STUDIA GEOMORPHOLOGICA CARPATHO-BALCANICA
VOL. XXIX KRAKÓW 1995 PL ISSN 0081-6434

WITOLD ZUCHIEWICZ (KRAKÓW)

LOWER QUATERNARY FLUVIAL DEPOSITS IN THE POLISH OUTER CARPATHIANS: A STATE-OF-THE-ART REVIEW

INTRODUCTION

There are different opinions as to the stratigraphic range of the Early Quaternary in Poland. Baraniecka (1990) places its upper boundary at the turn of the oldest (Menapian, Narew) Glacial stage and the Podlasie (Cromerian) Interglacial; Lindner (1991) tends to locate the boundary between the Podlasie Interglacial and Nida Glacial Stages; whereas Mojski (1993) puts it between the Eopleistocene and Middle Pleistocene Epochs, i.e., at the beginning of the Narew (Cromerian s.l.) stage. It should also be noted that some authors (cf. Lindner 1991) try to distinguish between the so-called pre-(proto) Pleistocene and the Early Pleistocene, the latter of which is supposed to embrace both the Narew Glacial and Podlasie Interglacial stages.

The aim of this paper is to give a short overview of the present-day opinions on stratigraphic position of the Polish Outer Carpathian terrace deposits.

PALAEOGEOGRAPHIC SETTING

During the earliest Quaternary (Praetiglian; Różce stage; cf. Baraniecka 1990, Lindner 1991), strath and erosion-accumulational terraces described from the Dniester, Stryj and San river valleys interfluve (130–150 m; Gofshtein 1963), the Beskid Sądecki Mts (150–160 m), the Łącko-Podegrodzie Foothills (140–150 m), and the Nowy Sącz Basin (120–130 m; cf. Zuchiewicz 1984), were formed.

Erosional flats 120–140 m high, previously assigned to the foothills or riverside levels/planation surfaces (e.g. Klimaszewski 1937), should also be considered as representing this time-span. The same applies to the Witów series (Starkel 1984), being equivalent to the lower Kozienice Formation in the South-Polish Uplands (Mojski 1982), and to the Połaniec and Osiek gravels that occur in the northern part of the Sandomierz Basin (Laskowska-Wysoczańska 1975). Recent palaeomagnetic studies (Nawrocki and Wójcik 1990) and new TL datings (e.g. Lindner 1988), however, allow us to assign the Witów series to a period comprised between the Jaramillo event and Brunhes/Matuyama boundary.

The climate of this stage was boreal and cold, resembling a subarctic one (Stuchlik 1987), suitable for boreal steppe plant communities.

The next stage in the evolution of the Polish Carpathians (Tiglian; Ponurzyca stage) showed moderately warm and temperate climatic conditions (Stuchlik 1987) and was characterized by deep erosional dissection which, in the Dunajec river basin, ranged from 25 to 60 m (Zuchiewicz 1984, 1988). Meanwhile, in Southern Poland, the deposition of the upper part of the Kozienice Formation began (Mojski 1993).

During the Otwock stage (Eburonian?; cf. Lindner 1991), strath and erosion-accumulational terraces, being associated with the so-called riverside level (planation surface?), were formed (Starkel 1984). I tend to include to them the following terrace levels (Zuchiewicz 1987): 120 m of the Soła river at Tresna, 100 m of the Skawa and Raba rivers, 100–120 m of the Dunajec and Poprad rivers, 90 m of the Biała Dunajcowa river, 90–110 m of the San river, as well as 90-m-high terrace plains described from the San, Dniester and Stryj interfluve. The Carpathians were then drained to the NE, via the Wieprz and Gorajec water-gaps (cf. Wojtanowicz 1977–78), whereas the North-Polish Lowland witnessed deposition of the lower Krasnystaw Formation (Mojski 1993). A well-pronounced climatic cooling at that time, typical for cold steppe and boreal forest-steppe conditions (Stuchlik 1987), was marked by the appearance of boreal elements within the forests of the Slovak (Vaskovsky and Vaskovská 1981) and Polish Carpathians.

Erosional deepening of the Carpathian valleys in the Celestynów stage (Waalian?) was increasing from 15–30 m in the Łącko-Podegrodzie Foothills, through 15–40 m in the Beskid Wyspowy Mts, up to 20–50 m in the Beskid Sądecki Mts in medial sector of the Polish Carpathians (Zuchiewicz 1984, 1991). In the Sandomierz Basin, a northeastward directed outflow (Wojtanowicz 1977–87) was then active, whereas the paleo-San river flowed on the "riverside" plains to the Dniester valley (Starkel 1972 and Laskowska—Wysoczańska 1975). In the North-Polish Lowland accumulation of the Krasnystaw Formation continued (Mojski 1993). Climatic amelioration favoured the recession of coniferous trees and made possible the expansion of deciduous and mixed forests. Moderately warm, interglacial or interstadial-type climate did prevail (cf. Stuchlik 1987).

The Narew stage (Menapian?) was characterized by the termination of fluvio-lacustrine deposition in the Podhale region (cf. Szafer 1953). All the main valleys of the Outer Carpathians, at least in their middle reaches, attained their present position. This is documented the formation of 80–90 m terraces of the Soła, Skawa and Raba rivers, 80–100 m terrace steps of the Dunajec and Poprad rivers, 80 m terrace in the Wisłoka and 70–80 m terrace plain in the San river valleys (cf. Klimaszewski 1967, Starkel 1972, 1984, Zuchiewicz 1984, 1987).

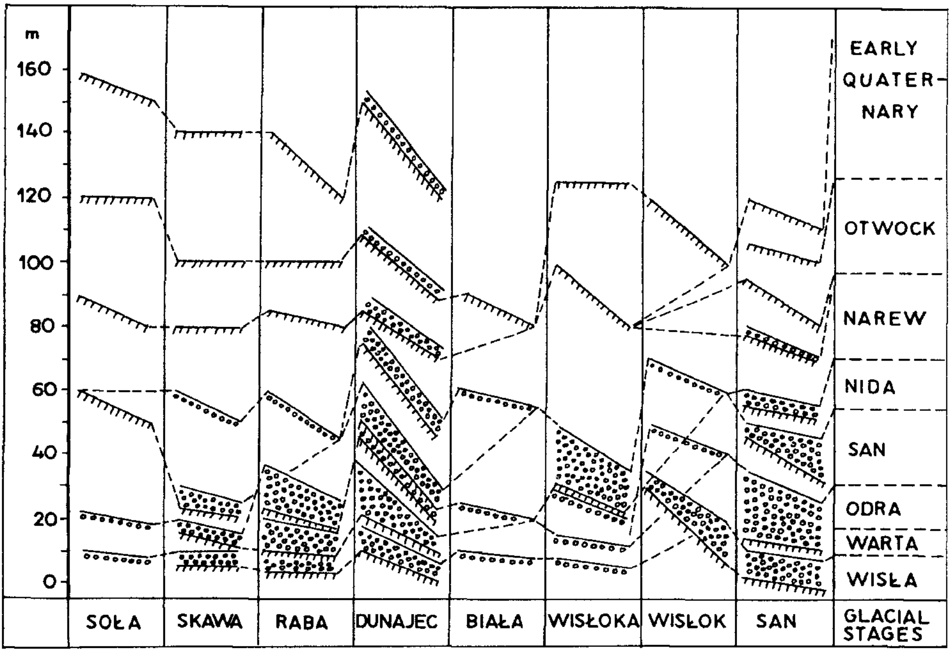

Fig. 1. Terrace stratigraphy in the Polish Outer Carpathians (based on different authors; redrawn from Zuchiewicz 1989)

Ryc. 1. Stratygrafia teras rzecznych w polskich Karpatach Zewnętrznych (wg różnych autorów; por. Zuchiewicz 1989)

Accumulation of the so-called "preglacial gravels" began in the lower reach of the Dunajec valley (Klimaszewski 1967). That was also the time of formation of the 70–80 m-high terrace plain within the San-Dniester-Stryj river valleys' watershed (e.g. Gofshtein 1963). An uplift of the South-Polish Uplands led to the cessation of the NE-ward directed drainage in the Sandomierz Basin (Wojtanowicz 1977–78). Gravel series occurring in the sub-Carpathian Furrow, in turn, were deposited on rock socles that — at present — occur at 210–215 m a.s.l. (Laskowska-Wysoczańska 1975, Starkel 1984). A sudden appearance of subarctic conditions in the Slovak Carpathians constrained the development of cold parkland vegetation, associated with mean annual temperatures ranging from 0 to –2° C (Vaškovský and Vaškovská 1981).

DISCUSSION

The terraces in question are shown more or less clearly on geomorphic and morphotectonic maps, the state of preservation being different from valley to valley, depending of their size and morphological conditions. The best-preserved examples (cf. Figs 1 and 2) have been described from the Dunajec

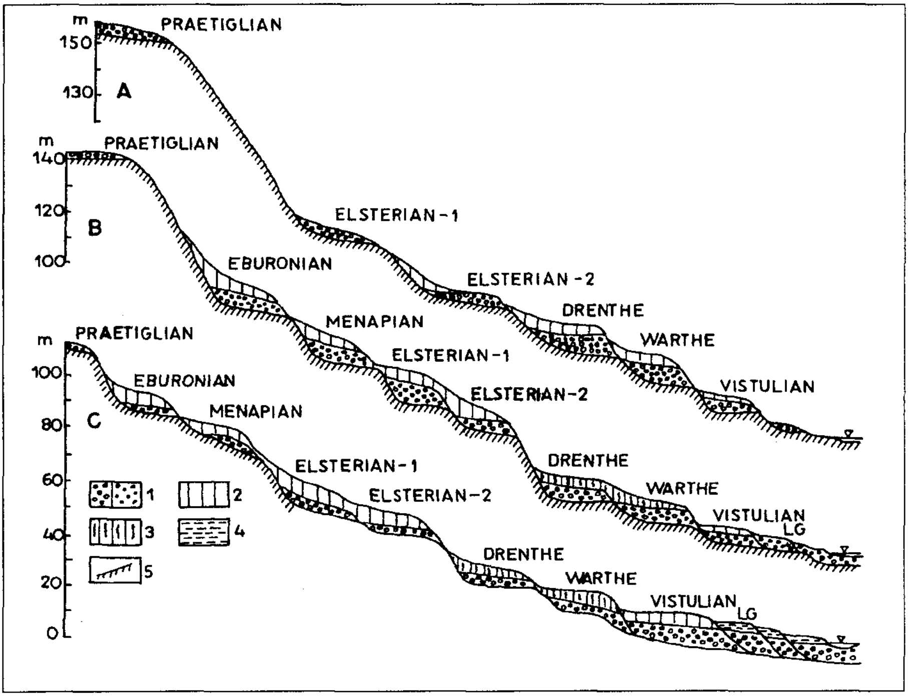

Fig. 2. An example of climatostratigraphic subdivision of fluvial deposits in the Dunajec river valley, medial sector of the Polish Outer Carpathians (based on Zuchiewicz and Oszczypko 1992): A — Beskid Sądecki Mts, B — Łącko-Podegrodzie Foothills, C — Nowy Sącz Basin. 1 — gravels composed of flysch- and Tatra-derived material, 2 — solifluction/slopewash deposits, 3 — loess, 4 — overbank deposits, 5 — rock socle. Tentative correlation with the Polish Lowland Quaternary stratigraphy: Praetiglian — Różce, Eburonian — Otwock, Menapian — Narew, Elsterian-1 — Nida, Elsterian-2 — San, Drenthe — Odra, Warthe — Warta, Vistulian — Wisła glacial stages; LG — Vistulian Late Glacial terrace step

Ryc. 2. Przykład podziału klimatostratygraficznego utworów rzecznych doliny Dunajca w środkowej części polskich Karpat Zewnętrznych (wg Zuchiewicz i Oszczypko 1992): A — Beskid Sądecki, B — Pogórze Łącko-Podegrodzkie, C — Kotlina Sądecka. 1 — żwiry złożone z materiału fliszowego i tatrzańskiego, 2 — utwory soliflukcyjno-deluwialne, 3 — less, 4 — utwory facji pozakorytowej, 5 — cokół skalny. Próba korelacji ze stratygrafią plejstocenu Polski pozakarpackiej: pretegelen — piętro Różce, eburon — piętro otwockie, menap — piętro Narwi, elstera-1 — piętro Nidy, elstera-2 — piętro Sanu, Drenthe — piętro Odry, Warthe — piętro Warty; LG — stopień z późnego glacjału piętra Wisły

river valley (cf. Zuchiewicz 1989, Zuchiewicz and Oszczypko 1992), wherefrom detailed morphological studies have been reported for almost 100 yrs. As far as the Early Quaternary landforms as concerned, the Kłodne, Maszkowice and Obidza alloformations (cf. Zuchiewicz 1992) should be reported, that are thought to be the equivalents of the Praetiglian (Różce), Eburonian (Otwock) and Menapian (Narew) stages. Their thickness ranges from 2–5 to 10–15 m.

The climatic and tectonic factors taking part in the formation of fluvial terraces can be a matter of debate for many years. Nevertheless, the terraces in question represent both strath and complex-response terraces (sensu Bull 1990) that could not be interpreted in the same manner as those formed during the proper glacial-interglacial cycles. It would be difficult to find any piece of evidence pertaining to the interfingering of fluvial and slope (i.e., solifluction and/or slopewash) deposits within the terraces under consideration; the evidence mentioned being valid for the Middle and Late Quaternary, only. The Early Quaternary terraces are situated above Elsterian fluvial covers that can easily be correlated along valley courses due to their intertonguing with fluvioglacial, Scandinavian erratics-bearing deposits left at the margin of the Carpathian Foothills.

The size of uplift during Early Quaternary times was the greatest during the whole of the Pleistocene (Zuchiewicz 1991), ranging from 110–70 m (Soła) through 50–60 m (Dunajec) to c. 40–30 m (San river valleys); the average rates being rather insignificant (i.e., 0.9–0.05, 0.05–0.04, and 0.03–0.25 mm/yr; respectively), as compared to those of the Middle-Late Pleistocene.

The number of terrace levels recorded in individual valleys is different, that may testify to diversified tectonic activity of neotectonic structures which embrace neotectonic elevations and depressions, described in detail by Rączkowski *et al.* (1985) and Zuchiewicz (1992). Such a different number of Pleistocene fluvial terraces, that should have been formed under the same glacial-interglacial cyclicity, may provide evidence for the diversified tectonic influence upon the formation of the fluvial regime of the Carpathian rivers.

CONCLUSIONS

Future stratigraphic studies should focus on magnetostratigraphic and — if possible — radiometric (TL) datings of the fluvial deposits in question. Additional morphometric analyses would also be welcomed; and particularly those that could discriminate between Pliocene "planation surfaces" and Early Quaternary fluvial landforms.

ACKNOWLEDGEMENTS

This research has been supported by the Committee for Scientific Research (Komitet Badań Naukowych) Grant no. 6 6134 92 03p/01.

Institute of Geological Sciences,
Jagiellonian University,
2A Oleandry Str., 30-063 Kraków, Poland

REFERENCES

Baraniecka M. D., 1990. *Revision proposals of the Quaternary stratigraphy for the detailed geological map of Poland 1:50 000 in the light of main stratigraphic survey results in the recent 20 years (Summary).* Kwartalnik Geol. 34: 149–166.

Bull W. B., 1990. *Stream-terrace genesis: implications for soil development.* Geomorphology 3: 351–367.

Gofshtein I. D., 1963. *Last pages of the Carpathian geological history (in Russian).* Comm. Sci. V Congr. Assoc. Carpatho-Balcan., Sec. 3, p. 105–113, Bucharest.

Klimaszewski M., 1937. *Morphologie und Diluvium des Dunajec-Tales von den Pieninen bis zur Mündung.* Prace Inst. Geogr. UJ 18: 1–54.

Klimaszewski M., 1967. *Polskie Karpaty Zachodnie w okresie czwartorzędowym,* [w:] *Czwartorzęd Polski,* red. R. Galon, J. Dylik. PWN, p. 431–497, Warszawa.

Laskowska-Wysoczańska W., 1975. *Zagadnienia paleohydrografii Kotliny Sandomierskiej.* Sesja Nauk.-Sprawozd. Prac. Geol. Czwartorzędu ZNG PAN, p. 17–31, Warszawa.

Lindner L., 1988. *Stratigraphy and extents of Pleistocene continental glaciations in Europe.* Acta Geol. Pol. 38: 63–83.

Lindner L., 1991. *Problems of correlation of main stratigraphic units of the Quaternary of mid-western Europe (Summary).* Przegl. Geol. 5–6: 249–253.

Mojski J. E., 1982. *Outline of the Pleistocene stratigraphy in Poland.* Biul. Inst. Geol. 343: 9–29.

Mojski J. E., 1993. *Europa w plejstocenie. Ewolucja środowiska przyrodniczego.* Wyd. PAE, Warszawa, 333 pp.

Nawrocki J., Wójcik A., 1990. *On age of the "Witów Series" in the light of palaeomagnetic studies.* Studia Geomorph. Carpatho-Balcanica 24: 3–11.

Rączkowski W., Wójcik A., Zuchiewicz W., 1985. *Neotectonic sections across the Polish Carpathians.* Acta Geophys. Pol. 33: 307–319.

Starkel L., 1972. *Karpaty zewnętrzne,* [w:] *Geomorfologia Polski,* red. M. Klimaszewski. PWN, 1: 52–115, Warszawa.

Starkel L., 1984. *Karpaty i Kotliny Podkarpackie,* [w:] *Budowa geologiczna Polski,* t. 1 *Stratygrafia,* cz. 3b, *Czwartorzęd,* red. J. E. Mojski. Wyd. Geol., p. 146–152, Warszawa.

Stuchlik L., 1987. *Review of palaeobotanical studies on Pliocene and Lower Pleistocene deposits in central and southern Poland (Summary),* [w:] *Problemy młodszego neogenu i eoplejstocenu w Polsce,* red. A. Jahn, S. Dyjor. Ossolineum, p. 53–63, Wrocław.

Szafer W., 1953. *Stratigraphy of the Pleistocene in Poland based on floristic data (Summary).* Ann. Soc. Geol. Pol. 22: 1–99.

Vaškovský I., Vaškovská E., 1981. *The development of the natural landscape in Slovakia during the Quaternary.* Biul. Perygl. 28: 249–258.

Wojtanowicz J., 1977–78. *Quaternary changes of the river system of the Sandomierz Lowland (Summary).* Annales UMCS, Sec. B, 32–33: 237–258.

Zuchiewicz W., 1984. *The Late Neogene-Quaternary tectonic mobility of the Polish West Carpathians. A case study of the Dunajec drainage basin.* Ann. Soc. Geol. Pol. 54: 133–189.

Zuchiewicz W., 1987. *Late Neogene-Early Quaternary evolution and structural control of the Carpathian drainage pattern (Summary),* [w:] *Problemy młodszego neogenu i eoplejstocenu w Polsce,* red. A. Jahn, S. Dyjor. Ossolineum, p. 211–225, Wrocław.

Zuchiewicz W., 1989. *Morphological development of the Beskid Niski Mts. and Quaternary palaeogeography of the Polish Flysch Carpathians.* Kwartalnik Geol. 33: 541–560.

Zuchiewicz W., 1991. *On different approaches to neotectonics: A Polish Carpathians example.* Episodes 14: 116–124.

Zuchiewicz W., 1992. *Stratigraphic position of Quaternary terraces in the Dunajec river valley, Polish West Carpathians (Summary).* Przegl. Geol. 7: 436–445, Warszawa.

Zuchiewicz W., Oszczypko N. (red.), 1992. *Przewodnik LXIII Zjazdu Polskiego Towarzystwa Geologicznego, Koninki 17–19 września 1992.* Wyd. ING PAN, 215 pp., Kraków.

STRESZCZENIE

W. Zuchiewicz

DOLNOCZWARTORZĘDOWE UTWORY RZECZNE W POLSKICH KARPATACH ZEWNĘTRZNYCH (ARTYKUŁ PRZEGLĄDOWY)

W głównych dolinach Polskich Karpat Zewnętrznych zaznaczają się trzy stopnie teras skalno-osadowych, o cokołach skalnych usytuowanych na wys. 90–160 m i miąższości pokryw żwirowych 2–5 do 10–15 m, odpowiadających wiekowo piętrom pretelegeńskiemu (Różce), eburońskiemu (otwockiemu) oraz menapskiemu (narewskiemu). Wymienione terasy reprezentują stopnie teras skalnych względnie skalno-osadowych, uformowanych przed etapem tworzenia teras związanych z cyklami glacjalno-interglacjalnymi środkowego i późnego plejstocenu (zapoczątkowanym terasami „południowopolskimi", a związanymi z zatamowaniem wylotów dolin karpackich przez lądolód skandynawski). Zróżnicowana wysokość cokołów skalnych rozważanych teras, odmienna dla różnych dolin Polskich Karpat Zewnętrznych, wiąże się z odmiennym tempem podnoszenia elewacji neotektonicznych rozcinanych przez doliny będące przedmiotem analizy. Rozmiary rozcięcia erozyjnego zmieniały się od 70–110 m (Soła) poprzez 50–60 m (Dunajec) do 30–40 m (San); podczas gdy tempo rozcinania wynosiło, odpowiednio, 0,05–0,9; 0,04–0,05 i 0,25–0,3 mm/rok.

Ilość poziomów terasowych zarejestrowanych w poszczególnych dolinach Karpat Zewnętrznych jest różna, w zależności od tempa ruchów wypiętrzających elewacje neotektoniczne Karpat Północnych.