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LANDFORM EVOLUTION IN MOUNTAIN AREAS

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YOUNG HOLOCENE ALLUVIA AND DENDROCHRONOLOGY OF SUBFOSSIL TRUNKS IN THE SAN RIVER VALLEY

Abstract. In the San river valley the Holocene terrace, 5–7 m high, is formed of the alluvial sediments containing subfossil tree trunks. The alluvia with tree trunks of the Holocene terrace at the Ostrów and Wysock sites were dated by radiocarbon method at 3,400–3,100 BP (1600–1400 cal BC). They determine the phase of flood deposition in the San valley, which is connected — apart from the climatic reasons — with the colonization attributed to the Lusatian Culture period (1700–1100 BC). Break of the flood deposition noticed about 2,300 BP (400 cal BC) at the Ostrów site is marked by the paleosol level occurring at the bottom of the overbank alluvia. Oak trunks buried by the pointbars of the San paleochannel at the Radymno site were characterized by apparent traces of the cutting and processing by prehistoric man. Dendrochronological dating of these trunks proved that they were cut during the 3rd and 4th centuries AD and this process was connected with the colonization of the Roman Period.

Key words: San river valley, Holocene alluvial sediments, subfossil tree trunks, dendrochronology

INTRODUCTION (OBJECTIVES, METHODS AND STUDY AREA)

The study performed in a frame of the research project of the (Polish) State Committee for Scientific Research No 2P04E 02729, for the last a few years have been concentrated on the Young Holocene alluvia of the San river valley and the dating of subfossil tree trunks. Part of the analyzed tree trunks have apparent traces of cutting by prehistoric man. The assemblages of major number of subfossil trees at the studied sites gave unique opportunity to the dating of tree felling phases and to determine the stratigraphy of the Holocene alluvia.

The tree felling phases identified in the San river valley were compared with the flood phases observed in the Vistula and Wisłoka river valleys (Starkel 1995; Starkel et al. 1996; Kalicki and Krąpiec 1996; Kalicki 1996). In the Young Holocene they could be correlated, apart from the climatic reasons, with the phases of intensified colonization and deforestation in the valleys of Carpathian tributaries of the Vistula river during the period of the Lusatian Culture, Roman Period and the Middle Ages.

The study area covered the Carpathian-Foothill (Pogórze Karpackie) section of the San river valley, where several gravel pits are situated; the largest one is located in Ostrów village near Przemyśl town. Contemporarily, the lowland section of the San river valley within the Sandomierz Basin (Kotlina Sandomierska) between Przemyśl and Jarosław towns, was surveyed, where the gravel pits in Radymno and Wysock villages are located. Detailed observations were conducted in three selected sites: Ostrów, Wysock and Radymno, in which the largest numbers of tree trunks within the alluvial sediments were found.

During the field works the geological outcrops and, especially, the position of tree trunks in sediments were described. The field works were supplemented by analysis of archival borehole descriptions available in the Przedsiębiorstwo Eksploatacji Kruszywa "Kruszgeo" in Rzeszów town. In order to radiocarbon dating of the alluvia 13 samples of the tree trunks were taken, while the overbank sediments were dated by analysis of one sample of the charcoal fragments and one sample of paleosol. These samples were analyzed in the Radiocarbon Laboratory in Kiev. During the field survey 58 wood slices of subfossil tree trunks were taken (using a gas-engine saw) for dendrochronological analysis carried out in the Dendrochronological Laboratory of the AGH University of Science and Technology in Cracow.

FORMER RESEARCHES

The occurrence of black oaks within the San river valley alluvia was mentioned by A. Łomnicki (1900) at the beginning of the 20th century in the description of the first Geological Map of Galicia Region. L. Starkel (1960) described many outcrops of the floodplain sediments downstream from Przemyśl town (e.g. in Hurko and Torki villages) represented by gravel alluvia containing subfossil tree trunks which were to be deposited in the Atlantic phase. Within the series of channel sediments (bearing tree trunks) of the Atlantic phase the younger, Subatlantic sand alluvia were inserted, which subsequently were aggraded by overbank sediments (alluvial loams). A. Szumański (1986) dated wood fragments and subfossil tree trunks taken from several depositional sequences located in the lower section of the San river valley, e.g. in the vicinity of Leżajsk town as well as Łazów, Przędzel and Tarnawiec villages. A few radiocarbon datings obtained by A. Szumański (1986) from the wood samples under the two-partite overbank sediments (madas) of the Holocene terrace, at the depth of 3–5 m represent the Atlantic and Subboreal phases as well as Middle Ages. In the 90s of the 20th century the studies of Late Glacial and Holocene evolution of the river valleys within the drainage area of the upper Vistula river were focused on the sites with tree trunks found in the Vistula river valley near Cracow and in the Wisłoka river valley (Kalicki and Krąpiec 1996; Starkel 1995; Starkel and Krąpiec 1995; Starkel et al. 1996). During these

researches wood samples were taken from the gravel pits in Krzemienna, Ostrów and Radymno in the San river valley and used for dendrochronological analysis, but most of them were dated only relatively against a floating chronology (Krąpiec 1996).

DESCRIPTION OF SITES, RESULTS OF DATING

OSTRÓW GRAVEL PIT

The gravel pit in Ostrów village is situated 5 km to the west from the center of Przemyśl town in the area of the Dynów Carpathian Foothill (Pogórze Dynowskie). Within the faces of this pit, several hundred meters long and 2.5–5.5 m high, the depositional sequence of the San river Holocene terrace (5–6 m high) is outcropped. The terrace framed by the San river loop is up to 1 km wide (Fig. 1A). On its surface next to the valley slope the straight-line paleochannel sections of the San river are discernible, while the remnants of smaller paleomeanders are preserved to the west of the terrace margin. The lower part of the valley floor is covered by narrow (100–200 m) ledge of the floodplain of the height 3–4 m above river. The studied segment of the plain (formed of the alluvia containing tree trunks) is situated south of the currently abandoned pits, in which six samples for dendrochronological datings were taken in the 90s of the 20th century (Krąpiec 1996). The trunks were dated against floating chronology and their location within the sediments is difficult to determine, now.

In the transversal cross-section of the valley the series of gravel-sand alluvia 4–12 m thick and bearing tree trunks fills the San river valley, which is eroded in the flysch shales. The gravel-sand unit is overlain with silty sands and alluvial clays 3.0–4.7 m thick (Fig. 1B, 2A). During the field survey in 2006–2007 the eastern face of the pit was described and the trunks situated within the alluvia at the level of water table (depth of 5.5–6.0 m) were sampled for radiocarbon analysis. Several samples were also taken from the tree trunks excavated due to gravel

Table 1

Results of analysis of oak trunks excavated at the Ostrów site

Lab. code	Description of samples	Number of rings	Sapwood	Dating of sequence	Radiocarbon dating
OS7	trunk fragment	133	—	#1–133	7,160 ± 60 BP (Ki-15325)
OS8	trunk fragment	132	—	#6–137	
OS9	trunk	98	—		7,980 ± 80 BP (Ki-15267)
OS10	trunk	89	—		
OS11	trunk	74	—		
OS12	foot of a tree	154	—		8,660 ± 70 BP (Ki-15326)

— relative dating according to the OS-A1 chronology

A

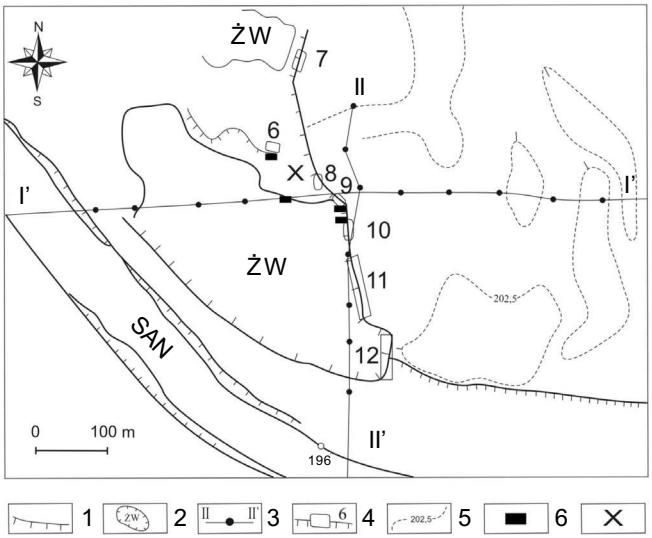

Fig. 1A. Location of studied depositional sequences and archival borehole logs in the Ostrów gravel-pit. 1 — erosional cuts and escarpments, 2 — active gravel-pit, 3 — cross-section line with archival boreholes, 4 — outcrop with alluvial sediments, 5 — contour lines, 6 — location of tree trunks dated by radiocarbon method, 7 — dumbs with tree trunks

B

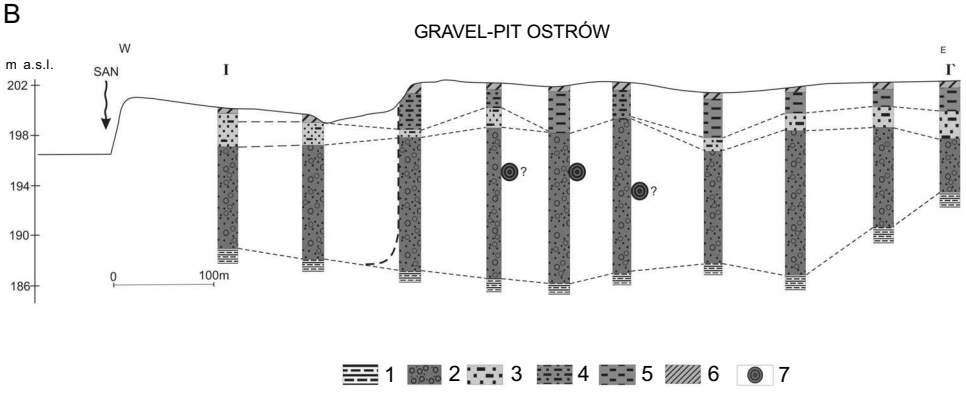

Fig. 1B. Cross-section of the Holocene terrace (5–6 m above San river) in the Ostrów gravel-pit. 1 — Pre-Quaternary substratum (flysh bedrock), 2 — gravel with sand, 3 — silty sand, 4 — sandy silts, 5 — silts (alluvial loam), 6 — Holocene soil, 7 — tree trunks

exploitation below the water table (Fig. 1A, 2B). Among the analyzed tree trunks several ones were much too old and redeposited, e.g.: pine trunk dated at 10,080 ± 80 BP (Ki-13839), elm trunk dated at 9,250 ± 70 BP) (Ki-13836) (G ę b i c a 2007). Six wood slices were taken from the excavated trunks for dendrochronological analysis. Two of them represent the same time period (Tab. 1). Radiocarbon datings of the trunks with the highest ring frequency indicate that most of them represent the 8th and 9th millenium BP, it means the Atlantic phase (Tab. 1).

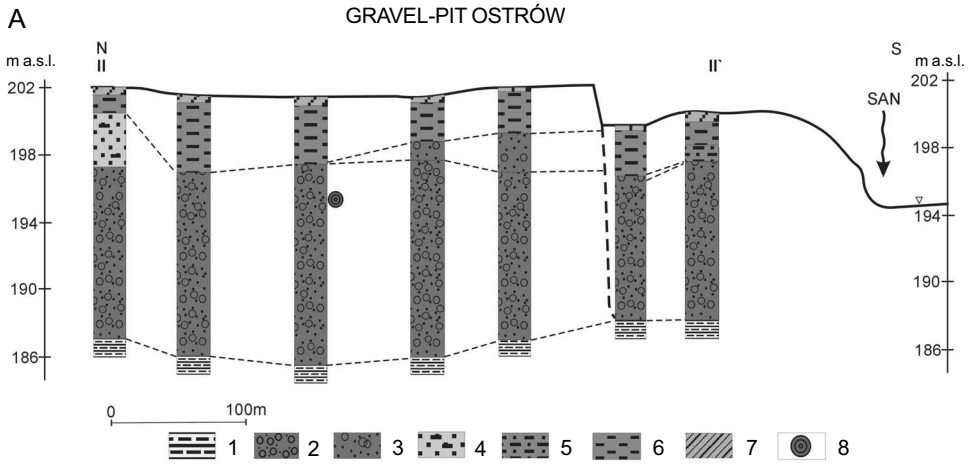

Fig. 2A. Alluvial filling of the San river valley in the Ostrów gravel-pit (location see Fig. 1A). 1 — Pre-Quaternary substratum (flysh bedrock), 2 — gravel with sand, 3 — sand with gravel, 4 — silty sand, 5 — sandy silts, 6 — silts, 7 — Holocene soil, 8 — tree trunks

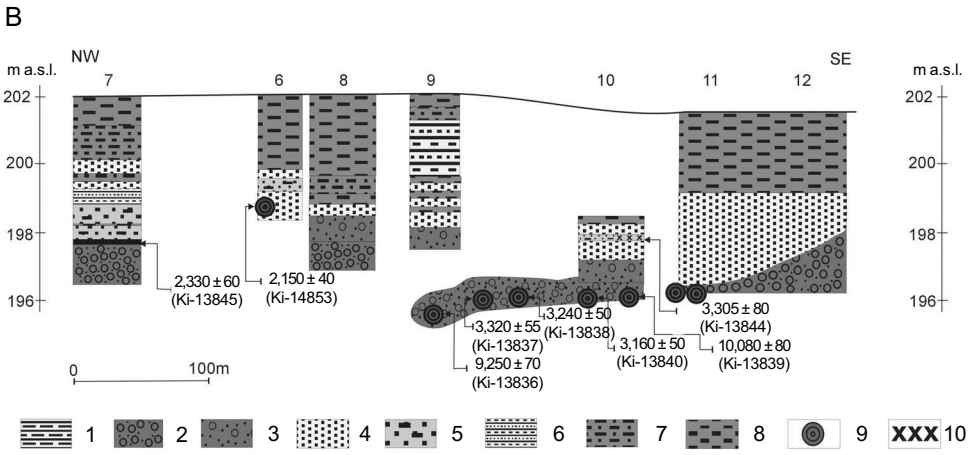

Fig. 2B. Outcrops of sequences of the alluvial sediments with tree trunk dated by radiocarbon method at the Ostrów site. 1 — Pre-Quaternary substratum (flysh bedrock), 2 — gravel with sand, 3 — sand with gravel, 4 — sand, 5 — silty sand, 6 – horizontally interbedding sands and silts, 7 — sandy silts, 8 — silts (alluvial loams), 9 — tree trunks, 10 – charcoals

At the depth of 5–6 m the younger trunks were found, as follows: ash trunk dated at 3,320±55 BP (Ki-13837), oak trunk (3 m long and 35 cm in diameter) dated at 3,240±50 BP (Ki-13838) and maple trunk (in the eastern part of the pit) dated at 3,160 ± 50 BP (Ki-13840). The meander sand pointbars occurring above this last trunk contained charcoal fragments which were sampled at the depth of 4.0 m and dated at 3,305 ± 80 BP (Ki-13844) (Fig. 2B). In the northern part of

the mentioned pit face, below bedded sandy-silty clays, at the depth of 4.3–4.5 m paleosol layer with humic horizon was found and dated at 2,330 ± 60 BP (Ki-13845). In turn, the sample of oak beam buried by sands above gravels at the depth of 3.5 m, and outcropped in the northern face was dated at 2,150 ± 40 BP (Ki-14853) (Fig. 2B).

Recapitulating, it should be postulated that within the San river valley, upstream from Przemyśl town, the segment of the Holocene terrace 5–6 m high is formed of the series of gravel-sand alluvia containing tree trunks, which were deposited by frequent floods during the period 3,300–3,100 BP (1600–1400 cal BC). Intensification of the flood activity and depositional aggradation within the San river valley in this time was probably connected with the agricultural expansion (and deforestation) in part of the San drainage area covering the Carpathian Foothill during the development of the Trzciniec and Lusatian Cultures. Formation of the paleosol humic horizon upon sands about 2,300 BP proves break of channel series deposition and stabilization of the plain, which is accurately correlated with the colonization recession attributed to the La Tene Period (2,300–2,100 BP) (Gębica 2007). Probably in this time the incision of the San riverbed connected with floods of the humid climatic phase (Starkel 2005a), and consequent aggradation of the plain by overbank sand and alluvial loams (during the floods) took place.

WYSOCK GRAVEL PIT

The gravel pit in Wysock village is situated on the right bank of the San river, 1.5 km to the northwest of the Radymno gravel pit, opposite of the Rada stream mouth into the San river (Fig. 3). It is located within the Holocene terrace 5–6 m high, bordered by apparent margins of the San paleochannel undercutting the plain 6–8 m high.

The unit of sands and sandy clays 3 m thick with gravel horizon at the depth of 1.2–1.5 m is the most characteristic structural element of the plain outcropped in the western part of the pit. Gravel and sand series 6–7 m thick, hidden below the water table at the depth of 4 m overlies the top of Miocene clays situated at the depth 10–11 m. Numerous trunks of black oaks were extracted from the gravel-sand series and stored in dumps during the exploitation works in the pit. These trunks were brown to dark brown, 4–5 m long and up to 1 m in diameter. They were sampled for dendrochronological analysis (30 samples). Some of them have traces of cutting and notching by prehistoric men. So, it is the next place in the southeastern Poland, apart from the Radymno site, where the subfossil trunks with traces of cutting were found.

The computer correlations and visual comparison of obtained dendrochronological sequences showed, that two groups of trees could be distinguished among the trunks found at the Wysock sites. These groups define two floating

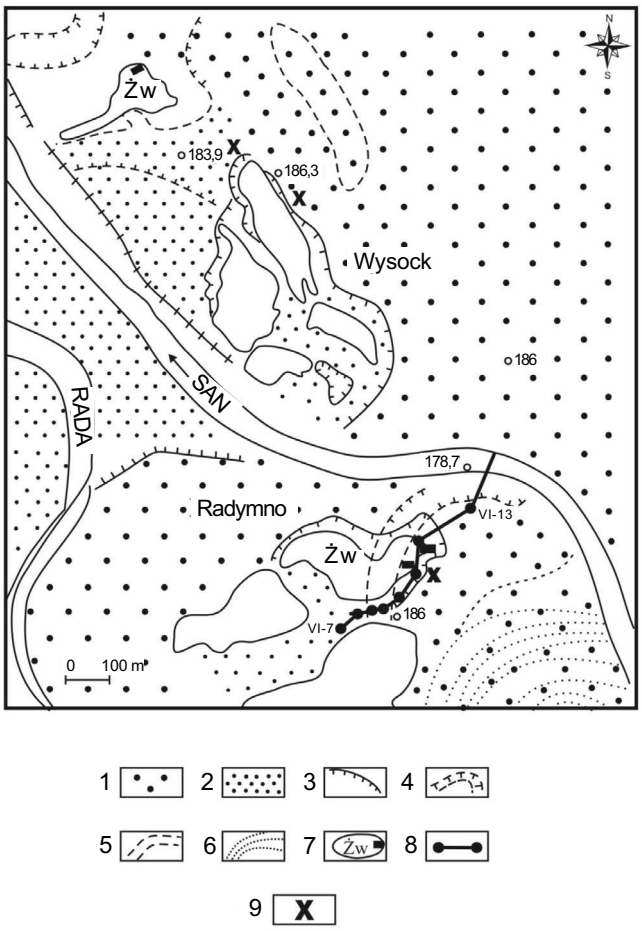

Fig. 3. Location of outcrops with subfossil tree trunks in Wysock and Radymno gravel-pits.
1 – Holocene terrace (7–8 m above river level), 2 – floodplain (5-6 m above river level),
3 – erosional undercuts and escarpments, 4 – distinct paleochannels, 5 – indistinct paleochannels,
6 – pointbars, 7 – active gravel pit with location of black oaks, 8 – cross-section line with borholes,
9 – dumps with black oaks studied by dendrochronological method

chronologies: WYS_A1 and WYS_A2 (Fig. 4). The older of them, WYS_A1 covering 262 years, spans the period ca 2700–3000 cal BC (radiocarbon dating of the inner rings of the sample WYS6 – 4,140 ± 50 BP (Ki-15262)). The younger one (WYS_A2) represents the time period ca 1400–1200 cal BC (radiocarbon dating of the inner rings of the sample WYS15 – 3,030 ± 40 BP (Ki-15322)). The next three radiocarbon datings (Tab. 2) indicate that other trunks represent similar time periods.

The analysis proves that the trunks were deposited in the alluvia by frequent floods of the San river during the Lusatian Culture colonization, similarly to the Ostrów (near Przemyśl) site during the intensive colonization of the valley

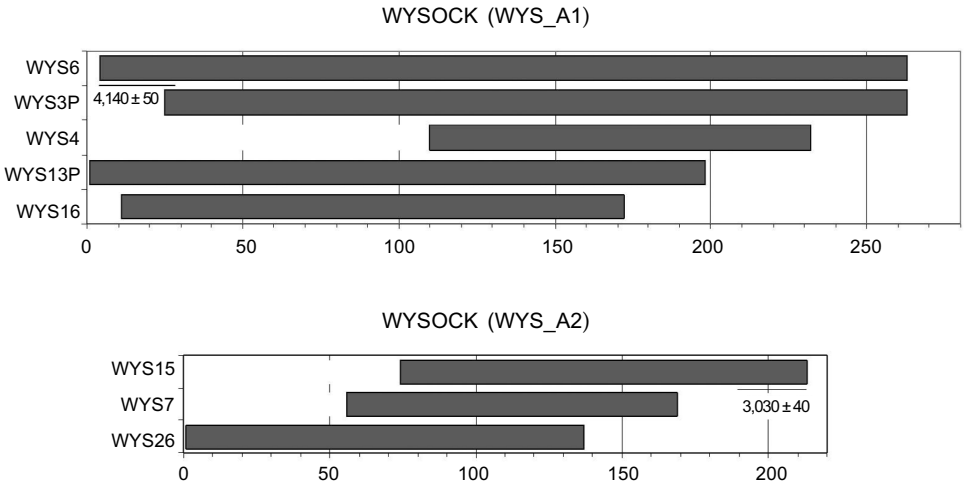

Fig. 4. Subfossil oaks from the Wysock gravel pit dendrochronologically dated — chronology WYS_A1 and WYS_A2

Table 2

Results of radiocarbon analysis of subfossil trunks excavated at the Wysock site

Lab. Code	Wood type	Number of rings	Sapwood	Radiocarbon dating
WYS8	oak	300	—	3,720 ± 40 (Ki-15383)
WYS11	oak	203	—	3,010 ± 40 (Ki-15321)
WYS12	oak	201	—	4,350 ± 50 (Ki-15263)

floor. The phase of tree felling between 3,200 and 3,000 BP (1500–1400 cal BC) was documented also in the Vistula river valley e.g. at the Wolica site near Cracow (Kalicki and Krąpiec 1996). The date about 4,000 BP can be related to the flood phase recorded in the upper San river valley in the peat-bog at the Tarnawa site (Ralska-Jasiewiczowa and Starkel 1975).

RADYMNO GRAVEL PIT

The Radymno gravel pit is situated on the left bank of the San river, 150–250 m to the south of the riverbed. Currently active pit lies north of the place when the "black oaks" were excavated during the nineties of the 20th century. These oak trunks were dated by dendrochronological method at the 4th century AD (Krąpiec 2001). The gravel pit occupies part of the Holocene terrace

6–7 m high, within which the San river paleochannel is perceivable. Its shape (Fig. 3) and original width ranging 70–110 m can be reconstructed on the basis of the geodetic maps. The San riverbed was gradually moving toward northwest, which is proved by the meander bars preserved on the plain within the inner side of the paleochannel.

The alluvial loams, 1.5 m thick, overlying laminated sand-silt overbank sediments (2 m thick) deposited during the floods, are outcropped in the pit faces. The lower part of the sequence outcropped in the pit is represented by the units of meander sand pointbars, 2 m thick, and fluvial gravels, 5–6 m thick, which overlie Miocene clays at the depth of 10–11 m (Fig. 5).

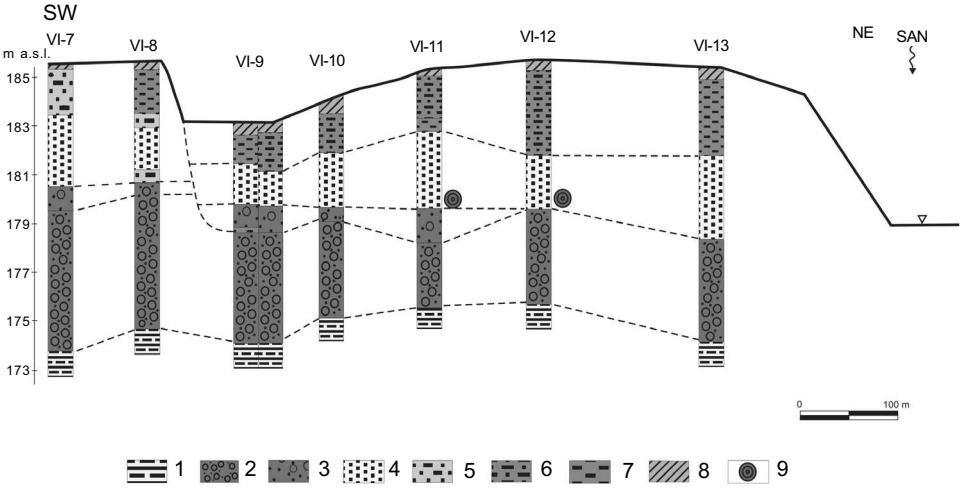

Fig. 5. Cross section of the Holocene terrace (7–8 m above San river) in the Radymno gravel-pit. 1 — Miocene clays, 2 — gravel with sand, 3 — sand with gravel, 4 — sand, 5 — silty sand, 6 — sandy silt, 7 — alluvial loams, 8 — Holocene soil, 9 — tree trunks

The subfossil trunks occurring within the alluvia were stored in a dump, where 22 wood slices were sampled for dendrochronological and radiocarbon analyses. The trunks were 4–12 m long and up to 1 m in diameter, light-brown or brown. Somewhere the sapwood was preserved. One of the trunks was 1.5 m in diameter, however its inner part was decayed. Among 22 analyzed tree trunks 7 were characterized by apparent traces of cutting and notching by prehistoric man. The dendrological sequences of the trunks display very close similarity, indicating that they grew in the very similar environment, most probably on the floodplain. They were cut during the time period of the 230s to 340s AD, while the highest number of the notched trees were cut between 260s and 270s AD (Fig. 6a).

The accumulation of the trunks with cutting traces confirms the logging of the oak forests on the San river floodplain during the period of the Roman

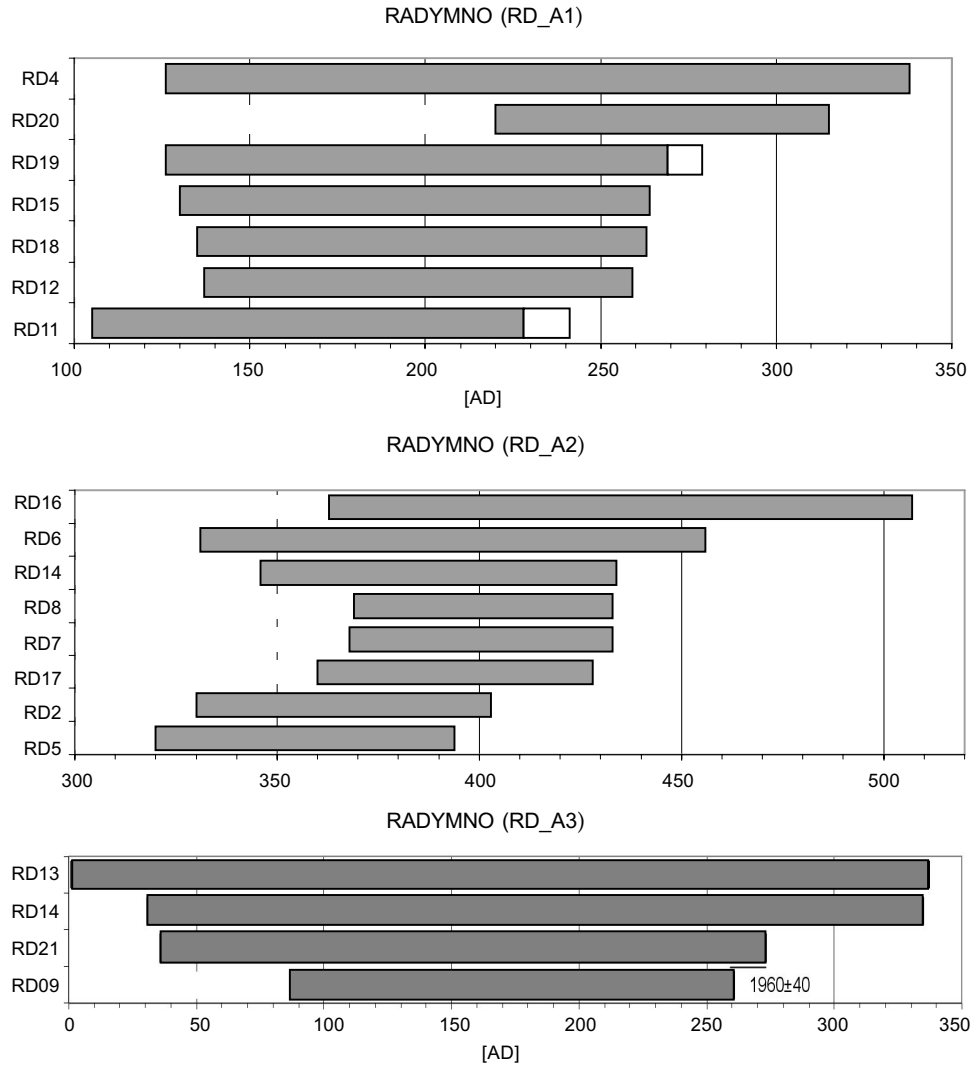

Fig. 6. Subfossil oaks from the Radymno gravel pit dendrochronologically dated — chronology RD_A1, RD_A2 and RD_A3 (sapwood diagonally hatched)

influences, which was formerly recorded at the several sites studied in the vicinity of Cracow (Kalicki and Krąpiec 1996; Starkel 2005a).

The other tree trunks found at the Radymno site (without the traces of anthropogenic processing) which were dendrochronologically dated, were deposited in the alluvia during the period between 460s and 620s AD (Fig. 6B). Among this trunk generation the most numerous group is represented by trees which felled in the first half of the 5th century, during the most recognizable phases of the trunks' deposition in southern Poland (Kalicki and Krąpiec 1996).

STRATIGRAPHY OF THE ALLUVIA AND CORRELATION OF THE FLOOD PHASES

Numerous dendrochronological analyses and radiocarbon datings of the subfossil trunks occurring within the alluvial sediments of the San river in the Przemyśl–Jarosław area make possible to identify periods of the trunk deposition. These periods can be identified with the phases of overflows and floods during which intensive lateral fluvial erosion developed.

The oldest tree trunks recorded in the Carpathian Foothill section of San river valley, at the Ostrów site were dated at the beginning of the Holocene (10,080 BP) and they are most probably redeposited (Gębica 2007). Fills of the paleochannels in the lower San river valley (Szumański 1986, Gębica et al. this volume) and aggradation of the terrace 5–8 m high in the Wisłoka river valley near Dębica town (Starkel 1995) prove high activity of fluvial processes and riverbed avulsion during this time.

Among the younger trunks several generation were distinguished. At the Ostrów site the black colored trunks with traces of mechanic erosion by fluvial (transported by river) material are relatively numerous. They are attributed to the 9th and 8th millenia BC. At the other sites trunks representing the younger flood phases recognized in other regions of Poland and neighboring areas are more numerous (Starkel et al. 1996; Kalicki 1991; Kalicki and Krąpiec 1996). Among them the following two generations should be mentioned: trunks representing the period 4,300–4,100 BP which were found at the Wysock site and trunks dated at about 3,200–3,000 BP at the Ostrów and Wysock sites. This latter generation is especially well correlated with the intensification of fluvial activity phase recorded at many sites, which are distributed on the area covering regions from western Poland (Oder river) to the Vistula river catchment area (Kalicki and Krąpiec 1991b). The break of the channel deposition and the stabilization of the floodplain at the Ostrów site about 2,300 BP is marked by the paleosol situated at the bottom of the overbank alluvia deposited during the Subatlantic phase (Gębica 2007).

The two subsequent flood and trunk felling phases were connected with the Roman Period. The first phase was controlled by the climatic changes and is attributed to the transition of the calendar epochs (BC–AD) (Starkel 1995; Kalicki and Krąpiec 1991a), while the latter, which spanned 260–270 AD, is represented by the trunks with traces of cutting and notching and was connected with human activity and deforestation of the floodplain.

The youngest tree trunks found in the study region, without traces of anthropogenic treatment (cutting), represent the phase, which is very well recognized at numerous sites distributed on Polish area and the neighboring territories, i.e. the first half of the 5th century, the period of colonization regression and simultaneous climate moistening (Kalicki and Krąpiec 1996; Starkel 2005a, b).

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