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PRELIMINARY RESULTS OF THE VEGETATION HISTORY IN THE GIANT MOUNTAINS (ÚPSKÁ RAŠELINA MIRE AND ČERNOHORSKÁ RAŠELINA BOG)

Předběžné výsledky k historii vegetace Krkonoš (Úpská rašelina a Černohorská rašelina)

HELENA SVOBODOVÁ

Institute of Botany, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice

The reconstruction of the vegetation development of the Giant Mountains is based on the pollen analysis of mires. The peat profiles studied were taken from the two types of vegetation and topographic diversified complexes; Úpská rašelina Mire (1420 m a.s.l.) is situated in the artic alpine tundra and Černohorská rašelina Bog (1105 m a.s.l.) under the forest limit in the forested zone in a valley of Černá hora Mt. and Světlá hora Mt. Two profiles has been studied from Úpská rašelina Mire, and a profile from Černohorská rašelina Bog. The cores were frozen and subsampled at intervals of 2.5 cm in 1 cm^3 subsamples were treated in laboratory by the classic methods of Erdtman and Overbeck (BERGLUND et RALSKA-JASIEWICZOWA 1986). The Subboreal has been determined in the submontane zone of Černohorská rašelina Bog. In the submontane zone, mixed forest of *Abies* and *Fagus* prevailed. In the montane zone, forests of *Picea* and *Corylus* prevailed. In the subalpine zone *Pinus* (probably, *P. mugo*) and *Betula* (cf. *B. nana*) were important. The Older Subatlantic (2500–600 B.P.) was evident from both Černohorská rašelina Bog and Úpská rašelina Mire. Very characteristic is the dominance of *Abies* and *Fagus* over *Picea*. *Abies* is remarkably dominant tree in this time. *Abies* and *Fagus* forest, with *Abies* prevailing very likely continued both in the submontane zone and in the montane zone. In the Younger Subatlantic (600 B.P. – 0) a decline of forest is evident. *Pinus* and *Picea* are the most important trees. *Picea* began to increase again in valleys and depressions. Other trees, especially *Abies* and *Fagus* were selectively cut. The Younger Subatlantic is characterized by a general increase of herbs, including anthropogenic indicators and cultivated plants *(Secale,* Cerealia*)*. *Juniperus* suggests the existence and expansion of dry pasture and deforestation as well. *Picea, Fagus* and *Abies* forests occurred in the submontane zone. *Picea* forests dominated in the montane zone and *Pinus (cf. P. mugo*) expanded in the subalpine zone.

Keywords: Pollen analysis, vegetation history, Holocene, Giant Mountains

1. INTRODUCTION

The Giant Mountains (Krkonoše in Czech, Riesengebirge in German) have not yet been palynogically studied in systematic way. There is however, a great need of modern palaeoecological research, in the support of landscape management planning of the Krkonoše National Park. Two mire groups can be distinguished: (1) patterned mires of the arctic-alpine tundra zone, 1230 to 1410 m a.s.l. in the western range and to 1440 m a.s.l. in the eastern range. The western range is exposed to high precipitation and has 36 mires, the largest of which are Pančavská louka and Jestřábí louka (mires). In the eastern range, the famous Úpská rašelina Mire (Koppenplanmoor in German) is accompanied by several smaller bogs; (2) montane bogs in the spruce forest belt, represented by (a) a group of nine bogs called Černohorská

rašelina Bog between 1105 and 1210 m a.s.l., and (b) ten mires situated in the spring area of Úpice river between 1000 and 1060 m a.s.l. (*cf.* Očadlík and Fuksa 1968, Jeník 1961).

The reconstruction of vegetation development of the Giant Mountains is based on pollen analysis of mires. The peat profiles studied were taken from the two types of mires as described above. The artic-alpine Úpská rašelina Mire (1420 m a.s.l.) is situated on the plain at the foot of the Snežka Mt. (1602.3 m a.s.l.). The montane Černohorská rašelina Bog (1105 m a.s.l.) lies below the timberline in the valley of Černá hora Mt. (1243 m a.s.l.) and Světlá hora Mt. (1244 m a.s.l.). At present, *Picea abies* in majority, and *Fagus sylvatica* in short intervals, form the altitudinal timberline, at an average cf about 1220 m a.s.l. (jeník 1961, jeník and lokvenc 1962).

According to a radiocarbon dated pollen diagram published by Hűttemann (Hüttemann and Bortenschlager 1987) from the Pančavská rašelina Mire, the oldest pollen data are from the Atlantic (6000 B.P.), with dominance of *Pinus* and *Corylus*. The vegetation of the mires has an alpine character with *Dryopteris,* Poaceae*,* Cyperaceae, and *Sphagnum*. In the Younger Atlantic, *Pinus sylvestris* was present and *Picea* arrived. In the Subboreal, according to results from Pančavská rašelina Mire (Hüttemann and Bortenschlager 1987, Jankovská 2000) and Černohorská rašelina Bog (Pacltová 1952, 1953, 1955, 1957), only *Picea* and *Fagus* are important in the forest ecosystems.

2. HISTORY OF PALAEOECOLOGICAL RESEARCH

Úpská rašelina Mire has been palynologically studied by Puchmajerová (1929), Rudolph and Firbas (1926, 1927) and Rudolph et al. (1928), Černohorská rašelina Bog by Pacltová (1952, 1953, 1955, 1957). Recently, research on the latter was focused on human impact during the Late Holocene (Speranza et al. 2000).

Tołpa (1949) and others (Cielińska and Dumanowski 1961) studied mires on the border between Poland and the Czech Republic.

3. METHODS

We cored three peat profiles with a Russian Intorf peat sampler, two in Upská rašelina Mire and one in Černohorská rašelina Bog. The cores were frozen and subsampled at 2.5 cm. 1 cm^3 subsamples were treated by the classic methods of Erdtman and Overbeck (Berglund and Ralska-Jasiewiczowa 1986) in the laboratory. A minimum of 500 arboreal pollen grains was counted in each subsample. For the calculation of pollen percentages the pollen sum (100 % by definition) includes arboreal pollen (AP) and non-arboreal pollen (NAP), but excludes pollen of Telmatophytes and spores of Pteridophytes. The pollen diagrams were constructed with the French palynological computer program GPALWin (Goeury 1997). Dots in the pollen diagrams indicate frequencies less than 1 %.

4. DESCRIPTION OF THE MIRES AND THEIR PALYNOSTRATIGRAPHY

4.1. Úpská rašelina Mire

Úpská rašelina Mire lies in the arctic alpine tundra, north of Studniční hora Mt. (1555 m) and east of Luční bouda chalet, on the water divide between Bílé Labe River and Úpa River and on the border of Poland and the Czech Republic. The bedrock is formed by biotic granite. Mean annual precipitation is 1513 mm, snow cover persists for 187 days per year, and mean annual temperature is 1.5˚C (Očadlík and Fuksa 1968). Úpska rašelina Mire is exposed to strong winds from the west and southwest (Očadlík and Fuksa 1968). Mire development was facilitated by shallow water springs, a moderate

inclination and stagnation of water in depressions (Očadlík and Fuksa 1968). The micro-morphology and the plant communities of this mire are similar to those in subartic and high-mountain regions. The depth of the mire varies from 0.3 m to 1.5 m. The vegetation is formed by *Oxycocco-Empetrion hermaphroditi* and *Sphagno lindbergii-Caricetum limosae* and in drier biotopes *Chamaemoro–Pinetum mughi* and *Sphagno robusti-Empetro hermaphroditi* (Hadač et Váňa 1967, Soukupová et al. 1991). Two cores (KR-2-A and KR-2-B) were taken from the central part of the mire. The peat stratigraphy is described in Tables 1 and 2 by the method of Troels-Smith (1955).

Tab. 1. Stratigraphy of Úpská rašelina Mire, profile KR-2-A

Depth	Peat composition (*Tb-turfa bryophytica, Th-turfa herbacea, Tl – turfa lignosa)*				Peat type
0–20 cm	*Tb (Spha)* 3	*Th (vagi.)* 1			*Sphagnum* peat
20–36 cm					Detritus
36–40 cm	*Tb (Spha)* 2			*Tl (Call)* 2	*Sphagnum* peat with *Calluna*
40–59 cm		*Th (vagi.)* 3	*Tb (hypn.)* 1		*Eriophorum vaginatum* peat
59–68 cm	*Th (p-cari.)* 3		*Tb (hypn.)* 1		*Carex* peat
68–80 cm		*Th (vagi.)* 3	*Tb (hypn.)* 1		*Eriophorum vaginatum* peat

Profile (Tab. 1.) KR-2-A is formed by sedges-cotton grass and sedges, the most upper part by mosses and *Sphagnum.*

Tab. 2. Stratigraphy of Úpská rašelina Mire, profile KR-2-B

Depth	Peat composition (*Tb-turfa bryophytica, Th-turfa herbacea, Tl – turfa lignosa)*			Peat type
0–22 cm	*Tb (Spha)* 3	*Th (vagi.)*1		*Sphagnum* peat
22–39 cm				Detritus
39–41 cm				*Picea* needles
41–50 cm	*Tb (Spha)* 3	*Th (vagi.)*1		*Sphagnum* peat
50–57 cm		*Th (vagi.)*3	*Th (cari.)*1	*Eriophorum vaginatum* peat
57–67 cm	*Tb (Spha)* 3	*Th (vagi.)*1		*Sphagnum* peat
67–79 cm	*Th (p-cari.)* 3		*Tb (hypn.)*1	*Carex* peat

The next profile (Tab. 2.) is of the similar composition of sedge-cotton grass and sedges. The important level with the needles of *Picea* witness the close presence of this species on the locality.

4.1.1. Pollen Analyses, pollen diagrams KR-2-A (Fig. 1.) and KR-2-B (Fig. 2.)

For both profiles two leading vegetation phases and two pollen assemblages zones (PAZU – pollen zones of Úpská rašelina Mire) were distinguished, as follows.

PAZ U1: *Fagus-Abies.* This phase is characterized by expansion of *Fagus* (maximum 30 %) and subsequently of *Abies* (maximum 30 %). *Quercus* and *Carpinus* are under 5 % as well as *Picea.* The presence of *Picea* needles as macroremains in profile KR-2-B indicates that the trees were growing in the very close vicinity. *Pinus* and *Alnus (Alnus viridis)* are local. Among herbs, *Poaceae* and *Cyperaceae* are dominant. *Melampyrum* reached 5 % in one horizont. High *Melampyrum* values were also observed in the corresponding Zone B of Černohorská rašelina Bog (Speranza et al. 2000). This taxon may indicate fires or changes in local hydrology.

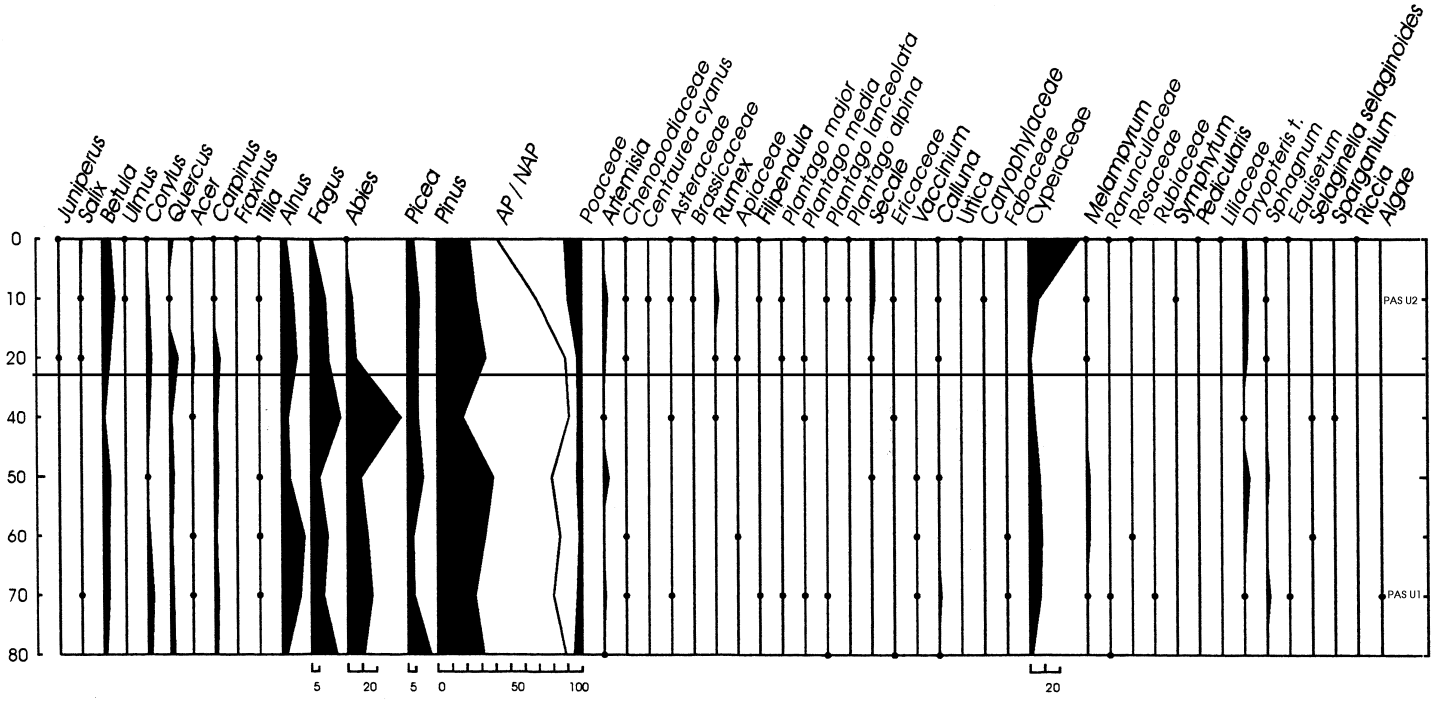
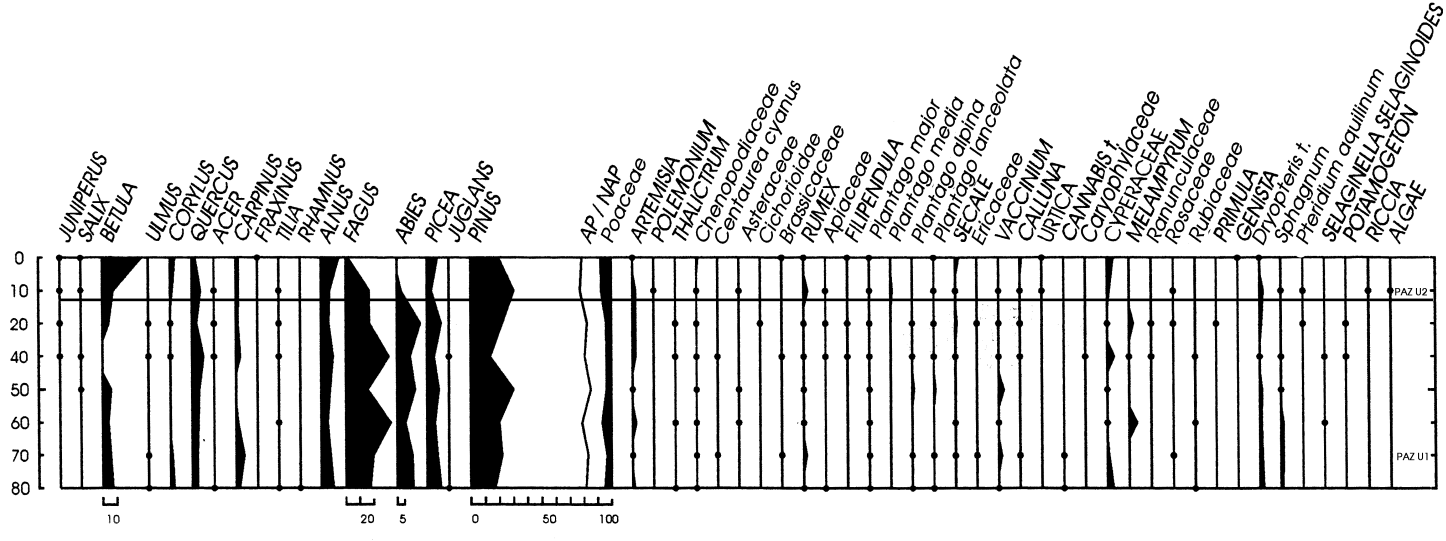


Fig. 1. Pollen diagram of Úpská rašelina Mire, profile KR-2-A



Analysis H.Svobodová

Fig. 2. Pollen diagram of Úpská rašelina Mire, profile KR-2-B

PAZ U2: Cyperaceae-Poaceae. Among trees, *Pinus* and *Betula* dominate. The dwarf shrubs *Vaccinium* and *Calluna* are present. Among herbs *Rumex, Plantago, Urtica,* and *Artemisia* dominate. Another peak of *Melampyrum* is found (cf. Zone D in SPERANZA et al. 2000). Cultivated plants are represented by *Secale* pollen.

4.2. ČERNOHORSKÁ RAŠELINA BOG

Černohorská rašelina Bog lies in the spruce forest belt. Biotic ortho-gneiss forms the bedrock. This forested valley bog lies north of Černá hora Mt. and is drained by Černohorský potok stream, a tributary of Úpice River. The northwestern part of the bog is arteficially drained. Towards to the center the bog is more saturated by water. The approximate peat thickness varies from 0.5 m to 1.0 m, and 2.5 m in the deepest part. *Sphagno-Piceetum* covers the bog at present. The occurrence of *Scheuchzeria* was always typical of this locality (SCHUSTLER 1918).

Core KR-1-A was taken from the edge of the bog. The peat stratigraphy is described in Tab. 3.

Tab. 3. Stratigraphy of Černohorská rašelina Bog, profile KR-1-A

Depth	Peat composition (*Tb-turfa bryophytica, Th-turfa herbacea, Tl – turfa lignosa)*			Peat type
20–67 cm	*Th (vagi.)* 1		*Tb (Spha)* 3	*Sphagnum* peat
67–150 cm	*Th (vagi.)* 3	*Tb (hypn.)* 1		*Eriophorum vaginatum* peat

Four pollen assemblage zones (PAZC – pollen zones from Černohorská rašelina Bog) were distinguished (Fig. 3.), grouped in a *Picea* vegetation phase (PAZ 1) and an *Abies-Fagus* vegetation phase (PAZ 2, 3, and 4), as follows:

PAZ C1: *Picea-Abies-Fagus* It has the first *Abies* maximum (30 %), and *Fagus* reaches about 20 %. *Quercus* increases above 5 %. Herbs are presented by Poaceae and Cyperaceae.

PAZ C2: *Abies-Fagus.* This phase is characterized by dominance of *Fagus* (25 %) and *Abies* (15 %). *Quercus, Corylus,* and *Carpinus* reach about 5 %. Many cultivated plants and anthropogenic indicators were encountered (*Secale, Cannabis,* Compositae Subfam. Asteroideae*, Artemisia, Rumex,* Chenopodiaceae*).*

PAZ C3: *Fagus-Abies*. This PAZ has the second *Abies* maximum (30 %) and also a *Picea* maximum (25 %). Local degradation of the bog is shown by appearance of Ericaceae*, Vaccinium,* and *Calluna.* Anthropogenic indicators are continuously present (*Rumex, Plantago lanceolata, P. media*).

PAZ C4: *Fagus-Picea.* This zone is characterized by a *Fagus* maximum (40 %). In this PAZ great forestation of *Fagus* is typical. *Rumex* and *Plantago* pollen most probably indicate anthropogenic montane meadows. Pollen of cultivated plants is scarce.

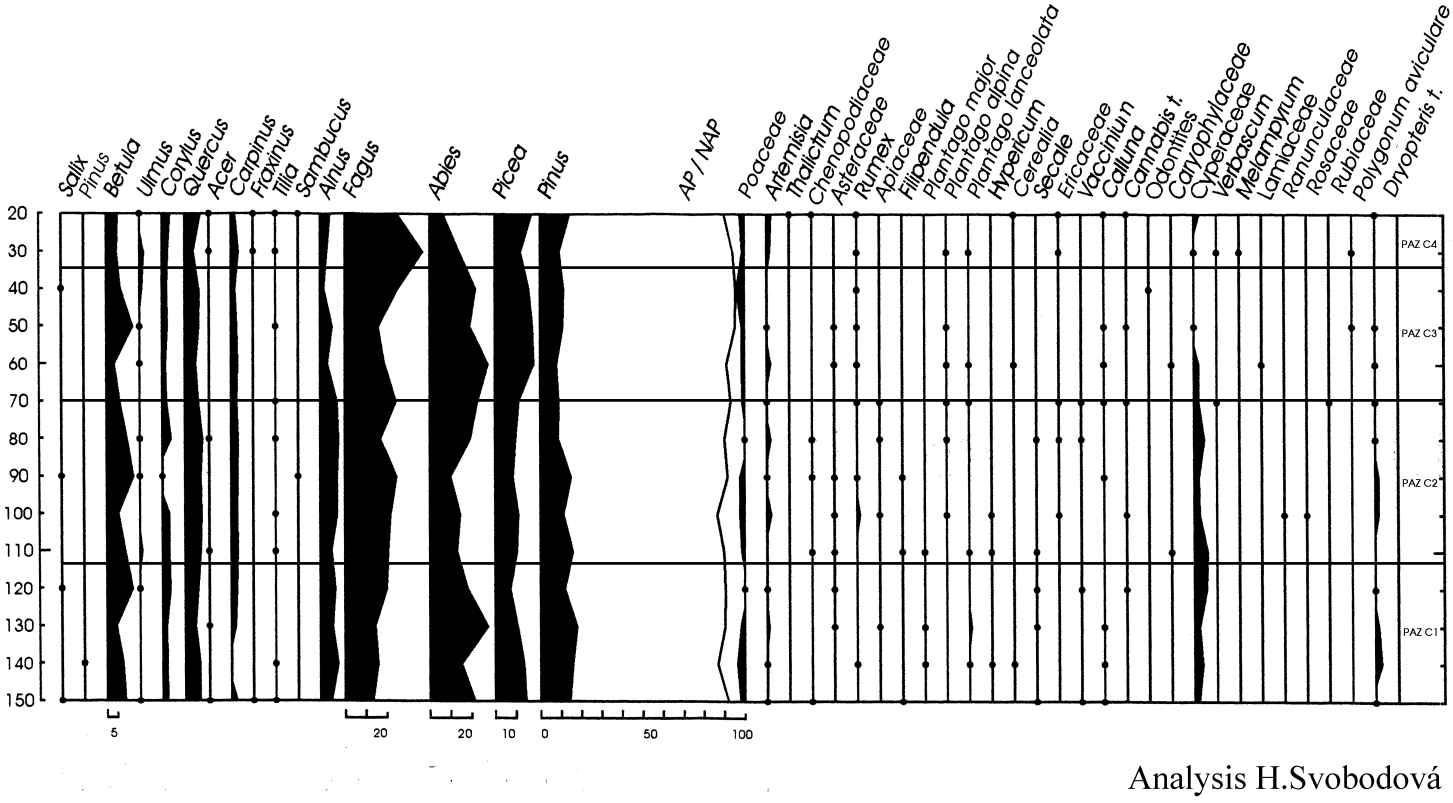


Fig. 3. Pollen diagram of Černohorská rašelina Bog, profile KR-1-A

5. RESULTS

Table 4. gives a chronostratigraphic correlation of the pollen diagrams.

Tab. 4. Chronostratigraphy of the Giant Mountains

Chronologie	Firbas 1949	Černohorská rašelina KR-3-A	Úpská rašelina KR-2-A	Úpská rašelina KR-2-B	Pančavská louka
		Svobodová 2002	Svobodová 2002	Svobodová 2002	Hutteman1987
600 B.P.	SA 2		PAZ U2	PAZ U2	PAZ 8
		PAZ C4		PAZ U1	PAZ 7
		PAZ C3			
2 500 B.P.	SA1	PAZ C2	PAZ U1		PAZ 6
		PAZ C1			PAZ 5
					PAZ 4
5 000 B.P.	SB				PAZ 3
6 000 B.P.	AT 2				PAZ 2
	AT 1				PAZ 1

5.1. SUBBOREAL (4500–2500 B.P.): Černohorská rašelina Bog, PAZ C1

From the palynological point of view *Picea* and *Pinus* formed the timberline. *Picea* had a minimum at 120 cm, *Fagus* remained constant, whereas *Abies* increased continuously towards its first maximum. *Picea* declined because of competition by *Abies. Quercus* and *Corylus* have relatively high values.

In the submontane zone, undisturbed mixed forest of *Abies* and *Fagus* prevailed. In the montane zone, forests of *Picea* and *Corylus* prevailed. In the subalpine zone *Pinus* (probably *P. mugo*) and *Betula (*cf. *B. nana)* were important.

5.2. Older Subatlantic (250–600 B.P.): Černohorská rašelina Bog, PAZ C2, 3, and 4, and Úpská rašelina Mire (KR-2-A), PAZ U1 and (KR-2-B), PAZ U1

Very characteristic for the Older Subatlantic is the dominance of *Abies* and *Fagus* over *Picea*. Mainly, *Abies* and *Fagus* formed the timberline from this time. *Abies* is remarkably dominant with 30 % at 65 cm in Černohorská rašelina Bog and in the same time with 40 % at 40 cm in Úpská rašelina Mire. *Fagus* has its maximum later, corresponding with PAZ C4 of Černohorská rašelina Bog. Among herbs *Artemisia* is an important indicator of human impact. *Abies* and *Fagus* forest, with *Abies* prevailing, very likely continued both in the submontane and in the montane zone. However, anthropogenic deforestation lowered the timberline. In the arctic-alpine tundra zone *Pinus* cf. *mugo* krummholz and *Betula nana* expanded on the mires. *Carpinus* and *Quercus* occurred in mixed forests of the submontane zone, but not in the montane zone.

5.3. Younger Subatlantic (600 B.P.- 0): Úpská rašelina Mire (KR-2-A), PAZ U2 and (KR-2-B), PAZ U2

In the Younger Subatlantic a decline of forests is evident. *Pinus* and *Picea* are the most important trees. *Picea* began to increase again in valleys and depressions, also very close to the coring location (shown by needles in the peat). Other trees, especially *Abies* and *Fagus* were selectively cut. This activity lowered the timberline and *Picea* prevailed in forming the timberline.

The Younger Subatlantic is characterized by a general increase of herbs, including anthropogenic indicators and cultivated plants. Pollen of cultivated plants *(Secale,* Cerealia*)* were transported on a long distance from the farming land under the mountains. *Juniperus* suggests the existence and expansion of dry pasture and deforestation. The increase of *Calluna* and *Vaccinium* indicate degradation of the bogs, probably caused by fire.

Picea, Fagus and *Abies* forests occurred in the submontane zone. *Picea* forests dominated in the montane zone and *Pinus (*cf. *P. mugo*) expanded in the subalpine zone (JANKOVSKÁ 2001). In this time *Picea* was also planted in montane zone.

6. FLUCTUATIONS OF THE TIMBERLINE

6.1. Climate and Timberline

Climatic change in the Giant Mts. during the Holocene has a Middle European character (HUNTLEY and PRENTICE 1988). A reduction of the vegetation period, which occured in several short intervals, resulted in depression of the timberline, which can amount to more than 200 m.

The pollen diagrams of Úpská rašelina Mire give evidence of timberline fluctuations caused by climatic change. The most important trees for the alpine timberline in the Subboreal were *Picea* and *Pinus,* in Older Subatlantic *Fagus* and *Abies,* and in Younger Subatlantic *Picea.*

6.2. Man and Timberline

Deforestation caused by man is shown in the pollen diagrams by the appearance of anthropogenic indicators and cultivated plants. This concerns not only direct deforestation, but also animal husbandry (cattle) and hay making, because humans began to use permanent huts (cottages) built at the timberline (LOKVENC 1958, 1995).

A very detailed study of the human role in the lowering of the timberline appeared recently on the example of Černohorská rašelina Bog (SPERANZA et al. 2000). The relation between palaeobotanical evidence of human occupation and historical sources was discussed in the detail.

SPERANZA et al. (2000) conclude on the basis of pollen analysis that the first colonisation of the mountains took place in the 7th–8th century A.D., but they found no support for mountain colonization in the historical sources. However, this event may be correlated with evidence of the first Slavonic tribes coming to the area (cf. KALFERST 1986, SIGL and VOKOLEK 1993, and others).

The next wave colonization, well known from historical sources, is the so-called German colonization in the 12th century A.D. This is well reflected in the pollen diagrams of SPERANZA et al. (2000). The third wave of mountain colonization was in the 16th century, and the last and greatest one was so called hut colonization of the 18th century, which introduced modern forestry practices in the area (LOKVENC 1995). A detailed study of colonization phases with high resolution is planned for the near future.

7. DISCUSSION AND SUMMARY

According to the pollen results of Pančavská rašelina Mire, Černohorská rašelina Bog and Úpská rašelina Mire *Abies* appeared later in the Younger Subboreal approximately synchronous with the arrival of *Carpinu*s, which plays an important role in mixed forest of the submontane zone. In the Younger Subatlantic *Abies* dominates the region. In this period human activities caused a strong deforestation of the Giant Mts (cf. SPERANZA et al. 2000).

SOUHRN

Rekonstrukce vývoje vegetace Krkonoš je založená na pylové analýze rašelinišť. Pylové profily byly odebírány ze dvou vegetačně topograficky odlišných rašelinných komplexů; z Úpské rašeliny a z Černohorské rašeliny. Arkto-alpinská Úpská rašelina (1420 m n.m.) leží na planině pod vrcholem Sněžky (1602,3 m n.m.) a montánní Černohorská rašelina (1105 m n.m.) je situována pod hranicí lesa v údolí Černé a Světlé hory. Z Úpské rašeliny byly studovány dva pylové profily a z Černohorské rašeliny jeden. Vzorky o obsahu 1 cm^3 byly odebírány ze zmrazené rašeliny po 2,5 cm a laboratorně zpracovány podle Erdtmana a Overbecka (Berglund et Ralska-Jasiewiczowa 1986).

Subboreal (4500–2500 B.P.) byl zjištěn na Černohorské rašelině. V této submontánní zóně převažoval nepoškozený smíšený les tvořený bukem a jedlí. V montánní zóně byly lesy se smrkem a lískou a v subalpinské zóně byla významná borovice, spíše však *Pinus mugo* a bříza (*Betula nana*).

Starší subatlantik (2500–600 B.P.) byl rozpoznán na profilech z Černohorské rašeliny i z Úpské rašeliny. Velmi charakteristická je dominance jedle a buku nad smrkem. V této době je zvláště jedle velmi dominantní dřevinou. Jedlo-bukové porosty s převažující jedlí byly jak v submontánní, tak i v montánní zóně.

V mladším subatlantiku (600 B.P. – současnost) je odlesňování jednoznačné. Borovice a smrk jsou nejdůležitějšími dřevinami. Zastoupení hlavně smrku se velice zvyšuje. Ostatní dřeviny jako jedle a buk, byly selektivně káceny. Mladší subatlantik je dále charakterizován hlavně zastoupením bylin, zahrnující i antropogenní indikátory a kulturní plodiny (obiloviny). Jalovec prezentuje existenci suchých pastvin a současně i odlesňování. Smrkové lesy s bukem a méně s jedlí jsou rekonstruovány v submontánní zóně, smrkové v montánní zóně a borovice je rozšířená v subalpinské zóně. Lidské indikátory potvrzují silný vliv člověka na odlesnění Krkonoš.

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REFERENCES

Berglund B. E. et Ralska-Jasiewiczowa M. 1986: Pollen analysis and pollen diagrams. In: Berglund B.E. (Ed.), 1986: Handbook of Holocene Paleoecology and Paleohydrology. Wiley & sons, Chichester, pp. 455–484.

Cielińska M. et Dumanowski B. 1961: The Karkonosze. INQUA-Congress Warsaw, Gb. B: 25–32.

Goeury C. 1997: Gestion, traitement et représentation des données de la paléoécologie. XVème Symposium de l'A.. P. L. F. Lyon: pp. 31.

Hadač E. et Váňa J. 1967: Plant communities of mires in the western part of the Krkonoše Mountains, Czechoslovakia. – Folia Geobot. Phytotax., 2: 212–254.

Huntley B. et Prentice I. C. 1988: July temperatures in Europe from pollen data. 6000 years before present. Science, 241: 681–690.

Hüttemann H. et Bortenschlager S. 1987: Beiträge zur Vegetationsgeschichte Tirols VI: Riesengebirge, Hohe Tatra – Zillertal, Küthai.- Ber.nat.- Med. Verein, 74: 81–112.

Jankovská V. 2001: Vegetation Development in the Western Part of the Giant Mts. During the Holocene (Pančavské rašeliniště Mire – palaeoecological research). Opera Corcontica 38: 11–19. Vrchlabí.

Jeník J. 1961: Alpinská vegetace Krkonoš, Králického Sněžníku a Hrubého Jeseníku. Praha.

JENÍK J. et LOKVENC T. 1962: Die alpine Waldgrenze im Krkonoše Gebirge. Rozpravy Čs. Akad. Věd 72, 1: 1–65.
JENÍK J. et SOUKUPOVÁ L. 1992: Microtopography of subalpine mires in the Krkonoše Mountains, The Sudets. Preslia 64: 313–326.
KALFERST J. 1989: Zjišťovací výzkum na hradišti „Valy" u Kalu (okr. Jičín). Zpravodaj Kraj. Muz. Vých. Čech, Hradec Králové, 16/1: 28–34.
LOKVENC T. 1958: Historie zalesňování nad horní hranicí lesa v Krkonoších. Práce výzk. úst. lesnických ČSR, 15: 149–166.
LOKVENC T. 1995: Analýza antropogenně podmíněných změn porostů dřevin klečového stupně v Krkonoších (Analysis of anthropogenic changes of woody stets above the alpine timberline in the Krkonoše Mts.). Opera Corcontica 32: 99–114. Vrchlabí.
OČADLÍK J. et FUKSA V. 1968: Topografie rašelinišť Krkonošského národního parku. Opera Corcontica 5: 53–81. Praha.
PACLTOVÁ B. 1952: Zpráva o výzkumu krkonošských rašelin. Zprávy o geol. výzkumech v r. 1952: 76–78.
PACLTOVÁ B. 1953: Zpráva o výzkumu rašelin na Černé hoře v Krkonoších. Zprávy o geol. výzkumech v r.1953: 153–159.
PACLTOVÁ B. 1955: Zprávy o výzkumech krkonošských rašelinišť. Zprávy o geol. výzkumech v r. 1955: 162–163.
PACLTOVÁ B. 1957: Rašeliny na Černé hoře a dějiny lesa ve východních Krkonoších. Ochrana přírody (Věstník státní ochrany přírody), 12, 3: 65–83.
PUCHMAJEROVÁ M. 1929: Les tourbières de la haute chaîne des Krkonoše et du massif central de la Jizera. Publications de la Faculté des Sciences de l'Université Charles, 89: 1–23.
RUDOLPH K. et FIRBAS F. 1926: Pollenanalytische Untersuchungen subalpiner Moore des Riesengebirges. Ber. Dtsch. Bot. Ges. 44: 227–248.
RUDOLPH K. et FIRBAS F. 1927: Paläofloristische und stratigraphische Untersuchungen böhmischer Moore. III. Die Moore des Riesengebirges. Beih. Bot. Zbl., 43: 69–144.
RUDOLPH K., FIRBAS F. et SIGMOND H. 1928: Das Koppenplanmoor im Riesengebirge. Lotos, B 76: 133–221.
SCHUSTLER F. 1918: Krkonoše. Rostlinozeměpisná (fytogeografická) studie. Archiv pro přírodovědecký výzkum Čech, 16. Praha.
SIGL J. et VOKOLEK V. 1993: Pravěké a raně středověké osídlení okolí Choustníkova hradiště (okr. Trutnov). Diss. Historiae 1: 141–153.
SOUKUPOVÁ L., JENÍK J. et ŠTURSA J. 1991: Krkonošské a skandinávské populace ostružiníku morušky *Rubus chamaemorus* L.Opera Corcontica 28: 73–103. Praha.
SOUKUPOVÁ L., KOCIÁNOVÁ M., JENÍK J. et SEKYRA J. 1995: Arctic-alpine tundra in the Krkonoše, the Sudets. Opera Corcontica 32: 5–88. Vrchlabí.
SPERANZA A., HANKE J., VAN GEEL B. et FANTA J. 2000: Late-Holocene human impact and peat development in the Černá hora bog (Krkonoše Mountains, Czech Republic). The Holocene 10/4: 481–491.
TOŁPA S. 1949: Torfowiska Karkonoszy i Gór Izerskich. Roczniki Nauk Rolniczych Pol. 52: 5–73.
TROELS-SMITH J. 1955: Karakterisering af løse Jordarter. Danm. Geol. Unders. 3/10: 1–73.