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Examples of valley and riverbed form dating by means of tree rings (Mala Panew meandering river, southern Poland)

D. Ciszewski[1] & I. Malik[2]

[1]Polish Academy of Science, Institute of Nature Conservation, Cracow 31-200, al. A. Mickiewicza 33, Poland, E-mail: ciszewski@iop.krakow.pl

[2]University of Silesia, Department of Quaternary Paleogeography and Paleoecology, Sosnowiec 41–200, ul. Bedzinska 60, Poland

Introduction

One of the factors controlling the patterns of meandering river channels is the riparian forest covering the valley floor (Hickin, Nanson 1984; Thorne 1990; Abernethy, Rutherfurd 2000; Brooks, Brierley 2002). Tree root systems protect the soil and older alluvial sediments against erosion and reduce the supply of material to the riverbed. Hence, rivers flowing through forested areas are not sufficiently charged with material coming from erosion of the valley slides. Lowland and upland rivers crossing the forested areas flow, very often, in a single channel. Frequent dams are formed from trees and Coarse Woody Debris (CWD). CWD is defined as fragments of dead trees longer than 1 m and not less than 10 cm in diameter at the fragment middle point (Van Sincle, Gregory 1990). These fragments fill the riverbed and make the water flow around them, contributing to increased river bendiness and channel roughness (Gregory 1992; Gurnell et al. 1995; Gurnell, Sweet 1998; Kaczka 1999). *Dendrochronological methods have been applied in fluvial geomorphology. Initially this methods concentrated to study of the riparian trees reaction on mechanical stress (Alestalo 1971). Dendrochronological study conducted especially in the mountains river valleys. Scars on riparian trees, adventitious roots and eccentric growth of trees, makes dating of erosion episodes feasible (Sigafoos 1964; Hupp 1986).*

Dendrochronological methods in fluvial geomorphology concentrate on the measurement of processes. Within the point bar similar-aged tree lines are observed. These tree lines are older and older when we go outside of the channel. The age of an individual line of trees show river channel lateral migration rate (Everitt 1968; Nanson, Beach 1977; Malik 2002, 2004a). This rate we can also estimate by dating of CWD laying *in situ* under the concave bank and growing on mid-channel islands and paleochannels (Ciszewski, Malik 2004).

Erosion episodes can be estimated by exposed roots analysis. After exposition to erosion wood cells in the tree rings divide clearly into early wood and late wood and start to became fewer. Making use of this process we can date erosion episodes of exposed roots. Roots sometimes have scars. In the roots cross sectional area of tree rings in callous tissue is effected by the mechanical stress of erosion and thus, we can date the bank erosion episodes too (Gärtner et al. 2001).

Study area

The Mala Panew River is a meandering river with a sandy bed which flows through the southern part of Poland (Fig. 1). The river drains an area of 2037 km² and flows through a closed forest for 20 km. The study area is dominated by alder (*Alnus glutinosa, Alnus incana*) (42%), pine (*Pinus sylvestris*) (35%), willow (*Salix purpurea, Salix fragilis)* (21.5%) and spruce (*Picea abies*) (2%). In addition, ash (*Fraxinus excelsior*), larch (*Larix decidua*) and birch (*Betula pendula*) occur sporadically. Pine monocultures grow on poor sandy habitats at the bottom of the Mała Panew valley. Fragments of a marshy riverside meadow overgrown with ash and alder have been preserved in the area.

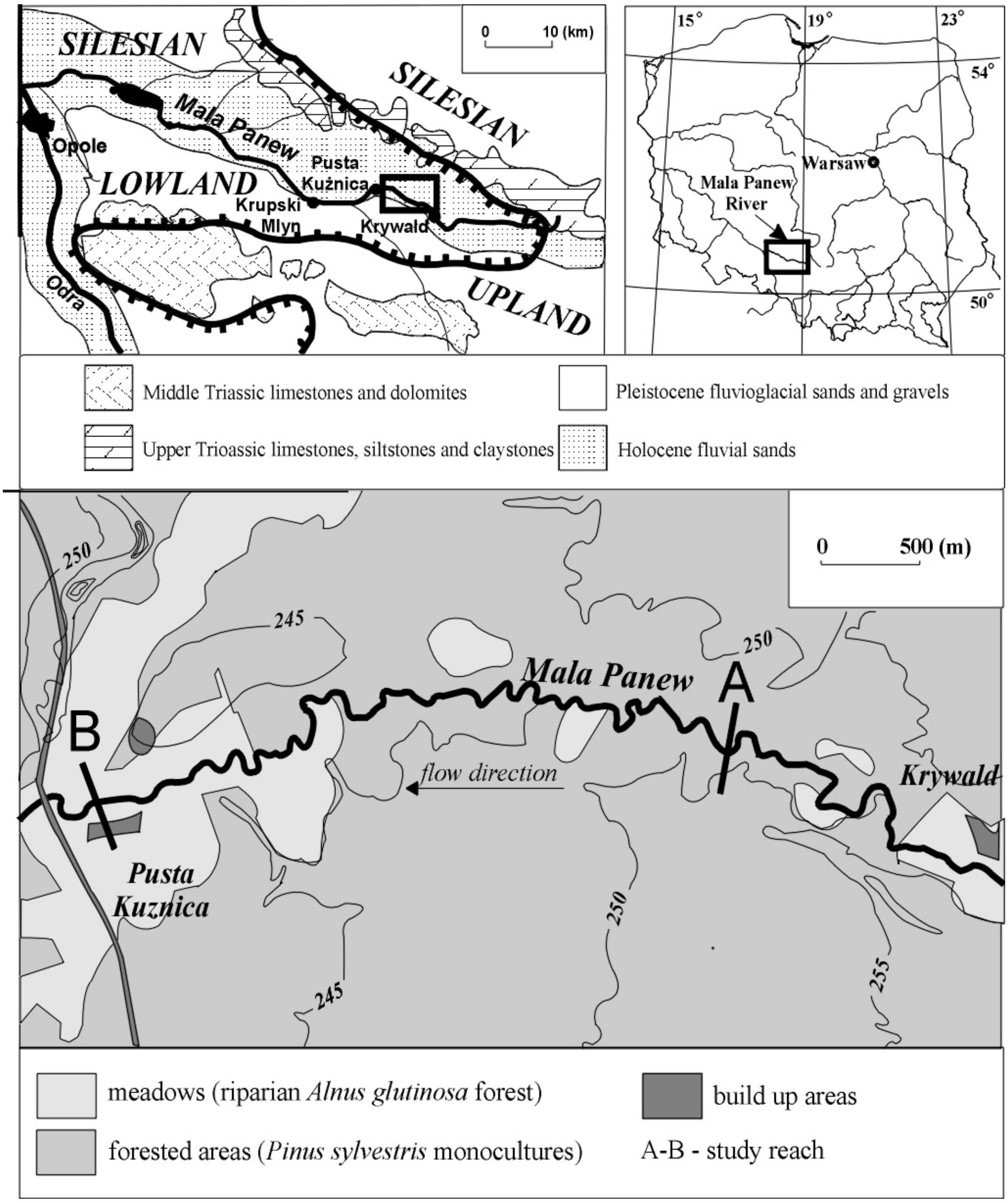

Figure 1. Study area

The study area is located in the upper Mala Panew river basin, where a 4 km reach was selected (Fig. 1). The valley bottom is filled with glacial and fluvioglacial sediments (> 10 m thick). The alluvia are composed of sands of varying grain size. A 2-3 km wide Pleistocene and three Holocene terraces (3-4 m , 2-3 m, 0.5-2 m) are observed in the Mała Panew valley. The mean annual precipitation in the area ranges from 650 to 750 mm. On average, the riverbed is 10 m wide and up to 2 m deep. The most frequent water stages in the Mala Panew river bed are 40-70 cm deep.The highest water stages in the Mała Panew channel occurred in the years 1953, 1966, 1968, 1970, 1982, 1985 and 1997 (Fig. 2).

Methods

Forms and processes investigated by CWD dating

During high discharges concave banks are undercut and the trees growing upon them fall into the channel where they stay as CWD. As the discharge wave subsides, mineral and organic material accumulates with CWD. Behind the CWD special bedforms, for example sand shadows, streamlined depressions, reverse depressions, outwashes and overflow kettles are generated (Malik 2004). When the CWD remain we can date bedforms generated by them. Large amounts of CWD laying *in situ* under the concave banks inform us about the erosion of this bank. Re-deposited CWD can be recognized by the lack of bark and sapwood, which has been separated from the rest of the log during the river transport. To distinguish re-deposited CWD, the analysis of the log orientation against the riverbed axis may also be helpful. Trees *in situ* are usually placed laterally across on the riverbed, whereas re-deposited and re-oriented stems occur in accordance with the riverbed axis direction (Kalicki, Krapiec 1995). Standard dendrochronological methods were used for developing the chronology and for cross-dating the CWD (Fritts 1972; Schwiengruber 1988). For *in situ* CWD dating a local tree ring chronology for Pinus sylvestris was constructed from the last 70 years. The chronology was based on tree ring analysis from 10 cores collected from pines currently living in the Mala Panew valley. Another stage of the study was the collection of discs from CWD pines laying in the riverbed. The 22 discs from CWD generated sand shadows and 16 from CWD laying under the concave river banks were collected from about 0.5 m above the root system. The tree rings from CWD disks were cross-dated against the local chronology. The percentage agreement coefficient (Gleichlaeufigkeit) was used to evaluate the similarity between the dendrochronological series obtained from individual disks and the chronology.

Forms and processes investigated by trees dating

Another method used for dating the trees tilting into the riverbed and mid-channel islands. The location of mid-channel islands, which relates to the river banks, as well as the dating of trees growing on the islands can also be helpful to determine the age of mid-channel island. The 15 black alders with the largest diameters at breast height were selected. Trees growing on mid-channel islands were sampled using a 40 cm Pressler's borer. The oldest trees growing on individual mid-channel islands informed us about minimal age of this forms. The

distance between the concave bank and mid-channel islands in relation to age of the oldest trees growing on mid-channel island led to dating the mid-channel islands
When the banks were cut, some of the trees growing on them tilted, and bedforms were generated. Consequently we can date the dendrochronological moment of tree tilting and thus describe the erosion episodes. Two cores were taken from all of the 14 tilted trees. One core was taken from the river side and another from the opposite side. Cores from every tree were cross-dated. A striking reduction in tree ring width indicates, the moment of tilting and consequently the occurrence of an erosion episode.

Results

Dating of the sand shadows showed that most of these forms were created in 1997 and 1985, also several in 1983, 1993, 1998. It shows a large correlation between meteorological and geomorphological events (Fig. 2). The large flood from 1997 was connected with intensive erosion because 10 events in this year were recorded. Small erosion episodes occurred in 1991, 1992 and 1998.

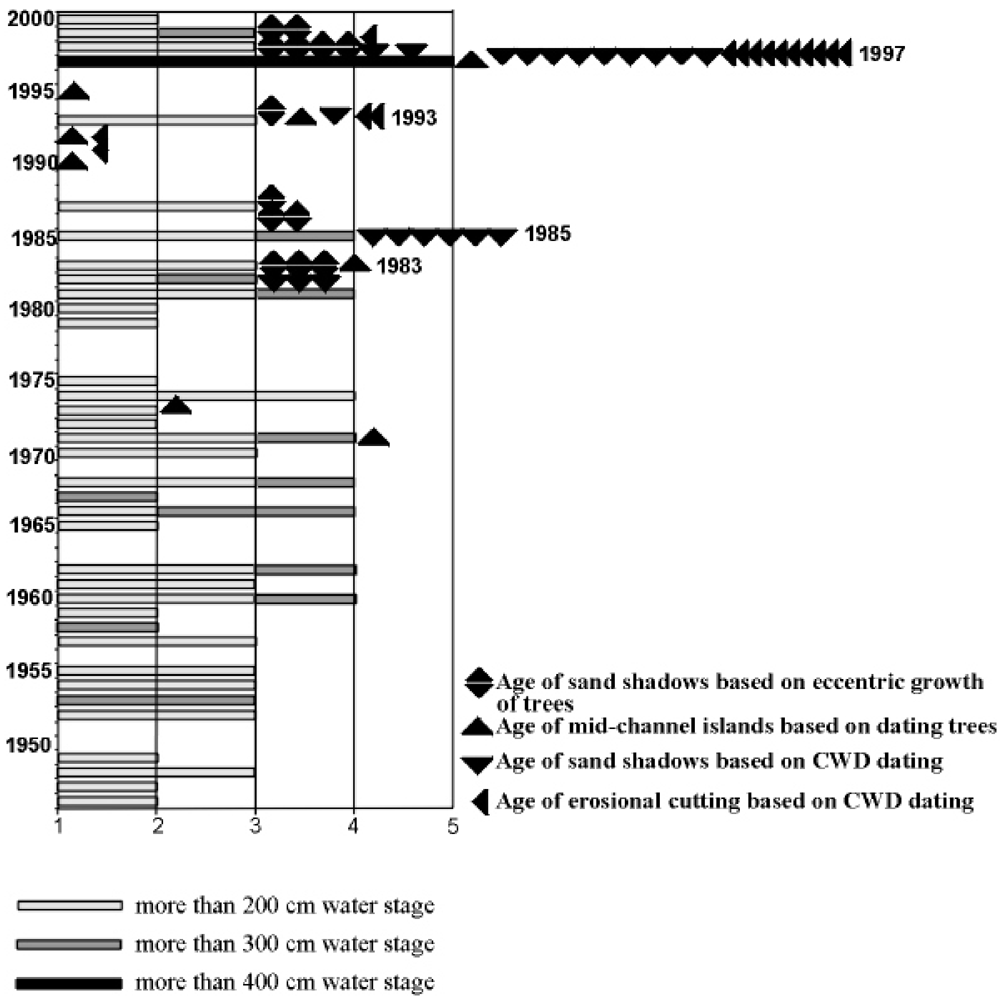

Figure 2: Water stages on Mala Panew River and geomorphology events

The dating of tilted alders showed that most of the trees were tilted in 1998, several events were recorded in 1983, 1986, 1987, 1994, 1999. The most distracted were results obtained from the mid-channel islands that were not double episodes. Erosion episodes were recorded in 1973, 1971, 1983, 1990, 1992, 1994, 1995, 1997.

The most precise results were obtained from CWD dating. There is a high correlation between erosion and meteorological events, especially in 1997 when an extraordinary flood in Mala Panew drainage basin was recorded. About 50 % of dated sand shadows, and bank erosion were intensive in 1997. Dating based on tilting trees was very precise too, but they occurred one year after the intensive erosion. Most of these episodes occurred in 1998 which correspond to the large flood recorded in 1997 with a delay of one year.
The results from mid-channel dating are less precise, there is no correlation with meteorological events. The mid-channel island dating is probably less precise because we are not sure about the age of the oldest tree growing on an individual form. The oldest tree can die during the cutting of the island from the bank. It means, we can only presume the minimal age of the mid-channel island and consequently the maximal lateral migration rate.

Conclusion

We can use dendrochronological dating to reconstruct erosion and accumulation in the riverbed. Most precise are results from CWD dating. Using these methods there is a big correlation between meteorological and dendrochronological events. The reconstruction taken from tilted alders is very precise but the reduction in tree rings forming at least one year after the investigated events. The results from mid-channel islands dating appear to be less precise.

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