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GEOCHRONOLOGY OF THE NIVAL-GLACIAL DEPOSITS OF THE UKRAINIAN CARPATHIAN MOUNTAINS

Summary. Holocene climatic changes characterized by short-term nature have been strictly manifestated in mountain areas because of vertical landscape zonation existing. Common palynological methods have no use due to the great spore and pollen transportation. This work discusses the interconnection between climatic changes and nival- glacial sedimentation in the ancient cirques. Favorable condition for peat sedimentation in over moistened cirques during the period of climatic optimum with overlain by firn in case of subsequent climatic cooling and by nival fine-grained soil in case of subsequent warming have been established. Then, sedimentation cycle described above repeatedly occurred in time. Radiocarbon analysis on organic sediments allowed us to establish the climatic optimum chronology in area under study.

CHRONOLOGIA SEDYMENTACJI OSADÓW NIWO-GLACJALNYCH W UKRAIŃSKIEJ CZĘŚCI KARPAT

Streszczenie. Krótkookresowe zmiany klimatyczne w holocenie szczególnie wyraźnie zaznaczają się na obszarach górskich. Odtworzenie charakteru tych zmian wyłącznie na podstawie analiz pyłkowych nie jest w pełni wiarygodne ze względu na możliwy daleki transport pyłku wraz z ruchami mas powietrza. Praca zawiera wyniki badań pyłkowych oraz analiz radiowęglowych osadów niwoglacjalnych i ich interpretację paleoklimatyczną.

1. Introduction

Only a few studies have been made on the paleogeography of the Ukrainian Carpathian. It might be referred to both the chronology of relief formation (Demcduk, 1971), the de-

velopment of vegetation (Malinovsky, 1980) and the of landscape in total.(Miller, 1961). Before this, only the suggestion based on the comparison with natural alpine cycles were made.(Koziy 1950, 1963; Tsys 1955, 1968; Tretyak and Kuleshko 1982). Adjacent areas to the west and south, West Carpathians are also insufficiently studied (Serebriany, 1978).

The aim of our investigations was to establish chronology for the major geological events of the Carpathians during Holocene and upper parts of Pleistocene. Such a time scale is necessary for estimating temporal and spatial parameters of the youngest relief formations, origin and dynamics of vegetation, the formation of landscape as well as for solving some environment protection problems. This scale is also of great importance for creating the models of regional climatic change.

2. Description of Nival–glacial model

In order to solve the problem the climatic changes, represented in different stages of glacial, glaciofluvial and nival–fluvial sediments have been studied. These changes are the most discernible in the sediments of the highest elevations of the Ukrainian Carpathians. Figure 1 shows the area of our study, on the northern slope of the Chernogorsky massif, where glaciation was most extensive.

Figure 2 presents a model of navio–glacial geosystems. Such a model offers informative data on continuous, uninterrupted depositions. The models functioning may be presented as follows:

1. Climate changes influence the local nival–glacial and vegetation regimes of alpine areas.

2. Snow and glaciers formed during cold and wet periods erode actively the slopes of the Carpathians.

3. Products of exaration are subjected to meltwater and gravitational drifting, accumulating in end moraines and forming strata of the friable mountain rock different from autochthonous fine–grained soil.

4. Warm and dry climates bring glacial and snow exaration to a halt. Accumulation of fine–grained soil in deposits also terminates. Favourable conditions for spreading of the marsch– medow and shrub vegetation arise.

5. During subsequent glacial stages characterized by humidity increasing fine–grained soil accumulation rejuvenates. Vegetation buried under the layer of fine–grained soil becomes consolidated with fossils' transformation into peat.

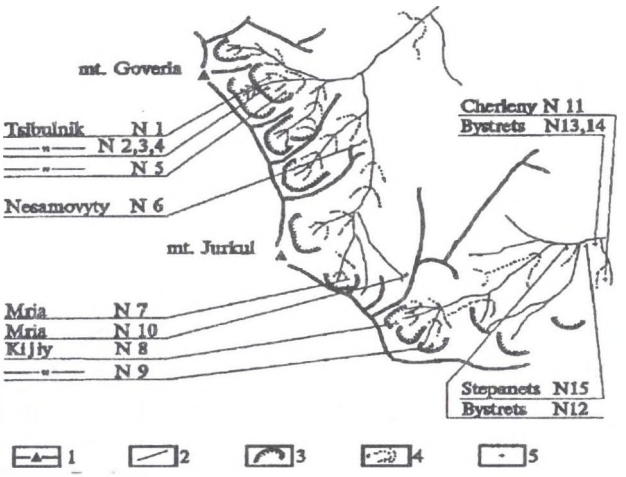

Fig. 1. Region under study: 1).watersheds and summits; 2).river sal post-glacial lakes; 3).ancient glacial cirques; 4).terminal moraines; 5).profiles

Rys. 1. Obszar badań: 1). działy wodne i szczyty; 2). koryta rzeczne; 3). dawne cyrki polodowcowe; 4). moreny czołowe; 5). położenie próbek

6. Buried peat layers may be dated with using radiocarbon analysis.

Intercalated layers of peat and fine-grained soil within the areas of glacial debris accumulation provide evidence of both prolonged action of glaciers and local climate features such as high humidity and snow accumulation exceeding, in some areas, local annual glacial ablation (Tretyak, 1978; Stoyko and Tretyak, 1979).

3. Results and discussions

We have studied four geosystems of this type (Fig. 1). With using ^{14}C dates and comparative study of nine profiles (Fig. 3. a and b) that we studied within end moraine zones of alpine areas of the Ukrainian Carpathians we have worked out original time scale for the most recent nival-glacial formations (Fig. 4). Moreover, while determining lower boundaries of interglacial stages only the earliest dates on fossil wood were taken into account.

Based on the ^{14}C dates obtained it is possible to reconstruct development of the Carpathian Mountain area starting from the upper levels:

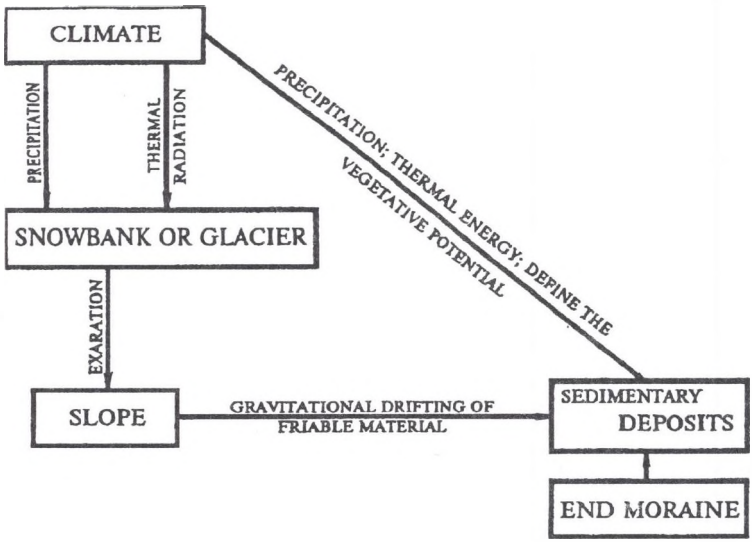

Fig. 2. Conceptional model of the nival–glacial geosystem

Rys. 2. Model systemu niwoglacjalnego

1. The modern climatic conditions were preceded by cold and wet period, from the 11th to 19th centuries. The period characterized by fine–grained soil accumulation at the foot of the cirque slopes. Climate cooling were repeatedly interrupted by warmer stages proved by the occurrence of buried peat layers dated to 350 and 540 yr in Profiles 7 and 9 respectively.(Fig. 3b.)

2. Prior to the cooling period, the second half of the first millennium was as warm and favorable for plant growth as at present the peat layers of Profiles 5, 7 and 9 attest to such a regime.

3. The amelioration was preceded by cold and heavy snow, dated to 1.5-2.5 ka (Profiles 1,5,7,9). Occurrence of some embryonic glaciers that fed by sliding snow in highly located cirques resulted in, after the ablation, depositing glaciofluvial debris at the lower levels. Glacial movements were likely to be more active than present ones; the fact proved by finding of nival fine-grained deposits at 1380m, Profile 1.

4. Climate cooling of 1.5-2.5 ka was preceded by climatic optimum of 2.5-3.2 ka which may be correlated to well-documented interruption of glaciation occurred in the Alps (Serebryany, 1978). Dates on the sediments of the highest Profiles 7 and 9 attest to the lack of glaciers during that period. This was the warmest period in the

Carpathians that proved by the presence of pine trunks remnants dated to 27-28 ka in Profile 1 at depth of 85-110m. Pollen analysis by Koziy (1950, 1968) proved the results obtained in spite of previous original erroneous correlation of the layers to Middle Holocene likely have been made because of lacking ^{14}C dates. Findings of sedge meadows rather than wet pine indicates that the climate was more dry than at present.

5. The underlaying stratum testify to long cold and wet period, described above, characterized by more active glacial exaration processes. Radiocarbon dates of 3.2-4.5 ka correspond to the middle Shrubbery (Neishtadt, 1983). Moraines of 5-th and 6-th stages of glacial degradation as well as glacio–fluvial fine– grained soils at the lower levels, up to 1300 m, were formed during the period.

6. An earlier climatic optimum occurred at 4.5-6 ka in the alpine area, confirmed by dates from Profiles 2, 4 and 6. This period maybe properly correlated with glacial invasion scale of the Alps (Serebryany, 1978; Tretyak and Kuleshko, 1982) corresponding to interruption of 4-6 ka.

7. The period of 6-10 ka apparently to be of great interest because of formation of moraic, glaciofluvial and nival–fluvial depositions in all areas. Such a depositions may be correlated with units of time scale of the Alps quite well (Tretyak and Kuleshko, 1982) corresponding to the Atlantic and Boreal periods. In the Carpathians, it was a period of intensive glacial exaration and formation of the moraine of 4th and 5th glacial degradation stages.

8. Climatic optimum of 10.3-12.3 ka should be correlated to the Late Holocene, the warmest phase corresponding to the Allerod; the fact confirmed by peat and wood dates at 12.100±140, Profile 6. Further gradual cooling proved by findings of Equisetum (horsetail) rhizomes in Profiles 2 and 4

9. Moraine of the second stage of the post–Wurmian glacial degradation are typical of period preceding above mentioned.

4. Conclusion

Preliminary results provide evidence for more complicated landscape history of the Carpathian Mountains than of the adjacent plain areas. Post–Wurmian glacial degradation occurred unevenly over several stages. Many glaciers likely to disappeared by the end of the Wurm and appeared at the late Holocene again. Holocene Glaciation, namely

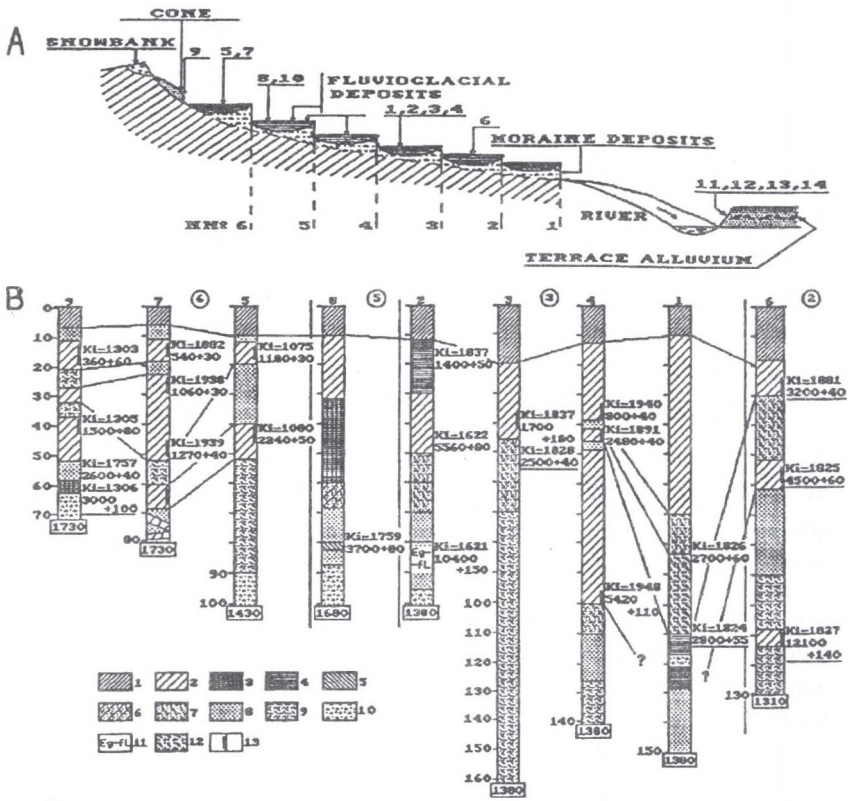

Fig. 3. A – Profile of the nival-glacial geosystem and its correla tion with the stages of end-moraine formation. Figures at the top: no. of the bore pit; at the bottom: no. of the moraine boundary. Wurm maximum referred to Tsys, 1968
B – Analysis of chronostratigraphic investigations of the alpine area of the Ukrainian Carpathians. Key to symbols: 1) modern turf; 2) peat; 3) peat with wooden remnants; 4) peaty soil; 5) buried herbaceous vegetation; 6) peat with fine-grained soil; 7) fine-grained soil with organics; 8) fine-grained soil; 9) fine-grained soil with gravel and gruss; 10) morraic deposits; 11) buried rhizomes and caulescents of equisetum; 12) buried pine trunks 13) sampling loci. Figures at the top: no. of the bore pit; Circled figures: stages of glacial degradations; Figures below the stratigraphic columns: depth, [m]. Underlined dates: dates on wooden fossils

Rys. 3. A – Profil systemu niwoglacjalnego i jego korelacji z etapami formowania moren (na podstawie Tsys N.P. 1968)
B – Wyniki badań chronostratygraficznych strefy alpejskiej Karpat Ukraińskich Cyfry u góry: numery odwiertu, cyfry w kółkach – stadia degradacji glacjalnej. Liczby pod kolumnami stratygraficznymi: głębokości w metrach. Liczby podkreślone – datowania drewana kopalnego

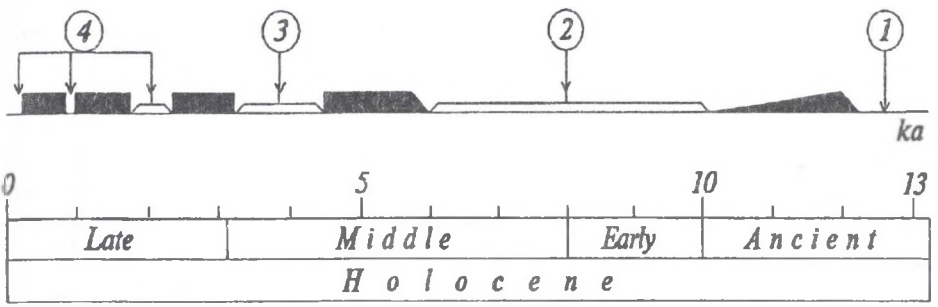

Fig. 4. Preliminary scale of nature rythm pattern in Holocene for Alpine middle mountain area of Carpathians. Circled figures – cold periods: 1 – late Wurm degradation of mountain glaciation; accumulation oflow–level fluvio–glacial sedimentations. 2 – glacial rejuvenation; formation of ending moraines typical of 4, 5, and 6 stages; formation of the middle levels of fluvio–glacial sedimentations. 3 – youngest moraines formation; formation of the upper levels of fluvio–glacial sedimentations. 4 – accumulation of nival–fluvial fine–grained soil near by large firns. Black area: warm periods, vegetation optimum

Rys. 4. Wstępna skala czasu dla naturalnych, podstawowych rytmów sedymentacyjnych w holocenie, dla strefy alpejskiej Karpat Ukraińskich. Cyfry w kółkach – okresy zimne: 1 – kumulacja dolnego poziomu osadów fluwioglacjalnych w późnym Wurmie, 2 – nasuwanie lodowca, formowanie moren czołowych typowych dla faz 4,5 i 6, formowanie środkowych poziomów osadów fluwioglacjalnych, 3 – formowanie się najmłodszych moren, tworzenie górnych poziomów osadów fluwioglacjalnych, osadzanie gleby drobnoziarnistej przy martwym lodzie. Pola zaczernione: okresy ciepłe optimum wegetacji

its degradation, comprised all the early and first half of the middle Holocene. The further climate optimum of 4.5 - 6 ka ago caused the glaciation disappeared. The youngest moraines might have been formed as late as 2 ka ago during considerable climate cooling. The aim of further investigations is to make comparison between radiocarbon dates and cryptogam analysis to be obtained.

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Streszczenie

Przedmiotem badań palinologicznych i radiowęglowych były osady niwoglacjalne, których depozycja następowała w holocenie, obecnie w cyrkach górskich na terenie Karpat Ukraińskich. W okresie optimum klimatycznego obserwuje się sedymentację torfów, który ulega przykryciu przez firn w okresie ochłodzenie po czym następuje depozycja drobnoziarnistego osadu niwoalnego w okresie ciepłym. Wymienione cykle sedymentacyjne

pojawiają się stosunkowo gwałtownie. Analiza radiowęglowa osadów organicznych pozwoliła określić chronologię występowania okresów zlodowaceń i optimów klimatycznych w badanym regionie. Zlodowacenie holoceńskie, które lepiej nazwać deglacjacją ogranicza się do wczesnego i pierwszej połowy środkowego holocenu. Stwierdza się wyraźne klimatyczne optimum w okresie 4.5–6 tysięcy lat temu spowodowane zanikiem zlodowacenia. Być może również młodsze moreny zostały uformowane nie później niż 2 tysiące lat temu, w czasie zauważalnego ochłodzenia klimatycznego.