Geological Quarterly, 1999, 43 (1): 27–38

Sediments of the Pleistocene terraces of the Bug and Huczwa Rivers in the vicinity of Hrubieszów

Leopold DOLECKI

Dolecki L. (1999) — Sediments of the Pleistocene terraces of the Bug and Huczwa Rivers in the vicinity of Hrubieszów. Geol. Quart., 43 (1): 27–38. Warszawa.

Geologic structure of the Pleistocene terraces of the Bug River within the Horodło Hills and the southern Dubienka Basin, and of the Bug and Huczwa Rivers in the Hrubieszów Basin, are described. There are three overbank terraces, two of them with a loess cover from the Upper Pleniglacial of the Vistulian Glaciation. The highest terrace was formed in the Wartanian Glaciation, the higher overbank terrace in the Lower Pleniglacial and the lower overbank terrace in the Upper Pleniglacial of the Vistulian Glaciation.

Leopold Dolecki, Institute of Earth Sciences, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland; e-mail: dolecki@biotop.umcs.lublin.pl *(received: November 3, 1998; accepted: January 15, 1999).*

Key words: Lublin Upland, Pleistocene, Vistulian Glaciation, river terraces.

INTRODUCTION

The study area is located in a northeastern part of the Hrubieszów Basin, and in a southern part of the Dubienka Basin in the vicinity of the Horodło Hills. The Polish–Ukrainian boundary along the Bug River delimits the study area in the east (Fig. 1).

The Huczwa River in the eastern part of this region cuts through the uplands and follows downstream a deep buried structure in the Upper Cretaceous rocks; the latter is filled with glacial, glaciofluvial, fluvial and aeolian sediments of the Eo- and Mesopleistocene (M. Prószyński, 1952; A. Jahn, 1956*a*, *b*; J. E. Mojski, 1965; L. Dolecki, 1977). The origin of this feature has not been entirely explained yet, and it seems to be a polygenic one and formed over a long period of time, what resulted in genetic and stratigraphic variability of its infilling. Tectonic factors (J. Rzechowski, 1987), supplemented with glacial, glaciofluvial, fluvial and limnic processes, contributed to a development of this depression. Locally, above the Eopleistocene deposits which directly overlie the Cretaceous bedrock, there are fragments of tills of the Sanian 1 Glaciation (L. Dolecki, 1995), overlain by glaciofluvial sands and gravel, clayey silts and alluvial loess-like silts from the Odranian Glaciation. They form commonly a direct basement of the alluvial terrace deposits, associated with the Wartanian and the Vistulian Glaciations (L. Dolecki 1977, 1981). Terraces of the Huczwa and the Bug Rivers are the main components of a surface morphology in this area (Figs. 2 and 3).

HIGHEST OVERBANK TERRACE

The highest terrace (III) from the Wartanian Glaciation occurs, due to a thick 4–12 m loess cover, even up to 205 m a.s.l. and 23 m above a river. As a buried terrace, it is perfectly exposed in outcrops in the Huczwa River valley near Lipice, Michałówka (J. E. Mojski, 1956, 1965) and Obrowiec (Fig. 4), and in the Bug River in the drillings Kolonia Hrebenne and Marta in the Horodło Hills (Fig. 5), and also in outcrops at Horodło close to the Dubienka Basin (L. Dolecki, 1972, 1985, 1991*a*, *b*; L. Dolecki, S. Skompski, 1986; Fig. 6). The actual top of the highest buried surface of the Pleistocene terrace is perfectly determined by the Eemian to the Early Vistulian complex of the palaeosol GJ1[1], developed on the older loess,

[1]Symbol of a palaeosol complex after stratigraphic scheme of H. Maruszczak (1980).

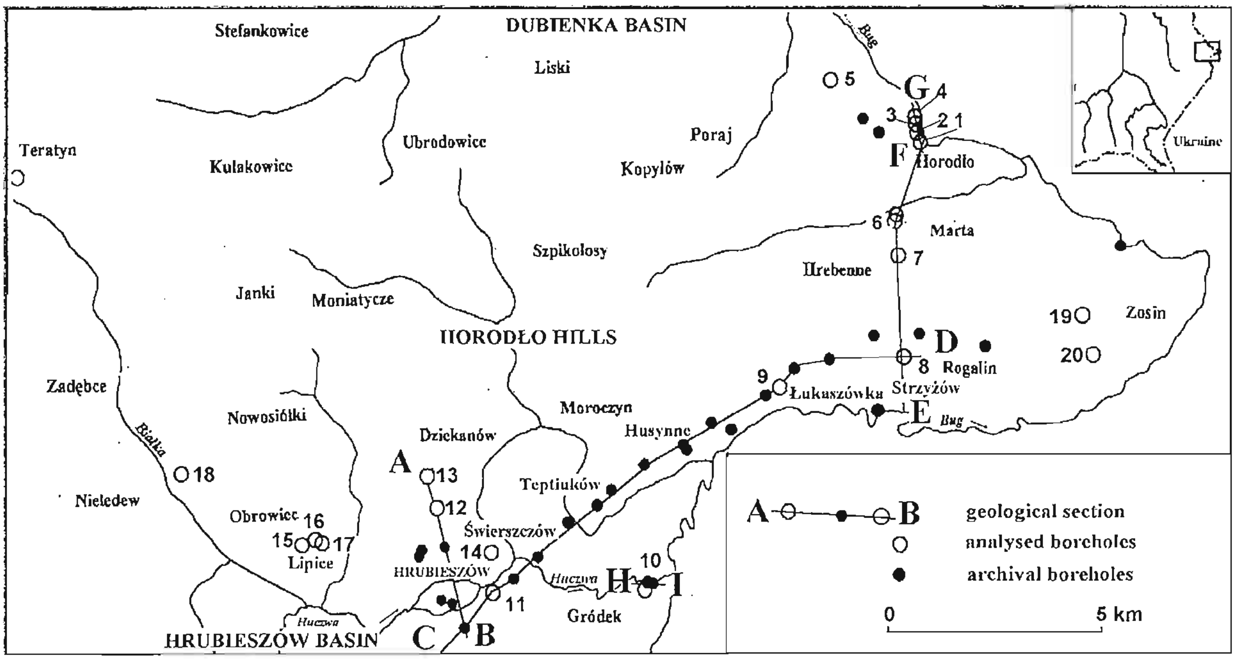


Fig. 1. Location of the study area

Examined sites with laboratory analyses: **1–4** — Horodło 1–4, **5** — Kolonia Horodło, **6** — Marta, **7** — Kolonia Hrebenne, **8** — Rogalin, **9** — Łukaszówka, **10** — Gródek 1, **11–13** — Hrubieszów, **14** — Świerszczów, **15, 16** — Obrowiec 1, 2, **17** — Lipice, **18** — Nieledew, **19, 20** — Zosin 1, 2

typically in alluvial and boggy facies. These soils do not occur in profiles of the higher overbank terrace (IIb), or they occur only in a zone attached to the highest terrace as reduced lower fragments of an illuvial layer of the Eemian soil, such as is observed at Horodło and Gródek near a mouth of the Huczwa River (Figs. 6 and 7). Sediments of the highest terrace were determined in the drillings at Kolonia Hrebenne (Fig. 1, point **7**) and Marta (Fig. 1, point **6**). The soil complex GJ1 from the Eemian and the Early Vistulian defines a top of the terrace, which could be also observed in outcrops at Horodło, where sediments of the highest terrace were subjected to river erosion and at present are covered by sediments of the higher and the lower overbank terraces.

The highest terrace in the Horodło 1 section (Fig. 6) is composed of silts with thin lenses of sands, which are the alluvial facies of the older upper loess (L. Dolecki, 1991*a*). These sediments are poorly sorted, single-mode, with a significant predominance of sandy fraction. The alluvial facies of the older upper loess was accumulated under variable dynamic conditions, which resulted in variability of grain size distribution and sorting. Trace content of humus (0.02–0.07%), similar to the one in an aerial facies of this loess, should be emphasized. The sediment was apparently periodically emergent, which is documented in structural traces of sediment drying (cracks) and swelling after wetting (involutions). It is underlain by a thick series of river and river-marginal sands of lacustrine type, containing shells of molluscs typical for a stagnant water and wetlands (L. Dolecki, S. Skompski, 1986). Sands were emergent at the end of deposition of these sediments, because shells of fresh-water molluscs of the loess type, such as *Pupilla muscorum* (Linnaeus) and *Succinea oblonga* (Draparnaud) were found. A deposition of the river-marginal sands was simultaneous with a deposition of the older loess on hills and terraces. An extensive hiatus is preserved at the bottom of these sands.

In the section Horodło 2 (Fig. 6) the highest terrace beneath the destructed palaeosol complex GJ1 is composed of the older loess (alluvial facies) with mollusc shells (51–59% of "loessy" fraction). Grain size distribution of these sediments ranges from silty clays at the bottom to silts in the upper part of this layer. Contents of iron oxides, carbonates and humus decreases upwards.

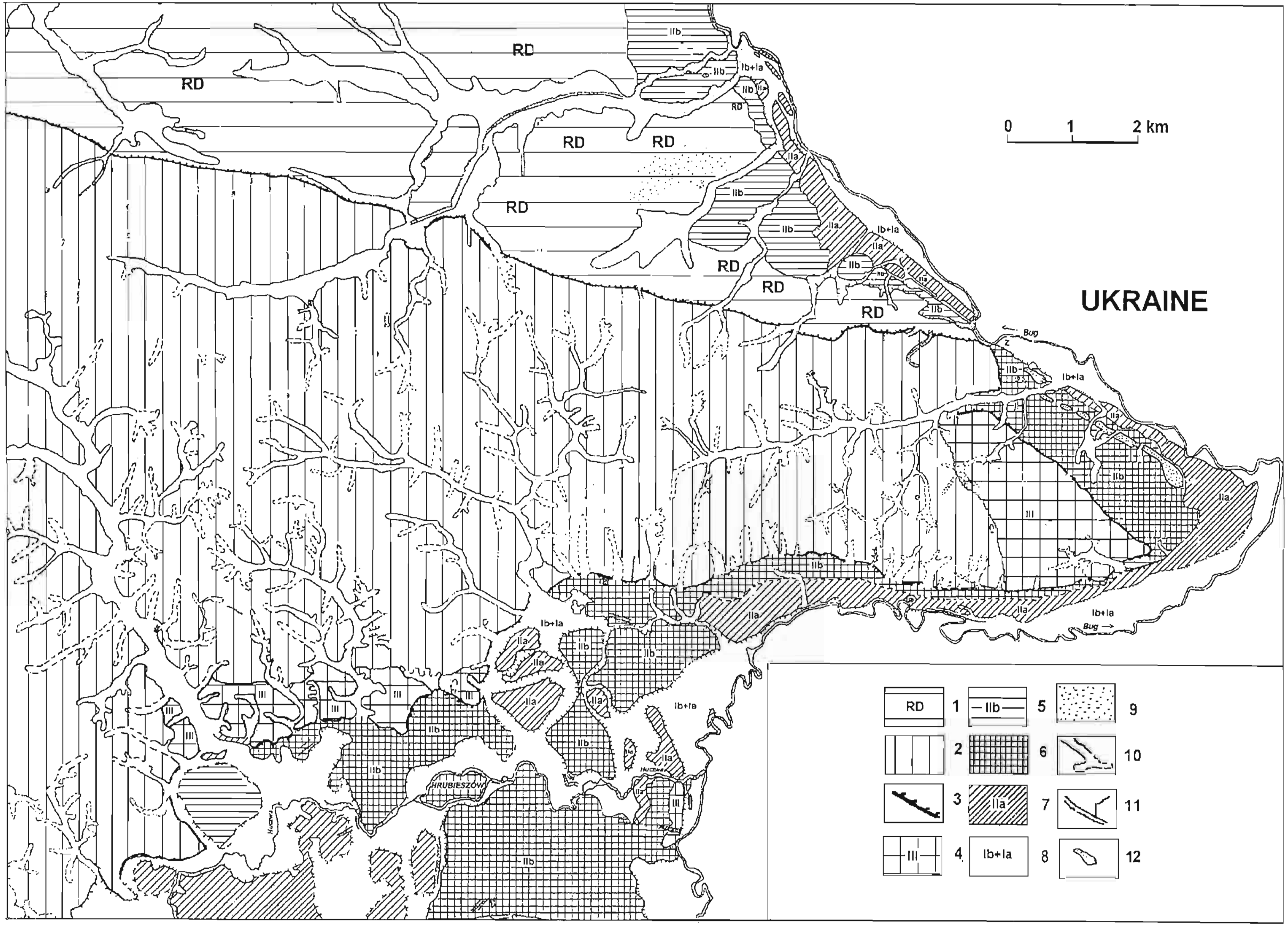
A sequence of sediments of the Wartanian Glaciation in the Horodło 3 outcrop (Fig. 1 and 6), beneath deposits of the higher cut-in-fill overbank terraces, starts at the top with denudation products of the soil complex GJ1. There are the following grain size coefficients: $Mz = 6.36\ \phi$, $Md = 5.91\ \phi$ (i.e. 0.0166 mm), $\delta_I = 2.18$, $Sk_I = 0.33$, $K_G = 0.92$, and contain 2.5–0.5% of carbonates, up to 2.39% of iron oxides, 1.59% of humus and 17% of clayey fraction. This sediment was thermoluminescence dated at 116±16 ka BP (Lub-64). Loessy silts from the Wartanian Glaciation occur below, where a gleyey palaeosol of the section A_1G–GC was determined, containing up to the 2.89% of humus in the humus horizon, and numerous concretions and concentrations of carbonates in the gleyey horizon, and up to 21% of clay. Dr. Krystyna Balaga found single pollen grains of a pine (*Pinus* sp.) and grasses (Polypodiaceae and Compositae) in this gleyey soil. The pollen grains were apparently preserved, due to their solid structure and probably are not representative, however, their composition reflects rather cool vegetation conditions. The gleyey soil developed on loessy silts. These silts form apparently an alluvial facies of the oldest component of the older upper loess (i.e. LSg4). Ecologically diversified abundant molluscs in the muds indicate a variable sedimentary environment, with respect to a palaeoclimate. Accumulation of silts in the lower part of the section occurred under cool climatic conditions which seem to be indicated by such cold water molluscs as *Vertigo parcedentata* (Braun) and *Pisidium lilijeborgi* Clessin. In a final deposition phase, a climate was significantly more moderate, which may be associated with an interphase within the older stadial of the Wartanian Glaciation. Diversity of molluscs (28 species), among which at least 8 occupy the water basins with exuberant vegetation (L. Dolecki, S. Skompski, 1986), indicates interphase conditions. The described gleyey soil developed during this interphase conditions after their emergence.

In the Horodło 5 section (Fig. 1 and 6), the lower overbank terrace is cut-in-fill into deposits which are genetically associated with the highest terrace. The above described alluvial silts (LSg4), present in outcrops throughout the Horodło 1 profile as far south as a curve of the Bug River, form a base of this terrace. These deposits contain, similarly to the other profiles, mollusc shells of a periglacial loess-like environment (L. Dolecki, S. Skompski, 1986). The sediment has the following mean grain size coefficients: Mz = 6.01 ϕ, Md = 5.48 ϕ (i.e. 0.00224 mm), δ_1 = 1.77, Sk_1 = 0.49, K_G = 1.17. They contain on the average 6.4% of carbonates, 0.39% of humus, and 1.8% of iron oxides.

Deposits of the buried highest overbank terrace were studied in profiles near Obrowiec, in a southern part of the Horodło Hills, in a lower part of the Huczwa River valley in the vicinity of Hrubieszów, where a top of the buried terrace is indicated by the soil complex GJ1 at 200 m a.s.l. in the profiles Obrowiec 1 (Fig. 1, point **15**) and Lipice (Fig. 1, point **17**), and in the profile Lipice examined by J. E. Mojski (1965). Loessy silts at Obrowiec 1 (Fig. 4), beneath the soil complex GJ1 (the soil B_2 was TL dated at 171±21 ka BP), developed on a streaked loess from a pleniglacial of the Wartanian Glaciation, and are intersected by ice-wedge casts, indicating a presence of a discontinuous permafrost. The silts contain 48–54% of 0.02–0.05 fraction and 13–14% of clayey fraction. They are underlain by loess alluvial facies (LSs) with traces of pedogenesis at the top, thin interlayers of fluvial sands, traces of periodic drying of sediments, numerous indications of deflation on a periodically emergent and dried surface of the terrace, also cryoturbation and locally solifluction. Basing on thermoluminescence dating, these sediments are correlated with the Odranian Glaciation. Deposits in a lower part of the profile were TL dated at 250±30 and 272±33 ka (L. Dolecki, 1991*b*). Palaeoclimatic and palaeoenvironmental analyses of S. Skompski (1993), based on the mollusc shells from the section Kolonia Hrebenne (Fig. 1, point **7**), determine an origin of deposits of the highest terrace. S. Skompski (1991) suggested that terrestrial mollusc species, species of stagnant and flowing water, and wetlands, occur alternately in the terrace deposits. Floods were more rare towards the upper part of the section as the aquatic species disappear. These sequences in the lithologic profile are also indicated by traces of morphologic processes at subaerial and periodically drying surface, traces of more intensive aeolian processes on surfaces of sand grains, and accumulation of the older upper loess, on which the Eemian soil developed.

HIGHER OVERBANK TERRACE

The term "higher overbank terrace (IIb)" refers to the main terrace which is the most widespread one (relative elevation 7–12 m), composed of silts interpreted as a loess alluvial facies from the Vistulian Glaciation and overlying a socle of deposits of different age, mostly silts of the Wartanian Glaciation. The higher overbank terrace in the Horodło Hills is significantly elevated by subaerial loessy covers of the Vistulian Glaciation. The terrace is the widest in the vicinity of Slipcze in the Hrubieszów Basin (more than 4 km). Fragments of the higher overbank terrace accompany a lower part of the Huczwa River up to Werbkowice. There are numerous closed depressions with seepages or suffosion wells, and also small water reservoirs — possibly of thermokarst origin. Many such forms particularly occur in the vicinity of Zosin and Luszkowo close to a gap of the Bug River. A detailed geologic structure of the overbank terraces of the Bug River was studied within a broad curve of this river at Horodło, very close to a northern edge of the Horodło loessy island (L. Dolecki, 1981, 1985, 1991*a*), where a river undercuts the terraces along a transverse intersection (Fig. 6). Detailed studies of deposits of the higher overbank terrace were conducted, based on the core drillings Zosin 1 (Fig. 1, point **19**) in the Horodło Hills and Kolonia Horodło (Fig. 1, point **5**) in the Dubienka Basin. These two drillings present a structure along the margins of the loessy island of the Horodło Hills and then, a structure of the terrace in the Dubienka Basin, thus outside the loessy island. The terrace at 180–185 m a.s.l., i.e. 8–10 m above the valley bottom (M. Harasimiuk *et al.*, 1989, 1995; W. Szwajgier, 1998), corresponds with the higher overbank terrace to the north from the gap of the Bug River valley across the Horodło Hills. Deposits of this terrace are inserted, as they are at Horodło, within the Dryas-type alluvial deposits of the Wartanian Glaciation, which is indicated by TL dates (Fig. 7). A palynologic study of the lower part of this series indicates a tundra in this area. However, the upper part of the series speaks for a boreal forests, which according to M. Harasimiuk *et al.* (1989, 1995) and W. Szwajgier (1998) seems to indicate a deposition of the terrace sediments already in the earlier phase of the Eemian Interglacial. It appears though, that basal deposits were included into the overbank terrace. Studies of the age of this terrace have not taken into account the age of the overlying sandy deposits, as they have to be younger than the deeper, TL-dated deposits, and thus they formed in the Vistulian Glaciation. Based on the terrace structure and geologic cross-sections at Horodło (F–G) (Fig. 6) and Gródek (I–H) (Fig. 8), an aggradation of the higher terrace deposits began in the Late Eemian and lasted until the Interpleniglacial. Alluvial deposits of this terrace are lithologically diversified to a small degree, what results from the fact that the younger lower and the middle loess, which may be easily stratigraphically subdivided within the terrace because


RD
IIb
Ib+Ia
IIa
III
0 1 2 km
UKRAINE
Bug
HRUBIESZÓW
Huczwa
RD 1
IIb 5
9
2
6
10
3
IIa 7
11
III 4
Ib+Ia 8
12

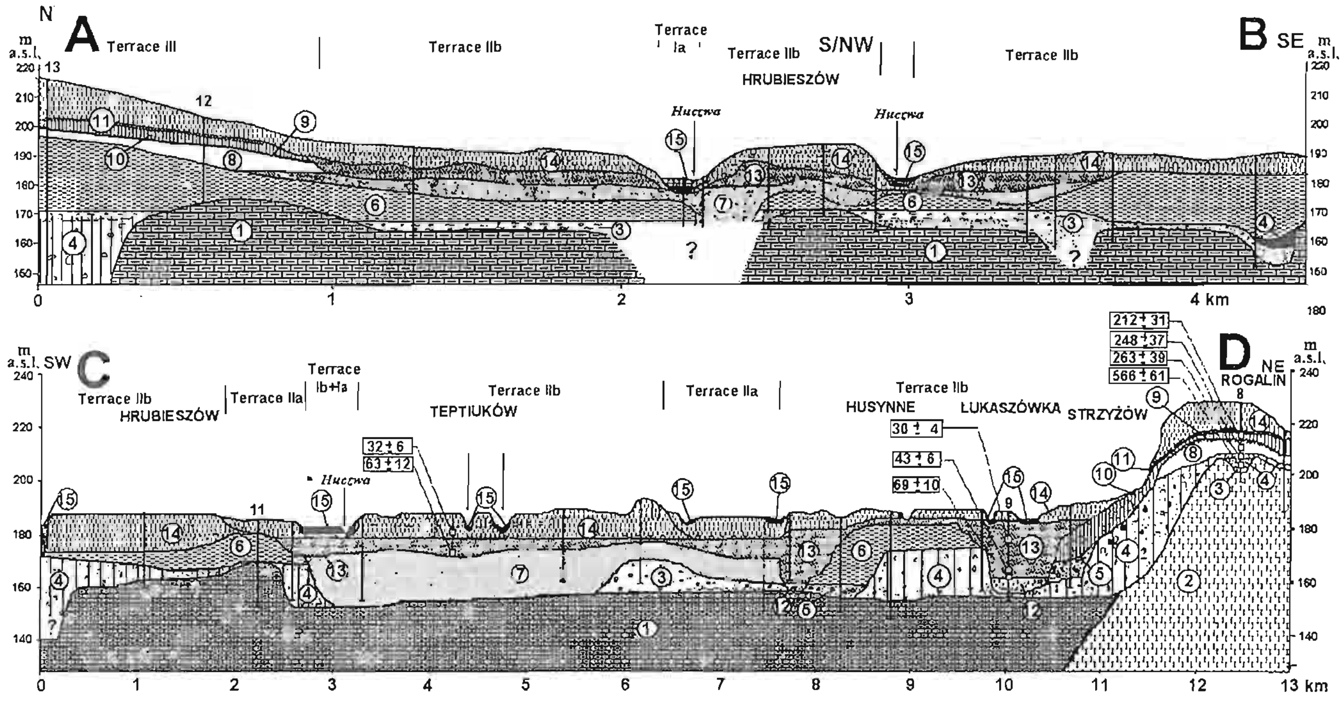


Fig. 3. Geologic cross-sections A–B (Hrubieszów refilling-railway station) and C–D (Hrubieszów–Rogalin)

Cretaceous: 1 — Campanian marls, 2 — Maestrichtian chalk; **Eopleistocene (Celestynów Interglacial?):** 3 — fluvial sands, gravels and muds; **Sanian 1 Glaciation:** 4 — till, 5 — glaciofluvial sands, 6 — varved clays; **Great Interglacial** *sensu lato*: 7 — fluvial sands; **Odranian and Wartanian Glaciations:** 8 — lower and middle older loesses; **Lublinian Interglacial:** 9 — palaeosol; **Wartanian Glaciation:** 10 — upper older loess; **Eemian Interglacial and Early Vistulian Glaciation:** 11 — palaeosol complex GJ1; 12 — fluvial sands with gravels; **Vistulian Glaciation: Lower Pleniglacial:** 13 — loess-like alluvial Dryas muds, **Upper Pleniglacial and Interpleniglacial:** 14 — loessy muds and younger loess; **Holocene:** 15 — alluvia, muds, peat and gyttja; in frames TL datings in ka BP (Lublin Laboratory)

of their diagnostic features were the source material of the terrace. The loess is superimposed and a soil of a low stratigraphic rank, developed as a marshy soil or a layer of distinct gleization, separates them in complete sections. A bottom of the terrace is indicated by a distinct erosive surface, locally accentuated by a fluvial sandy layer. Geologic structure of the higher overbank terrace (IIb) between the Horodło Hills and the Dubienka Basin is known from the drilling Kolonia Horodło (Fig. 9).

Interpretation of the profile is as follows:

a1–a2 — The Holocene soil developed on fine-grained fluvial sands with apparent contribution of aeolian sands. Mineral composition of heavy minerals (0.25–0.1 mm fraction) is represented by the complex: garnet>tourmaline>amphibole>staurolite>epidote. Sands are from the Vistulian Glaciation.

a3–b1–b2–b3 — River sands with interlayers of silt, strongly impregnated with iron compounds from the Vistulian Glaciation. They represent floodplain and levee facies.

c — Loess-like silts of alluvial facies of the younger upper loess (LMg), indicated by grain size parameters: $Mz = 5.55\ \phi$, $\delta_1 = 1.37$, $Sk_1 = 0.20$, $K_G = 0.75$. These deposits are carbonate-free, containing only traces of humus (0.09%) and content of Fe_2O_3 is typical for this layer (1.68%); they cover disconformably deposits of similar origin.

d1 — Alluvial loessy silts, apparently representing the older upper loess (LSg) from the Wartanian Glaciation, 4.53% $CaCO_3$, similar content of iron oxides (1.53%) and humus (0.06%) as in an aerial loess. Their average grain size parameters are similar to these of LMg of the alluvial facies and it is their diagnostic feature. They differ from LMg in a composition of heavy minerals, having predominance of resistant ones; it confirms similarity with LSg.

e — Alluvial silts i.e. river muds from a final phase of the Lublin Interglacial and a beginning of the Wartanian Glaciation, which is indicated by a significant content of iron oxides, suggesting still significant moisture during deposition, and also a high content of humus (1.11% at the bottom, 0.22% at the layer top). This sequence indicates gradual drying.

f1–f2 — River sands from the Lublin Interglacial, carbonate-free (Mz within 2.02–3.4 ϕ).

Fig. 2. Geomorphologic sketch of the Horodło Hills and adjacent areas

1 — loessy plains; 2 — areas of aeolian sands; 3 — small blow-out depressions; 4 — loessy marginal ridges; 5 — scarps of loessy patches; 6 — trough-like valleys; 7 — small flat-bottomed valleys; 8 — gullies; 9 — distinct edges of river terraces; 10 — indistinct edges of river terraces; 11 — river channels; 12 — highest overbank buried terrace (III); 13 — higher overbank terrace (IIb); 14 — higher overbank terrace (IIb) with loessy cover; 15 — lower overbank terrace (IIa); 16 — floodplain (Ib+Ia); 17 — abandoned channels; 18 — closed depressions; 19 — suffosion depressions and channels; 20 — denudation plains; 21 — karst sinkholes; 22 — outcrops; 23 — cultivated terraces; 24 — road ravines and ditches; 25 — earth banks and dykes

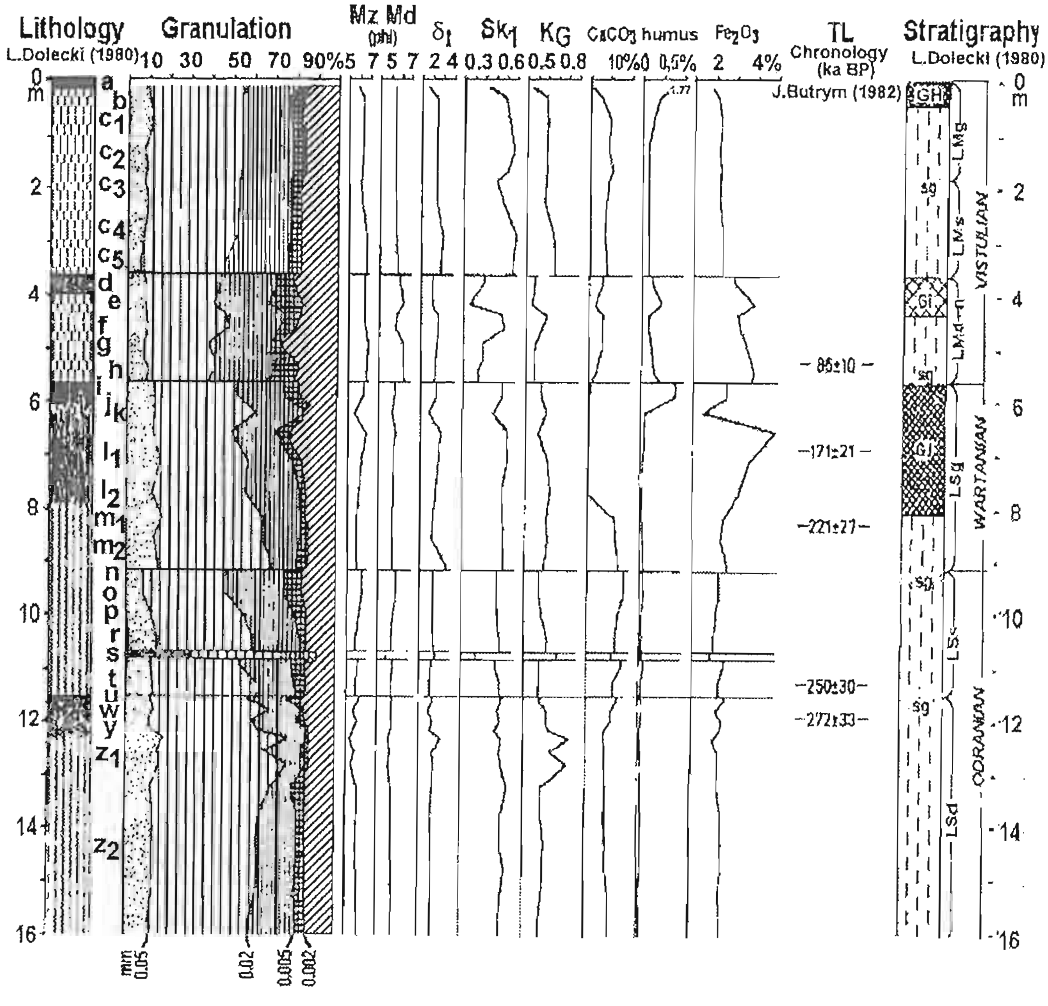


Fig. 4. Section Obrowiec 1

Stratigraphy: L — loess, M — younger, S — older, g — upper, s — middle, d — lower, n — lowest; soils: GJ — interglacial soil, Gi — interstadial soil, sg — soil sediment; diagram: Mz — mean grain size in phi, Md — median grain size in phi, δ_I — sorting index, Sk_I — skewness, K_G — curtosis, $CaCO_3$ — carbonate content (%), Fe_2O_3 — iron oxides content (%), humus — humus content (%)

g–h1–h2	Sandy silts with gravels of local rocks of colluvial origin; apparently formed in the Odranian Glaciation(?). They are apparently derived from the Eopleistocene fluvial sands as indicated by heavy minerals with the predominant complex: garnet>tourmaline>zircon>disthene>rutile. There is a significant content of the "loess" fraction 0.02–0.05 mm (30–40%).
i2–i3–j1–j2	Silts with gravel, sands and silts from the Eopleistocene, with characteristic heavy minerals in the complexes: disthene>zircon>tourmaline>staurolite>rutile and disthene>turmaline>staurolite>zircon>garnet. There is no Scandinavian material among gravels.
k1–k2	Weathering marls of the Upper Maestrichtian, indicated by diatoms (E. Gawor-Biedowa, 1993)

The section Kolonia Horodło might be successfully correlated with the sections Horodło 1–3 and 5. They give evidence of a geologic structure of the overbank terraces of the Bug River within the Horodło Hills and the southern Dubienka Basin.

The drilling Zosin 1 documents a structure of the overbank higher terrace within the Horodło Hills (Fig. 10):

a–b–c	The Holocene brown soil formed on the younger upper loess. It contains 0.46% of humus in the accumulation layer.
d	The upper younger loess of the aeolian facies, with 49.6% of the basic loess fraction, 9% of carbonates and only 0.17% of humus. This loess is relatively coarse-grained (Mz = 5.86 ϕ; Md = 5.35 ϕ, i.e. 0.024 mm), poorly sorted (δ_I=1.94), of a strongly positively skew grain distribution and leptokurtic curtosis. It was accumulated on the Bug River terrace quite intensively, which is indicated by its significant thickness, reaching almost 5.5 m.
e–f–g	The younger middle loess of the alluvial facies, clearly distinct by its higher content of sandy fraction and smaller of clayey fraction. It contains averaging 50% of the basic fraction for loess, 11% of carbonates and 0.15% of humus. It differs from the overlying LMg by a very strongly leptokurtic curtosis.
h1–h2–h3–h4	Loess-like alluvial deposits rich in calcium carbonate (22–24%), humus (0.21%) and iron oxides (up to 2.04%), with skewness index Sk_I = 0.06. Grain size distribution indicates that deposits experienced a selective washout or were redeposited, what is particularly characteristic for the lowest part of the layer, where indices of skewness are negative. These sediments were apparently deposited during deposition of the

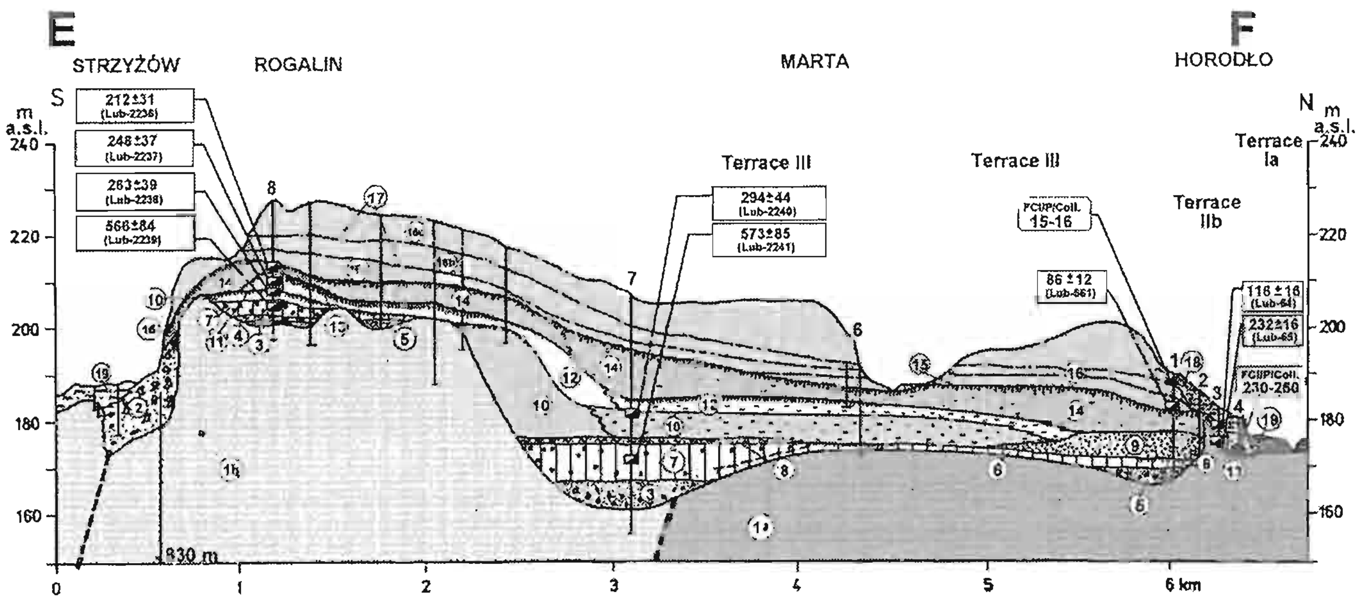


Fig. 5. Geologic cross-section E–F (Strzyżów–Horodło)

Cretaceous: 1a — Campanian marls, 1b — Maestrichtian chalk; **Eopleistocene**: 2 — weathering waste of local rocks, 3 — fluvial sands and sands with gravel, 4 — fluvial muds; **Sanian 1 Glaciation**: 5 — glaciofluvial sands and gravel, 6 — fluvioperiglacial loess-like muds, 7 — till; **Zbójno Interglacial**: 8 — fluvial clayey sands with mollusc shells, 9 — fluvial sands; **Odranian Glaciation**: 10 — lower older loess and alluvial loess-like deposits, 11 — interstadial gleyey soil, 12 — middle older loess; **Lublinian Interglacial and Early Wartanian Glaciation**: 13 — palaeosol complex GJ2; Wartanian Glaciation: 14 — upper older loess; **Eemian Interglacial and early stadials of Vistulian Glaciation**: 15 — palaeosol complex GJ1; **Vistulian Glaciation**: 16 — younger loess: a — lower, b — middle, c — upper, 17 — interstadial soils and signs of soil processes within the younger loess; **decline of the Vistulian Glaciation**: 18 — deluvia and colluvia of the younger loess; **Holocene**: 19 — sandy mud and alluvial soils in valley bottoms; in rectangular frames are TL datings (by J. Butrym, Lublin), in oval frames — datings by FCl/P/Coll method (by T. Wysoczański-Minkowicz, Warszawa); all datings in ka BP

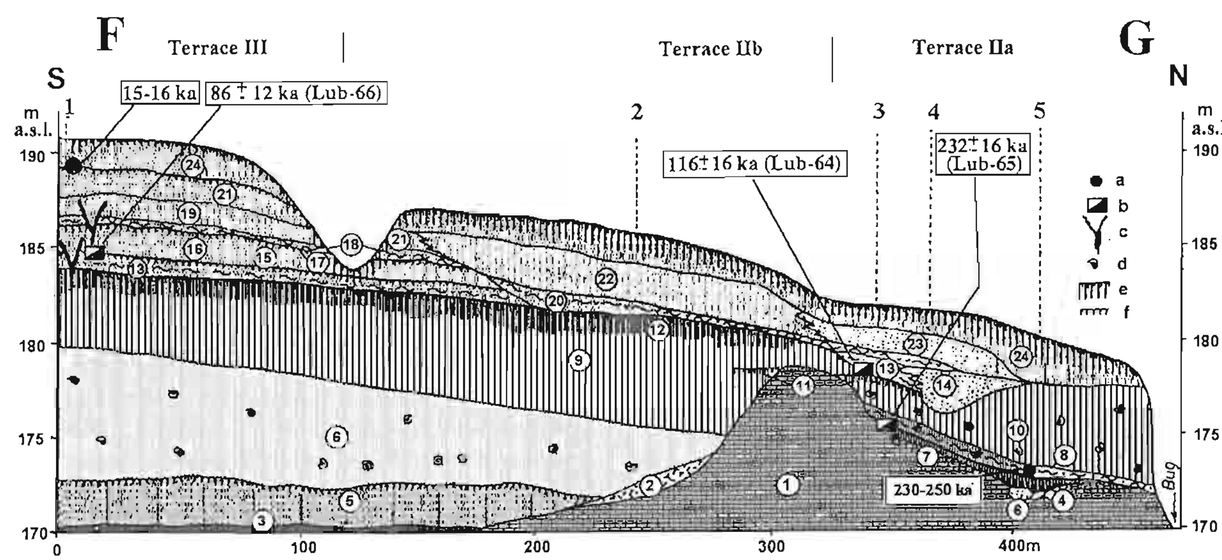


Fig. 6. Geological cross-section F–G of the Pleistocene terraces of the Bug River at Horodło

Cretaceous, Campanian: 1 — marls, 2 — marls debris; **Eopleistocene?**: 3 — grey-greenish sands with gravels; **Sanian Glaciation**: 4 — residual sands, gravels and stones of Scandinavian rocks, 5 — loessy silts (LN3b?); **Zbójno Interglacial**: 6 — fluvial sands; **Lublinian Interglacial**: 7 — humic rendzina; **Wartanian Glaciation**: 8 — deluvia and denudation products, 9 — upper older loess (LSg) of alluvial facies, 10 — upper older loess (LSg) of boggy facies, 11 — gleyey soil; **Eemian Interglacial and Early Vistulian Glaciation**: 12 — palaeosol complex GJ1; **Vistulian Glaciation**: 13 — denudation products of palaeosol complexes, 14 — fluvial sands of channel facies, 15 — interstadial soil Gi/LMn, 16 — lower younger loess (LMd) of alluvial facies, 17 — interstadial soil Gi/LMd; **Interpleniglacial**: 18 — denudation products of loess and soils, 19 — middle younger loess (LMs), 20 — denudation products of loess and soils; **Upper Pleniglacial**: 21 — upper younger loess (LMg), slope facies, 22 — upper younger loess, alluvial facies, 23 — alluvial silts and sands, 24 — upper younger loess (LMg) of subaerial facies, the Holocene soil in the top; a — samples dated by FCl/P/Coll method (in ka BP); b — samples dated by TL method (in ka BP), c — ice wedge casts, d — mollusc shells, e — interglacial soils, f — soils and soil sediments of a lower stratigraphic rank

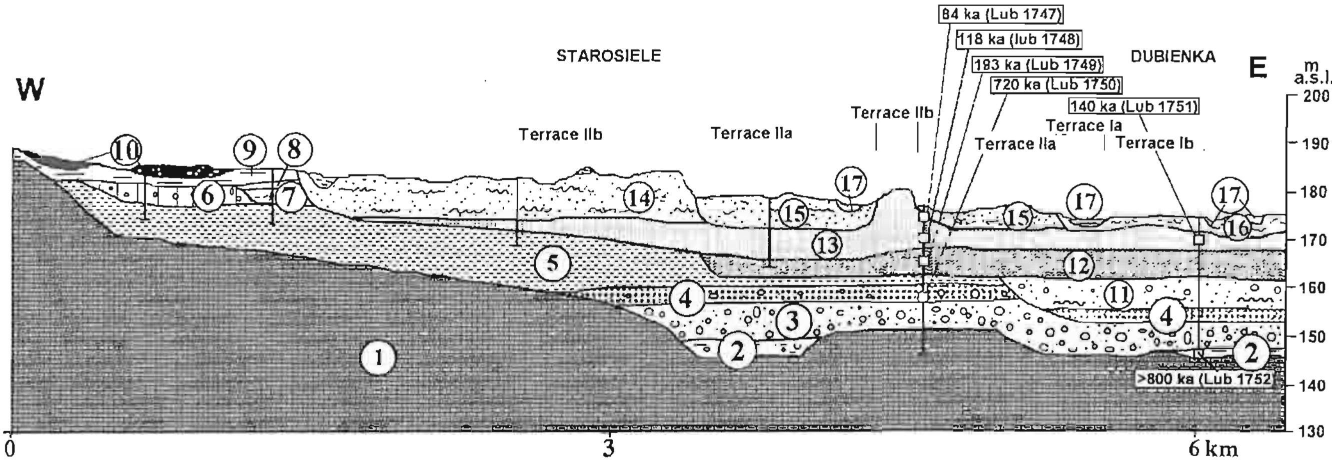


Fig. 7. Terraces in the Bug River valley near Dubienka after M. Harasimiuk *et al.* (1989), modified

Upper Cretaceous: 1 — marls; **Eopleistocene**: 2 — clayey marls with gravel and lake muds; **Podlasie Interglacial**: 3 — fluvial sands with gravel; **Sanian 1 Glaciation**: 5 — lake muds and clays, loess-like at higher altitude (LN3b), 6 — till, 7 — ice-dam clays and silts, 8 — glaciofluvial sands; **Sanian 2 Glaciation**: 9 — ice-dam clays, 10 — till; **Great Interglacial** *sensu lato*: 11 — fluvial sands with gravel and silts; **Odranian Glaciation**: 12 — limnoglacial silts and clayey silts; **Wartanian Glaciation**: 13 — fluvial and ice-dam sands; **Vistulian Glaciation**: 14 — muds and sands of the higher overbank terrace, 15 — sands and silty sands of the lower overbank terrace IIa; **Holocene**: 16 — fluvial sands and alluvial soils of the flood terraces, 17 — alluvia of valley bottoms; in frames are TL datings in ka BP (Lublin laboratory)

younger lower loess at tops of hills; however, a different stratigraphic interpretation cannot be excluded.

i–j–k–l–m Fluvioperiglacial sediments, apparently from the Wartanian Glaciation, of a very diversified energy distribution, which is documented by variability of the grain size indices in the section.

These deposits contain 19% of carbonates and 0.38% of humus. They formed apparently during a progressing phase of glaciation, which is indicated by a significant amount of organic sediment. Characteristics grain size distribution and significant carbonate content in sediments, typically not found in the older loess of the Vistulian Glaciation (i.e. in LMn), and similar stratification as in other sections, seem to confirm such stratigraphic interpretation.

LOWER OVERBANK TERRACE

The lower overbank terrace (IIa) has an erosive-accumulative character. It formed in result of river erosion during the Interpleniglacial and throughout the Vistulian Glaciation, which is indicated by a stratigraphic sequence of the alluvial loess facies, forming this terrace in its top part, and particularly physico-chemical features of these deposits which are comparable to features of the younger upper loess from the Upper Pleniglacial. This terrace occupies a large area, particularly above the gap of the Bug River valley through the Horodło Hills. It is composed of sands and silts, locally with a rich assemblage of mollusc shells and plant detritus. The lower overbank terrace occurs at 5–6 m above a river (L. Dolecki, 1977, 1981). Upper fragments of this terrace in the Hrubieszów area and fragments of the upper overbank terrace locally protrude within the Holocene terraces, forming significant morphologic elements of broad valleys of the Bug and the Huczwa Rivers, just upstream and downstream the gap in the Horodło Hills (M. Harasimiuk *et al.*, 1995). Deposits of the lower overbank terrace were studied in detail in the sections Zosin 2 (Fig. 1, point **20**) and Łukaszówka (Fig. 1, point **9**) near Strzyżów on the Bug River and in the sections Świerszczów (Fig. 1, point **14**) and Hrubieszów in the Huczwa River valley. Extensive archival materials from geologic-engineering, hydrogeologic and other drillings at Hrubieszów and its close vicinity were used. A bottom of silts with plant detritus, being a basal part of the lower overbank terrace at Łukaszówka, were TL-dated at 69±10 ka BP, middle layers were dated at 43±6 ka, while the upper ones at 30±4 ka BP. J. Rzechowski (oral information) received a similar date of 53 ka BP for deposits at the base of the terrace at Teptiuków, Czerniczyn and Kryłów. River sands with gravels, which apparently correspond to a bed facies of the Eemian river at the top of the Cretaceous bedrock, underlie silts which form a basal surface of the terrace at Łuszków. Hence, the lower terrace is of an erosive-accumulative origin and its basal surface is formed of lake sediments from the Early and Middle Vistulian Glaciation. The basal surface of the erosive-accumulative terraces may be, however, formed of deposits of different age. Marls of the Cretaceous, outcropping in a scarp of the river curve, form a basal surface near the church at Strzyżów on the Bug, however, the Mesopleistocene lake clays, an equivalent of lake clays and silts which were TL-dated in the Dubienka Basin at 620 and 660 ka BP, form its surface near Hrubieszów. The sequence is similar in other sections of the lower overbank terrace in the vicinity of Hrubieszów. Deposits of the lower overbank terrace near Teptiuków locally overlie fluvial sands which have been referred for a long time to the Great Interglacial in a general

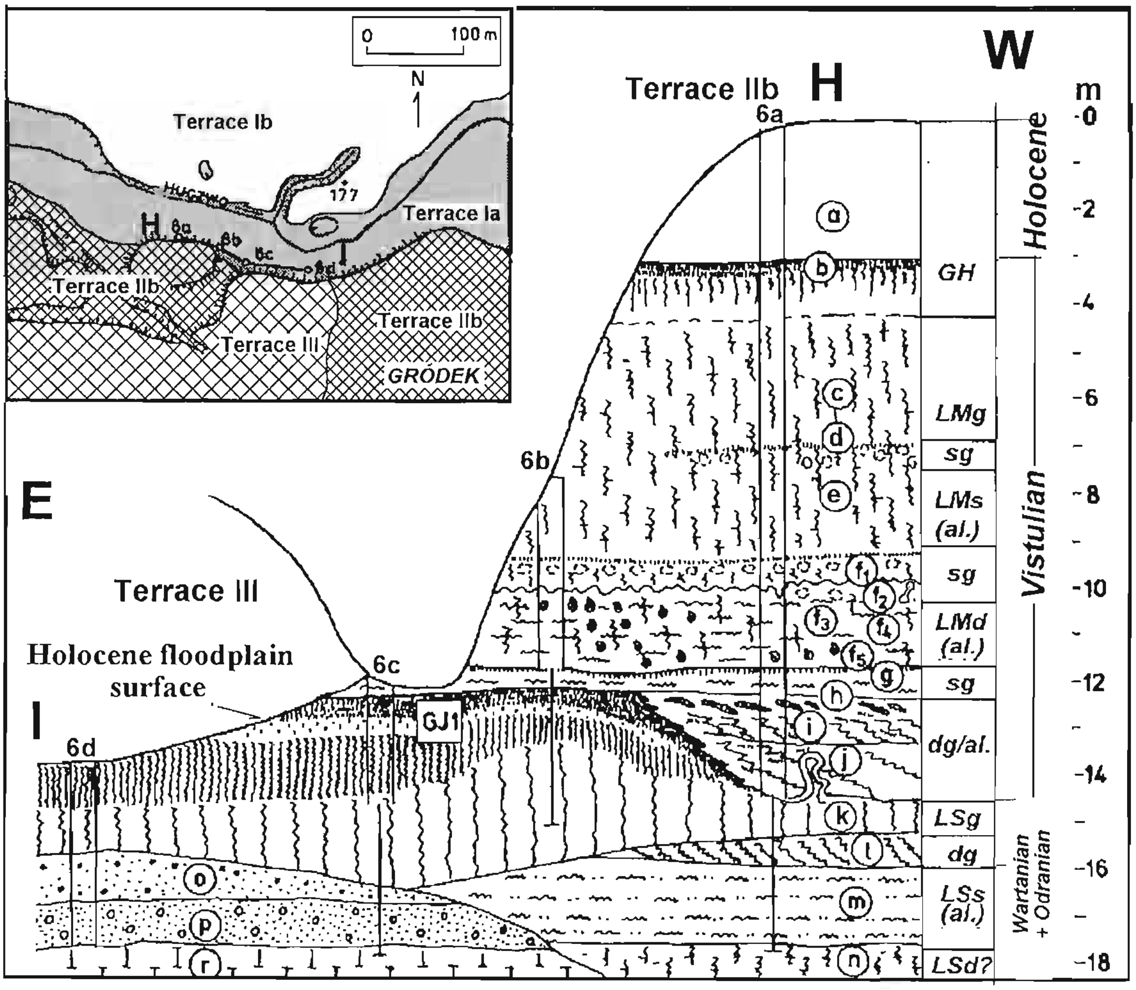


Fig. 8. Geologic cross-section I–H of the higher terrace (IIb) at Gródek near Hrubieszów

N+GH — Holocene soil covered by earthworks, L — loess, M — younger, S — older, g — upper, s — middle, d — lower, (al.) — alluvial facies, sg — soil sediment, dg/al. — deluvial and alluvial deposits, GJ1 — interglacial palaeosol complex of the Eemian and the Early Vistulian; a — ramparts, b — loess transformed by soil processes during the Holocene, c–k — facies of the younger loess, l — older loess on deposits of the Neo- and Mesopleistocene, and rocks of the Cretaceous, exposed in the Huczwa River channel, in the top — the palaeosol complex GJ1, denuded at a contact with deposits of the higher terrace; 6a–6d — exposures deepened with drillings

sense (M. Prószyński, 1952; A, Jahn, 1952, 1956*a, b*; J. E. Mojski, 1965).

Due to a big lithologic similarity, and also a similar palynologic content of deposits of the arctic tundra, it is occasionally difficult to determine a contact of the terrace deposits and its substrate. However, they are commonly separated by sands of a bed facies which marks a stratigraphic boundary.

Previous stratigraphic studies of the Bug terraces (M. Prószyński, 1952) provided extensive material, associated with lithologic features and palaeontologic content of deposits. We owe the most advanced works in this respect to A. Jahn (1946, 1947, 1952, 1956*a, b*). Samples studied by A. Środoń (1954, 1955) come exactly from the higher overbank terrace at Czumów, 11 m above a river and at 188 m a.s.l. Under 6 m of loess and 1 m of sands interbedded with silt, this author described silts with the Dryas-type plant detritus, indicating cool periglacial conditions during development of the terrace. According to A. Jahn (1956*a*), the discussed terrace is an extension of the Krystynopol terrace near Sokal, and loessy silts with plant detritus resemble the Dryas silts in the Wieprz River valley. The Dryas flora from the Krystynopol terrace was interpreted in different way, with respect to its age. According to interpretation of W. Szafer (1928), M. Klimaszewski (1952) connected it with ice sheet advance of the Cracovian Glaciation. It was considered as being even older by A. Jahn (1947) but later, the age of these deposits was most commonly referred to the Middle Polish Glaciation (W. Szafer, 1945; A. Jahn, 1952), thus the Dryas deposits of the Krystynopol terrace should be associated with this glaciation, or they form a basal surface of the terrace and should be connected with one of the Mesopleistocene glaciations. As was stated several times, the Dryas deposits contain a very limited stratigraphic content, and the species reflect an arctic tundra only, typical for a close neighbourhood of an ice sheet. Such deposits always accompany glaciations, however, it is

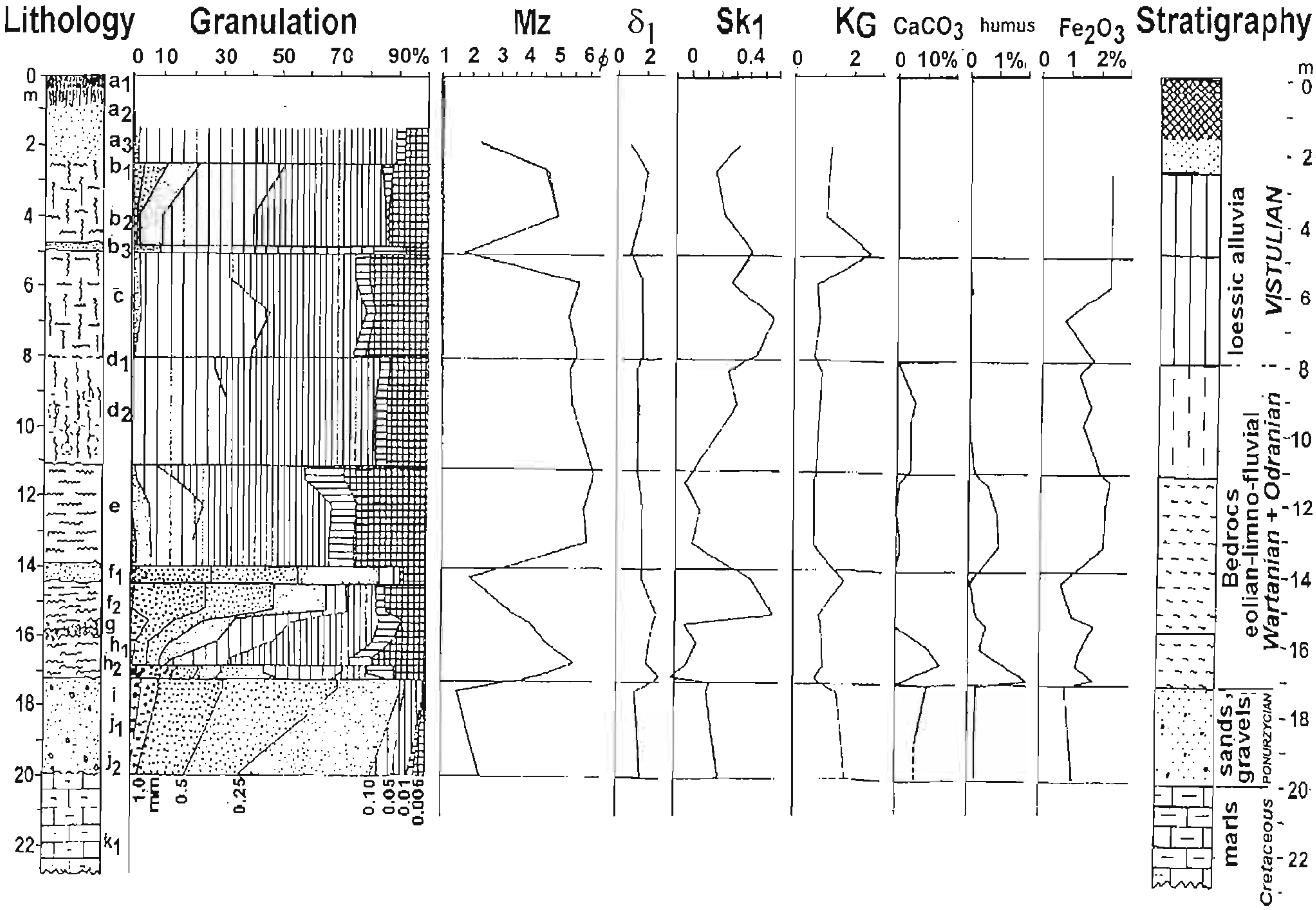


Fig. 9. Section Kolonia Horodlo

Lithologic and stratigraphic interpretation of deposits in the text; for other explanations see Fig. 4

not possible to correlate them with a specific glaciation. TL datings seem to provide a good chance to determine a stratigraphic division of these sediments whereas radiocarbon datings do not give suitable results, because these sediments are beyond a range of this method.

FLOODPLAIN

Two terraces at 1.5 and 3.5–5.0 m form the valley bottoms. The higher flood terrace (Ib) is flooded during catastrophic water levels only. These terraces cover a significant area between Hrubieszów and Strzyżów, and are less distinct in narrowings of the Bug valley. In the bottom they are composed of medium- and fine-grained sands, overlain by sandy-silty muds. Sediments of the Holocene terrace were studied in detail by Professor S. W. Alexandrowicz near Gródek, where they contain a rich and diversified (with respect to species) agglomeration of mollusc shells. Radiocarbon dating of these sediments indicates that muds in the lower part of the terrace (depth 3.3–4.0 m) were deposited at 2770±150 years BP (Gd-2261) and in the upper part (depth 0.4–0.5 m) at 580±140 years BP (Gd-2210), in connection with intensive activity of a man (S. W. Alexandrowicz, L. Dolecki, 1991). Peat, 3 m thick and passing downwards into a gyttja, occurs locally in the Bug valley. It is even up to 5 m thick in the tributary valleys.

CONCLUSIONS

The Pleistocene and the Holocene terraces occur in the valleys of the Bug and the Huczwa Rivers in the vicinity of the Horodło Hills.

The highest terrace (III) was formed during the Wartanian Glaciation and occurs as a buried feature, under a thick loessy cover. Its surface occurs at 205 m a.s.l. and about 23 m above a river. The actual top is indicated by a fossil complex from the Eemian and the Early Vistulian Glaciation. The terrace is of inundation character and is composed of loess-like silts, locally of the Dryas type, and of the alluvial loess of the Wartanian Glaciation, overlying sediments of the Odranian Glaciation and the Mesopleistocene deposits.

The higher overbank terrace (IIb) has erosive-accumulative character. It is overlain by loess of the Upper Pleniglacial

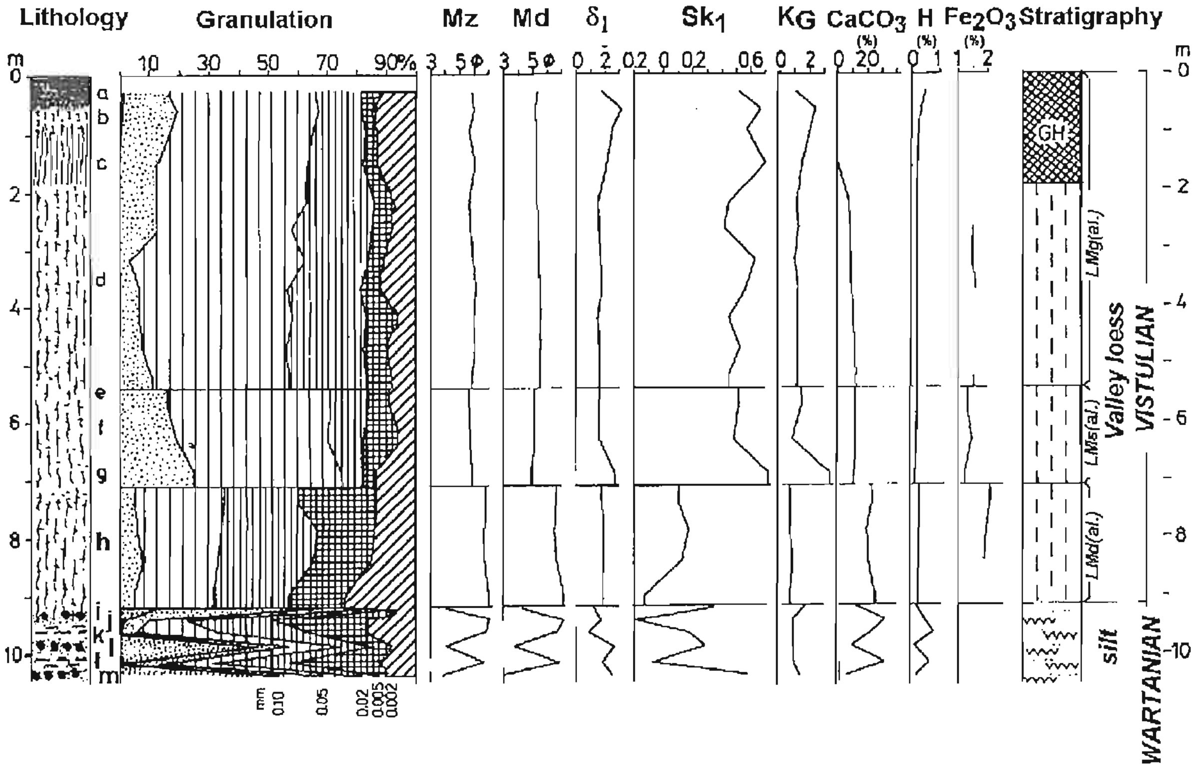


Fig. 10. Section Zosin 1

Lithologic and stratigraphic interpretation of deposits in the text; for other explanations see Fig. 4 and 8

of the last glaciation in a direct neighborhood and in the Horodło Hills. The terrace is 7–12 m high, depending whether it is overlain at the top by a subaerial loess, and occurs at 190–197 m a.s.l. The alluvial sediments, after the original surface during the oldest part of the Vistulian Glaciation was dissected, were accumulated until the Interpleniglacial of the last glaciation. The basal surface of the terrace is mainly formed of silts of the Dryas type from the Wartanian Glaciation, and locally also of the Mesopleistocene deposits.

The lower overbank terrace (IIa), about 5–6 m high and at 180–185 m a.s.l., is also of erosive-accumulative origin. After a bottom erosion occurred during the Interpleniglacial of the Vistulian Glaciation, deposits of the terrace were accumulated throughout the entire glaciation. The basal surface of the terrace is formed of deposits of various age, depending whether a terrace was formed in a central part of the valley or closer to its margins. The basal surface is formed of deposits from the Odranian Glaciation and the Mesopleistocene sediments in zones near the valley margins, while the bottom erosion typically affected only the alluvial sediments from the Vistulian Glaciation, forming the higher overbank terrace or the still lower marginal lake-marshy deposits from the Wartanian Glaciation in the valley axis. Because of that, there is a distinct stratigraphic unconformity, associated with a lack of deposits from the oldest part of the last glaciation.

The Holocene terraces Ib and Ia are 3.5–5 m and about 1.5 m high, respectively. In the lower part they are composed of medium- and fine-grained sands, while in the higher part of sandy-silty muds. They contain numerous and diversified (with respect to a number of species) mollusc shells. Radiocarbon dating indicates that the terrace Ib, 3.3–4.0 m high, was formed at 2770±150 years BP and in the upper part (depth 0.4–0.5 m) at 580±140 years BP.

REFERENCES

ALEXANDROWICZ S. W., DOLECKI L. (1991) — Sediments and malacofauna of the Holocene Bug River terrace in Gródek near Hrubieszów, Eastern Poland (in Polish with English summary). Zesz. Nauk. AGH, Geologia, **17** (1/2): 5–24.

DOLECKI L. (1977) — Quaternary deposits from the vicinities of Hrubieszów (in Polish with English summary). Kwart. Geol., **21** (4): 803–818.

DOLECKI L. (1981) — Lithology and stratigraphy of the loesses of the Grzęda Horodelska) (in Polish with English summary). Ann. UMCS, sect. B, **32/33**: 151–187.

DOLECKI L. (1985) — Loess section at Horodło. Guide-Book of the International Symposium „Problem of the stratigraphy and palaeogeography of loesses": 123–128. Lublin.

DOLECKI L. (1991*a*) — Loess section at Horodło (in Polish with English summary). In: Main sections of loesses in Poland (ed. H. Maruszczak): B43–50. UMCS. Lublin.

DOLECKI L. (1991*b*) — Obrowiec I loess section (in Polish with English summary). In: Main sections of loesses in Poland (ed. H. Maruszczak): B19–26. UMCS. Lublin.

DOLECKI L. (1995) — Litologia i stratygrafia mezoplejstoceńskich utworów lessowych południowo-wschodniej części Wyżyny Lubelskiej. Rozpr. hab. UMCS. Lublin.

Dolecki L.,Skompski S. (1986) — Pleistocene molluscan fauna at Horodło upon Bug River (in Polish with English summary). Kwart. Geol., **30** (2): 309–328.

GAWOR-BIEDOWA E. (1993) — Wyniki analizy mikropaleontologicznej 5 próbek z arkusza Horodło i 9 próbek z arkusza Teratyn Szczegółowej mapy geologicznej Polski 1:50 000. Centr. Arch. Geol. Państw. Inst. Geol. Warszawa.

HARASIMIUK M., RZECHOWSKI J., SZWAJGIER W. (1989) — Objaśnienia do Szczegółowej mapy geologicznej Polski 1:50 000, ark. Dubienka. Centr. Arch. Geol. Państw. Inst. Geol. Warszawa.

HARASIMIUK M., RZECHOWSKI J., SZWAJGIER W. (1995) — Problemy genezy i wieku tarasów nadzalewowych w dolinie Bugu w obniżeniu Dubienki. Konf. „Problemy geomorfologii i paleogeografii czwartorzędu": 75–76. Lublin.

JAHN A. (1946) — Stratigraphy of the Quaternary deposits in the Bug River basin (in Polish with English summary). Rocz. Pol. Tow. Geol., **16**: 126–138.

JAHN A. (1947) — Quaternary deposits and morphology of the valley of Bug-river near Sokal (in Polish with English summary). Kosmos, A, **65**: 9–55.

JAHN A. (1952) — Materials to the Quaternary geology of the northern part of the map sheet Zamość 1:300 000 (in Polish with English summary). Biul. Inst. Geol., **66**: 407–470.

JAHN A. (1956*a*) — Geomorphology and Quaternary history of Lublin Plateau (in Polish with English summary). Pr. Geogr. Inst. Geogr. PAN, **7**: 327–335.

JAHN A. (1956*b*) — Region lubelski; środkowa i wschodnia część wyżyny. In: Regionalna geologia Polski, **2**: 90–123. Kraków.

KLIMASZEWSKI M. (1952) — The problems of the Pleistocene in southern Poland (in Polish with English summary). Biul. Inst. Geol., **65**: 137–268.

MARUSZCZAK H. (1980) — Stratygrafia i chronologia lessów w Polsce. Przewodnik seminarium terenowego „Stratygrafia i chronologia lessów oraz utworów glacjalnych dolnego i środkowego plejstocenu w Polsce SE": 43–54. Lublin.

Mojski J. E. (1956) — Loess and other Geological Deposits in the Vicinity of Hrubieszów (in Polish with English summary). Biul. Inst. Geol.,**100**: 463–501.

MOJSKI J. (1965) — Loess stratigraphy in the drainage basin of the Lower Huczwa river in the Lublin Upland (in Polish with English summary). Biul. Inst. Geol., **187**: 145–216.

PRÓSZYŃSKI M. (1952) — Notes sur la géologie du bassin de la riviére de Bug (in Polish with French summary). Biul. Państw. Inst. Geol., **65**: 313–352.

RZECHOWSKI J. (1987) — Plio-Pleistocene deposits in the eastern part of the Lublin Upland (the Bug river basin) (in Polish with English summary). In: Problemy młodszego neogenu i eoplejstocenu w Polsce: 179–193. Ossolineum. Wrocław.

SKOMPSKI S. (1993) — Niektóre stanowiska fauny kenozoicznej z Grzędy Horodelskiej. Centr. Arch. Geol. Państ. Inst. Geol. Warszawa.

SZAFER W. (1928) — Entwurf einer Stratigraphie des polnischen Diluviums auf floristischer Grundlage. Rocz. Pol. Tow. Geol., **5**: 21–33.

SZAFER W. (1945) — Kopalna *Armeria* w plejstocenie europejskim ze szczególnym uwzględnieniem plejstocenu w Polsce. Starunia, **20**: 1–31.

SZWAJGIER W. (1998) — Plejstoceńska ewolucja doliny Bugu w Obniżeniu Dubienki. Przewodnik wycieczkowy IV Zjazdu Geomorfologów Polskich „Główne kierunki badań geomorfologicznych w Polsce, stan aktualny i perspektywy": 53–58. Lublin.

ŚRODOŃ A. (1954) — Pleistocene floras from Tarzymiechy on the river Wieprz (in Polish with English summary). Biul. Inst. Geol., **69**: 5–78.

ŚRODOŃ A. (1955) — The glacial flora from Czumów on the river Bug in Poland (in Polish with English summary). Acta Soc. Bot. Pol., **34** (3): 627–633.

BUDOWA GEOLOGICZNA I STRATYGRAFIA OSADÓW TARASÓW PLEJSTOCEŃSKICH BUGU I HUCZWY W REJONIE HRUBIESZOWA

Streszczenie

Teren badań stanowiły tarasy Bugu i Huczwy w obszarze przygranicznym Polski i Ukrainy, w bezpośrednim sąsiedztwie Grzędy Horodelskiej w okolicach Hrubieszowa (fig. 1 i 2). Rozpatrywano budowę tarasów nadzalewowych Bugu przed i za przełomem tej rzeki przez Grzędę Horodelską oraz tarasy nadzalewowe dolnego odcinka Huczwy w obrębie Kotliny Hrubieszowskiej. Podłoże czwartorzędu stanowią skały górnokredowe. Wyżej leżą zróżnicowane litologicznie i genetycznie osady eo- i mezoplejstoceńskie, tworzące w wielu miejscach powierzchnię bazalną tarasów neoplejstoceńskich. Najwyższy taras nadzalewowy (III) stwierdzony został pod przykryciem lessów z ostatniego zlodowacenia (fig. 2, 4–6). Jest to taras ze zlodowacenia warty, o czym świadczą daty TL, a także wykształcony w stropie osadów tarasowych kompleks glebowy interglacjału eemskiego i wczesnej części zlodowacenia wisły. Łącznie z przykryciem młodszego lessu (4–12 m) taras ma wysokość względną rzędu 23 m.

Taras nadzalewowy wyższy (IIb), erozyjno-akumulacyjny, zbudowany jest z osadów aluwialnych starszej części zlodowacenia wisły, z nadbudową w obrębie Grzędy Horodelskiej lessów młodszych górnego pleniglacjału tego zlodowacenia, natomiast utworów lessopodobnych i piasków poza Grzędą Horodelską. Wysokość względna tarasu nadzalewowego wyższego jest rzędu 7–12 m, w zależności od istnienia pokrywy lessu subaeralnego. Wysokość bezwzględna wynosi 190–197 m n.p.m. Powierzchnię bazalną tarasu stanowią głównie utwory plejstocenu, ale miejscami także kreda. Powszechnie utwory tarasu włożone są w różnogenetyczne osady zlodowacenia warty.

Taras nadzalewowy niższy (IIa), erozyjno-akumulacyjny, powstał w wyniku erozji w interpleniglacjale podczas zlodowacenia wisły, a osady akumulowane w obrębie tarasu pochodzą głównie z górnego pleniglacjału tego zlodowacenia. Wysokość względna tarasu jest zróżnicowana w obrębie Grzędy Horodelskiej oraz jej sąsiedztwie, zwykle waha się w zakresie 5–6 m w stosunku do poziomu wody w rzece. Wysokości bezwzględne są rzędu 180–185 m n.p.m. Powierzchnię bazalną tarasu stanowią utwory aluwialne dolnego pleniglacjału zlodowacenia wisły lub starsze osady plejstoceńskie.