Early Miocene conifer macrofossils from the Most Basin (Czech Republic)

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With 5 figures and 1 table

Abstract: A systematic overview of the conifer macrofossils (leaves, cones, seeds and wood) from the Lower Miocene of the Most Basin (Czech Republic) is presented and nine natural units (botanical species) are defined, belonging to three species of *Pinus* L. and one species of *Pseudolarix* Gordon, *Quasisequoia* Srinivasan & Friis emend. Kunzmann, *Taxodium* Richard, *Glyptostrobus* Endlicher, *Tetraclinis* Masters and *Cupressospermum* Mai emend. Kunzmann. Seeds of the latter taxon have been firstly described from the Most Basin. Different organs are rarely directly attached (pollen/seeds cones attached to a twig, a cone scale with seeds), but rather found in direct (close) or indirect (distant) association. The conifers are also characterized in environmental context as elements of several different vegetation types.

Key words: conifers, macrofossils, morphology, xylotomy, holistic approach, palaeoenvironment, Early Miocene, Most Basin, Czech Republic.

1. Introduction

The Most Basin (formerly the Northern-Bohemian Basin) is one of the most famous Tertiary palaeobotanical sites in the Czech Republic that has been continuously studied since the first half of the 19th century (e.g., Sternberg 1825). Sediments of the Most Basin have yielded over 160 various species of plant macrofossils (e.g., Kvaček et al. 2004a, b; Kvaček & Teodoridis 2007) and more than 100 species of pollen and spores (e.g., Konzalová 1976). Occurrences of conifers, due to their great quantity as well as their eye-catching, have been well collected and documented from different localities (Engelhardt 1876a, b; Menzel 1901; Brabenec 1909; Bůžek & Holý 1964; Kvaček 1976, 1989; Kvaček & Hurník 2000; Sakala 2000 etc.). The present study tries to summarize and evaluate existing data according to carpological, leaf morphological and xylotomic aspects following a holistic approach. It means to associate detached leaves and reproductive organs (cones and seeds) with fossil wood in order to reconstruct the whole plant as complete as possible (as it really looked like and lived in the area of the Most Basin in Early Miocene). The principles of this holistic approach, known also as a "Whole-Plant" concept, have been demonstrated by Kvaček (2004) for leaves and reproductive organs or by Sakala (2004) for association of wood with other organs. Recently, Martina Dolezych in her PhD Thesis (Dolezych 2005) and related papers (Dolezych et al. 2001; Dolezych & van der Burgh 2004; Dolezych in Junge et al. 2005; Dolezych & Schcneider 2006, 2007) sheds new light on relation

between different wood morphotaxa and their botanical affinities. The aim of the xylotomical part of the present paper is to re-evaluate the wood of Cupressaceae s.l. from the Most Basin in perspective of these new studies.

2. Geology, stratigraphy and dating of the Most Basin

The Most Basin is one of the five sedimentary basins of the Eger Graben and represents the largest freshwater sedimentary body of the Cenozoic in the Bohemian Massif. The total thickness of the younger part of the basin fill (i.e., Most Formation sensu Domácí 1977) is about 500 m in the center (Kvaček et al. 2004a). The base of the Most Formation has been estimated at the Oligocene/Miocene boundary (Bucha et al. 1987; Lotsch et al. 1994; Teodoridis 2002; Suhr 2003). The volcanic rocks underlying the Most Formation belong to the Střezov Formation sensu Domácí (1977), which consist of mostly deeply weathered lava flows and associated volcanogenic deposits. From the basin periphery, rivers and streams transported pebble, sand, silt and clay material into the basin. Deposits of the streams formed a relatively large belt of fluvial sandy facies ("Hlavačov Gravel and Sand" sensu Váně 1985) heading from central Bohemia and entering the basin near Žatec, then leaving the basin probably near Chomutov (Rajchl & Uličný 2005; Teodoridis 2004) or across the České středohoří Mts (Suhr 2003). These sediments formed the Duchcov Member of the Most Formation (Domácí 1977), i.e. Underlying Formation sensu Hurník & Marek (1962). They include well-known vertebrate localities, namely at Skyřice, Ahníkov and Tuchořice, all dated into the zone MN 3 (Fejfar 1989). During the Early Miocene, increasing subsidence of the basin caused spreading of flatland with the formation of swamps and shallow lakes (e.g., Rajchl 2006). In most parts of the basin, deposits of this period belong to the Holešice Member of the Most Formation (Domácí 1977). At first, only occasional flooding inundated wetlands. These transferred into periodically or steadily inundated local mires, where plant biomass accumulated as peat. This type of landscape stabilized in the basin during the formation of the Main Coal Seam. During flooding events the fluvial facies spread over large areas into the basin forming clayey-sandy layers in the peat. In the area of the larger vicinity of Žatec, where most streams discharged, sandy deposits prevailed due to lowering of the river gradient (cf. Rajchl & Uličný 2005), so that the conditions for peat formation were only limited and short-termed (known as "Žatec Delta" facies). Later, a partial stream reached the environs of Bílina, where a delta body originated (e.g., Mach 1997; Rajchl et al. in press). As already stated above, these deposits containing lignite seams and equivalent sandy-clayey delta bodies have been included into the Holešice Member (Domácí 1977). Generally, the above-mentioned sandy-clayey deposits, i.e. Lower Sandy-Clayey Beds with Basal Coal Seam, Lower Interseams Beds, Upper Interseam Beds sensu Hurník & Marek (1962), divided the Main Coal Seam into the Lower Seam Beds, Middle Seam Beds and Upper Seam Beds sensu Hurník & Marek (1962). The clay/claystone facies (Overlying Formation sensu Hurník & Marek 1962) spread over the mire and buried the peat layer. These mighty strata have been included into the Libkovice Member (Domácí 1977). In the Bílina area, the base of this member is built of the Břešťany Clay. While the Bílina Delta ceased to exist, several small streams entered the basin from the north (e.g., at Jezeří) and some others existed at Ústí nad Labem and Žatec. Northern streams transported less extensive sands but influenced the character of clay layers deposited in the lake by bringing traces of mica. Later the lake extended probably well beyond today's limits of the basin. In the area of the "Žatec Delta", the Libkovice Member is developed partly in the sandy-clayey facies, e.g., at the locality Přívlaky (Teodoridis 2006). At about 17-18 Ma (Bucha et al. 1987; Malkovský 1995), the lake was already almost filled and shallow swamp and mire conditions reappeared in the environs of Lom in the central part of the basin. This uppermost part of the Most Formation is defined as the Lom Member sensu Domácí (1977). It represents an incomplete denudation relict of limited extent and contains the Lom Seam.

3. Material and methods

The fossil leaf and carpological material studied here has been collected at different times and by various people. The first critical revision of leaf and cone material from the Most Formation was published by Menzel (1901). Additional material was collected during a previous fieldwork in sixties and seventies of the last century, by Č. Bůžek and F. Holý from the opencast mines of J. Šverma, J. Fučík, Bílina and Maxim Gorkij and from the cores: Břežánky (B 1, B 4), Droužkovice (Do 201, Do 206, Do 210, Do 211, Do 215), Chomutov (Co 199, Co 201, Co 210, Co 215, Co 225, Co 228), Chotěbudice (Cht 8), Havráň (Hň
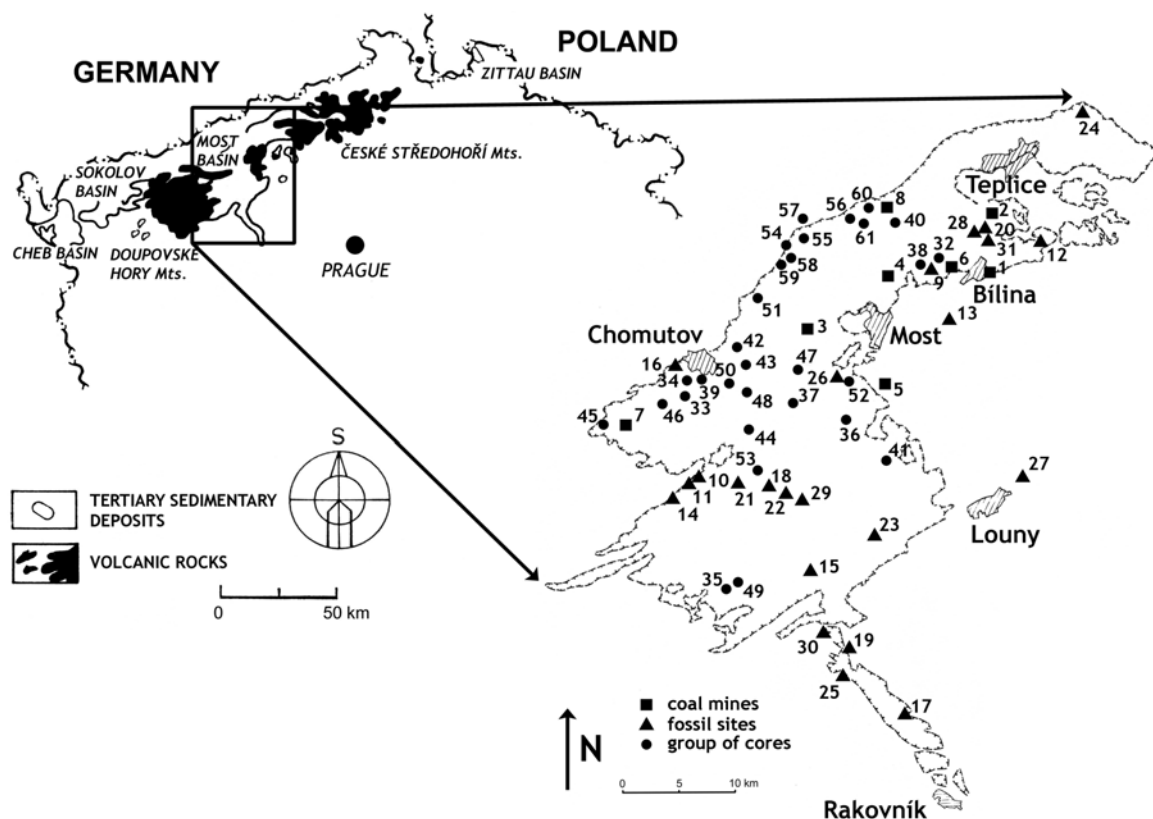
Fig. 1. Location of the fossil plant material studied from coal mines, fossil sites and cores in the area of the Most Basin and the "Hlavačov Gravel and Sand". – i.e., 1. Bílina Mine, 2. J. Fučík Mine, 3. J. Šverma Mine, 4. Ležáky Mine, 5. Marianna Mine, 6. Maxim Gorkij Mine, 7. Nástup-Tušimice Mine, 8. S. K Neumann Mine, 9. Břešťany, Břežánky, 10. Čermníky, 11. Chotěnice, 12. Chuděřice, 13. Dobrčice, 14. Dolany, 15. Holedeč, 16. Hradiště near Černovice, 17. Nesuchyně, 18. Přívlaky, 19. Sádek, 20. Straky, 21. Stranná, 22. Stroupeč, 23. Tuchořice, 24. Varvažova near Chlumec, 25. Velká Černoc, 26. Vršany, 27. Vršovice, 28. Zabrušany, 29. Záhoří near Žatec, 30. Želeč, 31. Želénky, 32. Břežánky (cores: B 1 and B 4), 33. Droužkovice (cores: Do 201, Do 206, Do 210, Do 211 and Do 215), 34. Chomutov (cores: Co 199, Co 201, Co 210, Co 215, Co 225 and Co 228), 35. Chotěbudice (core Cht 8), 36. Havráň (cores: Hň 35 and Hň 36), 37. Hošnice (core Hš 4), 38. Jenišův Újezd near Bílina (core Jú 224), 39. Kralupy near Chomutov (core Kr 11), 40. Libkovice (cores: Lb 77 and P 542), 41. Moravěves (cores: Ma 6 and Ma 8), 42. Otvice (cores: Ot 27 and Ot 36), 43. Pesvice (cores: Pe 18, Pe 19 and Pe 21), 44. Přečáply (core Pč 4), 45. Prunéřov (cores: Pn 130 and Pn 138), 46. Spořice (core Sp 95), 47. Strupčice (cores: Sr 39, Sr 40 and Sr 53), 48. Škrle (core Šk 3), 49. Široké Třebčice (core Štb 43), 50. Údlice (cores: Úd 80 and Úd 81), 51. Vysoká Pec (cores: VP 14, VP 15 and VP 16), 52. Vršany (cores: Vr 20 and Vr 22), 53. Vysočany (core Vy 1), 54. Černice (core CN 54), 55. Horní Jiřetín (core HJi 142), 56. Horní Litvínov (core LiH 13), 57. Janov (core Ja 28), 58. Jezeří (cores: JZ 42, JZ 44, JZ 47 and PVJK 234), 59. Kundratice (cores: KU 108, KU 114, KU 115, KU 116 and KU 127), 60. Lom (core LOM 16), 61. Mariánské Radčice (cores: MR 58 and MR 59).

35, Hň 36), Hošnice (Hš 4), Jenišův Újezd near Bílina (Jú 224), Kralupy near Chomutov (Kr 11), Libkovice (Lb 77, P 542), Moravěves (Ma 6, Ma 8), Otvice (Ot 27, Ot 36), Pesvice (Pe 18, Pe 19, Pe 21), Přečáply (Pč 4), Prunéřov (Pn 130, Pn 138), Spořice (Sp 95), Strupčice (Sr 39, Sr 40, Sr 53), Škrle (Šk 3), Široké Třebčice (Štb 43), Údlice (Úd 80, Úd 81), Vysoká Pec (VP 14, VP 15, VP 16), Vršany (Vr 20, Vr 22), Vysočany (Vy 1), Chuděřice (dug pit) – partly published in BŮŽEK & HOLÝ (1964). The other studied leaf, carpological and xylotomic samples come from elsewhere, i.e. Břešťany and Břežánky – see UNGER (1841-1847, 1852, 1861, 1864, 1866), ETTINGSHAUSEN (1866, 1868, 1869),

Čermníky (BŮŽEK 1971), Chotěnice (BŮŽEK 1971), Chuděřice, Dobrčice (KVAČEK & HURNÍK 2000), Dolany (BŮŽEK 1971), Holedeč (BRABENEC 1904; TEODORIDIS 2002), Hradiště near Černovice (ENGELHARDT 1877), Nesuchyně (NĚMEJC 1949; TEODORIDIS 2002), Přívlaky (TEODORIDIS 2006), Sádek (TEODORIDIS 2002), Straky (KVAČEK & HURNÍK 2000), Stranná, Stroupeč (KONRÁDOVÁ 1959), Tuchořice (KVAČEK & BŮŽEK 1982), Varvažova near Chlumec, Velká Černoc (TEODORIDIS 2002), Vršany (KVAČEK & HURNÍK 2000), Vršovice (VELENOVSKÝ 1881, KVAČEK & HURNÍK 2000), Zabrušany (KVAČEK & HURNÍK 2000), Záhoří near Žatec (TEODORIDIS 2003), Želeč

Hurník and Marek 1962		Domácí 1977	age
P R O D U C T I V E	Overlying Fm.	Lom Mb. **a1**	Early
		Libkovice Mb.	
		a2	
S E R I E S	S E A M F M	Upper Seam Beds **b**	Miocene
		Upper Interseam Beds **c**	
		Middle Seam Beds **d**	
		Lower Interseam Beds **e**	
		Lower Seam Beds **f**	
		Lower Sandy-Clayey Beds with Basal Coal Seam **g**	
		Holešice Mb.	
	Underlying Fm.	Duchcov Mb. **h**	
Volcano-detritic Series		Střezov Fm.	Oligocene
Basal Series		Staré sedlo Fm.	Eocene

Fig. 2. Summary of the stratigraphical classification of the Most Basin sediments (modified to KVAČEK & HURNÍK 2000).

(TEODORIDIS 2002), Želénky (KVAČEK & HURNÍK 2000), from other cores, i. e., Černice (CN 54), Horní Jiřetín (HJi 142), Horní Litvínov (LiH 13), Janov (Ja 28), Jezeří (JZ 42, JZ 44, JZ 47, PVJK 234), Kundratice (KU 108, KU 114, KU 115, KU 116, KU 127), Lom (LOM 16), Mariánské Radčice (MR 58, MR 59) – see in detail KVAČEK & BŮŽEK (1982), TEODORIDIS & KVAČEK (2006), and from still working (w) or former mines of Bílina (w), Nástup-Tušimice (w), Ležáky, Marianna and SK Neumann – for detailed location see Fig. 1.

The above-mentioned fossil material is housed in the paleobotanical and geological collections of the National Museum, Prague (NM), the Institute of Geology and Palaeontology, Faculty of Science, Charles University in Prague (UK), Bílina Mine (DB), Nástup-Tušimice Mine (DNT), Regional Museum of Teplice (RMT), Museum of Mineralogy and Geology in Dresden, Germany (MMG PB) and in private collections of Mr. Z. DVOŘÁK and Mr. J. VYKYDAL.

The fossil carpological material represents compressed, carbonaceous and three-dimensionally preserved fossils and was obtained from the cores mainly by washing. The leaf fossils studied are preserved both as impressions and as compressions with cuticle remains also preserved. The wood is preserved either permineralized (mainly silicified but also impregnated by other minerals as siderite, limonite or dolomite) or lignified as a hard xylite. All xylotomical observations were based on standard thin mineralogical sections cut following three planes: transversal, tangential and radial. In the case of several fragile xylitic specimens, the material was hardened before cutting by resin.

The comparative extant material was obtained from the herbaria of the Charles University, Prague (PRC) and National Museum, Průhonice (PR), W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków (KRA) and

Fig. 3. 1-2. *Pinus rigios* (UNGER) ETTINGSHAUSEN. 1. Three-needle fascicle, locality the Nástup-Tušimice Mine, DNT 201, scale bar 10 mm. 2. Incomplete 3-needle fascicles terminally attached to a branch, locality Břeš'any, MMG PB Bn 406, scale bar 10 mm. **3-5.** *Pinus engelhardtii* MENZEL, locality Břeš'any. 3. Two seed cones sub-oppositely attached to a branch, MMG PB Bn 355, scale bar 10 mm. 4. Complete seed cone, MMG PB Bn 390, scale bar 10 mm. 5. Complete seed cone, MMG PB Bn 348, scale bar 10 mm, (originally described as *P. horrida* MENZEL 1901, pl. 4, fig. 1). **6-7.** *Pinus urani* (UNGER) SCHIMPER, locality the Nástup-Tušimice Mine. 6. Incomplete seed cone, DNT 209, scale bar 10 mm. 7. Basal part of incomplete seed cone, DNT 213, scale bar 10 mm. **8-10.** *Pinus ornata* (STERNBERG) BRONGNIART, locality Břeš'any. 8. Incomplete seed cone, MMG 321, scale bar 10 mm. 9. Apical part of seed cone, RMT PA 1458, scale bar 10 mm. 10. Incomplete basal part of seed cone, RMT PA 1457, scale bar 10 mm. **11-13.** *Pinus* sp. indet., complete winged seeds, locality the Bílina Mine. 11. DB 2-79, scale bar 5 mm. 12. DB 11-80, scale bar 5 mm. 13. DB 71-74, scale bar 5 mm. **14-15.** *Pinus* sp. 1, cylindrical male cone, locality the Bílina Mine. 14. DB 73-78, scale bar 5 mm. 15. DB 11-78, scale bar 5 mm. **16.** *Pinus* sp. 2, five-needle fascicle, locality Velká Černoc, UK VČ-64, scale bar 5 mm. **17-18.** *Pseudolarix schmidtgenii* KRAEUSEL, locality Nesuchyně. 17. Isolated complete cone scale, UK Nn-50, scale bar 10 mm. 18. Incomplete winged seed, UK Nn-51, scale bar 5 mm. **19.** *Pseudolarix* sp., needle fragment, locality Nesuchyně, UK Nn-8, scale bar 10 mm. **20.** *Cupressospermum saxonicum* (MAI) KUNZMANN, seed, locality Jenišův Újezd (core JÚ 224, depth 151.2 m), NM G08555, scale bar 500 µm.
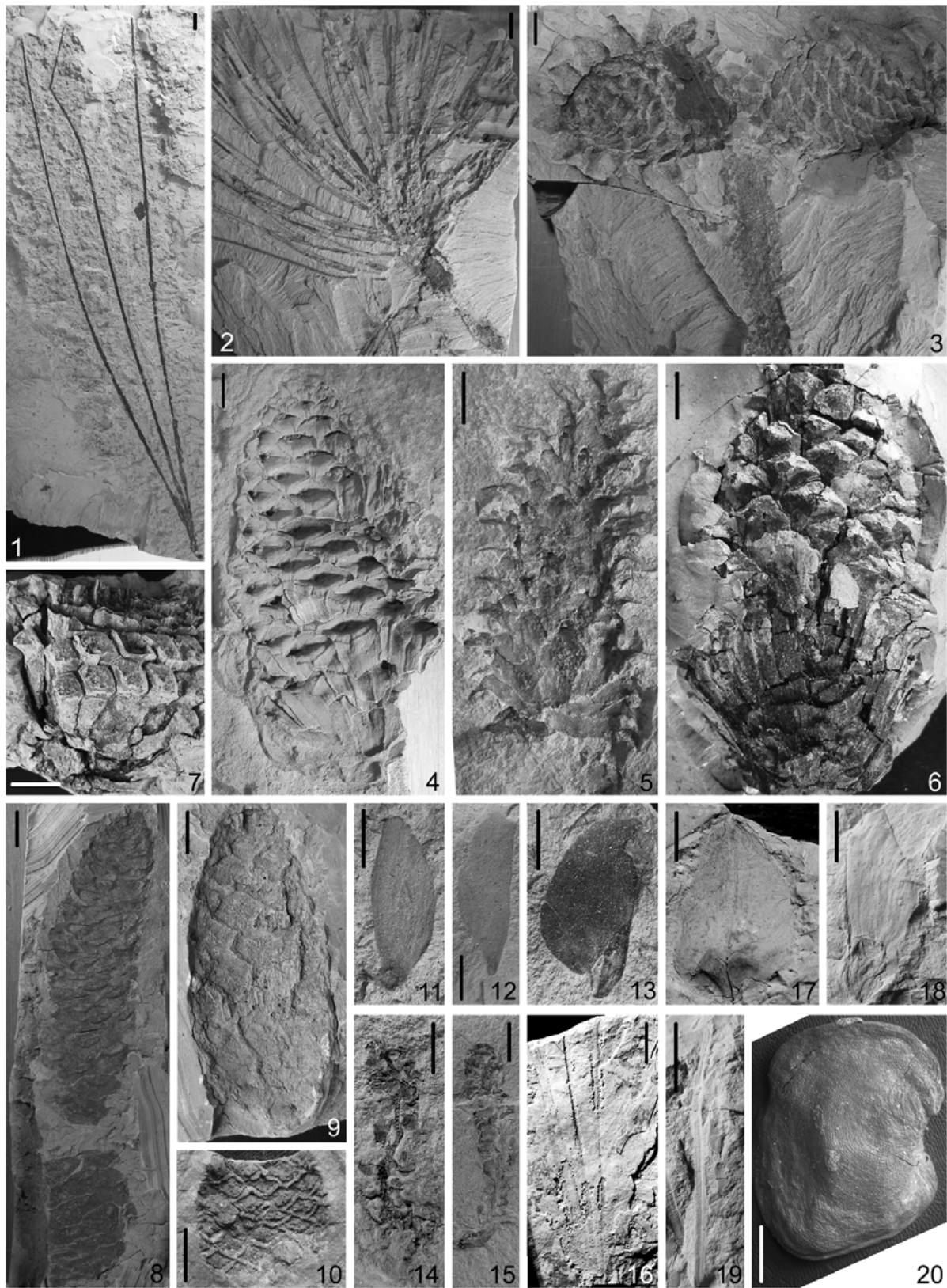
Fig. 3 (Legend see p. 290)

Institut de Botanique, Université de Montpellier II, Montpellier (MPU) and the comparative xylotomical collections of the Laboratoire de paléobotanique et paléoécologie (UPMC, Paris).

Basic observations were made using a binocular microscope. A digital camera Panasonic DMC-FZ8 was used for documentation of the leaf and cone macrofossils. An electron microscope (SEM) was used for detailed studies and documentation. The specimens were examined using a Jeol JSM – 6380 LV scattered electron microscope at 15 kV (Institute of Geology and Palaeontology, Faculty of Science, Charles University in Prague). Currently accepted morphological terminology follows Farjon (2005a, b) for leaves, cones and seeds and IAWA Committee (2004) for softwood anatomy.

Symbols "a, b, c, d, e, f, g, h" are used in the next text to mark different stratigraphical levels of the Most Basin (Fig. 2) and follows mainly informal stratigraphy given by Hurník & Marek (1962): Underlying Formation (h) – i.e., Duchcov Member sensu Domácí (1977); Lower Sandy-Clayey Beds with Basal Coal Seam (g), Lower Seam Beds (f), Lower Interseams Beds (e), Middle Seam Beds (d), Upper Interseam Beds (c) and Upper Seam Beds (b) – i.e., Holešice Member sensu Domácí (1977) and Overlying Formation (a) – i.e., Libkovice Member (a2) and Lom Member (a1) sensu Domácí (1977). Symbols "E1 (herbs), E2 (shrubs and lianas), E3 (trees under 25 m high) and E4 (trees over 25 m high)" are used for distinguishing vegetative storeys in environmental reconstruction.

4. Systematic part

<div align="center">

Pinaceae Adans.

Pinus L.

</div>

1. *Pinus engelhardtii* plant

1.1. *Pinus engelhardtii* Menzel 1901 emend. Mai 1986 (cones and seeds)
Fig. 3.3-3.5

1877   *Pinus hordacea* (Rossm.). – Engelhardt, p. 372, pl. 1, fig. 4.
1877   *Pinus oviformis* (Endl.). – Engelhardt, p. 371, pl. 1, fig. 1.
1901   *Pinus engelhardtii*. – Menzel, p. 57, pl. 3, fig. 28.
1901   *Pinus oviformis* (Endl.) Engelhardt. – Menzel, p. 50, pl. 2, fig. 1.
1901   *Pinus hordacea* Rossm. – Menzel, p. 52, pl. 2, fig. 5, pl. 3, figs. 23-27 (pro parte).
1986   *Pinus engelhardtii* Menzel. – Mai, p. 582, pl. 46, figs. 3-9, pl. 47, figs.1-3, pl. 50, fig. 5, text-fig. 4.

Material: Incomplete seed cones and their fragments (C) and winged seeds (S) – localities: Břešt'any, Břežánky [a2] (C), Bílina Mine [a2, b] (C, S), Hradiště near Černovice [a2] (C), Nástup-Tušimice Mine [a2] (C) and Varvažova near Chlumec [a2] (C); – cores: Kundratice /KU 115, depth 93-96.9 m [a2] (C), KU 116, depth 105-108 m [a2] (C)/ and Jezeří /PVJK 234, depth 83-84 m [a2] (C)/.

Description: Seed cones middle sized, slightly asymmetric, ovate in outline, 45.7-(101.5)-132.5 mm long and 21.2-(58.9)-67.9 mm broad, apophysis broadly rhombic, robustly conic to distinctly arched or uncinate, 7.9-(17.9)-20.4 mm long and 9.2-(10.1)-12.4 mm broad, maximal height up to 9.2 mm; umbo short, blunt, centromucronate, mucro small, often indistinct. Seed cones rarely sub-oppositely attached to a branch. Seeds winged, broadly oval in outline, 35 mm long and 6 mm broad (in the middle part), seed part broadly oval, 7 and 10 mm long, 4 and 5 mm broad, located basipetally and symmetrically to wing, wing apex obtuse, striation not preserved.

Remarks: Menzel (1901: 57, pl. 3, fig. 28) typified this taxon on the cone material from the locality Trmice (Thürmitz). An older and more common synonym of *P. engelhardtii* was *Pinus oviformis* (Endl.) Engelhardt known from the localities Hradiště near Černovice (Engelhardt 1877: 371, pl. 1, fig. 1; Menzel 1901: 50, pl. 2, fig. 3b) and Břešt'any, Věšt'any near Teplice and Lipenský háj near Teplice (Menzel 1901: 50, pl. 2, figs. 1, 2, 3a, 4). However, cone material of *P. oviformis* from Staré Sedlo (Endlicher 1847: 287) shows morphological similarity to *P. stroboides* (Rossm.) Mai – e.g., Mai (1986), Knobloch et al. (1996), Bůžek et al. (1996). Menzel (1901, pl. 2, fig. 5, pl. 3, figs. 23-27) described incomplete cone and 5 isolated scales including 2 incomplete winged seeds (in situ) as *P. hordacea* from Břešt'any. This carpological material shows also an affinity to *P. engelhardtii*. Raniecka-Bobrowska (1962) noted a cone impression of *P. engelhardtii* from the Early Miocene locality Osieczow upon Kwisą (Zastawniak, personal communication 2008) and calculated *P. roxburghii* Sarg. from mountain forests of the Himalayas as a living analogue. Mai (1986: 583) excluded this species as well as other pines from section *Sula* sensu Mayer because of longer seeds (over 20 mm) and centromucronate umbo of the fossil material, which matches better to pines of subsections *Pinaster* or *Australes* sensu Farjon (2005a). *P. engelhardtii* often co-occurs with leaves of *P. rigios* (Ung.) Ett. – see below. According to this fact, living pines of subsection Australes from the USA, Mexico and the Caribbean (e.g., *P. taeda* L. or *P. rigida* Miller) are comparable to *P. engelhardtii* – e.g., Kvaček et al. (2004b). Recently, Dieni & Mai (2007) re-described *Pinus priabonensis* Omboni from the Upper Oligocene of NE Italy together with a detailed key of other "centro-mucronate" pines.

1.2. *Pinus rigios* (Unger 1850) Ettingshausen 1866 (leaves)
Fig. 3.1-3.2

1850   *Pinites rigios* Unger, p. 362.
1852   *Pinites rigios* Unger, p. 25, pl. 13, fig. 3.
1866   *Pinus rigios* (Ung.). – Ettingshausen, p. 41, pl. 13, figs. 11-12.
1877   *Pinus hordacea* Rossm. – Engelhardt, p. 373, pl. 1, figs. 10-11.
1901   *Pinus rigios* Ung. – Menzel, pp. 61-62, pl. 3, figs. 1-4.

Material: Rarely complete or incomplete fascicles of needles and their fragments (N) rarely attached to a branch – localities: Břešťany, Břežánky [a2], Bílina Mine [a2, b], Hradiště near Černovice [a2] and Nástup-Tušimice Mine [a2].

Description: Isolated 3 - needled fascicles, needles 145.6 to 347.6 mm long and 2.2 to 2.6 mm broad, straight or slightly curved, primarily triangular in transversal section, secondarily compressed, apex acute to attenuate (rarely preserved), sheath 12.4-(18.8)-27.9 mm long and 2.86-(4.1)-5.1 mm broad, base rounded, margin entire, venation consisting of one medial vein (till 0.33 mm broad), parallel striation observed. Fascicles rarely attached to a branch.

Remarks: This species has a rather cumulative character due to its broad stratigraphical range and relatively large area, i. e. from the Late Oligocene to the Pliocene of Europe. MAI (1999: 15) commented the great morphological affinity to other fossil species, e. g., *P. gracilis* SAPORTA, *P. trichophylla* SAPORTA, *P. taedaeformis* (UNG.) HEER, *P. palaeotaeda* ETT. etc. *P. rigios* is typified on the leaf material from Bílina (UNGER 1850: 362), which was figured by UNGER (1852: 25, pl. 13, fig. 3). ETTINGSHAUSEN (1866) described the leaf material of *P. rigios* from Břešťany and Břežánky in association of one cone (ETTINGSHAUSEN 1866: 41, pl. 13, fig. 15) having probably affinity to *P. engelhardtii*. MENZEL (1901) figured new material from Břešťany and Sokolov (Falkenau) and commented possible leaf similarity with *P. hordacea* ROSSM. (ENGELHARDT 1877: 373, pl. 1, figs. 10-11) from Hradiště near Černovice. MAI (1999: 15) added an anatomical and epidermal characteristics of *P. rigios* from the Spremberg sequence from the second brown coal horizon in the Lausitz region (also in BŮŽEK et al 1996). However, he noted the dentate leaf margin and described his leaves as *Pinus* cf. *rigios*. It is possible to assume the association of these leaves and cones of the above-described species of *P. engelhardtii* based on the co-occurrence of both species in localities of Břešťany (Bílina Mine), Nástup-Tušimice Mine and Hradiště nearČernovice. Leaves of *P. rigios* are also known from the Cheb and Sokolov basins (RŮŽIČKA & BENEŠ 1951; BŮŽEK et al. 1996). According to the leaf morphological analysis, *P. rigios* shows an affinity to extant species of *P. taeda* L. and *P. rigida* MILL. (e. g., ETTINGSHAUSEN 1866) and/or other species from section *Pinaster* (MAI 1999). BŮŽEK et al. (1996) compared the fossil material of *P. rigios* from the Cypris Shale to extant *P. taeda* based on the needle length. However, this living species possesses dentate needles, which is not the case of the material from the Cypris Formation as well as the type area at Bilina.

2. *Pinus ornata* plant

2.1. *Pinus ornata* (STERNBERG 1825) BRONGNIART 1828
Fig. 3.8-3.10

1825   *Conites ornatus* STERNBERG, p. 39, pl. 55, figs. 1-2.
1828   *Pinus ornata* (STERNBERG). – BRONGNIART, p. 107.

1876a   *Pinus ornata* STERNBERG. – ENGELHARDT, p. 61, pl. 10, fig. 4.
1877   *Pinus ornata* STERNBERG. – ENGELHARDT, p. 47, pl. 2, fig. 4.
1901   *Pinus ornata* STERNBERG. – MENZEL, p. 54, pl. 2, figs. 6-7, 9.
1968   *Pinus ornata* (STERNBERG) BRONGNIART. – NĚMEJC, p. 384, pl. 39, figs. 2-3.
1994   *Pinus ornata* (STERNBERG) BRONGNIART. – MAI, p. 213, pl. 3, figs. 1-3, text-fig. 1b.

Material: Incomplete seed cones and their fragments (C) – localities: Břežánky [a2], Nástup-Tušimice Mine [a2] and Hradiště near Černovice [a2].

Description: Seed cones symmetric, oblong ovate to cylindric, 81.8-(112.3)-132.5 mm long and 28.4-(45.4)-61.3 mm broad, apophysis rhombic, flattened (mainly in the basal cone part) to slightly arched, 3.9-(4.6)-5.5 mm long and 5.5-(6.5)-8.2 mm broad, distinctly keeled and radially striated, umbo flattened to slightly arched, excentro-denti-culatomucornate, mucro small and indistinctly erected.

Remarks: This taxon was originally typified on the cone material from the Oligocene locality Valeč by STERNBERG (1825: 39, pl. 55, figs. 1-2). Unfortunately, the holotype disappeared from the collection of the Osek Monastery during the end of 19th century. ENGELHARDT (1876a: 61, pl. 10, fig. 4) described an incomplete cone associated with fragmentary needles (Pl. 10, figs 5-7) from the "Leitme-ritzer Mittelgebirge" (i. e., České středohoří Mts). ENGEL-HARDT (1877: 47, pl. 2, fig. 4) described an additional incomplete cone from the locality Hradiště near Černovice (Tschernowitz). MENZEL (1901: 54, pl. 2, figs. 6-7, 9) described some other cones from the localities Valeč and Břešťany. Additional cone material is known from the localities Staré Sedlo, Český Chloumek and Žitenice (ENGELHARDT 1876b; KNOBLOCH 1962; KNOBLOCH et al. 1996). Later on NĚMEJC (1968: 384, pl. 39, fig. 3) re-figured besides others the MENZEL's cone from Valeč which was marked as suitable material for the neotype by Z. KVAČEK & J. KVAČEK (1992, pl. 4, fig. 1). MAI (1986: 575) classified *P. ornata* into group No 15. "Merkussi" based on the flattened apophysis in the basal cone part and the character of relatively long stalk (till 2 cm). MAI (1986: 575, 1994: 213) has included to this group 11 other fossil species and their synonyms, mainly from French Miocene. The *P. ornata* cone and associated needle analysis shows a xero-phytic *P. halepensis* MILL. (from the Mediterranean Zone and West Asia) and *P. merkusii* JUNG. & DE VRIES (from Vietnam, Laos, Cambodia, China, Philippines, Malaysia and Indonesia) as the most comparable extant species. KVAČEK et al. (2004b) note *P. massoniana* LAMB. from Taiwan and China as a possible extant equivalent. But this species shows shorter cones (only 4-(2.5)-7 cm long), which are also more shortly stalked (FU et al. 1999) than *P. ornata*.

2.2. *Pinus hepios* (UNGER 1850) HEER 1855 sensu MENZEL (1901)

Discussion: Seed cones of *P. ornata* are usually associated with relatively short needles in 2- needled fascicles of *Pinus hepios* (UNGER) HEER (e.g., ENGELHARDT 1876a; MENZEL 1901). *Pinus hepios* (UNGER) HEER was usually used as a cumulative taxon name for pines with two-needle fascicles. However, the leaf material from the locality Valeč (sensu MENZEL 1901: 64f., pl. 3 fig. 4) has a direct relation to the type cone material of *P. ornata*. The leaves of *Pinus hepios* (UNGER) HEER were typified by UNGER (1850, 1852) from the locality Parschlug (e.g., KOVAR-EDER et al. 2004). MENZEL (1901: 65) noted the additional material from the locality Žitenice and Hradiště near Černovice. BŮŽEK (1971: 37, pl. 7, fig. 8) revised one sample of two-needle fascicle (incomplete needles 70 mm long, 10 mm and 20 mm broad) as *Pinus* sp. from the "overlying" sediments of the locality Čermníky (Libkovice Member of the Most Formation). This material was originally described as *P. rigios* by PROCHÁZKA (1954). Unfortunately, the above-mentioned fossil material from the Most Basin is missing. MAI (1999: 14, pl. 8, figs. 9-11, pl. 9, figs. 1-4) noted the leaf material described as *Pinus* cf. *hepios* (UNGER) HEER from Lusatia.

3. *Pinus urani* plant

3.1. *Pinus urani* (UNGER 1850) SCHIMPER 1872
Fig. 3.6-3.7

1850   *Pinites urani* UNGER, p. 363.
1852   *Pinites urani* UNGER, p. 98, pl. 37, fig. 5.
1872   *Pinus urani* (UNGER). – SCHIMPER, p. 262.
1901   *Pinus laricio* POIR. – MENZEL, p. 55, pl. 2, figs. 10-14.
1986   *Pinus urani* (UNGER) SCHIMPER. – MAI, p. 587, pl. 51, figs. 11-13, pl. 52, figs. 1-5, pl. 53, figs. 1-4, pl. 59, figs. 8-9, text-fig. 8.

Material: Seed cones and their fragments (C) – localities: Břešt'any [a2] and Hradiště near Černovice [a2]; – cores: Kundratice /KU 114, depth 42-73 m [a2], KU 115, depth 93-96.9 m [a2], KU 116, depth 105-108 m [a2]/ and Jezeří /PVJK 234, depth 83-84 m [a2]/

Description: Seed cones relatively small (up to 9 cm), asymmetric, widely oval or ovate in outline, rarely rounded, 36.1-(52.8)-66.9 mm long, 23.2-(33.5)-46.9 mm broad, apophysis widely rhombic to pentagonal, 2.9-(4.1)-5.1 mm long, 3.5-(6.8)-9.3 mm broad, distinctly keeled, umbo radially striated, flattened and slightly striated or uncinate to knobbed and broadly rhombic with a distinct diagonal keel (mainly in the middle cone part), excentromucronate, mucro small, denticulate, rarely erect, often indistinct in the basal cone part.

Remarks: These relatively smaller cones are known only from core material of the micaceous psammite facies occurring along the Krušné Hory Mts fault between Vysoká Pec and Albrechtice (TEODORIDIS & KVAČEK 2006) and from the quartzite sandstone of Hradiště near Černovice (Purberg, Tschernowitz) – ENGELHARDT (1877) and MENZEL (1901). The preservation of the core material is not so perfect (worn

out apophysis) therefore the identification is in some cases equivocal. The main diagnostic features are rhombic to knobbed umbo and small to middle sized cones. *P. urani* is based on a single cone from the Sarmatian locality Radoboj (Middle Miocene, Croatia). This incomplete cone occurring with a seed on one sample was firstly noted by UNGER (1850) and later figured in UNGER (1852: 98, pl. 37, figs. 5-6 /seed/). MAI (1986: 587f.) revised this taxon occurrences including some older synonyms and seeds mainly from the Late Miocene localities, e.g., Weisweiler near Düren (*P. stelwagii* KINKELIN and *P. weylandii* KIRCHHEIMER), Zülpich (*P. urani* and *P. schultzii* KLIPPER) and Konin-Patnów (*Pinus* sp.). MENZEL (1901) described and partly refigured a relatively abundant cone and cone scale material as *P. laricio* from several different localities, i.e., Hradiště near Černovice (pl. 2, figs. 10-11, 14), Davidovo údolí (pl. 2, fig. 12), Mokřina (pl. 3, fig. 22) and Valeč (pl. 2, fig. 13) in association with isolated seeds from Břešt'any (pl. 3, fig. 7), Kundratice (pl. 3, fig. 8), Mokřina (pl. 3, fig. 10) and Jehličná (pl. 3, fig 9) – see below. The cone scale from the locality Mokřina figured by MENZEL (1901, pl. 3, fig. 22) bears to 2 seeds in situ. Recently, NĚMEJC et al (2003: 126, pl. 2, figs. 1-3) described incomplete cones as *Pinus* cf. *urani* (UNG.) SCHIMPER complex from the quartzite of Býkov near Plzeň – originally in PURKYNĚ (1911: 2). Similar single cones are known from the Cypris Shale (BŮŽEK et al. 1996 – as *Pinus* sp.). Fossil cones of *Pinus urani* match well extant cones of *Pinus nigra* J. F. AM subsp. *larico* (POIR.) MAIRE from mountain forests of Corsica, S Alps and N Pyrenee.

4. Additonal material related to *Pinus* L.

4.1. *Pinus* sp. 1 (pollen cones)
Fig. 3.14-3.15

Material: 12 isolated pollen cones (M) – Břešt'any and Bílina Mine [a2].

Description: Pollen cones primarily cylindrical, secondarily compressed, 18.9-24.9 mm long 4.2 to 5.7 mm broad, apex obtuse, base narrowed rounded, sporangiophores spirally attached on stalk (up to 0.59 mm broad) bearing 2 anthers, anther oblong to rounded along the adaxial side, 1.24-1.52 mm long, 0.72-0.96 mm broad, pollen in situ unknown.

Remarks: An assignment of the above-described pollen cone from the Bílina Mine to the species level is problematic. MENZEL (1901) described and figured similar material from localities Davidovo údolí (Sokolov), Mokřina and Břešt'any (MENZEL 1901: 60f., pl. 3, figs. 13-14). MENZEL (1901) assumes affinity of the pollen cone from Břešt'any to the extant *P. halepensis* MILL. and *P. larico* POIR., which can be correlated to *P. urani* (see above). However, a detailed taxonomy of the above-described pollen cones is equivocal in spite of evident similarity with MENZEL's original material from Břešt'any. Morphologically comparable material is known from the Cypris Shale of the Cheb and Sokolov basins (BŮŽEK et al. 1996: 10, pl. 2, fig. 3). We can exclude an affinity to the most common

pine cones of *P. engelhardii* due to their similarity to recent pollen cones of *P. taeda* L. or *P. rigida* MILLER (see above) and co-occurrences in the Libkovice Member of the Most Formation.

4.2. *Pinus* sp. 2 (leaves)
Fig. 3.16

1953   *Pinus* sp. – NĚMEJC, p. 14, pl. 2, figs. 3-4.

Material: Incomplete needle fascicle (N) – locality Velká Černoc [h-g].

Description: Five-needled fascicle, needles incomplete, 31 to 33 mm long and 1 mm broad; sheath 5 mm long and 3 to 2 mm broad in basal part, upper surface poorly preserved, rarely one medial vein and parallel striation observed.

Remarks: One, incomplete impression and its counterpart of needles from the locality Velká Černoc (TEODORIDIS 2002) can be compared with fossil *Pinus pseudostrobus* BRONGNIART based on the number of needles in fascicle. This fossil taxon is relatively common in Late Oligocene to Pliocene of Europe and is related to extant species from sections *Cembra* and *Strobus* (MAI 1997; CZAJA 2003).

4.3. *Pinus* sp. indet. (leaves)

Material: Incomplete needles and their fragments (N) – cores: Kundratice /KU 108, depth 71.2-76.7 m [a2] (?N), KU 115, depth 90-99.2 m [a2], KU 116, depth 105-108 m [a2]/, Jezeří /JZ 42 65-66 m [a2], JZ 44, depth 57-58 m [a2], JZ 47, depth 53-57 m [a2]/, Černice /CN 54, depth 56-60 m [a2]/, Horní Jiřetín /HJi 142, depth 89-123 m [a2]/, Janov /Ja 28, depth 36.3-49.2 m [a2] (?N)/, Horní Litvínov /LiH 13, depth 42-57 m [a2]/ and Mariánské Radčice /MR 58, depth 111.5-143.3 m, MR 59, depth 99.0-135.0 m [a2] (N)/.

Remarks: Incomplete needles and their fragments from the above-mentioned cores have been assigned as inde-terminated species of *Pinus* L. (KVAČEK in TEODORIDIS & KVAČEK 2006). It is possible to estimate an affinity to the cone material of *P. urani* and *P. engelhardtii* due to their co-occurrence. However, an assignment to other conifer genera in the case of the fragmentary material is not ex-cluded.

4.4. *Pinus* sp. indet. (seeds)
Fig. 3.11-3.13

1901   *Pinus laricio* POIR. – MENZEL, p. 55, pl. 3, figs. 7-10.
1901   *Pinus* sp. – MENZEL, p. 59, pl. 3, figs. 5-6.
1901   *Pinus pseudonigra* ENGELHARDT. – MENZEL, p. 60, pl. 3, fig. 11.

Material: 2 different types of isolated seeds (S) – locali-ties: Břešťany [a2], Bílina Mine [a2].

Description: Type A – An isolated winged seed broadly oval in outline, 16.7 mm long and 5.9 mm broad, seed broadly oval, 4.4 mm long and 3.1 mm broad, located basipetally and asymmetrically to wing, apex obtuse, striation indistinct and parallel. Type B – Isolated winged seeds broadly oblong to oval in outline, 16.6, 13.8 and 19.8 mm long and 4.1, 5.1 and 6.1 mm broad, seed oval to rounded, 2.21, 1.4 and 1.4 mm long and 1.0, 1.3 and 0.70 mm broad, located basipetally and symmetrically to wing, wing apex obtuse, striation indistinct and parallel.

Remarks: Pine seeds are not so common in the Most Basin. We just recognized only two forms. The relatively large seed asymmetrically surrounded by a broad wing is characterizing as the form A. MENZEL (1901, pl. 3, fig. 7) described this seed belonging to *P. laricio* POIR. from Břešťany. He also associated this type of seeds (MENZEL 1901, pl. 3, figs. 7-10) to the same named seed cones, which correspond to *P. urani*. Contrary to the MENZEL's opinion, MAI (1986, 1994) indicates twice bigger seeds of *P. urani* from Weisweiler (MAI 1986: 587, pl. 59, figs. 8-9) and Val d'Arno Superiore (MAI 1994: 215, pl. 4, figs. 4-7). On the other hand, the seed morphology of our type A is very similar to the seeds from Schoenneg (ETTINGSHAUSEN 1890: 13, pl. 1, figs. 80-82 – *P. taeaformis* UNG.) and from the locality Mokřina and the Cypris Shale of the Cheb and Sokolov basins (BŮŽEK et al. 1996: 10, pl. 2, fig. 2 – *Pinus* sp.). BŮŽEK et al. (1996) noted a probable morphological affinity to seeds of living *P. taeda* L., *P. rigida* MILL… etc. associated to the fossil leaf species of *P. rigios* and/or seed cones of *P. engelhardtii*, which match the seed size data published in MAI (1986: 582, pl. 60, fig. 5). The B type with a less symmetrical seed is identical to the material from the Cypris Shale figured by MENZEL (1901, pl. 3, figs. 11-12) and BŮŽEK et al. (1996, pl. 10, pl. 2, fig. 5). BŮŽEK et al. (1996) noted a similarity with fossil seeds of *P. palaeo-strobus* ETT. and *P. prae-pumilo* ETT. (ETINGSHAUSEN 1890: 14, pl. 1, figs. 76-79) and pointed out that many modern pine species or other conifers, e.g., *Keteleeria* CARRIÈRE, produced a similar seed type.

Pseudolarix GORDON

5. *Pseudolarix schmidtgenii* plant

5.1. *Pseudolarix schmidtgenii* KRAEUSEL 1938 (cone scales, seeds)
Fig. 3.17-3.18

1938   *Pseudolarix schmidtgenii* KRAEUSEL, p. 26, pl. 3, fig. 7, text-fig. 4m-p.

Material: 26 cone scale (Sc) and 2 seeds (S) – locality Nesuchyně [h-g].

Description: Seed scale ovate in outline, 18.1-(22.5)-24.2 mm long and 11.2-(16.2)-20.3 mm broad, maximally in the first third of scale, apex obtuse or rarely acute, base cordate to rounded; midrib obvious on the concave adaxial side, strong and straight, narrowed to acute stalk at basal

scale part, 2 seed imprints or even winged seeds situated along midrib; bract visible in central part of the scale base on the convex abaxial side. Seed winged, oval in outline, 22.2 mm and 19.3 mm long, 7.1 mm and 6.2 mm broad, venation parallel following wing shape around margin areas, seed oval, 6.1 mm and 5.2 mm long, 3.1 mm and 2.5 mm broad.

Remarks: The cone scales, seed and fragmentary needles are known only from the locality Nesuchyně (NĚMEJC 1949; BŮŽEK & KVAČEK 1989; TEODORIDIS 2002) that belongs to the sedimentary belt of the "Hlavačov Gravel and Sand" (VÁNĚ 1985). This important taxon occurring in association of *Fagus saxonica* KVAČEK & WALTHER proved a phythostratigraphical correlation with the Floristic Assemblage of Thierbach sensu MAI & WALTHER (1991) and with the sediments of the lowermost part of the Duchcov Member of the Most Formation sensu DOMÁCÍ (1977) – see in detail Walther in LOTSCH et al. (1994) and TEODORIDIS (2002, 2004). An assignment of seed material to *Pseudolarix schmidtgenii* KRÄUSEL is based on morphological comparison with the seeds, which were described by KRAEUSEL (1938) from the locality Mainz-Kastel (Early Miocene). However, probably the first note about the fossil occurrences of *Pseudolarix* seed scale was published by FLORSCHÜTZ (1925) under the name of *P. kaempferi* GORGON *fossilis* FLORSCHUETZ from Reuver (Upper Pliocene).

P. schmidtgenii can be interpreted as a mesophytic conifer associated with the fluvial and/or extrabasin environment that corresponds to extant species *Pseudolarix amabilis* (J. NELSON) REHDER that enters the Mixed Mesophytic and the Mixed Montane Conifer Angiosperm Forests in East China (FARJON 1990, 2001).

5.2. *Pseudolarix* sp. (leaves)
Fig. 3.19

Material: Needle fragments – locality Nesuchyně [h-g].

Description: Needle incomplete 24.2-(45.3)-65.1 mm long and 1.1-(2.3)-3.1 mm broad, straight to slightly curved, narrowing, apex acute, basal part not preserved, distinct and relatively sunken medial vein dividing needle into 2 groves, margin entire, no cuticles preserved.

Remarks: Determination of associated fragmentary needles from locality Nesuchyně is problematic without evidence of cuticular analysis. The main argument is the fact that the needles are closely associated with the scales and seeds of *Pseudolarix schmidtgenii* KRAEUSEL and match in morphology those of the extant species *P. amabilis*.

Cupressaceae GRAY sensu FARJON 2005 b

Quasisequoia SRINIVASAN & FRIIS emend. KUNZMANN

6. *Quasisequoia couttsiae* plant

6.1. *Quasisequoia couttsiae* (HEER 1862) KUNZMANN 1999 (leaves, cones, seeds)
Fig. 4.1-4.4

1862   *Sequoia couttsiae* HEER, p. 1051ff., pls. 59-61.
1866   *Taxodium dubium* (STERNB.) HEER. – ETTINGSHAUSEN, p. 34, pl. 10, figs. 8-9, 20-22 (pro parte).
1881   *Sequoia langsdorfii* BRONGN. – VELENOVSKÝ, p. 16, pl. 1, figs. 30-35 (pro parte).
1884   *Athrotaxis couttsiae* (HEER). – GARDNER, p. 90f., pl. 6, figs. 1-9, pl. 10, figs. 6-9.
1901   *Sequoia couttsiae* HEER. – MENZEL, p. 91, pl. 5, figs. 17-25.
1901   *Sequoia langsdorfii* BRONGN. – MENZEL, p. 89, pl. 5, figs. 26-28.

Fig. 4. 1-4. *Quasisequoia couttsiae* (HEER) KUNZMANN. 1. Two complete seed cones attached to sub-oppositely branched sterile twig seed cones, locality the Bílina Mine, DB 02-81, scale bar 10 mm. 2. Complete seed cone attached to sterile twig, locality the Bílina Mine, DB 11-82, scale bar 10 mm. 3. Complete seed, locality the J. Šverma Mine [b], NM G 08556, scale bar 500 μm. 4. Incomplete seed, locality Strupčice (core Sr 40, depth 85 m), NM G 08557, scale bar 500 μm. **5-11.** *Taxodium dubium* (STERNBERG) HEER. 5. Immature seed cone terminally attached to sterile twig, locality the Bílina Mine, DB 01-76, scale bar 10 mm. 6. Twig, locality Břešť'any, MMG PB Bn 417, scale bar 10 mm (originally described as *Athrotaxidium bilinicum* MENZEL 1901, pl. 5, fig. 4). 7. Pollen cones arranged in long drooping clusters, locality the Bílina Mine, DB 24-70, scale bar 10 mm. 8. Seed cone scale with undulate umbo including upper submarginal row of distinct, sharp and isolated tubercles, locality the Bílina Mine, DB 21-59, scale bar 5 mm. 9. Incomplete seed cone, locality the Bílina Mine, DB 21-57, scale bar 5 mm. 10. Incomplete seed, locality the Bílina Mine, DB 2-63, scale bar 1 mm. 11. Seed, locality Vysoká Pec (core VP 14, depth 48.5 m), NM G 08558, scale bar 1 mm. **12-18.** *Glyptostrobus europaeus* (BRONGNIART) UNGER. 12. Two complete seed cones sub-oppositely attached to sterile twig, locality Břešť'any, MMG 292, scale bar 10 mm (originally described as *Glyptostrobus europaeus* BRONGNIART by MENZEL 1901, pl. 5, fig. 2). 13. Three complete seed cones alternately attached to sterile twig, locality Břešť'any, DB, scale bar 10 mm. 14. Pollen cones terminally or subterminally attached to sterile twigs, locality the Bílina Mine, DB 30-84, scale bar 10 mm. 15. Complete seed, locality Vršany (core Vr 22, depth 72 m, NM G08559, scale bar 1 mm. 16. Complete seed, locality Vysoká Pec (core VP 14, depth 59.5 m, NM G08560, scale bar 1 mm. **17-18.** *Tetraclinis salicornioides* (UNGER) KVAČEK, locality the Bílina Mine. 17. Incomplete foliage twig including sub-oppositely branched branchlets, DB 24-85, scale bar 10 mm. 18. Isolated two flattened branchlets, DB 30-86, scale bar 5 mm.
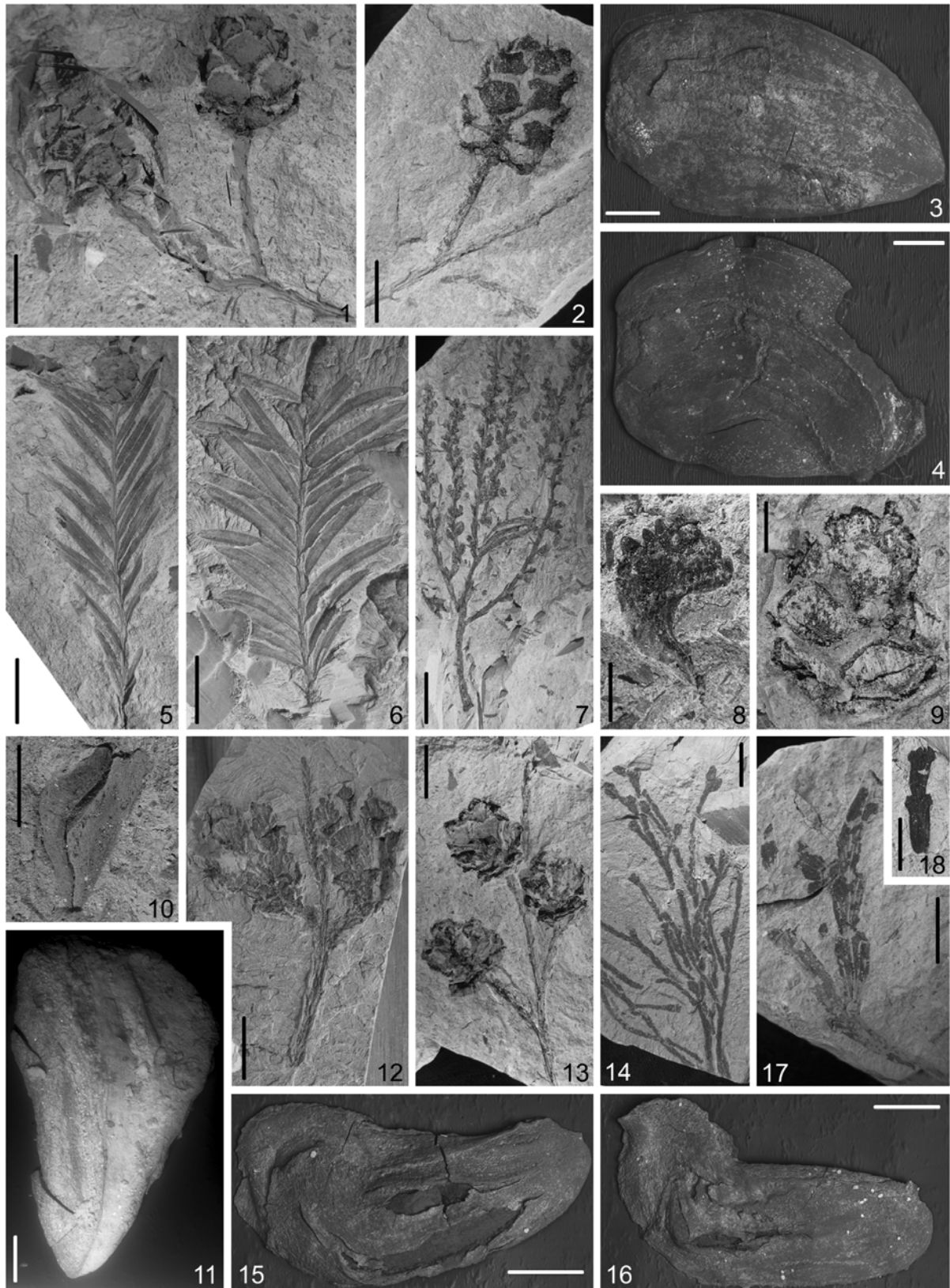
Fig. 4 (Legend see p. 296)

1964   *Sequoiadendron* cf. *couttsiae* (HEER) GRAMBAST. – BŮŽEK & HOLÝ, p. 112, pl. 3, figs. 1-11.
1999   *Quasisequoia couttsiae* (HEER). – KUNZMANN, p. 57, pl. 10, figs. 5-6, pls. 11-13, text-figs. 13-14.

Material: Great quantity of sterile twigs (T), seed cones (F), isolated cone scales (Sc), seeds (S) – localities: Březánky, Brešt'any [a2] (T, F, Sc, S), Bílina Mine [a2-b] (T, F, Sc, S), Dobrčice [c] (T, F), Dolany [c] (T, F), Chu-děřice [a2] (T, F), Marianna Mine [c] (T, F), Straky [a2] (F, T), Vršovice [c] (T, F), Záhoří near Žatec [c] (T, F), Želénky [a2] (T), J. Šverma Mine [b, d] (F, Sc, S, T) and J. Fučík Mine [b, d] (F, Sc, S) – cores: Březánky /B 1, depth 131.1 m [a2] (F, S); M 541, depth 103 m [a2] (Sc, S)/, Chomutov /Co 199, depth 66.3 m [c] (F, S), Co 215, depth 89.9 m [d] (Sc), Co 225, depth 57.8 m [f] (F, Sc), Droužkovice /Do 201, depth 65.6 m [a2] (F, Sc), Do 210, depth 47.5 m [b] (S)/, Hošnice /Hš 4, depth 21.5 m [b] (F, Sc)/, Kundratice /KU 127, depth 64-79 m [a2] (T)/, Libkovice /P 542, depth 94-95 m [a2] (F, Sc, S)/, Lom /LOM 16, depth 54.5-54.6 m [a1] (C, S, T)/, Otvice /Ot 36, depth 38-39.0 m [c] (Sc, S)/, Pesvice /Pe 18, depth 67 m [d] (F, Sc), depth 82.3 m [d] (F, Sc), Strupčice /Sr 39, depth 63 m [c] (Sc, S, T), Sr 40, depth 85 m [d] (Sc, S), depth 90 m [d] (S)/, Údlice /Úd 81, depth 125 m [g] (S)/, Vršany /Vr 20, depth 87.4 m [f] (S), Vr 22, depth 75 m [d] (Sc, S), depth 79-80 m [d] (Sc, S)/ and Vysoká Pec /VP 14, depth 48.5 m [c] (Sc, S); VP 15, depth 95-96 m [f] (S), VP 16, depth 45-46.0 m [c] (F, Sc, S), depth 65.0 m [c] (F, S)/.

Description: Twigs covered by scale-like, spirally ar-ranged leaves, closely adhering to the axis or just slightly protruding. Mature seed cone symmetric, rounded to oval in outline, 13.9-(17.6)-22.8 mm long and 11.2-(12.9)-16.3 mm broad, apex rounded, base rounded to broadly cuneate, com-posed of 8-12 scales, scale consists of distinctly narrowed stalk centrally attaching peltae apophysis, apophysis rhom-bic to oval, 2.9-(3.75)-4.9 mm long and 5.25-(5.6)-6.8 mm broad, always broader than longer, abaxial side wrinkled including poorly visible central mucro; immature cones smaller; winged seed ovate to triangular in outline, flat, often slightly curved, 3.18-(3.71)-4.26 mm long and 1.87-(2.3)-2.95 mm broad, base rounded to slightly cordate or rarely broadly cuneate, including slightly concave chalaza, apex acute to blunt containing a small prominent micropyle tip, seed oblong to elliptic, 0.82-(1.1)-1.34 mm broad, bordered by bifacial wings, often symmetric, upper surface poorly preserved, distinct longitudinal rows built by rec-tangular and oblong pits (100 x 120 µm).

Remarks: A relatively common conifer from coal facies of the Holešice Member and from the Brešt'any Clay (e. g., BŮŽEK & HOLÝ 1964; KVAČEK & HURNÍK 2000) are known as seed cones, their isolated scales, seeds and sterile twigs in the Most Basin. Sterile twigs, and pollen fertile twigs are morphologically indistinguishable from *Glyptostrobus europaeus*, however, cuticles of both taxa are different (e.g., KVAČEK 1985; KUNZMANNN 1999; SAKALA 2000). According to PINGEN (1994: 25), it is possible safely define several morphological features of seeds, which help to differentiate this taxon from *Sequoia abietina* (BRONGN. in CUVIER) KNOBLOCH. KUNZMANN (1999: 62) specified the seed morphology based on the "in-situ" material. On the other hand, it is necessary to calculate possible intraspecific seed variability, an aspect also known from seeds of living *Sequoia* ENDL. KUNZMANN (1999: 66-69) discussed pos-sible affinity to the living species of Cupressaceae sensu FARJON (2005 b) without finding an extant analogue.

Fig. 5. 1-5. *Taxodioxylon gypsaceum* (GOEPPERT) KRAEUSEL, locality the Bílina Mine. 1. General view with uniseriate medium rays and axial parenchyma with smooth transverse end walls, tangential longitudinal section, UK 012/98, scale bar 100 µm. 2. Partially biseriate ray, tangential longitudinal section, UK 012/98, scale bar 100 µm. 3. Taxodioid cross-field pits with horizontal apertures, mostly 4 per field arranged in one horizontal row (arrows), radial longitudinal section, UK 012/98, scale bar 50 µm. 4. Taxodioid cross-field pits in marginal ray cells arranged in two horizontal rows, radial longitudinal section, UK 013/98, scale bar 50 µm. 5. Triseriate pitting in radial tracheid walls, closely spaced with bars of Sanio (= crassulae), radial longitudinal section, UK 013/98, scale bar 100 µm. 6-12. *Taxodioxylon taxodii* GOTHAN. 6. General view with one very high ray (40 cells), tangential longitudinal section, locality the Bílina Mine, UK 008/98, scale bar 200 µm. 7. Axial parenchyma with nodular transverse end walls and globular resin contents, tangential longitudinal section, locality the Bílina Mine, UK 008/98, scale bar 100 µm. 8. Detail of prominent nodules in transverse end wall of the axial parenchyma (arrow), tangential longitudinal section, locality the Bílina Mine, UK 031/98, scale bar = 50 µm. 9. General view of the outermost part of the section with taxodioid cross-field pits and uni- to biseriate pitting in radial tracheid walls with pronounced bars of Sanio, radial longitudinal section, locality Vršany, UK 6/97, scale bar = 50 µm. 10. General view of growth rings with destroyed earlywood tracheids (darker parts), transverse section, locality Březánky, UK 3/97, scale bar 500 µm. 11. Detail of four prominent nodules in transverse end wall of the axial parenchyma (arrow), tangential longitudinal section, locality Březánky, UK 3/97, scale bar 50 µm. 12. Cupressoid cross-field pits with slightly inclined apertures, mostly 1-2 per field arranged in one horizontal row, radial longitudinal section, locality Březánky, UK 3/97, scale bar 50 µm. 13-15. *Glyptostroboxylon rudolphii* DOLEZYCH & VAN DER BURGH, locality the Bílina Mine. 13. One ray seven cells high with intercellular spaces, here in black, tangential longitudinal section, UK 007/98, scale bar 50 µm. 14. General view with "glyptostroboid" cross-field pits and uni- to biseriate pitting in radial tracheid walls with inconspicuous bars of Sanio, radial longitudinal section, UK 007/98, scale bar 50 µm. 15. "Glyptostroboid" cross-field pits with very wide horizontal apertures, mostly 1-2 per field arranged in 1-2 horizontal rows, radial longitudinal section, UK 007/98, scale bar 50 µm.
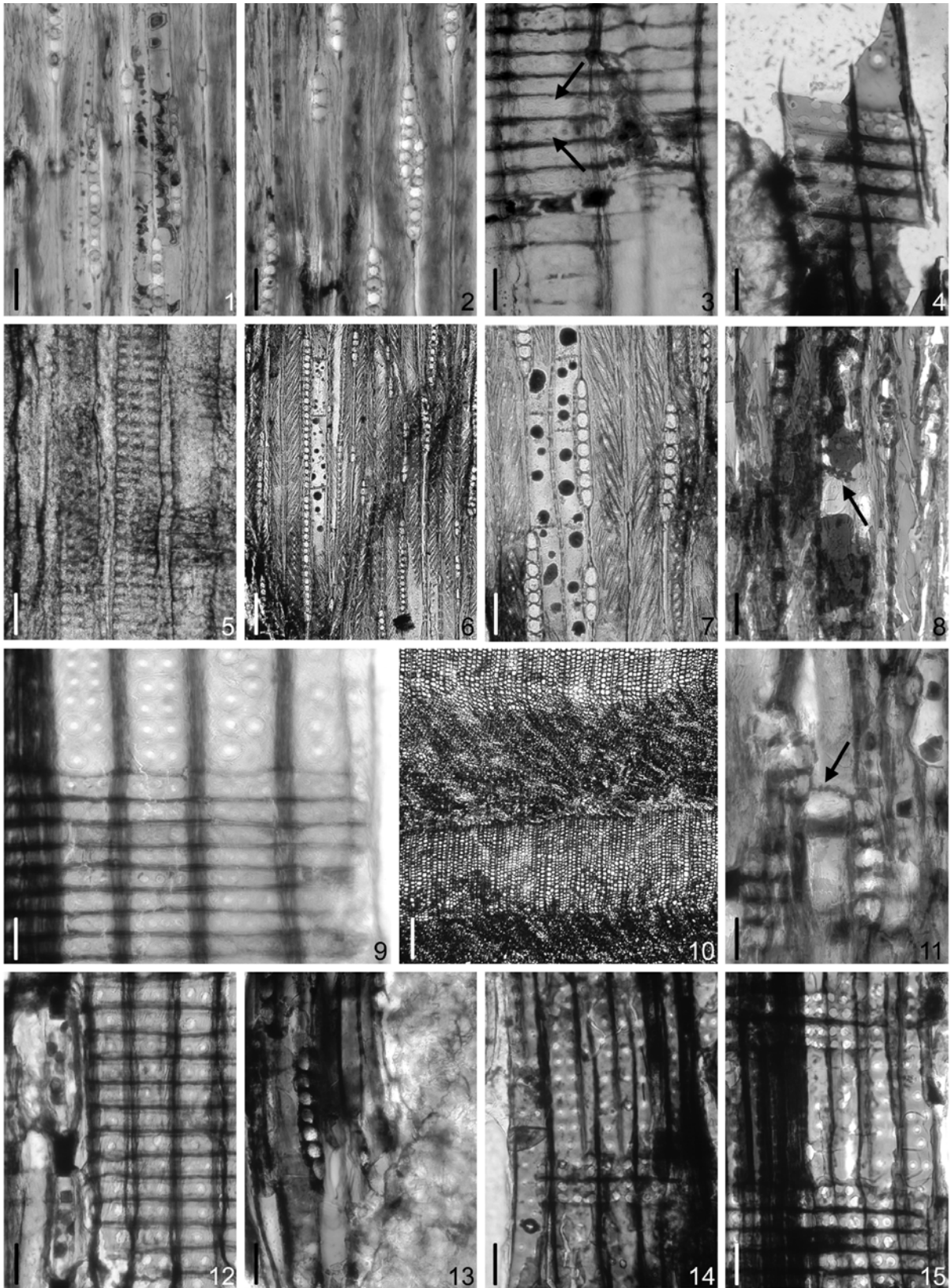
Fig. 5 (Legend see p. 298)

Menezl (1901: 99, pl. 5, figs. 6-8) noted a leaf and cone evidence of *Widdringtonia helvetica* Heer from the localities Břešťany, Březno (Priesen), Kučlín, Hradiště near Černovice and Staré Sedlo. Hovever the figured twigs from Břešťany   and Březno (figs. 6-7) show affinity to sterile twigs of *Q. couttsiae* or *G. europaeus* and figured cone (fig. 8) probably related to an endocarp of *Nyssa* sp.

Taxodioxylon Hartig

6.2. *Taxodioxylon gypsaceum* (Goeppert 1842) Kraeusel 1949 (wood)
Fig. 5.1-5.5

1842   *Pinites gypsaceus* Goeppert, p. 374, pl. 66, figs. 1-2, pl. 67, figs. 4-12.
1949   *Taxodioxylon gypsaceum* (Goeppert). – Kraeusel, p. 147.

Material: Isolated fragments of permineralized woods – localities: Břežánky [a2], Bílina Mine [a2], J. Šverma Mine [b] and Velká Černoc [h-g].

Description: Transverse section: Growth rings distinct with gradual transition from earlywood to latewood. Tracheids generally polygonal in cross section. Axial parenchyma diffuse or tangentially zonate in latewood. Tangential longitudinal section: Pits on tangential tracheid walls small circular bordered. Rays uniseriate or very rarely partially biseriate and medium to high in height (up to 20 cells, rarely more). Axial parenchyma cells with resin substance and smooth to irregularly thickened transverse end walls. Radial longitudinal section: Pits on radial tracheid walls bordered, circular, 1-3 (rarely up to 4) seriate, opposite, closely spaced with bars of Sanio (= crassulae). Ray tracheids absent. Ray cells procumbent, their horizontal walls thin and smooth, unpitted or very rarely pitted, indentures absent, their end (tangential) walls thin and smooth. Cross-field pits taxodioid, with horizontal to slightly inclined apertures, mostly 2-4 per field arranged in 1 horizontal row (in marginal cells up to 6 per field arranged in 2 horizontal rows).

Remarks: Gymnosperm wood is very common in the Lower Miocene of the Most Basin, however a very few studies are available. Ortmann (1922) described *Cupressinoxylon krasseri* from Duchcov, which in fact represents the type identical with *Taxodioxylon gypsaceum* according to Kräusel (1949). The genus *Taxodioxylon* is also recorded by Březinová (1964) from the Vrbenský Mine and by Selmeier (2001) from the Bílina and Libouš Prunéřov Mines. Finally, Hurník-Luft (1960) identified a conifer wood from Braňany as *Pinus* sp., but with respect to bad preservation and the insufficient description the attribution to Pinaceae remains very problematic. A new re-investigation of thin slides obtained from Z. Dvořák between years 1996-2002 (see descriptions hereafter) reveals that all identifiable specimens belong to Cupressaceae sensu Farjon (2005b), including Cupressaceae sensu stricto and the former Taxodiaceae without *Sciadopitys*. The wood is characterized by absence of normal resin canals and spirals on tracheid walls and by presence of rather abundant axial parenchyma, the abietoid (opposite) type of pitting on radial tracheid walls and cupressoid to taxodioid type of cross-field pitting. Even though the wood of Cupressaceae sensu lato is a very important element of the Tertiary of Europe and comparative anatomical studies of extant members are rather numerous, e. g., Henry & McIntyre (1926), Peirce (1936, 1937), Phillips (1948), Kräusel (1949), Greguss (1955), Gromyko (1982, 1990), Visscher & Jagels (2003), there is no consensus on their systematics. Practically, each specialist attributes a different importance to the features observed and a huge amount of wood morphotaxa is in striking contrast with only several elements, based on foliage and reproductive structures.

The specimens, which are here attributed to *Taxodioxylon gypsaceum*, are all characterized by rather abundant axial parenchyma with smooth transverse end walls, closely spaced multiseriate bordered pits with typical crassulae on radial tracheid walls and ray cells with thin unpitted horizontal and end walls and taxodioid cross-field pits with horizontal apertures arranged in horizontal rows. In fact, this morphospecies is one of the most frequent elements in the conifer wood record of the Tertiary of Europe (e. g., Privé-Gill 1977; Biondi 1982; van der Burgh & Meijer 1996; Süss & Velitzelos 1997 with the list of species of *Taxodioxylon*). As also emphasized by van der Burgh & Meijer (1996: 373) "…*T. gypsaceum* is highly variable polyphyletic species" which reflects a great variation recorded by Bailey & Faull (1934) in *Sequoia sempervirens* (D. Don) Endl.

Discussion: *Taxodioxylon gypsaceum* is traditionally compared with the wood of modern *Sequoia* (e. g., Privé-Gill 1977; Dolezych & Schneider 2006). Another possibility, mentioned also by Huard (1966), is that the wood of *T. gypsaceum* belongs not only to *Sequoia* but also to other extinct plants close to *Sequoia*, as for example *Quasisequoia couttsiae*. This was already suggested by van der Burgh & Meijer (1996) who found in the Schleenhain opencast mine (Upper Eocene, Germany) a layer with the wood of *T. gypsaceum* and leaves and cones belonging exclusively to *Q. couttsiae*. We believe that this is the only possible solution also in the case of the Most Basin where no leaves, cones or seeds of *Sequoia* (e. g., *S. abietina*) are present in the whole series in comparison with abundant remains of *Quasisequoia*. Hence, we propose *Taxodioxylon gypsaceum* as the wood of *Quasisequoia couttsiae* plant, which grew in Early Miocene in the Most Basin. Most recently, Dolezych proposes in the published version of her PhD Thesis (Dolezych 2005: 256), together with J. van der Burgh, a new genus *Quasisequoioxylon*, which is intermediate between *Cupressinoxylon* Goeppert (predominance of cupressoid cross-field pits) and *Taxodioxylon* (bi- to triseriate bordered pits on radial tracheid walls). Based on co-occurrence of this type of wood with remains of *Q. couttsiae* in the mines Piskowitz (Early/Middle Miocene, Germany) and Hambach (Late Miocene, Germany), Dolezych (2005) concludes that this wood belongs to *Q. couttsiae* plant. These two parallel interpretations remain unsolved till the wood is found in direct organic connection with leaves or cones of *Q. couttsiae*.

Taxodium Richard

7. *Taxodium dubium* plant

7.1. *Taxodium dubium* (Sternberg 1823) Heer 1853 (leaves, cones, seeds)

Fig. 4.5-4.11

1823   *Phyllites dubius* Sternberg, p. 37, pl. 36, fig. 3.
1853   *Taxodium dubium* (Sternb.). – Heer, p. 136.
1866   *Taxodium dubium* (Sternb.) Heer. – Ettingshausen, p. 34, pl. 10, fig. 13, pl. 12, figs. 1-7 (pro parte).
1876a   *Taxodium distichum miocenicum* Heer. – Engelhardt, p. 15.
1881   *Taxodium dubium* (Sternb.) Heer. – Velenovský, p. 14, pl. 1, fig. 27.
1901   *Taxodium distichum miocenicum* Heer. – Menzel, p. 86.
1901   *Torreya bilinica* Sap. et Mar. – Menzel, p.104, pl. 5, fig. 4.
1949   *Taxodium distichum miocenicum* Heer. – Němejc, p. 27, pl. 2, fig. 9, pl. 3, fig. 2, pl. 5, figs. 7-10.
1953   *Taxodium distichum miocenicum* Heer. – Němejc, p. 14, pl. 1, figs. 1-2.
1953   *Sequoia langsdorfii* Heer – Němejc, p. 14, pl. 2, figs. 1-2.
1964   *Taxodium dubium* (Sternberg) Heer. – Bůžek & Holý, p. 111, pl. 2, figs. 1-7.

Material: Great quantity of sterile twigs with needles (T), macroblasts (PT), unripe seed cones (F), isolated bract scales (Sc), seeds (S), pollen cones (M) – localities: Bílina Mine [a2-b] (T, PT, F, Sc, M), J. Fučík Mine [a2-b] (T, F), Břešťany, Březánky [a2] (T, PT, F, Sc, M, S), Čermníky [g, c] (T, F, Sc), Chotěnice [c] (T), Chuděřice [a2] (T), Dobrčice [c] (T), Dolany [c] (T), Ležáky Mine [a2-b] (T, F), Holedeč [c] (T), Nesuchyně [h-g] (T), Nástup-Tušimice Mine [e, c, a2] (T, Sc, M), Přívlaky [a2] (T), Stranná [a2] (T), Stroupeč [c] (T), J. Šverma Mine [a2-b] (T, F, Sc, S), Velká Černoc [h-g] (T), Vršovice [c] (T, Sc), Zabrušany [a2] (T), Želeč [g-h] (T) and Želénky [a2] (T); – cores: Březánky /B 4, depth 72.6 m [a2] (T, Sc)/, Droužkovice /Do 206, depth 117.4 m [f] (F, Sc); Do 210, depth 47.5 m [b] (F), Do 215, depth 44.5 m [d] (T, F, Sc)/; Havráň /Hň 35, depth 143 m [f] (S); Hň 36, depth 34.2 m [c] (S)/, Chomutov /Co 210, depth 40.9 m [a2] (T, Sc), depth 99.8 m [c] (T), Co 228, depth 98.75 m [d] (T, Sc), Otvice /Ot 27, depth 74.3 m [f] (Sc, S)/, Pesvice /Pe 18, depth 67 m [d] (Sc), Pe 19, depth 98, 8 m [d] (Sc), Přečaply /Pč 4, depth 80-81 m [e] (S)/, Strupčice /Sr 39, depth 63 m [c] (Sc)/, Široké Třebčice /Štb 43, depth 26.4 m [d] (S)/, Údlice /Úd 81, depth 47 m [b] (S)/, Vršany /Vr 22, depth 79-80 m [d] (Sc)/ and Vysoká Pec /VP 14, depth 48.5 m [c] (Sc, S), depth 50.5 m [c] (Sc), depth 59.5 m [c] (Sc, S); VP 15, depth 96 m [f] (S)/.

Description: Sterile twigs with needles, differently sized, flattened, distichous, alternate at unequal distances, linear to lanceolate, apex acute, base often very shortly petiolate and rounded, venation with strong and distinct midrib, often obvious dense parallel venation, rarely branched; uncommon perennial macroblast with spiral imbricate needles; unripe seed cone ovate to rounded in outline, 52 to 86 mm long, 43 to 63 mm; bract scale complex helicaly arranged, isolated bract scale, pelatate, distally rounded or broadly squared to rhombic, 8 to 12.5 mm high and 5.5 to 11 mm broad, rugose, with distinct transverse ridge caused by the relatively small bract and a sulacate to undulate upper margin, 2 seed imprints visible axillary; seed oblong to irregularly triangular to angular-ovate in outline, flattened, 7.8 to 10.3 mm long and 4.4 to 5.2 mm broad, often bent, base rounded, apex acute, margin undulate to finely cristate, seed cavity central oblong to triangular, often longitudinally furrow distinct, boarder by narrowed wing, densely, finely and longitudinally furrowed; pollen cones oval to rounded in outline, 1.2 to 2.3 mm in diameter, each cone attached in the axis of a small scale-like leaf, arranged in relatively long drooping clusters, sympodially branched.

Remarks: The most common conifer of the Most Basin (e.g., Menzel 1901, Brabenec 1909) mainly known from coal and clay facies as well as from the Tertiary fluvial remnants (Němejc 1949, 1953) was typified by Kvaček (1976: 290-294) including synonymy and as well as comments on affinity of *Taxodium balticum* Sveshnikova & Budantsev (1960). This taxon occurs as sterile deciduous twigs, unripe cones, isolated scales and seeds there. Epidermal characteristic published by e.g., Kvaček (1976, 1985), Sakala (2000) helps to safely distinguish *Taxodium* leaves from *Sequoia* Endlicher or *Metasequoia* Hu & W. C. Cheng leaves however several morphological diacritical features exist (e.g., Němejc 1968; Sakala 2000). Menzel (1901: 104, pl. 5, fig. 4) described isolated sterile leaf twig from Břešťany and Zichov as *Torreya bilinica* Sap. & Mar. (pl. 2, fig. 6). *T. dubium* matches morphologically both extant species of *Taxodium* – i.e., *T. distichum* (L.) Rich. occupying swampy regularly flooded forests from the southern-east area of the USA and *T. mucronatum* Ten. known as an element of mountain swampy forests from Mexico. But, the epidermal pattern shows affinity to *T. mucronatum* rather than *T. distichum* (Kvaček, personal communication 2008). The genus *Taxodium* from the Palaeogene and Neogene of Central Europe was most recently overviewed by Kunzmann et al. (in press).

Taxodioxylon Hartig

7.2. *Taxodioxylon taxodii* Gothan 1906 (wood)

Fig. 5.6-5.12

1906   *Taxodioxylon taxodii* Gothan, p. 164.

Material: Isolated fragments of the permineralized and one xylitic woods – localities: Břežánky [a2], Bílina Mine [a2] and Vršany [c].

Descriptions: Transverse section: Growth rings distinct with gradual transition from earlywood to latewood. Tracheids generally polygonal in cross section. Axial parenchyma diffuse or tangentially zonate in latewood. Tangential longitudinal section: Pits on tangential tracheid walls small

circular bordered. Rays uniseriate or very rarely partially biseriate and medium to very high in height (up to 38 cells). Axial parenchyma cells with resin substance and with typical nodular transverse end walls. Radial longitudinal section: Pits on radial tracheid walls bordered, circular, 1-2 (rarely up to 3) seriate, opposite, closely spaced with bars of Sanio (= crassulae). Ray tracheids absent. Ray cells procumbent, their horizontal walls thin and smooth, un-pitted or very rarely pitted, indentures not observed, their end (tangential) walls thin and smooth. Cross-field pits taxodioid, with horizontal to slightly inclined apertures, mostly 2-3 per field arranged in 1 horizontal row (in marginal cells up to 6 per field arranged in 2 horizontal rows).

Remarks: The woods, attributed here to *Taxodioxylon taxodii*, are in fact similar to the previously characterized *T. gypsaceum*. Both species have muliseriate piting on radial tracheid walls with crassulae, abundant axial parenchyma, and high uniseriate rays with thin smooth both horizontal and tangential walls and mostly taxodioid cross-field pits. The main difference consists in the character of transverse end wall in axial parenchyma which is nodular in *T. taxodii* contrary to smooth or irregularly thickened in *T. gypsaceum*. Other co-occurring differences which we have observed in ray height (generally higher in *T. taxodii* which can exceed 30 cells), pitting on radial tracheid walls (generally biseriate in *T. taxodii* vs. 2-4 seriate in *T. gypsaceum*) and cross-field pits (slightly more numerous per field in *T. gypsaceum*), are consistent with the previous observations (GOTHAN 1906; HUARD 1966; DOLEZYCH 2005, see comparative Table 4 in PRIVÉ 1975: 106-107). Contrary to the previous observations, we did not observe differences in thickness and character of horizontal ray walls (rather thick and pitted in *T. taxodii* according to DOLEZYCH & SCHNEIDER 2007) and size of cross-field pits (bigger in *T. gypsaceum* according to HUARD 1966). The measurement was difficult or even impossible, obscured by permineralization of the specimens studied. However, it should be noticed that there is a difference between palaeobotany and botany in perception of horizontal walls of rays in Cupressaceae sensu lato. Palaeobotanists generally attach importance to their thickness and possible pitting (HUARD 1966; PRIVÉ 1975; VAN DER BURGH 1973; DOLEZYCH 2005). On the other hand, IAWA COMMITTEE (2004: 48) recognizes 'distinctly pitted' walls for some members of Pinaceae only, as opposite to 'smooth unpitted' walls for other conifers. This surely corresponds to the fact that there is no secondary wall in ray parenchyma cells in other than Pinaceae as already noticed by BAILEY & FAULL (1934: 241-242). Similar difference between Pinaceae and other conifers is also present in transverse end walls in axial parenchyma (IAWA COMMITTEE 2004: 39). Finally, one specimen, No 3 (Březánky 3, see Fig. 5.10-5.12), with markedly nodular transverse end walls in axial parenchyma but uniseriate rarely biseriate pitting on radial tracheid walls and only cupressoid crossfield pits was also attributed to *T. taxodii*. In fact, there is no earlywood tracheid preserved in this specimen, they are all folded (see Fig. 5.10). We believe that the differences from the typical form of *T. taxodii* (cupressoid vs. taxodioid crossfield pits, uniseriate vs. biseriate pits on radial tracheid walls) are due to the fact that we observed features on latewood tracheids only which are obviously narrower. This interpretation is supported by the results of BAILEY & FAULL (1934: 238) on pitting on radial radial tracheid walls or GROMYKO (1990) on cross-field pits.

Discussion: Leaves, cones and seeds of *Taxodium dubium* are morphologically and ecologically similar to both species of extant *T. distichum* and *T. mucronatum* (KVAČEK et al. 2004b). Concerning the fossil wood, there is a general consensus that *Taxodioxylon taxodii* represents the wood of *Taxodium* as well. HUARD (1966) recognized two fossil species related to *Taxodium*, i.e., traditional *Taxodioxylon taxodii* compared with *T. mucronatum* and his new species *Taxodioxylon distichoides* related with *Taxodium distichum*. Differences between the two morphogenera (and the corresponding nearest living relatives) consist according to HUARD (1966) in bigger cross-field pits, thinner horizontal walls in rays and wider ray cells in *T. taxodii* (*Taxodium mucronatum*) comparing to *T. distichoides* (*Taxodium distichum*); data for modern representatives are partly based on GREGUSS (1955) partly on his own observations. The results published by GROMYKO (1982, 1990) do not confirm any unequivocal distinction between *Taxodium distichum* and *T. mucronatum*. Recently, DOLEZYCH & SCHNEIDER (2007) based on their own observations excluded relation of *T. taxodii* to *Taxodium distichum*, which contrary to the fossil species has both cupressoid and taxodioid cross-field pits, anatomical comparison with *Taxodium mucronatum* has however not been made. As a result, we can say that leaves, cones and seeds of *Taxodium dubium* and wood of *Taxodioxylon taxodii* all belong to the single *Taxodium* plant, the exact nearest living relative of which is however uncertain.

Z. DVOŘÁK (personal communication 2007) noticed that in the horizons with the dominance of *Taxodium* remains there were woods containing duxite, a specific type of fossil resin (see in VÁVRA et al. 1997). Our xylotomical analyses prove that all specimens of wood having duxite (with a single exception) can be attributed to *Taxodium*. Hence, we can speculate that the presence of duxite is of systematical importance and *Taxodium dubium* plant can be determined as the duxite producer tree.

Glyptostrobus ENDLICHER

8. *Glyptostrobus europaeus* plant

8.1. *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850 (leaves, cones, seeds)
Fig. 4.12-4.16

1833   *Taxodium europaeum* BRONGNIART, p. 168.
1850   *Glyptostrobus europaeus* (BRONGN.). – UNGER, p. 434.
1866   *Glyptostrobus europaeus* (BRONGN.) UNGER. – ETTINGSHAUSEN, p. 37, pl. 10, figs. 10-12, pl. 12, figs. 3-7, 11-12.
1866   *Glyptostrobus bilinicus* ETTINGSHAUSEN. – p. 39, pl. 11, figs. 1-2, 10.
1876a   *Glyptostrobus europaeus* (BRONGN.) UNGER. – ENGELHARDT, p. 29, pl. 4, fig. 9.

1881   *Glyptostrobus europaeus* (Brongn.) Unger. – Velenovský, p. 15, pl. 1, figs. 21-26.

1901   *Glyptostrobus europaeus* (Brongn.) Unger. – Menzel, p. 87, pl. 5, figs. 1-3.

1901   *Athrotaxidium bilinicum* Menzel, p. 97, pl. 5, figs. 13-16.

M a t e r i a l : Great quantity of sterile twigs (T), seed cones (F), isolated cone scales (Sc), seeds (S), pollen cones (M) – localities: Březánky, Břešťany [a2] (F, M, S, T), Bílina Mine [a2-b] (F, M, S. T), Čermníky [a2, c] (T, F), Dobrčice [c] (T), Dolany [c] (T, F), Holedeč [c] (T, F), Chotěnice [c] (T), Chuděřice [a2] (F, S), Ležáky Mine [a2-b] (T, F), Nástup-Tušimice Mine [a2, c, e, f] (T, F, Sc), Marianna Mine [c] (T, F), Nesuchyně [g-h] (T), Nechranice [a2] (T), Přívlaky [a2] (T), Stroupeč [a2] (T), Tuchořice [g] (T), Velká Černoc [g-h] (T), Vršovice [c] (T), Zabrušany [a2] (T), Záhoří near Žatec [c] (T), Želeč [g-h] (T), Želénky [a2] (T), J. Fučík Mine [a2-b] (T, F), J. Šverma Mine [a2-b] (F, Sc, S, T) and Maxim Gorkij Mine [a2-b] (Sc); – cores: Březánky /B 1, depth 131.1 m [a2] (F), depth 132.4 m [a2] (F)/, Chomutov /Co 199, depth 66.3 m [c] (S), depth 101.8 m [g] (S), Co 201, depth 86.1 m [d] (S), depth 87.0 m [d] (S), Černice /CN 54, depth 56-60 m [a2] (T)/, Droužkovice /Do 201, depth 65.6 m [a2] (F), Do 210, depth 47.5 m [b] (F, S, T), Do 215, depth 44.5 m [d] (Sc)/; Havráň /Hř 35, depth 54 m [c] (F, S), depth 143 m [f] (F)/, Horní Litvínov /LiH 13, depth 42-57 m [a2] (T)/, Hošnice /Hř 4, depth 45.2 m [d] (F, Sc, S, T), depth 60.4 m [e] (Sc)/, Kralupy near Chomutov /Kr 110, depth 98.65 m [f] (F, S, T)/, Kundratice /KU 127, depth 64-79 m [a2] (T), KU 115, depth 90-99.2 m [a2] (T)/, Libkovice /P 542, depth 94-95 m [a2] (F, S)/, Lom /LOM 16, depth 54.5-54.6 m [a1] (C, S, T)/, Mariánské Radčice /MR 58, depth 111.5-143.3 m [a2] (T)/, Moravěves /Ma 6, depth 116.1 m [f] (F), Ma 8, depth 66.5 m [f] (S)/, Otvice /Ot 27, depth 74.3 m [f] (S)/, Pesvice /Pe 18, depth 67 m [d] (Sc, S), Pe 19, depth 82.3 m [d] (Sc), depth 89.9 m [d] (Sc), Pe 21, depth 51.0 m [b] (F, Sc, S), depth 99.0 m [e] (S)/, Přečaply /Pč 4, depth 80-81 m [e] (S)/, Prunéřov /Pn 138, depth 60 m [g] (F, S, T)/, Spořice /Sp 95, depth 110. m [f] (T)/, Strupčice /Sr 39, depth 63 m [c] (S, T), Sr 40, depth 90 m [d] (F, Sc, S), Sr 53, depth 48.0 m [c] (S), depth 50 m [c] (S)/, Škrle /Šk 3, depth 61 m [d] (F, Sc, S)/, Široké Třebčice /Štb 43, depth 26.4 m [d] (Sc, S, T)/, Údlice /Úd 80, depth 45.4-45.7 m [e] (F, S), Úd 81, depth 106 m [f] (S)/, Vršany /Vr 22, depth 75 m [d] (F, S), depth 79-80 m [d] (Sc, S)/, Vysoká Pec /VP 14, depth 48.5 m [c] (S), depth 59.5 m [c] (S), depth 70.5 m [d] (S); VP 15, depth 95-96 m [f] (S), VP 16, depth 65.0 m [c] (S), depth 73 m [d] (S)/ and Vysočany /Vy 1, depth 71.0 m [d] (F, Sc)/.

D e s c r i p t i o n : Sterile twigs with spiral imbricate needles or cryptomeroid leaves (typical of young or fertile twigs). Incomplete seed cones 1.3-1.9 mm long and 8.5-1.2 mm broad, obovate to globular, only basal part usually preserved, apex obtuse, base cuneate to broadly cuneate, consisting of 8 scales (fragmentary), scale complexes rhombic to deltoid, in the lower part formed by bract scale, in the upper part by seed scale. Bract scales wedge-shaped, base narrowed, apical part mucronate, small umbo, abaxial side wrinkled, seed scale rounded or triangular with notched

margin, small notches numbering of 6 to 8, sculptured by radial furrows, seed scales overgrow about 2 to 4 mm beyond the bract scale. Seeds 4.6-11.4 mm long and 2.1-4.2 mm broad, apical winged, oblong in outline, distinctly bent, flat, seed bodies oval (1.8 to 2.46 mm long and 0.86 to 1.2 mm broad), often situated in lower third of seeds, finely longitudinally sculptured, seed wings bent, starting at basal parts, forming basal rims, bordered seeds towards obtuse apices, distinct concave sides crest-shaped, descending to convex sides, upper surface hardly visible, formed by elongated to polygonal pits (55.3 to 89.5 μm long and 19.1 to 31.6 μm broad).

R e m a r k s : The genus *Glyptostrobus* Endlicher is a common and well-known coal-forming conifer occurring in the whole area of the Most Basin as well as in Northern Bohemia. The taxon is proved by pollen and seed cones, their isolated scales, seeds and sterile twigs – e. g., Menzel (1901), Bůžek & Holý (1964). The sterile twigs of *Glyptostrobus* are morphologically identical with leaves of *Quasisequoia couttsiae* (Heer) Kunzmann and often co-occur in fossil sites (e. g., Bílina Mine). The difference in the epidermal structure of both taxa is noted by many authors – e. g. Kvaček (1985), Kunzmann (1999), Sakala (2000). Recently, Ma et al. (2007, table 1) summarize epidermal differences of several extant "Cupressaceous" taxa. Mai & Walther (1988: 68, pl. 6, figs. 4-9) newly combined *G. brevisiliquata* (Ludwig) Mai & Walther based on the seed material from the Pliocene localities of Gerstungen und Dorheim / Wetterau. However, associated twigs and cones were described as *G. europaeus*. This seed morphotaxon is common element for the Middle Miocene to Pliocene European localities (e. g., Mai 2000) and is often clearly undistinguishable from seeds of *G. europaeus* due to broad morphological inter-specific variability, which is also distinct in the seedy variability of living plants. Menzel (1901: 97, pl. 5, figs. 13-16.) described leaf and cone material as *Athrotaxidium bilinicum* Menzel from Břešťany. We interprete this material as immature and worn out seed cones of *G. europaeus* (cf. Kunzmann 1999: 60). *G. europaeus* can be interpreted as an autochthonous, predominant element of coniferous peat-forming swamp forest and mixed swamp forest (see below). A single living species *G. pensilis* (Staunton ex D. Don) K. Koch occupies humid biotopes on the riverbanks or near the seacoast in southern China (Sveshnikova 1963) and in southern Vietnam (Farjon 2005b).

Glyptostroboxylon Conwentz emend. Dolezych & van der Burgh

8.2. *Glyptostroboxylon rudolphii* Dolezych & van der Burgh 2004 (wood)
Fig. 5.13-5.15

2004   *Glyptostroboxylon rudolphii* Dolezych & van der Burgh, p. 409, text-figs. 6-7, pl. 2, figs. 1-9, pl. 3, figs. 1-5.

Material: One fragment of sideritic wood – locality: Bílina Mine [a2].

Description: Transverse section: Growth rings distinct with gradual transition from earlywood to latewood. Tracheids polygonal in cross section. Axial parenchyma tangentially zonate in latewood. Tangential longitudinal section: Pits on tangential tracheid walls small circular bordered. Rays uniseriate and medium in height (up to 14 cells). Axial parenchyma cells with unknown character of transverse end walls. Radial longitudinal section: Pits on radial tracheid walls bordered, circular, generally uni- to biseriate, closely spaced opposite with inconspicuous bars of Sanio (= crassulae). Ray tracheids absent. Ray cells procumbent, their horizontal walls thin and smooth, indentures not observed, their end (tangential) walls thin and smooth. Cross-field pits exclusively "glyptostroboid" (= taxodioid with very narrow borders approaching almost pinoid) with horizontal to slightly inclined apertures, mostly 1-2 per field arranged in 1 horizontal row (in marginal cells 3-5 per field arranged in 2 horizontal rows).

Remarks: The morphogenus *Glyptostroboxylon* is characterized by the presence of "glyptostroboid" cross-field pits, which means in terms of the IAWA Committee (2004) taxodioid cross-field pits with very narrow borders (or very wide horizontal to slightly inclined apertures) approaching almost pinoid ones. As already emphasized by Süss & Velitzelos (1997: 16) and Fairon-Demaret et al. (2003: 122), Gothan (1905) was apparently the first who noticed that this feature is typical not only of the recent genus *Glyptostrobus*, but also of *Cunninghamia* R. Brown ex Richard & A. Richard. This was most recently articulated by Dolezych & van der Burgh (2004) who emended the diagnosis of *Glyptostroboxylon* based on the original type material to accommodate fossil woods with affinities to both modern genera: *Glyptostroboxylon tenerum* (Kraus) Conwentz is newly interpreted as a wood of *Cunninghamia* contrary to *G. rudolphii* Dolezych & van der Burgh which represents the wood of *Glyptostrobus*. According to Dolezych & van der Burgh (2004), the type of cross-field pits (glyptostroboid) and transverse end wall of the axial parenchyma (smooth to slightly nodular) cannot help to distinguish these two species. The main differences consist in pitting in radial tracheid walls (biseriate with crassulae in *G. rudolphii*, uniseriate without crassulae in *G. tenerum*) and disposition of cross-filed pits (typically more numerous per field in *G. rudolphii*); the presence of indentures in *G. tenerum* and large intercellular spaces in rays of *G. rudolphii* can be noticed as subsidiary distinctive features. Our fossil wood despite its bad preservation can be related to *G. rudolphii*: numerous "glyptostroboid" cross-field pits correlate with biseriate pitting in radial tracheid walls (Fig. 5.14-5.15) and rays, even if generally badly preserved, seem to have large intercellular spaces present as dark triangles (Fig. 5.13).

Discussion: Generally, there is an interesting disproportion between abundant leaves and cones/seeds of *Glyptostrobus* and only one specimen of wood attributable to this genus. This is emphasized by the fact that *Glyptostrobo-*

xylon is traditionally considered as the main coal-forming element (e. g., Kvaček 1998). A possible interpretation could lie in taphonomy, i. e., in-situ upright stems in close vicinity of the coal seam, which are related to the *Glyptostrobus* association (sensu Kvaček & Bůžek 1982) characteristic of peat-forming swamps and supposed to belong directly to *Glyptostrobus*, are often preserved as xylite. These xylitic specimens are very numerous but they are generally badly preserved. They can hardly be identifiable at the specific or even generic level; we can only identify them as Cupressaceae sensu lato. This, however, does not exclude their affinity to *Glyptostrobus*. Recently, a petrified forest with wood of *Glyptostroboxylon rudolphii* was described from the Middle Pliocene of NW Italy by Vassio et al. (2008).

Tetraclinis Masters

9. *Tetraclinis salicornioides* plant

9.1. *Tetraclinis salicornioides* (Unger 1841) Kvaček 1989 (leaves)
Fig. 4.17-4.18

1841   *Thuites salicornioides* Unger, p. 11, pl. 2, figs. 1-4.
1989   *Tetraclinis salicornioides* (Ung.) Kvaček, p. 48, pl. 1, fig. 11, pl. 2, figs. 2-14, pl. 3, figs. 3-4, text-fig. 1.

Material: Incomplete sterile foliage twigs and their fragments (T) – localities Nesuchyně [h-g], Nástup-Tušimice Mine [a2] and Bílina Mine [a2-b], – core Kundratice KU 127, depth 64-79 m [a2].

Description: Incomplete foliage twigs mostly oppositely branched, up to 450 mm long, branchlets flattened, 6.1-(8.9)-11.3 mm long, base truncate to rounded, apex obtuse with terminal and two lateral incisions, towards apex gradually broaden, at base 1.3-(1.7)-2.1 mm broad and at apex 2.34-(3.86)-4.22 mm broad, individual needles imbricate, markedly flatted, 4 fused in a pseudowhorl, forming a cladode-like segment (cladodium), innervating with distinct midrib and two lateral thin veins.

Remarks: This conifer rarely occurs in the area of the Most Basin. Only fragmentary foliage material has been known from the localities Nástup-Tušimice Mine, Bílina Míne and Nesuchyně contrary to relatively common occurrences of fossil cones, seeds and foliage from Oligocene localities ofČeské Středohoří Mts and Doupovské hory Mts (detailed in Kvaček 1989). Two fossil species have been recognized from the European Tertiary – i. e. *T. salicornioides* (Ung.) Kvaček (Middle Eocene to Early Pliocene) and *T. brachyodon* (Brongniart) Mai & Walther 1978 (Early Eocene to Early Pliocene), although Mai (1997) merges these species to one entity. *T. salicornioides* is typified by sterile twigs from the Middle Miocene (Sarmatian) sediments of Radoboj (Unger 1841), where individual impressions were described as *Thuites salicornioides* Ung. Endlicher (1847) regarded fossil material to

the genus *Libocedrites* ENDLICHER. Similarly HEER (1855) re-assigned those fossils to *Libocedrus salicornioides* (UNG.) HEER. KVAČEK et al. (2000) defined a new variety, *T. salicornioides* (UNGER) KVAČEK var. *praedecurrens* (KNOWLTON) KVAČEK & MANCHESTER typical of the Oligocene and Miocene of western North America. Our material, as well as other material from Europe to Transcaucasia (Middle Eocene to Early Pliocene in age) belongs to variety *salicornioides* (KVAČEK et al. 2000). Generally, *T. salicornioides* is an element of the mesophytic, humid forests along river and basin banks. Extant *T. articulata* (VAHL.) MASTERS occupies warm, summer-dry vegetation of northern Africa, Malta and southern Spain (KVAČEK et al. 2000) that fits better to more xerophytic fossil *T. brachyodon*.

9.2. *Tetraclinoxylon vulcanense* PRIVÉ 1973 (wood)

Discussion: The wood of *Tetraclinis* is unknown from the Most Basin. However, it has been interpreted from the neighbouring volcanic area of the České středohoří Mts. and designated as *Tetraclinoxylon vulcanense* by SAKALA (2003) based on the fossil trunk from the Late Eocene locality Kučlín, described originally as *Podocarpoxylon helmstedtianum* GOTTWALD by BŘEZINOVÁ et al. (1994). Another interpretation of the wood of *Tetraclinis salicornioides* is done by DOLEZYCH (2005: 259) who described a different fossil wood from the clay pit Tetta-Buchholz (Middle Miocene, Germany) as *Cupressinoxylon boureaui* (GRAMBAST) DOLEZYCH & VAN DER BURGH. This new combination points to Dolezych's large concept of the morphogenus *Cupressinoxylon* (see in DOLEZYCH & SCHNEIDER 2006: 180).

Geinitziaceae KUNZMANN

Cupressospermum MAI 1960 emend. KUNZMANN 1999

10. *Cupressospermum saxonicum* plant

10.1. *Cupressospermum saxonicum* (MAI 1960) KUNZMANN 1999

1960   *Cupressospermum saxonicum* MAI, p. 75, pl. 3, figs. 1-5, text-figs. 1-2 (holotypus).
1974   *Cupressospermum saxonicum* MAI. – HOLÝ, p. 15, pl. 2, figs. 2-10.
1977   *Cupressospermum saxonicum* MAI. – KVAČEK & HOLÝ, p. 10.
1999   *Cupressospermum saxonicum* (MAI) KUNZMANN, pl. 92, pl. 21, figs. 1-9, pl. 22, figs. 1-9, pl. 23, figs. 1-9, text.-figs. 18, 21/5.

Material: 7 isolated seeds (S) – core: Jenišův Újezd near Bílina /Jú 224, depth 151.2 m [b]/.

Description: Seed flattened, reniform, cashew-nut shaped to broadly sub-circular in general outline, 1.59-(2.19)-3.2

mm long and 1.28-(1.66)-2.34 mm broad, maximal thickness in transversal plane 0.45 mm, distinctly winged on the dorsal convex side, relatively thick wing (ca. 0.35 mm broad) bordered whole seed excluding ventral concave side, locule campylotropous or amphitropous, rounded on both ends, hilum and micropyle basiventral, micropyle rarely obvious as rounded protuberance, upper surface rugulose, pits quadrangular or polygonal, rarely oblong 10.9-19.1 μm long and 8.2-16.3 μm broad, arranged into regular parallel grooves copying curvature of seeds, structure of testa (MAI 1960: 74 and KUNZMANN 1999: 96)

Remarks. This taxon was defined by MAI (1960: 75, pl. 3, figs. 1-5) on the basis of the seed material from Olbersdorf near Zittau including a second species, i. e., *C. chamaecyparoides* MAI from Hartau near Zittau (MAI 1960: 75, pl. 3, figs. 8-11). KUNZMANN (1999: 91-98) emended the genus and species diagnosis and added a detailed description of seed cones and of the epidermal structure of needle and cone. The above-described seeds give the first evidence of *Cupressospermum saxonicum* (MAI) KUNZMANN in the Most Basin. However, HOLÝ (1974: 15) noted the seed cones, isolated seed scales and seeds from the Kristina Mine (Hrádek part of the Zittau Basin). Similarly KVAČEK & HOLÝ (1977: 10) pointed out *C. saxonicum* from sandy deposits of the Habartov Member of the Sokolov Formation in the Sokolov Basin. This important taxon can be used as a phytostratigraphical marker which could correlate sediments of the uppermost part of the Holešice Member of the Most Formation with the Habartov Member of the Sokolov Formation and the Upper Coal Seams sensu lato of the Hrádek Formation as well as sediments of the Lower Miocene of Lausitz (Saxony, Germany). MAI & SCHNEIDER (1988: 107-110) interpreted *C. saxonicum* as an element of the eutrophic swamp forest associated with *Glyptostrobus* and *Taxodium* or as an element of the association of *Cupressospermum-Comptonia*.

Discussion: DOLEZYCH (2005: 250) described *Juniperoxylon pachyderma* (GOEPPERT) KRAEUSEL from the opencast mine Nochten (Early/Middle Miocene, Germany) as a fossil wood of Cupressaceae sensu lato however without any exact nearest living relative. This wood is characterized by nodular both transverse end walls in axial parenchyma and tangential walls in rays as well as by taxodioid to cupressoid cross-field pits and fits very well the broad concept of the genus *Juniperoxylon* GOTHAN proposed by VAN DER BURGH (1973). Based on co-occurrence of seeds and twigs of *Cupressospermum*, DOLEZYCH (2005) interpreted this wood as belonging very probably to this botanical genus. Unfortunately, such a wood structure is still unknown from the Most Basin.

5. Holistic approach – Whole-Plant Concept

Nine natural units – botanical conifer species (in systematical part numbered and denominated as different 'plants') were defined for the whole area of the Most Basin. They are based on the combination of

Table 1. Summary of the floristic conifer composition in different stratigraphical levels of the Most Basin. – Symbols: a1 (Lom Member sensu DOMACÍ 1977), a2 (Libkovice Member sensu DOMACÍ 1977), b-g (Holešice Member sensu DOMÁCÍ 1977) – i.e., in the sense of HURNÍK & MAREK (1962): b (Upper Seam Beds), c (Upper Interseam Beds), d (Middle Seam Beds), e (Lower Interseams Beds), f (Lower Seam Beds) and g (Lower Sandy-Clayey Beds with Basal Coal Seam), h (Duchcov Member sensu DOMÁCÍ 1977); F (seed cones), Sc (isolated scales of the female cone), M (pollen cones), S (seeds), L (leaves) and W (wood).

Taxon	Organs	a1	a2	b	c	d	e	f	g	h
***Pinus engelhardtii* plant**										
Pinus engelhardtii MENZEL	F, S		*	*						
Pinus rigios (UNGER) ETTINGSHAUSEN	L		*	*						
***Pinus ornata* plant**										
Pinus ornata (STERNBERG) BRONGNIART	F		*							
Pinus hepios (UNGER) HEER sensu MENZEL	L		*		*					
***Pinus urani* plant**										
Pinus urani (UNGER) SCHIMPER	F		*							
Additonal material related to *Pinus* L.										
Pinus sp. 1	M		*							
Pinus sp. 2	L								*	*
Pinus sp. indet.	L		*							
***Pseudolarix schmidtgenii* plant**										
Pseudolarix schmidtgenii KRAEUSEL	Sc, S								*	*
Pseudolarix sp.	L								*	*
***Quasisequoia couttsiae* plant**										
Quasisequoia couttsiae (HEER) KUNZMANN	F, Sc, L, S	*	*	*	*	*	*	*		
Taxodioxylon gypsaceum (GOEPPERT) KRAEUSEL	W		*	*					*	*
***Taxodium dubium* plant**										
Taxodium dubium (STERNBERG) HEER	F, Sc, L, S, M		*	*	*		*	*	*	*
Taxodioxylon taxodii GOTHAN	W		*		*					
***Glyptostrobus europaeus* plant**										
Glyptostrobus europaeus (BRONGNIART) UNGER	F, Sc, L, S, M		*	*	*	*	*	*	*	*
Glyptostroboxylon rudolphii DOLEZYCH & VAN DER BURGH	W		*							
***Tetraclinis salicornioides* plant**										
Tetraclinis salicornioides (UNGER) KVAČEK	L		*	*					*	*
***Cupressospermum saxonicum* plant**										
Cupressospermum saxonicum (MAI) KUNZMANN	S			*						

organs as leaves, cones, seeds and wood (see Table 1), but only two taxa (*Taxodium, Glyptostrobus*) are characterized by all of them. The organs were only very rarely directly attached to each other, e.g., seed/pollen cones attached to twigs. They were rather found in direct (close) association within one place/ locality or even indirectly (distantly) associated in one layer/time interval. The combination was then made on their common systematical affinity. The tenth group (additional material related to *Pinus*) is purely artificial and can partly be related to other species of *Pinus*.

6. Palaeoenvironmental signals

We distinguish two types of environmental regimes in the larger area of the Most Basin based on different lithological patterns, i.e., fluvial and/or delta and basin environments. Conifers represent more or less important elements of vegetation in these environ-

ments. Reconstruction of vegetation of the fluvial environment is based on the former floristic analysis of plant assemblages of the fluvial facies from Central and North Bohemia (e. g., TEODORIDIS 2001, 2002). A basic vegetation type may be interpreted as a relatively temperate riparian forest with predominance of deciduous elements (*Taxodium dubium*, *Fagus saxonica* and representatives of Betulaceae and Salicaceae). The riparian forest overlaps distally with the mixed swamp forest and proximally with the mesophytic forest. The association of the mixed swamp forest shows relatively low dynamic character and was often occupied by "swamp" conifers such as *Glyptostrobus* (E4), *Taxodium* (E4), *Quasisequoia* (E4) and *Cupressospermum* (E4), bound on the stagnant water or periodical, relatively long-lasting flooded biotopes of oxbow lakes in the river system. In the contrary, the mesophytic forests, characterized by zonal, more or less allochtonous, mesophytic elements, has established on relatively dry biotopes with lower water table in wider river vicinity or uplands. This vegetation contains among others zonal conifers, i. e. *Pseudolarix* (E4), *Tetraclinis* (E2) and *Pinus* (E3). For more information about the associated floras and additional plant associations see TEODORIDIS (2004). The delta environment shows a more or less similar structure as the fluvial environment. However, it is transformed and redistributed in the areas of Pětipsy and the Žatec Delta into a system of anastomosing river with low gradient, resembling recent inland deltas (TEODORIDIS 2004) and into a "true" delta regime in the Bílina area (KVAČEK 1998). Similarly, several partial types of vegetation within the basin environment can be distinguished. An assemblage, the most typical of coal seams, reflects the coniferous peat-forming swamp forest that corresponds to the association of *Glyptostrobus* sensu KVAČEK & BŮŽEK (1982). This association, characterized by a relatively high water table and relatively long-lasting floods changing to permanent floods in the distal part of the basin, contains predominantly *Glyptostrobus* stands (E4) associated with *Quasisequoia* (E4) and other elements in proximal part of basin (e. g., BOULTER et al. 1993). A next association overlapping towards waterside is the mixed swamp forest that is comparable to the *Nyssa-Taxodium* association sensu KVAČEK & BŮŽEK (1982). Conifers are important elements there, mainly newly appearing *Taxodium* (E4) and mutually integrated *Quasisequoia* and *Glyptostrobus* from the previous association. Other elements represent a mixture of the angiosperms and

ferns (e. g., KVAČEK & BŮŽEK 1982; BOULTER et al. 1993; KVAČEK et al. 2004a). The next association characterized by the occurrence of "our" conifers is the evergreen broad-leaved forest. This association occupies extra-basin, mesophytic and acid biotopes, such as crystalline rock elevations of the Krušné Hory Mts. (i. e., sandy and micaceous facies) and containing monotonous *Pinus* (E3) stands and *Tetraclinis* (E2) combined with other angiosperm elements (e. g., TEODORIDIS & KVAČEK 2006).

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