region where it was documented from the Pannonian and Pontian only on the basis of leaves. The cupules are well known from the Middle-Upper Miocene and Pliocene (Brunssumian and Reuverian) localities of Central and West Europe. Besides, they were recently described from the uppermost part of the "Indener Schichten" of the open mines Hambach and Fortuna in West Europe (Van der BURGH 1987). This sections of the sedimentary complex are most probably of Messinian age (Van der Burgh 1988). In the Hambach mine, further cupules of *Fagus* were found in the levels which are probably younger than Brunssumian in age (Van der BURGH 1983). Although the Messinian was correlated with the Pontian of Paratethys, the carpological floras from Visonta seem to be generally similar to those of the Hambach mine. The composition and climatic character of vegetation of these localities indicate some warm periods that apparently cover both time intervals of the Upper Miocene and Pliocene which are characterized by the presence of *Fagus*.

## CONCLUSIONS

General picture of the vegetation in the basin region at Visonta, northern Hungary, so far known from macrofloristic and palynological data, may be now completed by new results obtained from the washings materials.

As indicated by these plant remains, during the Upper Pannonian (e.g. uppermost Dacian to lowermost Romanian) it was a swampy landscape with very diversified vegetation of the wetland and marginal riparian forest including aquatic plants which had evidently a wide distribution in the open water conditions. The water vegetation was present by some younger representatives of *Salvinia* and *Nymphaeaceae*.

On the other hand, the upland forest occurring in the distant periphery of the basin is poorly documented in the washings, namely by *Fagus decurrens* and some conifers. The presence of genera such as *Fagus*, *Abies*, and *Tsuga* indicates warm temperate climatic period covered by levels between the coal seams I and II of the sedimentary complex at Visonta. This warm phase seems to be analogous with climatic phases of Messinian (Pontian), Brunssumian and post-Brunssumian (Reuverian) time, which are documented by floras from the Hambach and Fortuna mines and other localities in the Rhine basin where *Fagus decurrens* was also found.

## ACKNOWLEDGMENTS

We should like to thank to Dr. Z. KVAČEK for his anatomical data to the leaves of conifers and *Alnus*, and to Dr. M. KONZALOVA for her palynological verification in the case of male catkins of *Alnus*. Thanks are also to photolaboratories of Czech Geological Survey and Hungarian Geological Survey for preparing the photographs.

## ÖSSZEFOGLALÁS

1969-ben Visontán nyitották meg a Mátra-Bükkaljai lignitvonulat első nagyméretű külfejtését, a Thorez bányát. (1. ábra) Az ősnövénytan gyűjtőmunka 1977-ben kezdődött ebben a bányában, majd folytatódott a Visonta Ny-i, Visonta K-i és a bükkábrányi lignitkülfejtésben. A Thorez bányában 1983-ban lehetett utoljára gyűjteni. Az onnan előkerült igen érdekes flóra levélananyagát PÁLFALVY I. és RÁKOSI L. (1979), majd a levél és termésleleteket LÁSZLÓ J. (1989a/b, 1991a/b) írta le. A mag és termésleletek leíró feldolgozását ebben a munkában teszik meg a szerzők.

A Bükkaljai Lignit Formációba tartozó lignittelepes összlet keletkezése a pannoniai (s.l.) kor Daciai és Romaniai korszakára tehető.

A mag és termésanyag feldolgozása során nagyszámú olyan taxon került meghatározásra melyek a levélananyagban nem fosszilizálódtak. Így egy jóval gazdagabb és összetettebb növényzetű *Glyptostrobus* láp flóra és környezeti rekonstrukciója vált lehetővé.

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PLATE I.: Fig. 1 - Thorez mine, Visonta; the middle coal seam (II) with intercalation well visible / compare the profile on text-fig. Fig. 2 - Clays and sands to clayey sands with the stumps of trees and small lenses of plant debris including fruits, seeds and needles.

PLATE II.: Figs. 1-4 - *Salvinia* cf. *intermedia* NIKITIN ex DOROFFEV, sori, in lateral (Figs. 1 and 4), inner and basal views, x 20. Figs. 5-11 - *Ceratophyllum dubium* (LUDWIG) KIRCHHEIMER, fruits; 6, 7 the same specimen, opposite sides; 10, 11 - the same specimen, Fig. 11 shows inner

side with "mark" of the vascular bundles, x ca. 10. Fig. 12 - *Decodon gibbosus* (E. M. REID) E. M. REID, seed, x 20. Fig. 13 - *Liriodendron* sp., double seed. Figs. 14, 15. - *Oenanthe* sp., fruits x 20. Fig. 16 - *Lycopus* cf. *europaeus* L., fruit x 20. Fig. 17 - *Hartziella miocenica* SZAFER, fruit, x 15. All figured material from the Thorez mine, between coal seams I and II, if not otherwise stated.

PLATE III.: Figs. 1, 2 - *Selaginella* sp., megaspore, opposite sides, x 20. Figs. 3-5 - *Glyptostrobus europaeus* (BRONGN.) UNGER, two seeds and twig, x 6. Figs. 6-8 - *Tsuga* sp., needle leaves, x 6. Fig. 9 - *Ranunculus* sp., fruit, x 6. Fig. 10 - *Pinus* (*Strobus*) sp., brachyblast, x 6. Figs. 11, 12 - *Pinus* (*Pinus*) sp., brachyblast and fragment of needle leaf, x 6. Fig. 13 - *Alnus* sp., male catkin, x 10. Fig. 14 - *Sambucus pulchella* C. et E. M. REID, seed, x 10. Figs. 15-20 - *Abies* sp., needle leaves, x 6. Figs. 21, 22 - *Picea* sp., needle leaves, x 6.

PLATE IV.: Figs. 1-5 - *Nuphar palfalvyi* sp.n., seeds, x 10. Fig. 6 - *Actinidia faveolata* C. et E. M. REID, seed, x 20. Fig. 7 - *Nymphaea szaferi* KNOBLOCH, seed, x 15. Figs. 8, 9 - *Nyssa disseminata* (LUDWIG) KIRCHHEIMER, endocarp, opposite sides, x 3. Fig. 10 - *Sambucus pulchella* C. et E. M. REID, seed, x 15. Figs. 11-15 - *Pseudoeuryle* cf. *dravertii* DOROFEEV, seeds, x 10.

PLATE V.: Figs. 1-17 - *Alnus* sp.; 1, 2 - fragment of male catkin, opposite sides, x 10; 3 - another fragment (from Pl. VIII, Fig. 10) in cross section, with anthers and pollen sacs well seen, x 15; 4 - two scales of male catkin with pitted surface, x 10; 5-14 - female cones in different stages of destruction, opposite sides, x 3; 15-17 - isolated fruit scales, the last from inner (adaxial) side, x 10.

PLATE VI.: Figs. 1-4 - *Carpinus* sp. ex gr. *betulus* L., fruits, x 10. Fig. 5 - *Prunus* sp., endocarp, x 10. Figs. 6, 7 - *Pterocarya* sp., endocarp, from above and below, x 10. Figs. 8-11 - *Salix* sp.; 8-10 - bud scales, x 10; 11 - fruit, x 15. Figs. 12-14 - *Cornus* aff. *gorbunovii* DOROFEEV, endocarps, x 10. Fig. 15 - *Ilex* sp., endocarp, x 10.

PLATE VII.: Figs. 1-14 - *Fagus decurrens* C. et E. M. REID, cupules, opposite sides, with exception of specimens Figs. 1-3 and 12; 3 - incomplete cupule with two fruits, x 3; 13-14 - cupules from Figs. 4 and 6 showing two scars in the base of interior, x 10. Figs. 15, 16 - *Meliosma* cf. *wetteraviensis* (LUDWIG) MAI, endocarp in lateral views, x 10. Figs. 17, 18 - cf. *Stuartia beckerana* (LUDWIG) KIRCHHEIMER, fruit in lateral views, x 3.

PLATE VIII.: Figs. 1-9 - *Fagus decurrens* C. et E. M. REID; 1-3 - detached valves; 4, 5 - incomplete cupules; 6-9 - fruits of different form and size, all specimens x 3. Material for comparison, Visonta, Nyugati (West) mine, between coal seams I and II. Fig. 10 - *Alnus* sp., fragment of flattened male catkin in lateral view (see cross section on Pl. V, Fig. 3), x 10. Fig. 11 - *Sprematospermum wetzleri* (HEER) CHANDLER, x 3. Fig. 12 - *Taxodium* sp., seed, x 3. Figs. 13-15. - *Stratiotes tuberculatus* C. et E. M. REID, seeds and surface structure of testa in detail (SEM) from specimen on Fig. 14, x 12 and 100. Material for comparison, Visonta, Nyugati (West) mine, between coal seams I and II (Fig. 13) and between coal seams II and III (Fig. 14).

PLATE IX.: Figs. 1-4 - *Carex* sp.: 1 - isolated nut; 2-4 - urticuli with nuts inside, x 15. Fig. 5 - *Caldesia* cf. *cylindrica* (E. M. REID) DOROFEEV, fruit, lateral view, x 15. Fig. 6 - *Potamogeton* sp., fruit, lateral view, x 15. Figs. 7-12 - *Stratiotes tuberculatus* C. et E. M. REID, seeds, opposite sides, x 10.

PLATE X.: Figs. 1, 2 - *Pseudoeuryle* cf. *dravertii* DOROFEEV, seed wall in the section and cellular structure of the surface in detail (SEM), x 240 and x 900. Figs. 3, 4 - *Nuphar palfalvyi* sp.n., cap region of the seed and cellular structure of the surface in detail (SEM), x 300 and x 900. Figs. 5-12 - *Glyptostrobus europaeus* (BRONGN.) UNGER; 5 - cone, x 3.5; 6, 7 - cone scales, x 4; 8-12 - seeds, x 3.

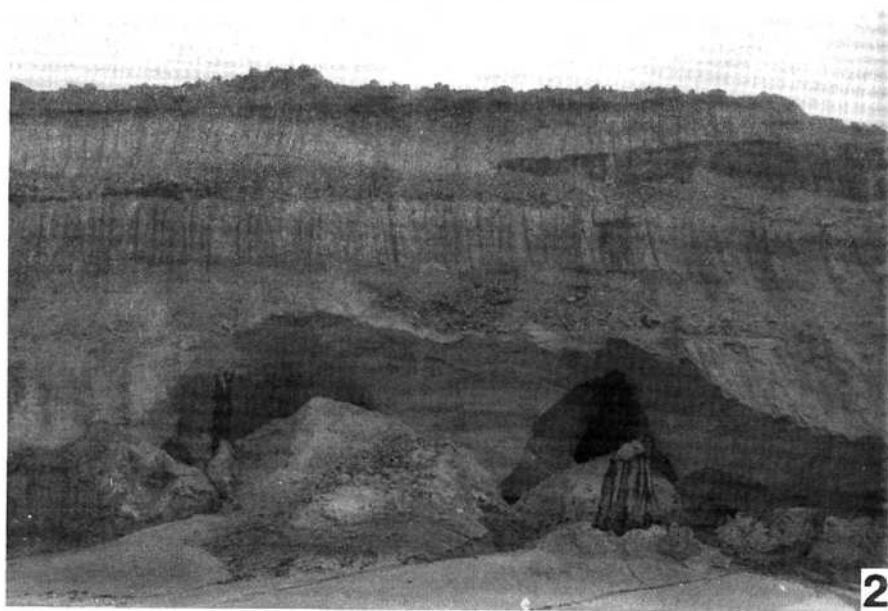
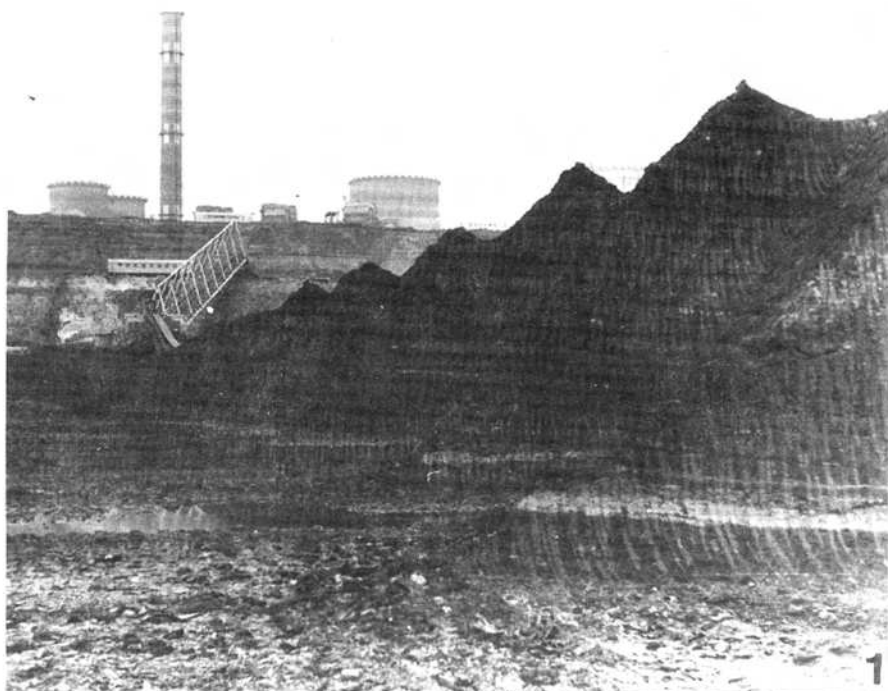
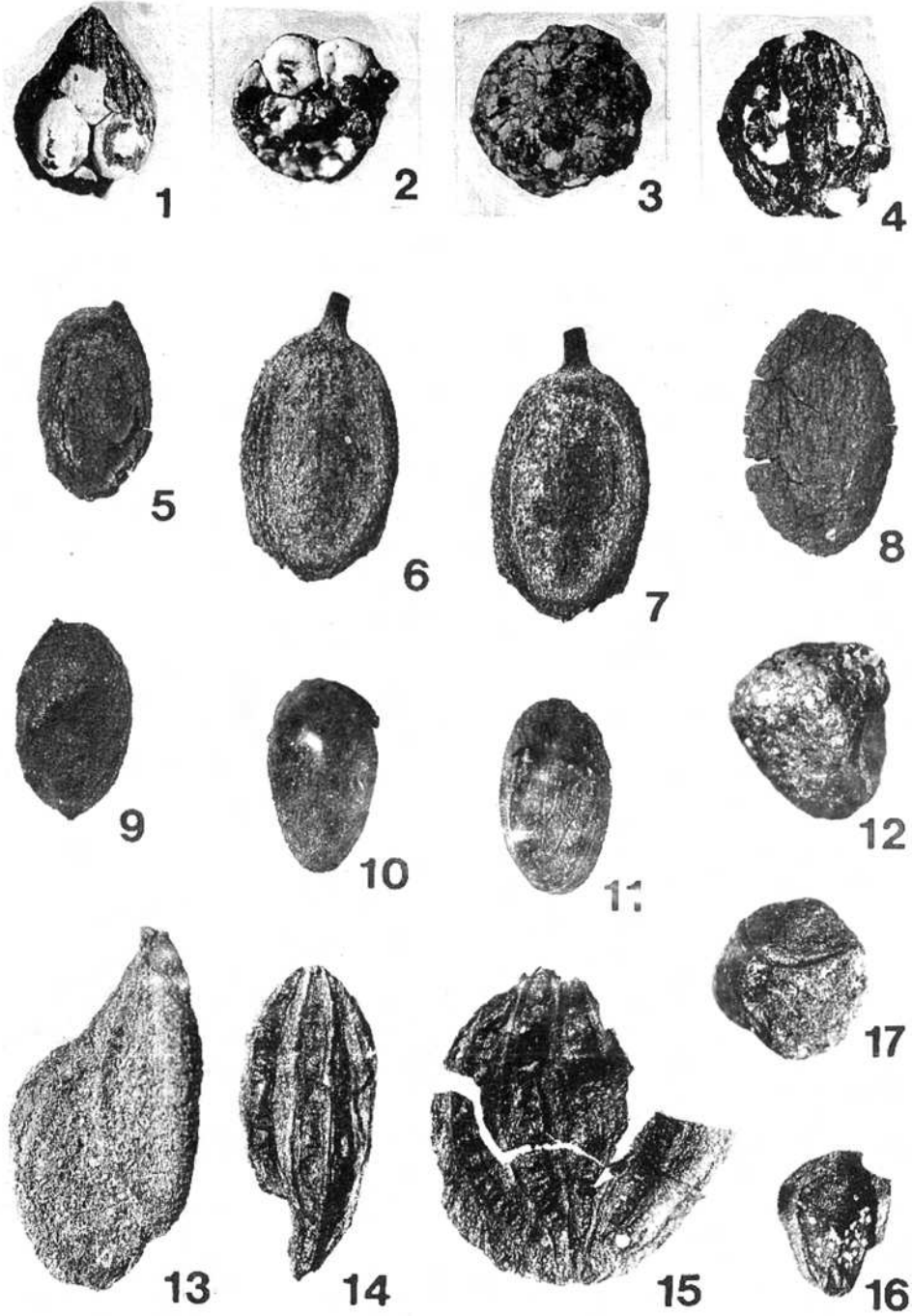


PLATE II.



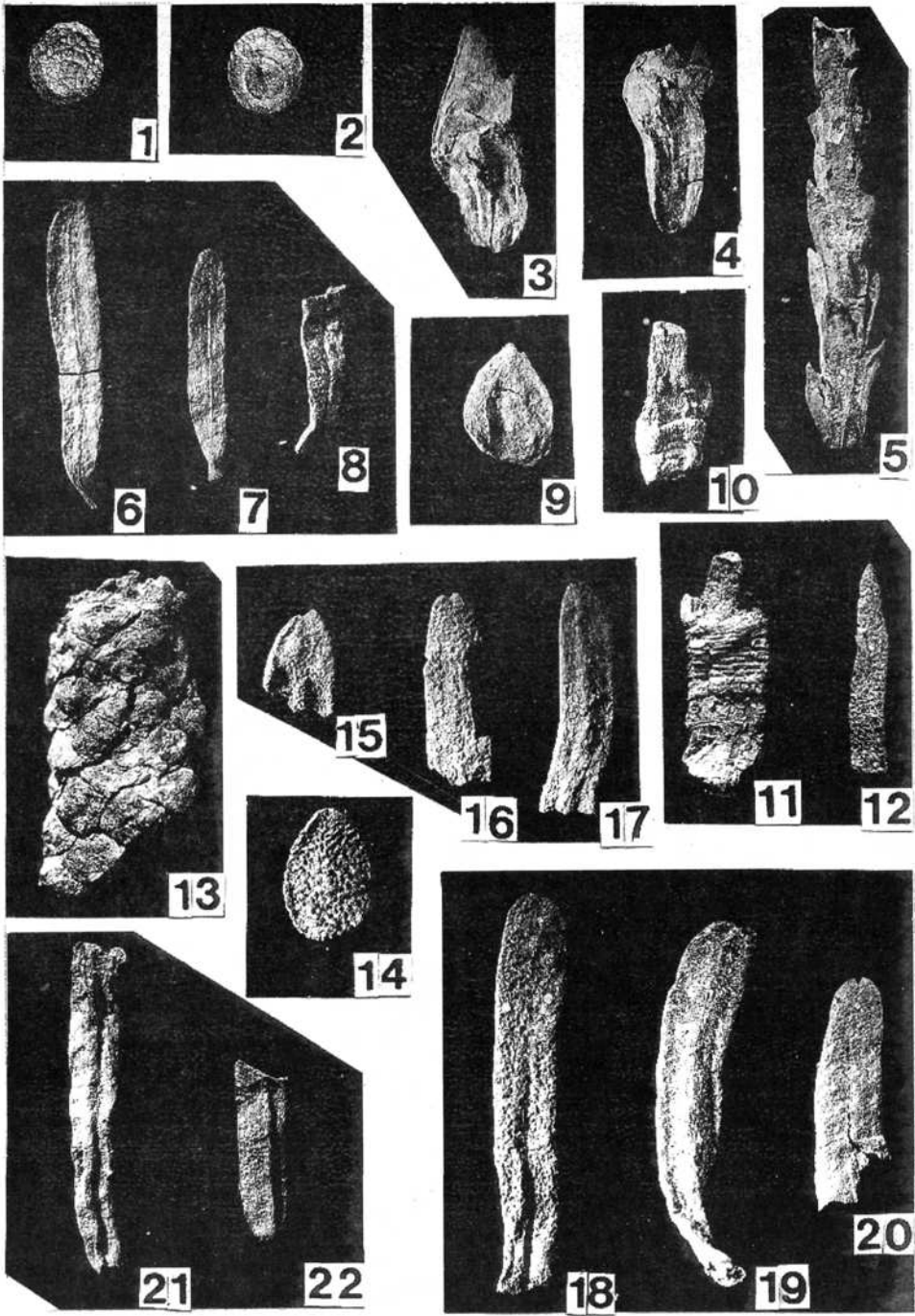
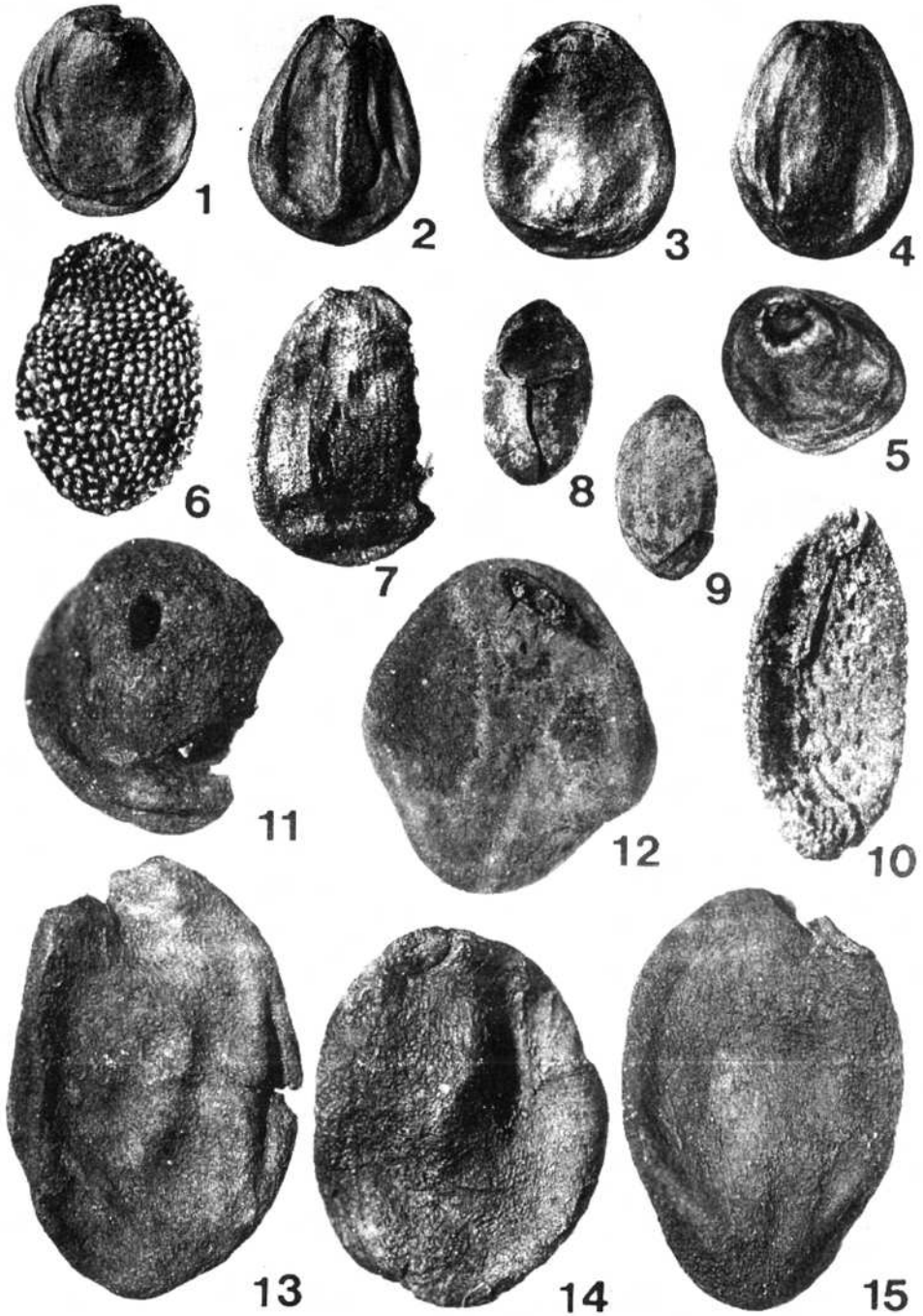
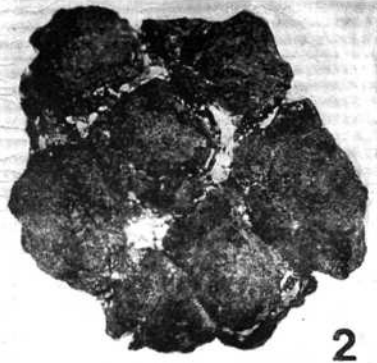


PLATE IV.





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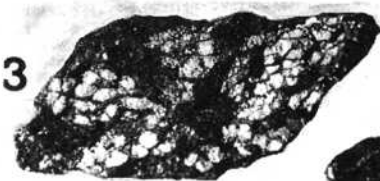
2



5



6



3



4



7



8



9



10



11



12



13



14



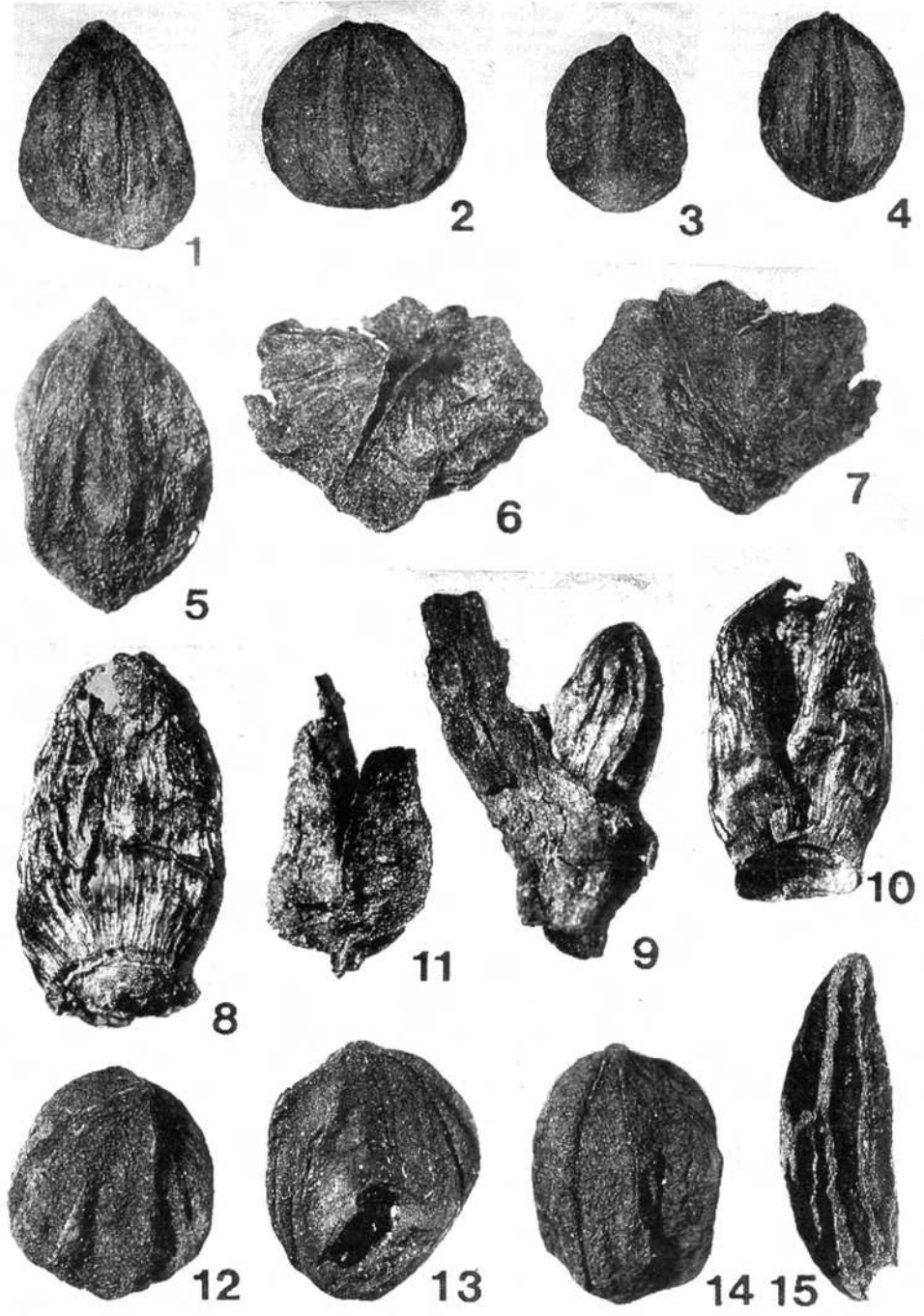
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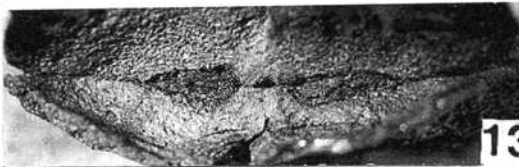
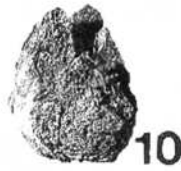


16



17





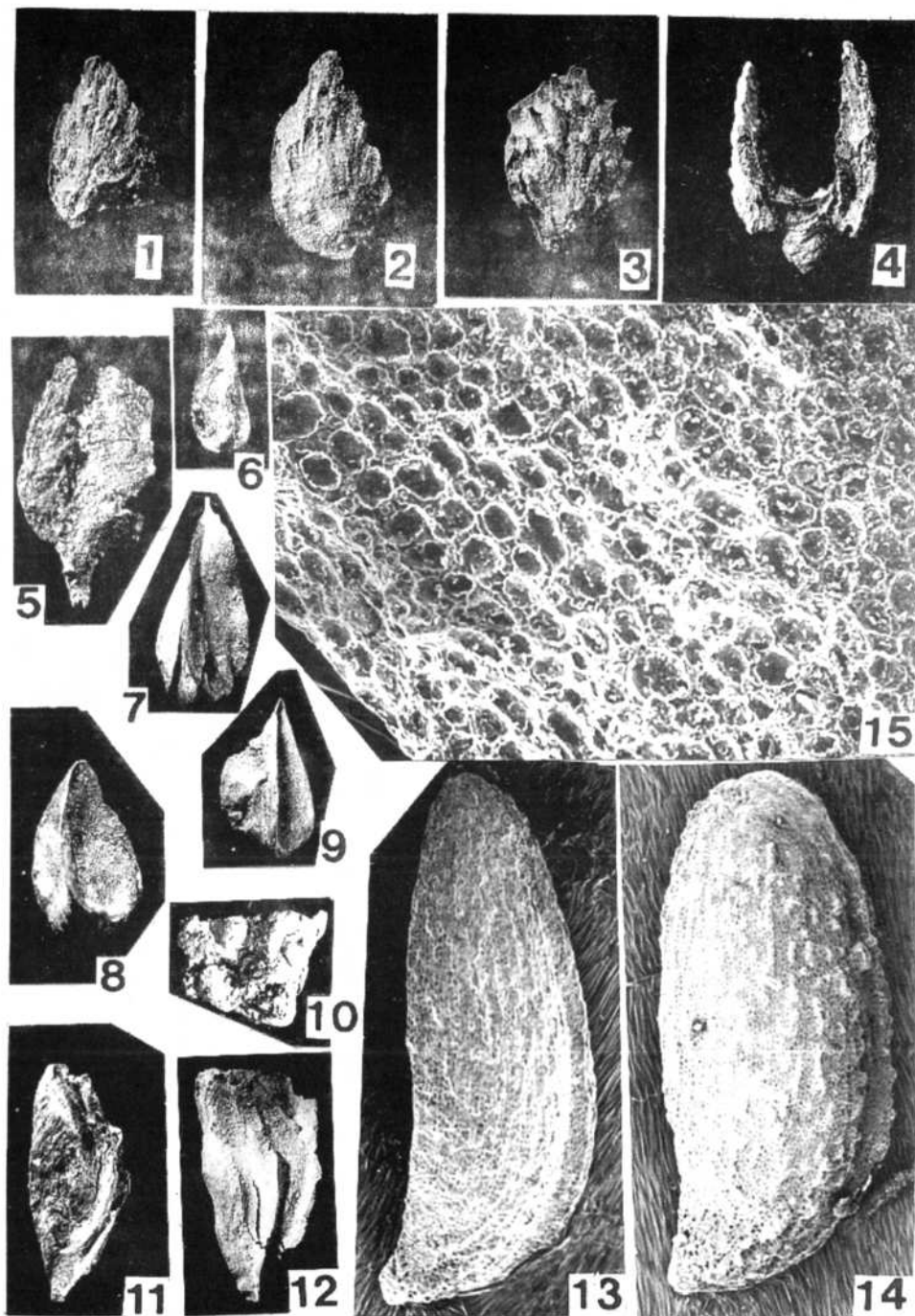
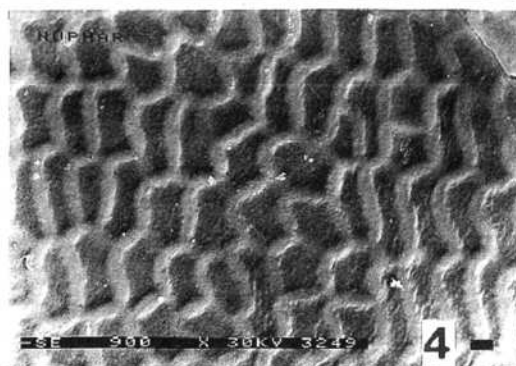
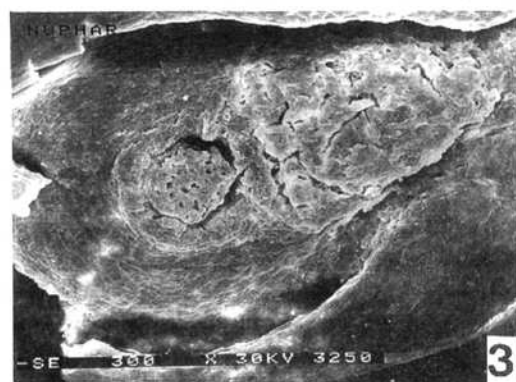
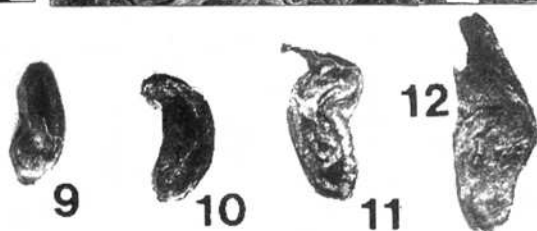
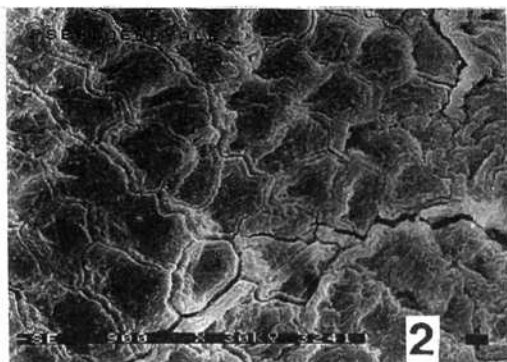
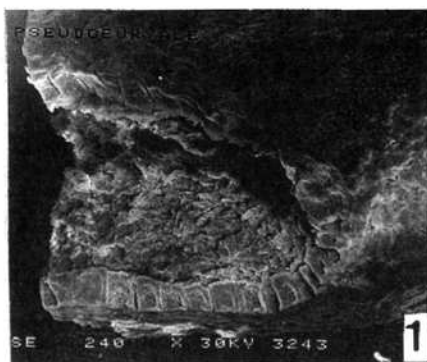




PLATE X.



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