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Pollen-bearing Middle Pleistocene deposits at Huba, southern Poland (West Carpathians)

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ABSTRACT. Pollen-bearing lacustrine sediments developed as plastic clays, and silty to sandy clays with sand intercalations, over 5.75 m thick (bottom not exposed) occur in the lower part of the Middle Pleistocene section at Huba, the Orawa-Nowy Targ Intramontane Basin, West Carpathians (southern Poland). Their pollen diagram indicates middle to late climatic phases of the Mazovian (Holsteinian, Mindel/Riss) Interglacial. The lacustrine sediments are overlain by a fluvioglacial/fluvial gravel cover (5–8 m thick) which is correlated with the Riss Glaciation of the Tatra Mountains and, probably, with the beginning of the Riss/Würm Interglacial. The pollen-bearing sediments at Huba are the first and the only site of the Mindel/Riss Interglacial fossiliferous deposits discovered so far in the West Carpathians. They were slightly tectonically tilted during Late Pleistocene.

KEYWORDS: geology, pollen analysis, Middle Pleistocene, Mazovian (Holsteinian, Mindel/Riss) Interglacial, Riss Glaciation, ?Riss/Würm Interglacial, West Carpathians

CONTENTS

LOCATION AND HISTORY

The Middle Pleistocene pollen-bearing deposits at Huba occur in the north-eastern part of the Orawa-Nowy Targ Intramontane Basin, West Carpathians, southern Poland (Fig. 1). This basin is situated between the Tatra Mountains, the Spisz Mountain Range and the Maruszyna Hills in the south, and the Gorce Mountain Range in the north. It is renown for numerous sites of fresh-water plant-bearing strata of Miocene, Pliocene and Pleistocene ages (e.g. Szafer 1949, 1954, Stupnicka & Szymański 1957, Birkenmajer 1958, 1961, 1962, 1963, 1976, 1978, 1979, 1987, Birkenmajer & Środoń 1960, Środoń 1960, Sobolewska & Środoń 1961, Koperowa 1962, Oszast 1970, 1973, Zastawniak 1972, Tran Dingh Nghia, 1974, Birkenmajer & Stuchlik 1975).

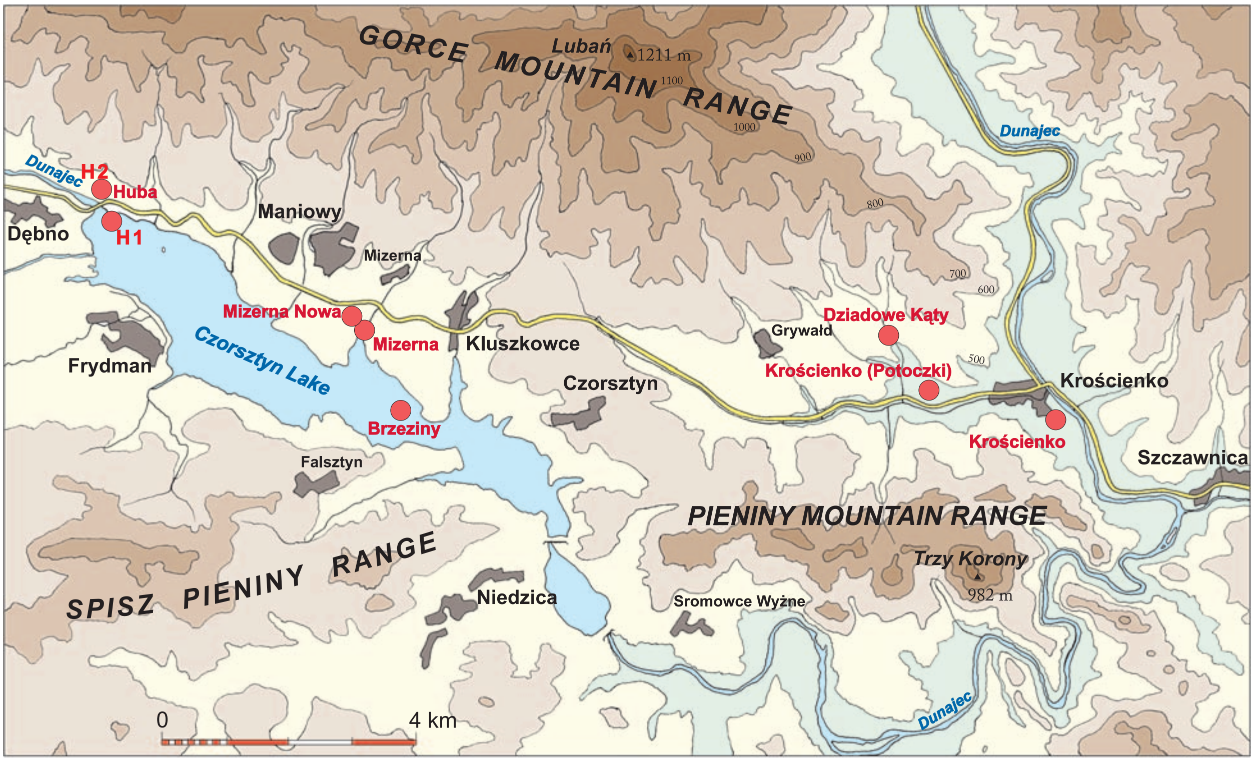

Fig. 1. Location of the Huba sites in the West Carpathians: H 1 – Huba 1 (Late Miocene); H 1 – Huba 2 (Mazovian Interglacial); Mizerna (Pliocene–Early Pleistocene); Brzeziny (Brørup Interstadial); Krościenko-Potoczki (Pliocene); Dziadowe Kąty and Krościenko (Late Pleistocene)

The pollen-bearing Middle Pleistocene strata described here were exposed in the 1970-ties in a road-cutting at Huba, north-eastern margin of the Orawa-Nowy Targ Intramontane Basin (Fig. 2). Geological field observations and description of the strata (by K. Birkenmajer) and sampling for palynological analysis (by J. Oszast and L. Stuchlik) were made on October 8, 1977. Unfortunately, due to illness and death of Dr Janina Oszast, palynological elaboration of the samples was left unfinished up to present.

GEOLOGICAL SETTING

The southern slopes of the Gorce Mountain Range between Nowy Targ, Czorsztyn and Krościenko are built by strongly folded Palaeogene flysch deposits of the Magura Nappe (Birkenmajer 1962, 1963). They form bedrock of the Miocene, Pliocene and Pleistocene fresh-water plant-bearing sediments which fill a system of narrow buried stream valleys eroded in the flysch strata (Birkenmajer 1958, 1961, 1979, 1987). A succession of Pleistocene fluvioglacial gravel terraces (now partly flooded by artificial Czorsztyn Lake), and of Holocene fluvial gravel terraces (mostly flooded by the Czorsztyn Lake) had developed there along course of the Dunajec River – the major river of the area. Once, they masked outliers of plant-bearing fresh-water deposits of Late Miocene age at Huba, and of Pliocene-Early Pleistocene age at Mizerna – both now flooded by the artificial Czorsztyn Lake.

These Neogene to Early Pleistocene outliers were cropping out along the northern fault-bounded margin of the Frydman Graben (Birkenmajer 1960, 1962). The latter is a latitudinal, narrow, down-faulted depression filled by Early to Middle Pleistocene fresh-water fluvioglacial to fluvial deposits about 100 m thick, underlain by the Mizerna-type clays (Niedzielski 1971, Birkenmajer 1978).

Two fluvioglacial gravelly terraces are preserved at Huba (Birkenmajer 1962): the high and the low ones. The high terrace, at (28)30–48 m above the Dunajec River bed, has been attributed to the Middle-Polish Glaciation (= Riss), and the low terrace, at 15–17 m above the Dunajec River bed – to the Baltic Glaciation (= the Vistulian Glaciation = Würm). Palaeogene flysch strata, locally overlain by thin

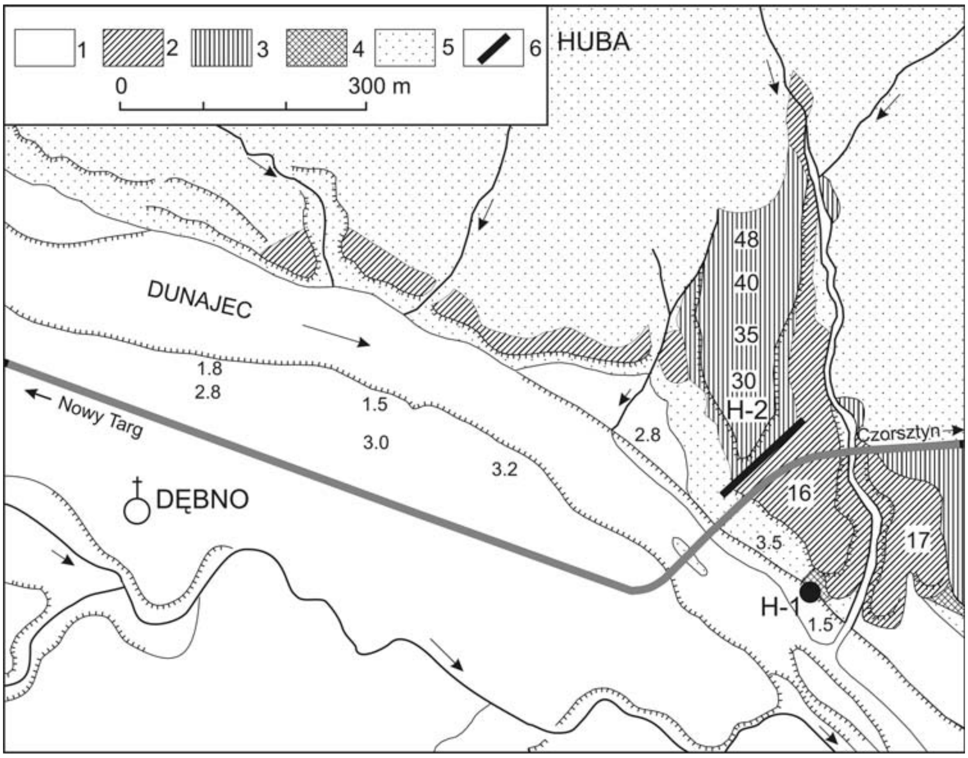

Fig. 2. Location of the Huba 1 (H-1) and the Huba 2 (H-2) sites in the Nowy Targ Intramontane Basin (southern Poland). Geology after Birkenmajer (1962), simplified. **1** – Holocene terraces; **2** – Würm terrace; **3** – Riss terrace; **4** – Upper Miocene deposits; **5 –** Paleogene flysch bedrock; **6** – H-2 exposed section; dentated – escarpments and terrace margins; numbers denote terrace altitudes above the Dunajec River level

Late Miocene plant-bearing clays, form bedrock of the Würm fluvioglacial cover at Huba (Fig. 2).

HUBA 1

Fluvioglacial terrace gravels attributed to the Würm Glaciation overlie fresh-water plant-bearing deposits at the Huba 1 site (see Fig. 2). They were once exposed in road scarp south-east of the road bridge over the Dunajec River. In 1949, they were drilled by a shallow borehole located just above river bed. In this borehole, brown Neogene clays with sand intercalations were found at 0.7 down to 7.5 m below the surface. Based on their plant content, they were attributed either to the Pliocene (Szafer 1949, 1954) or to the Miocene (Badenian – Oszast 1973). Palaeogene flysch rocks form bedrock of the Miocene clays.

HUBA 2

Geological section, here described as the Huba 2 site (Figs 3, 4), lies in the area of Huba hamlet (the site is called "Na Hubie"), on southern slopes of the Gorce Mountain Range (see Fig. 2), immediately north of the new road bridge over the Dunajec River/Czorsztyn Lake. In 1977 the section was well accessible in north-western scarp of the new road (Dębno-Czorsztyn), constructed as part of the Czorsztyn water-dam project. At ca 15 to 23 m above the Dunajec River bed, it exposed lacustrine pollen-bearing sediments attributed now to the Mazovian (= Holsteinian = Mindel/Riss) Interglacial (see pp. 95–98 of this paper). They were capped by a 5–8 m thick cover of fluvioglacial/fluvial gravel attributable to the Riss Glaciation (= Middle Polish Glaciation – Birkenmajer 1962) and, probably, to basal part of the a Riss/Würm Interglacial.

The bedrock of the lacustrine deposits consists of Palaeogene flysch sandstones and shales of the Magura Nappe (Fig. 3). Lateral contact of the lacustrine deposits with the bedrock was exposed in the SW part of the outcrop. It indicated that these deposits fill a rather steep-walled buried stream valley more than 8 m deep, cut into the bedrock. Flysch bedrock was not exposed in the deepest (axial) part of the buried valley. According to field observations in the vicinity (see Birkenmajer 1962), it should also consist of flysch strata.

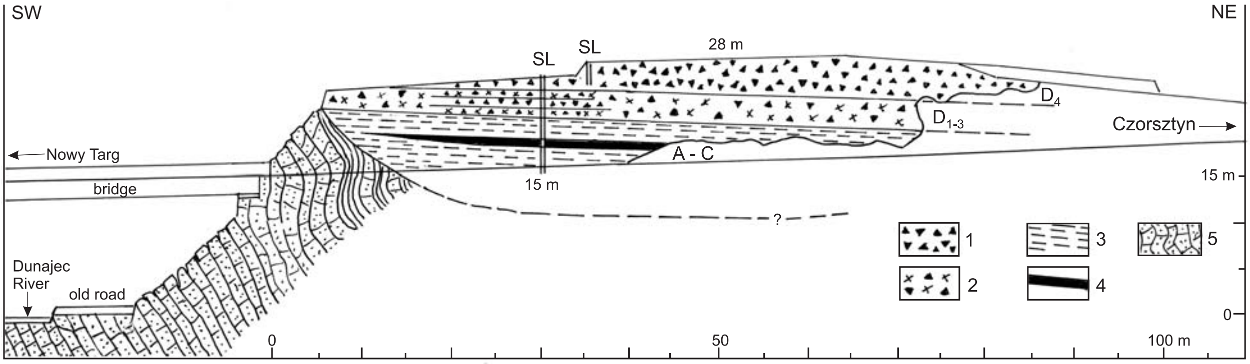

Fig. 3. Geological exposure at Huba 2 site showing relation of the Pleistocene deposits to the Palaeogene flysch bedrock, as observed on Oct. 8, 1977. **1** – ?Riss/Würm Interglacial, fluvial terrace gravel (D_4 flysch-sandstone gravel); **2** – Riss Glaciation, fluvioglacial/fluvial terrace gravels (complexes D_1, $_3$ – mixed gravel; complex D_2 – flysch-sandstone gravel); **3** – Mindel/Riss Interglacial, sandy/silty clays (complexes A, C); **4** – Mindel/Riss Interglacial, brown plastic clays (complex B); **5** – Palaeogene flysch bedrock; **SL** – site of stratigraphic log (see Fig. 4)

SEDIMENTARY LOG AT THE HUBA 2 SITE

The Huba 2 sedimentary log is here decribed in stratigraphic order (Figs 3, 4), from its base (ca 15 m above the Dunajec River bed) to its top (ca 28 m above the Dunajec River bed).. Twenty beds combined in four sedimentary complexes have been distinguished:

A-C – lacustrine deposits (63 samples for pollen analysis were taken, numbered from the top of the section downwards): A – sandy clay and sand; B – brown clay; C – sandy clay and clayey sand;

D – fluvioglacial/fluvial gravel cover: D_1 – mixed fluvioglacial gravel; D_2 – local flysch-sandstone fluvial gravel; D_3 – mixed fluvioglacial gravel; D_4 – local flysch-sandstone fluvial gravel.

Complex A (sandy clay and sand, >1.75 m thick; samples 63–45):

1. Clay, silty to sandy, with fine-grained sand streaks, bluish. Coarse-grained sand (Magura flysch type) lenses, yellowish-grey to yellowish-green, with very thin green clay streaks occur in the middle and at the top of the bed (samples 63–55);

2. Clay, sandy, and plastic clay, with alternating bluish and greenish laminae (samples 54–49);

3. Clay, bluish, with streaks of sand, with scattered single, small (1–3 cm) fragments of flysch sandstone (samples 48–45);

Complex B (brown clay, 1.6 m thick; samples 44–25):

4. Clay, plastic, brown to nearly black (samples 45–36);

5. Clay, plastic, grey to brownish (samples 35–29);

6. Clay, plastic, brownish-rusty: ortstein (samples 28–25);

Complex C (sandy clay and clayey sand, 2.4 m thick; samples 24–1):

7. Clay, sandy, greenish-blue, and clayey sand, alternating yellowish-rusty laminae (samples 24, 23);

8. Sand, clayey, rusty: ortstein (samples 22, 21);

9. Sand, clayey, and sandy clay, alternating greenish-blue and yellowish-rusty laminae (samples 20–16);

10. Sand, fine-grained, clayey, passing into sandy clay, alternating bluish and greenish to rusty laminae (samples 15, 14);

11. Sand, fine-grained, clayey, alternating yellowish-green and blue laminae (samples 13, 12);

12. Clay, plastic, slightly sandy (with white mica flakes), with streaks of clayey sand, blue-greenish (samples 11–7);

13. Clay, sandy, rusty, with angular fragments of weathered flysch sandstone 0.5–1.0 cm in diameter (sample 6);

14. Clay, sandy, greenish-blue, with diagonal streaks of sand (samples 3–5);

15. Fossil soil (regolith): rusty sandy clay (samples 1, 2);

Complex D (fluvioglacial and fluvial gravels, four units, D_1-D_4, altogether 5.5 m thick; no samples for palynological analysis were taken):

16 (D_1). Mixed gravel (0.5 m thick): rounded to well-rounded, poorly imbricated pebbles of granite (completely weathered), 2–10 cm in diameter, dominating over much rarer Werfenian quartzite of similar size; a small admixture of local flysch sandstone was found. There is a sharp contact with the underlying bed 15 (regolith);

17 (D_2). Flysch gravel (1.25 m thick) consisting of flysch sandstones (Magura Formation, Piwniczna Sandstone Mbr type), 1–15 cm in diameter, angular to subrounded, devoid of imbrication;

18 (D_3). Mixed gravel (0.6 m thick) consisting mainly of flysch sandstones (as in bed 17), angular to subrounded, 1–15 cm in diameter. Admixture of single granite (weathered) and quartzite pebbles 0.1–1.0 cm in diameter;

19 (D_3). Mixed gravel (0.6 m): gravel as in bed 18, with pebbles of granite (weathered), 0.5–5.0 cm in

diameter, and of Werfenian quartzite, 1–2 cm in diameter. Admixture of clayey sand with fine fragments of granite, quartzite and flysch-sandstone, and of flysch-sandstone pebbles (1–10 cm in diameter). Yellow colouration of the bed;

20 (D_4). Flysch gravel (3 m thick) consisting of sandstone (as in bed 17) pebbles 2–5 cm, occasionally up to 20 cm in diameter, subangular to subrounded, not imbricated, with a considerable admixture (5–20%) of sand. Grey-yellowish colouration of the bed.

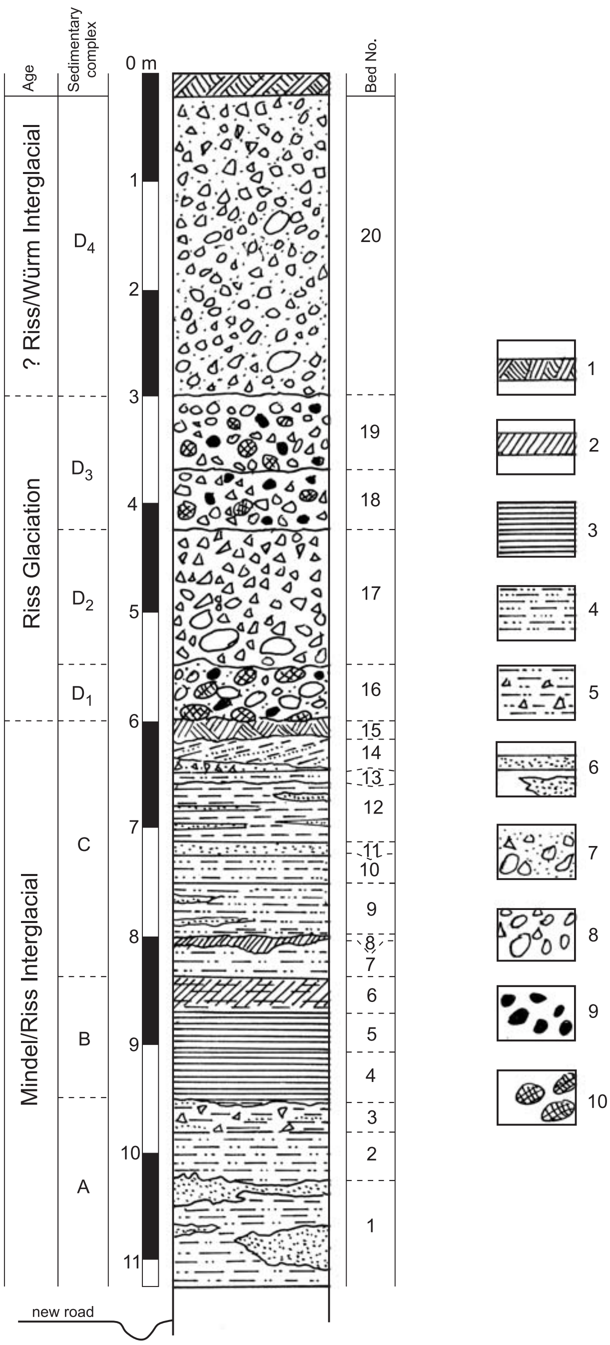

Fig. 4. Stratigraphic log of the Pleistocene deposits, Huba 2 section, as measured on Oct. 8, 1977. **1** – recent and fossil soils (**rg** – regolith); **2** – ortstein (**o**); **3** – dark plastic clays; **4** – sandy and/or silty clays; **5** – sandy and/or silty clays with flysch-sandstone clasts; **6** – sand intercalations; **7** – flysch-sandstone gravel, sandy; **8** – flysch-sandstone gravel; **9** – Werfenian quartzite pebbles in mixed fluvioglacial gravel; **10** – granite pebbles in mixed fluvioglacial gravel; detailed description in the text

GEOLOGICAL INTERPRETATION OF SEDIMENT SUCCESSION AT HUBA 2 SITE

MINDEL/RISS INTERGLACIAL: LACUSTRINE DEPOSITS (COMPLEXES A-C)

Blue to greenish, often laminated, sandy and silty clays, with thin sand intercalations (Complexes A and C), divided in two by brown plastic clay (Complex B), are interpreted as lacustrine deposits. They had formed in a shallow lake (Huba palaeolake) which once filled a small valley eroded by a stream – the left tributary to the Dunajec River system, flowing down from the Gorce Range. Lack of granite and quartzite fragments in the clays indicates that the Huba palaeolake was well divided from the main Dunajec-Białka river course, probably by a gravelly-sandy point bar.

Fine lamination of the sediment, and repeatedly appearing admixture of silt- and sand-grade clastic material might be an effect of seasonal (winter/summer) change in supply of well weathered clastic material washed down to the lake from the Gorce Range. This source of the sediment is confirmed by appearance of small fragments of flysch sandstone (bed No 3). The clayey material which dominated the deposition process in the lake derived, likewise, from well-weathered shales of the flysch complex. Infrequent lenses of well-washed sand indicate occasional incursions to the lake by small brooks descending from the range.

There are some breaks in lacustrine deposition indicated by limonitisation (bed No 6), and thin ortstein zones (beds Nos 8 and 15). They evidence short episodes of draining the lake, followed by temporal stabilisation of groundwater table. However, no evidence for dry-land vegetation which would encroach upon the temporarily exposed lacustrine sediments, such as macroscopically recognizable plant roots/rootlets and/or remains of tree stems, was found.

Based on interpretation of pollen diagram (see pp. 95–98 of this paper), the complexes A-C have been attributed to the middle-to-late parts of the Mazovian Interglacial (Holsteinian), i.e. to the Mindel/Riss Interglacial.

RISS GLACIATION: FLUVIOGLACIAL/FLUVIAL DEPOSITS (COMPLEXES D_1-D_3)

These gravelly complexes reflect an interplay of fluvial transportation by the Dunajec-Białka river couple which brought moraine-derived well-rounded gravel from the Tatra Mountains, with formation of local alluvial cones that consisted of unworked rock detritus derived from the Gorce Range.

Generally small to medium sizes of rather well-rounded pebbles of granite (weathered) and Werfenian quartzite (material from the Tatra Mts), and a considerable admixture of poorly rounded flysch sandstone (probably mainly from the Podhale flysch), might indicate that the beds Nos 16, 18 and 19 were deposited not in the main river channel but, rather, in subordinate channels at margin of alluvial cone, where the current velocity was smaller. This would also explain the lack of pebble imbrication so typical of flood-generated gravel bars which frequently develop in these rivers at present.

1st climatic phase. An abrupt change from lacustrine conditions (Complexes A-C) to fluvioglacial conditions (Complex D_1) seems to evidence onset of the Riss Glaciation in the Tatra Mountains (?Riss-1 in the standard proposed by Nemčok et al. 1994).

2nd climatic phase. Appearance of the Magura flysch-sandstone gravel bed (No 17 – Complex D_2) might point to temporal amelioration of glacial climate (Riss-1/Riss-2 Interstadial ?) that caused thawing of permafrost layer, allowing for downslope mass movement and transportation by running water of rock debris from the Gorce Mountain Range.

3rd climatic phase. Reappearance of mixed gravel beds (Nos 18, 19 – Complex D_3) could evidence the second phase of the Riss Glaciation in the Tatra Mts (?Riss-2 in the standard proposed by Nemčok et al. 1994).

Note: In the lack of more detailed dating, it would be premature to attempt at closer correlation of the above deposits from the Huba 2 site, attributed to three successive climatic phases of the Riss Glaciation, with the TL-dated fluvioglacial deposits in head part of the Biały Dunajec valley attributed by Lindner et al. (1993, 2003) to the Riss I and the Riss II glaciations. A similar reservation may also be extended to the Biała Woda valley segment in the Tatra Mts where presence of the Riss Glaciation moraines is put in doubt (Birkenmajer 2009).

RISS/WÜRM INTERGLACIAL (?): SLOPE DEPOSIT (COMPLEX D_4)

The highest gravel beds (No 20: 3 m thick) consist exclusively of unstratified Magura-flysch sandstone gravel with a considerable admixture of sand. The sandstone fragments are poorly rounded or angular, and show no imbrication. This bed was probably an effect of redeposition of weathering cover from slopes of the Gorce Range by a sheet-flood generated by heavy rainfall at transition from cold climate (Riss Glaciation) to much milder one (Riss/Würm Interglacial), in the absence of forests, and along with progressive decay of permafrost.

TECTONIC DISTRURBANCE OF THE HUBA 2 DEPOSITS

Gentle tilt of the lacustrine deposits (Complexes A-C) and the overlying fluvioglacial/fluvial gravel beds (Complex D) as well, of the order of 2 degrees due NE or N is best recognizable on dips of the clayey beds in the Complex B, and at the Complex C/D interface (Fig. 3). This tilting might be of tectonic origin. It could have happened during the Riss/Würm Interglacial, or later.

A similar gentle tilt, but of opposite direction (due south) with respect to that at Huba, was recognized in the Günz/Mindel pollen-bearing varved clays at Szaflary quarry (Birkenmajer & Stuchlik 1975, Birkenmajer 1976). Its origin was explained by vertical displacement of the Pieniny Klippen Belt orogen (upthrown) respective to the Magura Nappe block (downthrown), along a major fault (the Northern Boundary Fault) which separates these two tectonic units. At Szaflary, it occurred during the Mindel/Riss Interglacial (Birkenmajer 1976).

Tectonic tilting of the Szaflary-quarry Mindel and pre-Mindel deposits (due south) and that of the Huba-2 Mindel/Riss deposits (due north), may point to recurrent tectonic instability at the Northern Boundary Fault of the Pieniny Klippen Belt during the Pleistocene.

MATERIAL AND METHODS

Material to the study was collected by K. Birkenmajer and L. Stuchlik in 1977. Altogether 63 samples were taken from the exposed section at 6.0–11.3 m.

For the pollen analysis purposes the clayey sediments were sampled at 5 cm intervals,while sandy clay samples were sampled every 10 cm. All samples for pollen analysis were acetolized according to the Erdtman's method (1960). Pollen and spores were identified using the Amplival Zeiss-Jena light microscope. Pollen spectra for each sample were counted on two slides of a surface area of 20×20 mm. The frequency of pollen grains was low and very low. Only 28 samples were qualified for the pollen analysis. Results of this study are presented in pollen diagram (Fig. 5). Most of the analyzed pollen grains were damaged, probably due to water transport.The counting was carried out up to ca 200–300 grains.

PREVIOUS PALAEOBOTANICAL RESEARCH IN THE PIENINY MTS AREA

Palaebotanical research of the Pieniny Mountains area were mainly concentrated on younger Pleistocene floras: glacial flora of Vistulian age at Dziadowe Kąty near Grywałd (Środoń 1952) and at Kąty near Sromowce Wyżnie (Dyakowska 1947, Mamakowa et al. 1975); Brørup Interstadial at Maniowy and Brzeziny near Czorsztyn (Birkenmajer & Środoń 1960); Holocene succession peat bogs at. Staszowa near Szczawnica Wyżnia (Koperowa 1962) and on Bryjarka Mt (Pawlikowa 1965). The Pliocene/Pleistocene transition was recognized in the profiles from Mizerna (Szafer & Oszast 1964), and of Pliocene deposits with rich fossil flora at Krościenko on Dunajec (Szafer 1946–1947).

RESULTS OF PALYNOLOGICAL RESEARCH OF THE HUBA 2 PROFILE

LOCAL POLLEN ASSEMBLAGE ZONES (L PAZ)

In the profile from Huba 2 two local pollen zones were distinguished (Tab. 1). They indicate the end of mesocratic phase and the beginning of telocratic phase of the Mazovian Interglacial. Low frequency of pollen, and low percentage of tree pollen (AP), in pollen spectra – often slightly less than 50%, suggest that the pollen grains probably were redeposited.

VEGETATION AND CLIMATE

Hu-1 *Betula-Alnus-Pterocarya* L PAZ (Complex A)

Sandy and silty clays, often laminated, are considered to be lacustrine deposits (see p. 92 of this paper). At the end of Mazovian (Holsteinian) Interglacial (mesocratic pollen period III) climatic optimum, the environment of Huba was dominated by birch forests and watery, often flooded alder forest with *Pterocarya*, *Ulmus*, and *Salix*. In undergrowth of this communities could grow ferns, Poaceae, Ranunculaceae, *Urtica* and other herbaceous plants. The appearance of *Ilex* on drier habitats and considerable high frequency of *Pterocarya* suggests that the climate at Huba was mild, with oceanic characteristics (cf. Mamakowa 1989 after Iversen 1944, Szafer 1954).

Deciduous forests with *Carpinus*, *Corylus*, *Quercus*, and *Tilia*, typical in this part of Mazovian (Holsteinian) Interglacial, did not play

Table 1. Description of local pollen assemblage zones (L PAZ)

Symbol	Name	Depth (m)	Description
Hu-1	*Betula-Alnus-Pterocarya*	11.40–11.00	AP up to 50–70%. Pollen of *Alnus* is dominant (up to 35%) and *Betula* (up to 23%). Continuous curves of other trees: *Pinus* (3.5%), *Corylus* (3.5%), *Ulmus* (up to 2.9%), *Salix* (up to 2.7%), *Carpinus* (4%), and *Pterocarya* (up to 6.5%). The other trees are represented by low frequency of pollen: *Picea* (2%), *Ilex* (2%), *Tilia* (2.5%), and *Quercus* (1%). Among NAP the highest proportion have Poaceae (up to 17%), Asteraceae 17%, and Ranunculaceae 10%. Rubiaceae reach 4.3%, Ericaceae (3%), *Artemisia* (2%). Spores of Filicales increased up to 3.6% and *Lycopodium* up to 26%. This zone has no upper boundary .
Hiatus		11.00–9.70	
Hu-2	*Pinus-Picea*-NAP	9.70–8.60	High percentage of AP (up to 95%), average 64.5%. *Pinus* pollen varies from 25% to 92%. *Picea* in the bottom of zone – 17% decreased to 2%, *Alnus* decreased from 5% to 1%, *Betula* about 1%, other occasionally *Ulmus*, *Carpinus*, *Corylus*,and *Salix*. High amount of NAP: Poaceae at the bottom of the zone reach 57%, Cyperaceae ca 9%. Ericaceae 11%, *Artemisia* 2.2%, Asteraceae 1%, Ranunculaceae 4.2%, and Rosaceae 4.4%. Often but in low amount occur Chenopodiaceae, Rubiaceae, Primulaceae, Potentilla, *Thalictrum*, *Filipendula*, Filicales spores about 2%, and *Lycopodium* about 3%. In the middle part of the zone the amount of *Sphagnum* increased up to 33%.

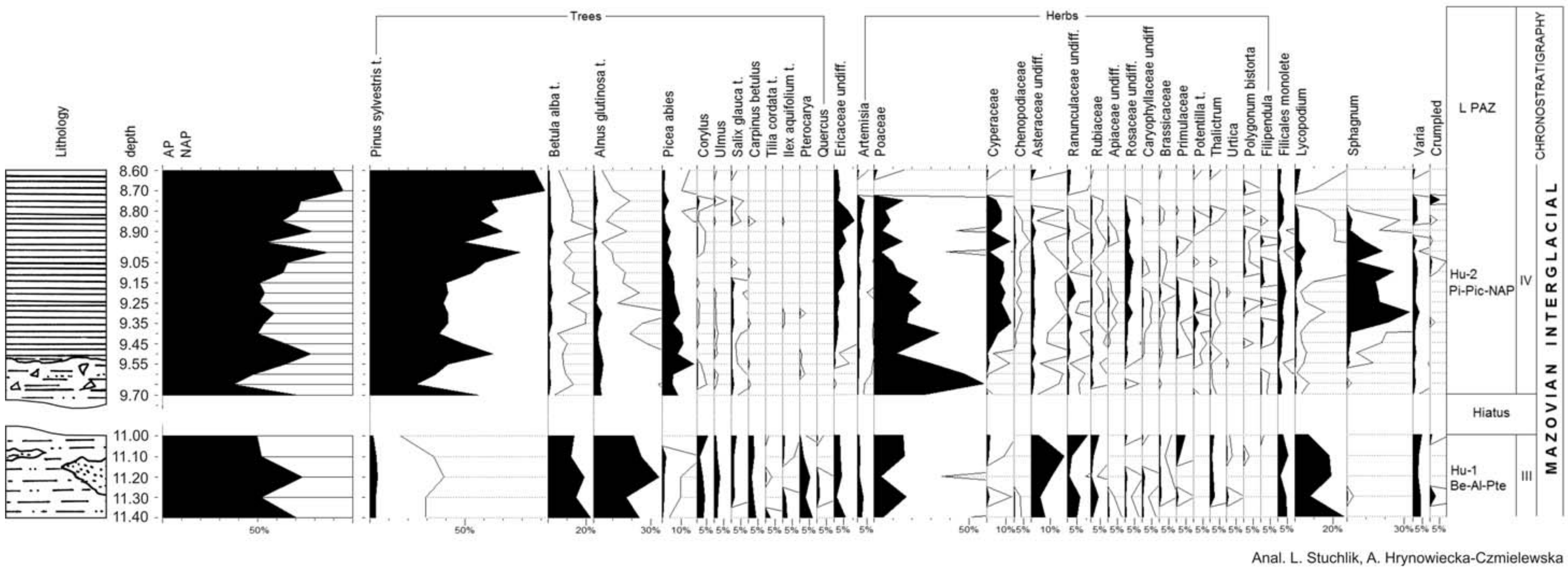

Fig. 5. Percentage pollen diagram of the profile Huba 2. Lithology as in Figure 4.

an important role in the landscape; they occupied small areas.

The plant communities along the riverside (the present Dunajec River) formed mostly meadows with predomination of Poaceae, Ranunculaceae, Rubiaceae, Primulaceae, and *Thalictrum*. On more dry habitats, stepped-like communities with predominating *Artemisia*, *Helianthemum nummularium*, Asteraceae, and Chenopodiaceae, as well as heaths with Ericaceae, and *Lycopodium* occurred.

Hu-2 *Pinus-Picea*-NAP L PAZ (Complex B)

The beginning of the Mazovian Interglacial decline (IV Pollen Period – thelocratic) was characterized by increasing forestation which reached its maximum in the final phase of the zone. Domination of Poaceae at the beginning of this phase indicates a short episode of cooling, which, however, quickly ended and boreal climate was established, with pine forests and a considerable admixture of spruce. In these forests grasses, heaths, ferns, and *Lycopodium* grew. The assemblages of alder forests with willow retreated, restricted to riverside zone only.

Meadow communities with *Artemisia*, Asteraceae, Chenopodiaceae, Cichorioideae, and Caryophyllaceae developed on dry habitats, while Cyperaceae, Ranunculaceae, Apiaceae, Rosaceae, Rubiaceae, Brassicaceae, Primulaceae, *Potentilla*, *Polygonum bistorta*, and *Filipendula* on more moisty habitats. High frequency of *Sphagnum*, indicates the presence of peat bog at Huba, which was located close to the Dunajec and Białka rivers.

CHRONOSTRATIGRAPHY

The characteristic distribution of the taxa confirm that the studied Huba 2 profile represents the Mazovian (Holsteinian) Interglacial of Middle Pleistocene (see Lindner et al. 2004).

Occurrence of *Pterocarya* pollen grains in large quantities (about 6.5%, Hu-1 *Betula-Alnus-Pterocarya* zone) shows that this part of the profile represents the end of climatic optimum of the Mazovian Interglacial. This is also confirmed by continous curves of some more thermophilous trees and shrubs, such as *Corylus*, *Ulmus*, *Quercus*, and *Carpinus*, low amount of *Picea* and very low amount of pine pollen (*Pinus*). The second recognized pollen zone – Hu-2 *Pinus-Picea*-NAP – with predomination of pine pollen, as well as initially quite large amount of spruce pollen is recognized as the beginning of IV Pollen Period of the Mazovian Interglacial (Szafer 1953).

A sediment coeval with the Huba 2 site was recognized in the Carpathians only in deposits from the palaeolake Stonava about 20 km eastwards from Ostrava, the Czech Republic (Břizová 1994). The Huba 2 site is the first locality in the Polish part of Western Carpathians with the recognized Mazovian (Holsteinian) Interglacial flora.

POLLEN SUCCESSION AT HUBA 2 AS COMPARED WITH SOME OTHER SITES OF THE MAZOVIAN (HOLSTEINIAN) INTERGLACIAL

The end of the Pollen Period III was characterized by the dominance of *Abies* and *Carpinus* forests, and, additionally, by a high frequency of *Pterocarya* and *Picea*, and a very poor frequency of *Pinus*. This is typical for the Mazovian (Holsteinian) Interglacial flora in Polish Lowlands. The presence of *Pterocarya* was recorded, e.g., from Biała Podlaska (Krupiński 1988), Ossówka (Krupiński 1995), Kaliłów (Bińka & Nitychoruk 1996), Konieczki (Nita 1999), Brus (Pidek 2003), Nowiny Żukowskie (Hrynowiecka-Czmielewska 2010). A great role was sometimes played by birch and alder, as at Huba 2 (West Carpathians) and Stonava (Ostrava, Břizová 1994) sites. In the Huba 2 profile *Abies* pollen was absent.

Pollen Period IV was characterized by dominance of *Pinus*, initially accompanied by a high amount of *Picea*. The Lowlands profile from Brus (Pidek 2003) is characterized by a high frequency of *Alnus*, while that from Gajec (Winter & Urbański 2007) by high pollen frequency of *Quercus* and *Corylus*; this confirms influence of marine climate. In the Huba 2 profile initially a great amount of Poaceae occurred.

FINAL REMARKS

The palynological characteristics of pollen succession from the Huba 2 site permit to correlate it with the Mazovian (Holsteinian) Interglacial pollen succession. Two pollen zones were distinguished. The first zone (Hu-1 *Betula-Alnus-Pterocarya*) was correlated with the end of Pollen Period III; it is characterized by the presence of *Pterocarya*, *Carpinus*, and *Ilex* pollen, and by very low *Pinus* frequency. The second zone (Hu-2 *Pinus-Picea*-NAP) represents the IV Pollen Period as indicated by domination of *Pinus* and *Picea*. This is the first profile in the Polish part of the Carpathians with the Mazovian (Holsteinian) Interglacial flora.

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