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Vegetation of the Upper Orava region (NW Slovakia) in the last 11000 years

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ABSTRACT. The paper concerns the history of vegetation in the Upper Orava region, NW Slovakia (the Oravská Kotlina intramountain basin and the surrounding Oravské Beskydy uplands) during the past ca. 11000 years. Both landscape types have been very changed due to intensive human impacts since the 13th or 16th centuries respectively. Therefore, the attempt to reconstruct the composition and spatial distribution of major pre-settlement climax vegetation types has been done using combined pollenanalytical and phytosociological approaches. The evaluation of the uppermost cultural pollen spectra and their comparison with known historical data help to understand the present state of the environment in the region.

KEY WORDS: pollen analyses, postglacial, Late Glacial, Holocene, vegetation history, pre-settlement natural vegetation, Upper Orava, NW Slovakia

INTRODUCTION

Reconstructing the natural vegetation of the Upper Orava region (NW Slovakia) during the compilation of the geobotanical map of Slovakia (Michalko 1987), we had to face certain specific problems compared to the other highland parts of the West Carpathians. The landscape is either completely deforested with only fields, pastures and settlements in lower parts (the Oravská Kotlina intramountain basin and its margins), or very changed with mostly secondary forests alternating with grazing places and only few arable land and scattered settlements in the surrounding uplands. To understand the development and present state of vegetation we constructed pollen diagrams from representative peat deposits distributed in different parts of the region.

The five pollen diagrams presented (Bobrov, Jedlová, Zlatnická Dolina, Slaná Voda, Suchá Hora) could bring information not only about the character of vegetation in different periods of the Postglacial but also, which is important in our case, to determine the composition and representation of trees in the pre-settlement climax forest types. Subsequently, the evaluation of uppermost "cultural" pollen spectra and its confrontation with known data about the land occupation, land use and other human activities helps to understand the present state of vegetation and landscape generally.

Several papers concerning the history of vegetation, both in Polish and Slovak parts of the Upper Orava and neighbouring regions were published earlier. While the pre-war papers by Peterschilka (1927), Dyakowska (1928) and Puchmajerová (1942) can be used to a very limited extent, the post-war pollen analyses from neighbouring Polish territory (Koperowa 1958, 1962, Stuchlikowa & Stuchlik 1962, Obidowicz 1989, 1990) are of great importance for us and are essentially exploited.

Selected and preliminary results of our studies are included as contributions prepared for several meetings (Rybníček 1982, Rybníčková 1982, Rybníček & Rybníčková 1985, Rybníčková & Rybníček 1989), in a chapter concerning the palaeoecological events in the

Slovak Republic (Rybníčková & Rybníček 1996) or in a paper dealing with forest line oscillations in the Slovak and Polish Carpathians (Rybníčková & Rybníček 1993).

THE REGION AND ITS PRESENT ENVIRONMENTS

The Upper Orava region is situated in the NW part of Slovakia and continues to Poland. It is a part of the Western Carpathians (see Fig. 1) belonging to the drainage areas of the rivers Biala Orava, Čierna Orava (Czarna Orawa) and Oravica and covers the areas above their confluences. The border of our investigation area corresponds approximately with the borders of the Upper Orava Protected Landscape Area. The center of the region forms the Oravská Kotlina intramountain basin (flooded mostly with the Orava water reservoir at present), and its margins between ca. 600–700 m a.s.l., representing a very specific landscape type. The higher elevations over ca. 650–700 m belong mostly to the uplands of the Oravské Beskydy orographic system. The highest points are Babia Hora (Babia Góra), 1723 m and Pilsko, 1557 m, both at the border with Poland. At least two major landscape types – the basin itself and the surrounding slopes and ridges of the uplands – must be respected in our considerations and evaluations of the data for the vegetation history of the Upper Orava region.

The Oravská Kotlina basin is flat or slightly undulated, filled in with poor, mostly acid Quaternary fluvioglacial gravels and sands. The system of broad river terraces together with suitable hydrogeologic conditions supported the formation of many, sometimes very extensive, peatlands. The marginal slopes are built with loamy hill wash sediments and/or with Palaeogene flysh facies of sandstone and claystone deposits (Kodym et al. 1967).

The climate in this landscape type is moderately warm with short summers, from moderately dry up to wet. Winters are very long and cold with a long duration of snow cover (Quitt 1971). Vesecký (1958, 1961) gives mean annual temperatures between 5–6°C (January ca. –5,5°C, July 15–16°C), annual precipitations oscillate around 920 mm (January 52 mm, July 133 mm). Climate of the basin and its margins is characterized with distinct

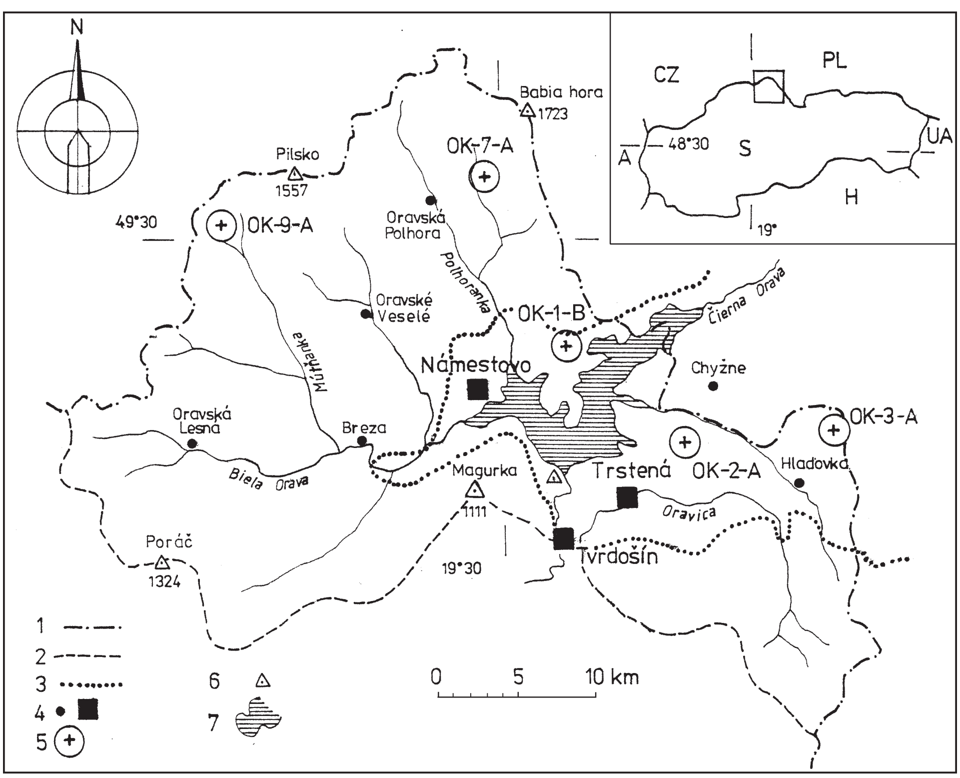


Fig. 1. The Upper Orava region and location of mire sites investigated. **1**. state border; **2**. border of the region; **3**. border of the Oravská Kotlina basin; **4**. villages, towns; **5**. mire sites investigated; **6**. geodesic point; **7**. extent of present Orava water reservoir

winter inversions (Milata ex Obrębska-Starklowa 1963) and late, locally even summer, ground frosts.

The surrounding uplands of the Beskydy orographic system (prevailing elevation between 700–900/1050 m) consist of the Oravské Beskydy Mts, of the Podbeskydská Brázda furrow and Podbeskydská Vrchovina uplands. On the Polish side it is connected with Podhale region. The system of the Beskydy was folded together with other parts of the Carpathians in the late Tertiary. Various flysh sandstones and claystones of the Eocene and/or Palaeocene age are the prevailing rocks. The geomorphology of the main chain of the Oravské Beskydy Mts is quite diversified with steep slopes and deep valleys, prevailing elevation span between 800–1200 m. The upland parts of the Beskydy system have wide ridges with less steep slopes divided by wide valleys of the Orava river tributaries. Their alluvia are filled with young, mostly Holocene sands and gravels. Numerous spring sloping and/or valley fen mires are usually very small. A list and characteristics of the most important mires was published by Raučina (1979) and, recently, by Trnka (2000) and Viceníková et al. (2000).

The Beskydy Mts climate (Quitt 1971, Vesecký 1958, 1961) reveals normal vertical zonation. We can denote the region as a moderately cold (to about 1100 m) to a cold one (over ca. 1100 m) with short cold and wet summers and long, very cold and moderately wet winters. Annual mean temperatures at lower altitudes (Oravská Lesná monitoring station, 769 m) is 4.3°C, on the summits (Babia Hora station, 1616 m) it is 0.8°C. The January means are –6.3°C and –9.5°C, the July means ca. 14.0°C and 9.5°C respectively. Annual mean precipitations for the same monitoring stations are ca. 1100 mm and 1500 mm respectively.

Existing phytogeographic division of Slovakia (Futák 1966, 1980) places the Upper Orava in the West Carpathian phytogeographical region (Carpaticum occidentale) namely in the West Beskydy phytogeographical district. In general, the original flora of the Carpathian forest (with e.g. *Salvia glutinosa, Euphorbia amygdaloides, Dentaria glandulosa, D. bulbifera, Luzula luzulina, Soldanella carpatica, Impatiens noli-tangere, Actaea spicata, Galium odoratum, Veronica montana, Hordelymus europaeus, Festuca altissima,* etc.) is in the prevailing secondary spruce plantations impoverished due to human activities (e.g. grazing) and proceeding soil degradation at present. Just a few remnants of the original beech and fir natural forest remain in less accessible sites at the highest elevations up to present. Other natural non-forest habitats are concentrated in the subalpine belt (flora of rocks, subalpine meadows, *Pinus mugo* communities) of Babia Góra and Pilsko. For characteristics of these vegetation types see Celiński and Wojterski (1963).

Mires are spread over the region at lower and middle altitudes and they are formed both by different minero- and ombrotrophic vegetation types. Mires of the Upper Orava represent habitats, where several phytogeographical elements of Europe meet or met: boreo-suboceanic and oceanic species (e.g. *Lycopodiella inundata, Rhynchospora alba, Juncus squarrosus, Carex pulicaris, Sphagnum papillosum, S. imbricatum*), boreo- subcontinental/continental plants (e.g. *Ledum palustre, Naumburgia thyrsiflora, Carex chordorrhiza, C. diandra, C. appropinquata, Calla palustris, Scheuchzeria palustris, Sphagnum obtusum*), boreo-circumpolar species (e.g. *Salix myrtilloides, Carex dioica, C. limosa, C. lasiocarpa, Helodium blandowii, Paludella squarrosa, Meesia triquetra, Cinclidium stygium*) and finally also typical central-European elements (*Carex davalliana, Pinus rotundata*).

Flora of substituting non-forest habitats like grazing places, meadows, weed flora of fields and ruderal sites is comparatively poor and uniform within the region.

METHODOLOGICAL NOTES

Being interested in the vegetational development and, finally, in the composition of pre-settlement natural climax forests in both landscape types, we tried to choose for our analyses those sites, which could be representative for the Oravská Kotlina basin itself and for the surrounding uplands. Therefore, we took our samples from the mires smaller than 10 ha, which reflect, beside the local flora, also the climax vegetation in the nearest vicinity (see Tauber 1965). Thus the pollen diagrams from mire sites Bobrov and Jedlová represent the situation in the Oravská Kotlina basin, while the diagrams from the Zlatnická Dolina and Slaná Voda sites reflect the conditions in the Oravské Beskydy uplands. A huge raised bog complex Suchá Hora was studied as a reference profile, giving information about the changes in wide, neighbouring regions.

FIELD WORKS AND SAMPLING

The sediments of the profiles were collected from exposed cleaned walls of dug pits as monolith-like vertical sections and stored in metal boxes 50×10×10 cm. In the profile from the Suchá Hora bog we used a Russian borer when sampling the lowest layers (over 300 cm). The peat profiles were described immediately in the field, using the Troels-Smith (1955) characterisation of Quaternary unconsolidated sediments, "Munsell soil color charts" (1954) were used for colour determination.

LABORATORY WORKS

The samples for pollen analyses were taken from the monoliths at intervals of 5 cm in most cases and treated with usual laboratory methods (Faegri & Iversen 1975), i.e. acetolyses with HF pre-treatment in case of mineral admixture. Minimum 600, but usually 900–1000 pollen grains of AP and NAP were counted. The standard percentage pollen diagrams were constructed using the basic sum AP + terrestrial NAP = 100%. The percentages of spores and pollen grains of aquatic plants are related to this total sum. Full pollen analytical data (absolute counts of sporomorphs) of the pollen diagrams from Bobrov, Jedlová and Zlatnická Dolina are stored in the European Pollen Data Base in Arles (France).

SUPPORTING STUDIES IN PRESENT VEGETATION

One of the aims of our work was to (re)construct the pre-settlement natural vegetation cover and its distribution in the region. Therefore, additional phytosociological observations had to be performed. They concerned the present distribution of climax trees indicated by pollen analyses, their habitat, coenotical affinities, and occurrence of herb diagnostic species in the remains of natural forests. Though we have to accept that we can get just a certain approximation to the past reality, it is believed that our combined pollenanalytical and phytosociological approach brings better results than the traditional solely phytosociological mapping methods (Tüxen 1956, 1963, Mikyška 1968, Neuhäusl 1975, Michalko 1987).

NOMENCLATURE

The nomenclature of vascular plants follows generally Flora Europaea (Tutin et al. 1964–1980, see also Neuhäuslová & Kolbek 1982). Names of mosses are based on the work by Corley et al. (1981). Syntaxonomic nomenclature follows the survey of plant communities by Mucina & Maglocki (1985). Nomenclature of sporomorphs is conventional and need not correspond to presently used names of their plant producers.

^{14}C DATING AND ZONATION OF POLLEN DIAGRAMS

Critical horizons of two pollen diagrams (Bobrov and Zlatnická Dolina valey) were dated in the Radiocarbon Dating Laboratory, Lund (head Sören Hakansson at the time of dating). Conventional uncalibrated ^{14}C dates are in years B.P. A survey of all dates from the region is in Tab. 1. All other data presented (in brackets) are the approximate ages of corresponding layers calculated from the accumulation rate curves or correlated with historical evidences (beginning of settlement in the neighbourhood). In undated diagrams the ages (also in brackets) are based on synchronisation with the dated ones. The pollen diagram from the Suchá Hora bog is synchronized with the ^{14}C dated profile from similar bog of Puścizna Rękowiańska (Obidowicz 1990) situated only 10 km northwards.

Table 1. Radiocarbon dates

Profile	Depth in cm	Lab. No	Date ^{14}C B.P.
Bobrov	209–213	Lu 2219	10150±90
(OK-1-B)	204–206	Lu 1922	9830±85
	175–178	Lu 1928	9480±85
	163–165	Lu 1923	9330±85
	141–144	Lu 1924	8660±80
	128–131	Lu 1925	8510±80
	105–107	Lu 1930	7780±75
	77–80	Lu 1926	6880±85
	65–70	Lu 2220	6450±70
	53–55	Lu 1927	4180±55
	45	Lu 2221	2650±50
	30–32	Lu 1929	990±45
	21–23	Lu 2222	360±45
Zlatnická Dolina	0–335	Lu 2410	7450±130
	299–303	Lu 2411	6060±70
	270–272	Lu 2412	4300±70
	248–250	Lu 2413	3800±60
	48–50	Lu 2414	1030±45

The time zonation follows, in principal, the Nordic proposal of chronozones by Mangerud et al. (1974), which seems to be used even in central Europe recently (see, e.g., Behre et al. 1996, Ralska-Jasiewiczova et al. 1998). However, having at our disposal radiocarbon dates, it is not difficult to make a parallel between the chronozones used and the traditional periods by Firbas (1949).

MIRE SITES INVESTIGATED AND THEIR STRATIGRAPHY

Location of mires investigated is shown in Fig. 1. Data on size and depth of the sites, published by Raučina (1979) and Viceníková et al. (2000) are revised according to our own observations.

Bobrov, OK-1-B
(620 m a.s.l., 49°26′50″N, 19°33′30″E)

The site (local name "Vydierky") was situated ca. 1500 m NE from the margin of the village Bobrov on the left bank of a nameless brook, near the road. The surface of the minerotrophic spring fen was clearly domed above the surrounding ground, the maximum depth in the central highest part was 2.2 m, the mean depth ca. 1.2 m. The size of the domed part was estimated at about 3 ha, with waterlogged margins ca. 7 ha. Fen vegetation can be classified in the Caricion lasiocarpae and Caricion davallianae with, e.g., *Carex dioica, C. lepidocarpa, C. davalliana, Eriophorum latifolium, Eleocharis quinqueflora, Epipactis palustris, Pinguicula vulgaris, Camptothecium nitens, Campylium stellatum, Drepanocladus revolvens, Aneura pinguis*, etc. The fen peat was excavated in the early 70s and the mire does not exist any longer.

Stratigraphy and evolution

For description of the profile and the sediments characteristics see Tab. 2.

The beginning of peat accumulation is dated back to ca. 11000 years B.P. It probably started with tall herb spring communities (cf. finds of *Veratrum, Lythrum, Thalictrum, Lycopus europaeus, Aconitum, Polemonium*) with sporadic *Salix* cover. During the Boreal at ca. 8500 years B.P. sedges started to dominate, later with *Phragmites australis* as a co-dominant. Finds of macro remains and pollen of *Alnus glutinosa* together with *Frangula alnus* and *Salix* sp. indicate the existence of open alder carr. Presence of numerous spores of ferns supports this statement.

The alder carr was probably more or less artificially changed (cutting of trees and/or grazing ?) between 800–500 years B.P. in an open treeless brown moss fen communities of recent state. Remains of *Drepanocladus* sp., *Camptothecium nitens*, root tissues of *Carex* spec. div., nutlets of *Carex rostrata* and *C.* sect. *flavae*, seeds of *Galium* cf. *uliginosum, Comarum palustre, Potentilla erecta* and pollen of *Pinguicula vulgaris, Menyanthes trifoliata, Linum catharticum* were found. For pollen diagram see Fig. 2.

Jedlová (Zimník), OK-2-A
(660 m a.s.l., 49°23′30″N, 19°39′40″E)

The minerotrophic sloping spring fen is situated on the left bank of the Zimník brook some 4 km NE from the margin of the town of Trstená, south from the forest called "Jedliny". The size is 6.4 ha, the depth is 2.3 m in the central oldest part of the site.

Communities of the Sphagno warnstorfiani-Tomenthypnion with e.g. *Carex rostrata, C. flava, C. davalliana, C. dioica, C. lasiocarpa, Epipactis palustris, Geum rivale, Crepis paludosa, Eriophorum latifolium, Potentilla erecta,*

Table 2. Stratigraphy and sediment description according to Troels-Smith (1955) of the profile Bobrov (OK-1-B)

Depth in cm from	0	23	27	52	137	202	209	>213
to	23	27	52	137	202	209	213	
Physical properties								
lim.		1	1	0	1	1	2	0
nig.	3	2	2	2	2	2	1	1
strf.	1	0	0	2	3	1	0	0
elas.	1	0	0	2	2	2	0	0
sicc.	3	3	2	2	2	1	1	1
color.	7,5 YR 3/2	2,5 YR 2/2	10 R 2/1	5 YR 2/1	10 YR 3/3	5 Y 4/2	10 YR 4/1	10 YR 6/2
Component elements								
Tb (Hyp.)	2^1	++	2^3			3^2		
Tl		2^2						
Th	1^2	1^2		2^2	2^2	1^2		
Dh	1	1			1			
Dg			1	2	1		2	
As							2	1
Ag								1
Ga								1
Gb								1

Drosera rotundifolia, Camptothecium nitens, Sphagnum warnstorfii, S. teres, Aulacomnium palustre, Paludella squarrosa, Helodium blandowii prevail in the present vegetation. Besides, the following rare plants were found: *Carex diandra, C. paniculata, C. chordorrhiza, Eriophorum gracile, Eleocharis quinqueflora, Cinclidium stygium, Calliergon giganteum.*

Stratigraphy and evolution

Description of the profile and sediments are given in Tab. 3. The sedimentation started with treeless moss communities (*Amblystegiaceae, Mniaceae, Sphagnum*) with mostly tall herbs (remains of *Lycopus europaeus, Symphytum, Menyanthes, Polygonum bistorta, Thalictrum, Galium* sp., *Cardamine* cf. *pratensis, Carex rostrata, Equisetum*) between ca. 10500–10000 years B.P. In the middle and upper Holocene, between about 8000–1000 years B.P., the *Alnus* carr covered the mire surface and wood peat was produced. Remains and pollen of *Alnus glutinosa, Frangula alnus, Carex* cf. *paniculata, Caltha palustris, Aconitum* sp., *Menyanthes trifoliata, Urtica dioica,* ferns, *Mnium* sp. were found. Origin of the present state of vegetation is dated back to 500–600 years B.P. It is indicated by the absence of wood remains and high participation of light-demanding *Carex* species (*C. rostrata, C. panicea, C.* sect. *flavae*), *Potentilla erecta, Ranunculus* cf. *auricomus* and mosses *Camptothecium nitens, Sphagnum* spec. div. in corresponding upper layers. For pollen diagram see Fig. 3.

Zlatnická Dolina, OK-9-A
(850 m a.s.l., 49°30′N, 19°15′30″E)

The investigated sloping spring mire is located in the area of the Zlatý Potok stream brook at the foot of the Minčol Mt, about 5 km N of the village Mútné. It is a part of the protected area “Spálený Grúnik”. The size of the mire is ca. 6 ha, the maximum depth ca. 2.7 m of peat, and 3.4 m with the lowest clayey layers with peat admixture. The mean depth is approximately 1.2 m. The present surface is covered with oligo-ombrotrophic peat communities of the Sphagnion medii (*Eriophorum vaginatum, Carex pauciflora, Oxycoccus palustris, Andromeda polifolia, Vaccinium uliginosum, Sphagnum magellanicum, S. capillifolium, S. fallax*) with several minerotrophic elements (*Carex nigra, C. echinata, Eriophorum angustifolium, Potentilla erecta, Viola palustris, Molinia caerulea*). These stands tend to be overgrown with *Picea abies, Alnus incana* and willows. Marginal parts cover plant communities of the Sphagno apiculati-Caricion canescentis with *Carex rostrata, C. nigra, C. canescens, C. echinata, Eriophorum angustifolium, Agrostis canina, Viola palustris, Potentilla erecta, Sphagnum flexuosum, S. fallax, Polytrichum commune.*

Table 3. Stratigraphy and sediment description according to Troels-Smith (1955) of the profile Jedlová (OK-2-A)

Depth in cm from	0	20	35	65	78	100	190	195
to	20	35	65	78	100	190	195	200
Physical properties								
lim.		0	0	1	0	0	1	2
nig.	2	2	2	3	3	3	2	1
strf.	0	1	1	0	0	0	0	0
elas.	3	2	1	1	0	0	0	0
sicc.	1	1	1	1	1	2	2	2
color.	5 YR 6/3	7.5 YR 4/4	10 YR 3/3	5 YR 3/2	2.5 YR 2/4	10 R 2/2	7.5 YR 4/4	2.5 Y 6/0
Component elements								
Tb (Sphag.)	2^0							
Tb (Hyp.)	1^2	1^3		3^3	2^3	3^3	2^3	
Tl			1^1		1^1			
Th	1^1	1^2	1^3					
Dg		2	2	1	1	1	1	
As							1	3
Ga								1

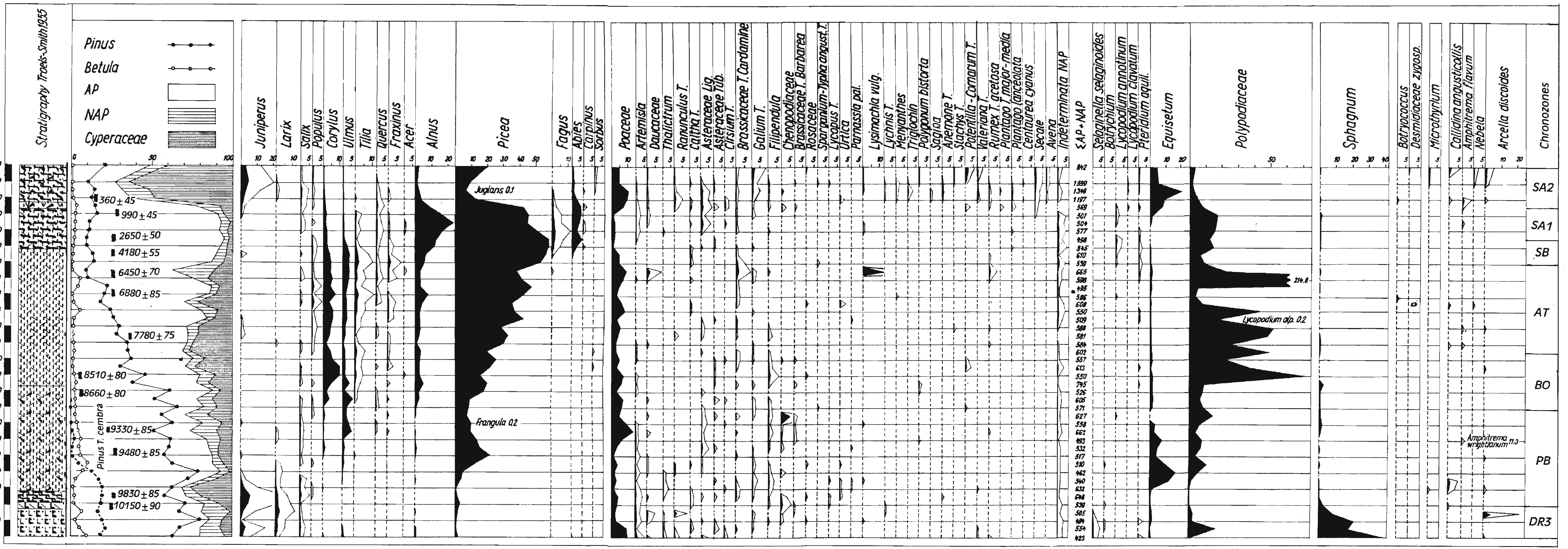
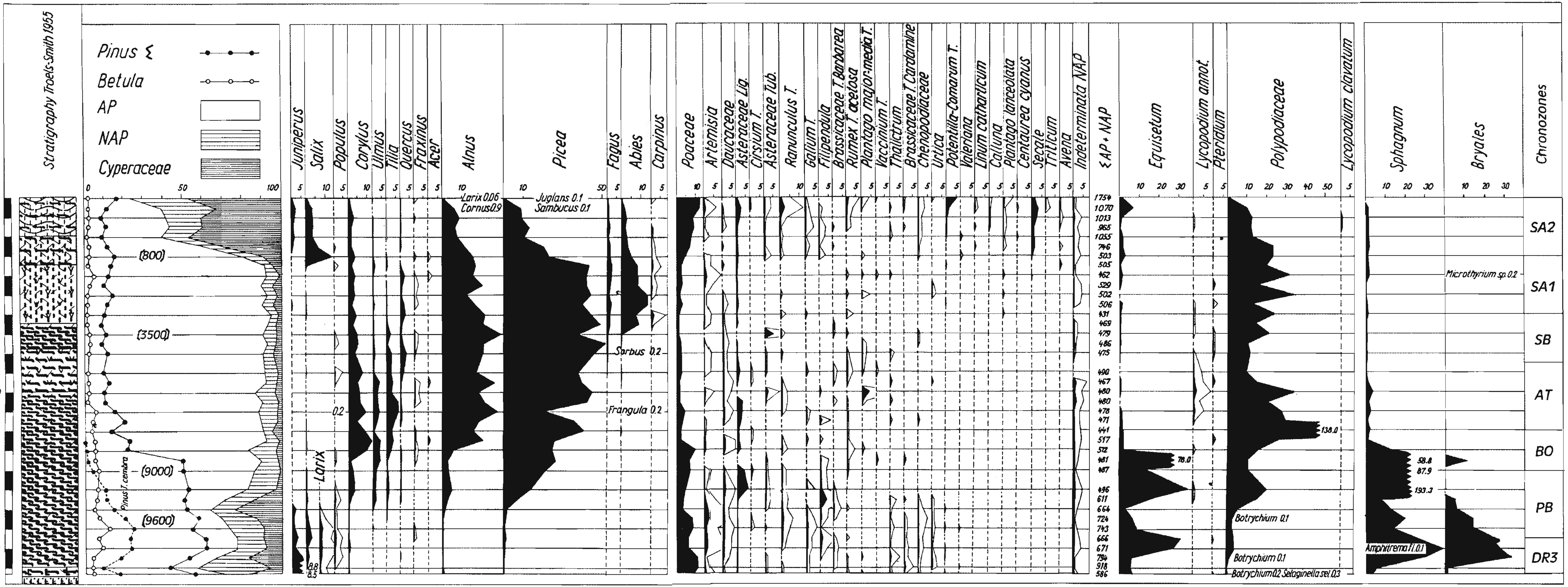


Fig. 2. Pollen diagram Bobrov (OK-1-B). Following scarce pollen grains were found (depth in cm: pollen type, percentage): 225: *Lythrum* 0.2, 220: *Veratrum* 0.4, *Petasites* 0.2, 210: *Centaurea scabiosa* 0.2, 195: *Aconitum* 0.2, *Epilobium* 0.2, 190: *Polemonium* 0.2, 170: *Campanula* 0.2, 165: *Mentha* 0.5, 160: *Campanula* 0.2, 155: *Vaccinium* 0.2, 105: *Melampyrum* 0.2, 100: *Melampyrum* 0.2, *Potamogeton* 0.2, 95: *Veratrum* 0.2, 70: *Calluna vulgaris* 0.3, 25: *Melampyrum* 0.2, *Spergularia* 0.2, 15: *Cannabis* t. 0.1, *Linum catharticum* 0.1, *Lotus* t. 0.1, *Pinguicula* 0.1, 10: *Aconitum* 0.1, *Calluna vulgaris* 0.1, 0: *Pinguicula* 0.1, *Trifolium pratense* 0.1

Analysed by E. Rybníčková



Analysed by E. Rybníčková

Fig. 3. Pollen diagram Jedlová (OK-2-A). Following scarce pollen grains were found (depth in cm: pollen type, percentage): 195: *Anemone* 0.2, 190: *Lycopus* 0.1, Silenaceae 0.1, *Symphytum* 0.1, *Mentha* 0.1, *Sanguisorba officinalis* 0.1, 185: *Anemone* 0.1, *Symphytum* 0.1, *Menyanthes* 0.1, *Triglochin* 0.1, 180: *Lycopus* 0.1, *Symphytum* 0.1, *Serratula* 0.1, 175: *Lycopus* 0.2, *Symhytum* 0.2, Scrophulariaceae 0.2, 170: *Lycopus* 0.1, *Anemone* 0.1, Rosaceae 0.1, Silenaceae 0.1, *Symhytum* 0.1, *Sparganium* 0.1, *Sanguisorba officinalis* 0.1, *Helianthemum* 0.1, 165: *Alisma* 0.4, *Polemonium* 0.1, *Polygonum bistorta-viviparum* t. 0.1, Scrophulariaceae 0.1, 160: Silenaceae 0.2, *Alisma* 0.2, *Melampyrum* 0.2, *Polygonum bistorta-viviparum* t. 0.2, 155: Scrophulariaceae 0.3, 140: Rosaceae 0.2, 105: *Menyanthes* 0.2, 100: *Campanula* 0.2, 95: Rosaceae 0.2, 70: *Melampyrum* 0.2, 65: *Caltha* 0.2, *Anemone* 0.2, 50: *Aconitum* 0.2, 45: *Polygonum aviculare* 0.2, *Parnassia* 0.2, *Alisma* 0.2, 40: Liliaceae 0.4, 35: *Parnassia* 0.2, 30: Rosaceae 0.2, 25: *Symphytum* 0.1, 20: *Lycopus* 0.1, Silenaceae 0.3, *Vicia* t. 0.1, *Fagopyrum* 0.1, 15: *Aconitum* 0.1, *Caltha* 0.3, 10: *Polygonum persicaria* 0.1, *Centaurea rhenana* 0.1, 0: *Lycopus* 0.1, *Lysimachia vulgaris* 0.1, *Polygonum aviculare* 0.1, *Trifolium* 0.1, *Cannabis* t. 0.1, Liliaceae 0.1, *Linum usitatissimum* 0.1, *Lotus* t. 0.1

Stratigraphy and evolution

For sequence of layers and characteristics of sediments see Tab. 4. The accumulation of clayey peat started some 8000 years B.P., that of the minerotrophic peat ca. 4500 years B.P.

Table 4. Stratigraphy and sediment description according to Troels-Smith (1955) of the profile Zlatnická Dolina (OK-9-A)

Depth in cm from	0	10	20	157	270	275	318
to	10	20	157	270	275	318	337
Physical properties							
lim.		1	1	1	2	0	1
nig.	1	3	2	2	1	1	1
strf.	1	1	2	2	1	1	1
elas.	1	1	2	1	0	0	0
sicc.	2	2	2	1	2	2	3
color.	10 YR 5/3	5 YR 3/2	7.5 YR 3/3	5 YR 3/4	10 YR 4/2	10 YR 4/1	10 YR 4/1
Component elements							
Tb (Sphag.)	3^1	2^2	1^2				
Tl			1^2	1^2			
Th	1^1	1^2	1^2	2^2	2^2	1^2	
Dg		1	1	1	1		
As					1	3	3
Ga							1

The oldest local treeless plant cover is dominated by *Carex* species (nutlets of *Carex nigra, C. echinata, C. rostrata, C. canescens*), minerotrophic fen heliophytes (seeds of *Viola palustris, Ajuga reptans, Mentha* cf. *arvensis, Ranunculus* cf. *acris, Caltha palustris*) and scattered brown-mosses (*Caliergonella cuspidata*). Later on, *Phragmites australis* appeared. At the beginning of the Subboreal reed and sedges (*Carex rostrata, C. nigra*) with *Comarum palustre, Viola palustris, Mentha* sp. and *Sphagnum* (sect. *cuspidata*) were the peat forming plants. Between 2500–2000 B.P. the water level decreased and subsequently birch, willows and spruce (finds of bark, leaves and wood, cones, seeds and needles) invaded the site. Simultaneously, first sheets of *Eriophorum vaginatum* appeared. Thus the beginning of the oligo-ombrotrophic peat forming process is dated back to ca. 2000 B.P., e.g., to the middle of the older Subatlantic. It is indicated with remains of the *Eriophorum vaginatum, Oxycoccus palustris, Sphagnum magellanicum* and *S.* sect. *cuspidata*. Nevertheless, at least *Menyanthes trifoliata, Comarum palustre, Carex nigra, Viola palustris, Potentilla erecta, Lycopodiella inundata* and scattered *Picea abies, Betula* (*pubescens*?) and *Salix aurita* survived from the preceding minerotrophic stands. For pollen diagram see Fig. 4.

Slaná Voda, OK-7-A

(780 m a.s.l., 49°32′N, 19°28′50″E)

The ombro-oligotrophic discontinuous bog complex is located at the foot of Babia Hora Mt about 1 km N from the tourist chalet “Slaná Voda” (salt water) and inside the open waterlogged spruce forest in the area of the village Oravská Polhora. The whole bog system has an extent of ca. 10.5 ha, our particular site 4 ha.

Present vegetation is formed by communities of the oligotrophic Sphagno recurvi-Caricion canescentis and the ombrotrophic Sphagnion medii. The marginal lagg towards the left bank of the Vonžovec brook cover stands of the Caricion lasiocarpae. Among rare plants belong: *Carex limosa, C. pauciflora, Drosera rotundifolia, Sphagnum papillosum, S. imbricatum*, in the mesotrophic lagg grow *Blysmus compressus, Carex lasiocarpa, Pinguicula vulgaris, Epipactis palustris.*

Stratigraphy and evolution

For sequence of layers and characteristics of sediments see Tab. 5. The age of the bog is es-

Table 5. Stratigraphy and sediment description according to Troels-Smith (1955) of the profile Slaná Voda (OK-7-A)

Depth in cm from	0	15	40	100	115	156
to	15	40	100	115	156	
Physical properties						
lim.		1	1	1	2	1
nig.	1	1	2	3	2	1
strf.	1	1	1	0	0	0
elas.	1	1	1	1	0	0
sicc.	0	0	1	2	2	2
color.	5 Y 6/4	10 YR 5/6	7.5 YR 3/2	5 YR 3/3	10 YR 5/4	10 YR 7/2
Component elements						
Sh					1	
Tb (Sphag.)	2^1	2^2	1^2	1^3		
Tl			1^2	2^2		
Th	2^1	2^2	2^2	1^2		
Dg					1	
As					2	3
Ag						1

timated to be ca. 4300 years B.P. The peat accumulation started from the open spruce-carr with *Sphagnum* moss layer and ferns, *Lycopodium annotinum* in the herb layer and admixture of *Alnus* (*glutinosa* vel *incana*) in the tree layer. At ca. 2200 years B.P. the first remains of *Eriophorum vaginatum*, *Vaccinium* spec. div., *Oxycoccus palustris* and sphagna of the section *cuspidata* appeared and the succession toward the Oxycocco-Sphagnetea stands started. A predomination of treeless bog vegetation with *Eriophorum vaginatum*, *Oxycoccus palustris*, sphagna sect. *cuspidata*, *Sphagnum magellanicum*, *S. papillosum* was probably supported by tree cutting and grazing after the adjacent villages of the Oravská Polhora and Rabčice in 1580 and 1564 A.D. respectively, were established. Pollen diagram is in Fig. 5.

Suchá Hora, OK-3-A

(720–765 m a.s.l., 49°23′30″N, 19°47′E)

The site is situated north of the village Suchá hora. It is a complex of more or less connected raised bogs of estimated original extent about 350 ha. The complex includes so-called “Sosniny” covered with open pine bog and “Rudné” on the Slovak territory or “Puścizna” on the Polish side. Treeless ombrotrophic bog vegetation of the Oxycocco-Sphagnetea forms the lawn and the Leuko-Scheuchzerion stands are in pools and hollows (Jurko & Peciar 1959, Dohnány 1946). The original maximum and mean depth of peat was ca. 10 m or 4.5 m respectively but it decreased after deep drainage, because an industrial peat winning has been in progress in the Rudné site since 1957. Old extensive peat cutting, used for heating by local inhabitants, reduced the original extent of the complex especially in Poland. Our profile (390 cm) was located in the less destroyed protected area of the Rudné bog in its SW part.

Stratigraphy and bog evolution

For description of sediments see Tab. 6. The beginning of peat accumulation is estimated back at ca. 8700–8900 years B.P. in place of our profile. The sequence of peat formation started the acidophilous minerotrophic mire communities with *Carex* (*rostrata*, *lasiocarpa*) and sphagna of sect. *cuspidata*. *Scheuchzeria* is present in upper minerotrophic layers. The change from the minerotrophy to ombrotrophy

Table 6. Stratigraphy and sediment description according to Troels-Smith (1955) of the profile Suchá Hora (OK-3-A)

Depth in cm from	0	9	320	370	378	385
to	9	320	370	378	385	
Physical properties						
lim.		1	1	2	1	1
nig.	1	2	2	3	2	1
strf.	0	1	2	1	0	0
elas.	1	2	2	1	0	0
sicc.	2	2	3	3	2	2
color.	5 Y 6/3	5 YR 5/4	10 YR 4/4	10 YR 3/2	7.5 YR 3/2	5 YR 6/1
Component elements						
Tb (Sphag.)	3^0	2^2	2^3	1^3		
Th	1^0	2^2	2^3	2^3	2^2	
Dh				1	1	
As					1	3
Ag						1

is dated back to ca. 4000 years B.P. at the turn of the Atlantic and Subboreal. It is indicated with *Eriophorum vaginatum*, *Scheuchzeria* and sphagna of sect. *cuspidata*, later also sphagna of sect. *acutifolia* and *Sphagnum magellanicum* with diminishing representation of *Scheuchzeria*. Dwarf-shrubs (*Vaccinium* spec. div., *Empetrum nigrum*, *Calluna vulgaris*, *Ledum palustre*) have invaded abundantly the bog vegetation since ca. 1000 years B.P. For pollen diagram see Fig. 6.

CHANGES OF PALAEOVEGETATION BETWEEN THE LATE GLACIAL AND SUBBOREAL (ca. 11000–2500 YEARS B.P.)

YOUNGER DRYAS (DR 3) AND PREBOREAL (PB), 11000–8000 YEARS B.P.

Bobrov OK-1-B (230–210 cm / 210–150 cm), Jedlová OK-2-A (195–175 cm / 175–140 cm).

The character and composition of the Late Glacial and early Holocene palaeovegetation can be reconstructed only for the Oravská Kotlina basin, since the oldest diagram representing the Beskydy Mts uplands (Zlatnická Dolina) begins first with late Boreal pollen assemblages.

The assemblages of AP (trees) in the Late Glacial and Preboreal are represented mainly by the pollen of coniferous trees: *Pinus cem-*

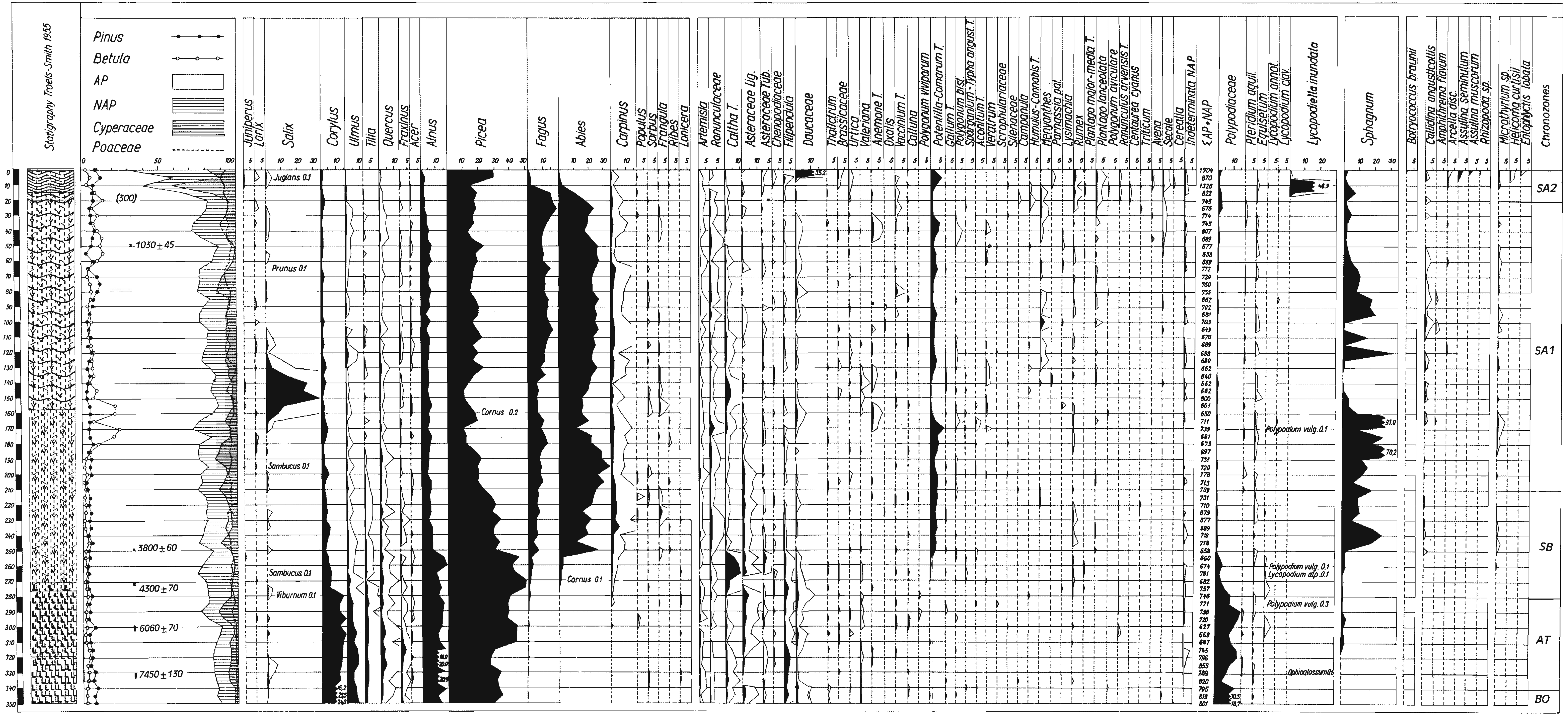


Fig. 4. Pollen diagram Zlatnická Dolina (OK-9-A). Following scarce pollen grains were found (depth in cm: pollen type, percentage): 350: *Bupleurum* 0.1, 345: *Viscum* 0.1, 340: Viciaceae 0.2, 330: *Mentha* 0.1, *Triglochin* 0.,1, 325: *Mentha* 0.1, Rosaceae 0.1, 320: *Gentiana* 0.1, 315: Rosaceae 0.1, 295: *Centaurea scabiosa* 0.6, 290: *Symphytum* 0.1, 265: *Galeopsis* 0.1, *Trollius* 0.1, 260: *Hypericum* 0.1, 255: *Hypericum* 0.2, *Trollius* 0.2, 230: *Sanguisorba minor* 0.1, 225: Viciaceae 0.1, 220: *Drosera* 0.1, Liliaceae 0.1, 215: *Drosera* 0.1, 210: *Epilobium* 0.3, *Mentha* 0.3, *Scheuchzeria* 0.3, 200: *Chrysosplenium* 0.1, *Typha latifolia* 0.1, 165: *Sanguisorba minor* 0.1, 160: *Lotus* t. 0.2, 155: *Lamium* 0.3, *Centaurea rhenana* 0.2, 150: *Sanguisorba officinalis* 0.1, *Sanguisorba minor* 0.1, *Viscum* 0.1, 130: *Lamium* 0.2, 125: *Geranium* 0.1, 105: *Drosera* 0.2, 100: *Bupleurum* 0.1, 95: *Lamium* 0.3, 80: *Lotus* t. 0.1, 50: *Galeopsis* 0.1, 45: *Alisma* 0.3, 40: *Helianthemum* 0.1, 25: *Melampyrum* 0.2, 20: *Oxycoccus* 0.3, 10: *Circaea* 0.2, *Sanguisorba officinalis* 0.1, *Centaurea scabiosa* 0.1, 0: *Melampyrum* 0.1, *Symphytum* 0.1, *Viola* 0.1

Analysed by E.Rybníčková

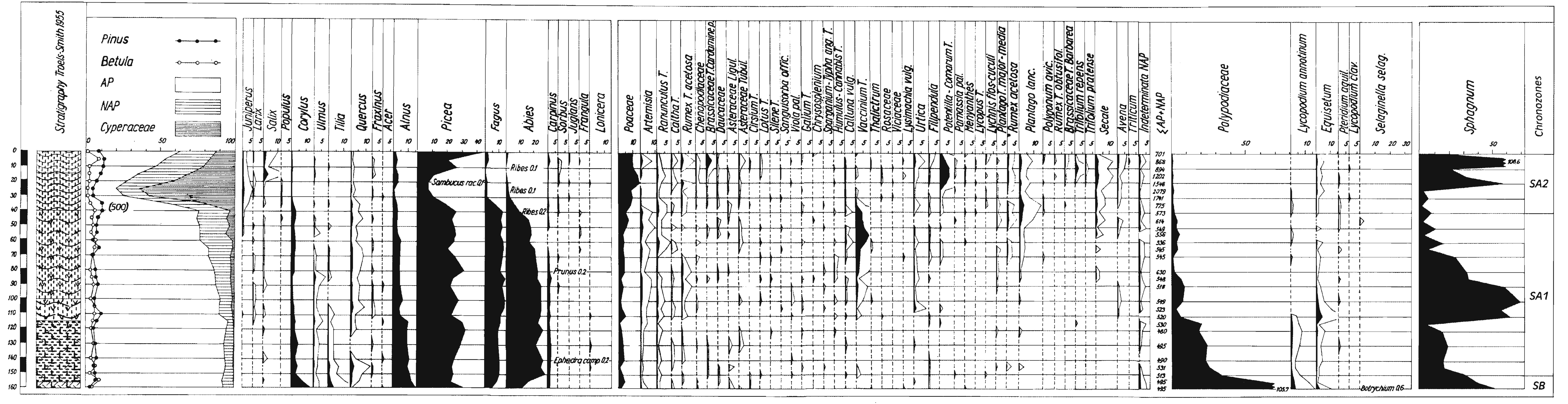


Fig. 5. Pollen diagram Slaná Voda (OK-7-A). Following scarce pollen grains were found (depth in cm: pollen type, percentage): 155: *Anemone* 0.2, 150: *Polygonum hydropiper* 0.2, 140: *Epilobium* 0.2, 130: *Valerianella* 0.2, 110: *Melampyrum* 0.2, 105: *Viola arvensis* 0.2, 90: *Polygonum bistorta-viviparum* t. 0.2, 85: *Campanula* 0.2, *Viola arvensis* 0.2, 80: *Montia* 0.2, *Lamium* 0.2, 70: *Rumex sanguineus* 0.2, *Valeriana dioica* 0.2, *Anemone* 0.4, *Typha latifolia* 0.4, 65: *Melampyrum* 0.2, *Valeriana dioica* 0.2, 60: *Pulmonaria* 0.2, *Veratrum* 0.7, 55: *Lamium* 0.1, 45: *Geranium* 0.2, *Oxycoccus* 0.2, 35: *Galeopsis* 0.1, 30: *Aconitum* 0.1, *Galeopsis* 0.1, *Sambucus ebulus* 0.1, 25: *Trientalis* 0.1, *Oxalis* 0.1, *Melampyrum* 0.1, *Linum cartharticum* 0.1, 20: *Lamium* 0.1, *Rumex sanguineus* 0.1, 15: *Drosera* 0.2, *Agrostemma* 0.1, *Trientalis* 0.2, *Oxalis* 0.1, 10: *Centaurea cyanus* 0.2, *Centaurea rhenana* 0.3, *Montia* 0.1, 5: *Centaurea scabiosa* 0.1, *Polygonum bistorta-viviparum* t. 0.1, *Polygonum persicaria* 0.1, *Aconitum* 0.1, 0: *Pedicularis* 0.3, *Stachys* 0.1

Analysed by E. Rybníčková

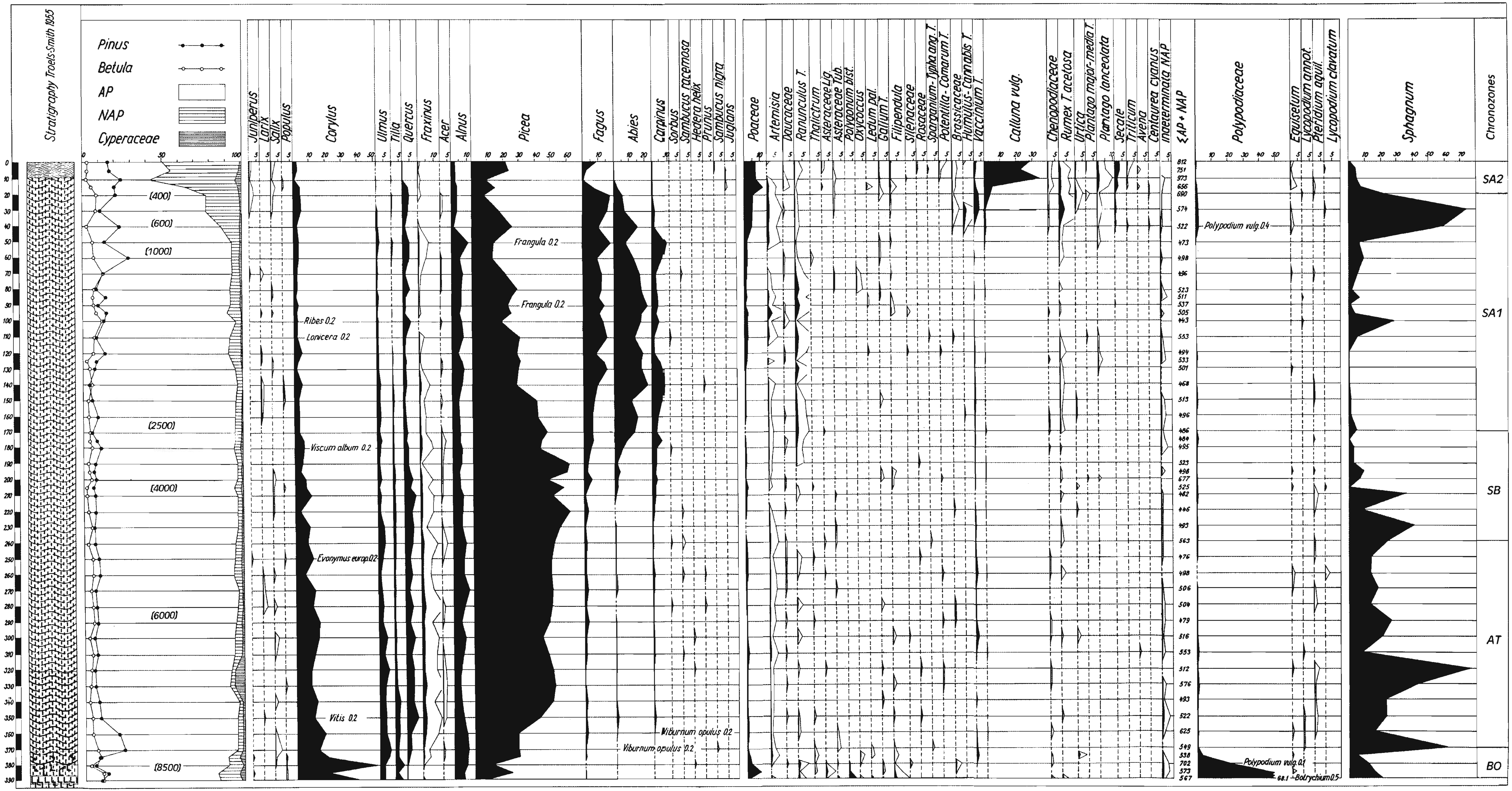


Fig. 6. Pollen diagram Suchá Hora (OK-3-A). Following scarce pollen grains were found (depth in cm: pollen type, percentage): 390: *Cirsium* 0.4, *Epilobium* 0.2, 385: *Valeriana officinalis* 0.2, 380: *Viola palustris* 0.1, *Campanula* 0.1, 370: *Vicia* 0.2, 360: *Lysimachia vulgaris* 0.2, *Parnassia* 0.2, 340: *Lysimachia vulgaris* 0.2, 330: *Typha latifolia* 0.2, 200: *Trollius europaeus* 0.2, 175: *Anemone* 0.2, 125: *Melampyrum* 0.2, 120: *Andromeda* 0.2, 95: *Impatiens* 0.2, 85: *Campanula* 0.2, *Anemone* 0.2, 40: *Polygonum aviculare* 0.2, 30: *Lotus* t. 0.5, *Melampyrum* 0.2, 20: *Echium* 0.2, *Lamium* 0.2, Liliaceae 0.2, 15: *Drosera* 0.3, *Echium* 0.2, *Fagopyrum* 0.2, *Centaurea jacea* 0.2, 10: *Campanula* 0.1, *Polygonum aviculare* 0.1, Scrophulariaceae 0.1, 5: *Lycopus* 0.1

Analysed by E. Rybníčková

bra, Pinus t. *sylvestris/mugo, Larix, Juniperus* and scattered grains of *Picea* cf. *abies*. From deciduous trees and/or shrubs only the pollen of *Populus* (*tremula* ?), *Betula* (*pubescens* agg. ?) *Salix* and few grains of *Alnus* occurred.

Among the NAP (herbs), Poaceae and Cyperaceae prevail, accompanied by pollen of *Artemisia*, Chenopodiaceae, Daucaceae, Asteraceae, Brassicaceae t. *Cardamine, Thalictrum* (*aquilegiifolium*), *Ranunculus*, Polypodiaceae and in the diagram from Jedlová, also *Urtica*. In addition, scattered or single pollen of *Polemonium, Veratrum, Lycopus, Valeriana officinalis, Melampyrum, Aconitum, Polygonum bistorta-viviparum* t., *Serratula tinctoria, Sanguisorba officinalis, Petasites, Cirsium, Alisma, Helianthemum, Anemone* t., Silenaceae, *Centaurea scabiosa, Polygonum aviculare, Rosaceae* and spores of *Botrychium, Selaginella* etc. were found. They all indicate the existence of heliophilous grassland stands.

Preboreal pollen assemblages represent a protocratic transition between the cryocratic Late Glacial and the mesocratic Holocene climatic phases. Pollen grains of *Pinus sylvestris/mugo* still prevail, while, numbers of other coniferous pollen (*Pinus cembra, Larix, Juniperus*) decrease, but the occurrence of *Picea abies* pollen is growing. Among deciduous trees pollen of *Betula* remains, *Salix* and *Populus* retain their values, pollen of *Corylus* and *Ulmus* are appearing. Just small changes in NAP assemblages can be observed, namely counts of *Artemisia*, Chenopodiaceae and *Thalictrum* pollen are lower.

When evaluating the composition of pollen spectra and ecological/coenotical affinities of the potential pollen producers we can distinguish three major vegetation types in the Oravská Kotlina basin in the Late Glacial and Early Holocene:

A) Light open coniferous forest of *Pinus sylvestris* and/or *P. mugo, P. cembra, Larix, Juniperus* and also *Picea abies*. Little admixture of *Betula* (polycormonal shrub forms of *B. pubescens* agg.?), occurrence of *Salix* and *Populus* are indicated too. The herb layer was probably dominated by grasses (possibly some species of *Deschampsia, Calamagrostis, Agrostis, Poa, Festuca, Nardus* ?), regular representation had to have *Thalictrum aquilegiifolium, Melampyrum* (*sylvaticum, pratense?*), *Aconitum, Polygonum bistorta* and/or *viviparum*, ferns. Besides of missing dwarf shrubs (*Vaccinium, Empetrum*) all these trees and herbs are typical for present stands at the forest limit situated ca. 1000 m higher in the High Tatra Mts and denoted as spruce woods with *Pinus cembra* or Vaccinio-Piceetum cembretosum (Magic 1987).

Similar Late Glacial palaeovegetation types can be reconstructed also in other intramountain basins surrounding the Tatra Mts, both in Poland (Środoń 1952, Koperowa 1958, 1962, 1970, Pawlikowa 1965, Harmata 1987, Obidowicz 1990) and Slovakia (Jankovská 1984, 1988, 1998, Dolejšová 1984). Later, from the beginning of the Preboreal, these stands moved up to the mountains, as mentioned earlier (Rybníčková & Rybníček 1988, 1993). The vacated niche, after the heliophilous coniferous stands, was subsequently occupied with local *Picea abies* specimens, spreading very quickly after the Holocene climatic improvement.

Pollen and also partly macro-remains of spruce and alder have been found in small quantities, but regularly in all Late Glacial sediments at the foot of the High Tatra Mts and other neighbouring regions, (see papers mentioned above and also Kneblová 1960, Samek 1973, Opravil 1978).

The apparent discrepancy between the low pollen counts and expected spruce representation can be explained by existing observations in pollination and reproduction biology of the tree. The usual flowering period of *Picea abies* is 3–4 years but may prolong even to 15 years at the alpine and/or polar limits, where the spruce also produces mostly female flowers (Klika et al. 1953, Hess et al. 1967, own observations). Another important feature of spruce is the vegetative way of propagation under severe climatic and edaphic conditions, when lower branches of dwarf stoloniferous forms of *Picea* root and create new colonies (Svoboda 1953, Andreev pers. comm. and our own observation from central European mountains and also from the Chibiny Mts, Kola Peninsula at the arcto-alpine tree limit).

B) Tall herb communities, distributed probably in waterlogged, mostly alluvial sites, flushes and similar habitats represent probably the second major vegetation type in the basin. They are represented by several pollen types: *Veratrum* (*lobelianum* ?), *Petasites, Cirsium, Urtica* (*dioica*), *Thalictrum aquilegiifolium, Epilobium, Aconitum, Polemonium* *coeruleum, Polygonum bistorta-viviparum* t., *Filipendula ulmaria*, Daucaceae (*Anthriscus, Angelica, Heracleum* ?), Asteraceae (*Mulgedium, Adenostyles, Senecio, Solidago, Cirsium, Crepis, Doronicum*?), Ranunculaceae (*Ranunculus*). Several of these pollen producers certainly grew inside the coniferous stands, but most of them built treeless communities with *Salix* shrubs and scattered specimens of alder, birch and spruce. These stands could possibly be compared with some present subalpine communities of the Mulgedio-Aconitetea. Their extent seems to decrease in Preboreal, probably due to the spread of *Picea* and transformation of open tall herb communities in the waterlogged spruce stands.

C) The third palaeovegetation type developed in open treeless, more or less dry probably sandy habitats. Plants representing steppe as well as subartic/subalpine plant communities were typical there. Their existence is indicated with pollen of families Poaceae, Cyperaceae, Silenaceae, genera *Allium, Anemone, Helianthemum* and species *Polygonum aviculare, Sanguisorba officinalis, Serratula tinctoria*, as well as spores of *Selaginella selaginoides* and *Botrychium* (*lunaria* ?). Absence of typical Late Glacial elements like *Ephedra* and *Hippophaë rhamnoides*, which could be expected here, should be noted. Gradual extinction of this palaeovegetation type depended on growing forest density during the Preboreal.

BOREAL (BO) AND ATLANTIC (AT), ca. 8000–5000 YEARS B.P.

Bobrov, OK-1-B (150–115/115–60 cm); Jedlová, OK-2-A (140–120/120–85 cm); Zlatnická Dolina, OK-9-A (350–340/340–280 cm); Suchá Hora, OK-3-A (390–370/370–240 cm).

Picea pollen dominate among the AP in pollen assemblages of these periods. Pollen of *Ulmus* and *Corylus* is regularly present, low frequencies have *Quercus, Tilia, Acer* and *Fraxinus*. Pollen curves of azonal *Alnus* reach more than 20% TS, lower representation is at the site of Bobrov. Pollen of typical heliophilous coniferous trees of the previous stage (*Pinus cembra, Juniperus, Larix*) quite disappeared, other heliophilous trees and shrubs (*Pinus sylvestris/mugo, Betula, Salix*) decreased. Total representation of NAP, including the local types (Cyperaceae), oscillates mostly between 10 and 20%. Regular, but low frequencies of pollen of *Fagus* and *Abies* in the diagram of Suchá hora indicate, that both trees approached the central West Carpathians but their presence in NW Slovakia could still be excluded.

Spruce forests with ferns and *Lycopodium annotinum* in the ground layer were the major vegetation type both in basin and surrounding uplands. *Corylus* accompanied spruce in the shrub layer as it is known from the boreo-continental parts of Europe at present (see, e.g. Isachenko 1980 and also Bohn et al. 2000). However, in addition we should take into account also the existence of stands of some mesocratic trees, like *Ulmus* (*glabra* ?), *Tilia* (*cordata* ?) at lower and middle altitudes of the uplands, with a maximum of their distribution in the Atlantic period. *Fraxinus excelsior* and *Acer* (*pseudoplatanus* ?) occurred probably more or less regularly, though their pollen counts are very low in the diagrams. In case of *Fraxinus* it is due to the bad preservation of its pollen, in case of *Acer* it is because of small pollen productivity and poor dispersion ability (see Andersen 1970, Huntley & Birks 1983 and our own observation). Beside the montane spruce stands all these trees formed successively mixed deciduous submontane forests in the uplands.

Ground layer herbs in both forest types were represented with species of Poaceae, *Symphytum, Galeopsis, Campanula, Circaea, Melampyrum, Oxalis, Vaccinium, Anemone, Stachys*, determined in corresponding pollen assemblages.

Waterlogged habitats and alluvia were covered with discontinuous alder and/or spruce stands with mostly tall herb stands in the ground layer (*Trollius, Veratrum, Valeriana, Mentha*, Asteraceae pp., Daucaceae pp., Polypodiaceae pp.).

SUBBOREAL (SB), ca. 5000–2500 YEARS B.P.

Bobrov, OK-1-B (60–45 cm); Jedlová, OK-2-A (85–60 cm); Zlatnická Dolina, OK-9-A (280–210 cm); Slaná Voda OK-7-A (160–150 cm); Suchá Hora, OK-3-A (240–170 cm).

Pollen assemblages of the SB are characterized by maximum values of *Picea* pollen in most diagrams, reaching around 50% TS. Frequencies of *Corylus* pollen decrease, as well as those of mesocratic trees (*Quercus, Ulmus, Tilia*). *Fraxinus* and *Acer* retain their previous low representation. Regularly growing numbers of *Fagus*, *Abies* and also *Carpinus* pollen are an important feature. Their values indicate the presence of these trees in (*Fagus*, *Abies*) or near (*Carpinus*) the Upper Orava region at the end of SB. Similarly as in the case of *Picea*, *Alnus* pollen reached its maxima. Total counts of NAP are negligible, varying between 5–15% of TS, including local elements.

The SB is the period when the palaeovegetation continued to differentiate in both our subregions – in the Oravská Kotlina basin and the Beskydy Uplands. Spruce forests with ferns, seemingly quite dark, were the only vegetation type in the basin. Azonal e.g. alluvial and waterlogged habitats covered alder and/or spruce stands.

In the uplands mixed spruce-fir-beech stands beside the spruce forests started to form. We can see it best in the diagram from the Zlatnická Dolina mire (Fig. 4), situated at ca. 850 m near to the main mountain ridge of the Oravské Beskydy Mts. Azonal stands were represented mostly with waterlogged alder and spruce communities. The diagram by Stuchlikowa and Stuchlik (1962) from the Zubrzyca Górna, representing the neighbouring eastern foot of the Babia Góra and the Polica range in Poland depicts a similar situation.

RECONSTRUCTION OF PRE-SETTLEMENT VEGETATION

OLDER SUBATLANTIC (SA1) 2500 – ca. 600 (500) YEARS B.P.

Bobrov, OK-1-B (45–25 cm); Jedlová, OK-2-A (60–30 cm); Zlatnická Dolina, OK-9-A (210–20 cm); Slaná Voda, OK-7-A (150–40 cm); Suchá Hora, OK-3-A (170–20 cm).

Generally, the older Subatlantic is a period with climatic conditions comparable to those of today. In addition to that, the immigration and areas of distribution of major native trees reached the present state in Central Europe. *Fagus sylvatica*, *Abies alba* and *Carpinus betulus* occurred last. Therefore, the development of climax vegetation and soils approached the state of reconstructed natural vegetation.

The growing divergence in vegetation development between the Oravská Kotlina basin and surrounding Oravské Beskydy Mts uplands subregions is remarkable. While *Picea abies* with scarce presence of *Abies alba* is an absolute tree dominant in the vegetation of the basin, the mixed forests of *Abies alba*, *Picea abies* and *Fagus sylvatica* have formed the stands in the uplands, where they substitute previous montane mixed deciduous forests. Zonal spruce forests were probably situated just at the highest altitudes.

This difference is best documented when we recalculate the pollen frequencies of climazonal trees in relation to the sum of AP (excl. *Alnus* and *Salix*) = 100%. Mean percentage values of major species (*Picea*, *Fagus*, *Abies*) and a complex of all other trees from the SA1 spectra are presented in Fig. 7. It shows a representation of these trees in the basin (pollen diagrams Bobrov and Jedlová) and in the upland areas (diagrams Slaná Voda, Zlatnická Dolina and, in addition, the diagram by Stuchlikowa & Stuchlik 1962).

The following tree elements are considered to be forest determinants of the pre-settlement vegetation: *Picea abies* and *Abies alba*, less frequently *Fraxinus excelsior*, cf. *Betula pube-*

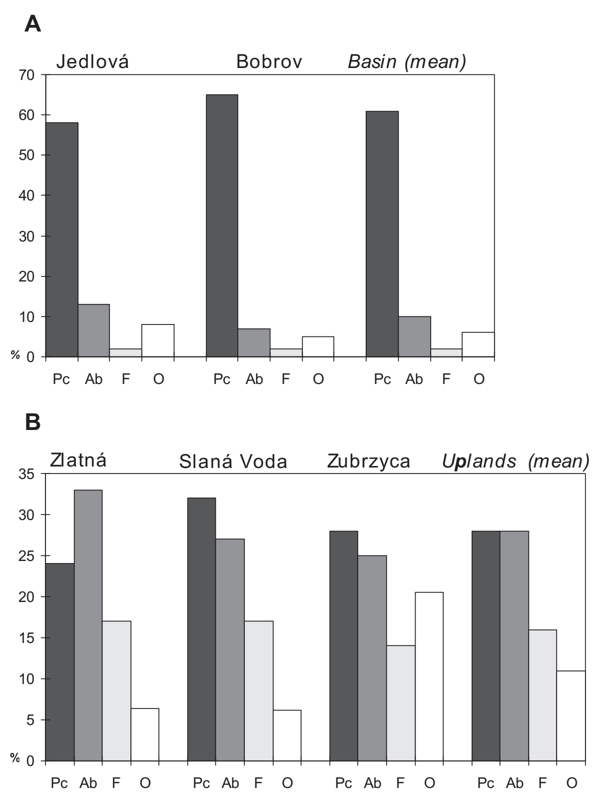


Fig. 7. Mean percentage values for major trees in the Oravská Kotlina basin (A) and neighbouring uplands (B). Counted from the Older Subatlantic (pre-settlement) pollen assemblages. Explanation: **Pc** – *Picea abies*; **Ab** – *Abies alba*; **F** – *Fagus sylvatica*; **O** – other trees (excl. *Alnus* & *Salix*)

scens agg., *Corylus avellana* in the Oravská Kotlina subregion; *Picea abies, Abies alba, Fagus sylvatica, Ulmus* (*glabra* ?), *Acer* and as accessory species *Sorbus aucuparia, Corylus avellana* in the Beskydy Uplands subregion. *Alnus glutinosa, A. incana, Betula pubescens* agg., *Salix* spec. div. were the most important trees and/or shrubs in azonal waterlogged habitats of alluvia and in mire margins .

We do not see any phytogeographical and ecological possibility of regular occurrence of trees like *Quercus* (*robur, petraea*), *Carpinus betulus* and *Tilia* (*cordata, platyphyllos*) directly in the Upper Orava region during the SA1. The nearest stands of *Carpinus betulus* are at the village of Krivá (550 m a.s.l.), some 9 km southwards of the limit of our region at present. *Quercus* does not reach the Upper Orava at all. Small-sized and impoverished stands of the Carpinion (without *Quercus* and *Carpinus*) are just on the lime-rich Cretaceous outcrops at the confluence of the Orava and Oravica rivers at 560–580 m near the town of Tvrdošín. In any case, most of the pollen of the Carpinion trees certainly come from outside our region.

Additional phytosociological research in presently existing remains of more or less natural forest communities, observation of their general habitat conditions and comparison of results of pollen analyses helped to construct a map showing probable spatial distribution of major vegetation types in the SA1 (Fig. 8).

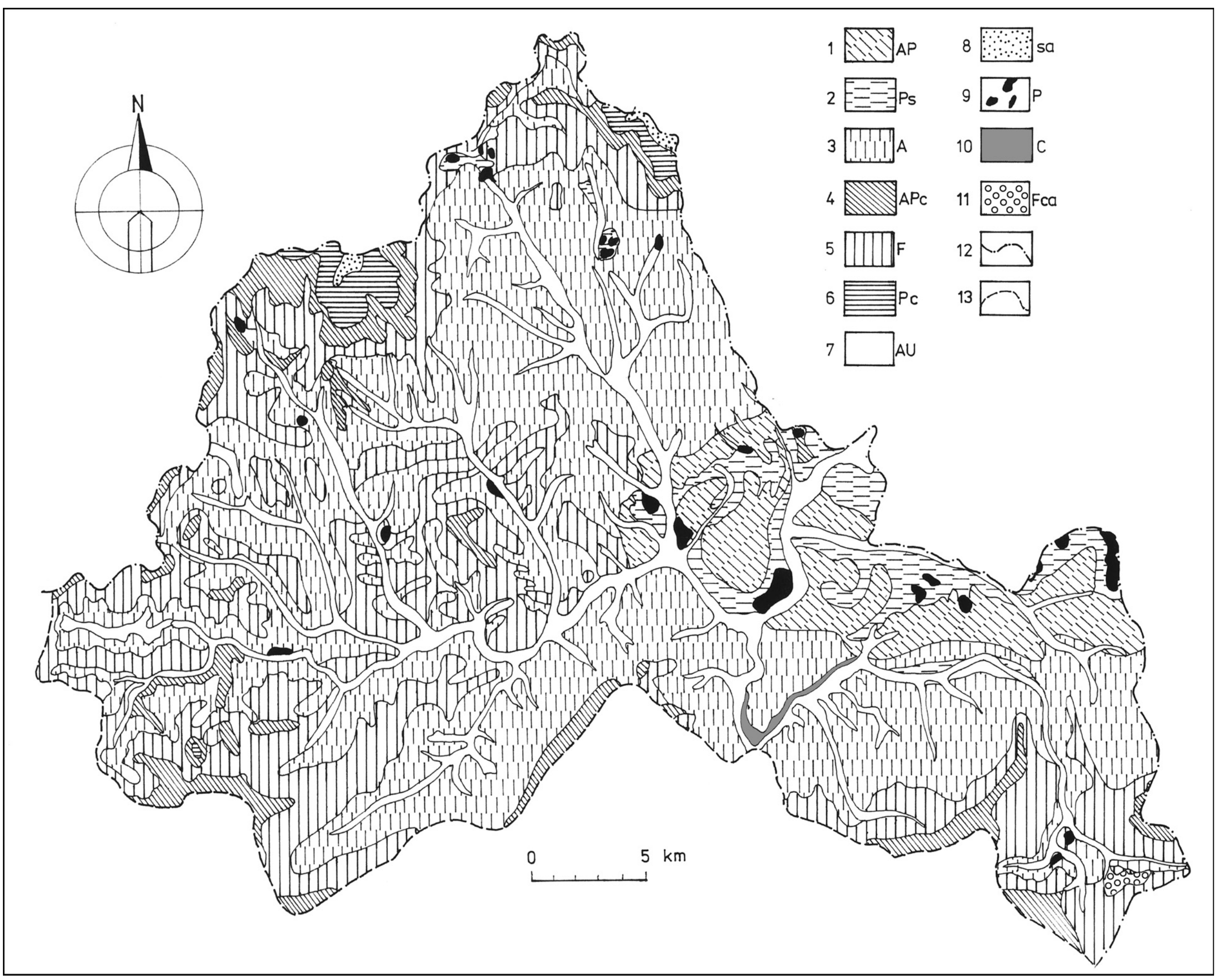


Fig. 8. Schematic distribution of pre-settlement vegetation (SA1) of the Upper Orava, based on combined pollenanalytical and phytosociological research. Explanation: **1**. AP – azonal spruce and fir forests (azonal Vaccinio-Abietetum); **2**. Ps – azonal waterlogged spruce forests (Sphagno-Piceetum); **3**. A – herb rich fir forests (zonal Galio rotundifoliae-Abietetum); **4**. APc – zonal montane spruce fir forests (Blechno-Abietetum, Dryopterido-Abietetum); **5**. F – montane beech forests (Dentario glandulosae-Fagetum); **6**. Pc – montane spruce forests (zonal Vaccinio-Piceetum); **7**. AU – alluvial older stands (Alnion glutinoso-incanae); **8**. sa – (subalpine communities); **9**. P – mires; **10**. C – fragments of the Carpinion; **11**. Fca – calciphilous beech forests (Cephalanthero-Fagetum); **12**. State border; **13**. Border of the region

Using combinations of diagnostic species (just the most important ones are mentioned) we can reconstruct 7 major forest types in our region and characterize them as follows:

1) AP – Azonal spruce and fir forests: *Picea abies, Abies alba, Lonicera nigra, Carex brizoides, Calamagrostis villosa, Luzula luzulina, Doronicum austriacum, Gentiana asclepiadea, Oxalis acetosella.*

2) Ps – Azonal waterlogged spruce forests: *Picea abies*, (*Alnus incana, Betula pubescens*), *Calamagrostis villosa, Veratrum lobelianum, Doronicum austriacum, Gentiana asclepiadea, Vaccinium myrtillus, Equisetum sylvaticum, Lycopodium annotinum, Oxalis acetosella, Polytrichum commune, Sphagnum girgensohnii.*

3) A – Zonal submontane herb-rich fir forests: *Abies alba, Picea abies, Lonicera nigra, Luzula luzulina, Carex sylvatica, Galium rotundifolium, Cardamine trifolia, Oxalis acetosella, Paris quadrifolia, Dentaria glandulosa, Galeobdolon luteum, Phyteuma spicatum, Prenanthes purpurea, Actaea spicata, Senecio nemorensis, Vaccinium myrtillus, Viola reichenbachiana.*

4) APc – Zonal montane spruce – fir forests: *Picea abies, Abies alba, Calamagrostis arundinacea, Vaccinium myrtillus, Homogyne alpina, Oxalis acetosella, Gentiana asclepiadea, Blechnum spicant, Dryopteris dilatata, Lycopodium annotinum.*

5) F – Zonal montane beech forests: *Fagus sylvatica*, (*Abies alba, Picea abies, Acer pseudoplatanus*), *Euphorbia amygdaloides, Impatiens noli-tangere, Mercurialis perennis, Dentaria bulbifera, Asarum europaeum, Galium odoratum, Senecio nemorensis, Salvia glutinosa.*

6) Pc – Zonal montane spruce forests: *Picea abies, Sorbus aucuparia, Calamagrostis villosa, C. arundinacea, Deschampsia flexuosa, Luzula sylvatica, Vaccinium myrtillus, Oxalis acetosella, Gentiana asclepiadea, Homogyne alpina, Polygonum viviparum, Huperzia selago, Dryopteris dilatata, Athyrium filix-femina, A. distentifolium, Plagiothecium undulatum, Bazzania trilobata.*

7) AU – Azonal alluvial alder stands: *Alnus glutinosa, A. incana*, (*Picea abies, Fraxinus excelsior, Betula pubescens, Salix* spec. div.), *Petasites albus, Cirsium oleraceum, Filipendula ulmaria, Chaerophyllum hirsutum, Crepis paludosa, Ranunculus repens, Caltha palustris, Veratrum lobelianum, Thalictrum aquilegiifolium, Aconitum firmum, Plagiomnium undulatum, Rhizomnium punctatum, Brachythecium rivulare.*

This version of the map differs from the one, published by Michalko (1987) especially by better delimitation of the fir stands (our unit 3-A) against the herb rich beech forests (our unit 5-F).

The map presented shows not only the approximate distribution and character of vegetation, but also the starting state for all post-settlement changes, transformation of natural forests in the grasslands, fields, synanthropic vegetation and, at the end, also in secondary spruce plantations. It can be used also as a basis for efforts to restore and improve the degradated secondary forests and/or to reforestate the less productive agricultural soils, including pasture lands.

SETTLEMENT AND VEGETATION CHANGES

YOUNGER SUBATLANTIC (SA2), BETWEEN ca. 700–350 YEARS B.P. IN DEPENDENCE ON SETTLEMENT TIME AND PRESENT

Bobrov, OK-1-B (25–0 cm); Jedlová, OK-2-A (30–0 cm); Zlatnická Dolina, OK-9-A (20–0 cm), Slaná Voda, OK-7-A (40–0 cm); Suchá Hora, OK-3-A (20–0 cm).

Three distinct settlement phases can be distinguished in the Upper Orava region. Detailed historical information can be found especially in Kavuljak (1955) and Beňko (1978). Each of the settlement phases concerns compact, from the point of views of geography and vegetation, well defined landscape types. For a survey of the settlement sequence see Fig. 9.

PRE-MEDIEVAL AND MEDIEVAL SETTLEMENT PHASE (ca. 100–1370 YEARS A.D.)

While the Lower Orava region (broader vicinity of present Dolný Kubín town) has been settled according to archaeological finds since at least the middle of the Bronze Age (ca. 1500–1300 years B.C.), the first evidences of man's presence in the Upper Orava is dated back to Roman time. The settlement was limited to the narrow strip of land along the lowest Oravica river between the present towns of Tvrdošín and Trstená. It followed the merchant route, connecting the Roman Pannonia with northern Baltic regions via the Slovak towns Martin, Tvrdošín and Polish

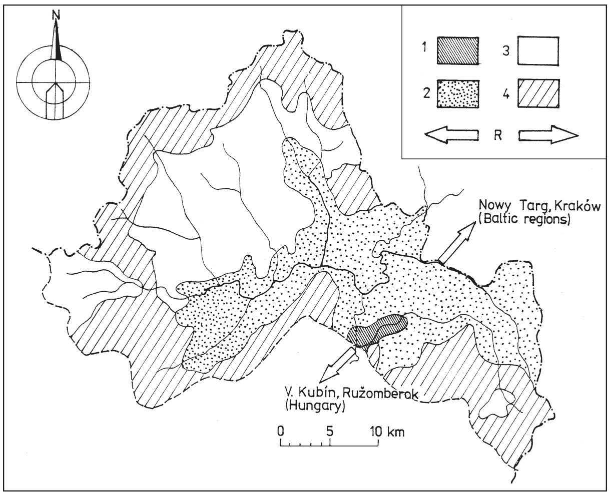


Fig. 9. Sequence of regular continuous settlement in the Upper Orava region. **1**. Medieval and pre-medieval settlement, 100–1370 A.D.; **2**. Walachian colonization, 1550–1580 (–1609) A.D.; **3**. Post–Walachian settlement, 1615–1691 (–1732) A.D.; **4**. Forested, continuously not settled areas; **R**. Directions of old merchant routes

Chyżne, Nowy Targ and Kraków (Chaloupecký 1923, Kolník 1980). According to pollen analyses sporadic and possibly just temporary settlement did not influence the vegetation in any essential way. The importance of merchant route decreased during the Migration and Slavonic times and it was probably connected also with settlement retreat.

The restoration of merchant connections in the early Medieval time (Žudel 1980) renewed the significance of the route so much, that a fortified custom station was established in the present town of Tvrdošín (Turdessina) in the middle of the 13th century (Kavuljak 1955). It controlled especially the import of lead, salt and cloth in the Hungarian monarchy.

Growing density of population along the route was subsequently connected with the growth of the most important settlements in our part of the region, namely the settltment of Tvrdošín and Trstená. Archive documents from the 14th century mention an existence of their properties (fields, meadows, pastures and forests) to be extended in the broader vicinity of both centres towards the easternmost parts of the basin, including the Polish borderland. The establishment of these oldest seats was based on the so-called rural law (ius ruralis), supporting especially field farming and crafts.

This first and oldest phase of regular settlement brought the beginnings of continuous deforestation of mostly spruce stands (change of AP from about 95% to about 40%, sudden retreat of *Picea abies* pollen), field cultivation (beginning and increase of cereals, pollen of *Fagopyrum* and *Centaurea cyanus*), and, formation of pastureland. First distinct indications of grazing reflect the reappearance of *Juniperus*, increase of Poaceae curve from about 5% to about 13% and regular occurrence of pollen of *Plantago lanceolata* and *Ranunculus* t. in corresponding layers. This all is reflected best in the diagram from Jedlová (Fig. 3). The extent of the cultivated land of that time had to be big enough to supply the garrison of the fortified custom office and of all other inhabitants of the Tvrdošín parish, established before 1395 (Kavuljak 1955).

THE SECOND PHASE OF SETTLEMENT (2nd HALF OF THE 16th CENTURY)

This phase was connected with the so-called Walachian colonization which was in progress during the second half of the 16th century. Twenty seven regular Walachian settlements were established between the years 1550 (villages of Ústie and Vitanová) and 1600 (Vasilov, Vavrečka). The Walachian colonists received important privileges according to the special law (ius valachale), concerning namely free cutting and use of wood, forest grazing and establishing mountain chalets for sheep, goat and cattle grazing. The villages were concentrated mostly in the Oravská Kotlina basin itself. They were built in valleys along the larger water streams. The deforestation and grazing affected the spruce and fir-spruce forests as well as fir stands in elevations between ca. 600–700 (750) m , however, the summer grazing and sheep chalet building practices extended up to ca. 850 m and affected also mixed beech forests.

The activities of the Walachian colonists are reflected best in the pollen diagram from Bobrov (village established 1564), situated just in the middle of the " Walachian" area (Fig. 2). AP representation decreased from about 95% to 30% TS due to disappearance of spruce stands. Representation of *Juniperus communis* pollen is similar to that in the Late Glacial (to about 5% TS). Regular and comparatively high occurrence of Poaceae, *Plantago lanceolata, Plantago major – media, Rumex acetosa, Ranunculus* t., partly also Cyperaceae pollen indicates first of all the high importance of grazing. On the other hand, very low frequencies of cereal pollen (to about 0,5% TS only), and, cereal weeds support the written data, mentioning field-farming as only a supplementary activity. Finds of *Cannabis* t. and *Linum usitatissimum* pollen indicate cultivation of hemp and flax besides the cereals and buckwheat in the fields.

POST-WALACHIAN SETTLEMENT (THE 17th CENTURY)

At least 9 earlier temporary settled groups of summer chalets developed in the regular permanent villages during the third phase of Upper Orava colonization between 1615–1690 (Oravská Lesná – Erdätka 1732). The solitary cottages on flat upland ridges only later concentrated to the valleys along the tracks and got the character of real village.

The earlier deforested areas and pastures were extended to about the present state and reached locally the elevation up to about 850 m. Besides of fir and fir-spruce also mixed beech forests were cleared. It is indicated by the sudden decrease of pollen curves of *Fagus* and *Abies* in upland diagrams from Zlatnická dolina (Fig. 4) and Slaná voda (Fig. 5). Very low pollen representation of heliophilous *Juniperus* (1–2% TS compared to 4–5% in diagrams of the basin) in the same diagrams shows widespread forest grazing, which certainly influenced the remaining natural tree stands on the southern slopes and foots of the main ridge of the Oravské Beskydy Mts uplands. This all means that the Walachian way of grazing remained the most important activity. Field agriculture had to be very extensive and unproductive, hand cultivation of soils of lowest qualities was practised till the fifties of the 20th century. Low frequencies of cereal pollen (to about 1% TS) and other cultivated plants in both diagrams are typical in this connection.

Generally, the Walachian style of land use and overgrazing brought huge damages especially in forests, but also caused degradation of soils and erosion. The grazing retarded or even stopped the natural forest regeneration so much that the original Walachian privileges had to be reduced and controlled (often in vain) from at least 1620 by the county officers. For more details and factual data about grazing see, e.g., in Kavuljak (1942), Chaloupecký (1947), Jostowa (1972). In both upland diagrams we can observe also a reflection of reforestation efforts and of plantation of secondary spruce stands in the last 2 centuries (see the increasing representation of spruce pollen in the uppermost assemblages).

During the third phase of settlement two other non-agricultural communities were established in the earlier colonised Oravská Kotlina basin, namely the settlements of Hamry (1615) and Osada (1602). Their inhabitants worked in iron-mills and were protected and supported directly by landlords of the Orava county. Production of iron from local sources and its processing certainly needed great quantities of wood, which, beside the grazing, contributed to the general retreat and degradation of forests in the region.

CONCLUSIONS

The results of palaeogeobotanical investigations in the Upper Orava regions presented can be summarized as follows:

1) There is clear divergence in vegetation development in two subregions of the Upper Orava, namely in the Oravská Kotlina basin and the surrounding upland areas. While in the palaeovegetation of the basin dominate the coniferous stands since the Late Glacial (see below), the upland areas and main mountain chains are covered with mixed deciduous tree stands with spruce from the end of the Boreal. Stands with montane deciduous trees of *Corylus, Ulmus, Tilia, Acer, Fraxinus* and *Picea abies* changed into mixed beech forests (*Fagus sylvatica, Abies alba, Picea abies*) at the end of the Subboreal in the upland areas. There are no data about the development of palaeovegetation from the Beskydy Uplands between the Late Glacial and Boreal. Using analogies from other similar regions we can expect the tundra-like vegetation in the Late Glacial, pine, birch and spruce stands in the Preboreal and spruce and hazel stands with growing representation of *Ulmus, Tilia, Fraxinus* in the Boreal.

2) Pollen analyses document the existence of specific light mixed coniferous stands in the Oravská Kotlina basin at the elevations between ca 600–700 m during the Late Glacial and the Preboreal. These stands were formed

by *Pinus cembra, Pinus sylvestris* (incl. *Pinus mugo* ?), *Larix decidua, Picea abies, Juniperus communis* and heliophilous plants in the shrub and ground layers. A possibility of glacial surviving of *Picea abies* in the intramountain basins around the High Tatra Mts is discussed. Supporting evidences from the biology of spruce, such as limited pollen production under severe climatic conditions and simultaneous ability of vegetative reproduction, are mentioned in this connection. Expected Late Glacial presence of spruce in the region explains the sudden expansion of the tree after the early Holocene climatic improvement and predominance of *Picea abies* in all of the following Holocene periods.

3) Combined pollenanalytical and phytosociological research helped to reconstruct the pre-settlement natural vegetation in detail. The map of Subatlantic distribution of 7 major forest types is presented (Fig. 8). These pre-settlement natural forest types are characterized by groups of indicator species, based on present state. *Picea abies* with *Abies alba* were certainly the dominant trees in the whole region, while *Fagus* was represented just in the upland parts of the region later in the Subatlantic. The map can contribute to the revitalisation of secondary, changed and degradated forests and/or reforestation efforts in some previously cleared plots.

4) Pollen analyses reflect well three phases of settlement and human impact on vegetation (see Fig. 9). The oldest pre-medieval and medieval settlements were concentrated to a little area in the lowest marginal part of the region around the towns of Trstená and Tvrdošín. It was connected with the existence of an old merchant route to and from Poland. Deforestation affected mostly spruce stands, which were transformed into fields and grazing places. The second phase of settlement during the so-called Walachian colonization (2^{nd} half of the 16^{th} century) was restricted approximately into the limits of the Oravská Kotlina basin. Deforestation concerned spruce and fir-spruce forests, which were transformed into grazing places, meadows and, to a lesser degree, fields. The Walachian way of summer mountain grazing extended from the permanent seats in the basin to the neighbouring uplands. These summer grazing farms changed the regular villages during the third phase of settlement in the 1st half of the 17^{th} century. It was connected with further deforestation of beech, fir and spruce forests and also brought a more intensive forest grazing in the remaining montane forest complexes.

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