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EVOLUTION OF RIVER VALLEYS IN SOUTHERN POLAND DURING THE PLEISTOCENE-HOLOCENE TRANSITION

Abstract

Reconstruction of changes in river activity in the upper Vistula catchment basin is based on the analysis of forms and deposits which have been detaily recognized in 57 sites (Fig. 1, 2, tab. I) thanks to 106 radiocarbon datings.

It has been stated that dissection of the Vistulian accumulative cover began ca 25 ka BP what caused the upbuilding of the upper terrace with loess. Deposits from the end of the Plenivistulian are burried under the Late Vistulian deposits. Well noticeable in the valley evolution are abrupt climatic warmings, expansion of vegetation and changes in the rivers regime and material supply which are the reasons of succeeding changes in river pattern from braided to meandering ones (13,0–12,5 ka BP) and from big meanders to small ones at the beginning of Preboreal time. In the Younger Dryas river-bed pattern in some cases come back to braided ones again. Those changes are overlapped by fluctuations of the secondary range which are visible in aggradation during the Younger Dryas and more frequent floods took place there at the end of Boreal and at the beginning of the Atlantic times (8,5–7,7 ka BP).

STATE OF RESEARCH

Researches on the late Quaternary river alluvia in the upper Vistula catchment basin started during the preparation of the Geological Atlas of Galicja (Friedberg, 1903; Łomnicki, 1895–1903; Zaręczny, 1894) when it was stated that not only alluvial soils but channel deposits with the Holocene forest flora as well are inserted into alluvia from the cold period. Just before the World War II in the Jasiołka valley at Roztoki there were found the Late Glacial deposits recording succession on boreal forests (Szafer, 1948; Klimaszewski, 1948b). In the 1950s and 1960s in valleys at the edge of the Carpathians there were stated alluvia fills from the late Pleistocene, dated by palynological and then radiocarbon methods (Starkel, 1960a; Ralska-Jasiewiczowa, Starkel, 1975). Among the examined sites an erosional step in Podhale Basin was noticed which was cut in glacifluvial deposits and covered by an organic series beginning from the Bølling (Klimaszewski, 1961; Koperowa, 1962). In the San valley the cut-off paleochannel started to be filled from the Allerød (Mamakowa, 1962). Detailed researches in the Wisłoka and San valleys and then in the Vistula with many tens of datings began in the 1970s, connected with the programme IGCP 1958, Paleohydrology of the temperate zone during the last

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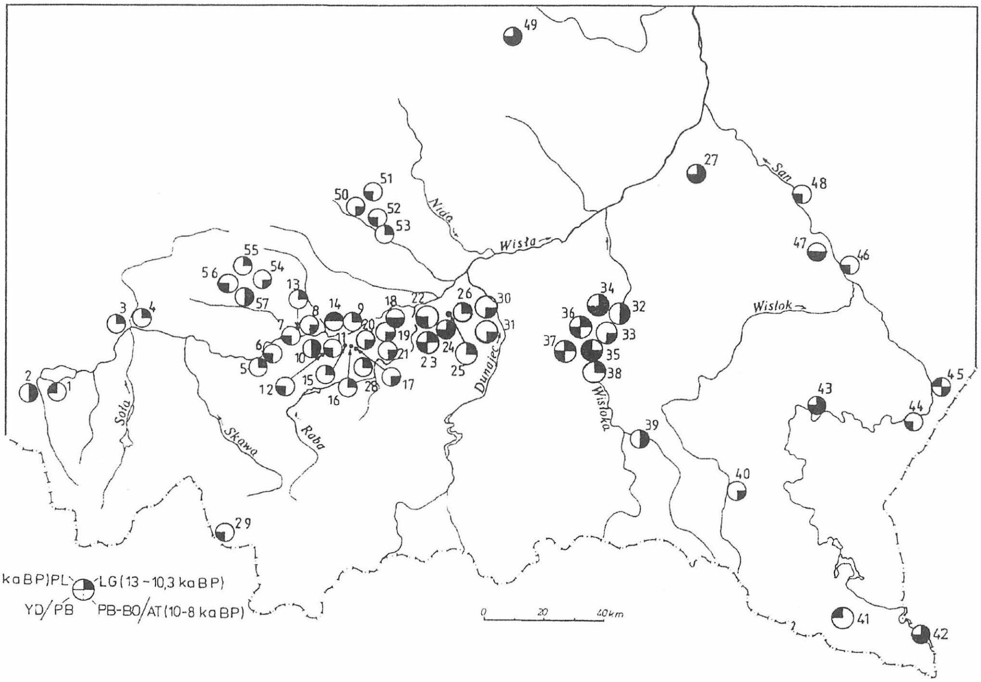

Fig. 1. Location map of sites with dated alluvial sediments in Southern Poland (by STARKEL and GĘBICA, 1992)

Pl – Plenivistulian; LG – Late vistulian; YD – Younger Dryas; PB – Preboreal; BO – Boreal; AT – Atlantic. Numbers refer to sites: 1. Chybie; 2. Drogomyśl; 3. Bieruń Nowy; 4. Gorzów; 5. Skawina 1; 6. Skawina 2; 7. Rondo Mogilskie; 8. Nowa Huta; 9. Branice; 10. Rybitwy; 11. Brzegi; 12. Przewóz; 13. Łęg; 14. Pleszów; 15. Podłężówka – stanow.: Pł. 40; 16. Podłężówka Pł. 17; 17. Zabierzów Bocheński; 18. Grobla G3; 19. Grobla G26; 20. Drwinka; 21. Drwinka G28; 22. Uście Solne; 23. Gróbka Gr1; 24. Gróbka STM11; 25. Strzelce małe STM10; 26. Szczurowa; 27. Kobylarnia; 28. Łężkowice; 29. Orawa; 30. Zabawa; 31. Niwka; 32. Brzeźnica; 33. Dębica Kolejowa; 34. Wola Żyrakowska; 35. Podgrodzie; 36. Dębica Wolica; 37. Latoszyn; 38. Strzegocice; 39. Roztoki: 40. Besko-Zapowiedź; 41. Smerek; 42. Tarnawa; 43. Podbukowina; 44. Przemyśl Przekopana; 45. Stubno; 46. Rzuchów; 47. Jelna; 48. Ulanów; 49. Sieradowice; 50. Biedrzykowice I; 51. Biedrzykowice II; 52. Biedrzykowice III; 53. Bronocice; 54. Szklary; 55. Racławka I; 56. Racławka II; 57. Racławka III

15,000 years realized in the years 1978–1988 (STARKEL 1981, 1982, 1987, 1990, 1991). At the same time studies on the valleys of the Małopolska Upland were carried out (ŚNIESZKO, 1985; ALEXANDROWICZ, 1985; RUTKOWSKI, 1991; JERSAK *et al.*, 1992). In comparison to the upper Vistula catchment basin, the basin of the Odra has been poorly recognized (SZCZEPANKIEWICZ, 1989).

Distribution of the searched localities is uneven (Fig. 1.). There were 106 radiocarbon datings in 57 localities and they are presented in tab. 1. These represent the period from 17 to 8 ka BP. There is good palynological documentation only for 18 localities and documentation for 16 of them covers more than 3,000 years. Lack of longer time sequences in the vertical profile is the result of tendency to lateral erosion and increasing deposition of bars characterictic for the Late Vistulian and Holocene. Thanks to it in some localities there are 2–4 fills representing the end of the Pleistocene and the early Holocene (Fig. 3). Particularly rich sequence has been registred at the immediate Carpathian foreland and in the Vistula valley reach close to Cracow (KALICKI, 1991; STARKEL, 1995).

VALLEY EVOLUTION AND ALLUVIA AT THE END OF THE PLENIVISTULIAN (18–13 ka BP)

Along the Vistula valley there is a terrace 15–18 m high which is built in its lower part of alluvia covered by interpleniglacial silts and in its upper part by younger loess (MAMAKOWA, ŚRODOŃ, 1977). Correlation with the profiles from Lublin Upland (HARASIMIUK, 1991) and the Prosna valley (ROTNICKI, 1987) allows to suggest that also in Sandomierz Basin the first cause of erosion ca 25 ka BP was the climatic aridization (STARKEL, 1995) and not as it was earlier supposed – lowering of the base during the ice sheet recession (STARKEL, GĘBICA, 1993). In the Wisłoka valley, near Brzeźnica, a series of silts and sands building 15 m high terrace not covered with loess is dated in its middle part at ca 28 ks BP (ALEXANDROWICZ *et al.*, 1981). Between that terrace and flood plain, with the Late Vistulian–Holocene paleochannels, which are 6–10 m incised, there are local fragments of 10–12 m high terrace. Sometimes they are reworked by dunes like in the Oświęcim Basin (KLIMEK, 1987) or with signs of braided channel dated for 21,300 ± 1,200 BP and > 33,500 BP near Wola Żyrakowska in the Wisłoka valley (STARKEL, 1995). Deepening of the valleys is proved by deposits of flood facies on the height 3,5 m above the Wisłoka river-bed level in Podgrodzie dated for 22,450 ± 340 years BP (ALEXANDROWICZ *et. al.*, 1981). Upstream of the Wisłoka course lowly situated silts were also dated for 24–25 ka BP (PAZDUR, 1985).

Two localities of paleochannels with organic fillings prove deep incision before the Late Vistulian: one in Pleszów on the Vistula (Fig. 1, no 14) in the level of the present river bed dated for 13,260 ± 160 years BP (KALICKI, 1991) and the second one in Stubno in the San valley dated in its base for 15,200 ± 500 years BP (Fig. 1, no 45; KLIMEK, 1992). Deep location of braided alluvial plain is also proved by the base of Allerød peat-bogs spread in wide depressions on the Raba fan (GĘBICA, 1995; Fig. 2, no 23, 24) An insertion of peat with wooden fragments between two members of gravels in Smerek in the upper San catchment basin suggest climatic oscilations of the interstadial type (Fig. 1, no 45). The insertion is preliminary dated for 16,925 ± 325.

VALLEY EVOLUTION AND ALLUVIA IN THE LATE VISTULIAN (13–10 ka BP)

Warming up and slow succession of forest communities were reflected in the change of hydrological regime, decrease of floods frequencies and material supply (STARKEL, 1983). The effect of that is the change in riverbed pattern from braided to meandering one, known from the San valley (SZUMAŃSKI, 1986) and the Wisłoka (ALEXANDROWICZ *et al.*, 1981). There were huge paleomeanders with parameters greater than they are at present and by 3–4 times bigger than early Holocene ones (Fig. 4). Width of the channels reached from 100 to 200 m and their radii were 650 – 1,100 m. Among them there were stated at least two generations: from the Bølling and Allerød and from the Younger Dryas. The older one, from the Bølling, was stated near Oświęcim (Bieruń Nowy, No 3 dated for 12,500 ± 230 years BP), in the montane parts of the Wisłoka (No 38, 39; Fig. 1, tab. I) and the San valley (No 43; MAMAKOWA, 1962) and from the older part of the Allerød on the Vistula near Cracow (KALICKI, 1991; No 8, 13; Fig. 1, 2).

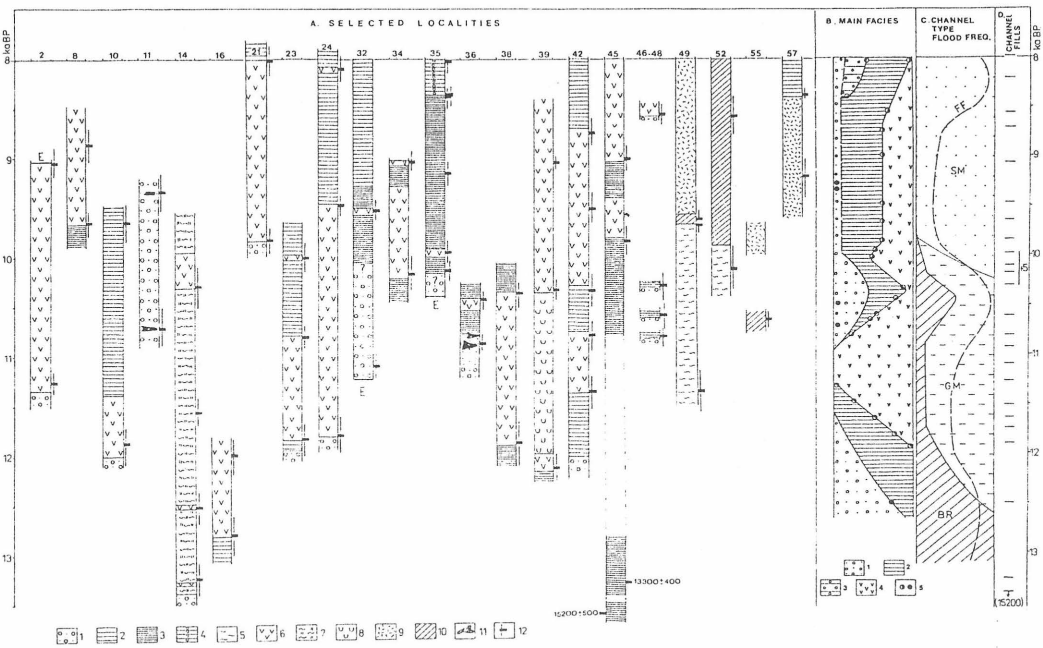

Fig. 2. Plenivistulian – Early Holocene history of the river valleys in Southern Poland (by STARKEL and GĘBICA)

A – selected localities (numbers – see Fig. 1 and tab. I); Signs: 1. channel facies; 2. overbank facies; 3. Paleochannel fill facies; 4. alluvial fan depoeits; 5. deluvial loess; 6. peat; 7. gyttia; 8. lake chalk; 9. calcareous tufa; 10. fossil soil; 11. wood; 12. position of radiocarbon datings with intervals of accuracy; E – erosional surface; B – main facies (their participation in alluvial sequences); Signs: 1. channel facies; 2. overbank facies; 3. alluvial fan facies; 4. organic deposits over the floodplain; 5. position of samples dated by radiocarbon method; C – channel type and flood frequency; BR – braided river; GM – great meanders; SM – small meanders; FF – flood frequency curve; D – channel fills-radiocarbon dating from the bottom of paleochannel fills in the upper Vistula Basin (5+ means 5 paleochannels dated approximately by palynological method)

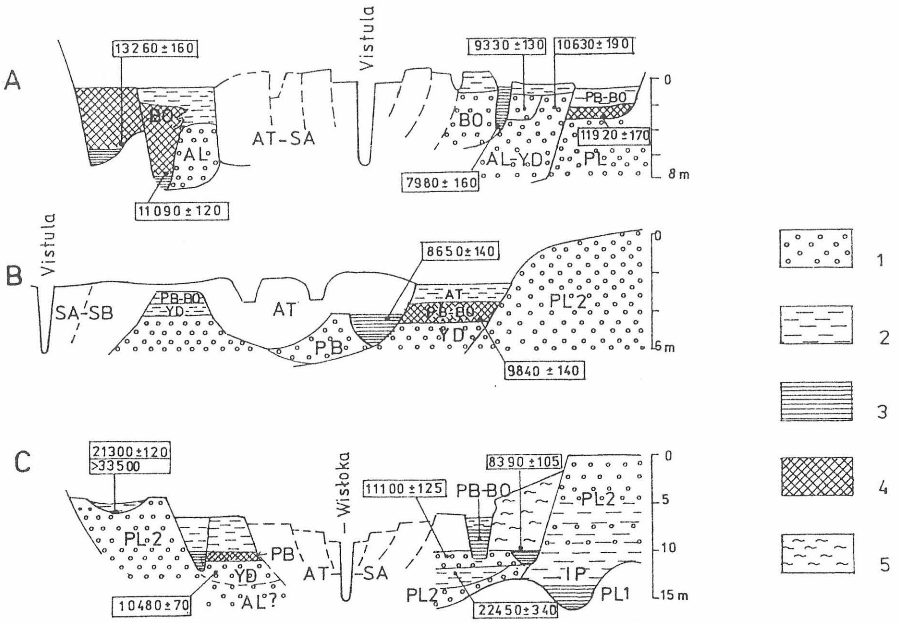

Fig. 3. Simplified cross-sections of river valleys representing the Late Pleistocene and Early Holocene alluvial fills

A – Vistula valley downstream of Cracow (after KALICKI, 1991); B – Vistula valley in the Grobla Forest (after STARKEL *et al.*, 1991); C – Wisłoka valley near Dębica (after STARKEL *et al.*, 1982, changed); Signs: 1. channel facies; 2. overbank facies; 3. paleochannel fills; 4. peat; 5. alluvial fan facies; PL1–SA – abbreviations of stratigraphic units

At the same time sandy plains on their whole width in the valley bottoms were overgrown with peat (No 10, 15–16, 23–26, 42) what confirms the stabilization of the river channels.

Distinct climatic change took place at the beginning of the Younger Dryas. From those times are known channel and overbank deposits "transgreding" over the older alluvia or organic deposits. Very often they cover peat, like in the upper San valley (Tarnawa No 42) and on the wide Raba fan (No 23, 26). Channel alluvia from those times are known from the Vistula valley near Cracow (tab. I, No 11) and the Wisłoka near Dębica (tab. I; No 36). During those times rivers in some parts changed the character of their channels from meandring to braided again like in the Drwinka depression (Fig. 1, 2, 3; No 18, 21). In those places where the river kept its character like in the Wisłoka on the Carpathian foreland, rivers with wide meandering channels with similar parameters like in the Bølling or older Allerød were undercutting older terraces even cutting steps in the Miocene clays (ALEXANDROWICZ *et al.*, 1981; STARKEL 1995; tab. I; No 32–35). Many of paleochannels with preserved point bars from the

Localities with dated alluvial sediments

Table I

No	Locality	River valley	Facies Dated material	Radio-carbon dating BP	Other methodes			References
					P	S	M	
1.	Chybie	Vistula	ob, om	16880±400	*	*		Niedziałkowska, Szczepanek, 1994
2.	Drogomyśl	Vistula	cf, p w w, p	9020±120 11250±110 11220±100	*	*		Niedziałkowska et al., 1985
3.	Bieruń Nowy	Vistula	cf, om	12500±230				Klimek, 1992
4.	Gorzów	Przemsza	cf, p	11900±200				Klimek, 1992
5.	Skawina 1	Skawinka	ob, om p	7880±140 12150±100				Rutkowski, unpubl.
6.	Skawina 2	Skawinka	ob, om	10300±130				Rutkowski, unpubl.
7.	Rondo Mogilskie	Vistula	cf, p	9390±180	*			Mamakowa, 1970
8.	Nowa Huta	Vistula	cf, p p om	8860±160 9660±110 9660±180	*	*		Kalicki, 1991 Kalicki, Zernickaya, in print
9.	Branice	Vistula	cf, om	10920±230	*	*		Kalicki, Starkel, 1987
10.	Rybitwy	Vistula	ob, om p	9660±180 11920±170		*		Kalicki, 1991
11.	Brzegi	Vistula	ch, w w	9330±180 10690±190		*		Kalicki, 1991
12.	Przewóz	Vistula	ch, w	9280±100		*		Kalicki, 1991
13.	Łęg B	Vistula	cf, p	11090±120		*		Kalicki, 1991
14.	Pleszów II	Vistula	cf, p g p g	10320±190 11570±130 12540±150 13260±160	*			Nalepka, 1991 Kalicki, 1991
15.	Podłężówka Pł.40	Podłężówka	ob, p	11420±150	*			Nalepka, 1991
16.	Podłężówka Pł.17	Podłężówka	ob, p p	11850±170 12650±200	*			Nalepka, 1991
17.	Zabierzów Bocheński	Vistula	cf, p	9040±120 9470±130				Kalicki et al., in print
18.	Grobla G3	Vistula	ob, p	10520±110	*	*		Gębica, Starkel, 1987
19.	Grobla G26	Vistula	cf, p g	8540±130 8650±140		*		Starkel et al., 1991
20.	Drwinka	Vistula	cf, p p p	7980±70 9520±110 8750±90	*	*		Gębica, Starkel, 1987, Nalepka, 1991
21.	Drwinka G28	Vistula	ob, p p	8010±40 9840±40		*		Starkel et al., 1991
22.	Uście Solne	Vistula	ob, p	10640±110		*		Gębica, in print
23.	Gróbka Gr1	Raba	ob, p p p	10020±140 10820±120 11860±160	*	*		Gębica, in print
24.	Gróbka STM11	Raba	ob, p p p	8090±120 9480±100 11800±170		*		Gębica, in print
25.	Strzelce Małe STM10	Vistula	ob, p	11560±120	*	*		Gębica, in print

Younger Dryas were stated in the lower San valley (SZUMAŃSKI, 1986, tab. I, No 46–48). Increase of process intensity probably at that time is also confirmed by fans superimposed on the solifluctional accumulative plains at the foothills of ridges in the Beskid Wyspowy (STARKEL, 1960b). However, there are parts of valleys in which there are no signs of great paleo-

26.	Szczurowa	Vistula	ob, p	10440±200 11300±140		*		Gębica, in print
27.	Kobylarnia	Vistula	cf, p	8570±100 11640±100				Mycielska-Dowgiałło, 1987
28.	Łężkowice	Raba	ob, om	9850±210		*	*	Alexandrowicz, Wyżga, 1992
29.	Orawa	Orawa	cf, p	10010±100		*		Baumgart-Kotarba, 1992
30.	Zabawa	Dunajec	cf, p	8200±140				Sokołowski, in print
31.	Niwka	Dunajec	cf, p	9640±180				Sokołowski, in print
32.	Brzeźnica	Wisłoka	ch,cf, p w	9535±100 11100±125	*	*		Alexandrowicz et al., 1981
33.	Dębica Kolejowa	Wisłoka	cf, p p	9962±130 10100±260	*	*		Alexandrowicz et al., 1981
34.	Wola Żyrakowska	Wisłoka	cf, p p	9040±100 10170±190				Starkel, in print
35.	Podgrodzie	Wisłoka	ch,cf,af w w w w w w p w w	 8015±135 8370±90 8000±100 8390±105 9160±135 9945±100 9955±115 10130±115 9915±95	*	*	*	Niedziałkowska et al., 1977, Alexandrowicz et al., 1981
36.	Dębica Wolica	Wisłoka	ch,ob, p p	10060±90 10480±70				Starkel, in print
37.	Latoszyn	Wisłoka	cf,af, w	10080±70			*	Alexandrowicz, Klimek 1985
38.	Strzegocice	Wisłoka	cf, p p	9980±120 11500±230				Klimek, 1992
39.	Roztoki	Jasiołka	lac,ob,p p	9920±100 11740±150	*		*	Wójcik, 1987
40.	Besko-Zapowiedź	Wisłoka	lac,ob,p p	7900±100 9530±150	*	*		Koperowa, Starkel, 1972
41.	Smerek	San	ch, p	16925±325	*			Ralska-Jasiewiczowa, 1980
42.	Tarnawa	San	ob, p p w p p p	8730±140 9510±150 9770±150 10340±160 10790±160 11360±170	*			Ralska-Jasiewiczowa, 1980
43.	Podbukowina	San	cf, p		*			Mamakowa, 1962
44.	Przemyśl Przekopana	San	ch, w	10375±125				Starkel, 1977
45.	Stubno	San	cf, p om om om	9000±120 9840±140 13300±400 15200±500				Klimek, 1992
46.	Rzuchów	San	cf, om	10590±130				Szumański, 1986
47.	Jelna	San	cf, p g	8560±100 10300±140				Szumański, 1986
48.	Ulanów	San	ob, p	10800±100				Szumański, 1986
49.	Sieradowice	Psarka	del,fs,w w w	9630±100 9680±60 11360±220	*	*	*	Jersak, Klatka, Śnieszko, 1983
50.	Biedrzyko-wice I	Sancygniówka	cf, w	9970±110		*		Śnieszko, 1985

meanders. Directly below the plain with braided river pattern there are smaller Holocene paleomeanders and sings of braiding from last hundreds of years. It partly concerns the outlet part of the Soła (KLIMEK, 1987), the fan of the Przemsza (tab. I; No 4; KLIMEK, 1992), the lower course of the Dunajec and below its outlet to the Vistula valley (SOKOŁOWSKI, 1987). Those tributaries transport great amounts of bed load. The lack of great meander phases should be explained by survival of braided system untill the beginning of the Holocene (STARKEL, 1990).

51.	Biedrzyko-wice II	Sancygniówka	cf, p	9055±230		*	*	Śnieszko, 1985
52.	Biedrzyko-wice III	Sancygniówka	del, fs fs	8600±230 10130±210		*		Śnieszko, 1985
53.	Bronocice	Nidzica	ob, om	10820±130			*	Śnieszko, 1987
54.	Szklary	Szklarka	calc	9440±90			*	Alexandrowicz, 1989
55.	Racławka I	Racławka	calc, fs	10630±80		*	*	Alexandrowicz, Pazdur, Szulc, 1988
56.	Racławka II	Racławka	ob, om	9420±80				Rutkowski, 1991
57.	Racławka III	Racławka	ob, om calc	8350±150 9200±200		*	*	Rutkowski, 1991

P- palynological, S- sedymentological, M- malacological, ch- channel facies, ob- overbank facies, cf- paleochannel fill, af- alluvial fan facies, del-deluvia, lac- lacustrine deposits, p- peat, om- organic mud, g- gyttia, w- wood, calc- calcareous tufa, fs- fossil soil

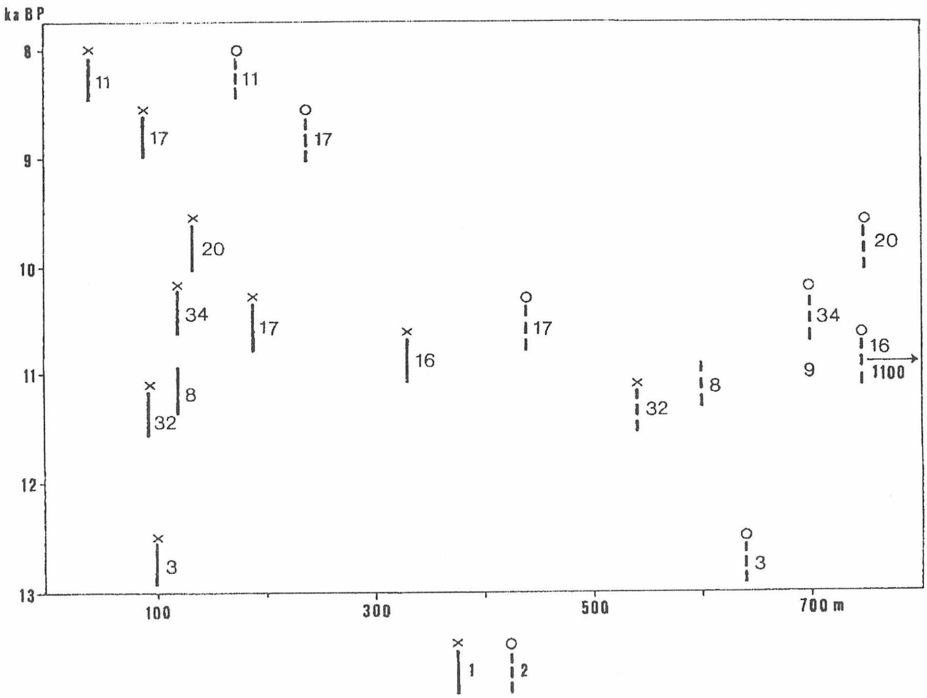

Fig. 4. Parameters of dated Late Vistulian and Early Holocene paleomeanders in the Carpathian foreland

1. paleochannel width; 2. paleochannel radius. The line below the dated sample indicate the probable longer period of stability when the parameters were formed. The number indicate the locality on Fig. 1 and tab. I.

Late Vistulian aluvia present clear division into a channel and overbank facies (Fig. 5). River-bed deposits are similar but the Late Vistulian overbank madas are more silty and sandy (Mz=4–7Ø) than the Eoholocene in which madas with smaller mean diameter prevail (Mz=8–10Ø). The madas from the Younger Dryas (Mz=6,5–9,5Ø) are finer than the older overbank deposits and they are similar to the Eoholocene ones.

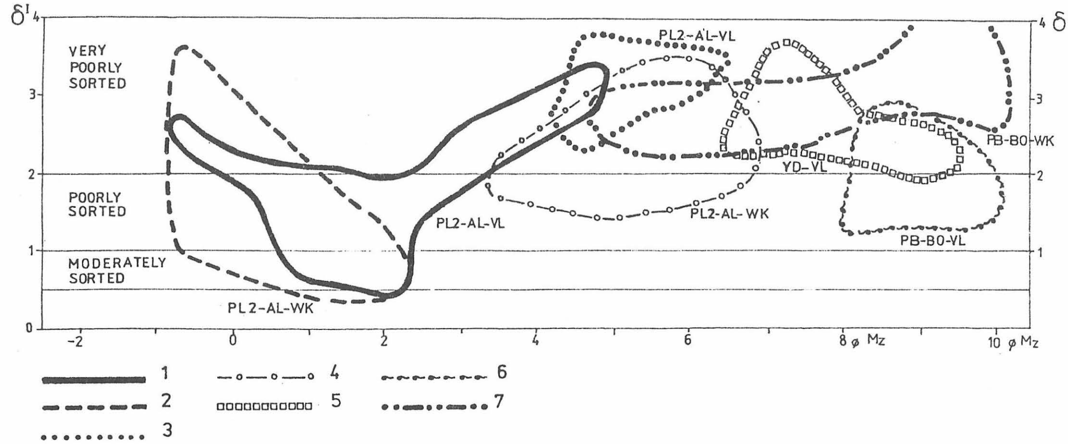

Fig. 5. Mean grain size (Mz) and standard deviation of the alluvial sediments of different age (after NIEDZIAŁKOWSKA, 1991; STARKEL *et al.*, 1991; GĘBICA, 1995)

1. channel facies Plenivistulian-Late Vistulian in Vustula valley and Raba fan; 2. channel facies Plenivistulian-Late Vistulian in Wisłoka valley; 3. overbank facies Plenivistulian-Alleröd in Vistula valley and Raba fan; 4. overbank facies Plenivistulian-Alleröd in Wisłoka valley; 5. overbank facies Younger Dryas in Vistula valley and Raba fan; 6. overbank facies Preboreal-Boreal in the Vistula valley and Raba fan; 7. overbank facies Preboreal-Boreal in Wisłoka valley; PL2 – Upper Pleinvistulian; VL – Vistula valley; WK – Wisłoka valley

EVOLUTION OF VALLEYS AND ALLUVIA IN THE EOHOLOCENE (10,3–8,5 ka BP) AND DURING THE FIRST HOLOCENE WET PHASE (8,5–7,7 ka BP)

Beginning of the Holocene is characterized by rapid warming, transgression of vegetation cover also into the montane areas and widespreading at first of boreal forests in the still continental climate (STARKEL, 1992, 1994). It caused stabilization in the valley bottoms. Silty and sandy madas were replaced by loamy ones (Mz=8–10Ø) and peat is recorded from many sites (No 21, 24, 32, 36). At the same time the incisions of the river-beds are sometimes marked by accumulation changes in oxbow lakes from clay into peat (Roztoki, No 39).

Following, meandering rivers were shifting their channels in the result of bar construction what is known from the Vistula valley down of Cracow (No 11, 12). Parameters of those paleochannels were preserved after the first Holocene wet phase which was ca 8,5–8,0 ka BP (NIEDZIAŁKOWSKA *et al.*, 1977; STARKEL, 1983). These are channels with small radii r=100–200 m and width 30–50 m (Fig. 4). Accumulation of carbonate tuffa in the valleys of the Małopolska Upland confirms the existence of warm climate (sites No 49, 55, 57; PAZDUR *et. al.*, 1988).

Increase of fluvial processes is marked by higher sedimentation rate of overbank deposits, avulsions of channels and covering of organic deposits by madas (tab. I; No 19, 20, 24, 42 and others). Intensity of erosional processes is confirmed by alluvial fans overlapping the older paleochannel deposits (No 33, 35, 40). At Podgrodzie site (NIEDZIAŁKOWSKA *et al.*, 1977, ALEXANDROWICZ *et al.*, 1981) such fans contain 7 m thick series representing the period 8,400 – 7,700 years BP (comp. Fig. 2).

CONCLUSIONS AND DISCUSSION

Obtained facts show how different is the present picture of changes from the classical model of glacial-interglacial cycle in the valleys of the temperate climatic zone (SOERGEL, 1921).

Evolution of valley bottoms in the upper Vistula catchment basin shows that the predominant factor in the times 20–8 ka BP were climatic changes reflected in the type and frequency of floods and in the conditions of sediment supply to the river-beds. It appeared that not only the damming of the Vistula by the glacier but also the lowering of the erosional base during deglaciation were the factors of secondary range. Besides loess accumulation (MARUSZCZAK, 1991) the erosion which began ca 25 ka BP confirm aridization and continentalism of climate during 25–13 ka BP. Parallelly, the number of information is insufficient to estimate more precisely the position of river channels at the end of the Plenivistulian. Forms from that phase have not been preserved as they were covered with the Late Vistulian and then by the younger Holocene deposits.

In the evolution of river systems very well are marked the rapid warmings of the climate and expansion of vegetation and superimposed on them fluctuations of the lower range, presented as alluvia insertions (Fig. 3). Reconstruction of paleochannel types and river discharge undertaken by some authors (STARKEL *et al.*, 1982; STARKEL, 1990) require great care because of possibility of co-existence during the late Vistulian of braided and meandering channels not alternately in different parts of the Vistula valley (or its tributaries) but also parallelly in the same valley reach. The phenomenon is known from the Siberian valleys with discontinuous permafrost.

The factor modifying the records of climatic changes in fluvial deposits and forms, were tectonical movements. Segments with deepened river channels in the uplifted areas have been already described (FROEHLICH *et al.*, 1972). On the other hand, in the areas which are undoubtfully sinking, like in the Oświęcim Basin (NIEDZIAŁKOWSKA *et al.*, 1985) a tendency for aggradation and channel avulsion is observed. Similar phenomenon of avulsion is well known from the intramontaneous Orava–Nowy Targ Basin (BAUMGART-KOTARBA, 1992).

Translated by Teresa Mrozek

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