Preistoria Alpina - Museo Tridentino di Scienze Naturali	Vol. 28 (1992)	pagg. 103-112	Trento 1994

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Paleography of the Late Vistulian and Early Holocene in the Carpathian Mts.

ABSTRACT

STARKEL L., 1993 - Paleography of the Late Vistulian and Early Holocene in the Carpathian Mts. [Paleografia del Tardo Vistuliano e del Primo Olocene nei Monti Carpazi]. *Preistoria Alpina*, 28: 103-112.

The Author shows the history of the Carpathian geoecological vertical zones during the Late Pleistocene and Early Holocene. The warming of climate, from a continental periglacial climate to a more oceanic one, and the rise in humidity were two engines of environmental changes.

Parole chiave: paleogeografia, periglaciale, tardo Vistuliano e primo Olocene.

Key words: palaeogeography, periglacial, Late Vistulian and Early Holocene.

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1. Introduction

The present-day vertical climatic vegetational zones in the Carpathians show a sequence typical of the zone (cf. HESS, 1965). The foothill belt with deciduous forests of Tilio-Carpinetum rises up to 650 m a.s.l. The next zone of the lower mountain forests of Fagetum carpathicum extends to 1050-1200 m a.s.l. with the mean annual temperature + 4°C. The upper forest belt with the spruce rises to 1450-1550 m a.s.l. The upper forest limit coincides with the mean annual temperature + 2°C and July temperature + 10°C.

The next Pinus mughus belt extending from 1750-1800 m is followed by the alpine meadows and above 2200 m a.s.l. with the temperature below - 2°C there extend the cryonival belts (fig. 1). This Carpathian vertical zonality is modified by the thermic inversion in the basins and the warm slope mesoclimatic belt (OBREBSKA-STARKEL, 1972).

These deviations are reflected in the relict localities of the Pinus mughus in the Orawa-Nowy Targ depression (600-700 m a.s.l.), cool spruce forests in the valleys of the Bieszczady Mts. (600-700 m a.s.l.) and the remains of the lime woodland in Muszyna, 150-200 m above the Poprad river.

During the cold stage the northern slope of the Carpathians was exposed to the ice sheet influences expressed in low temperature and strong winds. The distance from the ice sheet extended only 200 km (fig. 2) and therefore all typical features of the periglacial zone are well manifested in the Carpathians (STARKEL, 1988a).

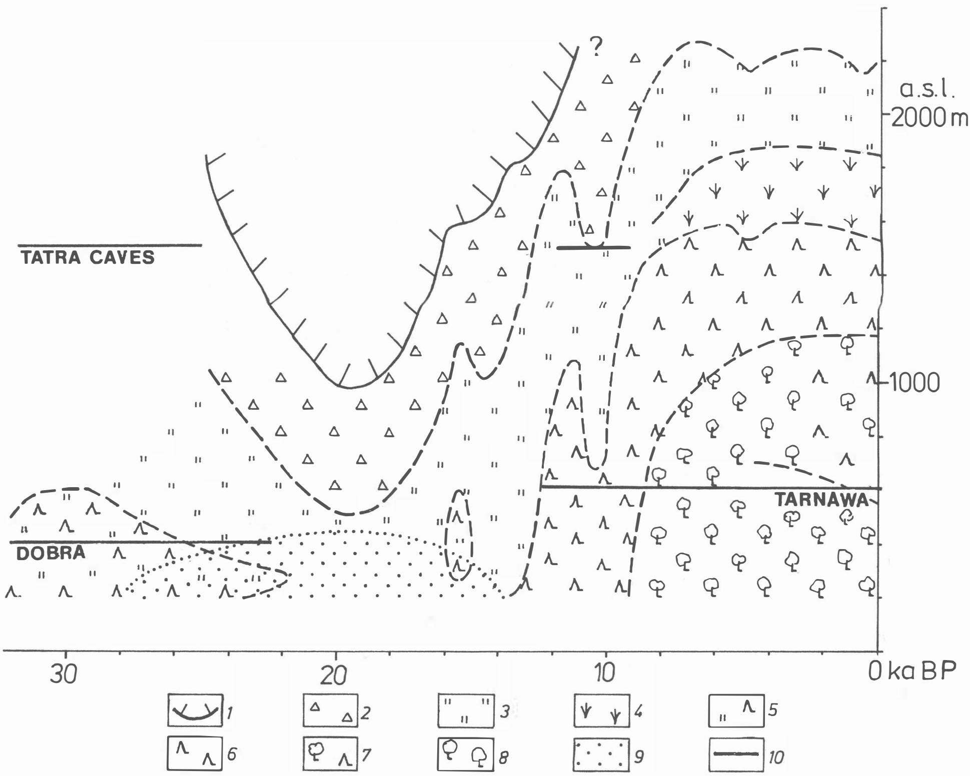

Fig. 1 - Changes of the natural vertical zones in the Polish Carpathians since 30 ka BP.
Signs: 1. lowest position of the Tatra glaciers (after KLIMASZEWSKI *and others*), 2. cryonival belt, 3. arctic tundra and alpine meadow belt, 4. Pinus mughus belt, 5. forest-tundra and forest-steppe, 6. boreal forest, 7. mixed forest (Fagetum carpathicum), 8. deciduous forest, 9. loess deposition, 10. localities with long sequence of records.

2. The Carpathians during the maximum extent of the last glaciation

Our knowledge of the vertical zonation during that phase in the Carpathians is relatively poor. The Tatra valley glaciers flowed down to the elevation of 900-1100 m a.s.l. and the snowline ran at about 1500 m (KLIMASZEWSKI, 1967) (fig. 1).

The frosty climate of the present belt of upper treeline is indicated by the lack of faunal remains and calcareous precipitation just between 25 and 12 ka BP (HERCMAN *et al.,* 1987) (fig. 3). The higher zone of the Flysch Carpathians built of resistant sandstones was occupied by the blockfields and the feet of slopes were covered by solifluction, deluvial and loess-like deposits up to 20 meters thick (KLIMASZEWSKI, 1971; STARKEL, 1969; ZUCHIEWICZ & BUTRYM, 1990). The radiocarbon and TL datings indicate their up-

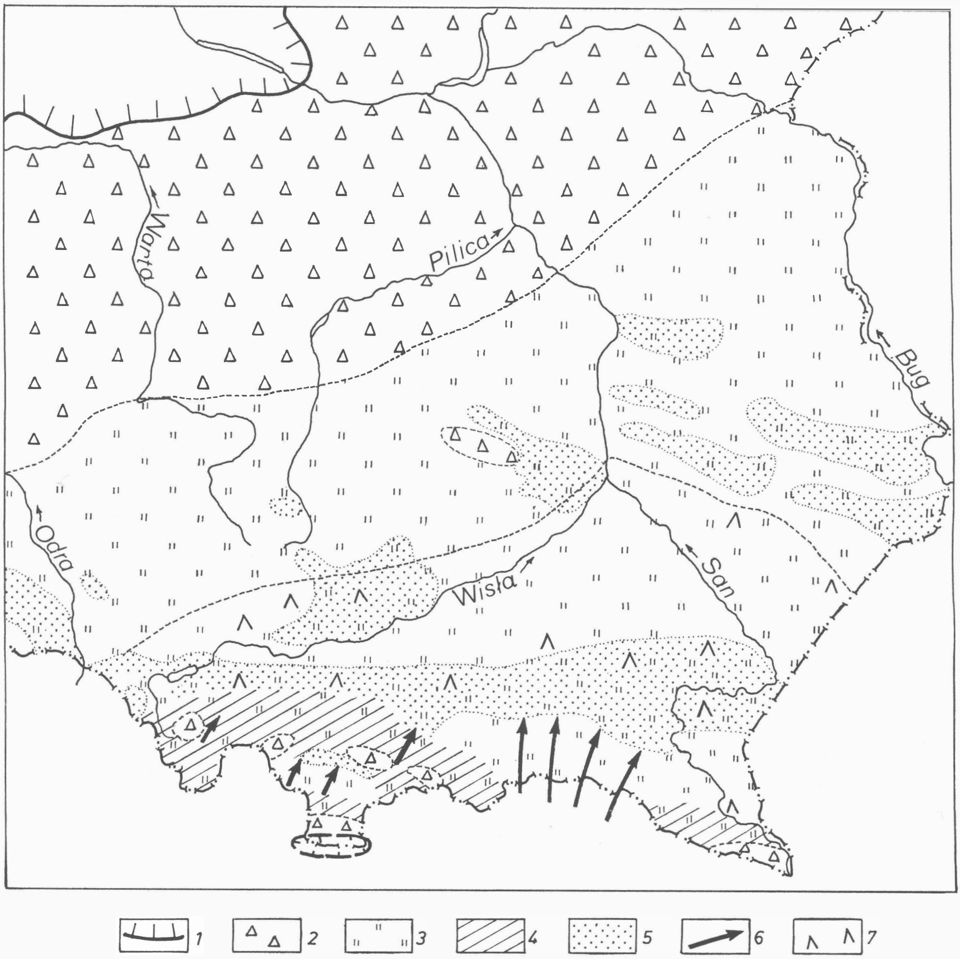

Fig. 2 - Paleogeographic reconstruction of territory of the southern and central Poland about 22-18 ka B.P. (after STARKEL, 1988a, partly changed). 1. maximum extent of the ice sheet and Tatra glaciation, 2. arctic desert with eolian activity, 3. tundra and tundra-steppe zone, 4. slightly more humid areas with dominant solifluction processes, 5. areas of loess and loess-like deposition, 6. direction of strong winds and deflation, 7. patches of trees preserved.

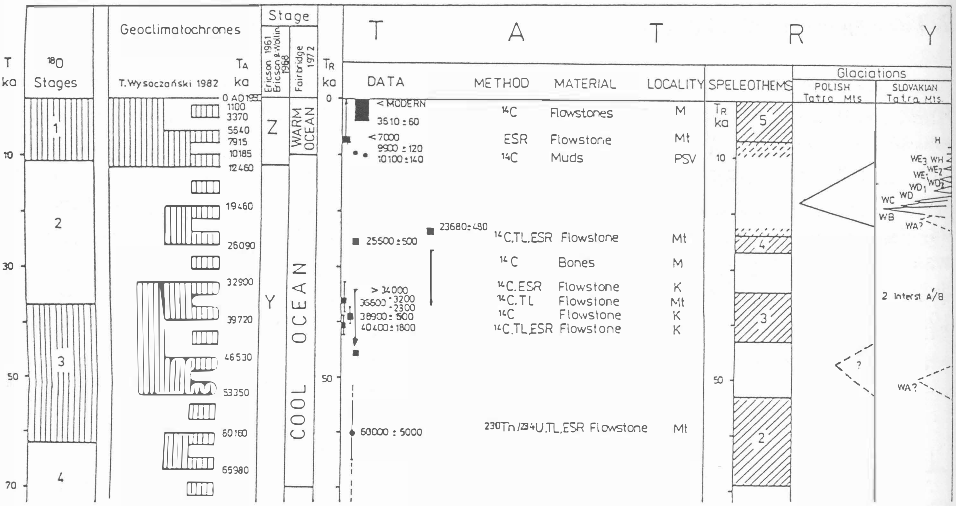

Fig. 3 - Stratigraphic correlation of upper Vistulian events in the Tatra Mountains (after Herzman *et al.,* 1987). Dated material from following caves in the Tatra Mts.: Mt. Magurska Cave, Mt. Mietusia Cave, K-Kasprowa Nižnia Cave, PSV-Five Lakes Valley Dashed areas - warm periods with speleothem deposition.

per pleniglacial age. Of special interest is the great spacial variety of these slope deposits, which can not always be explained by the lithological difference of the substratum and by the sequence of events (cf. Starkel, 1969). In the western part of the Polish Carpathians, as well as at higher elevations there dominate the solifluction deposits, which may be influenced by a higher precipitation and a denser vegetation cover. In the foothill belt (250-500 m a.s.l.) especially in their eastern part, there prevail the deluvial and loess-like deposits (Cegla, 1963) which may reflect the very low precipitation, more open tundra vegetation and intense eolian activity. This picture is very clear in the zone of the great transversal depression of the Carpathian arch, in the Jaslo-Sanok Depression, where the deflational oriented basins, cut in the low resistant flysch, were discovered (Gerlach *et al.,* 1972), and on the northern margin the loess loams up to 20 meters thick (Gerlach *et al.,* 1991).

This areal variety of the geomorphic processes and sediments suggest that the patterns of habitats and plant communities were also very differentiated. The presence of 50% of tree pollen (AP) in the member dated at 22450+340 BP at Podgrodzie at the foot of the escarpment of the Carpathian foothills may indicate (Mamakowa & Starkel, 1977) that on the slopes foothills there were preserved patches of trees with *Pinus silvestris, Pinus cembra, Larix, Betula* and *Populus* which may reproduce in the vegetative way. On the sites of the mammoth hunters at Zwierzyniec in Cracow there were found charcoals of unidentified trees dated ca 23-20 ka BP (Kozlowski *et al.,* 1974). Moreover, in the cave deposits of the Cracow Upland the mixed steppe-tundra-forest fauna indicates the presence of various plant communities growing side by side (Madeyska, 1979). We may expect that lower Carpathian zone was characterised by a mosaic of vegetation, similar to that observed up to the present-day in the central Mongolian mountains at the southern limits of the forest and the permafrost (Kowalkowski & Starkel, 1984), as well as on the hills in Skania during the late Vistulian (Berglund & Rapp, 1988).

3. Decline of the pleniglacial

Before the Bölling warming the first stages of the ice sheet recession were combined with a distinct rise of temperate and the retreat of permafrost under extremely continental climate. The loess deposition and intensive slope wash processes continued at least till 14 ka BP (TL dating from Zwierzyniec 14+2 ka BP - Konecka-Betley & Madeyska, 1985; TL dating from Roztoka 18 and 17 ka BP - Zuchiewicz & Butrym, 1990). Of special interest is the Smerek site in the Eastern Polish Carpathians elevated 600 m a.s.l., unfortunately supported only by one 14 C date 16925±325 BP (Ralska-Jasiewiczowa, 1980). The pollen spectrum with 60-80% of AP (supported by pine wood) includes *Pinus silvestris, Pinus cembra, Picea, Larix* and *Betula*. This site may be correlated with the Lascaux or Ula interstadial (Chebotarieva & Makaricheva, 1974), preceding the Pomeranian phase with the ice sheet readvance (ca 15.2 ka BP - cf. Kozarski, 1988). The patches of forest may develop under favourable mesoclimatic conditions, and this does not mean that they extended over the whole Carpathians. The absence of any deposits older than Allerod in the deflational depression indicates a continuous eolian activity in the Jaslo-Sanok depression (Gerlach *et al.*, 1972).

Parallel with lowering of the Vistula's base level which followed the retreating ice sheet (Wiśniewski - in Starkel ed., 1990) it was the period of an intensive incision of river valleys. This is proved by the very low elevation of the buried pre-Bölling paleochannels in the Vistula valley near Cracow (Kalicki, 1991), in the San valley (Klimek, 1992), as well as pre-Bölling cutting of the erosional bench in the fluvioglacial fan in the Orawa-Nowy Targ Basin (Koperowa, 1962).

4. The late Vistulian warming and the episode of the Younger Dryas

The expansion of forest vegetation over the former periglacial zone was a very complicated process. On the phone of a general warming and the rise of precipitation the rate of expansion was controlled by the topoclimatic variety and grain-size composition of the regoliths and slope deposits (Starkel, 1991). Bölling is very weakly represented in the profiles. Finally, in the Allerød the forest passed the height of 1000 m a.s.l. (Koperowa, 1962; Ralska-Jasiewiczowa, 1980). The deep water circulation after the melting of the permafrost facilitated the leaching of soils and the development of landslides (Starkel, 1960, 1985). The calcareous chalk was deposited in the deflational basins and paleochannels in the Jaslo-Sanok Depression built of rocks rich in $CaCO_3$ (Gerlach *et al.*, 1972; Wójcik, 1987). In the Slovak Carpathians there started the deposition of the calcareous tuffa (Ložek, 1990). The decline of the sediment load in the foreland caused changes in the pattern of the river channel from braided to large meanders (Zumański, 1983), excluding only the rivers with a higher gradient and starting in higher mountain groups (Sola and Dunajec rivers - cf. Starkel, 1990). In the Tatra Mountains the retreat of glaciers exposed the cirques filled by lakes.

The Younger Dryas cooling (11-10 ka BP) caused the lowering of the upper forest limit to ca 600-700 m a.s.l. (Ralska-Jasiewiczowa, 1980). Probably at that time in the Beskidy Mts. there were deposited the debris fans overlying the solifluctional glaciers (Starkel, 1960). The reactivation of frost weathering and slope processes was reflected in the rising of the channel bottoms and their tendency to braiding and lateral erosion

(STARKEL, 1990; KALICKI, 1991). The eolian activity in the Subcarpathian basins caused the blowing out of the sand from the braided channels (STARKEL, 1988b).

5. The early Holocene

The rapid rise of the temperature at the beginning of the Holocene (RÓŻAŃSKI *et al.*, 1992) was the cause of the progressing afforestation of the Carpathians and the substantial change in the water balance and sediment load (STARKEL, 1988b, 1991) (fig. 4). Those changes occurred under continental climate and therefore the boreal forests still dominated with *Pinus silvestris, Pinus cembra* and *Picea excelsa* (RALSKA-JASIEWICZOWA, 1980, 1989). Deciduous trees entered slowly from the long - distance refuges (RALSKA-JASIEWICZOWA, 1993). The warming was accompanied by calcareous precipitation in the Carpathians Foothills. On the loess plateaus of Southern Poland the open woodlands facilitated the deposition of the organic matter and the formation of the chernozem soils dated between 9 and 8 ka BP (SNIEŻKO, 1985).

The bottoms of wide valleys underwent paludification. The activity of rivers declined, many river channels in the foreland reaches changed to narrow and deep meanders (cf. SZUMAŃSKI, 1983). In higher elevations the patches of forests reached their present altitudes probably in 9.5-9 ka BP, preceeded by dense meadows. The change from mineral deposits to organic gyttya in the High Tatra lakes was dated at 9900+120 BP (WICIK, 1984).

6. The turn to oceanic climate in the Late Boreal time

Some sites in the valleys registered the phase of high and frequent floods between 8.5 and 8.0 ka BP (STARKEL, 1977, 1984, 1991). The break in the deposition of peat and the formation of alluvial fans 5 and more meters thick may be explained by the turn to the frequent westerlies, and cyclonic circulation. It was the first Holocene wet phase, since that repeated several times during the Holocene (STARKEL, 1983). The supporting data are delivered by frequent channel alluvions (STARKEL, 1990) and landslides (STARKEL, 1985). During that time LOŽEK (1975) recorded the activisation of the carstic processes in the Slovak Carpathians (fig. 4).

The plant communities reacted to that change by the occupation of slopes by dense mixed and deciduous forests with Ulmus, Corylus, Quercus, Tilia etc. (RALSKA-JASIEWICZOWA, 1989). In the higher elevation the upper forest limit probably exceeded the present one by ca. 200 meters, which may be supported by the presence of the oval karren, later on dissected due to the lowering of the tree limit (KOTARBA & STARKEL, 1972). But the synchronity of this shift with a more humid phase is very problematic because just in the diapazone 8.7-8.0 ka (PATZELT, 1977) registered in the Alps three advances of glaciers of the Venidiger phase. In any case, this oceanic humid phase closed finally a long period of adaptation of the Carpathian geoecosystems inherited from the periglacial environment. The stabilisation of the interglacial-temperate communities started in whole Europe. Even in the south this was the time of the formation of Mediterranean forest communities (BEUG, 1982; STARKEL, 1991).

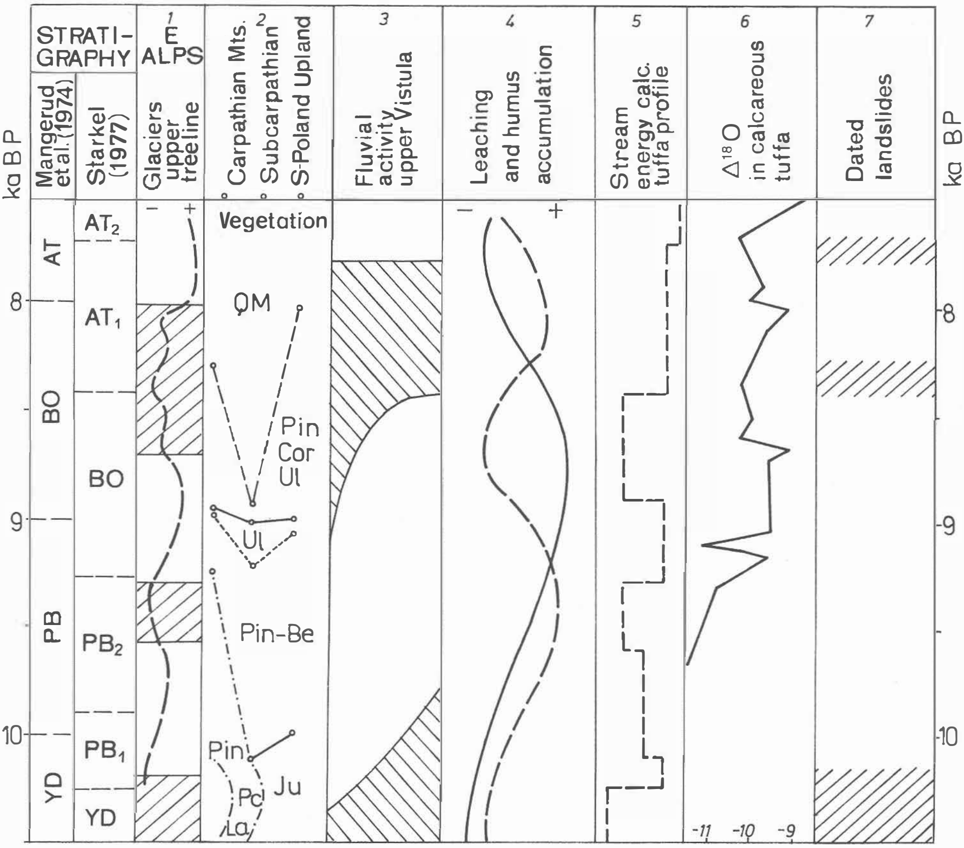

Fig. 4 - Paleogeographic changes between 10500 and 7500 a B.P. in Southern Poland (after STARKEL, 1991). Column 1: glacial advances and curve of the upper tree line in the Austrian Alps (BORTENSCHLAGER, 1987; PATZELT, 1973); Column 2: vegetation changes in S-Poland (RALSKA-JASIEWICZOWA, 1988) abbrev. of dominant species: Ju-Juniperus, La-Larix, Pc-Picea, Pin-Pinus, Be-Betula, Ul-Ulmus, Cor-Corylus, QM-Quercetum- mixtum; Column 3: Fluvial activity - active periods shown by nature (after STARKEL, 1987); Column 4: Rate of leaching (dotted line) and humus deposition (full line) - (after KOWALKOWSKI, 1990), Column 5: stream energy reconstructed by J. Szulc (after PAZDUR *et al.*, 1988), Column 6: ^{18}O curve of calcareous tuffa profiles in S-Poland (PAZDUR *et al.*, 1988), Column 7: age of dated landslides hatured (STARKEL, 1985).

7. Final remarks

The history of the Carpathian geoecological vertical zones during the late Pleistocene and early Holocene teaches us that there were two engines of environmental changes: the warming of climate and the delayed rise in humidity. The latter played a substancial role in the rate of changes, in the diversity of habitats, reflecting also the mesoclimatic variety. In each of the analysed time units there were preserved in the landscape some elements inherited from previous periods, which later on became incorporated in the new systems of the exchange of energy and matter. In the penetration of the mountain areas by the late Paleolithic and the Mesolithic man an important role was played by the fertility of habitats and the density of forest communities. On the northern slope of the Western Carpathians the first distinct rise in biomass production was stated either in the Bölling or in the Allerød. But dense forests occupied the Carpathian slopes probably not earlier than in the Boreal phase.

SUMMARY

During the last cold stage the Carpathians were exposed to the continental periglacial climate. Their environment was very diverse depending on the mesoclimate and substratum. There existed dry regions with strong eolian activity as well as active solifluction covers and refugies of boreal trees. During the Lateglacial the expansion of forest and retreat of permafrost facilitated deep water percolation and deep leaching. Next, the rapid warming at the beginning of the Holocene caused a decline of slope and fluvial processes. The continentality of climate delayed the invasion of deciduous trees and supported the formation of chernozem on the loess plateaus. A final turn to a more oceanic climate followed between 8.5 and 8.0 ka BP was manifested by frequent floods, landslides, and the expansion of Quercetum mixtum. All main paleogeographic phases of the Northern Carpathians correlate very well with the changes in the Alps.

RIASSUNTO

Durante l'ultima fase fredda i Carpazi furono esposti al clima periglaciale continentale. Gli ambienti erano molto diversi e variavano a seconda del mesoclima e del substrato. Vi erano sia regioni secche con forte attività eolica, che coltri di soliflusso attivo e rifugi di piante boreali. Nel corso del Postglaciale l'espansione delle foreste ed il ritiro del permafrost facilitarono la percolazione delle acque di profondità e la lisciviazione di profondità. Successivamente, il rapido riscaldamento avvenuto all'inizio dell'Olocene provocò una diminuzione dei pendii e dei processi fluviali. La continentalità del clima ritardò l'invasione delle piante decidue e favorì la formazione di chernozema sugli altopiani di loess. In seguito, tra l'8,5 e l'8,0 dell'età potassio/argon BP si ebbe un ultimo cambiamento del clima che divenne più oceanico, come comprovano le frequenti inondazioni, le frane di terra e l'espandersi del Quercetum mixtum. Tutte le principali fasi paleologiche dei Carpazi settentrionali possono essere correlate molto bene ai cambiamenti intervenuti nelle Alpi.

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