S T U D I A G E O M O R P H O L O G I C A C A R P A T H O - B A L C A N I C A
Vol. XLIII, 2009: 5–37 PL ISSN 0081-6434
L A N D F O R M E V O L U T I O N I N M O U N T A I N A R E A S

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EVOLUTION OF THE LOWER SECTION OF THE STRVYAŽ RIVER VALLEY DURING THE HOLOCENE (FORELAND OF THE EASTERN CARPATHIANS)

Abstract. The valley floor of the lower section of the Strvyaž river, tributary of the Dnister river within the Carpathian foreland is formed of Holocene sediments underlain by Late Glacial sediments of the total thickness ranging 5–8 m. Radiocarbon datings, supplemented by dendrochronological data and palynological analyses enabled to distinguish several units and paleochannels of the Late Glacial, Atlantic phase (clay units) and the subsequent alluvial fills dated at 3500–3000 BP, 2300–2500 BP as well as two- or three-partite series of the first millenium AD. In the sediments of the overbank facies numerous gley horizons and poorly developed paleosols have been recorded. The phases of flood activity in the Holocene in the Strvyaž river valley were accurately correlated with the flood phases in the upper Vistula and its tributaries, whereas the aggradational tendency in the Middle Ages was related to the anthropogenic impact. The incision of the Holocene floodplain propagated from the Carpathian margin toward depressed area of the Upper Dnister Basin, which can be connected with the tectonic activity.

Key words: Strvyaž valley, Holocene fluvial activity, lithology, ^{14}C, micromorphology, dendrochronology, palynology

INTRODUCTION

The state of the scientific examination of Holocene alluvial sediments in the Upper Strvyaž river valley and the lower sections of its tributaries was unsatisfactory, fragmentary. In the first half of the 20th century the alluvia and terraces of the Strvyaž and Dnister rivers as well as peat-bogs were studied during the geological mapping of the region (Łomnicki 1905; Teisseyre 1938; Kostyniuk 1938). After the Second World War the peat-bogs of the Upper Dnister Basin (Kotlina Górnego Dniestru) were surveyed by Ukrainian scientists (Czerewko 1967; Artiuszenko et al. 1982).

At the end of the 20th and beginning of the 21st centuries, in a framework of the interdisciplinary research project of (Polish) State Committee for Scientific Research: "The changes of the natural environment of the Carpathian Foreland between the Wisłoka and upper Dnister river valleys during the Neolithic and the later periods", related to the archaeological excavations, more than ten sites of alluvial sediments and several sites of peat-bogs have been analyzed and dated, using the palynological, archaeological and radiocarbon methods (Harmata, Machnik, Starkel eds. 2006). The observations proved an increase in fluvial activity at the Atlantic-Subboreal transition as well as during the Roman Period and the Middle Ages (Starkel 1997; Budek et al. 2001; Starkel and Jacyšyn 2006). In the same time the group of German scientists working in the three selected sections of the middle Dnister valley (downstream from the Upper Dnister Basin) identified up to seven Holocene terrace levels formed of the inserted alluvial fills, using W. Schirmer's (1983) model formerly applied for the Men river valley. The terrace levels were dated on the basis of the state of maturation of alluvial soils and paleomeander systems as well as radiocarbon analysis of wood fragments and rare black oaks (Huhmann and Brückner 2002; Huhmann et al. 2004). The number of datings was insufficient and the authors did not take into account the redeposition of tree trunks. Moreover, the publication does not comprise the documentation of cuts and fills as well as detailed description of paleosols differing the distinguished stratigraphic horizons.

In 2006–2008 the area of researches was expanded, including new sites located in the lower section of the Strvyaž valley and in the Dnister valley between the Staryi Sambir town and the area of the Upper Dnister Basin (Fig. 1). In 2006 the field works of Polish-Ukrainian group were concentrated in the lower section of the Strvyaž valley where several profiles were studied again and new sites were described (Jazy II, III, Zarieče–clay pit). The preliminary results, supplemented with the micromorphological observations (Budek 2007), indicated the complex structure of the seemingly homogenous floodplain of the Strvyaž valley and the occurrence of fills representing the Atlantic phase, the first and the second millenium BC and the first millenium AD (Gębica et al. 2008).

In 2007 new sites with tree trunks in the Strvyaž valley were examined. They were situated downstream from town of Chyrov in Murowane, Zasadky and Zarieče villages. In this last site 11 boreholes were drilled along transect line connecting the Zarieče Za 2A and Za 2B sites. The second examined transect, 1.5 km long comprising 4 boreholes was situated near the clay pit in Zarieče village. New profiles with tree trunks were described also in the Dnister valley.

During the field survey 31 wood slices of the subfossil tree trunks were sampled (using a gas-engine saw) for the dendrochronological analysis carried out in the Dendrochronological Laboratory of the AGH University of Science and Technology in Cracow. Samples with the organic material were used for the palynological analysis in the Lviv State Ivan Franko University. Wood fragments and samples of organic material were dated by radiocarbon method in the Gliwice Radiocarbon Laboratory of the Silesian University of Technology, the Kyiv Radiocarbon Laboratory of the National Academy of Sciences of Ukraine and

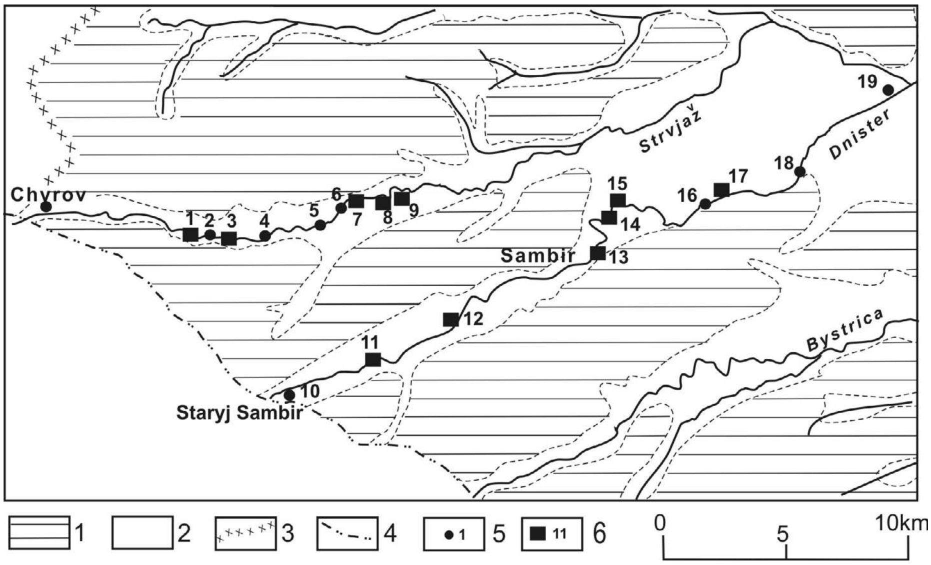

Fig. 1. Study area of the Strvyaž river valley and fragment of Dnister valley. 1 — Uplands with fragments of Pleistocene terraces, 2 — valley floors with Holocene accumulations, 3 — Dnister and San watershed 4 — margin of the Carpathians, 5 — sites elaborated in 90-ies, 6 — sites elaborated in 2006–2008. 1 — Murowane, 2 — Zasadky, 3 — Zasadky II, 4 — Čapli, 5 — Humanec, 6 — Jazy I, 7 – Jazy II and Jazy III, 8 — Zarieče village, 9 — Zarieče clay-pit, 10 — Sozan, 11 — Targowiče, 12 — Bierežnica, 13 — Chatky, 14 — Sambir II, 15 — Sambir I, 16 — Kružyky II, 17 — Kružyky IV, 18 — Hordynja I, 19 — Hordynja II

the Radiocarbon Laboratory of the Belarussian Academy of Sciences in Minsk. Totally about 40 samples taken from 15 borehole logs and about 10 outcrops were dated (Tab. 1). In three chosen profiles the analysis of granulometric compo-

Table 1

Radiocarbon ages of samples. a – tree trunk, b – wood, c – charcoal, d – peat, e – organic detritus, f – organic clay/silt, *older ^{14}C dates published in H a r m a t a et al. 2006

Locality and profile no.	Material	Depth [m]	Laboratory no.	^{14}C age BP	Age cal. BP 1σ95%
MUROWANE					
Murowane 4U-MUR2z16	a	1.60–2.20	Ki-15258	3,280 ± 60	1630–1490 BC
ZASADKY					
Zasadky 1/2	b	4.95	Ki-15243	3,290 ± 60	1640–1510 BC
Zasadky U-ZAS 1w25	a	4.0	Ki-15249	2,140 ± 40	350–320 BC 210–90 BC
Zasadky 2/3	a	4.00	Ki-15254	2,210 ± 50	370–200 BC
Zasadky 2/4	a	4.50	Ki-15253	2,380 ± 50	540–390 BC
Zasadky1/6	a	4.90	Ki-13841	2,310 ± 50	410–350 BC 290–230 BC

Table 1 cont.

Locality and profile no.	Material	Depth [m]	Laboratory no.	^{14}C age BP	Age cal. BP 1σ95%
Zasadky 1/7	a	4.50	Ki-13842	2,240 ± 50	390–350 BC 320–230 BC
Zasadky 1/8	a	2.30	Ki-13843	3,280 ± 50	1630–1490 BC
Zasadky*	a	3.70	Ki-7858	3,890 ± 70	
Zasadky*	a	2.40	Ki-7859	2,590 ± 60	
ČAPLI*					
Čapli*	a	4.50	Ki-7555	7,730 ± 70	
Čapli*	a	4.60		6,405 ± 100	
Čapli*	e	3.50		3,000 ± 110	
JAZY I					
Jazy I U-5	a	5.10–5.20	Ki-13389	3,480 ± 50	1880–1740 BC
Jazy IA*	f	5.50	Gd-13048	9,820 ± 350	
Jazy*IA	b	5.50	Ki-7556	11,340 ± 140	
JAZY II					
Jazy II U_JAZY 1z20	a	2.0–2.20	Ki- 15384	870 ± 40	1150–1230 AD
Jazy II/6	b	2.30–2.40	Gd-12909	1,190 ± 50	680–970 AD
Jazy II U_JAZY 4Z	a	4.0	Ki-15258	3,670 ± 80	2150–1930 BC
Jazy II U-2	a	5.30–5.50	Ki-13390	3,340 ± 40	1690–1600 BC
JAZY III					
Jazy III U_JAZY 10w20	a	3.0	Ki-15323	1,410 ± 40	600–665 AD
Jazy III U-1	c	3.0	Ki-13395	1,470 ± 60	540–650 AD
Jazy III/11 U-4	e	5.50	Ki-13394	1,880 ± 55	70–220 AD
ZARIEČE VILLAGE					
Zarieče ZA 2/A-1	d	5.6–5.70	IGSB-1350	11,270 ± 130	11420–10970 BC
Zarieče ZA 2/A-2	f	5.95–6.0	IGSB-1365	4,940 ± 460	4800–2400 BC
Zarieče U_ZARZ1w30	a	5.0	Ki-15385	1,150 ± 30	860–970 AD
Zarieče ZA 1/1	b	4.1	IGSB-1348	1,635 ± 60	250–560 AD
Zarieče ZA 1/2	b	5.15–5.25	IGSP-1347	1,860 ± 85	40BC–390 AD
Zarieče ZA 1/3	d	5.3–5.4	IGSB-1349	11,385 ± 260	11850–10900 BC
Zarieče ZA 8/1	d	5.75–5.77	IGSB-1351	11,415 ± 200	11750–10950 BC
Zarieče ZA 8/2	d	6.15–6.17	IGSB-1352	12,655 ± 220	13600–12100 BC
ZARIEČE clay-pit					
Zarieče U-6	f	3.0	Ki-13396	6,310 ± 170	5425–5395 BC 5390–5195 BC
Zarieče ZA-G 2/14	f	3.79–3.74	IGSB-1353	6,490 ± 680	6800–3800 BC
Zarieče ZA-G 2/27	b	9.05–9.15	IGSB-1346	11,400 ± 375	12200–10600 BC
Zarieče ZA-G 4/18	b	5.50	IGSB-1363	4,250 ± 145	3350–2450 BC
Zarieče ZA-G 4/17	b	5.63	IGSB-1364	2,950 ± 375	2200–200 BC

sition of sediments in the laser granulometer Analysette 22 (Fritsch) and using sieve technique was carried out in the Department of Geomorphology and Hydrology of Mountains & Uplands, Institute of Geography and Spatial Organization, Polish Academy of Sciences (PAS) in Cracow. Apart from the surveyed earlier sites Čapli and Humanec, in the new profiles Jazy and Zarieče 15 samples of alluvial soils with original structure were taken and used for the preparation of thin sections. These thin sections were examined based on the procedure of the micromorphological features description proposed by P. Bullock et al. (1986) and G. Stoops (2003) in the Department of Geomorphology and Hydrology of Mountains & Uplands, Institute of Geography and Spatial Organization PAS in Cracow and the Institute of Geological Sciences PAS in Cracow.

GEOLOGICAL AND GEOMORPHOLOGICAL SETTINGS

Survey of the Holocene terraces was concentrated in the Strvyaž and Dnister valleys, between the Carpathian margin and the Upper Dnister Basin area (Fig. 1), where meandering river channels, freely developed within the wide and flat valley floor separating the plateau patches formed of Miocene clays covered by loess. During floods the rivers erode the banks, revealing the sequences of the terrace levels.

Within the Dnister valley between the towns of Staryj Sambir and Sambir the valley floor, 2–3 km wide is terraced. Close to the mountain margin the winding Dnister riverbed with the gravel bars is accompanied with high gravel terrace–alluvial fan up to 10–11 m high. Downstream, near Biereźnica village the system of terrace, 5–6 m high and floodplain, 3–4 m high occur. Downstream from Sambir town, the Dnister is characterized by lower gradient and its channel meanders. Apart from the terrace 5 m high and floodplain 3 m high, fragments of the terrace 7 m high are discernible. In turn, within the Upper Dnister Basin area the aggradation predominated and peat-bogs developed up to recent. Currently, the Dnister riverbed and its tributaries are artificially reconstructed and cut into one terrace 5–6 m high (Jacyšyn 2001).

In the lower section of the Strvyaž river, whose springs are situated in Polish part of marginal zone of the Bieszczady Mountains, the valley floor 1–2 km wide is occupied by the terrace about 5–6 m high. Between Chyrov town and Čapli village and downstream from Biskovici village the river flows close to the right valley slope, whereas between Čapli and Biskovici villages the river channel runs close to the left valley slope. In this section, comprising the sites of Jazy and Zarieče within the right-side plain 1.5–1.8 km wide, the natural levee can be discerned. Its slope gently dips to the south, toward flat basin depressed 1.5 m and currently used by the Jasienica stream (a tributary of the Strvyaž river). In the depositional sequences of terrace 5–6 m high, two types of sediments outcrop. Lower, gravel member with admixture of sand, which represents channel facies is overlain by upper unit of overbank, sand-clay sediments of variable thickness ranging 2–5 m. Wood particles, tree trunks as well as gley horizons and paleosols enabled to distinguish different stratigraphic units during the early stages of researches (Budek et al. 2006; Gębica et al. 2008).

In some sections of the Strvyaž river valley 2–4 levels of the low floodplain of height ranging 1–3 m occur. The thickness of both (described above) units, especially overbank unit, is visibly lower. In the top part of the sequence the lack of alluvial soil profiles as well as dark gley interbeddings or paleosols prove young age of the sediments (Jacyšyn 2001; Budek et al. 2006).

DESCRIPTION OF SITES

STRVYAŽ VALLEY

Murowane

In Murowane village, on the right bank of the Strvyaž river, about 5 km downstream from Chyrov town, the floodplain 2.5 m high is formed of the upper unit of sandy clays with gravel inserts of flood origin and the lower unit of gravels and sands with tree trunk at the depth of 1.60–2.20 m. The radiocarbon date obtained from a trunk, 3,280 ± 60 BP (Ki-15237), suggests (comparing to other profiles), that it is redeposited and much older than the alluvia of the floodplain.

Zasadky

The profile in Zasadky village is situated on the right bank of the Strvyaž river, about 300 m upstream from the bridge. In the riverbed loop the alluvia of the terrace 5 m high and floodplain 2.5 m high were exposed. Within both terrace and the floodplain subfossil tree trunks occur. The tree trunk buried at the depth of 3.5 m within the alluvial clays underlying sands in the outcrop (currently not existing) of the terrace (4.5 m) was dated at 2,590 ± 60 BP. The tree trunk lying within the overbank silts of the floodplain (2.5 m) was dated at 3,890 ± 70 BP (Starkel and Jacyšyn 2006). In May 2007 the next two trunks located within the terrace 5 m high were dated (Gębica et al. 2008), and subsequently the description of the outcrops (with the gravel bed exposed above the water table), receded after flood, were supplemented twice. The trunks were buried both within coarse-grained gravels of the channel facies (ca 1 m above the water table) and within the overbank sands above the gravel unit. The lowermost trunk of the sequence Zas 3 was dated at 2,310 ± 50 BP (Ki-13841), the three upper trunks were dated at 2,380 ± 50 BP (Ki-15253), 2,240 ± 50 BP (Ki-13842) and 2,210 ± 50 BP (Ki-15254) (Fig. 2). The younger, nested fill is formed of upper silty clay unit and lower clayey silt unit at the depth of 2.40–4.20 m, which represent the oxbow-lake fills (Zas 2) (Fig. 3). The trunk buried within alluvial silts, next to the boundary between silts and sand with gravel at the depth of 4.10 m was dated at

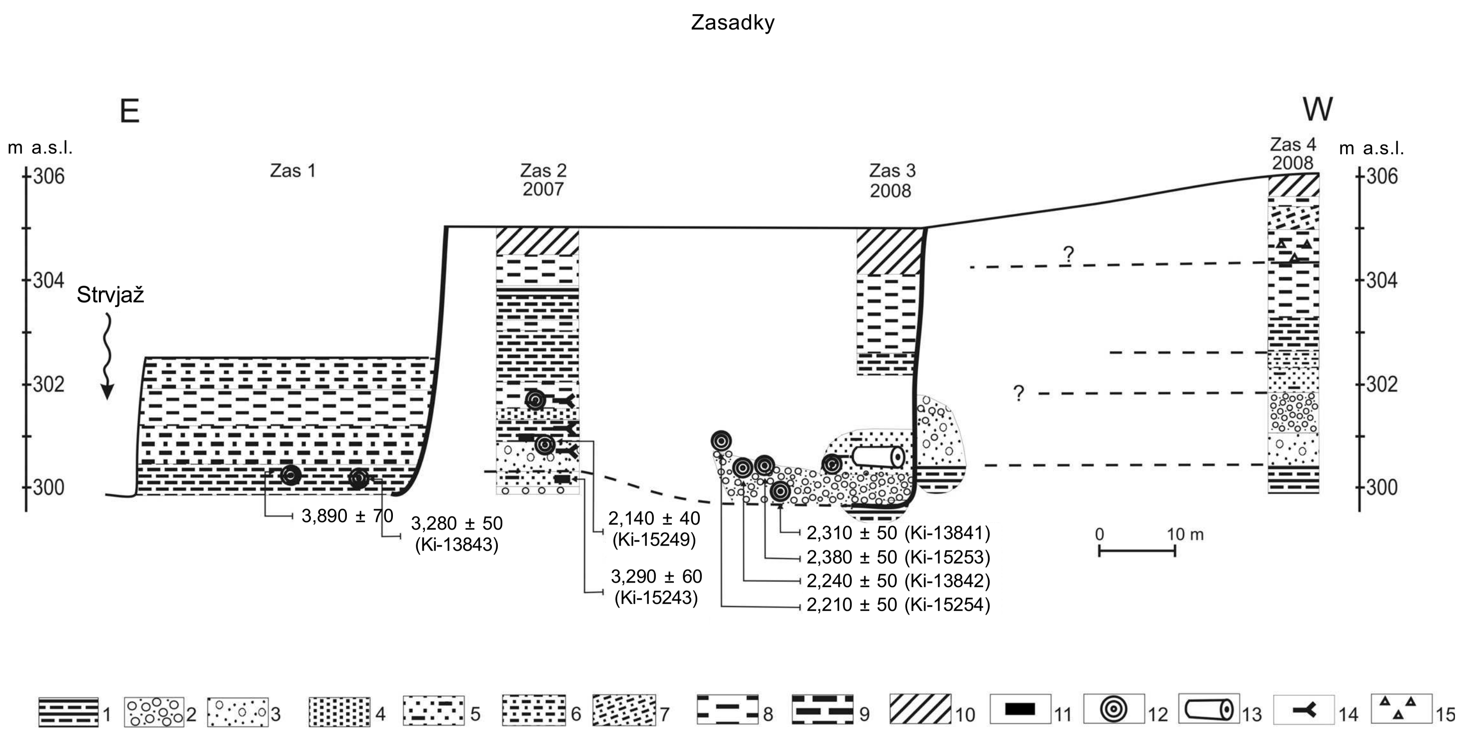

Fig. 2. Profiles of 5–6 meters terrace in Zasadky with subfossil trunks (elab. by P. Gębica and A. Jacyšyn). 1 — Miocene clay, 2 — gravel with sand, 3 — sand with gravel, 4 — sand, 5 — silty sand, 6 — sandy mud, 7 — sandy silt, 8 — silt, 9 — clayey mud, 10 — soil, 11 — dated fragment of wood, 12 — trunk, 13 — trunk parallel to exposure, 14 — organic detritus, 15 — slope deposits

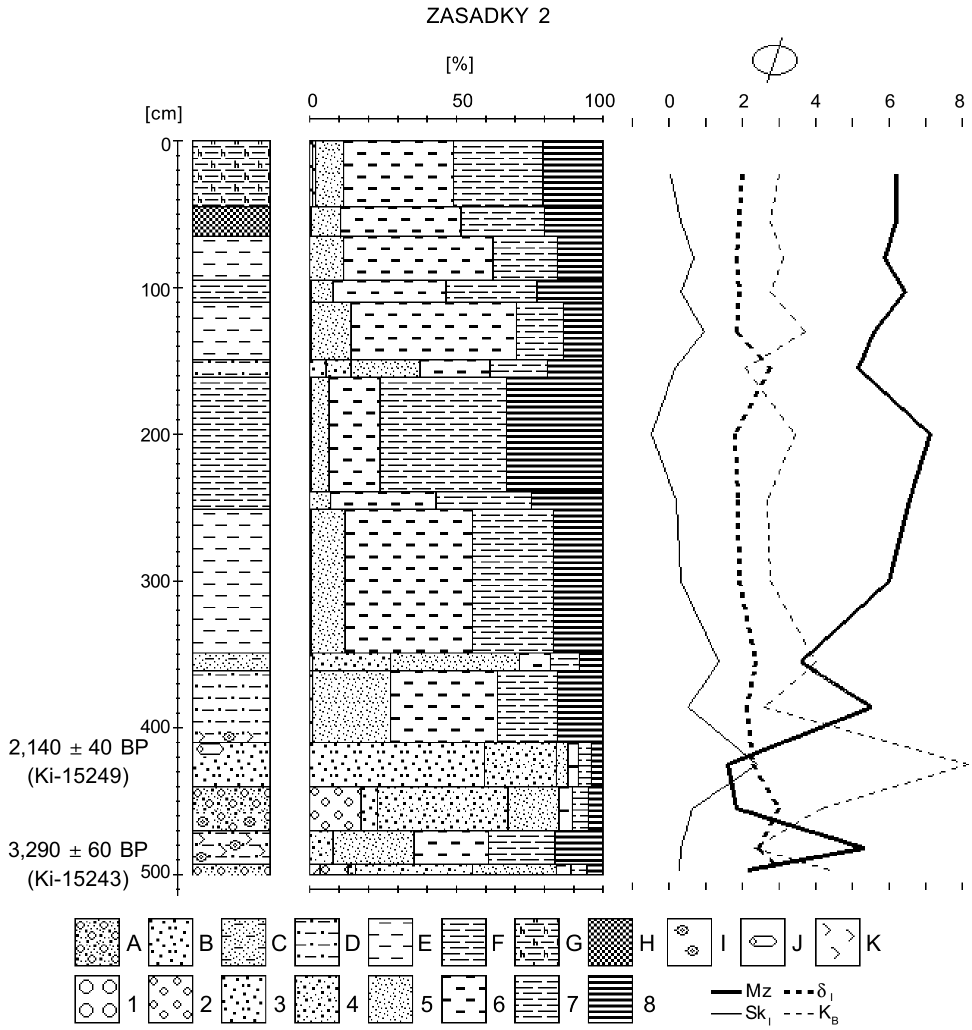

Fig. 3. Grain size composition and Folk-Ward's grain size distribution patterns at Zasadky 2 profile. Sediments: A — sands with gravel, B — coarse sand, C — loamy sands, D — sandy loam, E — loam, F — silt, G — clayey peat, H — peat, I — trunk transversal to outcrops, J — trunk parallel to outcrops or fragment of wood, K — organic detritus. Fractions: 1. coarse gravels (above –4 φ), 2 — gravels (–1– –4 φ), 3 — coarse sand (–1–1 φ), 4 — medium sand (1–2 φ), 5 — fine sand (2–4 φ), 6 — coarse and medium silt (4–6 φ), 7 — fine silt (6–8 φ), 8 — clay (under 8 φ), Mz — mean size in φ, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

2,140 ± 40 BP (Ki-15249). The wood particles occurring within silty sands at the depth of 4.95 m, in the lowermost part of the sequence (below the channel sands and gravel), were dated at 3,290 ± 60 BP (Ki-15243).

The tree trunks of the age 3,900–3200 BP buried within the floodplain 2.5 m high, formed of the young alluvia, should be considered to be redeposited. The lowermost section of the terrace 5 m high is formed of the older paleochannel fills bearing wood particles dated at about 3,300 BP. It is overlain by younger unit of the channel gravels and overbank sediments with the trunks dated at 2,300–2,100 BP, evidencing the phase of frequent floods at the beginning of the Subatlantic.

Čapli

At the firstly described Čapli site (Starkel 1997) on the Strvyaž river, the left-side terrace 5 m high is formed of gravels and sands within which tree trunks occur at the depth of 4.0–4.5 m. They were dated at 7,730 ± 70 and 6,405 ± 100 BP (Fig. 4). Within these channel alluvia the paleochannel was cut and filled with sandy silts, containing organic detritus in the uppermost part. This detritus was dated at 3,000 ± 110 BP. The uppermost unit 3.3 m thick is represented by the overbank silts with admixture of sand grains, within which dark horizons can easily be distinguished. These horizons were formerly interpreted as paleosols, and then as gley horizons (Starkel 1997; Starkel and Budek 2006). Subsequent micromorpholo-gic observations proved the processes of clayey material translocation in the whole sequence, which contributed to the development of initial lessive soil without distinct eluvial horizon (E) in the Čapli site (Budek 2007).

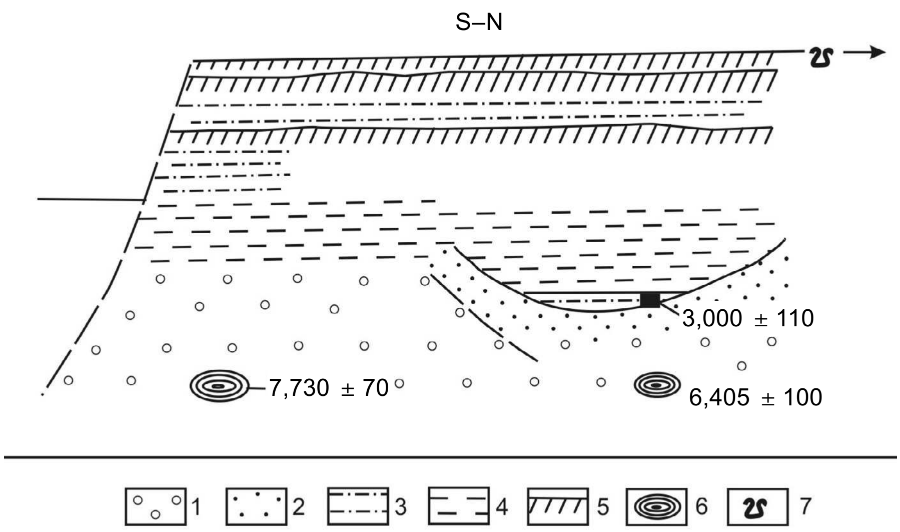

Fig. 4. Cross-section of 5 m high terrace west of Čapli (after Starkel 1997). 1 — gravel, 2 — sand, 3 — loamy sand, 4 — loam, 5 — dark buried layer (G?), 6 — tree trunk (dated), 7 — ceramics from late Roman Period on terrace surface

Numerous artifacts of the Late Roman ceramics found on the terrace (5 m high) surface indicate colonization of the plain, which was not overflowed later (M a c h n i k et al. 2006). Therefore, the deposition of the overbank sediments, since the filling up of the paleochannel, till the floodplain formation took place between 3,000 and 1700 BP.

The lower terrace levels commonly occurring downstream, in the vicinity of Humanec village are characterized by distinctly different structure and they are undoubtedly younger. Within the sequence of the Humanec site the brown mada with dark horizon at the depth of 1.35–1.55 m developed.

The dark horizons described above ("fossil soils"), do not represent features of humic horizons because of very low percentage of organic material and lack of plant fragments. However, oxidation-reduction processes that are clearly visible, suggest that they are gley horizons (G). Iron oxides rarely form the regular concentrations — nodules. The iron oxide concentrations are usually characterized by indistinct margins, suggesting migration of the ferruginous compounds to the groundmass (V e p r a s k a s et al. 1994; B u d e k 2007).

JAZY

Within the undercutting of the 5 m high terrace, three sites were described: Jazy I (IA and IB), Jazy II and Jazy III (Fig. 5).

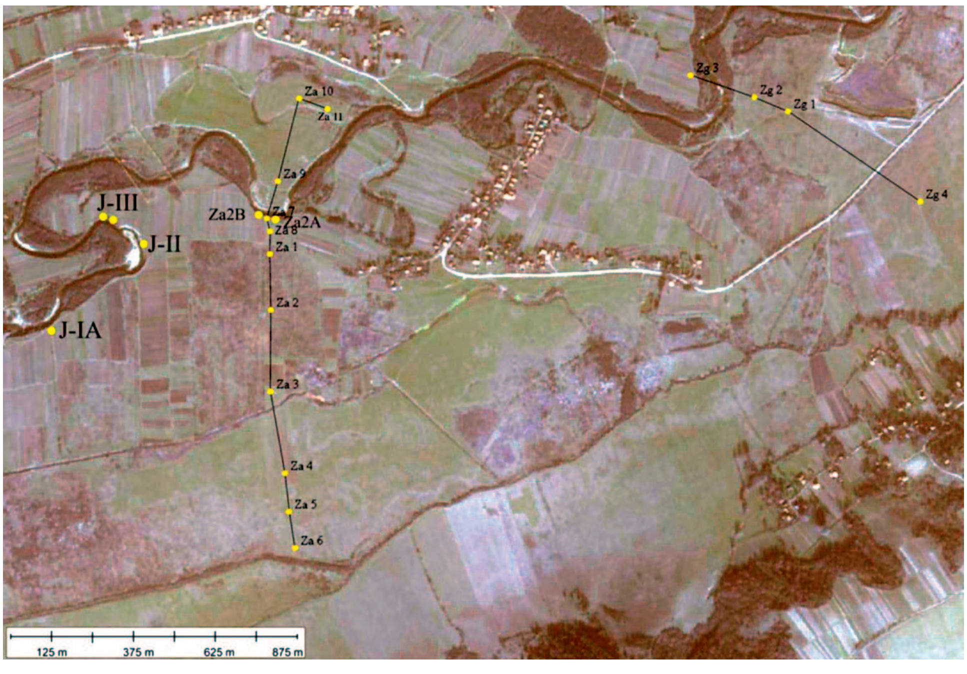

Fig. 5. Location map with described profiles and borings in Jazy and Zarieče

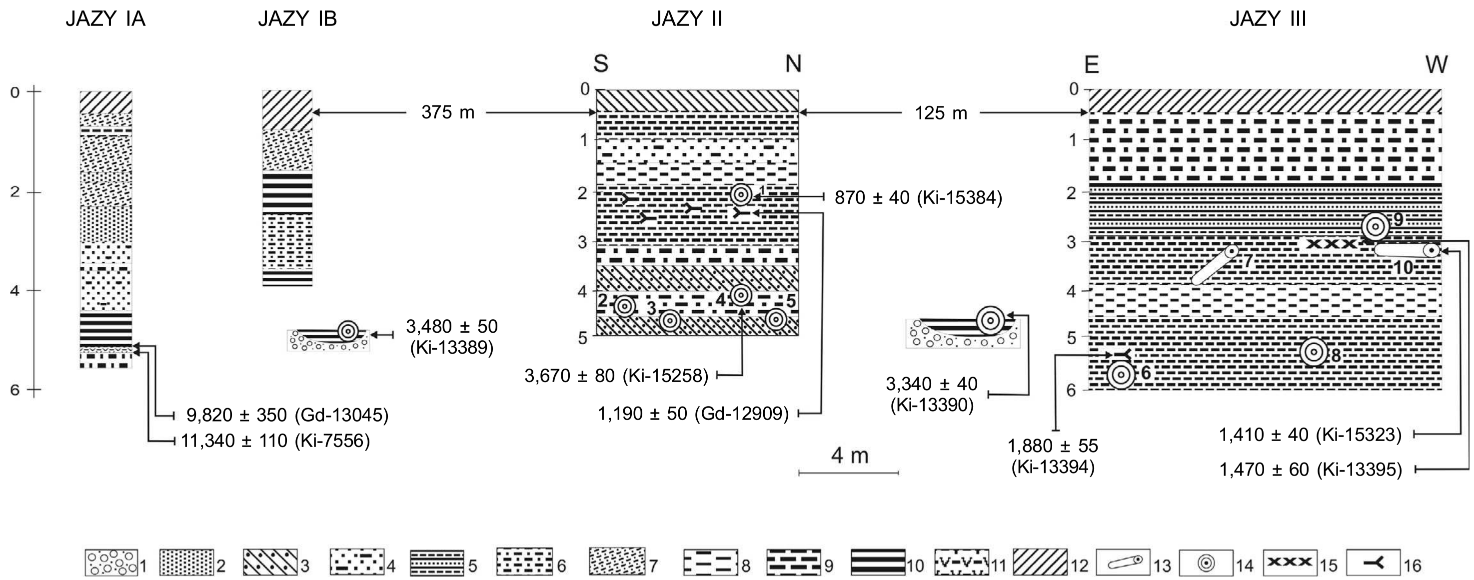

Fig. 6. Profiles of excavations in Jazy I, II, III (elab. by P. Gębica). 1 — gravel with sand, 2 — sand, 3 — diagonally laminated sands, 4 — silty sand, 5 — horizontaly laminated sands and muds, 6 — mud with sand, 7 — sandy silt, 8 — silt, 9 — clayey mud, 10 — clay, 11 — organic mud, 12 — Holocene soil, 13 — trunk parallel to outcrops, 14 — trunk transversal to outcrops, 15 — charcoal, 16 — organic detritus

Jazy IA

Jazy IA depositional sequence, situated in the right bank of the Strvyaž river and 5.5 m high, was described in 1998 (Fig. 6). It comprises the overbank facies: sands interbedded with clays, three horizons of which display gleization features, whereas one black horizon, at the depth of 0.4–0.8 m, can represent paleosol. The insert of silts bearing organic material in the lowermost part of the sequence was dated at 9,820 ± 350 BP, and a wood fragment — at 11,340 ± 140 BP. Based on these datings it was postulated that the sequence represents floodplain aggradation, progressing during the whole Holocene (B u d e k et al. 2006).

The later micromorphological observations proved that within the uppermost section of the Jazy IA sequence very well decomposed organic material occurs. The content of organic carbon at the depth 0.7 m ranges about 1.5% (Tab. 2). The organic material could have been delivered during floods, which is suggested by pedofeatures. The current soil processes are marked by bioturbations and biocanals with fresh, undecomposed organic material. Below the

Table 2

Grain size distribution, chemical properties, colour of Jazy and Zarieče clay-pit profiles

	Depth [cm]	Particie size distribution [%]			Lithology	Munsell collour moist	pH		Organic carbon
		1–0.1 mm	0.1–0.02	<0.02			[H_2O]	[KCl]	
Jazy 1a/1	0–40	18	47	35	silty loam	7.5YR 4/2	7,49	6,80	1,16
Jazy 1a/2	40–77	6	39	55	clay	7.5YR 3/2	6,93	6,60	1,49
Jazy 1a/3	77–117	11	36	53	clay	7.5YR 4/2	6,87	6,39	0,39
Jazy 1a/4	117–162	7	53	40	silty clay	10YR 5/6	6,97	6,44	0,20
Jazy 1a/5	162–212	2	25	73	clay	10YR 4/4	6,81	—	0,71
Jazy 1a/6	212–252	9	35	56	clay	10YR 4/2	6,63	5,96	0,92
Jazy 1a/7	252–362	20	56	24	clay silt	10YR 4/2	6,34	5,60	0,008
Jazy 1a/8	362–390	66	23	11	sendy loam	10YR 4/4	6,54	6,09	0,06
Jazy 1a/9	390–450	37	43	20	silty loam	10YR 4/4	6,96	6,44	0,66
Zarieče 1	0–40	—	—	—	—	10YR6/4	6,29	5,81	1,91
Zarieče 2	40–87	2	14	84	clay	10YR6/4	6,45	6,03	0,99
Zarieče 3	87–120	7	18	75	clay	10YR 5/2	6,65	5,98	0,53
Zarieče 4	120–145	3	14	83	clay	2.5Y 3/3	6,74	—	0,48
Zarieče 5	145–210	1	4	95	clay	2.5Y 4/3	6,53	5,73	0,91
Zarieče 6	210–260	3	9	88	clay	2.5Y 4/4	6,45	5,80	1,15
Zarieče 7	260–295	8	7	85	clay	2.5Y 3/1	6,27	5,49	1,55
Zarieče 8	295–320	4	5	91	clay	2.5Y 1/1	5,20	4,66	1,30

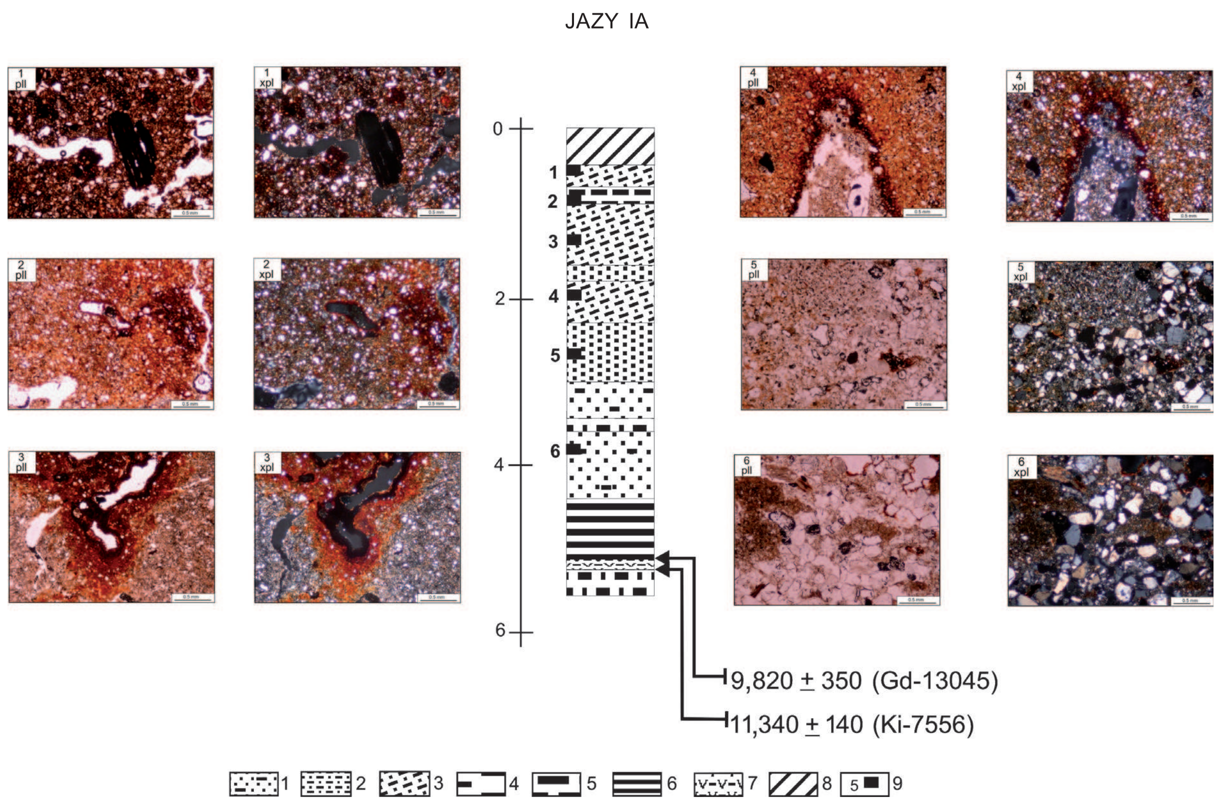

Fig. 7. Micromorpholofical features of Jazy I profile (elab. by A. Budek). Sediments: 1 — silty sand, 2 — mud with sand, 3 — sandy silt, 4 — silt, 5 — clayey mud, 6 — clay, 7 — organic mud, 8 — Holocene soil, 9 — micromorphological samples. Micromorphological photos: 1 — decomposed organic matter, depth 0–40 cm, 2 — Iron hypocoating, depth 40–77 cm, 3 — Iron coatings and hypocoatings, depth 117–162 cm, 4 — Iron hypocoatings and loose discontinuous infillings, depth 162–212 cm, 5 — dense and loose discontinuous infillings of fine material, depth 252–362 cm, 6 — silty clay peds, depth 362–390 cm, pll — picture in plain polarized light, xpl — picture in cross polarized light

Table 3

Micromorphological features of Jazy profile (A. Budek)

Depth [cm]	Mineral composition		Microstructure	Voids	Pedofeatures			
	coarse material	fine material			nodules	coatings and hypocoatings	infillings and other features	organic features
0–40	rough quartz grains, rarely feldspar, micas, glaukonite	orange brown loam, c/f limit = 5 µm c/f ratio = 30/70, b-fabrics speckled	subangular blocky and channel	channel, cracks	iron nodules; typic, with quartz grains inside	silty coatings on peds	coarse material in peds	fresh root fragments,
40–77	rough quartz grains, rarely feldspar, micas, glaukonite	dark brown and orange loam, c/f limit = 5 µm c/f ratio = 30/70, b-fabrics speckled	subangular blocky and channel	channel, cracks	iron nodules; typic, with quartz grains inside and geodic	iron hypocoatings	loose discontinuous infillings	moderately decomposed root fragments, decomposed tissue residues in groundmass
77–117	rough quartz grains, rarely feldspar, micas, glaukonite	reddish brown silt c/f limit = 5 µm c/f ratio = 30/70, b-fabrics speckled	subangular blocky and channel	channel	iron and iron-manganese nodules; typic, geodic, pseudomorphic	iron coatings and hypocoatings	loose discontinuous infillings	decomposed tissue residues in groundmass, charcoal
117–162	small and rough quartz grains, rarely feldspar, micas, glaukonite, opaque minerals	yellowish grey silt, weakly sorted, c/f limit = 5 µm c/f ratio = 40/60, b-fabrics speckled	channel and massive	channel	iron and iron-manganese nodules; typic, disjointed, pseudomorphic	iron hypocoatings	coarse material in peds, dense and loose discontinuous infillings	—
162–212	small and rough quartz grains, rarely feldspar, micas, glaukonite	reddish brown silt, c/f limit = 5 µm c/f ratio = 30/70, b-fabrics porostriated	channel	channel, voids, cracks	iron and iron-manganese nodules; typic, disjointed, geodic, pseudomorphic	iron and silty-clay coatings, iron-manganese hypocoatings	coarse material in channels, dense and loose discontinuous infillings of silty clay	fresh root fragments, decomposed tissue residues in groundmass, charcoal

Table 3 cont.

Depth [cm]	Mineral composition		Microstructure	Voids	Pedofeatures			
	coarse material	fine material			nodules	coatings and hypocoatings	infillings and other features	organic features
212–252	rough quartz grains, rarely feldspar, micas, glaukonite	reddish brown sandy loam, segregated, c/f limit = 5 µm c/f ratio = 40/60, b-fabrics porostriated	channel	channel, voids, cracks	iron and iron-manganese nodules; disjointed, pseudomorphic	cryptocrystaline iron coatings, silty-clay and clay coatings, iron-manganese and clay hypocoatings, papules	dense and loose discontinuous infillings of silty clay	decomposed plant tissue
252–362	rough quartz grains, rarely feldspar, micas, glaukonite, opaque minerals	orange gray loam, c/f limit = 5 µm c/f ratio = 90/10, b-fabrics speckled	massive, channel	channel, voids	iron and iron-manganese nodules; disjointed, pseudomorphic	iron-clay hypocoatings	dense and loose discontinuous infillings	—
362–390	rough quartz grains, rarely feldspar, micas, glaukonite	brown sand, c/f limit = 10 µm c/f ratio = 80/20, b-fabrics granostriated	massive, channel (very rare)	voids, channel	—	thin iron-clay coatings	silty clay peds	well decomposed plant tissue

depth of 0.8 m the oxidation-reduction processes predominated within the depositional sequence. In the thin sections of sediments occurring as deep as about 2 m the structures of flood deposition were transformed by pedogenic and diagenetic processes. The reddish-orange color of groundmass indicate the high content of iron oxides. Within the whole sequence iron nodules, iron coatings and hypocoatings occur and the coarse-grained material predominated. However it is interbedded with the fine-grained sediments. Occasionally the silty-clayey material forms aggregates with apparent ferruginous coatings. In the sequence, below the depth of 2.2 m fluvial laminations and traces of clay material movement in channels are preserved. Clay and iron oxides coatings are destroyed (Fig. 7). Below the depth 2.5 m the percentage of clay material decreases in the groundmass, whereas the grain fraction coarser than 5 μm predominates (Tab. 3). In consequence, the iron oxides precipitated within cracks. Within the coarser material (represented mainly by quartz grains) aggregates of fine-grained material occur. They are often characterized by a rounded shape, which suggests short transport of these aggregates.

Jazy IB

Jazy IB site, described in 2006 and 2007, about 50 m downstream from the Jazy IA site, was characterized by similar sequence of sediments. Within the sequence the rusty-gray and black layer occurs. Below this horizon two apparent clay layers are situated within the alluvial silts. At the depth of 5.1–5.2 m, upon the sand layer subfossil tree trunk was found and dated at 3,480 ± 50 BP (Ki-13389). This trunk lay within the paleochannel fill at the depth of 5.1–5.2 m (Gębica et al. 2008) (Fig. 6). The occurrence of the gley horizons similar to ones at the Humanec site and in the upper section of the Čapli sequence can indicate the age of the whole sequence not older than 3,000–3,400 BP. Therefore, the organic detritus representing the beginning of the Holocene found earlier in the Jazy IA site (Budek et al. 2006) are probably redeposited.

Jazy II

Around 375 m downstream, within the undercuting of the riverbed bend (running south-north) the site Jazy II was described in 2006 and 2007 (Figs. 5 and 6). The uppermost section of the sequence is formed of silty clay unit 1 m thick, crowned with humus horizon. Below this unit a sequence of sand underlain by sandy silt is located. The second clay layer reaches the depth of 3 m and displays features of the oxbow-lake fill. Within the top part of this unit an oak trunk occurred (no. 1), which was dated at 870 ± 40 BP (Ki-15384), while the underlying clays containing wood fragments (at the depth of 2.35–2.40 m) were dated at

1,190 ± 50 BP (Ki-12909). Below this unit, 2 m thick series of cross-bedded sands with inserts of silts was described. This units represent the flood sediments deposited in the oxbow lake, in which four tree trunks 15–30 cm in diameters were buried at the depth of 3.95–4.70 m. The trunk situated at the depth ca. 4 m (no 4) was dated at 3,670 ± 80 BP (Ki-15258).

The wood fragments found several tens meters upstream, below the overbank sediments, within paleochannel sediments (?), close to the water table (depth 5.2–5.3 m) were dated at 3,340 ± 40 BP (Ki-13390).

Jazy III

About 120 m downstream (Fig. 5), within the next undercutting in the right river bank an outcrop (6 m high and 16 m wide) of the depositional sequence is located (Fig. 6). Under the humus layer sandy clays as deep as 1.9 m occur. They overlie sands interbedded with loams and characterized by downward increase in clayey admixture. At the depth of 2.90–4.90 m steely-grey clayey silts occur. They bear thin tree trunks and charcoal fragments in the top part. The charcoal fragments were dated at 1,470 ± 60 BP (Ki-13395), while the horizontally lying trunk — at 1,410 ± 40 BP (Ki-15323). The felling of this oak trunk (no 10) dated by dendrochronological method occurred after 578 AD (Tab. 4). Within the lower clayey silts unit giant ash trunk is buried (no. 6). The organic detritus sampled next to this trunk, at the depth of 5.5 m was dated at 1,880 ± 50 BP (Ki-13394).

Table 4

Tree trunks dated by dendrochronological method (M. Krąpiec)

Lab. code	Locality	Species	No. of rings	Age of species	Age of falling
U-JAZ	Jazy	Quercus	120	449–568 AD	after 578 AD
U-ZARZ 3	Zarieče	Quercus	112	468–579 AD	after 589 AD
U-ZARZ 4A	Zarieče	Alnus	171+2	424–594 AD	after 596 AD
U-ZARZ 5U	Zarieče	Umlus	102	487–588 AD	after 588 AD

Examination of the river bank outcrops at the Jazy sites indicates generally young age of the alluvia and several cuts of river as deep as the horizon of the channel gravel facies. At the Late Glacial the river channel was incised similarly to the current riverbed, while the younger cuts are dated by the tree trunks at the period 3,700–3,300 BP. The trunks are buried within the channel sediments. The next period of the fluvial activity acceleration, after the filling up the oxbow lakes with clays, took place subsequently to the Roman Period, when the aggradation of the alluvia commenced. Tree trunks and flood sand sediments are dated at 6th–8th centuries AD. The youngest tree trunk buried by the overbank sediments felled in the 11th century AD. It can be supposed that the floodplain was already cut in this time. Therefore, the incision took place much later than in the area of the Čapli site, where the colonization of the valley floor developed during the Roman Period (S t a r k e l 1997).

ZARIEČE VILLAGE

The floodplain with the near-bank natural levee is cut as deep as 6.5 m. It dips to the south, toward the flat-bottomed depression of the Jasienica stream, which flows 1.5 m lower than the Strvyaž riverbed 650 m far from it. On the opposite side of the Strvyaž riverbed a 200 m wide ledge of the floodplain (3 m high) lies. Above it a narrow ledge of the terrace (5 m high) is situated. In the outcrop in the river bank the depositional sequence Za 2A with peat unit was described, while 41 m to the west from this site the sequence Za 2B abundant in tree trunks was studied (Figs. 5 and 8).

The top part of the Za 2A sequence is formed of alluvial silts grading downward into sandy silts and passing into silty sands at the depth of 2.10 m

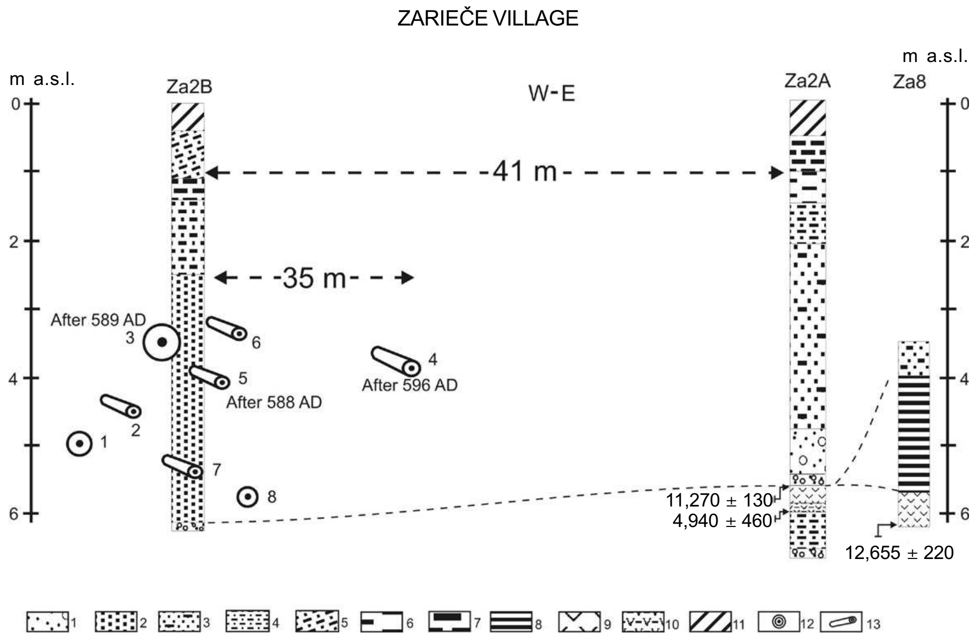

Fig. 8. Profiles of outcrop in Zarieče-village (elab. by L. Starkel and M. Krąpiec). 1 — sand with gravel, 2 — sand, 3 — silty sand, 4 — mud with sand, 5 — sandy silt, 6 — silt, 7 — clayey mud, 8 — clay, 9 — peat, 10 — organic mud, 11 — Holocene soil, 12 — trunk transversal to outcrops, 13 — trunk parallel

(Fig. 9). At the depth interval 2.62–5.46 m partially bedded sands occur, which are underlain by sands with gravels. The sands with gravels discordantly overlie peat unit 0.4 m thick, with clayey-sandy admixture in the bottom part. Below the

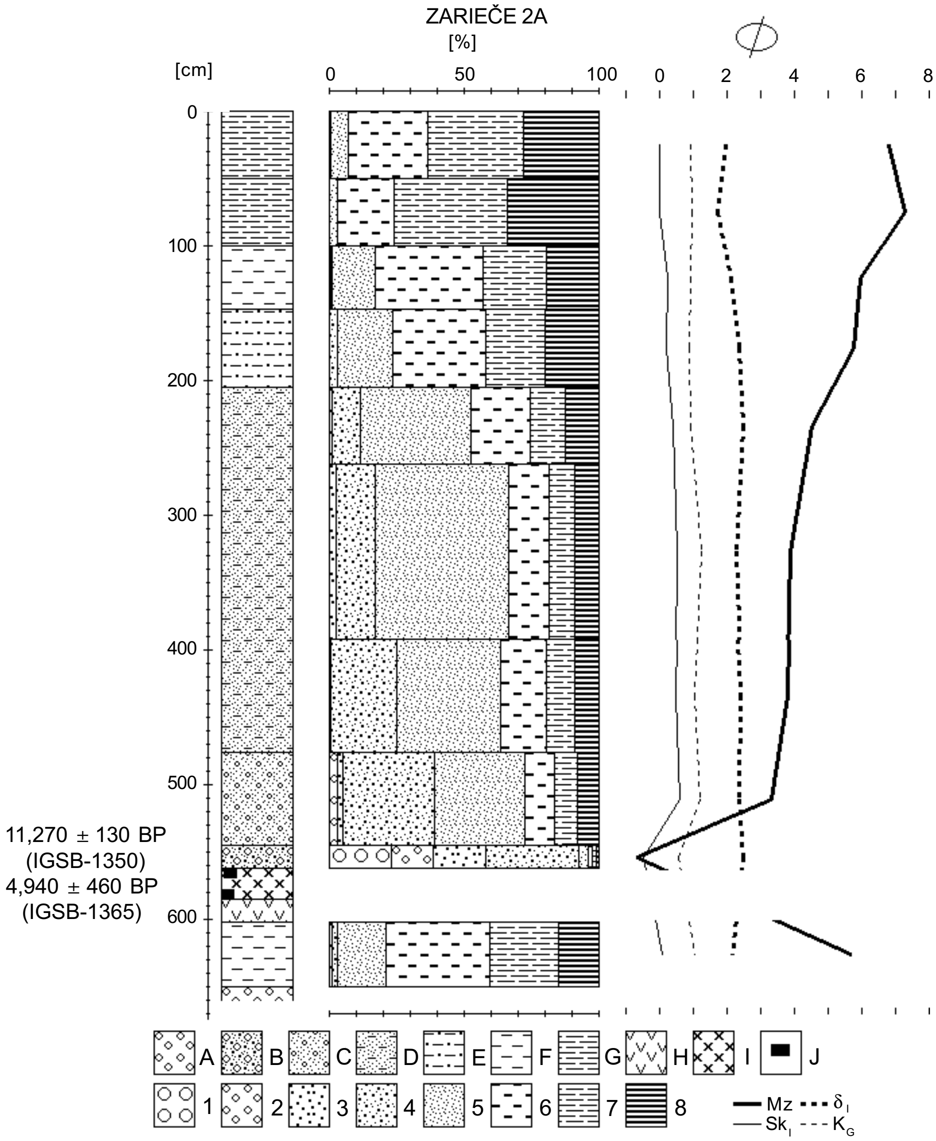

Fig. 9. Grain size composition and Folk-Ward's grain size distribution patterns at Zarieče 2A profile (elab. by P. Gębica and D. Płoskonka). Sediments: A. Gravels, B. Sands with gravels, C. Sands with single gravels, D. loamy sands, E. Sandy loam, F. loam, G. silt. H. clayey peat, I. peat, J. ^{14}C dates Fractions: 1 — coarse gravels (above –4 φ), 2 — gravels (–1––4 φ), 3 — coarse sand (–1–1 φ), 4 — medium sand (1–2 φ), 5 — fine sand (2–4 φ), 6 — coarse and medium silt (4–6 φ), 7 — fine silt (6–8 φ), 8 — clay (under 8 φ), Mz — mean size in φ, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

peat layer, unit of sandy silts 0.5 m thick and lowermost (situated at the water table) gravel units (with pebbles up to 4 cm in diameter) occur. Within the peat unit pollen grains of the following plants were found: pine, larch, birch, as well as common willow and sedge, which indicate the Late Glacial. The date 11,270 ± 130 BP (IGSB-1350) was obtained from the top of the peat layer, while the bottom of this unit was dated at 4,940 ± 460 BP (IGSB-1352). This second date is surely rejuvenated (possibly by the tree roots growing in the river bank).

Within the depositional sequence of the Za 2B site, situated 41 m far from the Za 2A site, silts with apparent clayey horizon of steely-gray color (gleization at the level 1.10–1.32 m) pass into sands at the depth of 2.47 m. The sand unit reaches the depth 6.10 m, and overlies the gravel unit. The lack of peat layer, probably eroded, is characteristic for this sequence. Nevertheless, within the sand unit, at the depth of 3–6 m eight horizontally oriented tree trunks were found. Three trunks were dated using the dendrochronological method. The oak trunk U_ZARZ3 (no. 3) buried at the depth of 3.5 m was felled after 589 AD, the elm trunk U_ZARZ5U (no. 5) at the depth of 4 m — after 588 AD, while the alder trunk U_ZARZ4A (no. 4) — after 596 AD (see Tab. 4, Fig. 8). Therefore, the sand series bearing tree trunks represents the phase of frequent floods and tree felling at the end of the 6^{th} century, distinguished in the Upper Vistula valley, e.g. in the sites of Wolica and Kujawy near Cracow (Kalicki and Krąpiec 1995).

In 2007 eleven boreholes were drilled along the transect of the length of 1,350 m, transversal with respect to the Za 2A–Za 2B sites in Zarzecze village (Fig. 5). Within the structure of the terrace 6 m high, several cuts and alluvial fills of different age have been distinguished (Fig. 10). The oldest unit of these fills, overlying gravel series, is represented by peat and clay sediments of the oxbow lake, which are outcropped within the Strvyaž riverbed. They were drilled in the boreholes Za 7, Za 8 and Za 1 situated south of the Za 2B site. In the log of Za 7 borehole, drilled less than 20 m far from this site, under the sand unit, at the interval 5.05–5.60 m clays occur. Lower unit (interval 5.60–6.35 m) is represented by peat containing tree pollen grains (from 87% up to nearly 100%), characteristic of the Late Glacial, as follows: pine, stone pine, larch, spruce, birch etc. The dating of the peat unit bottom in the Za 7 borehole log at 12,655 ± 220 BP (IGSB-1352) and its top at 11,415 ± 200 BP (IGSB-1351) confirms the result of the palynological analysis and indicates that the oxbow lake was filled up during the Bølling and the Alleröd Interstadials. The similar date was obtained from the peat unit top at the Za 2A outcrop (situated in the river bank). In the log of Za 8, drilled 40 m south of the outcrop the thickness of clay cover (above the peat unit) increases up to 1.8 m. In turn, in the borehole log of Za 1, drilled 120 m far from the outcrop, the clay unit is absent, while the sequence comprises the peat unit dated at 11,385 ± 260 BP (IGSB-1347) overlain by sands containing wood fragments. These wood fragments were dated at 1,860 ± 85 BP (IGSB-1347) within the lower section of this unit and at 1,635 ± 60 BP (IGSB-1348) within its upper

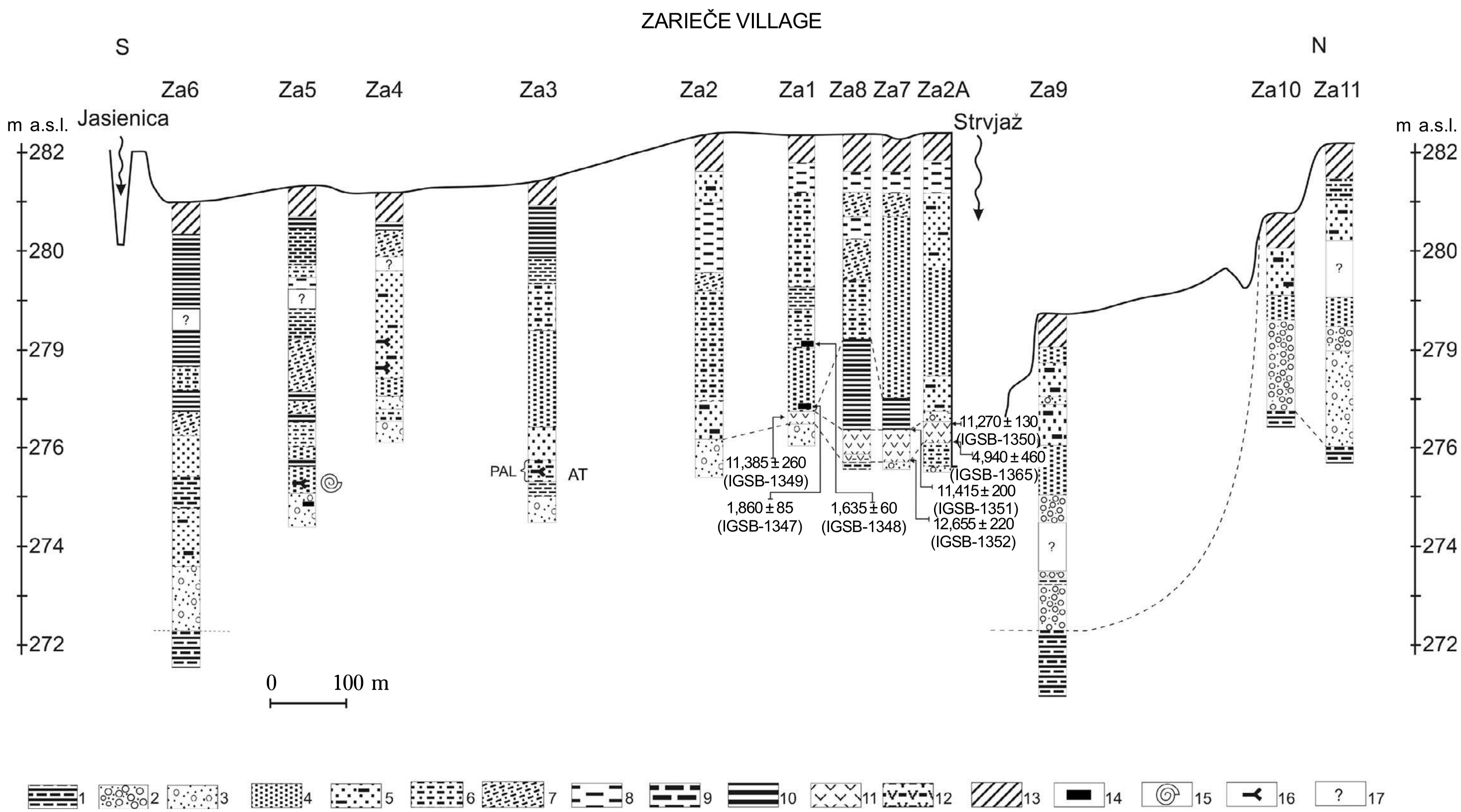

Fig. 10. Cross-section of Strvyaž valley floor in Zarieče village with numbers of drilling (elab. by P. G ę b i c a). 1 — Miocene clay, 2 — gravel with sand, 3 — sand with gravel, 4 — sand, 5 — silty sand, 6 — mud with sand, 7 — sandy silt, 8 — silt, 9 — clayey mud, 10 — clay, 11 — peat, 12 — organic mud, 13 – soil, 14 – fragment of wood, 15 – shells, 16 – organic detritus with palynological analysis (suggested age — Atlantic period — AT), 17 — lacking fragment of core

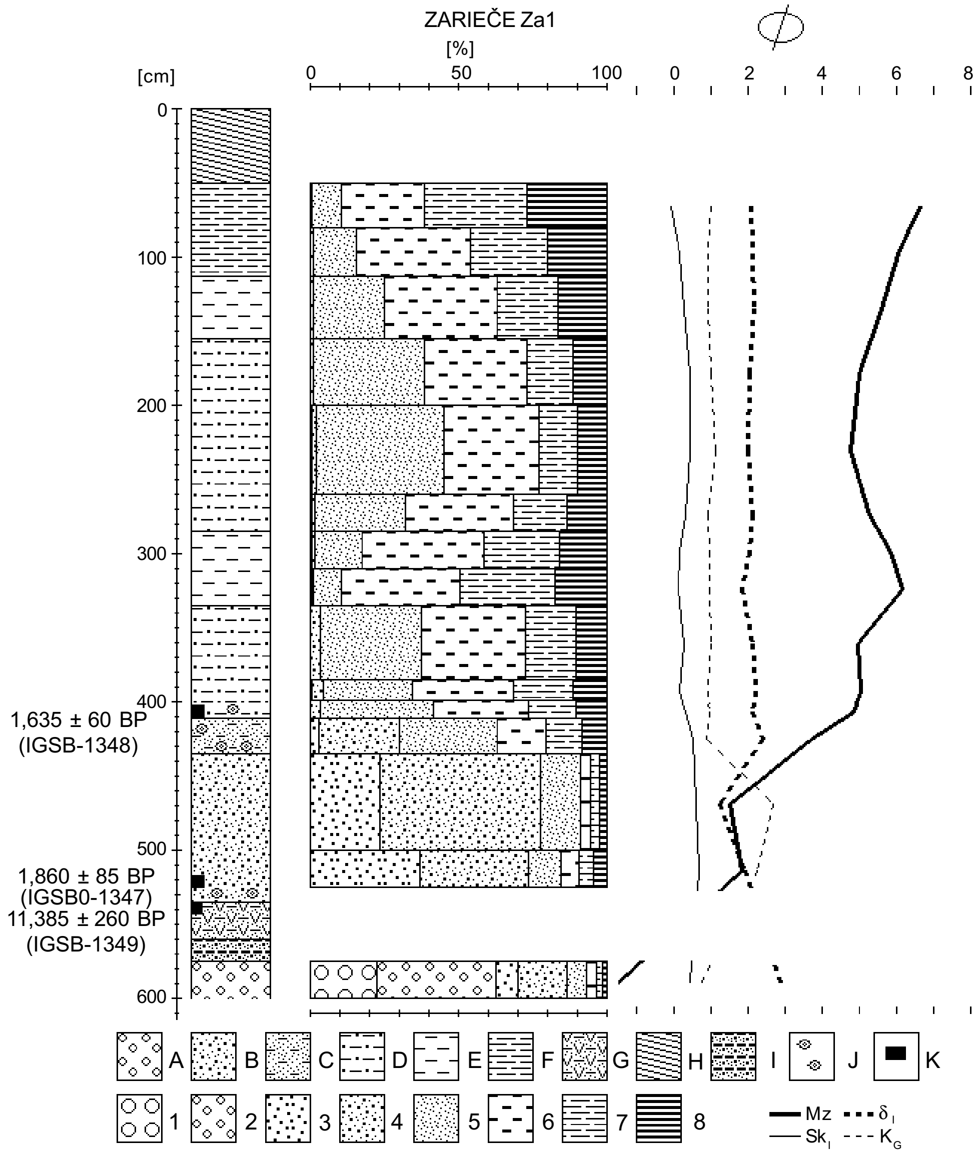

Fig. 11. Grain size composition and Folk-Ward's grain size distribution patterns at Zarieče village Za 1A profile (elab. by P. Gębica and D. Płoskonka). Sediments: A — gravels, B — coarse sand, C — loamy sands, D — sandy loam, E — loam, F — silt. G — clayey peat, H — soil, I — sands interbedded with clay, J. tree trunks or fragment of wood, K. ^{14}C dates. Fractions: 1 — coarse gravels (above –4 φ), 2 — gravels (–1– –4 φ), 3 — coarse sand (–1–1 φ), 4 — medium sand (1–2 φ), 5 — fine sand (2–4 φ), 6 — coarse and medium silt (4–6 φ), 7 — fine silt (6–8 φ), 8 — clay (under 8 φ), Mz — mean size in φ, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

part (Fig. 11). The sand unit represents alluvial fill deposited during the Late Roman Period, synchronic with the bottom part of the Jazy III sequence. Above the sand unit layers of overbank silts and sandy silts, with the clayey silts in the top occur. In the Za 3 borehole log, drilled at the distance 540 m from the Za 2A site, out of the natural levee, sandy-silt sediments at the depth interval 5.60–6.20 m contain organic material and small amount of pollen grains of pine, lime, birch as well as synantropic plants, which can indicate the Atlantic Phase. They lie 1 m deeper than the top of the Late Glacial peat unit, which suggests the occurrence of the deep trough filled with the alluvia of the Atlantic Phase. About 350 m to the south of Za 2B site, in the Za 5 borehole log, in the intervals 5.70–5.95 m and 6.05–6.15 m sands and silts containing organic detritus, wood fragments and snail shells occur, similarly to the Za 3 borehole log. In the log of Za 6 borehole situated on the Jasienica stream, below clays and silts with charcoal fragments (interval (3.20–3.35 m) of the sequence upper part, sands and gravels occur, overlying Miocene clays at the depth of 8.30 m.

On the left bank of the Strvyaž river, around 100 m to the north of the Za 2B site (outcrop abundant in tree trunks) in the Za 9 borehole log situated at the ledge of 3 m high floodplain, the upper section of the sequence (up to 3.5 m) is represented by sands, while the lower section is formed of gravels lying upon Miocene clays at the depth of 6.05 m. In the borehole log of Za 10 situated at the terrace (5 m high) uppermost sands reach the depth of 2.8 m. It is underlain with gravel composed of pebbles 4–5 cm in diameters, which lies upon Miocene clays at the depth of 3.80 m. It proves the existence of the erosional socle probably older than the Holocene.

ZARIEČE CLAY PIT

Different structure of the valley floor is exhibited in a clay pit situated 1.5–2 km east of the transect of the Zarieče village site (Fig. 5). Clays up to 3 m thick outcropped in the northern part of the pit were described in 2006. In the outcropped sequence two horizons of black clays separated with gray clays displaying gleization, deposited within the flood basin, far from the Strvyaž riverbed. The organic matter taken from the lower black clay horizon was dated at 6,310 ± 170 BP (Ki-13396) (G ę b i c a et al. 2008).

In 2007 the western face of the pit was sampled for the micromorphological analysis. In the upper part of the sequence (as deep as 1 m) the bioturbation structures were observed. Inside the channels fragments of fresh root appear. In the groundmass the partially or completely decomposed plant tissue occurs. The character of the sediments was conductive to the development of oxidation-reduction processes, which resulted in formation of iron and manganese-iron nodules and hypocoatings as well as amorphous concentrations of iron within the groundmass (Tab. 5). Commonly in thin sections occurs the rounded forms of vesicles, according to M. I. G e r a s i m o v a et al. (1992), developed

Table 5

Micromorphological features of Zarieče clay pit (A. Budek)

Depth [cm]	Mineral composition		Microstructure	Voids	Pedofeatures			
	Coarse material	Fine material			Nodules	Coatings and hypocoatings	Infillings and other features	Organic features
0–40	small, rough quartz grains, small fragments of muscovite-shist, single:, feldspar, glaukonite, secondary calcium carbonates	brown gray, unsorted silty clay, c/f limit = 2 μm c/f ratio = 20/80, b-fabrics speckled	vughy microstrusture	vughs, channels, cracks	iron and iron-manganese nodules; typic, geodic, pseudomorphic	iron hypocoatings	dense complete infillings	fresh root fragments tissue residues
40–87	single quartz grains	reddish gray clay, c/f limit = 2 μm c/f ratio = 5/95, b-fabrics porostriated	crack and channel	cracks, channels, voids	iron and manganese nodules: compound impregnative, disjointed and aggregate	iron and clay hypocoatings	loose discontinuous infillings	tissue residues, excrements
87–120	small quartz grains, plagioclase, muscovite-schist, glaukonite	reddish, brown and black silty clay, c/f limit = 5 μm c/f ratio = 20/80, b-fabrics porostriated	prismatic	planar voids, channel	iron and manganese amorphous and cryptocrystaline nodules: compound impregnative, disjointed and aggregate	iron coating and hypocoatings	infilling channels by coarse mineral material, loose discontinuous and dense incomplete infillings	tissue residues
120–145	small quartz grains, plagioclase, muscovite-shist, glaukonite	reddish, brown silty clay, c/f limit = 5 μm c/f ratio = 20/80, b-fabrics porostriated	prismatic	planar voids, channel, cracks	iron and manganese amorphous and cryptocrystaline nodules: compound impregnative, disjointed	iron coating and hypocoatings	loose discontinuous and dense incomplete infillings	tissue residues

Table 5 cont.

Depth [cm]	Mineral composition		Microstructure	Voids	Pedofeatures			
	Coarse material	Fine material			Nodules	Coatings and hypocoatings	Infillings and other features	Organic features
145–210	single quartz grains	reddish gray clay, c/f limit = 2 µm c/f ratio = 5/95, b-fabrics speckled	cracks in the upper part of thin section and channel in the bottom	cracks, channel, vughs	iron and manganese amorphous and cryptocrystaline nodules: compound impregnative, disjointed	iron hypocoatings	loose discontinuous and dense incomplete infillings	root fragments, tissue residues, excrements
210–260	single quartz grains	reddish gray and dark brown clay, c/f limit = 2 µm c/f ratio = 10/90, b-fabrics speckled	crack and channel	planar voids, channel, cracks	iron and manganese amorphous and cryptocrystaline nodules: compound impregnative, disjointed	iron-manganese coatings and hypocoatings	loose discontinuous and dense incomplete infillings	amorphous organic matter, tissue residues, excrements
260–295	single quartz grains	reddish gray and dark brown clay, c/f limit = 2 µm c/f ratio = 10/90, b-fabrics speckled	crack and channel	planar voids, channel, cracks	iron and manganese amorphous and cryptocrystaline nodules: compound impregnative, disjointed	iron-manganese coatings and hypocoatings	loose discontinuous and dense incomplete infillings	root fragments, tissue residues
295–320	single quartz grains	dark brown and black clay, c/f limit = 2 µm c/f ratio = 5/95, b-fabrics poro and circular striated	crack and channel	cracks, channels, voids	iron and manganese amorphous and cryptocrystaline nodules	iron-manganese coatings and hypocoatings	loose discontinuous and dense incomplete infillings	amorphous organic matter, tissue residues, excrements

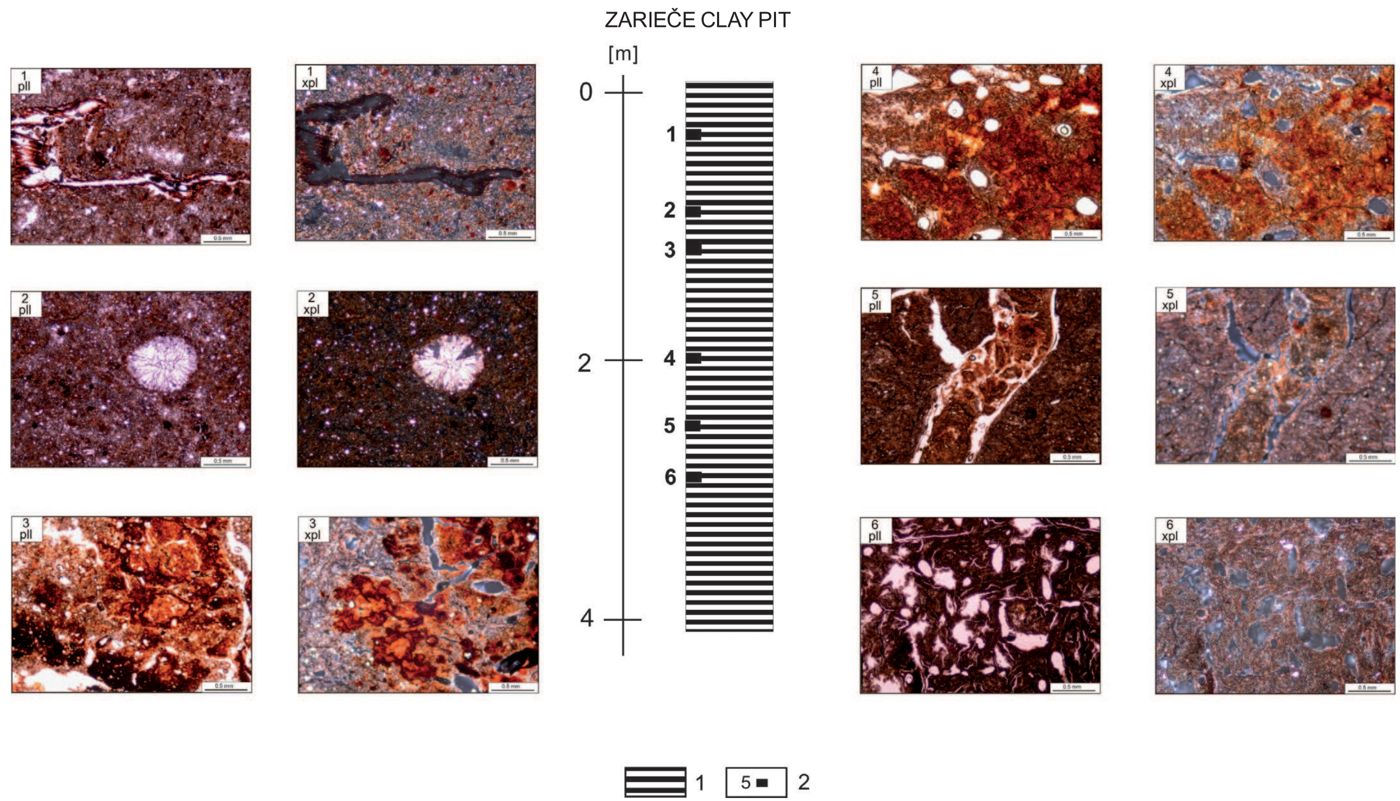

Fig. 12. Micromorphological features of Zarieče profile (elab. by A. Budek). Sediments: 1 — clay, 2 — micromorphological samples. Micromorphological photos: 1 — decomposed organic matter in channel, depth 0–40 cm, 2 — secondary calcium carbonates, depth 40–87 cm, 3 — iron and iron manganese impregnation of groundmass, depth 120–145 cm, 4 — iron impregnation of groundmass and round voids, depth 145–210 cm, 5 — dense incomplete infillings, depth 210–260 cm, 6 — amorphous organic matter and round voids, depth 295–320 cm, pll — picture in plain polarized light, xpl — picture in cross polarized light

in water saturated deposits as air bubbles. These features (concentration of iron and vesicles) proved that the soil developed in semihydrogenic environment as gleysol (Fig. 12).

The transect with four boreholes was located along the line running close to the Zarieče clay pit (Figs. 5 and 13). In the log of Zg 2 borehole, drilled close to the Strvyaž riverbed the structure of the natural levee deposits is observed. At the depth of 3.7 m, the top of dark steely-gray clays and clayey silts deposited in the flood basin was dated at 6,490 ± 680 BP (IGSB-1353). Therefore, the clay unit is synchronic with similar clay sediment in the clay pit. Within the commented sequence (Zg 2 log) under the clay and silty clay units, in the depth interval 5.3–7.0 m sands and silts of the overbank facies occur. They contain pollen grains of pine, birch, stone pine and larch, which indicate their deposition during the cool phase of the Late Glacial (Younger Dryas?). It is confirmed by the dating of wood fragments occurring within sands with gravels at the interval 9.05–9.15 m. They were dated at 11,400 ± 375 BP (IGSB-1346). The location of the dated sediments 1.5–3.5 m below the current Strvyaž riverbed indicates deep paleochannel filled with the channel sediments of the Late Glacial.

On a plain of the Jasienica stream (south of the clay pit) the Zg 4 borehole drilled clays at the top and, below it, sandy silts and sands (Fig. 13) containing pollen grains of trees and synantropic plants. This lower unit at the depth of 5.5 m is dated at 4,250 ± 145 BP (IGSB-1363) and at the depth of 5.63 m at 2,950 ± 375 BP (IGSB-1364). The Subboreal phase is also probably represented by the alluvial fills on the left side of the Strvyaž river (Zg 3 borehole), where rare pollen grains of pine, fir, birch, alder, hazel and oak as well as cereals were found at the depths of 6.55 and 6.85 m.

Recapitulating, several types of sediments have been recorded in Zarieče village, clay pit and boreholes (Zg 2, 3, 4): paleochannel fills overlying gravels at the level of riverbed and attributed to Bølling and Alleröd Interstadials as well as channel sediments and overbank silts probably representing Alleröd-Younger Dryas, and filling the paleochannel as deep as 3 m below the current Strvyaž riverbed. The Late Glacial sediments are overlain with the unit of flood-basin clays of the Atlantic age, which are covered by the younger natural levee sediments. Within the basin of the Jasienica stream younger fills, representing the Atlantic and Subboreal phases were recorded. The youngest fill of sand sediments forming now the natural levee should be probably related to the flood phase of the Roman Period, while the nested fills bearing tree trunks at the Zarieče village site represent the phase of frequent floods between the 5^{th} and 7^{th} centuries AD.

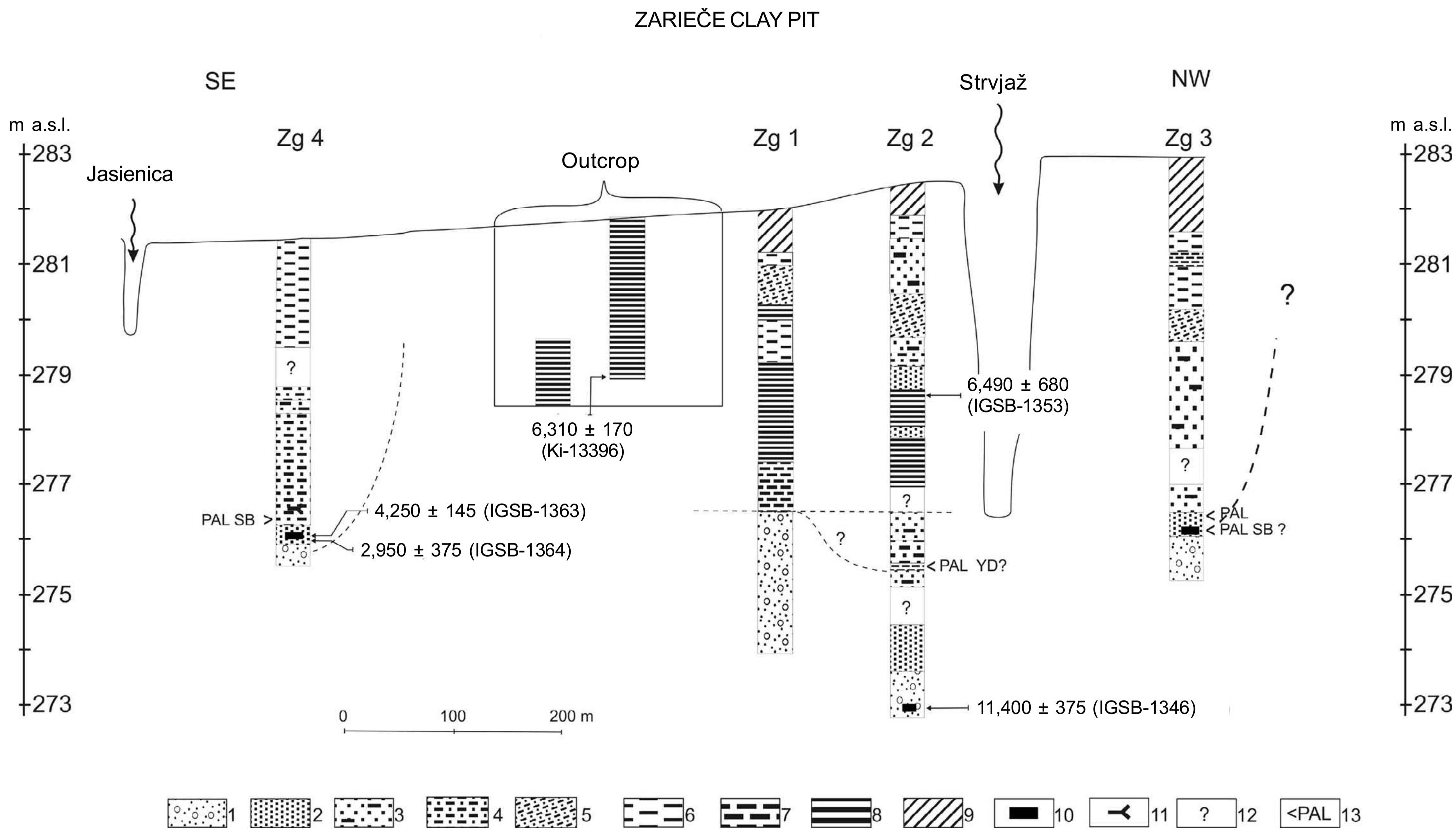

Fig. 13. Cross-section of Strvyaž valley floor in Zarieče clay-pit with numbers of drilling (elab. by P. Gębica). 1 — sand with gravel, 2 — sand, 3 — silty sand, 4 — mud with sand, 5 — sandy silt, 6 — silt, 7 — clayey silt, 8 — clay, 9 — Holocene soil, 10 — fragment of wood, 11 — organic detritus, 12 — lacking fragment of core, 13 — plynological analysis (suggested age — Younger Dryas — YD, Subboreal – SB)

STRATIGRAPHY OF HOLOCENE ALLUVIA AND CORRELATION OF FLOOD PHASES

The oldest sediments within the Strvya river valley are represented by peats and paleochannel clays found at the Zarieče sites and attributed to the Bölling-Alleröd Interstadials (12,600–11,200 BP).

During the Alleröd and Younger Dryas alluvia filled up the deep paleochannel covered by clays deposited within the flood basin at the Zarieče clay pit site during the Atlantic Phase (6,400–6,100 BP). The flood sediments of the Atlantic-Subboreal phases dated at 4,200 and 2,950 BP and cereals pollen grains are represented by the fills nested in the plain of the Jasienica basin (Fig. 14).

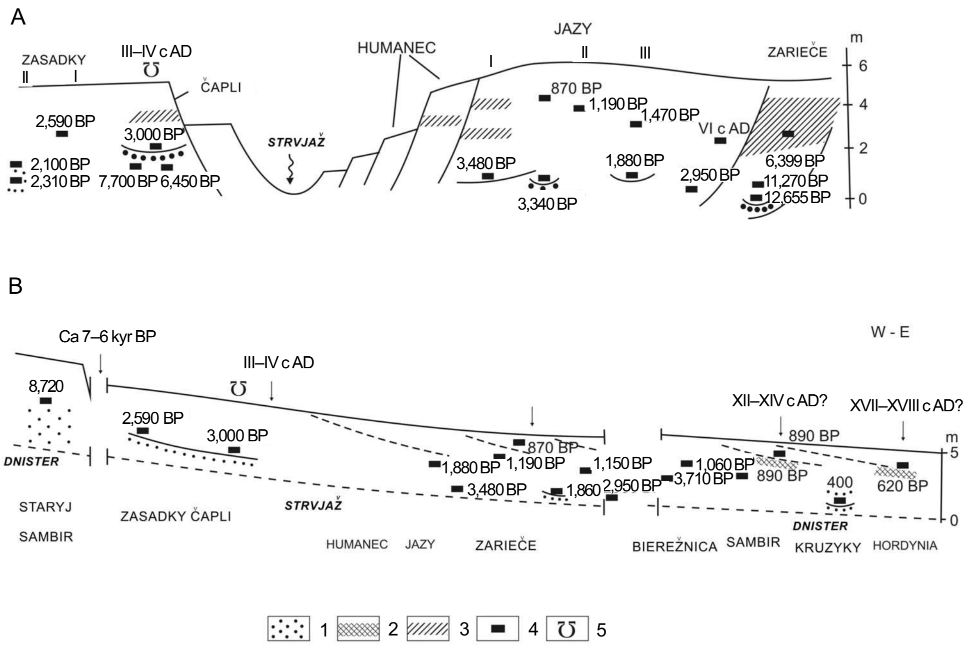

Fig. 14. Schematic transversal (A) and longitudinal (B) profiles of 5–6 m terraces along the lower section of Strvyaž river. On longitudinal profile the corresponding reaches of Dnister valley are added (elab. by L. Starkel). 1 — gravels of channel facies, 2 — peat, 3 — clayey or gley horizons, 4 — ^{14}C dates, 5 — archeological artefacts

Closer to the Strvyaž valley axis (sites Čapli and Jazy), under the 2.5–5 m thick unit of the overbank sediments the fills of paleochannels and subfossil tree trunks occur. They are attributed to the flood phase within the time interval 3500–3000 BP. At the Zasadky site a unit of channel gravels bears numerous trunks deposited during frequent floods between 2,300 and 2,100 BP, at the beginning of the Subatlantic phase. In turn, the depositional sequences with tree trunks at the Jazy sites on the Strvyaž river bank evidence the phase of frequent floods connected with tree felling and filling up of the paleochannels between 1,880 and 1,470 BP (Jazy III). The sequences at the Zarieče village site represent deposition of flood clays containing tree trunk dated at 1,190 BP as well as overbank silts and sands deposited above the tree trunk dated at 870 BP (Jazy II). This last date indicates that the uppermost cover of sandy silts has been deposited since the 11th century.

Parallel research works in the Dnister valley proved that during the Middle Ages (9th–10th centuries) the gravel floodplain 3–4 m high was formed at the Bierežnica site (date 1,060 ± 40 BP), at the Kružyky I site the oxbow-lake sediments were covered by flood sediments after 890 ± 70 BP, while at the Hordynja site, close to the Strvyaž river mouth, the peat was covered by overbank silts about 620 ± 110 BP (J a c y š y n et al. 2006). Deforestation and acceleration of agricultural activity since 14th–15th centuries reinforced deposition of the overbank sediments recorded within the depositional sequence of the terrace (5 m high) at the Kružyky IV site with the oak trunk buried in the alluvia at the riverbank level (date 400 ± 35 BP). It is accurately correlated with the dendrochronologically dated sequence of tree trunks felled or cut during the whole 14th century and buried in the alluvia of the Wielky Łukavec stream (tributary of the Bystrycia Sołotvinska river) near the Starunia village (A l e x a n d r o w i c z et al. 2005). The cutting of the alluvial plain (5–6 m) progressed synchronically, because the floodplain (1–3 m high) of the Strvyaž valley are devoid of characteristic gley horizons and paleosols, known from the terrace 5–6 m high, formed in the earlier phases.

The observations in the lower section of the Strvyaž river valley, although based on fewer sites than in the upper Vistula river valley and the Wisłoka river valley (S t a r k e l ed. 1981; S t a r k e l 1995; K a l i c k i 1991; S t a r k e l et al. 1996), indicate synchronicity of the phases of frequent floods, river avulsions and accelerated deposition in the valleys of the upper Vistula river and the upper Dnister river. The dated sites evidence the occurrence of separated cuts and fills and systems of paleochannels within the main level of the alluvial plain of the Strvyaž river valley. These forms are accurately correlated with the ones defined in the upper Vistula river valley (S t a r k e l et al. 1996; S t a r k e l 2001). Apart from the lowermost Late Glacial series, the following phases of accelerated fluvial activity and the frequent floods have been distinguished in the Strvyaž river valley: 3,500–3,000 BP, 2,200–1,700 BP as well as 5th–7th centuries and 14th–17th centuries AD. The terrace both of the Strvyaž and Dnister valleys, which is 5–6 m high, was eroded in various segments in different times, so it is diachronic. Later and later erosion progressing downstream the Strvyaž as well as Dnister valleys in the area of Sambir town (Fig. 14) suggests that the morphological contrast between the outlets of mountain valleys and the Upper Dnister Basin with extensive peat-bogs can be partially generated by the neotectonic movements: uplift of the Eastern Carpathians and relative deepening of the basin.

The distinct contrast is discernible between the granulometric composition of the overbank alluvia and the deposition rate of the alluvia accumulated during the phases which were controlled by climatic changes and those accumulated during the periods of human activity (see Kalicki 1991; Starkel 2005). This contrast of the sedimentation probably is reflected also in the formation of gley horizons as well as in fossilization of peat horizons and paleosols (Budek 2007).

ACKNOWLEDGEMENTS

The researches in 2006–2008 were performed within the frame of project granted by the Polish Committee of Scientific Research (KBN) no 2P04E027 29: "Stratigraphy of alluvia and phases of Holocene floods within the drainage basins of the San river and the upper Dnister river (based on the sedimentological, dendrochronological and radiocarbon methods)" realized by the authors of this paper. The authors wish to express their special thanks to Prof. Anna Pazdur, director of the Radiocarbon Laboratory of the Silesian University of Technology in Gliwice, dr. Nikolay Kovalyukh from the Radiocarbon Laboratory of the Ukrainian Academy of Sciences in Kiev and dr Nikolay Mikhailov from the Radiocarbon Laboratory of the Belarussian Academy of Sciences in Minsk for the radiocarbon analysis. We would like to thank also to MSc. Dominik Płoskonka from the Department of Geomorphology and Hydrology of Mountains & Uplands, Institute of Geography and Spatial Organization, Polish Academy of Sciences in Cracow for the analysis of granulometric composition as well as Dr Małgorzata Nazarkiewicz from the Department of Soil Sciences, Environmental Chemistry and Hydrology, Rzeszów University for the chemical analysis.

The graphic preparation of some figures was performed by MSc Dariusz Niemasik from Rzeszów, while translation into English was done by Dr. Jan Urban from the Institute of Nature Conservation, Polish Academy of Sciences in Cracow. We also acknowledge the active participation in the fieldwork of MSc. Dariusz Wieczorek from Kielce and students: Marek and Łukasz Gębica from Rzeszów.

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