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River valleys of the Eemian Interglacial in central Poland

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The presented fluvial pattern of the Eemian Interglacial in central Poland is the most complete and based on a critical review of the published and archival data. In the final image, the most significant was a relation of this fluvial pattern to a water level of the Eemian sea in the lower Vistula region. Fluvial sediments of the Eemian Interglacial are also present in the tributary valleys, i.e. the Wieprz, Pilica and Narew rivers. A fluvial pattern of the Eemian Interglacial in central Poland is roughly reflected by the present one, with its main northern watershed in the southwestern Mazury Lakeland. Similar fluvial patterns have developed during successive interglacials in the Polish Lowland and therefore, central Poland has acted as a river junction.

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Key words: central Poland, Eemian Interglacial, palaeovalleys, rivers.

INTRODUCTION

Fluvial pattern of the Eemian Interglacial in central Poland is presented. Occasional information on sediments of this age can be found in regional monographs and short communications. A little more data on fluvial sediments of the Eemian Interglacial in central Poland have been supplied by geological mapping during the last 30 years. Many years mapping in the Polish Geological Institute supplied with numerous geologic data, which have been used occasionally only to palaeogeographic reconstruction. These data indicate undoubtedly that a central part of Poland (and particularly, the Warsaw Basin) acted as a main hydrographic junction of the Central European Lowland, but conclusions drawn by different authors were fragmentary and many a time, also contradictory to one another.

Central Poland has not been occupied by an ice sheet since the Wartanian Glaciation but only subjected to successive episodes of fluvial erosion and accumulation. At present many main rivers of the Polish Lowland pass across this very area. However, a fluvial pattern of the Eemian Interglacial could not have been reconstructed in detail yet.

METHOD

Analysed were results of lithologic examination of cores of the research boreholes in central Poland, as well as published sheets (together with attached geologic sections) of the *Detailed Geologic Map of Poland* in scale of 1:50 000. Geologic sections of research boreholes for these sheets were analysed, to distinguish the Pleistocene buried fluvial series of different age and to describe their lithologic properties. Supplemented with other published information on ancient fluvial series, all these data could be put together and critically revised. This analysis enabled reconstruction of a fluvial pattern of the main river valleys of the Eemian Interglacial in central Poland. Unfortunately, a considerable part of the examined area has not been covered yet with sheets of the *Detailed Geologic Map of Poland*, on the other hand some sheets have been finished many years ago, what means that they are distinctly out-of-date and present a surficial geologic structure only. The resulting cartographic image of a palaeovalley system of the Eemian Interglacial is considerably varied if its geologic evidence is concerned, and it is still incomplete in many places. The latter is particularly true for

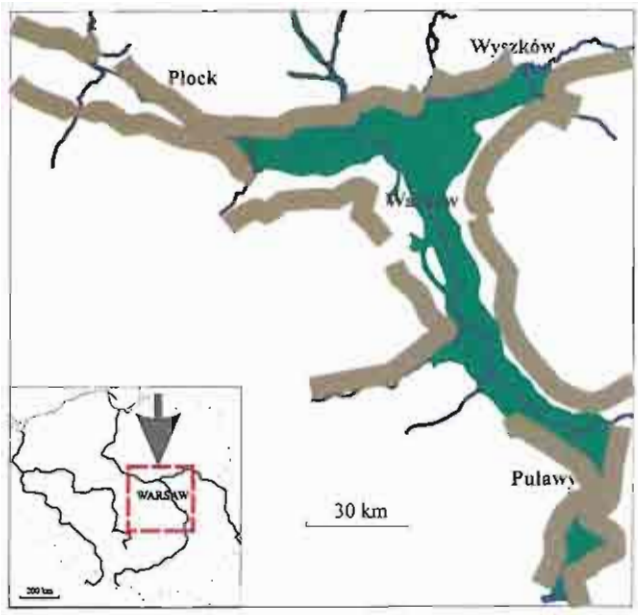

Fig. 1. Fluvial sediments (green) of the Eemian Interglacial against the present valley scarps (brown) in central Poland

the area to the east of Warsaw, i.e. the drainage basins of the Narew, and the lower and middle Bug rivers, where many sheets of the *Detailed Geologic Map of Poland* have not been finished or even the mapping has not been started yet.

CRITERIA

Generally the Pleistocene fluvial sediments are not outcropping at the land surface in central Poland and can be analysed in the borehole sections only. Among them, research boreholes for the *Detailed Geologic Map of Poland* in scale of 1:50 000 created foundations for a correct spatial correlation of the buried fluvial sediments.

Standard lithologic analyses of cores of the test-cartographic boreholes comprise grain size composition, heavy mineral content, simplified petrography of gravels in fraction 5–10 mm (collected mostly from tills), carbonate content and roundness of quartz grains. For determination of fluvial origin the most important are commonly: roundness of quartz grains, heavy mineral content and grain size composition. A simplified petrographic analysis of gravels can be applied occasionally to a rough dating of the analysed fluvial series (*cf.* K. Kenig, 1998). The authors renewed examination of the original archival material for the *Detailed Geologic Map of Poland* indicated that the most promising results are to be received from a selective analysis of heavy mineral content and to a smaller degree, from grain size composition (*cf.* L. Marks, K. Pochocka, 1998*a*). On the other hand, a principal role ascribed commonly to roundness of quartz grains does not seem reasonable. Good roundness may result from a considerable admixture of the Tertiary material, therefore it does not play a decisive role in determination of the origin of the examined sediment.

EEMIAN RIVER VALLEYS

Critical review of the previously published data, maps included (derived firstly from the *Detailed Geologic Map of Poland,* scale 1:50 000), enabled to create quite a compact image of a fluvial network of the Eemian Interglacial in central Poland (L. Marks, K. Pochocka, 1998*a–c*). Its reliability was verified by connecting this ancient fluvial pattern with sediments of the Eemian sea in the Lower Vistula Valley (*cf.* A. Makowska, 1979, 1984, 1986). Stratigraphic location of the latter was determined by A. Makowska (1979), who found a gradual transition from marine sediments in the north, through deltaic sediments to typical fluvial series in the south. Much helpful was the evidence that a water level of the Eemian sea was very close to the present water level in the Baltic Sea (L. Marks, K. Pochocka, 1998*a–c*; see also K. L. Knudsen, 1985; B. Kosack, W. Lange, 1985; B. Menke, 1985; G. Steinich, 1992; J. E. Mojski, 1993).

The presented fluvial network of the Eemian Interglacial seems to be the most complete and critically revised collection among the available information. It is reliably related to the assumed water level of the Eemian sea in the Lower Vistula region. Fluvial sediments of the Eemian Interglacial were found mostly close to and within the present Vistula valley, but they have been occasionally dated only. They fill an ancient river valley, about 10 km wide (Fig. 1), wider in vast basins at mouths of the larger tributaries, e.g. the Pilica River (to 15 km wide) and the Narew River (even to 25 km). In the northern part of the Sandomierz Basin in southern Poland, a base level of erosion of the Vistula from the Eemian Interglacial occurs at about 120 m a.s.l. In the Vistula gap of the South Polish Uplands (between a mouth of the Kamienna River and Puławy), a base of a fluvial erosion during the Eemian Interglacial depended mostly on lithology of the bedrock (Fig. 2). Where the latter is composed of the Upper Cretaceous gaizes and limestones, the palaeovalley is relatively narrow (from 1 km near Kazimierz Dolny to 2.5 km near Opole Lubelskie), and incised to about 120 m near Zawichost and 115 m a.s.l. (i.e. 5 m below a bed of the Holocene fluvial series) at mouth of the Kamienna River (W. Pożaryski *et al.*, 1994*a, b*). Further downstream it drops to 112 m near Opole Lubelskie (W. D. Dowgiałło, 1991), 110 m at Janowiec (W. D. Dowgiałło, 1982) and 105 m a.s.l. at Puławy (Fig. 2).

No convincing evidence for neotectonic movements are provided, except for the Puławy region where the Tertiary dislocations have been presumably rejuvenated during the Quaternary. Lithology of the bedrock changes downstream: the more easily eroded Palaeocene gaizes and sands with admixture of phosphorite concretions occur in the reach Puławy–Dęblin, and downstream there are the Oligocene and Miocene sands. Therefore, the river bed of the Eemian Interglacial drops down to 85 m at Dęblin (M. Żarski, 1991), and

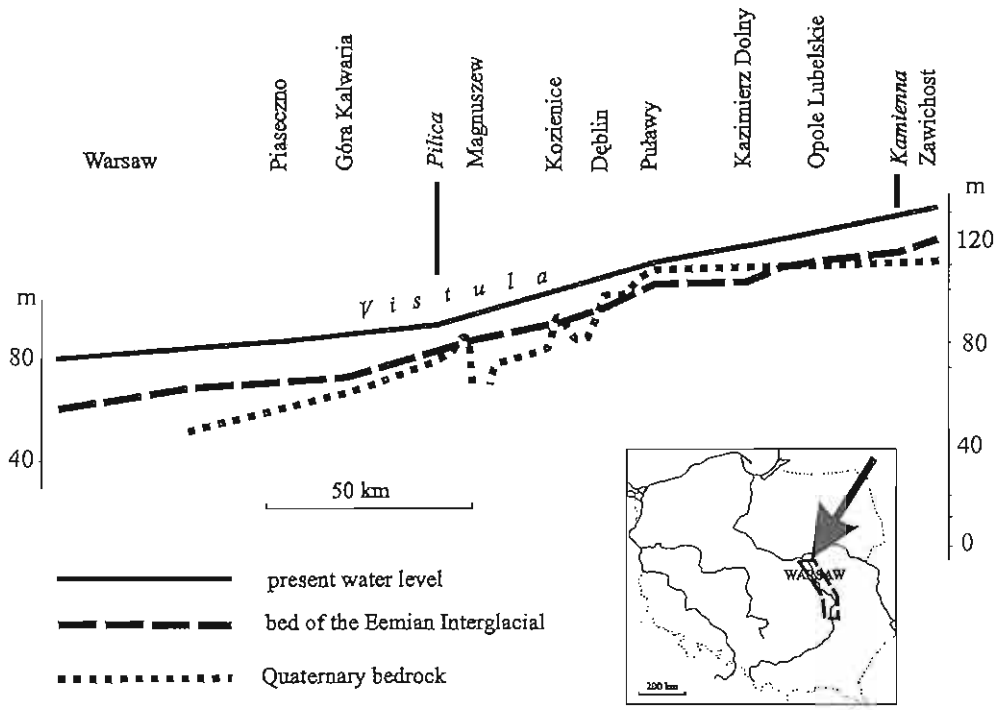

Fig. 2. Longitudinal section of the middle Vistula

80 m a.s.l. at Kozienice (M. Żarski, 1996*a*, *b*; however, after A. Makowska, 1969, it is assumed to occur at about 88 m a.s.l. there), and the palaeovalley gets considerably wider (Fig. 1). In the vicinity of Kozienice, sediments of the Eemian Vistula were thermoluminescence dated at 93±13 ka BP (M. Żarski, 1996*a*, *b*).

This gradual lowering of the bed of fluvial sediments of the Eemian Interglacial is disturbed near Magnuszew where it rises to 84 m a.s.l., and they are located within a fluvial series of the Mazovian (Holsteinian) Interglacial (Z. Sarnacka, 1979). Such a high location of the bed of fluvial sediments of this interglacial does not seem reasonable. It can be exclusively due to incorrect chronologic determination of the sediments. To the north from a mouth of the Pilica River, the Eemian alluvia are underlain by fluvial sands of the Mazovian (Holsteinian) Interglacial but oecasionally, they also contact directly with the Pliocene clays (especially in Warsaw and to the south of it), among others near Góra Kalwaria where river erosion reached to about 70 m a.s.l. (Z. Sarnacka, 1966, 1968), i.e. 20 m below the present water level of the Vistula (Fig. 2). Fluvial sediments of the Eemian Interglacial are also present in the tributary valleys, e.g. of the Wieprz and Pilica rivers.

In Warsaw, the buried fluvial sediments of the Eemian Interglacial occur at 72–65 m a.s.l. (W. Morawski, 1979; Z. Sarnacka, 1980). The river reached locally the glaciotectonically deformed Pliocene sediments, i.e. its bed is located at 58–62 m a.s.l. Fluvial sediments are 25 m thick and form 3 sedimentary cycles. Sometimes a bed of fluvial sediments of the Eemian Interglacial has been determined wrongly as too low in the Warsaw area, i.e. at 40–45 m a.s.l. (J. Nowak, 1977, 1978; Z. Sarnacka, 1992; W. Słowański *et al.*, 1995). Down stream from Warsaw the pre-Narew River or most probably, the pre-Bug River joined the main river from the east (Fig. 1). In the north-central Poland, a bed of the Eemian fluvial sediments occurs at 60–54 m a.s.l. and a course of the Eemian river valley is generally reflected by the present one. General coincidence of the present and the Eemian fluvial network in central Poland is disturbed downstream (*cf.* A. Makowska, H. Ruszczyńska, 1960). In the Płock Basin where no Eemian sediments of the pre-Vistula are noted — directly beneath fluvial series formed during the last glaciation (series of the ice-marginal spillway), there are older tills of the South Polish Glaciations (Elsterian). The Eemian fluvial sediments appear, however, again near Dobrzyń and Włocławek in the Toruń Basin, with their bed at about 50–58 m a.s.l. (J. E. Mojski, 1961; S. Skompski, 1972). On the other hand, J. W. Jeziorski (1991) determines a bed of fluvial sediments of the Eemian Interglacial near Ciechocinek at about 30 m a.s.l., what seems really reasonable.

In the valley of the lower Bug River, a bed of fluvial sediments of the Eemian Interglacial occurs at 70 m a.s.l. at Ostrów Mazowiecka (R. Żuk, 1993) and Małkinia Górna (K. Wrotek, 1995). In the Bug River valley near Treblinka, alluvia of the Eemian Interglacial were thermoluminescence dated at 83±12 ka BP (K. Wrotek, 1995). Further westwards, a bed of fluvial sediments of the Eemian Interglacial drops to 60 m at Wyszków (K. Straszewska, 1968) and about 50 m a.s.l. at outlet of the Bug River into the Narew River (Fig. 3). Then it rises to 60 m at the outlet of the Narew River into the Vistula near Zakroczym, and drops again to 54 m a.s.l. near Wyszo-

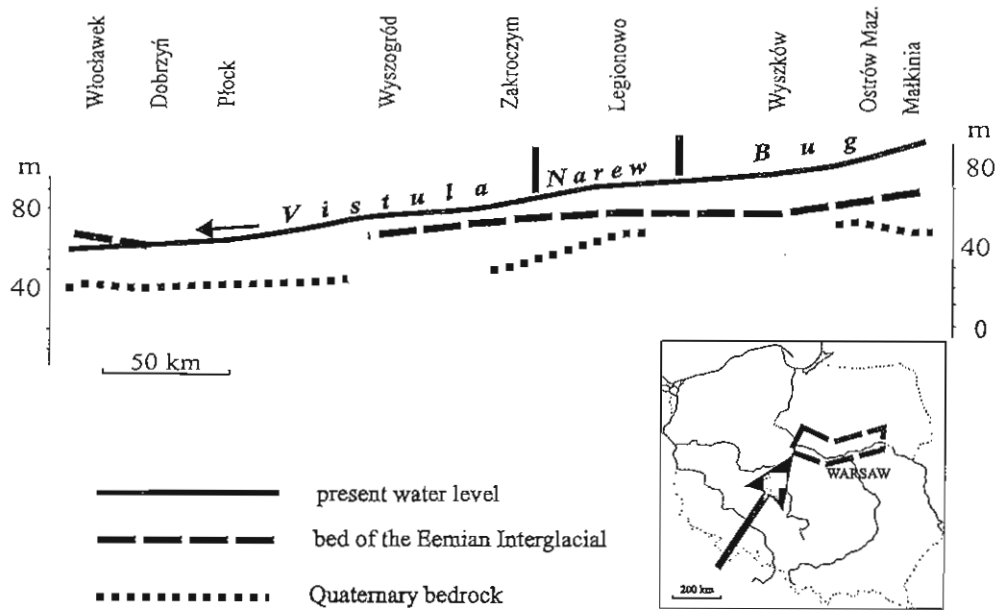

Fig. 3. Longitudinal section of the lower Bug and Narew, and the northern middle Vistula

gród. Such overdeepening in the interfluve of the Vistula and the Narew at Legionowo corresponds exactly to a distinct depression (glacial tunnel valley) in the Quaternary bedrock and seems to result from varied post-depositional compaction of the sediments (Fig. 3).

CONCLUSIONS

The presented fluvial network of the Eemian Interglacial in central Poland is the most complete and a critical review, both of the published and the archival data. Similar fluvial patterns have developed during successive interglacials in the Polish Lowland; thus, mid-central Poland acted as a junction of a fluvial system during the Quaternary. In the final image, the most significant was a relation of this fluvial pattern to the probable level of the Eemian sea in the Lower Vistula region. In central Poland a fluvial pattern of the Eemian Interglacial is roughly reflected by the present one (*cf.* I. Pawłowskaja, 1996), and the main northern watershed ran in the southwestern Mazury Lakeland (L. Marks, 1988). Fluvial sediments of the Eemian Interglacial are also present in the tributary valleys to the Vistula, e.g. valleys of the Wieprz, Pilica and Narew rivers. This pattern resembles therefore a fluvioperiglacial drainage system, developed at the end of the Wartanian Glaciation. During the Vistulian Glaciation, it was considerably transformed due to widespread ice-dam deposition, when the ice sheet which advanced into the Płock Basin, made a northwestward runoff impossible and a vast ice-dam lake developed in the Warsaw Basin. The latter resulted in a rise of the base of erosion in the middle Vistula Basin and partly also in the upstream part of this river. The valley of the middle Vistula was filled with widespread ice-dam deposition and then considerably incised, due to development of a vast ice-marginal spillway during the Vistulian Glaciation. Only sediments of the youngest Pleistocene river runoff are present at a land surface in the Vistula valley and its tributaries. They form overbank terraces which correspond to water outflow in ice-marginal spillways that developed in ice sheet forefield during the Vistulian Glaciation.

The presented spatial image of the buried river valleys of the Eemian Interglacial is not in fact a simultaneous one and has never existed as such (Fig. 1). It presents, however, a complex image of a fluvial discharge, changing during the Eemian Interglacial, and possible misunderstandings result mainly from a lack of credible dating methods.

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SIEĆ RZECZNA INTERGLACJAŁU EEMSKIEGO W POLSCE ŚRODKOWEJ

Streszczenie

Celem badań było kartograficzne przedstawienie systemów dolin rzecznych ukształtowanych w interglacjale eemskim na obszarze Polski środkowej. System ten odgrywał w czwartorzędzie rolę węzła hydrograficznego. Przez ten rejon przepływały główne rzeki Niżu Polskiego, a jednocześnie po zlodowaceniu warty nie został on już przykryty przez lądolód i od tego czasu następowało w nim nakładanie się na siebie kolejnych, coraz młodszych systemów rzecznych. Przeanalizowano arkusze *Szczegółowej mapy geologicznej Polski* w skali 1:50 000, wykonane dotychczas dla obszaru Polski środkowej, w tym również przekroje geologiczne załączone do tych arkuszy oraz archiwalne opracowania litologiczno-petrograficzne. Zestawiono profile kartograficznych otworów badawczych, w których na podstawie wyników szczegółowych analiz laboratoryjnych wyróżniono różnowiekowe kopalne serie rzeczne oraz określono ich charakterystyczne właściwości litologiczne. W uzupełnieniu wykorzystano również zawarte w publikacjach informacje dotyczące kopalnych serii rzecznych.

Ostateczna weryfikacja przedstawionego obrazu paleogeograficznego została oparta na wzajemnej relacji systemu rzecznego i poziomu morza eemskiego w Dolinie Dolnej Wisły. Układ sieci rzecznej interglacjału eemskiego w Polsce środkowej był w przybliżeniu podobny do współczesnego (fig. 1), z głównym działem wodnym w południowo-zachodniej części Mazur. Osady rzeczne interglacjału eemskiego występują również w dolinach dopływów Wisły, m.in. Wieprza, Pilicy i Narwi (fig. 2, 3). Cały system interglacjalny odzwierciedla w znacznym stopniu drenaż fluwio-peryglacjalny, ukształtowany w schyłkowej części zlodowacenia warty. Został on jednak nieco przekształcony podczas zlodowacenia wisły, kiedy podparcie odpływu rzecznego przez lądolód w Kotlinie Płockiej i utworzenie rozległego zastoiska w Kotlinie Warszawskiej spowodowało podniesienie bazy erozyjnej w dorzeczu środkowej, a w mniejszym stopniu — również górnej Wisły. Dolina Środkowej Wisły została wypełniona osadami zastoiskowymi, które następnie podlegały rozcięciu przez powstający przepływ pradolinny w okresie zlodowacenia wisły.

Przedstawiony w sposób kartograficzny obraz przestrzenny kopalnych dolin rzecznych interglacjału eemskiego Polski środkowej (fig. 1) jest najpełniejszym, krytycznym przeglądem dotychczasowych materiałów publiko-

wanych oraz archiwalnych i ma charakter zbiorczy. Oznacza to, że sieć rzeczna została uznana za równowiekową, chociaż faktycznie nigdy nie istniała w takim ujęciu. Jest to natomiast synteza przepływu rzecznego zmieniającego się w czasie interglacjału, zaś istniejące niejasności wynikają z braku wiarygodnych metod datowania osadów rzecznych.

W analizowanym obszarze Polski środkowej nie stwierdzono dotychczas przekonywających dowodów na intensywne ruchy neotektoniczne. Jedynym wyjątkiem jest rejon Puław, gdzie uskoki trzeciorzędowe zostały najprawdopodobniej odnowione w czwartorzędzie.