ACTA UNIVERSITATIS CAROLINAE
2000 GEOGRAPHICA, XXXV, SUPPLEMENTUM, PAG. 99–110

Natural Development and Anthropogenic Impacts on the Vegetation of the Passeiertal, South Tyrol, during the Late-Glacial and Holocene

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ABSTRACT

This study presents pollen and sediment analyses from a subalpine fen in northwestern South Tyrol. A complete sequence from Oldest Dryas to Subatlantic is preserved there. After the retreating of ice, pioneer vegetation and alpine meadows spread followed by immigration of larch and Siberian cedar even during the Allerød. Both were replaced during the early Atlantic by spruce. At the start of the Subatlantic, anthropogenic impact become evident through forest fires and increasing pastures. Another period of clearing – strongly connected with the spreading of larch – occurs at the beginning of the High Middle Ages.

Key words: development of vegetation, Passeiertal, the Late-Glacial, the Holocene

1. Introduction

The vegetation history of the South Tyrol has been poorly investigated compared to adjacent regions in Austria and Switzerland. According to distribution maps of Schneider (1985) and Wahlmüller (1993), supplemented by my own surveys (Stumböck 1999), only the area around Bozen has been studied so far (e.g. Kofler 1992, Schmidt 1975, Seiwald 1980). It is necessary to fill this gap for a better regional understanding of the re-establishment and development of vegetation after the ice age and of human influences. One step towards this goal is the study presented in this paper. The sediments of the investigated fen Kurzmoos reveal a complete and undisturbed sequence from Late-Glacial to Subatlantic time. Pollen diagrams seem to be especially suitable for the interpretation of the vegetation history of subalpine altitudes from the Passeiertal and adjacent areas.

2. Study Area

The study area is situated in the upper Passeiertal approximately 23 km north of Meran near the Italian-Austrian border (Fig. 1). This area of the eastern Central Alps is mainly characterized by metamorphic rocks (schist and gneiss) and subcontinental climate. Platt (1147 m a.s.l.), for example, experiences an annual precipitation of 1035 mm and an average annual temperature of 8.0 °C (Hydrographisches Amt 1994, 1995).

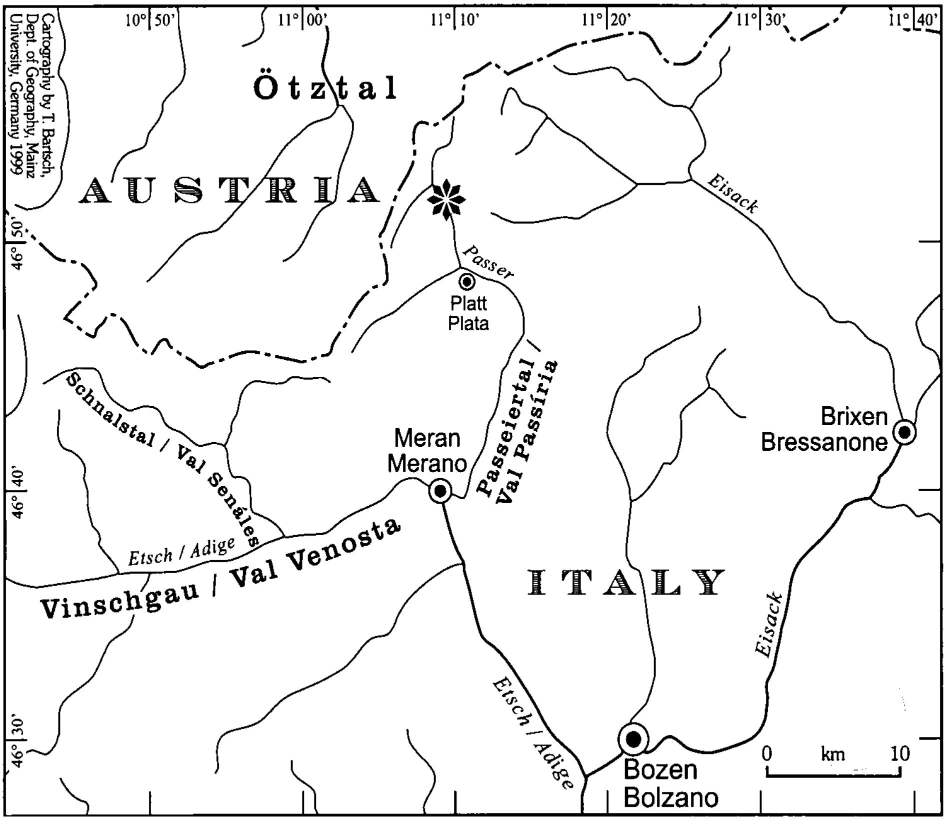

Figure 1: Map of northwestern South Tyrol. The investigated fen Kurzmoos (1820 m a.s.l.) is indicated by an asterisk.

The investigated site Kurzmoos (46° 52' N lat.; 11° 09' E long.) is located adjacent to the inn Schönau at an altitude of 1820 m. The moderately tilted fen has developed within a long and narrow depression up to a depth of 5.15 m and reaches 250 x 20 m. The stable slopes and apparently no fluvial dynamics show ideal conditions for an almost undisturbed accumulation of organic material.

Kurzmoos is situated within the subalpine belt composed of dense spruce (*Picea abies*) and larch (*Larix decidua*). The ground vegetation is dominated by dwarf shrubs (*Calluna vulgaris, Rhododendron ferrugineum, Vaccinium* spp.) and grasses (e.g. *Deschampsia flexuosa, Festuca rubra*). The vegetation of the fen is heterogeneous and rich in species. Some of the more common plants are *Carex nigra, Eriophorum latifolium, Pinguicula vulgaris, Potentilla erecta* and *Scirpus caespitosus.* According to Biologisches Landeslabor (1991), Kurzmoos may be described as a fen with certain taxa typical for raised bogs such as *Drosera rotundifolia.* Today, no indication of grazing can be recognized within the area.

3. Methods

Using a Russian sampler with a chamber length of 50 cm and a diameter of 4 cm, corings were taken in the centre of the eastern part of the Kurzmoos, where the basin reaches its maximum depth. Additionally, the first 50 cm were dug. The sediments were prepared at the Botanical Institute, University of Innsbruck, following standard methods including ultrasonic tube and HF (described, e.g., in Moore et al. 1991). The slides have been counted generally on 600 arboreal pollen and by a computer program (Stumböck, Müller 1996) and the pollen diagram has been plotted using "POLPROF" (Tranquillini 1988). The diagram is designed as a percentage diagram (Fig. 3) supplemented by pollen concentration.

4. Results

4.1. Chronostratigraphy

The AMS-radiocarbon datings (Tab. 1) were determined by the R. J. Van de Graaff Laboratorium (University of Utrecht, The Netherlands). The $d^{13}C$ (‰) measurements show typical values for terrestrial sediments and indicate no significant role of the hard water effect.

A diagram showing sediment age versus depth is given in Figure 2. The mean sedimentation rate is 2.90 cm/100 years (calibrated). Following extremely low sedimentation during the Late-Glacial, the rate increases to a maximum of 25.8 cm during the early Atlantic. In the uppermost 50 cm (Modern Age) a secondary maximum is reached.

Table1: Radiocarbon datings of the Kurzmoos

Depth (cm)	Years BP conventional	Material	$\delta^{13}C$ (‰)	Laboratory no.
30	311 ±31	seeds	–24.8	UTC 5348
44	385 ±31	seeds	–25.4	UTC 5349
65	990 ±70	wood	–25.8	UTC 5042
78	1100 ±29	wood	–28.5	UTC 5666
118	2598 ±40	wood	–24.2	UTC 5043
277	7410 ±90	wood	–28.8	UTC 5773
316	7590 ±80	wood	–27.3	UTC 5044
442–444	10060 ±80	wood/plant	–24.8	UTC 4436
466–468	11330 ±60	clay	–24.3	UTC 5774
496–498	14290 ±70	clay	–21.3	UTC 5063

4.2. Lithostratigraphy and wood findings

The sediments (Tab. 2) reveal in the lowest parts mineral subsoil and highly decayed gyttja. Above these layers, *Carex* peat occurs followed by a large section of wood peat rich in fragments of *Alnus viridis* and *Picea-Larix*-type. The latter may not be separated adequately (Schweingruber 1990). The uppermost part again shows *Carex* peat poor in wood.

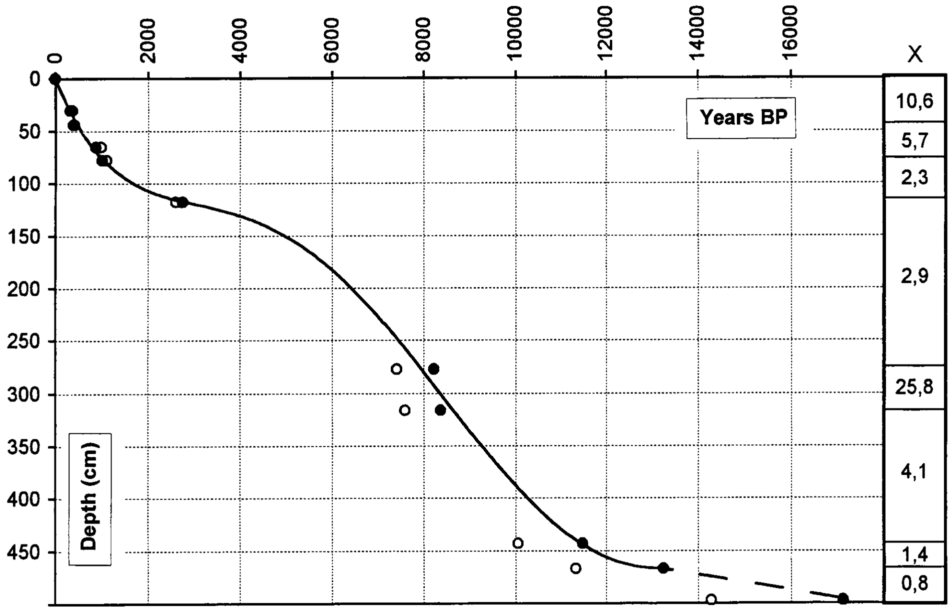

Figure 2: Age-depth relationship of Kurzmoos. Black dots are calibrated radiocarbon datings, open dots are conventional. X means rate of sedimentation in cm/100 years calib.

Table 2: Lithostratigraphy and wood fragments of the Kurzmoos

Depth (cm)	Layer	Colour	Wood fragments (cm)
0–5	*Sphagnum*	yellow	
55–22.5	*Carex* peat	dark brown	
22.5–23	*Carex* peat and coarse sand	grey brown	
23–27.5	*Carex* peat	dark brown	
27.5–28.5	*Carex* peat and coarse sand	grey brown	
28.5–75	*Carex* peat	dark brown	*Alnus viridis* (67)
75–317	wood peat	black	*Picea-Larix* (120, 222, 235, 260, 290), *Alnus viridis* (240, 260), *Pinus* (290)
317–330	wood peat and *Carex* peat	black brown	*Alnus viridis* (solid layer 315–318)
330–375	*Carex* peat	dark brown	
375–415	*Carex* peat and gyttja	black brown	*Salix* (386)
415–454	gyttja	black brown	
454–490	clay	dark grey	
490–493	clay and sand	dark grey	
493–500	clay	dark grey	

4.3. Palynostratigraphy

The local pollen assemblage zone 1 (LPAZ 1) (14,300-10,000 BP) in Fig. 3 is dominated by non-arboreal pollen types typical for the Late-Glacial period, such as *Poaceae, Artemisia, Caryophyllaceae* and *Cichorioideae*. Characteristic pollen from shrubs are *Ephedra* and *Pinus*. The sediment almost exclusively consists of clay.

Zone 2 (10,000 – ~9,000 BP) has the highest *Pinus cembra* percentages in the core (15 %). Because of the difficulties in separating the pollen of *Pinus cembra* from *P. mugo* and *P. sylvestris* (cf. Klaus 1975), the real percentages are higher. Within this zone *Betula* is increasing to a maximum of nearly 50 % and *Larix* to 5 % respectively. *Alnus viridis* shows a prominent increase from the middle of the zone. Non-arboreal pollen types, especially *Poaceae*, are negligible up to zone 5. The sediment is gyttja followed by peat.

Zone 3 (~9,000 – ~8,000 BP) shows similar characteristics as to zone 2. The most notable change is the increase of local *Cyperaceae* correlated with *Rosaceae* from *Potentilla*-type. The sediment is almost pure *Carex* peat.

Zone 4 (~8,000 – ~7,000 BP) is characterized by fluctuating increase in *Picea, Betula* and *Alnus viridis* and a triple peak in *Salix* pollen. *Larix* and *Pinus* decrease permanently. Arboreal pollen types are the highest in the core (95 %). The sediment is wood peat which continues up to zone 7.

Zone 5 (~7,000 – 2,600 BP) is dominated by the highest *Picea* percentages (approx. 50 %). Other arboreal pollen are decreasing, except for *Alnus viridis*. *Abies* and *Fagus* are present throughout. Indefinable spores ("Monolete") are represented with a maximum of 33 %.

Zone 6 (2,600 – ~2,400 BP) is poorly defined by just three samples. Only the sudden and limited peak in *Poaceae* pollen and the increase in *Alnus viridis* and Particulae carbonae (charcoal) justify this zone.

Zone 7 (~2,400 – 1,100 BP) shows a slow decline in *Picea* pollen with two collapses around 100 cm and 60 cm.

Zone 8 (<1,100 BP) is defined by the strong increase in non-arboreal pollen types, e.g. *Poaceae, Caryophyllaceae* and *Cichorioideae*. Almost all arboreal pollen are decreasing except for *Larix*. Anthropogenic indicators, such as *Secale, Triticum, Castanea* and *Juglans*, are represented continuously. Similar to zone 3, *Cyperaceae* combined with pollen from *Potentilla*-type occur.

5. Discussion

5.1. Late-Glacial

The radiocarbon dating 14,290 BP shows one of the oldest ages within the subalpine altitudes of the Eastern Central Alps immediately after the retreating of Würm ice. At Chanoua (Lower Engadine, Eastern Switzerland) 17,100 BP has been dated, yet older carbonate have presumably caused these very high ages (Zoller et al. 1996). Within the Kurzmoos, the period from the Oldest Dryas to the end of the Allerñd is shortened to 30 cm and therefore considerably compressed. Only the homogeneous diagram and the

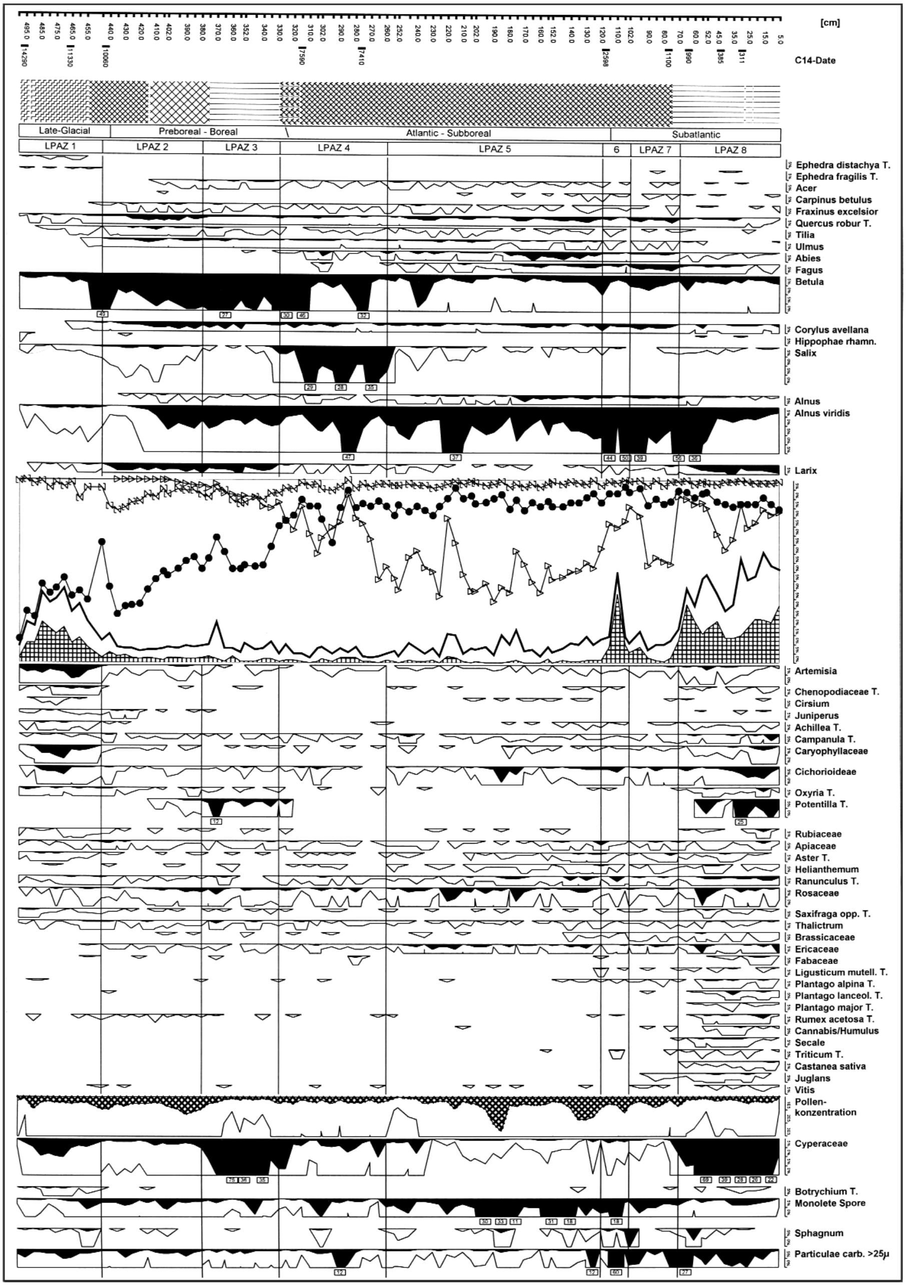

Figure 3: Simplified pollen percentage diagram of Kurzmoos, South Tyrol. The percentages are calculated on all terrestrial pollen (Ephedra to Vitis). Main diagram: D = Picea abies; ∑ = Pinus total; z = Pinus cembra; the bold continuous line divides arboreal pollen from non-arboreal pollen; squared area = Poaceae. Additionally, the concentration of all terrestrial pollen is shown (1 unit = 100,000 pollen/1 cm^3 sediment).

high pollen concentration apparently give evidence of continuous sedimentation and exclude a larger hiatus within this section.

The basin of Kurzmoos is sealed with clay - mixed with sand - in the lowest parts. The coarse sand especially characterizes a landscape almost free of vegetation (Wahlmüller 1990). According to Rausch (1975), the very high *Pinus* percentages at the basis of the core stem from long distance transport of lower altitudes, because the still poor pollen production of the sparse local vegetation cannot receive higher percentages within the diagram. The pollen of *Hippophae*, a pioneer shrub, have also been transported from lower altitudes and indicate steppe vegetation.

Subsequently, *Pinus* pollen are retreating and typical plants of bare soil and pioneer meadows, such as *Artemisia, Botrychium, Caryophyllaceae, Chenopodiaceae, Cichorioideae* and *Cirsium*, are progressing. In addition to these apocrats, *Poaceae* and *Cyperaceae* are increasing. The latter are the part of the spreading meadows and do not indicate a fen within the basin, because at that time Kurzmoos is a lake almost free of plants that is slowly filled with mineral sediments.

Pollen of *Ephedra* are common during the Late-Glacial. This fact was accepted earlier as an indicator of steppe or semi desert at lower altitudes with cold-continental climate (Lang 1951; Welten 1957). Yet further investigations have shown that glaciers of the Alps contain modern pollen of *Ephedra fragilis*-type. These pollen (*Ephedra altissima*) have been transported from Northern Africa by dust storms (Bortenschlager 1967, 1970). Therefore, long distance transport from other climatic regions or from another continent cannot be excluded even during the Late-Glacial.

The treeline cannot directly be deduced from the pollen diagram. Within the inner Ötztal this line was at least 1900 m a.s.l. during the Allerød (Bortenschlager 1991). In contrast to this, trees just reached 1500 m within the area of Gardasee, Northern Italy, (Grüger 1968) and 1600 m within Lower Engadine, Eastern Switzerland (Zoller et al. 1996). The diagram of the Kurzmoos shows an increase of *Larix decidua* and *Pinus cembra* pollen above 465 cm in the cores which may indicate sparse local occurrence of these treeline species at 1800 m a.s.l. during the Allerød and even the Younger Dryas. The low percentages do not disprove this hypothesis, because of difficulties in separating *Pinus cembra* from other *Pinus* species (cf. palynostratigraphy, zone 2). *Larix* is a poor pollen producer with few percentages indicating local occurrence (Ammann and Wick 1993).

The deteriorating climate during the Younger Dryas is represented just a little within the core. Pioneer plants, such as *Poaceae, Caryophyllaceae* and *Cyperaceae*, show a secondary maximum. *Artemisia* has its primary maximum within this period. At the end of the Younger Dryas, *Betula* dominates and *Pinus, Pinus cembra* and *Larix decidua* stagnate. This indicates a lowering of the treeline and a thinning-out of Late-Glacial forests. The extreme peak of *Betula* seems to be caused by local environmental conditions.

5.2. Preboreal and Boreal

From the beginning of the Preboreal the adjacent slopes of the Kurzmoos are covered by *Pinus cembra* and *Larix decidua*. These forests are also shown by obviously retreating apocrats and *Poaceae*. The latter are almost negligible up-to the beginning of the Subatlantic and therein resemble many pollen diagrams of subalpine and montane altitudes of the Central Alps (Seiwald 1980, Burga 1980). Extreme fluctuation of *Betula* occurs up to the early Atlantic which is an unique and locally restricted phenomenon, as other pollen diagrams indicate (e.g. Seiwald 1980). Despite these large pollen amounts, no conclusive macrofossils and wood could be found within the core.

The modern distribution and ecology of the snow tolerating *Alnus viridis* might favor Late-Glacial immigration of this subalpine shrub. Yet the spreading of *Alnus* was hampered effectively by the dry climate during the Late-Glacial and even during Preboreal according to Zoller et al. (1996).

From the early Holocene, the lowlands of the Inn valley are dominated by Quercetum mixtum composed of *Fraxinus, Quercus, Tilia* and *Ulmus* often accompanied by *Corylus*. These pollen are insignificantly preserved within the diagram, because of the far distance.

During the Preboreal, the basin of the Kurzmoos was still covered by a lake and water plants, such as *Sparganium* and *Potamogeton*, occur (not shown in the pollen diagram). Later during the Boreal, the basin filled with sediments to such an extent that *Cyperaceae* spread widely. Synchronously, pollen of *Potentilla*-type are increasing, probably *P. erecta*, which is typical for the modern Kurzmoos. In the uppermost zone of the diagram, this combined occurrence happens again.

5.3. Atlantic and Subboreal

At the beginning of the Atlantic, the dense subalpine forests composed of *Pinus cembra* and *Larix decidua* are terminated by immigrating *Picea abies* which dominates from 7,600 BP. This time fits well with the general overview of the vegetation history of the Eastern Central Alps (Kral 1979). Since then, *Pinus cembra* and *Larix* were restricted to the treeline region.

Abies alba and *Fagus sylvatica*, important trees within montane altitudes, show continuous pollen percentages from 185 cm. This depth corresponds to the middle Atlantic as pollen diagrams from adjacent Sarntaler Alps indicate. Yet an occurrence of these trees at subalpine altitudes may be excluded during the whole Holocene.

The Kurzmoos itself was covered by trees, as many findings of wood fragments from *Alnus viridis* and *Picea-Larix*-type indicate. Yet the few pollen of *Larix* clearly show prevailing *Picea*. During the early Atlantic, high amounts of *Alnus viridis, Betula* and *Salix* pollen occur. Probably these are caused by unstable environmental conditions within the basin of the Kurzmoos, which allowed the dominance of different woods at various times. From about 7,000 BP, the Kurzmoos was permanently covered by *Picea* with an understorey of *Ericaceae*. During that time, *Poaceae* and *Cyperaceae* were extremely diminished.

5.4. Subatlantic

At the turn from the Subboreal to the Subatlantic, anthropogenic impacts from the Iron Age are obvious. Neolithic influences, as described e.g. from the inner Ötztal (Vorren et al. 1993), may not be confirmed according to available data within the Kurzmoos. At 2,600 BP, a short peak of *Poaceae* pollen can be seen. This may be correlated with a weak increase of *Triticum* – the first distinct anthropogenic indicator within the diagram. The strong slumps of *Picea* within this section are combined with peaks of *Alnus viridis* and increasing *Poaceae* and other indicators for grazing, such as *Artemisia* and *Cichorioideae*. These indicate clearing of subalpine forests, shown also by the high contents of Particulae carbonae and simultaneous spreading of subalpine bushes, pastures and meadows. Probably these impacts have been locally restricted and may be described as shifting cultivation. This means, during various times of the Subatlantic, the surroundings of the Kurzmoos have been cleared and used as pastures. Later-on these areas have been deserted and bushes followed by forests re-immigrate.

In the diagram, another period of clearing may be recognized at the beginning of the High Middle Ages followed by a permanent increase of *Poaceae* and other indicators of grazing. Trees and shrubs are diminishing with the exception of *Larix decidua*, which remarkably extends its area. The reason for that is that *Larix* is a pioneer tree and is therefore favored by clearings.

Pollen of the cereals *Secale* and *Triticum* are rare within the diagram of the Kurzmoos. *Hordeum* probably occurs, too. Due to the difficulties in separating *Hordeum* from other *Poaceae* (Andersen 1979), *Hordeum* has been included in *Poaceae*. There is no evidence given that an appreciable amount of cereals have been cultivated in the surroundings of the Kurzmoos. This is deduced from the negligible pollen percentages and their good ability of long distance transport. Even at high alpine altitudes of the Central Alps, percentages larger than 1 % have been reported (Burga, Perret 1998). Adjacent to the Kurzmoos, another fen at 2,230 m a.s.l. has been investigated (Stumböck 1999). At this alpine altitude, the growing of cereals has always been impossible. Despite this fact, a few percentages occur in the pollen diagram, too. Therefore, it may be concluded that the vast majority of cereal pollen of the Kurzmoos came from the lowlands of South Tyrol. Within the inner Passeiertal, Fischer (1974) reports on a few small farmlands between 1,600 and 1,700 m a.s.l. Even if the altitudinal limit of growing of cereals was somewhat higher during the High Middle Ages, these small patches might not have been reflected in the pollen diagram.

Juglans regia and *Castanea sativa* were introduced to the Tyrol by the Romans between the 1st century BC and 0 AD (Beug 1964, Bortenschlager 1976). The pollen of both Mediterranean trees occur late in the diagram and derive from the lowlands of Vinschgau.

The clearings during the High Middle Ages obviously have considerably changed the ecosystem of the fen Kurzmoos, because they are combined with a higher water table, establishment of *Cyperaceae* and corresponding peat accumulation. Complete deforestation, especially of coniferous trees, has strong effects on hydrology by drastically reducing interception and transpiration (Burschel, Huss 1987). This may cause higher drainage on the surface. The development of a fen in the upper decimeters of Kurzmoos is not unusual. According to Zoller et al. (1996), many fens of the Lower Engadine developed after clearings.

6. Conclusions

Table 3 shows the immigration and spreading of predominant trees within high montane and subalpine altitudes from various regions of the Eastern Central Alps. Other important trees and bushes, such as *Alnus viridis, Betula, Pinus mugo* and *Pinus sylvestris*, have not been taken into consideration, the reasons being, e.g., difficulties in separating pollen types, anemophily with extreme pollen production and pronounced far distance transport. Another fact is that these species might not have contributed significantly to stable climax forest communities.

It has to be concluded that the Late-Glacial and Holocene vegetation history of subalpine altitudes of the Passeiertal corresponds well to the Eastern Central Alps, especially the inner Ötztal. Therefore, northwestern South Tyrol, as reflected in the investigated sediments of Schnalstal and Passeiertal, has to be considered as part of the Central Alps.

Acknowledgements

This research was supported by grants from the Deutsche Forschungsgemeinschaft (DFG), Bonn, Germany. I am particularly thankful to Prof. S. Bortenschlager and the staff of the Botanical Institute, University of Innsbruck (Austria), for their help with the pollen analysis. Wood fragments were determined by Dr. W. Oberhuber, Botanical Institute, University of Innsbruck.

References

AMMANN B., WICK L. (1993): Analysis of fossil stomata of conifers as indicators of the alpine tree line fluctuations during the Holocene. – In: Frenzel B. (ed.): Oscillations of the alpine and polar tree limits in the Holocene. Gustav Fischer, 175–185, Stuttgart, Jena, New York.

ANDERSEN S. T. (1979): Identification of wild grass and cereal pollen. – Danmarks Geologiske Undersøgelse Årbog 1978, 69–92, København.

BEUG H.-J. (1964): Untersuchungen zur spät- und postglazialen Vegetationsgeschichte im Gardaseegebiet unter besonderer Berücksichtigung der mediterranen Arten. – Flora, 154, 401–444, Jena.

Biologisches Landeslabor (ed., 1991): Kataster der Moore und Feuchtgebiete Südtirols. – Tätigkeitsbericht Biologisches Labor Autonome Provinz Bozen, 6, 214 p., Bozen.

BORTENSCHLAGER I. (1976): Beiträge zur Vegetationsgeschichte Tirols II. Kufstein – Kitzbühel – Paß Thurn. – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, 63, 105–137, Innsbruck.

BORTENSCHLAGER S. (1967): Pollenanalytische Ergebnisse einer Firnprofiluntersuchung am Kesselwandferner (3240 m, Ötztal, Tirol). – Grana Palynologica, 7, 259–269, Stockholm.

BORTENSCHLAGER S. (1970): Neue pollenanalytische Untersuchungen von Gletschereis und gletschernahen Mooren in den Ostalpen. – Zeitschrift für Gletscherkunde und Glazialgeologie, 6, 107–118, Innsbruck.

BORTENSCHLAGER S. (1984): Beiträge zur Vegetationsgeschichte Tirols I. Inneres Ötztal und unteres Inntal. – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, 71, 19–56, Innsbruck.

BORTENSCHLAGER S. (1991): Die Waldgrenze im Postglazial. – In: Kovar-Eder J. (ed.): Palaeovegetational development in Europe and regions relevant to its palaeofloristic evolution, 9–13, Wien.

BURGA C. A. (1980): Pollenanalytische Untersuchungen zur Vegetationsgeschichte des Schams und des San Bernardino-Paßgebietes (Graubünden, Schweiz). – Dissertationes Botanicae, 56, 165 p., Berlin/Stuttgart.

BURGA C. A., PERRET R. (1998): Vegetation und Klima der Schweiz seit dem jüngeren Eiszeitalter. – Ott, 805 p., Thun.

BURSCHEL P., HUSS J. (1987): Grundriß des Waldbaus. – Paul Parey, 352 p., Hamburg, Berlin.

FISCHER K. (1974): Das Passeiertal. Grundzüge einer geographischen Landeskunde. – Der Schlern, 48, 344–380, Bozen.

GRÜGER J. (1968): Untersuchungen zur spätglazialen und frühpostglazialen Vegetationsentwicklung der Südalpen im Umkreis des Gardasees. – Botanisches Jahrbuch, 88, 163–199.

Hydrographisches Amt (ed. 1994): Precipitazioni 70 anni di osservazioni in Alto Adige 1921–1990 – Niederschläge 70 Jahre Beobachtungen in Südtirol 1921–1990. – Autonome Provinz Bozen-Südtirol, 185 p., Bozen.

Hydrographisches Amt (ed., 1995): Annale Idrologico – Hydrologisches Jahrbuch 1991. – Autonome Provinz Bozen-Südtirol, 238 p., Bozen.

KLAUS W. (1975): Über bemerkenswerte morphologische Bestimmungsmerkmale an Pollenkörnern der Gattung Pinus L. – Linzer biologische Beiträge, 7, 329–369, Linz.

KOFLER W. (1992): Die Vegetationsentwicklung im Spätpaläolithikum und Mesolithikum im Raume Trient. – Preistoria Alpina – Museo Tridentino di Scienze Naturali, 28, 83–103, Trident.

KRAL F. (1979): Spät- und postglaziale Waldgeschichte der Alpen aufgrund der bisherigen Pollenanalysen. – Österreichischer Agrarverlag, 175 p., Wien.

KRAL F., CARMIGNOLA G. (1986): Ein Pollenprofil aus dem Wölflmoor bei Deutschnofen. – Der Schlern, 60, 733–739, Bozen.

LANG G. (1951): Nachweis von Ephedra im südwestdeutschen Spätglazial. – Naturwissenschaften, 38, 334–335.

MOORE P. D., WEBB J. A. AND COLLINSON M. E. (1991): Pollen analysis. – Blackwell, 216 p., Oxford.

NOTHEGGER B. (1997): Palynologische Untersuchungen zur Ermittlung von Waldgrenz- und Klimaschwankungen in den Ostalpen anhand der Profile Schönwies und Rotmoos. – Thesis, unpubl., Botanical Institute, University of Innsbruck, 54 p., Innsbruck.

RAUSCH K.-A. (1975): Untersuchungen zur spät- und nacheiszeitlichen Vegetationsgeschichte im Gebiet des ehemaligen Inn-Chiemseegletschers. – Flora, 164, 235–282, Jena.

SCHMIDT R. (1975): Pollenanalytische Untersuchungen zur spätglazialen bis mittelpostglazialen Vegetationsgeschichte im Raume Bozen. – Linzer biologische Beiträge, 7, 225–247, Linz.

SCHNEIDER R. (1985): Palynological research in the southern and southeastern Alps between Torino and Trieste. – In: Lang G. (ed.): Swiss lake and mire environments during the last 15,000 years. – Dissertationes Botanicae, 87, 83–103, Berlin/Stuttgart.

SCHWEINGRUBER F. H. (1990): Anatomie europäischer Hölzer – Anatomy of European woods. – Paul Haupt, 800 p., Bern, Stuttgart.

SEIWALD A. (1980): Beiträge zur Vegetationsgeschichte Tirols IV. Natzer Plateau – Villanderer Alm. – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, 67, 31–72, Innsbruck.

STUMBÖCK M. (1999): Die spät- und postglaziale Vegetationsgeschichte des nordwestlichen Südtirols mit einem Beitrag zur Verknüpfung natürlicher Archive mit historischen Quellen. – Gebrüder Borntraeger, 129 p., Berlin, Stuttgart.

STUMBÖCK M., MÜLLER J. (1996): Computerprogramm und Tastatur zum Zählen von Pollen. – Telma, 26, 61–64, Hannover.

TRANQUILLINI A. (1988): Polprof: Ein Programm zum computergesteuerten Zeichnen von Pollenprofilen. – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, Suppl. 2, 27–34, Innsbruck.

VORREN K. D., MØRKVED B. AND BORTENSCHLAGER S. (1993): Human impact on the Holocene forest line in the Central Alps. – Vegetation History and Archaeobotany, 2, 145–156, Berlin.

WAHLMÜLLER N. (1990): Spät- und postglaziale Vegetationsgeschichte des Tschögglberges (Südtirol). – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, 77, 7–16, Innsbruck.

WAHLMÜLLER N. (1993): Palynologische Forschung in den Ostalpen und ihren vorgelagerten Gebieten. – Berichte naturwissenschaftlich-medizinischer Verein Innsbruck, 80, 81–95, Innsbruck.

WELTEN M. (1957): Über das glaziale und spätglaziale Vorkommen von Ephedra am nordwestlichen Alpenrand. – Berichte der Schweizerischen Botanischen Gesellschaft, 67, 33–54, Bern.

ZOLLER H., ERNY-RODMANN C. AND PUNCHAKUNNEL P. (1996): The history of vegetation and land use in the Lower Engadine (Switzerland). Pollen record of the last 13,000 years. – Nationalpark-Forschung in der Schweiz, 86, 65 p., Chur.

PŘÍRODNÍ VÝVOJ A ANTROPOGENNÍ IMPAKTY NA VEGETACI PASSIERTAL V JIŽNÍM TYROLSKU V POZDNÍM GLACIÁLU A HOLOCÉNU

Résumé

V práci jsou předloženy výsledky pylové a sedimentární analýzy ze subalpinského močálu v severozápadním Jižním Tyrolsku, v němž je zachována úplná sekvence od nejstaršího Dryasu do Subatlantiku. Po ústupu ledovce se rozšířila prvotní vegetace a alpinské louky následované výskytem modřínu a sibiřského cedru v Allerødu, které byly během raného Atlantiku nahrazeny smrkem. Od Subatlantiku se projevil antropogenní impakt výskytem lesních požárů a rozšiřováním pastvin. Další období odlesňování, které se výrazně projevilo např. na změně ekosystému močálu Kurzmoos, proběhlo počátkem středověku.

V tabulce 3 je znázorněn výskyt a rozšíření hlavních stromů ve vysokohorských a subalpinských výškách různých oblastí východních Centrálních Alp. Porovnání historie subalpinské vegetace v pozdním glaciálu a holocénu podle dokladů ze sedimentů v údolích Passiertal a Schnalstal s celým tímto regionem ukazuje, že severozápadní Jižní Tyrolsko může být pokládáno za součást Centrálních Alp.