ON THE LOWER VISTULA VALLEY DEVELOPMENT IN THE LIGHT
OF GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL INVESTIGATIONS

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Abstract. The paper concerns the Lower Vistula River valley relief development from the Late Glacial until the present, based on the author’s geological and geomorphological mapping of this area. Relations between the older (originating prior to the last glacial advance) foundations of the valley and deposition modes within its edges during the last glaciation are described. Particular attention has been paid to traces of dead-ice blocks which had a huge impact upon the development of glaciofluvial and glacial terraces during the Late Glacial. Description of the Vistula River floodplain that reflects a morphological effect of an increasing human impact upon natural environment, its development, landforms and sediment properties, are presented in detail. Their analysis leads to the conclusion that the present-day floodplain resembles partly an initial stage of the anastomosing rivers.

Key words: relief evolution, dead-ice landforms, floodplain, Lower Vistula River valley, Late Glacial, Holocene.

INTRODUCTION

The Vistula River, taking into account the outflow, is the biggest one with a fully developed system of valley terraces in the Baltic Region. It is considered to have a constrained channel system (Falkowski, 1990). The area occupied by the Holocene floodplain channel deposits is rather small and therefore, the Vistulian deposits are not concordant with the present-day hydrodynamic channel conditions (no equilibrium meandering fluvial pattern is achieved). The sedimentation within the valley bottom resembles in some way an initial stage of the anastomosing fluvial system i.e. presence of large biogenic wetlands, fine flood deposits and fairly stable main channel belt (Smith, Smith, 1980; North et al., 2007). Therefore, the investigations upon the Vistula River sediments, especially the flood deposits, can help in better understanding a development of anastomosing fluvial systems in the formerly glaciated areas in Europe.

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Detailed geomorphologic and geological mapping were used as the main investigation methods. The analysed reach of the valley comprises the western part of the Toruń Basin, Fordon Gap, Unisław Basin, Świecie Basin and the southern part of the Grudziądz Basin between Pędżewo in the south and Szympych in the north. The Świecie Basin was chosen as a test area (about 25 km reach of the river course), which exemplifies a spatial distribution relations between various types of flood sediments (see further illustrations). For a description of the area about 8000 hand-made boreholes, 4000 among them from the test area of Świecie were used. They were supplemented by the sedimentary structures and the texture observations in over 250 outcrops and pits.

METHODS

DISTINCTIVE FEATURES OF THE LOWER VISTULA VALLEY

The Vistula River valley is a polygenetic one (Drozdowski, 1979, 1982, Bryczewski, 1986). Its lower part downstream from Bydgoszcz as far as the Żuławy Delta Plain makes a large gorge through the morainic plateaux and recessional end moraines of the Poznań and Pomeranian phases (Mojski, 2005). The Lower Vistula River valley has a well-developed system of terraces. In the Grudziądz Basin 10 such terraces are distinguished (11 terraces along the whole Lower Vistula River region). A development of the terrace system was so quick that as early as on the onset of the Holocene, the shape of the valley was very similar to the present one (Drozdowski, Berglund, 1976). On the terraces XI to IX (see Fig. 1) the outflow was directed to the south, on the terraces VIII to VI a bifurcation occurred when the Vistula headed simultaneously to the west to the Toruń-Eberswalde streamway and to the north to the Gulf of Gdańsk. Starting with the terrace VI the outflow has been established in the northern route (Galon, 1953; Niewiarowski, 1968). The floodplain is generally subdivided into two or three topographic levels (Galon, 1934; Niewiarowski, 1987; Babiński, 1990, Kordowski, 1999, 2001). The first two are natural, the youngest one is anthropogenic, developed due to a consistent river regulation at the end of 19th century.

RELIEF EVOLUTION AND SEDIMENTATION OF DEPOSITS DURING THE LATE GLACIAL AND THE HOLOCENE

Valley depression caused modifications of the movement direction in the ice sheet sole. The tills thus coming into being in its surroundings were distinctly more sandy than those from far-distant plains (Fig. 2). Shapes of grain-size cumulative curves resemble the ones of the older fluvial and glaciofluvial sediments, incorporated into the ice body. Frequency diagrams indicate strong bimodality or polymodality. The fines, are to be connected with shearing processes in the ice sheet, whereas a sandy mode is to be associated with incorporation into the ice of older, mostly fluvial, local deposits, accumulated prior to the last glacial advance. The clasts are enriched in local rocks, mainly glauconitic sandstones and Mesozoic limestones. The Vistula valley edges modified the extent and the course of minor ice sheet oscillations, what can be examined in the southern part of the Grudziądz Basin and in the northern part of the Chelmno Upland (Niewiarowski, 1961; Drozdowski, 1974).

During a retreat of the ice sheet numerous small terminglacial lakes emerged but, unlike in the morainic plains, the varves have not been well developed. Instead of a slow deposition from suspension, density and grain flows were more important. The valley depression favoured formation of dead-ice blocks, hence common existence of tiny kame terraces, kettles and debris flow tongues occur (Figs 3–5). In the larger ice crevasses the sandy infilling landforms were formed.

The meltwaters from the ice sheet passed across the valley heading towards the Chelmno Upland. After partial melting of the ice-dam in the valley, a process of glaciofluvial and fluvial terraces development has become. Subsequently to final development of the terrace system at the valley bottom, vast valley lakes and mires commonly occurred, in which a thick deposition of calcareous gyttjas took place (Figs 6, 7). These sediments have buried the Late Glacial fluvial braided structures present at the valley bottom (Figs 8, 9). In the Unisław Basin the subaqueous fans graded into the existing depressions occupied by the lakes. A beginning of the organic accumulation was dated by Niewiarowski (1987) at 10 250 14C BP. Gyttjas and peats are enriched in non-carbonate material (~30%), indicating a fluvial influence. They are also rich in carbonates, about 25% on the average. The rest is constituted by organic matter. According to Bartkowiak (2008), the carbonates are overwhelmingly amorphous (67.5–98.6%), therefore indicating an enhanced solubility.

RESULTS

FLOODPLAIN SEDIMENTS AS INDICATORS OF POSSIBLE EARLY STAGE INITIATION OF RIVER ANASTOMOSIS

About 3400 14C BP (the oldest radiocarbon dating from the sample in alder leaves peat in Podwiesk), the evolution of the cover of flood sediments has begun (Figs 7–11).

The average thickness of flood deposits, estimated on the basis of the analysis of over 6000 boreholes, is equal to about 2.23 m and reaches 7 m maximum (Maksiak, 1983). A common grain size composition is: clay 6%, silt 60%, sands...
Fig. 1. Geomorphologic outline of the Lower Vistula River valley
Fig. 2. An example of the till structural and granulometric properties at the Paparzyn site (see Fig. 1), located nearly 1 km from the present edge of the valley.
Fig. 3. The geomorphologic map of the southern part of the Grudziądz Basin. The map presents crevasse-infillings in a very low geomorphologic position (signature 5). Geological cross-sections from Fig. 4 are also presented.

Fig. 4. Geological cross-sections through crevasse infilling in the Grudziądz Basin. The form is straight-lined, 12 m high. The length is about 1.5 km but its eastern part is buried under the sediments of fluvial fans developed at the mouth of Młynkówka subglacial channel at the edge of the Chelmno Upland.
Fig. 5. An example of the debris flow tongues with cross-sections at Nowa Wieś Chelmińska in the north-eastern part of the Świecie Basin.
Fig. 6. Organic and carbonate deposits thickness in the south-eastern part of the Unislaw Basin
Fig. 7. Organic deposits thickness in the Świecie Basin
Fig. 8. Overbank deposits (flood, blue clays and organic ones) thickness in the Świecie Basin
Fig. 9. Flood deposits thickness in the vicinity of Chelmno and Swiecie
Fig. 10. Flood basin deposits thickness in the vicinity of Chełmno and Świecie
Fig. 11. Extent and thickness of sandy flood deposits (natural levees, sandy shadows, micro-deltas and sandy ribbons) in the Świecie Basin
A development of the Lower Vistula River valley was strongly influenced by the older geological setting. The present valley in the basin areas resembles in many places the valley depressions, which had come into being before the Vistulian valley in the basin areas resembles in many places the valley strongly influenced by the older geological setting. The present ice jams. The analysis of biogenic sediments leads to the conclusion that they are overwhelmingly limnic. A development of the floodplain was also associated with shallow and vast lakes development. These features allow assuming that development of the initial stage of an anastomosing-like fluvial pattern in the present Vistula floodplain was recently interrupted by the human impact (river regulation).

In the case of the lower Vistula region the anastomosing has been most probably caused by presence of many valley basins occurring over former valleys established prior to the last glaciation (Vistulian Main Stadial) and gaps between them, where no valley occurred. They have played to some point, a similar role to mountain foredeeps, favouring development of typical anastomosis (i.e. Smith, Smith, 1980; Rust, 1981; Miall, 1996; Makaske, 1998; Makaske et al., 2002; Wang et al., 2002).

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REFERENCES


