ABSTRACT BOOK

Kielce-Suchedniów
FLAG
Fluvial Archives Group
Biennial Meeting
12-18.09.2016

Evolution of river valleys in Central Europe

Ed. Tomasz Kalicki, Marcin Frączek

Polish Association for Environmental Archaeology

Department of Geomorphology, Geoarchaeology
and Environmental Management,
Institute of Geography, Jan Kochanowski University in Kielce

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Kielce - 2016

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ABSTRACTS

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QUANTIFYING FLUVIAL-CAPTURE-INDUCED DENUDATION AND SURFACE LOWERING IN IBERIA (DUERO, EBRO AND TAJO BASINS)

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Iberia is one of the highest regions in Europe, with an average elevation above 600 m.Its peculiar topographic signature is the result of the interplay of tectonic and erosional processes, whose relative importance changed over times. In this context fluvial processes are responsible for the erosion and the sediment transport at the continental scale. Although, quantifying these processes, their relevance and rates at specific times still remains a challenge.

The Iberian Peninsula is a key natural laboratory for the study of large-scale capture processes and the influence of those on topography and landscape evolution. Nowadays, three main rivers (Duero, Ebro and Tajo) drain almost half of the total Iberia surface. These watersheds cover an area over 250 km^2, where the development of the present-day drainage network was related to the opening of formerly closed fluvial systems, developed within ancient Cenozoic basins.

For these main foreland basins the opening of an outward drainage system leads to high incision and denudation rates, within intrabasinal areas. However, key questions on the timing and processes involved in the basins opening, as well as the influence of tectonics on it, remain open. The signature of that change in drainage conditions is still preserved in some areas, and can be studied through the analysis of longitudinal profiles shapes, the present day topography and the spatial distribution of surface erosion associated to the exorheic history of the basins.

This work approaches the analysis of the denudation processes for the main basins, through the reconstruction of the former (Late Miocene) sedimentary infill. It provides a quantification of the sediment fluxes in response to the drainage opening, and allows the construction of denudation maps for each basin.

Results reveals almost one order of magnitude higher eroded volumes, and over four fold surface lowering, in the former Ebro Basin when compared to the Duero and the Madrid (Tajo) basins. An integrated analysis of erosional volumes and spatial distribution of dissection are approach in terms of timing, tectonic influences and the fluvial response to the captures.

The study highlight important questions about the different response of the studied catchments, which may help to understand the processes and timing involved in the post Neogene drainage and the topographic evolution of Iberia.

TECTONİC AND CLİMATİC CONTROLS ON QUATERNARY FLUVİAL PROCESSES AND TERRACE FORMATİON AT THE GOKSU RİVER, SOUTHERN ANATOLİA

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All river terraces are characteristic morphological forms which are common worldwide as key elements for understanding the nature of fluvial landscape evolution. They express also the relationships of that fluvial evolution with changing internal dynamics, climate-related (hydrological regime) variations in water and sediment supply, as well as tectonic/climatic (eustatic) base-level fluctuations.

It is our goal to discuss in this study the fluvial accumulation during the relatively warm and cold periods of an important river from Anatolia, called the Göksu River, and to determine the effects of climate change in combination with tectonic movements on the valley morphology.The Göksu River settles in the Mut Neogene Basin in South Anatolia, and is located in the Taurus Mountains tectonic zone. The river, with its a well-developed terrace sequence, has its source in the Central Taurus Mountains and reaches the Mediterranean Sea through the Silifke delta, draining an area of approximately 10.400 km^2. The remnants of the fluvial terraces of the Göksu River (T1-T16) at approximately 50-100 km inland from the coast of the Mediterranean Seaexpose a wide range of altitudes between 10 m and 367 m above the present-day river channel. The high levels, T1-T6, are flat surfaces which rarely contain fluvial deposits and have only limited extent. In comparison with those higher levels, the younger terraces T7-T16 are relatively well-preserved and expose conglomeratic deposits with thickness between 1-10 meters.

Thepresent results are largely based on detailed archiving and analysing of the sedimentary structures observed in a number of outcrops. They are described according to Miall's (1996) lithofacies, lithological properties, and thickness to derive the sedimentary processes. The chronology of the latest fluvial aggradation-incision phases of the river system is based on OSL datings of the sediments within one of the youngest terraces. In the investigated section of the study area two distinct fluvial phases can be distinguished. The age interval of the first phase ranges from 225 to 185 ka, pointing to an interglacial phase corresponding with MIS 7, whereas the second phase is situated in the interval between 170 and 161 ka. According to these ages, it is assumed that the Göksu River began to accumulate its fluvial sediments during the warm climate conditions, creating coarse- grained deposits in the lower parts of the terrace sediment series, and continued its fluvial accumulation with relatively fine-grained sediments in the upper parts of the terrace series during the next cold phase. The incision of the Göksu River prior to all deposition of the terrace should have taken place at theprevious cold-warm transition.

Additionly, since the study field is located in the Taurus orogenic belt, the Goksu River valley was probably affected byalso tectonic movements. Some morphological markers, such as narrow floodplain of the river, several normal and oblique faults, the knickpoints in the field show that tectonics could have been effective both regionally and locally in the Goksu River valley.

ISSUES IN GENERATING EFFECTIVE FIELD-MODEL COMPARISON IN LANDSCAPE EVOLUTION MODELLING

Rebecca M. Briant[1], Kim Cohen[2], Stephane Cordier[3], Alain Demoulin[4], Mark Macklin[5,6],Anne Mather[7], Gilles Rixhon[8], Tom Veldkamp[9],John Wainwright[10], Alex Whittaker[11], Hella Wittmann[12]

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Landscape evolution modelling is inherently different from hydrological modelling or other modelling approaches applied over shorter timescales. The requirement for prediction is rare; rather what is aimed for is an ‘insightful simplification’, which allows understanding to be developed. From this, we can explain what has happened in landscapes, better understand driving factors and allow emergent behaviour where a simple set of factors may lead to apparently complex behaviour. Evaluating such modelling against field datasets is essential to assess the adequacy of a model; adequate models being more useful for explaining how processes operate and depositional records form. However, the nature of the field data collected is inherently different from both the model input parameters that need to be specified and the outputs generated. We therefore need to develop approaches to field-model comparison that allow for the differences between these two approaches. For example, where site-specific field data are to be compared with continuous three-dimensional model data, differences between field-sampling and numerical-scheme resolution(s) have to be overcome. Changing both field-data-collection strategies and model-output specification can do much to ensure greater comparability, and improve our understanding of how systems operate. We discuss the issues involved in field-model comparison specifically in relation to landscape evolution models, and evaluate current practice.

This talk comes from the work of the FACSIMILE network (Field And Computer SIMulation In Landscape Evolution)

MAKING SENSE OF THE LOWER AND MIDDLE PALAEOLITHIC: FLUVIAL ARCHIVES TO THE RESCUE

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Throughout Europe, much of the evidence for early hominin occupation is associated with fluvial archives, a consequence of the numerous lithic artefacts discovered in river terrace sediments over more than two centuries. It has long been recognized that there are numerous differences in styles of knapping and shapes of tools amongst material that represents the activities of pre-*sapiens* humans over a lengtgh period of the Middle Pleistocene. Hitherto, however, it has proved difficult to resolve these differences into meaningful chronologically significant patterns, apart from recognizing the advance from 'mode 1' flaking of cores to 'handaxe' making and then the appearance of Levallois knapping technology, the last occurring over a large area of the 'Old World' at around 250 ka. There seems also to be a scarcity of early handaxes in the eastern part of Europe and into Asia. Much of the variety in handaxe shapes has been ascribed by many to the vagaries of raw material properties.

Considerable advances have been made in recent years, however, particularly in connection with handaxes from the British sequence and based on a greatly improved understanding of the chronostratigraphy of the fluvial contexts for much of the artefact database. It is now possible to suggest that groupings of characteristic handaxe types occur preferentially in deposits of particular age. Thus assemblages with seemingly 'primitive handaxes, made with minimal flake removals and probably with stone hammers, indeed seem to be amongst the oldest assemblages, occurring in pre Anglian (pre-MIS 12) contexts. Assemblages with significant numbers of tools with twisted edges are associated with MIS 11 or MIS 11–10, whereas others with notable proportions of cleavers and 'ficron' (lanceolate) handaxes appear to be correlated with deposits formed at around the time of the MIS 9 interglacial. The recognition of such patterns, stemming initially from the well-dated Thames sequence, must not to be conflated with the previous usage of handaxe typology as a crude dating indicator based on ideas of relative refinement of knapping techniques. The extension of these patterns into other parts of the English record and, more tentatively, into the near continent, seems to hold good. In the near future the authors hope to explore the extent to which they can be extended further into the European Continent.

GEOPHYSICAL UNDERWATER RESEARCH ON THE VISTULA RIVER IN CRACOW

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Geophysical underwater research belong to the group of hydroacoustic research. It uses physical properties of ultrasound waves to detection, measuremerent and localization different statical and on the run objects underwater or in the depths. Also it uses as remote control of assessment of the technical condition different construction and technical building. Vistula was an important thoroughfare and commercial, junctive earths lying within of historic region Malopolska and southeastern Poland. This way one floated to Baltic ports among other things emblements and the salt from salt-mines Wieliczka and of Bochnia. Historic sources make mention on numerous passages and beards located in regions of Cracow. Still in the first half of XX age Vistula was considerably more intensely used than at present. In 2013-th the team of underwater archaeologists leads non-invasive research, targeting diagnosis the bottom of the river of Vistula in Cracow. Accordingly one used the Side-sonar and Echo Sounder (Lowrane HDS-5), Sonar MS 1000 (Kongsberg Mesotech Ltd.) (Fig.1).This research targets has localized and veryfication relics which can be underwater.

Project was financed by National Heritage Board of Poland and The Ministry of Culture and National Heritage and internal funds of the Association of Field Archaeologists „STATER"

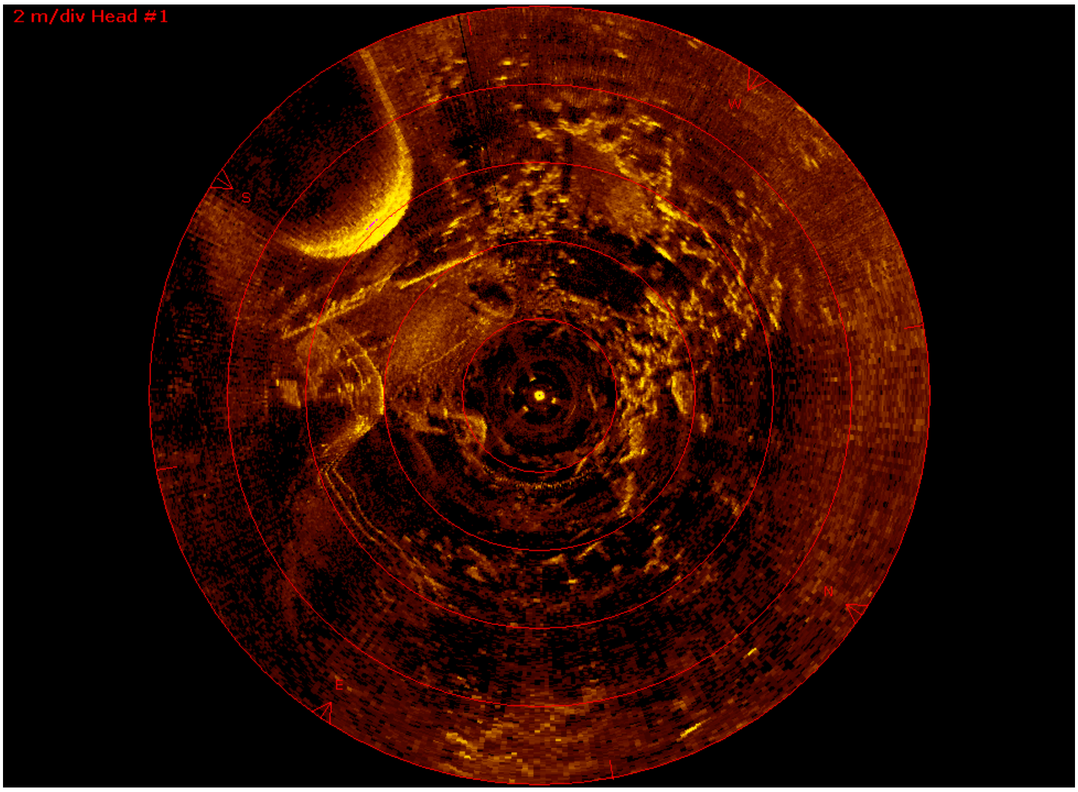

Fig.1 Sonar MS 100 Kongsberg Mesotech Ltd. Echoprint data example of part of the bottom of Vistula River in Cracow (Sławomir Chwałek).

APPLICATION OF HYDROACOUSTIC SYSTEM IN RESEARCH OF THE RIVERBEDS

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Geophysical prospection is one of the most important of new researching methods. Non-invasion reconnaissance and tests research makes the decision about following plans and choice of methodology much easier for future research. It is a non-destructive technique of surveying the continuity and homogenity of the ground. The measurement method is based on calculating the time from the moment of sending beams of sound from the transducer located for instance aboard the vessel until it is sent back to the transmitter, which is changed to electrical energy and processed gives a picture on the screen or on paper as a series of darker and lighter points (depending on the strength of the reflection echoes from the bottom, or depending on its facility).

The assortment of devices is large and is still increasing. These devices and systems are using the physical properties of ultrasonic waves to detect, measure and localize different statical and running objects underwater or in the depths. It can be also used to visualise sediment structures for dredging, geological surveys and the location of embedded objects like wrecks, pipelines or boulders with excellent resolution and penetration. New technologies significantly increase the efficiency of obtaining the necessary information and data such as the structure of deposits, the type of sludge and sludge volume (fig.1).

Multifunction aspects of hydroacoustic systems manifests in data of bathymetry, different kind of deposits and reconstruction of the geographical environment.

During presentation I am going to refer some of hydroacoustic systems like:
Single-Beam Echo Sounders SBES, Multi-Beam Echo Sounders MBES and parametric echo sond Sub-Bottom Profiler (sediment echo sounder).

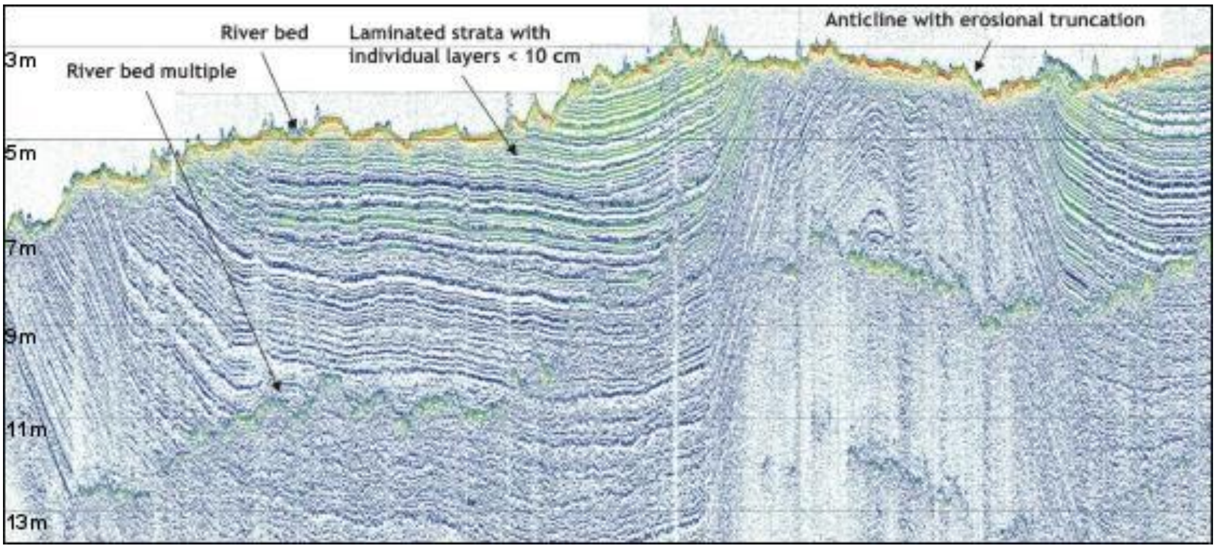

Fig.1 "Innomar SES-2000 standard" *parametric sub-bottom profiler echoprint data example from a river cable route survey (water depth 3–7m; range 2–14m below sea level; frequency 8kHz pulse width 0.13ms); (www.innomar.com).*

INVESTIGATION OF GRAIN SIZE COMPOSITION OF VERY COARSE-GRAINED ALLUVIUM IN PAPHOS REGION (SW CYPRUS) – FIRST RESULTS

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The investigation of grain size composition of very coarse-grained sediments is troublesome (Rutkowski 2007) and rarely published (e.g. Bluszcz et al. 1997).

The sieve analysis may be carried out for sediments containing clasts not coarser than 256 mm. The material is screened *in situ* on canva. The content of the coarsest fractions is determined by putting manually cobbles through the sieves-frames of the size of 64, 128 and 256 mm (-6, -7, -8 phi), and then weighing them on the balance of the capacity of 10 kg. For fractions 16 and 32 mm (-4 and -5 Ø), case sieves made on one's own are used. The sieve analysis is made by weighing particular fractions and gradually reducing the material under investigation. Fractions finer than 16 or 8 mm are analyzed in the laboratory. Results are given in weight percentages. This method permits sieve analyses of several hundred kilogramme samples *in situ* by one or two persons (Rutkowski 2007).

Granulation may also be investigated using the Wolman method (1954), where the size of clasts situated on the measurement lines is determined every fixed number of metres or centimetres, or clasts occurring on the crossing of a net of squares superimposed on the surface of bar or on the walls of the outcrops. Results may be given in percentage, of number or weight of grains. In case of large boulders embedded in the walls of exposures, a planimetric method can be used, described in petrography textbooks. It consists of the measuring of length of sections falling on clasts of definite size and converting them into percentages. The latter are the volume percentages (Rutkowski 2007).

This last method was carried out for alluvium of episodic rivers Ezousas and Koskinas in Paphos region (SW Cyprus) in 2015. Fixed number on cross lines was 2 cm. Results are given in percentage. Sediments of present-day gravely bars (Fig. 1, 2, 3) and geological outcrops of gravely terrace alluvium (Fig. 4) were studied. Methods is very useful and helpful for quantitative characteristic channel deposits of different age. It is possible to distinguished grain size differentiation in longitudinal profile of the rivers caused by local factors as tributaries, type of river section (gap and wide reaches of valleys etc.).

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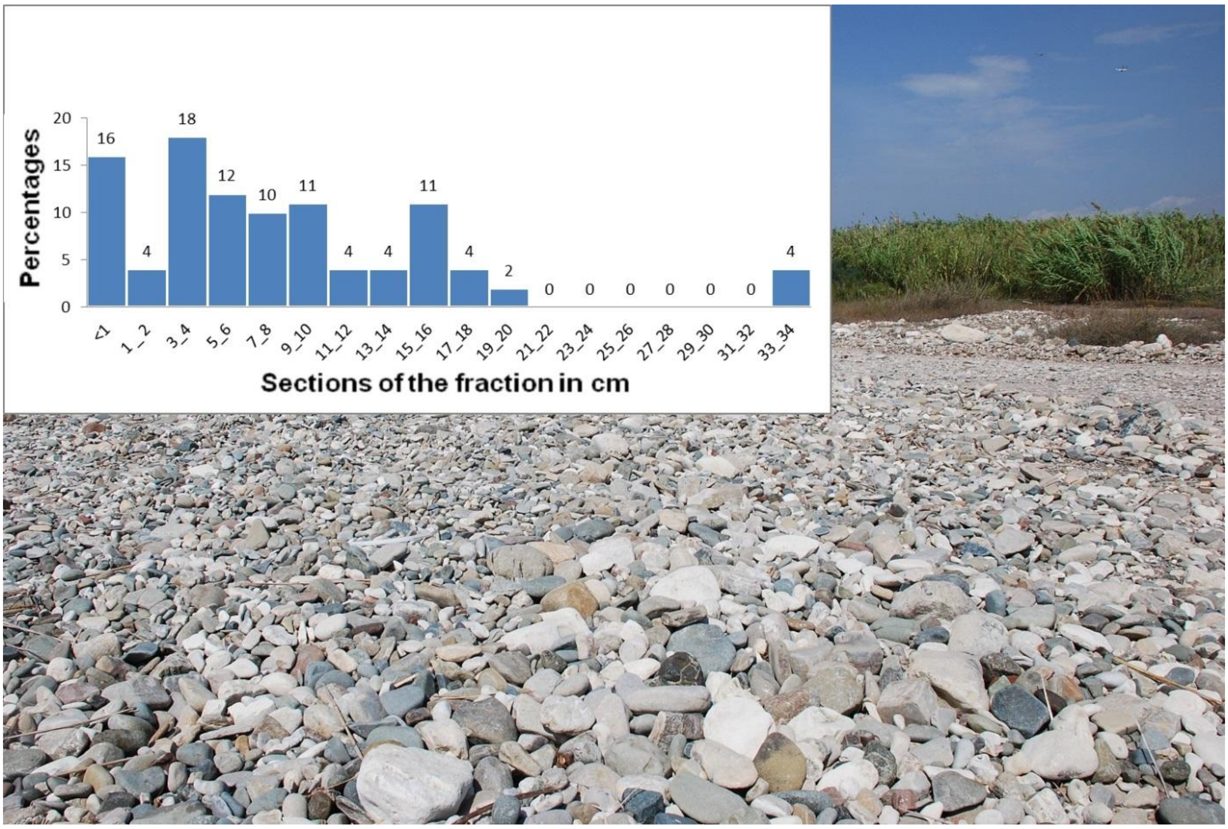

Fig. 1. Ezousas 1 site. Present-day delta sediments of episodic Ezousas river and the percentage histogram of alluvium (photo by T. Kalicki; histogram by S. Chwałek)

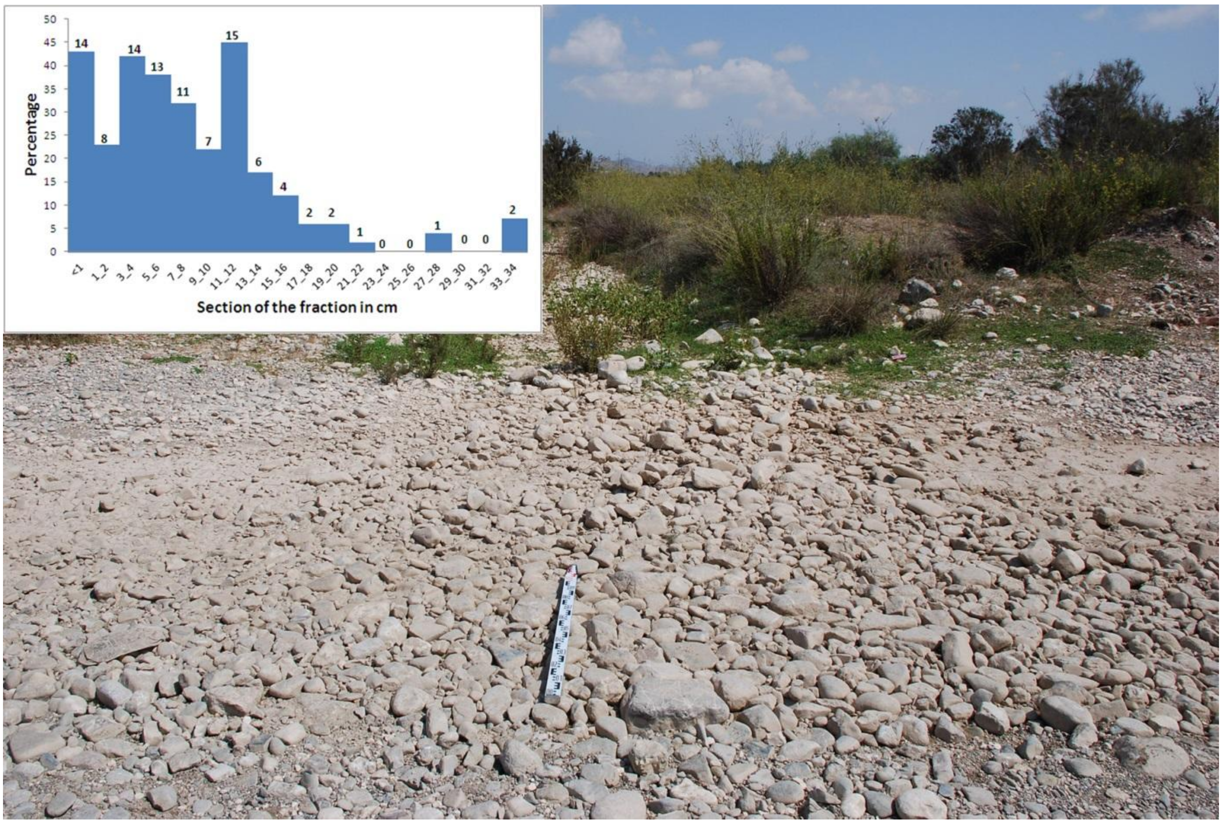

Fig. 2. Ezousas 2 site. Present-day episodic Lower Ezousas riverbed and the percentage histogram of its alluvium (photo by T. Kalicki; histogram by S. Chwałek)

Fig. 3. Ezousas 9 site. Present-day episodic Lower Ezousas riverbed downstream of gap section and the percentage histogram of alluvium (photo by T. Kalicki; histogram by S. Chwałek)

Fig. 4. Ezousas 3 site. Outcrop of Lower Ezousas river terrace sediments and the percentage histogram of alluvium (photo by T. Kalicki; histogram by S. Chwałek)

CITY AS AN AREA OF INTENSIVE FLUVIAL PROCESSES ON EXAMPLE OF KIELCE (POLAND)

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In urban areas the intensity and dynamics of water inflow to rivers and sediment supply to fluvial transport, in comparison to areas with different types of land use, is extraordinary variable across time and space. This is the effect of differentiation in hydrological and geomorphological processes intensity in urban catchments and also in the riverbeds of watercourses that flow through the cities (Trimble 1997, Ghani et al. 2000, Ciupa 2002, 2006, 2007, Nelson & Booth 2002, Akan & Houghtalen 2003). Those processes have surface, linear or point character. In the first case they relate to catchments, which surface parameters change in time due to the rainfalls of various intensity and amount that reach the ground with different saturation (which is dependent, among other factors, on the amount of the prior rainfall) and seasonally variable ground cover (Collins 1981, Froehlich 1982, Czaja 1999, Barszcz & Banasik 2008, Ciupa 2009, Brun & Band 2000, Wałek 2014). In quasinatural catchments only a small part of mineral and organic material amount that have been moved from standstill reaches the riverbed in fluvial transport process and later drains outside the catchment (Froehlich 1982, Zwoliński 1989, Świeca 1998). The aim of this work is to present the significance of an urban area in forming of contemporary fluvial processes – erosion, transport and accumulation in riverbeds of small watercourses that drain Kielce city and its suburbia (Holy Cross Mountains).

Detailed studies were held in catchments of different land use and land coverin order to perform comparative analysis. These were the catchments of Silnica (49,40 km^2) and Sufraganiec (62,01 km^2) rivers and catchments of a few small permanent and periodic watercourses. In the two first catchments 6-year stationary measurements were held, in the others field surveys were the basis of analytical process. The Silnica river in its upper section flows through forested areas, below it reaches suburbia and finally runs across the Kielce city center. On the other hand, the Sufraganiec river in its upper and middle part drains a catchment covered mainly by forest and farmlands. In its lower part it flows through the areas with growing urbanization. In the catchments of above mentioned rivers a stationary observations included daily measurements of water level, suspended solids concentration, specific conductance and temperature. Furthermore, from May to October, continuous records of water level and rainfall amount were performed by 6 limnigraphs and 4 pluviographs in a number of gauging sections.

On the basis of the field measurements and spatial analysis in GIS a possibility analysis of sediment supply to riverbeds have been done. Four categories of sediment source areas were distinguished: A – material is moved across the hillsides and supplies partly dry valleys; B – material is moved on to the floodplains; C – material is moved directly to the riverbeds; D – material is moved directly to the riverbeds by the storm water drainage systems and also along roads. In the Sufraganiec catchment areas of the C category reach 1.5% of the total catchment area, while in the urbanized Silnica catchment they reach only 0.2%. Similar spatial distribution in the Sufraganiec catchment characterizes the B category areas, which are discontinuously scattered along the main river valley and along some of its tributaries occupying from 4.2 to 12.5%. In the Silnica catchment they hardly occurs (0.0-2.5%). This spatial distribution of sediment source areas determines the temporality of sediment supply to rivers. Material accumulated on the floodplains can be transported almost only during the catastrophic floods. This was observed in the Sufraganiec catchment during the floods in July 1997 and July 2001. In both catchments the percentage of direct sediment supply areas (D category) grows downstream the rivers. In the Sufraganiec catchment it varies from 0.0 to 6.9% and in the Silnica catchment from 0.0% (Obwodnica) to 45.9% (Pakosz) and 40.9% (Białogon). In the central part of the city the D areas contribution reaches 64.9% (Ciupa 2009).

In the analyzed urbanized parts of the catchments, in comparison to their parts covered mostly by forests and farmlands, the most important reasons and hydrological effects of the existing sediment supply areas and their spatial distribution changes were: 1. Big contribution of impervious or almost impermeable surfaces areas (roads, pavements, parksides, roof etc.), which resulted in significant reduction and locally disappearance of infiltration which, in consequence, reduced the subsurface flow and groundwater runoff; 2. Decrease of catchments surface roughness and retention capacity that contributed to the acceleration of surface runoff; 3. Dense, two-level drainage system (roads, underground gutters, storm water drainage system etc.), which drains large catchments areas resulted in unnatural extension of the sediment supply areas; 4. Fast surface water runoff to riverbeds – resulted in several fold increase of flood waves height and volume, simultaneously significantly reducing their concentration time; 5. Regulated riverbeds in urbanized areas, with low roughness and increased size, often at the expense of natural floodplains, contributed to further increase pf flood waves height, riverbed retention and water flow hydraulic parameters including its velocity and depth (Ciupa 2008).

In natural or quasinatural conditions the sediment supply areas concentrates in narrow zones along the main stream and its tributaries, reaching a few percent of the total catchment area (Walling & Web 1981). In the rural catchments of the Holy Cross Mountains those zones covers from 10 to 30% of catchments areas. Meanwhile, in the urbanized Silnica river catchment, in many places sediment supply areas reach water divides and locally, by the underground drainage system, they overpass them. The transition from the rural to urban catchments is followed by the drastic increase of sediment supply areas reach along the dense and heterogeneous drainage system (Ciupa 2009). Earlier investigations performed in upland catchments have shown that these areas could change seasonally – due to different weather conditions, where the floods of different types could be formed (Collins 1981). However, in the urban catchments, sediment supply areas also changes in time and space, but to a much lesser extent. Generally impervious areas does not change during a year and urban water drainage system reacts even to very low rainfall depth (1.3 mm). In urban conditions we could observe effective and accelerated sediment supply to riverbeds along a dense network of roads and artificial storm water drainage system. A significant quantity of loose sediment accumulates on exposed surfaces within the impervious areas in urban catchments. This material is easily washed away and quickly transported by the linear drainage system to riverbeds. Sediment transported in urban areas comes mainly from traffic pollutants accumulated on roads, roadsides, parking and pavements. In this process the atmospheric deposition plays a minor role.

In the Sufraganiec riverbed all of the annual fluvial loads (dissolved matter,suspended sediment, bed load) increase downstream. In mouth section of the river the mean annual dissolved matter load exceeds 5000 tons, suspended sediment load – 550 tons and bed load – 90 tons. In the Silnica catchment, in a gauging section localized just below the Kielce city center, the mean annual load of dissolved matter exceeds 7000 tons, suspended sediment – 1000 tons and bed load reaches 600 tons. In the lower part of the Silnica riverbed, which length is about 3 km, above 300 tons of alluvia is deposited during the year. They form mainly the mid-channel deposits. This deposition isa result, among other factors, of the river overload with material that comes mostly from the city, the influence of riverbed vegetation and decrease of the riverbed slope in its mouth section.

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A REVIEW OF THE INFLUENCE OF GLACIAL DYNAMICS ON RIVERS IN GLACIALLY-FED FLUVIAL SYSTEMS

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Many studies over the last decades have focused in Europe and other continents on the fluvial response to climate forcing in unglaciated catchments. However, glacial activity may have a profound impact on the behaviour of the fluvial systems located downstream. In comparison to ice-free basins, these systems are characterised by distinctive hydrological and sediment supply regimes. Over Quaternary timescales, the fluvial records are influenced by periglacial (in non-glaciated areas),proglacial, and paraglacial processes. Understanding the impacts of these processes on the formation and preservation of the Quaternary geomorphological and sedimentary archives is key for our understanding of glacial-fluvial interactions. We investigate the impact of Quaternary glacial activity on fluvial sediment transfer, deposition, and preservation for rivers especially from across Europe, to examine how glacial forcing of fluvial systems varies spatially in different basin settings, and temporally over successive glacial-interglacial cycles. In particular, we focus on the ways in which the primary glacial-fluvial depositional signal could be distinguished from periglacial and paraglacial reworking and redeposition.

NEW DATA ON THE CHRONOLOGY OF THE VALE DO FORNO SEDIMENTARY SEQUENCE (LOWER TAGUS RIVER TERRACE STAIRCASE) AND ITS RELEVANCE AS FLUVIAL ARCHIVE OF THE MIDDLE PLEISTOCENE IN WESTERN IBERIA

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The stratigraphic units that record the evolution of the Tagus River in Portugal (study area between Vila Velha de Ródão and Porto Alto villages; Fig. 1) have different sedimentary characteristics and lithic industries (Cunha et al., 2012):

- a culminant sedimentary unit (the ancestral Tagus, before the drainage network entrenchment) – SLD13 (+142 to 262 m above river bed – a.r.b.; with probable age ca. 3,6 to 1,8 Ma), without artefacts;
- T1 terrace (+84 to 180 m; ca. 1000? to 900 ka), without artefacts;
- T2 terrace (+57 to 150 m; top deposits with a probable age ca. 600 ka), without artefacts;
- T3 terrace (+43 to 113 m; ca. 460 to 360? ka), without artefacts;
- T4 terrace (+26 to 55 m; ca. 335 a 155 ka), Lower Paleolithic (Acheulian) at basal and middle levels but early Middle Paleolithic at top levels;
- T5 terrace (+5 to 34 m; 135 to 73 ka), Middle Paleolithic (Mousterian; Levallois technique);
- T6 terrace (+3 to 14 m; 62 to 32 ka), late Middle Paleolithic (late Mousterian);
- Carregueira Sands (aeolian sands) and colluvium (+3 a ca. 100 m; 32 to 12 ka), Upper Paleolithic to Epipaleolithic;
- alluvial plain (+0 to 8 m; ca. 12 ka to present), Mesolithic and more recent industries.

The differences in elevation (a.r.b.) of the several terrace staircases results from differential uplift due to active faults.

Longitudinal correlation with the terrace levels indicates that a graded profile ca. 200 km long was achieved during terrace formation periods and a strong control by sea base level was determinant for terrace formation. The Neogene sedimentary units constituted the main source of sediments for the fluvial terraces (Fig. 2).

Geomorphological mapping, coupled with lithostratigraphy, sedimentology and luminescence dating (quartz-OSL and K-feldspar post-IRIR290) were used in this study focused on the T4 terrace, which comprises a Lower Gravels (LG) unit and an Upper Sand (US) unit.

The thick, coarse and dominantly massive gravels of the LG unit indicate deposition by a coarse bed-load braided river, with strong sediment supply, high gradient and fluvial competence, during conditions of rapidly rising sea level. Luminescence dating only provided minimum ages but it is probable that the LG unit corresponds to the earlier part of the MIS9 (ca. 335 to 325 ka), immediately postdating the incision promoted by the very low sea level (reaching ca. -140 m) during MIS10 (362 to 337 ka), a period of relatively cold climate conditions with weak vegetation cover on slopes and low sea level.

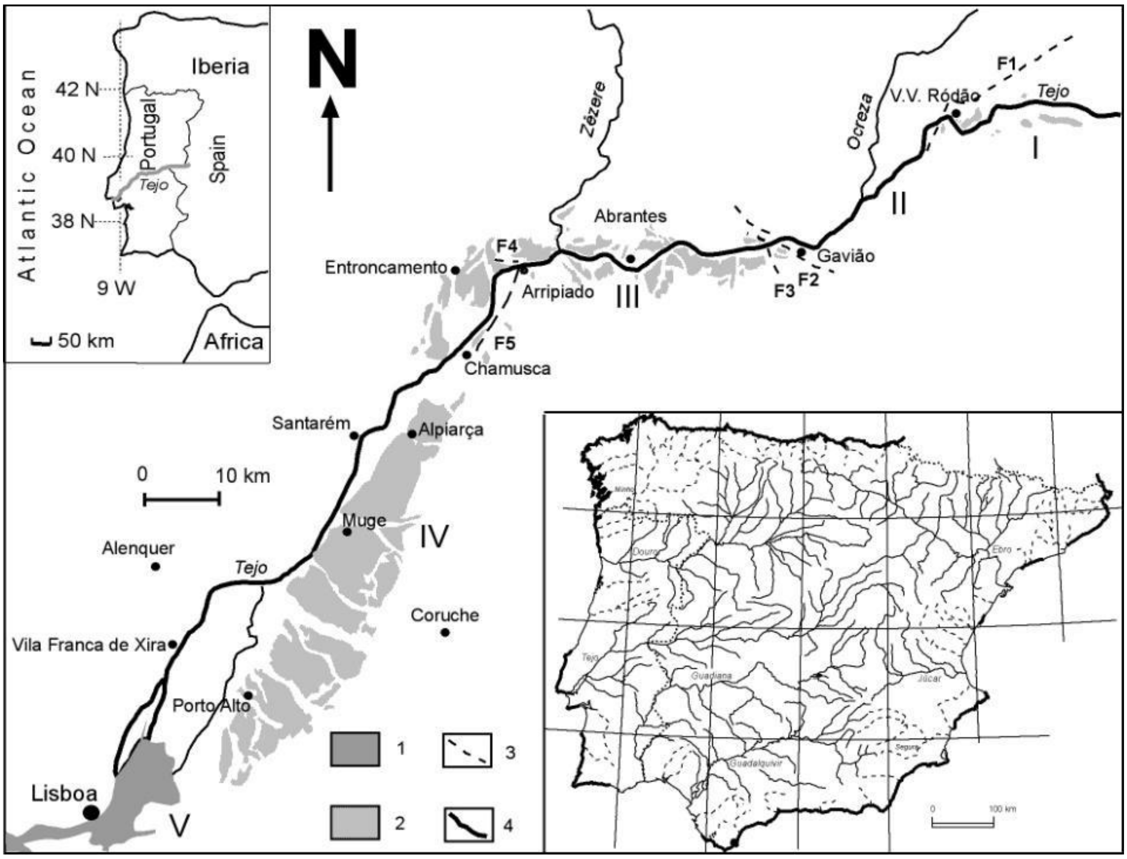

Fig. 1 Main Portuguese reaches in which the Tagus River can be divided (Lower Tagus Basin): I – from the Spanish border to Arneiro (a general E–W trend, mainly consisting of polygonal segments); II – from Arneiro to Gavião (NE–SW); III – from Gavião to Arripiado (E–W); IV – from Arripiado to Vila Franca de Xira (NNE-SSW); V – from Vila Franca de Xira to the Atlantic shoreline. The faults considered to be the limit of the referred fluvial sectors are: F1 – Ponsul-Arneiro fault (WSW-ENE); F2 – Gavião fault (NW-SE); F3 – Ortiga fault (NW-SE); F4 – Vila Nova da Barquinha fault (W-E); F5 – Arripiado-Chamusca fault (NNE-SSW). 1 – estuary; 2 – terraces; 3 – faults; 4 – Tagus main channel. The main Iberian drainage basins are also represented (inset).

The lower and middle parts of the US unit, comprising an alternation of clayish silts with paleosols and minor sands to the east (flood-plain deposits) and sand deposits to the west (channel belt), have a probable age of ca. 325 to 200 ka. This points to formation during MIS9 to MIS7, under conditions of high to medium sea levels and warm to mild conditions.

The upper part of the US unit, dominated by sand facies and with OSL ages of ca. 200 to 154 ka, correlates with the early part of the MIS6. During this period, progradation resulted from climate deterioration and relative depletion of vegetation that promoted enhanced sediment production in the catchment, coupled with initiation of sea-level lowering that increased the longitudinal slope.

The Vale do Forno and Vale da Atela archaeological sites (Alpiarça, central Portugal) document the earliest human occupation in the Lower Tagus River, well established in geomorphological and environmental terms, within the Middle Pleistocene. The Lower Palaeolithic sites were found on the T4 terrace (+26 m, a.r.b.).

The oldest artefacts previously found in the LG unit, display crude bifacial forms that can be attributed to the Acheulian, with a probable age of ca. 335 to 325 ka.

The T4 US unit has archaeological sites stratigraphically documenting successive phases of an evolved Acheulian, that probably date ca. 325 to 300 ka. Notably, these Lower Palaeolithic artisans were able to produce tools with different sophistication levels, simply by applying different strategies: more elaborated reduction sequences in case of bifaces and simple reduction sequences to obtain cleavers.

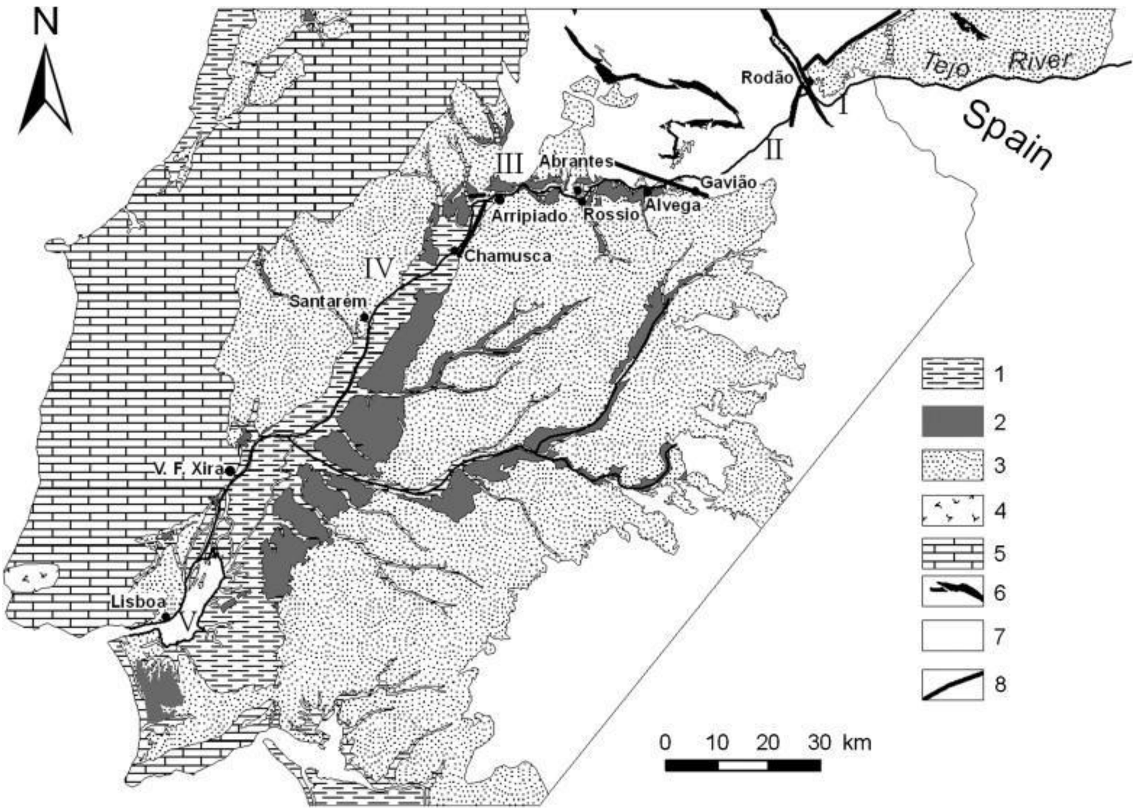

Fig. 2. Simplified geologic map of the Lower Tagus Cenozoic basin, adapted from the Carta Geológica de Portugal, 1/500000, 1992). The study area (comprising the Vale do Forno and Vale de Atela sites) is located on the more upstream sector of the Lower Tagus River reach IV, between Arripiado and Chamusca villages. 1 – alluvium (Holocene); 2 – terraces (Pleistocene); 3 – sands, silts and gravels (Paleogene to Pliocene); 4 – Sintra Massif (Cretaceous); 5 – limestones, marls, silts and sandstones (Mesozoic); 6 – quartzites (Ordovician); 7 – basement (Proterozoic to Palaeozoic); 8 – main fault. The main Portuguese reaches of the Tagus River are identified (I to V).

The VF3 site (Milharós), containing a Final Acheulian industry, with fine and elaborated bifaces) found in a stratigraphic level located between the T4 terrace deposits and a colluvium associated with Late Pleistocene aeolian sands (32 to 12 ka), has an age younger than ca. 154 ka but much older than 32 ka.

In the study area, the sedimentary units of the T4 terrace seem to record the river response to sea-level changes and climatically-driven fluctuations in sediment supply.

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LATE CENOZOIC EUPHRATES TERRACES DEVELOPED AS A RESULT OF REGIONAL AND LOCAL TECTONICS, CLIMATE AND VOLCANISM: TURKEY, SYRIA AND IRAQ

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We shall summarize the results of a major research effort to document the Late Cenozoic fluvial sequence of the River Euphrates from its headwaters in the Anatolian Plateau uplands in northeastern Turkey, downstream into the Arabian Platform in southeastern Turkey, Syria and Iraq. This work began in 2002 in both Turkey and Syria; we have not worked directly in Iraq, but have integrated our outputs with the existing literature from there. Fieldwork is currently unfeasible in the majority of the Euphrates catchment; we thus now take stock of what has been accomplished. The principal achievements of this work include:

-…Accurate surveying, using differential GPS, of terrace heights across most reaches within Turkey and Syria.

-…Reliable dating of terrace deposits using Ar-Ar or unspiked (Cassignol) K-Ar dating of lava flows that overlie the terraces at many sites. This includes demonstrating great antiquity of some of the terraces, for example ~9 Ma at Shireen in NW Syria and ~11 Ma at Siverek İskelesi in SE Turkey.

-…The resulting reliable dating framework provides a chronological context for the Palaeolithic archaeology associated with the terraces, superseding previous workers' attempts to do this, which had resulted in serious underestimation of the antiquity of much of the record. Thus, the first record of handaxe use can now be placed in the mid Early Pleistocene, like elsewhere in the Levant (notably, in the Jordan valley); this record is preceded by occurrences of flake artefacts. There is a question, however, over whether the oldest evidence for a human presence, from finds of 'trihedral' artefacts, might instead represent eoliths.

-…The accurate surveying enables instances where the fluvial terraces are warped or offset across active faults to be identified; the dating framework enables fault slip rates to be determined. It has thus been possible to settle a number of controversies regarding the timing of slip on faults in the study region, for example in the Palmyra Fold Belt in NE Syria and for the Bozova Fault in SE Turkey.

-…Rates of vertical crustal motion correlate with crustal type, being much higher in eastern Anatolia, where the lithosphere is thin and hot, but lower in the interior of the Arabian Platform, where the lithosphere is thicker and colder. This is in accordance with the predictions of modern physical models; however, the chronology of uplift (especially for Anatolia) contradicts some of the more speculative and controversial hypotheses suggested by others, enabling these notions to be superseded.

In summary, we have reconstructed the evolution of the River Euphrates from the Middle Miocene, shortly after the land in SE Turkey rose above sea-level and the river debouched into the almost landlocked 'Mesopotamian Basin' in Syria and Iraq, through to the present day.

HOLOCENEFLOODPLAIN CHRONOLOGIESIN GLACIALLY-CONDITIONED, LOW-RELIEF, ENVIRONMENTS OF SOUTHERN ONTARIO, CANADA

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Holocene floodplain development in drainage basins situated in lowland environments of the Laurentian Great Lakes region of North America is influenced by the legacy of past glaciations. Channel processes operating since deglaciation, and the floodplains that have been created, are often semi-alluvial in nature. Channel bed and river bank boundary materials often exhibit highly variable resistance to erosion with material properties changing rapidly over relatively short downstream distances. This makes predictions of the lateral and vertical stability of river reaches somewhat problematic and complicates interpreting floodplain genesis as well as associated sediment accumulation chronologies. To assess the temporal and spatial variability in type and rate of floodplain development in southern Ontario, Canada, investigations of river reaches and valley infill deposits have been undertaken using a combination of detailed point-bar investigations combined with rapid geomorphic assessments of entire channel reaches.

An exploration of factors that might be most important in controlling floodplain development included nine candidate fluvial process variables and 12 floodplain/channel metric variables (Table 1). Measurements made at 109 "representative" floodplain sites were

Reach Variables	Transformation[a]	Normality
Fluvial Process Variables (and Environmental Controls)		
Slope, S (m m^{-1})	Log S	statistical pass[d]
Discharge, 2-Year Flood, Q_2 (m^{3}s^{-1})	Log Q_2	statistical pass[d]
Total Stream Power, Ω (Wm^{-1})	Log Ω	statistical pass[d]
Specific Stream Power, ω (Wm^{-2})	$\sqrt{\omega}$	statistical pass[d]
Shields Stress, τ/D_{95} (Nm^{-1})	Log τ/D_{95}	statistical pass[d]
Specific Stream Power-to-D_{50} Ratio, ω/D_{50} (Wm^{-3})	Log ω/D_{50}	statistical pass[d]
Critical Specific Stream Power[b] for D_{50}, ω_{cr} (Wm^{-2})	Log ω_{cr}	histogram[e]
Specific Stream Power Ratio, ω/ω_{cr} (dimensionless)	Log ω/ω_{cr}	histogram[e]
Floodplain Variables (and Channel Metrics)		
Channel Bankfull Width, w (m)	Log w	statistical pass[d]
Channel Bankfull Depth, d (m)	Log d	statistical pass[d]
Channel Width-to-Depth Ratio, w/d (dimensionless)	Log w/d	statistical pass[d]
Total Floodplain Thickness, F_t (m)	Log F_t	statistical pass[d]
Fine Alluvial Floodplain Thickness, F_{fa} (m)	$\sqrt{F_{fa}}$	histogram[e]
Floodplain Sand Equivalent thickness in F_{fa}, FSE (m)[c]	$\sqrt{FSE}$	histogram[e]
Percent Organic Matter in Fine Alluvial Floodplain, OM (%)	Log OM	statistical pass[d]
Percent Silt-Clay Fraction in Fine Alluvial Floodplain, M_{SC} (%)	$\sqrt{M_{SC}}$	statistical pass[d]
Percent Sand Fraction in Fine Alluvial Floodplain, M_{Sa} (%)	$\sqrt{M_{Sa}}$	histogram[c]
Bed Material Size, D_{50} (mm) → Φ_{50}	-Log$_2$ D_{50}	histogram[c]
Bed Material Size, D_{95} (mm) → Φ_{95}	-Log$_2$ D_{95}	histogram[c]
Relative Roughness, D_{95}/d (m m^{-1})	Log D_{95}/d	histogram[e]

Table 1 Variables measured at 109 floodplain sites used to discriminate floodplain development processes and floodplain composition. From Phillips and Desloges (2015).

analyzed using clustering and discrimination techniques to produce a parsimonious set of predictor variables. Variables related to stream energy, best represented by specific stream power, dominated one of two major principal components. A 2nd component representing floodplain response (thickness and structure), is shown to be highly dependent on accumulation characteristics of the sand fraction in both lateral and vertical accretion deposits. It is therefore possible to group floodplains of southern Ontario into four classes based on these simplified discrimination criteria (Fig. 1). Thick, vertically-accreted,

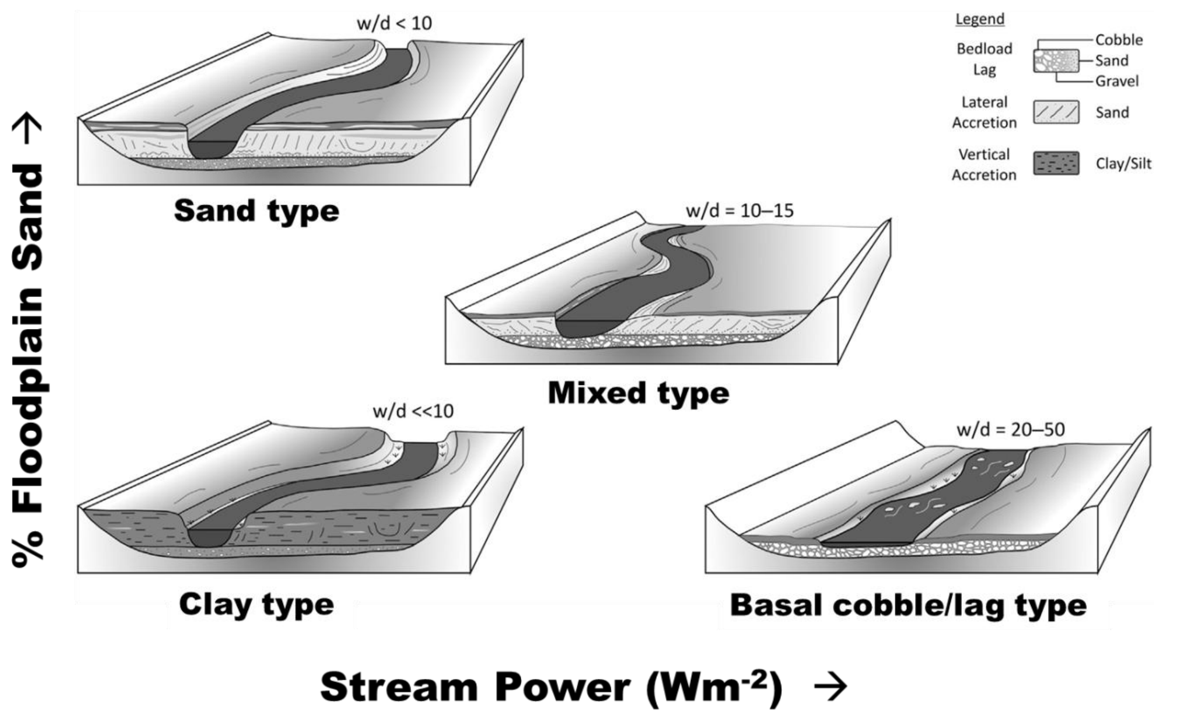

Fig. 1 Classification of dominate channel-floodplain types in southern Ontario based on stream energy and sand composition of vertical and lateral accretion deposits. Adapted from Phillips and Desloges (2016)

low stream power floodplains (clay-type) dominate the lower reaches of watersheds especially in areas of extensive glaciolacustrine silts and clays deposited early following Laurentide Ice Sheet retreat. In more confined zones of glacial outwash sands and gavels that terminated in ice-marginal lakes, thick vertically and laterally accreted sand accumulations dominate (sand-type). River channels in these locations are single-thread and relatively narrow. With increasing stream power and greater diversity in sediment contributions from coarse till deposits and ice-marginal moraines, floodplains in upper and middle watershed positions exhibit higher stream powers, coarser basal-lag sediments and thinner laterally-accreted accumulations of sand and fine gravel (mixed and basal/lag types; Fig. 1). Channels in these types are characterized by occasional channel chutes and localized channel splitting.

Floodplain ages and associated sediment accumulation rates are derived using ^{14}C and OSL dates taken from the contact between basal sediments and the top of the floodplain excluding any overbank deposits related to accelerated erosion from land clearance over the last 200 years. Fig. 2 shows the relation between average accumulation rate using the entire thickness of the deposit and age at the base of the sequence. The 30 data points are divided into three stream power groups of low, medium and high stream energy based on contemporary channel widths, slopes and bankfull discharges. The average accumulation rate is 0.42 mm a^{-1} with rates rapidly declining as age increased. As indicated by Knox (2006), because ages are from basalpoint bar locations, the steep decline in accumulation rate with increasing age reflects the dominance of the lower sedimentary sequence by lateralaccretion deposition.

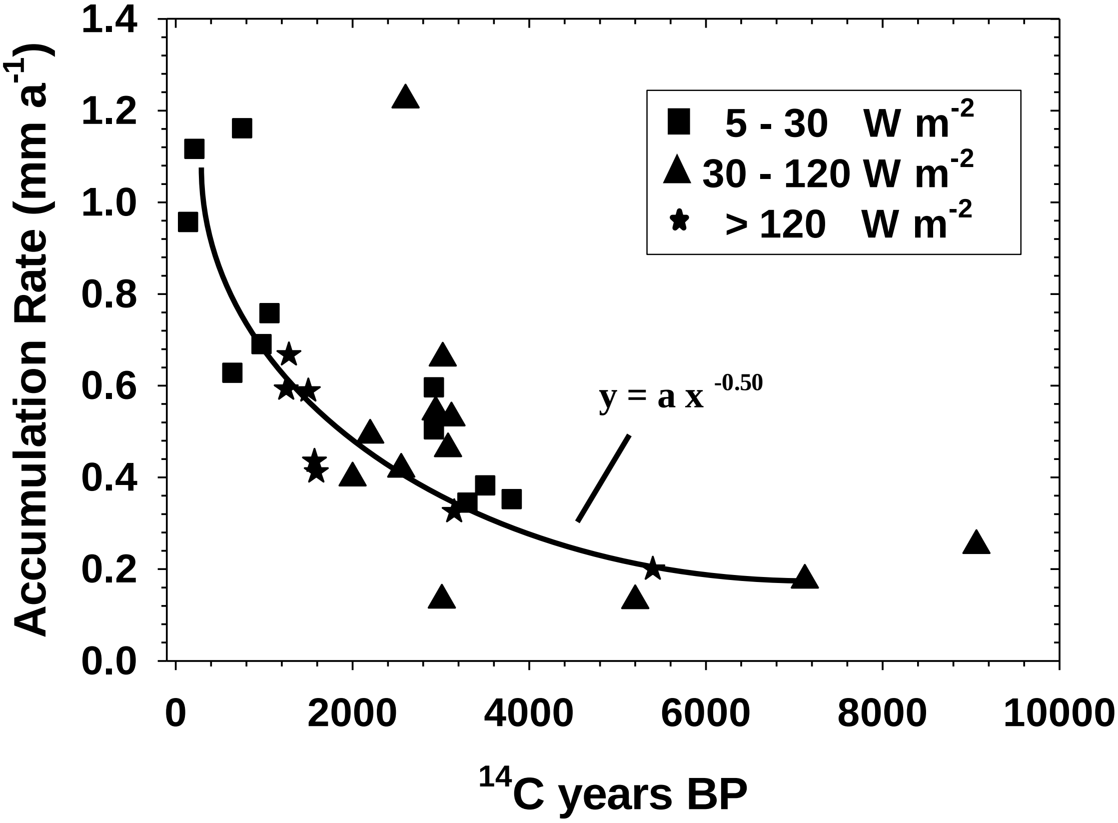

Fig. 2 Floodplain accumulation rates for selected southern Ontario river reaches.

The results suggest that higher rates of accumulation occur in the lower-energy floodplain systems where vertically accreted silts and sands are derived from glaciolacustrine and glaciofluvial legacy deposits. Lowest accumulation rates are from the older, medium-energy floodplain sequences in river reaches subject to wider meander belts and progressive, but slow, cross-valley lateral migration of the channel. The overall trend of decreasing accumulation rates follows a very similar negative square root trend identified by Knox (2006) for upper Mississippi Valley tributaries. The majority of floodplain ages from southern Ontario floodplains are younger than 4000 ^{14}C years BP indicating that residence time for the bulk of stored sediment are shorter than expected. Accelerated erosion from agricultural land clearance beginning 200 years ago has deposited up to 50 cm of vertically accreted fine sand sediment on pre-existing soils. This is most noticeable in reaches draining more than 100 km^2.

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THE GEOMORPHOLOGY AND HUMAN ACTIVITY IN THE VISTULA RIVER VALLEY DOWNSTREAM OF CRACOW (SOUTHERN POLAND), FROM THE 3RD C. BC TILL THE 7TH C. AD

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The Vistula river downstream of the Cracow Gate flows through the western part of the Sandomierz Basin. The erosional relief developed on the Miocene clays was covered by a variety of Quaternary sediments. On the left river-side there occur the Pleistocene two Vistula terraces (12 and 15-25 m above river) covered by Vistulian loess). Within the 8 km wide and 4-5 m above the river flood plain there are several segments of various age (Kalicki 1991, 2006). Locally as erosional remnants, relicts of the Young Pleniglacial and Lateglacial braided alluvial plains are preserved. In the remaining area numerous paleomeanders or their systems of different age occur. The flood plain is made up by gravel with sands changing upward to sands and silty overbank deposits on the top.

During the Holocene the Vistula was a meandering, slowly aggradating river (Kalicki 1991, 2006). During more than 5000 years its meandering belt on the study section had a W-E direction and crossed diagonally the recent flood plain. Very important changes, which consequences space to the time of the Roman period, just in the late Atlantic and early Subboreal occurred. Most important were the subsequent two avulsions of the Vistula river bed at Las Grobla and Zabierzów Bocheński sections dated back to ca. 5000 and 4500 years BP, respectively (Starkel et all. 1991, Kalicki et all. 1996). The flowing direction change of the Vistula river from W-E to SW-NE downstream of Niepołomice was a consequence of the avulsions of river bed to the north. Besides planar changes, by straitening and shortening the river bed of some tens of km, the avulsions were also responsible for triggering incision. About 2000-1500 yr BP the incision reached its maximum, almost 3 m, i.e. the same level as Alleröd paleomeanders (Kalicki 1991). Meandering and incising river formed the lower level of the flood plain. The top of this was more 1 m below the surface of present-day flood plain.

The above depicted morphological evolution also affected the hydrological condition of the flood plain, by improving its drainage (this causing dropping of site humidity) and increasing the seasonal fluctuations of the ground water level. The instability of climate in Roman Period increased also flood frequency, bank erosion and quickly development rate of the point bars. Therefore a huge number of subfossil trees dated to this period and buried in alluvia was found (Krąpiec 1998). This very active zone, however, was relatively narrow and limited to the lower level of flood plain zone. By contrast, on the higher level of flood plain, probably only depressions as paleomeanders were overflooded by water with suspended load and further, just during peak discharges.

The beginning of the La Tène culture in western Lesser Poland was connected with a presence of Celts on Polish territories and was resulted from their eastward expansion. Chronological framework of Lesser Poland settlement enclave comprises period from the beginnings of the 3rd century BC to the first decades AD (Woźniak 1992). In the areas to the east of Cracow the first Pre-Roman settlement was Celtic. According to Woźniak (1996) and Poleska (2006) the Celts were joined by people of Przeworsk culture around the third quarter of the 3rd century BC. However, the appearance of the Przeworsk people might have taken place later – about the mid of the 1st century BC (Dulęba 2009). In the study area there are 28 discovered sites dated to the Pre-Roman period, concentrated mainly on the loess terrace of the left bank of the Vistula and less frequently on the right river bank. During the first two phases of the La Tène period we currently know only of small settlements with 2 to 5 domestic structures (Kraków-Mogiła 1, Kraków-Pleszów 17-20). In contrast, settlement Krzesławice 41, dated to the third phase, the youngest (from the middle 1st c. BC to the early 1st c. AD), was larger, with several (up to a dozen or so) buildings and production structures (Poleska 2006) (Fig. 1A). It belongs to mono-phase sites comparing with multi-phase settlements, such as, for example Kraków-Pleszów 17-20.

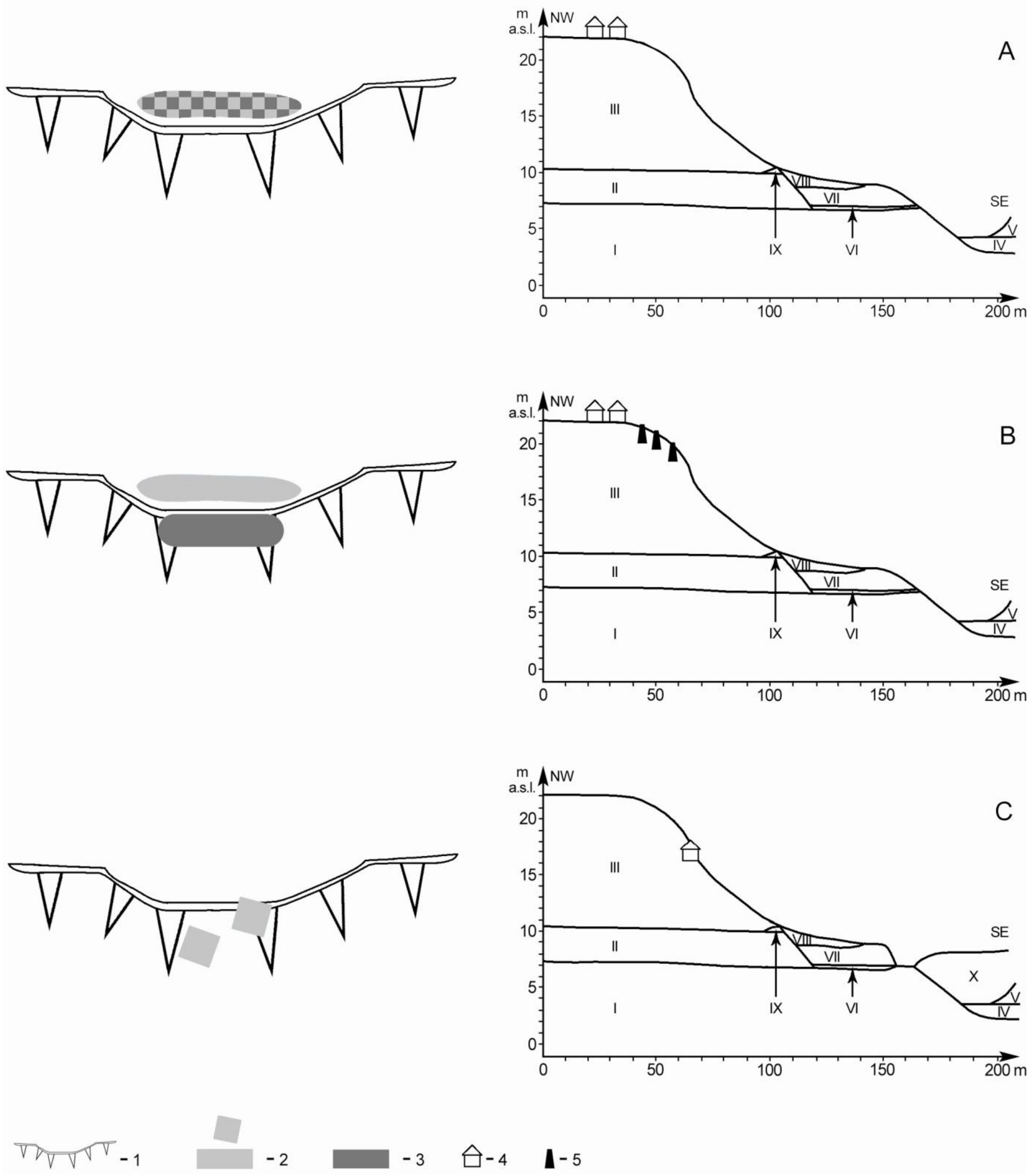

Fig. 1. Settlement models and changes of terrace edge in the Vistula river valley downstream of Cracow in La Tène (A), Roman (B) and Early Slav (C) periods
1 - loess terrace and edge, 2 - dwellings, 3 - production features, 4 - houses, 5 - pottery kilns
I- Miocene clay, II- Pleistocene channel alluvia, III- loess, IV- sandy-gravel alluvia of Young Pleniglagial/Late Glacial braided river, V- sandy alluvia of Young Pleniglagial/Late Glacial braided river, VI- lag deposits, VII- Neoholocene overbank deposits, VIII- Neolithic (?) colluvia, IX - meadow ore.

Przeworsk culture settlement flourished in western Lesser Poland, in the Roman period, from the 1st c. AD, especially between the 2nd half of the 2nd and the third quarter of the 4th centuries AD (Dobrzańska 1997). There are 44 known sites of that time, which are grouped mainly on the loess terrace of the left bank of the Vistula and were not so common on the right bank of the river. Roman period people also settled on higher parts of the flood plain. The remains of settlement Kraków-Wyciąże 6 (Glanc-Kwaśny, Rodak 2004) were found on a point bar of the Subboreal palaeomeander (Dobrzańska et al. 2009). The settlement at Kraków-Przewóz 2 (A. Jaszewska and A. Leciejewska personal communication) was located on the levee of the Vistula river. Settlements are rather small sites with a few dwellings (Dobrzańska 1990, Dobrzańska, Kalicki 2003, 2004). Their housing zone, located on the flat part of the terrace, was separated from the production zone (Zofipole) (Dobrzańska 2000) or production-housing zone (Igołomia) on the terrace edge (Dobrzańska 1997, Dobrzańska et al. 2009) (Fig. 1B). In the Roman period multi-phase model of settlement dominated.

Settlement in the Vistula valley in the period between the 2nd half of the 5th c. and 2nd half of the 7th c. AD is commonly associated with Slavic people (Parczewski 1988a, b, Godłowski 2000). There are 9 sites, located on the loess terrace edge or close to it. Characteristic of the Early Slavic period are rather small settlements with 2-4 dwellings interred in the ground, quasi-rectangular, with hearths (ovens) in the corner, accompanied by utility structures (Parczewski 1988b, Kobyliński 1988, 1997). A choice of place for houses on the terrace edge was advantageous from constructional point of view. Moreover such places were better drained than terrace plateau. The sites were mono-zonal and mono-phase (Fig. 1C). Scanty remains of dwellings and artifacts suggest rather unstable settlement of that period. Slavs chose loess promontories densely populated in the Roman period.

The economy of the settlers of the Vistula river valley in the periods of our interest depended on farming. The location of settlements on the loess terrace of the right bank of Vistula covered by fertile soils was advantageous for agriculture. It also facilitated garden-type cultivation at the terrace base as well as an access to the fodder resources of the flood plain. These activities are confirmed by palaeobotanical and palaeozoological data, and also by archaeological evidence (Lityńska-Zając 1997, Dobrzańska 1990, Poleska 2006, Dobrzańska et al. 2009 see further references). Due to dynamic relief and less fertile soils the left river bank was less advantageous for agriculture.

Pre-Roman and Roman period peoples in the Vistula valley also developed crafts - iron and bronze founding, jewellery-making, amber working, pottery production, and woodworking (Dobrzańska 1990, Poleska 2006). Remains of iron production for small scale are known from the Roman period. Limited size of iron metallurgy can be attributed to insufficient resources of meadow ore (Dobrzańska et al. 2009).

Analyses indicate that non-agricultural activities, especially building works, involved the extensive use of oak. Due to almost completely deforested loess terrace, the wood was obtained probably from the Vistula flood plain. Miocene clay, utilized by potters, was excavated from this area as well.

The settlement and economic development (between the 2nd half of the 2nd c. and the end of the third quarter of the 4th c.) resulted in a great demand for wood. It may have been a reason for no oak growth on the river flood plain. At the same time fallen trees indicates increased bank erosion caused by recurring floods. Small tributaries, flowing at the foot of the loess terrace, on the Vistula flood plain supplied settlements with water.

Numerous finds imported from outside confirm trading contacts between local inhabitants and other cultural milieu.

During the La Tène and Roman periods settlement flourished in the Cracow region. The economy based on farming and crafts. People settled near the edge of the loess Vistula terrace. Penetration of the flood plain in the Roman period is confirmed by stray finds and two sites of longer use.

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ENVIRONMENTAL CONTEXT OF SUBNEOLITHIC SETTLEMENT IN THE UPPER BIEBRZABASIN (NE POLAND)

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Study area is located in NE part of Poland in upper Biebrza basin. Relief of this region formed during Middle Polish Glaciation –Wartha Glaciation. However during the next ice-sheet advance until the Pomeranian phase of last glaciation (Val'chik 1992: 15,5-15,0 ka BP; Kozarski 1995: 16.2 ka BP) outflow from the dam lakes Naroch-Wilia and Skidel and river waters of the upper Neman river followed Łosośna river valley, its tributary Tatarka river breakthrough Pripilin-Nurki gap section to Biebrza and Narew river valleys (Val'chik 1992, Żurek 1994). Therefore the upper Biebrza is underfit river with vast peat-bogs on its valley floor. The Pleistocene relief of the valley was transformed in small degree during the Late Glacial and Holocene. Controling factors of the evolution were climate and vegetation changes. This type of lanscape was settled by Prehistoric people since the Palaeolithic. Subneolithic cultures, the last hunter-gatherer community in the borderland of East and West Europe, are among the least recognized issues of Polish prehistory. Their way of life, inextricably linked and driven by environmental considerations. Among other things, determined the cyclical nature of the selection and location of settlements. They preferred a small, dry hills situated directly within the valley floor.

Geological, geomorphological and geoarchaeological studies were conducted near the Krasnoborki site in western part of upper Biebrza river valley. "Dune-like" elevation is located here on the bottom of the marginal valley (pradolina) near its northern slope. Distance between this form and present-day river is about 650 m (Kalicki et al. 2016a, b).

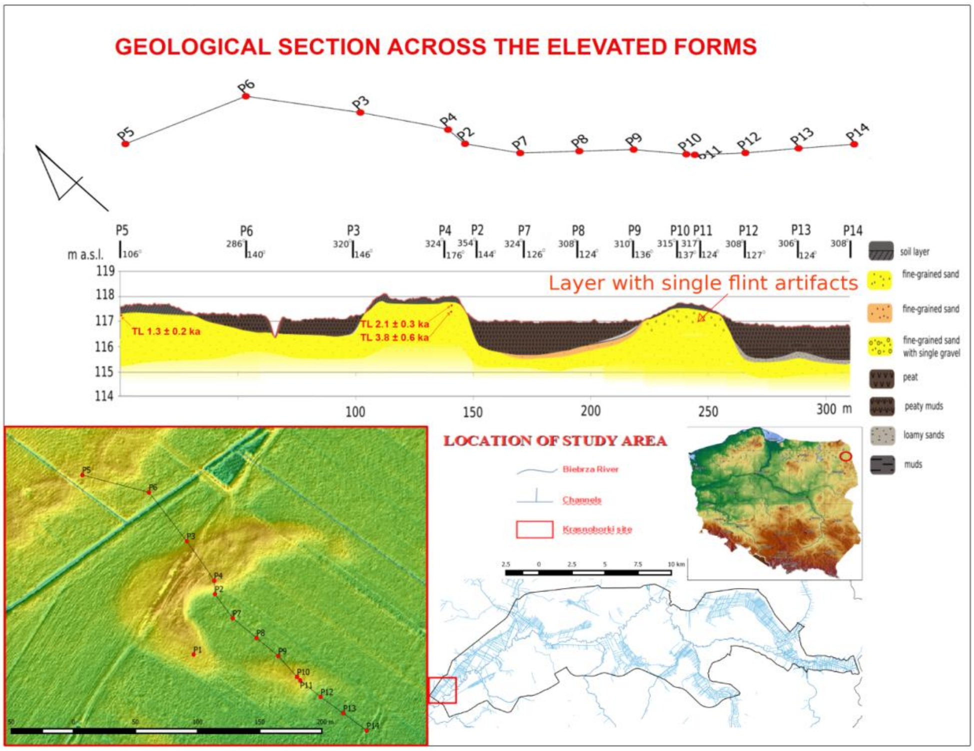

Fig. 1 Location of study area and geological cross section

Geological section (drillings up to 2 m depth) across this form and surrounding area of valley floor was done (length 250 m). Elevation is composed ofsands, and belowthesandswithgravelsand it issurrounded bypeatwith thicknessup to 2m. The upper parts of sands were TL dated at 3.8±0.6 ka (KIE-885), 2.1±0.3 ka (KIE-884) and 1.3±0.2 ka (KIE-886). These young datings could be connected with non-bleaching of sediments.

Two archaeological outcrops were located on elevation slope (trench 1) and valley bottom (trench 2). Few flint artefacts with lithic technology of the Late Mesolithic Janisławice culture and assemblage of burned bones (catfish bones) over the wooden structure (depth about 60 cm below surface) were located between peat and sands in trench 1. Wood from this structure was ^{14}C dated at 4190±50 BP cal. 2899-2626 BC (MKL 2854).

The trench 1 indicate traces of some phases of soil erosion and formation of delluvial covers, which interfinger with the surrounding peats (Fig. 2).

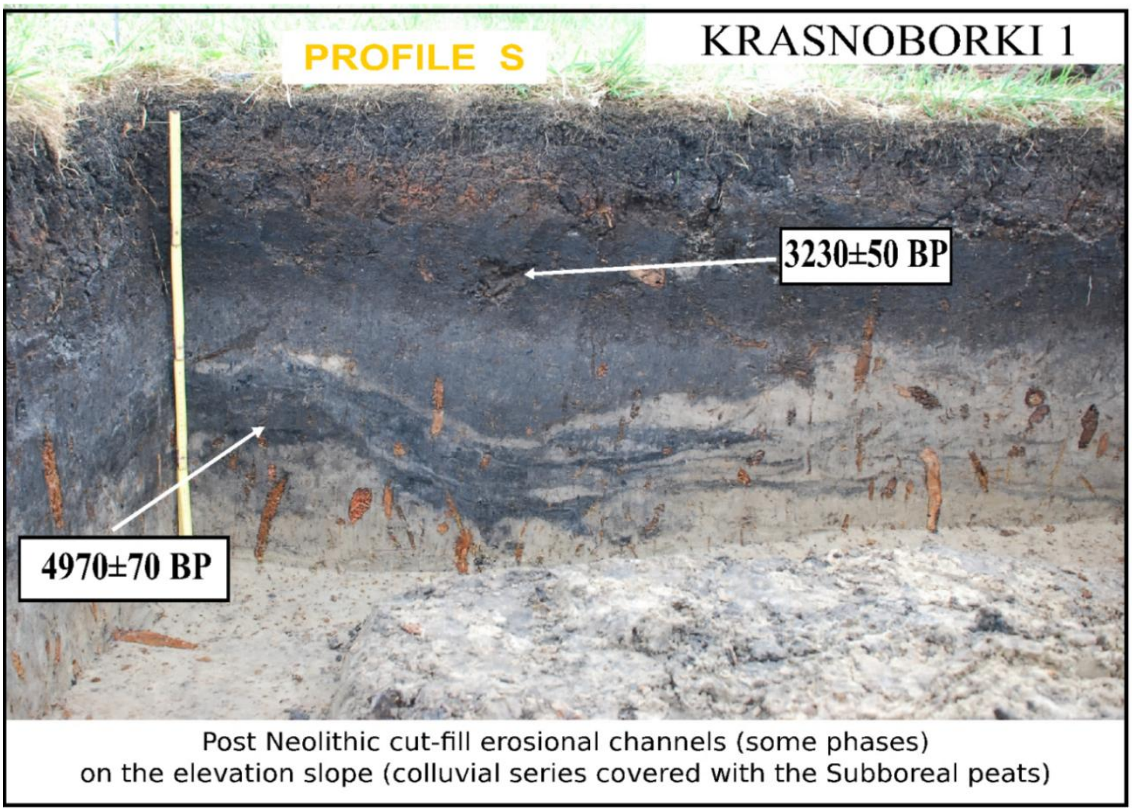

Fig. 2. Archaeological trench 1 (southern wall)

This erosion took place after 4970±70 BP (MKL 2857) and after 4330±60 BP (MKL 2860) and before 3230±50 BP (MKL 2858) and 3110±60 BP (MKL 2859) when the colluvia was covered with peats.

At the same time tree stumps preserved in peats at trench 2 indicate a drier periods, when the trees could encroach on a peat-bog in the valley bottom. However an increase of ground water level in the end of the Atlantic lead to dying and fallen of trees at 5060±60 BP (MKL 2856). Due to structure and texture of sediments elevation is not a dune but erosional remnant of sandy-gravel fluvioglacial deposits. This form was settled in one phase (homogenous flint artefacts in one geological strata) bySubneolithic gatherers of Niemen culture. Layer of artefacts are Late Neolithic occupation horizons because people of this culturewithout intensive and stable settlement didn’t formed typical cultural level. Late Mesolithic lithic technology outlived until Late Neolithic (1^{st} half of 3^{rd} millenium BC)

Niemen culture.Lack of potterycould be connected with small area of excavation or function of this settlement (hunting or fishing).

Fig. 3. Archaeological trench 2

Tree stumps preserved in peats (trench 2) indicatehumid period in the end of the Atlantic, when the trees couldn'tgrowth on a peat-bog in the valley bottom. Traces of the Subboreal soil erosion and colluvial (delluvial) coversformation on slope elevation (trench 1) occurred. Second humid period and beginning of peat accumulation on Subboreal colluvia (delluvia) occured about 3200-3100 BP. Climate fluctuationscorrelate very well with phases distinguished in Centraleuropean river valleys (Kalicki 2006).

The research was carried out in cooperation with the project: „Preservation of wetland habitats in the upper Biebrza Valley" LIFE11/NAT/PL/422.

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OSL DATING OF EMSCHER RIVER SEDIMENTS

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About twenty years ago, fluvial sediments from the Emscher river near Bottrop-Welheim (Emscher river sewage treatment plant) were investigated in detail owing to the presence of an unusually rich horizon with cold-period mammal tracks (about 30 trackways) of Late Pleistocene age. The footprints included two large carnivores, the cave lion *Panthera leo spelaea* and the wolf *Canis lupus* as well as reindeer, large bovids (Bison or Bos), horses and other, which is very unique in Central Europe (von Koenigswald, 1995). By means of biostratigraphy the track horizons correlates to the Middle Weichselian, which was supported by a TL/IRSL/OSL dating approach. This latter dating approach (Frechen 1995) showed large uncertainties owing to insufficient bleaching of the sediments prior to deposition and the methodological approach (multiple aliquot TL, IRSL and OSL) used at that time. However, the IRSL age estimates showed good agreement with a radiocarbon date on wood taken from sediments (valley sands) above the periglacial loess floodplain.

As no material from the previous study was left, new samples were taken from core drilling the vicinity of the Emscher river sewage treatment plant near Bottrop and from samples around Herne and Gelsenkirchen covering the stratigraphic key horizons like “bone” gravel (“Knochenkiese”), snail sands (“Schneckensande”), periglacial floodplain (“periglaziale Lössaue), valley sands (“Ältere und jüngere Talsande”).

The new dating study used a multiple aliquot approach for luminescence dating, including quartz OSL and K-feldspar post-IR IRSL (pIRIR) dating techniques, have been applied for the age determination. The quartz OSL ages fall into the range between ~20 ka to ~300 ka. However, group of samples yield D_e values beyond 300 Gy, all of which are larger than their corresponding $2D_0$ values, suggesting that the OSL signals were in saturation and may give unreliable results. Hence, the pIRIRdating of K-feldspar at 225°C was further carried out. Before D_e measurements, dose recovery test, fading and residual measurements have been conducted for all samples to evaluate the performance of the $pIRIR_{225}$ protocol. The preliminary results yielded an age range from Holocene to more than 300 ka (saturation) giving evidence for a complex aggradation history of the Emscher river sediments.

The aim of this dating study is to set up a more reliable chronological framework for the Emscher river sediments and shed new light into the chronostratigraphic interpretation of the famous track horizon.

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TIMELINE FOR HUMAN INFLUENCE ON RIVER LANDSCAPES: A REVIEW

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Interpreting Quaternary fluvial archives requires researchers to consider the onset and intensity of anthropogenic influence. Arable agriculture and deforestation enhanced sediment runoff, creating “legacy sediments” and a mid-late Holocene discontinuity in fluvial records worldwide (Brown et al., 2013). However, human influence on river systems may have had much earlier beginnings.

After evolving in Africa at ~7 Ma, hominins walked lightly on the Earth in comparison with other animals, leaving mainly stone tools but possibly using fire as early as 1.6 Ma. Neanderthals used fire in technology in Europe at 3-400 ka, and aboriginal use of fire in hunting may have affected vegetation in Australia by ~45 ka, although this is controversial.

Grain processing is known by 23 ka in the Middle East. At ~13 ka (latest Pleistocene), Natufian cultures began to use cereals intensively in the upper Euphrates valley, paving the way for later innovations, and irrigation-based cultivation dates to ~10 ka (early Holocene) at Jericho. Irrigation systems for crops and date palms were widespread in Mesopotamia and Arabia within a few thousand years and, by 3 ka, principles of groundwater were well understood.

In Asia, rice was domesticated by 9 ka in China, spreading to SE Asia, Japan, and India within a few thousand years. By 4-7 ka, irrigated ricefields were common on river plains in China. Maize and squash were cultivated in Mexico by ~9 ka and in Peru by 5 ka, and dark anthropogenic soils date to >3 ka in Brazil.

Domesticated animals probably contributed to early landscape modification. Grazing sheep and goats were domesticated by ~10 ka in the Near East, horses were used on the steppes by 5-6 ka, and water buffalo were in use by ~4.5 ka.

The rise of cities and empires greatly changed rivers, especially through canals and water-supply systems in Mesopotamia, Egypt and the Indus Valley. The Pharaohs built a stone-faced dam 14 m high and >100 m long in 4.5 ka, and the Romans constructed 45 large dams in the Middle East. In England, the Domesday Book of 1086 A.D. lists 5,624 water mills -- one for every 250 inhabitants.

River use intensified with the Industrial Revolution. More than 60,000 small dams lined northeastern US rivers by 1840, and the big dam era began in the late 1800s, following hydraulic gold mining that devastated western US rivers after 1849. Thereafter, most rivers worldwide have experienced enormous effects from agriculture and hydropower dams.

This brief survey suggests that humans began to influence river systems via agricultural irrigation and grazing from the earliest Holocene onwards, with possible effects in the latest Pleistocene. The use of fire may have modified landscapes much earlier. Documented change in sediment flux extends back at least 4000 years, andhuman and climate effects become indistinguishable in the Loess Plateau of China by 2 ka. However, researchers need to be aware that some much earlier channel, floodplain and upland events could be anthropogenic.

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DEGRADATION OF THE PHYSICAL STRUCTURE OF POLISH CARPATHIAN RIVERS DURING THE TWENTIETH CENTURY

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In the 19th century multi-thread morphology was common in the rivers draining the Polish Carpathians. The 20th century, however, saw a nearly complete disappearance of the braided channel pattern from these rivers (Wyżga et al., 2015). Re-establishing multi-thread morphology in some sections of the rivers is now considered to improve their ecological state and increase channel storage of flood waters. However, to make such restoration plans feasible, it is necessary to establish the exact extent of the multi-thread morphology of Polish Carpathian rivers in the 19th century as well as the patterns and causes of the subsequent channel changes.

The case studies of the rivers Soła, San and Dunajec were thus used to demonstrate changes in planform geometry of the rivers draining the western and eastern part of the Polish flysch Carpathians and those originating in the high-mountain Tatra massif, respectively, between the second half of the 19th century and the present. Differences in the cartographic presentation of rivers on 19th-century and contemporary maps limited the comparison to the number and width of the low-flow channels of the studied rivers. In the second half of the 19th century, the rivers flowed in wide channels. The Soła supported a braided channel along its entire course, the Dunajec was mostly braided, with a single-thread channel within gorge sections, whereas in the San the braided pattern was limited to the river reaches within intramontane and submontane depressions. Over the 20th century, the braided channel pattern was nearly completely eliminated and substituted by single-thread channels; multi-thread channel sections remained only in the upper course of the Dunajec River. Average low-flow-channel width significantly decreased, even by 66%, and this was accompanied by a reduction in the variability of low-flow channel width along the rivers.

The change in planform channel geometry was accompanied by river incision.In foreland reaches of Polish Carpathian rivers, it began in the late 19th century or the beginning of the 20th century; here rivers incised by 2.7 m on average, with two-third of the total value accomplished in the first half of the 20th century (Fig. 1A). In foothill river reaches, incision was typically initiated at the beginning of the 20th century and the rivers incised by 2.6 m on average, with 56% of that attained in the first half of the century (Fig. 1B). In the mountain reaches of Polish Carpathian rivers 1.2 m of incision occurred over the 20th century, mostly during its second half (Fig. 1C).

Twentieth-century changes of Polish Carpathian rivers also encompassed a radical change in the facies pattern of channel deposits, accompanied by an increase in their mean grain size and sorting as well as the development of bed armour (Wyżga, 1993; Wyżga et al., 2012). Moreover, transformation from alluvial to bedrock boundary conditions took place in many reaches of Polish Carpathian streams and rivers. The changes were mostly associated with channel regulation, although the efficiency of the engineering works was enhanced by a decrease in sediment supply caused by land-use changes, and the reduced availability of bed material for fluvial transport due to in-channel gravel mining and the construction of dam reservoirs on the rivers. With the environmental changes in the catchments, feasibility of the restoration of braided morphology is limited to those river reaches where such a channel pattern developed in response to a natural occurrence of coarse bed material and non-cohesive nature of the alluvial plains rather than to the high sediment supply from the highly deforested catchments in the 19th century (Wyżga et al., 2015).

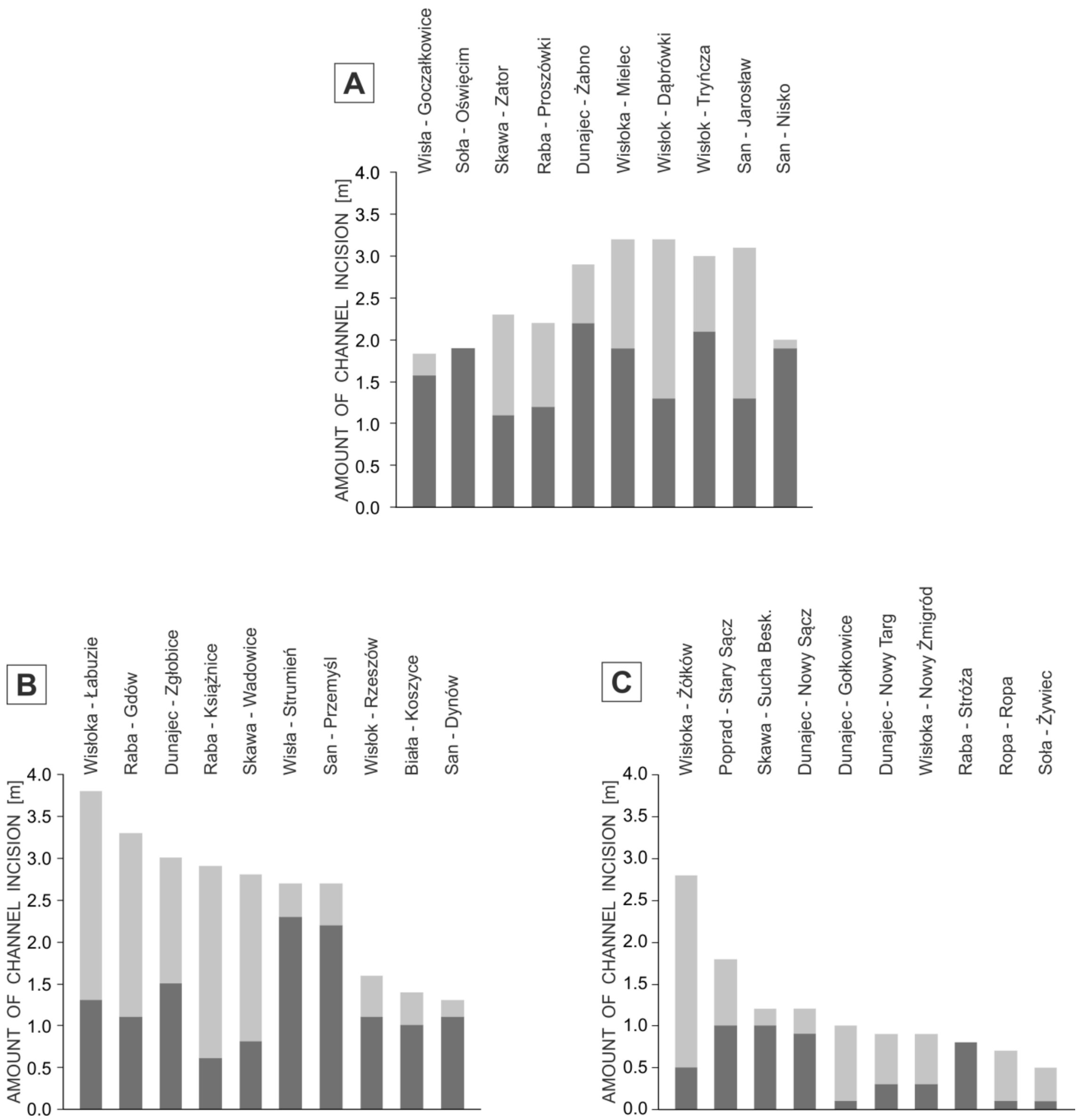

Fig. 1 Amount of channel incision of Polish Carpathian rivers during the 20th century and in its first (light grey) and second half (dark grey) determined on the basis of the lowering of minimum annual water stages at gauging stations from the foreland (A), foothill (B), and mountain (C) river reaches. Above each column, river and gauging station is indicated.

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SPATIAL-TEMPORAL ANALYSIS OF THE LOCATION AND OPERATION OF MEDIEVAL FORTIFIED SETTLEMENTS IN THE BARYCZ-GŁOGÓW ICE-MARGINAL VALLEY (MILICZ BASIN)

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Studies conducted in Wielkopolska show that in the Early Middle Ages fortified settlements were located along river valleys (Hilczerówna 1967, Kurnatowska 2008, 2009). Such a location was supposed to offer access to soils attractive in agricultural terms. They ensured abundant crops and good grazing conditions for the cattle. The enclosure by river water (the upper sections of the Barycz and its tributaries) and the resulting limited access to a settlement was significant primarily for defensive reasons. The similarity between fortified settlements of Wielkopolska and Silesia may be indicative of historical links between those neighbouring areas. Most fortified settlements are dated to the 10th c., i.e. the period when the Wielkopolska-Silesia borderland came under the influence of the state ruled by the Piast dynasty (Fig. 1). The fortified settlements of this borderland showed greater Czech, Moravian and Polabian influences than those in Wielkopolska, which in turn can suggest their connection with Silesia.

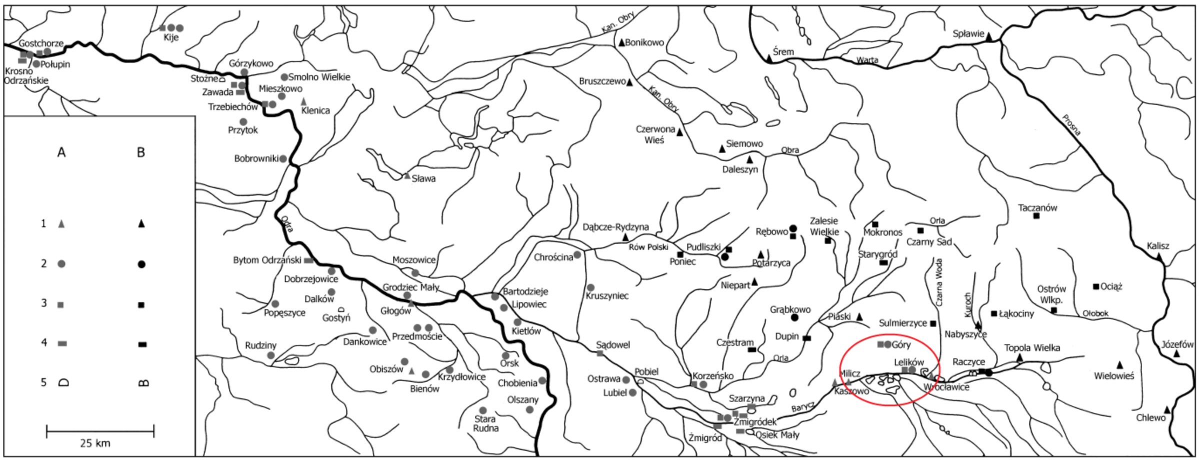

Fig. 1 Location of medieval fortified settlements in the south-eastern Wielkopolska-Silesia borderland: a - Silesian fortified settlements, b - Wielkopolska fortified settlements; 1 - fortified settlements dated dendrochronologically, 2 - fortified settlements generally dated to tribal period, 3 - fortified settlements dated to mid-10th - mid-11th centuries, 4 - fortified settlements operating from mid-11th to mid-13th centuries, 5 - cult-related places; red ellipse marks the study area in the Milicz Basin

The area selected for a detailed study was the Milicz (Odolanów) Basin together with its northern fringe, or a fragment of the Kalisz Upland. The Milicz Basin is the eastern fragment of the Barycz-Głogów ice-marginal valley. Morphometric differences are slight here, from 104 to 178 m a.s.l. The southern borders of the Basin are the morainic Trzebnica and Ostrzeszów Hills.

Compared with Wielkopolska, settlement in the north-eastern Silesian borderland is still poorly known, hence the decision to take up this problem. To start with, hydromorphometric characteristics of the location of medieval fortified settlements were examined against the background of the prehistorical settlement pattern. So far 1,475 archeological sites have been identified in terms of Polish Archaeological Record (henceforth AZP). Analyses showed that with time the area was settled more and more densely. The greatest number of settlement traces were found near the north-eastern and south-eastern slopes of the Cieszkowskie Hills (the Kalisz Upland). Those are morainic hills with slopes rising above the low-lying ice-marginal valley and river valleys, which made settlements protected from the variable hydrological conditions. With time settlement spread to the ice-marginal valley (the area of today's fish-farming ponds). This pattern of settlement processes could follow from both, hydrological conditions (e.g. in the Early Middle Ages), and political-administrative decisions (the formation of the state of the first Piast kings).

As can be concluded from the relation between the location of settlement and morphometric features, a significant role in its pattern could be played by the climate affecting the hydrological situation in the area. Climatic conditions favourable or unfavourable to settlement processes determined the choice of land lying lower or higher in relation to valley bottoms. The better the climatic conditions, the larger the area of land, diversified in terms of altitude, that could be used for settlement purposes. The high humidity of the Neolithic climate is corroborated by settlement giving then preference to the highest lying areas. In the Bronze and Iron Ages settlement chose intermediate values in terms of altitude. In the Early Middle Ages - a period of a climatic optimum - lower-lying areas tended to be selected. The last stage analysed was that of the Late Middle Ages, a period with worsening climatic conditions. This is reflected by the choice of relatively high-lying areas for settlement.

As can be concluded from the relation between the settlement pattern and land inclination, areas selected for settlement most frequently were ones only slightly inclined, of 0.5% and 0.25% slopes. This results from the hydromorphometric characteristics of the area. Intermediate settlement indices are documented in areas with 1% and 1.5% slopes, and the lowest ones, on 3% and 2% slopes. In the Bronze Age (the Lusatian culture) and in the Early Middle Ages the least inclined areas were preferred. Characteristic of the Neolithic, in turn, were settlement areas with the highest slope indices. Intermediate land inclination values were typical of the Late Middle Ages, while the Iron Age settlement pattern reflects the natural distribution of slope classes.

As follows from the relation between settlement and slope exposure, it was the most intensive on slopes with a northern exposure. The fewest sites were located on slopes with an eastern exposure, while the number of archeological sites with a southern and western exposure is a bit greater. The tendency was different only in the Neolithic, when the greatest number of sites tended to be situated on slopes with a southern exposure. Slopes with an eastern exposure were not settled at all. This settlement pattern follows from the natural (north-east /south-west) orientation of the morainic ridge running across the central part of the study area.

What affected the distance of a settlement to the river network were climatic conditions. Dry and hydrologically stable periods allowed locating settlements nearer to rivers. They occurred in the Mesolithic and the Iron Age, although in the latter case reasons for the riverside location of sites were more diverse. Traces of settlement coming from the Neolithic and Late Middle Ages have been found at greater distances from rivers and other areas with a potential threat of floods. Intermediate distances were chosen in the Bronze Age and the Early Middle Ages.

Excavation and geoarcheological studies embraced selected medieval fortified settlements in the Milicz Basin and a fragment of the Kalisz Upland: Milicz, Góry, Lelikowo and Wrocławice. Only Góry is situated outside the Barycz ice-marginal valley. To establish fortified settlements, use was made of mid-channel bar rising above the surrounding area. In some situations settlements were founded on eolian landforms that had developed on them (Lelików, Wrocławice). Parts of dune arms were used as ramparts of the settlements being built. The small settlement at Góry, in turn, is situated at the bottom of a little erosional-denudational valley, in its marginal zone. In its entirety it is a man-made form. Geophysical studies show that in the course of its construction also one of the paleochannels - evidence of the former water flow in the valley - was covered by sediments. The fortified settlements examined differ in terms of the construction solutions applied, their layout, and the time and stages of their operation.

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ORIGIN OF THE YELLOW RIVER

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The middle reach of the Yellow River from the Chinese Loess Plateau downward to the North China Plain, runs through the uplifted Jinshan Groge and subsiding Fenwei Basin, offers a favorable setting where the response of the fluvial landscape to the uplift and climatic change can be evaluated individually. A series of continuous fluviolacustrine deposits with a chronological framework of >8.3-3.7 Ma were accumulated along the west front of the Luliang Mtns, and regarded as correlated sediments of a Planation Surface occupying the main part of the Ordos block. The statistics of gravel fabric and lithology in these fluviolacustrine sediments reveals that lots of paleo-lakes fed by local streams dominated the Jinshaan gorge before the Yellow River was entrenched. In addition, two sets of fluvial gravel layers with local provenance, covered by Red Clay, were distributed discretely on this Planation Surface, along the northern Jinshaan gorge. Their formation times were dated prior to 4.9 Ma and 3.7 Ma respectively. They maybe represent a northward flowing stream, which is different from the southward flowing Yellow River, and linking some paleo-lakes with the Hetao Basin. The dramatic surface uplift initiating prior to 3.7 Ma not only interrupted the fluviolacustrine sedimentation, but also leaded to uplift of the Planation Surface. The hypsographic relief was enlarged, and resulting in fluvial head erosion. In the northern Jinshaan Gorge, the northward flowing stream was pirated by the river in the southern Loess Plateau, and then the Yellow River was entrench along its middle reach prior to 1.2 Ma. Subsequently, an episode of uplift initiating at 1.2 Ma forced the Yellow River to continuously downcut, developing a series of fluvial terraces. The modern spectacular landscape of alternating deep-cut valleys and subsiding basins has been shaped gradually by the Yellow River since this uplift.

EVIDENCES FOR SUBMERGED ANCIENT RIVER COURSES IN SRI LANKA

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Sri Lanka is an Island in the Indian Ocean. It is situated 32 km east of the southern tip of India separated by Palk Strait and the Gulf of Mannar and 880 km north of the Equator. The total land area measures 65,610 square kilometers. PhysiographicallySri Lanka consists as a central mountainous mass or central highland surrounded by alow,flat plain on all sides and extending to the sea. The rivers beginning from the mountains and flowing to the sea from all the directions shows a radial drainage pattern. There are 103 river basins. Surrounding the Island is the continental shelf. The shelf around Sri Lanka is narrower and shallower.

Inland coral deposits, shell beds, raised beaches, and gravel deposits etc. are the direct evidences to indicate the sea level rise. Occurrence of submarine canyons opposite some of the major river outfalls shows higher erosion of rocks during the lower sea levels in later periods. These are evidences to show the sea level fluctuation during Pleistocene. The present live coral reefs in shallow sea indicate the sea level rise again in Holocene.

At present, the submarine contour lines in the wide continental shelf area shows some valley shape submarine surface changes along the existing rivers NW part of Sri Lanka. These submarine valleys connected to the rivers are assumed as submerged river courses.

The other evidence is 75m thick alluvial deposit at the Mahaweli river mouth in NE part of Sri Lanka. The canyon head in the sea along the river path indicates the level of ancient river course which is submerged now.

Seven canyons have been recognized in the continental shelf and continental slope around the coastal zone of Sri Lanka. The distances to the canyon heads from the shore vary from 200m to 16km and those are situated opposite of some major river outfalls. It can be assumed that the canyons have been formed as a result of bedrock erosion by these rivers during low sea level period (glaciation). Now these eroded features exist as canyons under the sea levels with the submerged ancient river paths.

STUDY OF MORPHOLOGICAL ANOMALIES OF TAJO WATERSHED (SPAIN) FROM THE ANALYSIS OF BOTH THE DIGITAL ELEVATION DATA AND THE STREAMS LONGITUDINAL PROFILES

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The Tajo River, located in central Iberia, is one of the largest in the Iberian Peninsula. It flows westward from the Iberian Chain to the Atlantic Ocean, dissecting several cenozoic continental basins and incising the variscan basement. The western area is in the Variscan Domain, which represents the remains of the Hesperian Massif, formed during the Upper Devonian and Lower Carboniferous. The Tajo watershed is located in the Central Iberian Zone (Pérez-Estáun et al. 2004), it includes the northern sector of the Lusitanian basin (or Lower Tajo) to the west, and the so called Tajo basin at centre, which is formed by two sub-basins: the Intermediate Depression or Loranca Basin, and the Madrid basin (Alonso-Zarza et al. 2004). These are a serie of intracratonic basins located within the Iberian Microplate, a crustal block that articulates the convergence between the African and Eurasian plates, where two large Alpine Ranges, the Betic and Pyrenean, have developed on the edges (Garrote et al. 2008) (Fig. 1). With the aim to establish a conceptual model of the Tajo river fluvial basin we tried to detect the main morphological anomalies by means of terrain elevations data (Digital Elevation Model, DEM) analysis. The study focuses on the analysis of the longitudinal profile shapes, because they represent one of the most sensitive indicators to detect the influence of climate, lithology and tectonics (Whipple 2004) on the fluvial network. We used the mapping Shuttle Radar Topography Mission (SRTM) sampled at 3 arcseconds (approximately 90 meters) using a resampling technique cubic convolution for open distribution, from NASA and NGA, available on the web server US Geological Survey's (USGS).

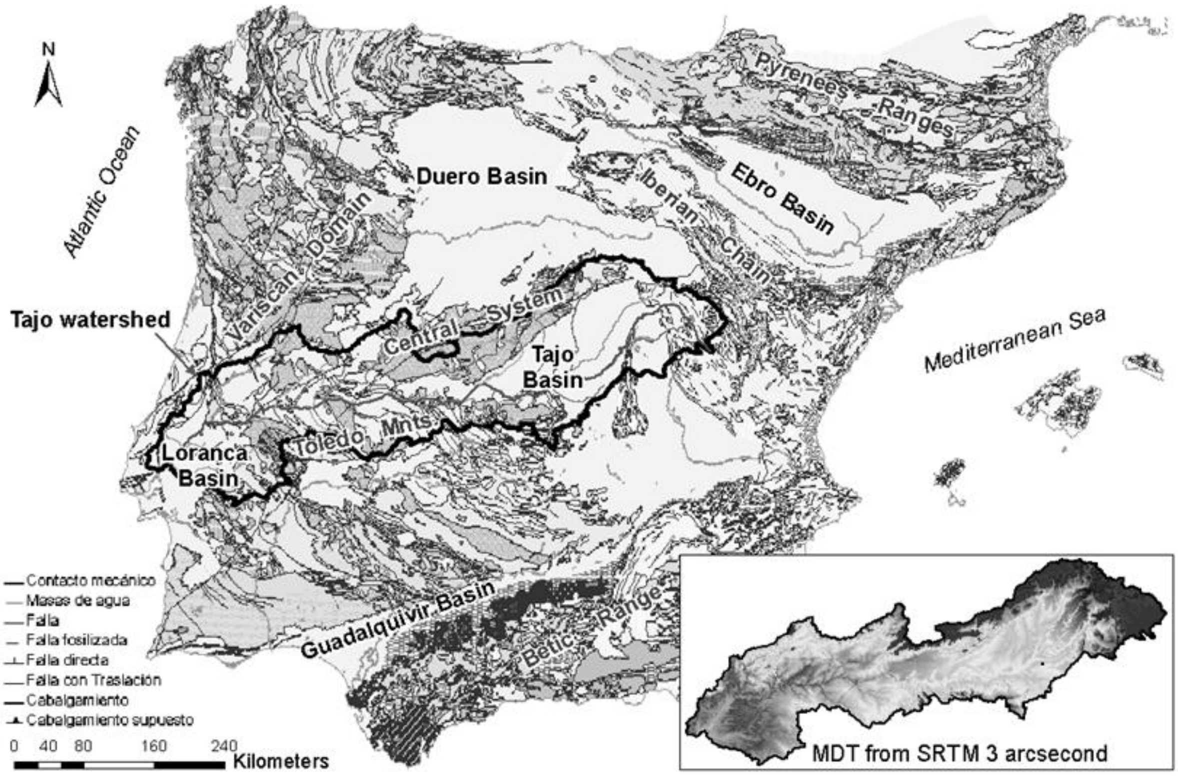

Fig.1 Regional geological setting of the Tajo Basin represented by Tectonics mapping of the Iberian Peninsula and Balearic – IGME. And detail of the MDT obtained from SRTM.

Longitudinal profiles for the Tajo channel and 30 tributaries were constructed by combining digital elevation models and vectorized stream analysis. The profiles were locally corrected for the effects of dams, based on linear interpolation method. The resulting longitudinal profiles (LP) were analyzed by converting distance measurements into logarithms, and plotted on arithmetic scales. The Gradient index (SL) is proportional to the slope of the plotted profile, and its numerical value was calculated from both: tabulated data at any point and the average of certain homogeneous intervals (Hack, 1973). Some transversal profiles to the Tajo channel were constructed for valley floor width–valley height ratio (Vf) calculation (Bull, 2007). An expression of the profile concavity was established by the maximum elevation difference between longitudinal profiles and the straight line connecting the two ends (headwater and mouth) of the profile, as proposed by Demouline (1998). The watershed area measured is ~77503 Km.2 2-D and ~7782 Km.2 3-D, within a perimeter of ~3203 Km. This is a very elongated basin, in east-west direction (3.25 Gravelius index, 0.30 elongation coefficient, 0.07 shape factor). The watershed comprises a range of altitudes from sea level (sea mouth, Lisbon) to 2430 meters (Peñalara peak, Central System) with 600 meters as average altitude. The hydrographic network has 5238 channels, with a total length over 30000 Km and a drainage density of 0.4, where the Horton's laws are verified. Although several knickpoints were identified, there may be knickpoints not observed in the Tajo profile, because nearly 50% of its route is covered by reservoirs. Nevertheless a significant change in concavity is observed at headwater, which doesn't fit with any strong lithological contrast. By converting the length measurements to logarithms, we note the profile's shape changes in terms of gradient-index (SL). Thus, the head reaches present an anomalous SL value compared to the general trend (Fig. 2). This signal might be associated with actively uplifting in the head of the Tajo river (Garrote et al., 2008, Giachetta et al., 2015). SL increases downstream with a value above the overall average (Fig. 2).

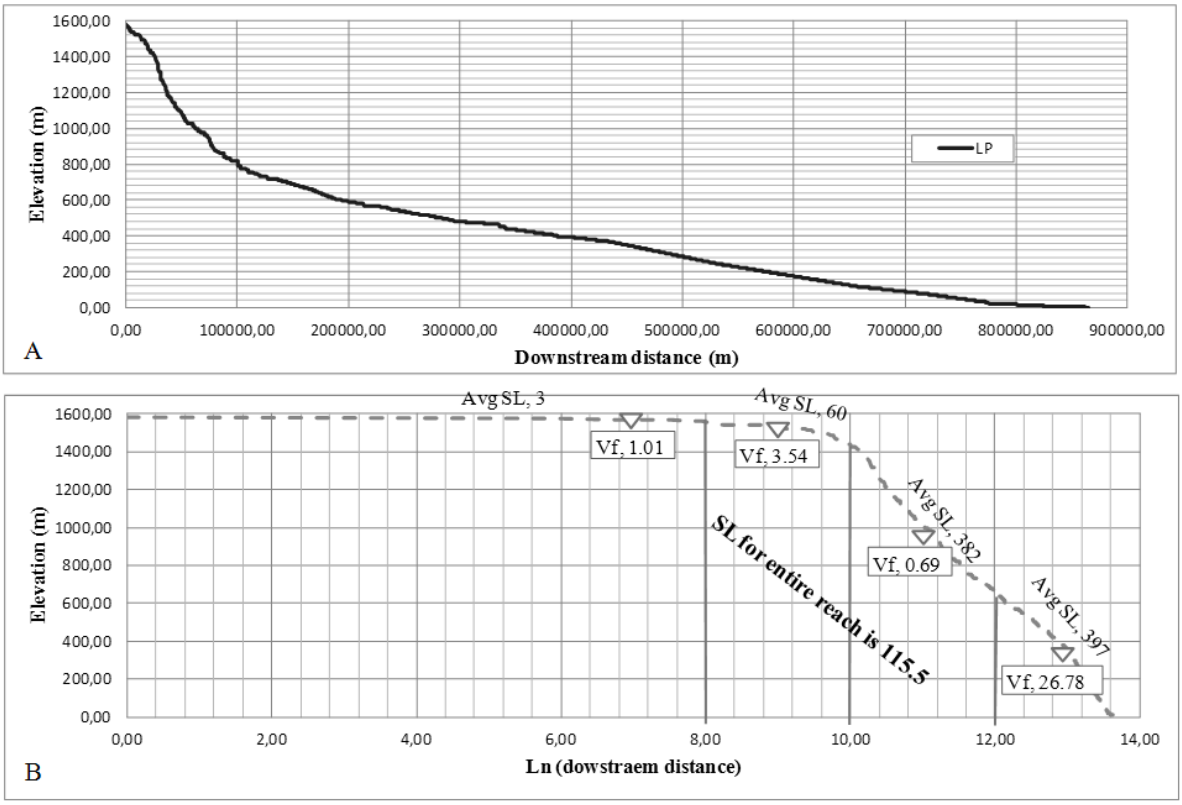

Fig.2 A: Tajo LP. B: LP in terms of the logarithm of the distance. SL average value for homogeneous slope sections and for entire reach. Vf value at the midpoints of each section.

With the exception of Algodor, Gebalo, Guadiela and Salor rivers, a similar pattern is observed in the normalized concavity distribution within the tributaries, and also in Tajo river. The SL values obtained are generally low for the entire basin, indicating a contrast in slopes, with the exception of Zezere river in which this is only observed in the upper half (Fig. 3). At this stage the cause for this is not established, however it seems important to note that the slope contrast relates to the concavity of the upper-middle reaches, in the case of both the Tajo river and the tributaries of the northern sector; and to the middle strech in the tributaries of the southern sector. Work in process include the comparison of results with other indices such as DS (Goldrick and Bischop, 2007), watersheds' asymmetry (Af), and the characterization of other morphological features such as nickpoints, bedrock lithology, etc.

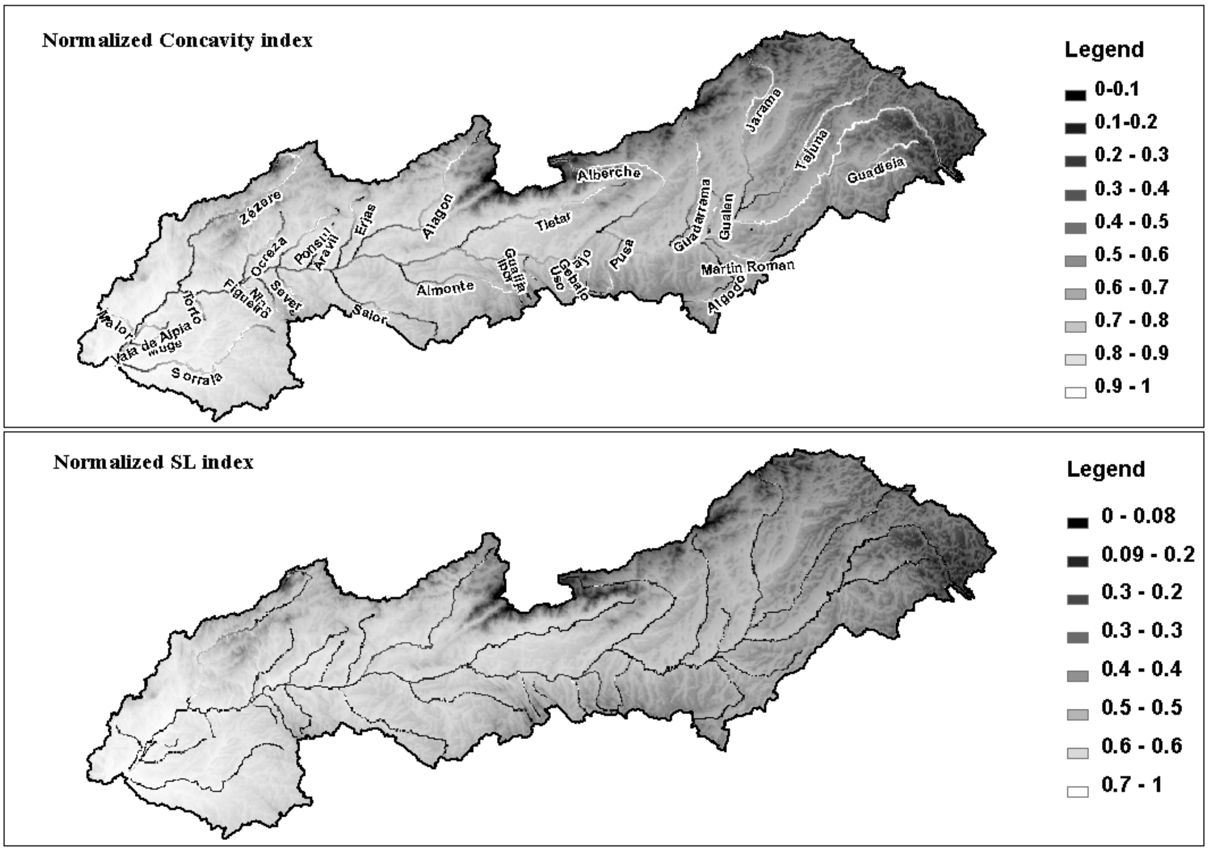

Fig.3Mapping of the SL and Concavity normalized values for thestudied channels.

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A VAST MEDIEVAL DAM-LAKE CASCADE IN NORTHERN CENTRAL EUROPE: LATE HOLOCENE WATER LEVEL DYNAMICS OF RIVER HAVEL (BERLIN-BRANDENBURG REGION, GERMANY) AS DERIVED BY GEOARCHAEOLOGICAL AND PALAEOECOLOGICAL DATA

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An interdisciplinary study was carried out to trace the hydrological changes of the medium-scale river Havel in northeastern central Europe over the course of the last c. 2000 years. This research was driven by the hypothesis that the present-day riverscape is to a large degree a result of medieval and modern human transformation of the drainage system. The river forms a chain of dammed lakes and meandering river sections which were greatly altered through hydraulic engineering in the past.

Along the middle course of the Havel, sixteen sedimentary sequences available by geoarchaeological and palaeoecological research were analysed in order to reconstruct regional water level dynamics. Chronological control was ensured through a multitude of palynological, dendrochronological, archaeological, and radiocarbon data.

The sections upriver from the Brandenburg/H. and Spandau weirs, representing sites with historic watermills, reveal substantial water level changes during the late Holocene. Generally, lower water levels before and higher levels during the medieval German colonisation of that area (c. 1180/1250 AD) can be inferred. This water level increase, which is attributed to dams constructed for watermills, took place rapidly and amounted to a relative height of c. 1.5 m. It widened river sections and increased the size of existing lakes or initiated secondary formations when already aggraded, and thus caused a flooding of large parts of land. The rising water level even influenced the settlement topography to a large degree. Several medieval rural settlements were abandoned due to flooding (Fig. 1).

The c. 150 km-long lake cascade of the lower and middle Havel is one of the largest anthropogenic dam lake structures in historic times globally, despite its relatively low dam heights and short dam lengths.Thereof, the c. 70 km-long middle river course between Brandenburg/H. and Spandau is the largest medieval dam lake in central Europe known thus far.

From a general perspective, the hydraulic effects of medieval to modern watermills in northern central Europe can be classified by the impoundment effect: besides numerous small-scale dammings of streams and minor rivers which often form chains of small dam impoundments, there is also a large-scale effect, comprising dam lakes with a longitudinal range of up to some tens of kilometers. Several larger river valleys in the lowlands were drowned in this way (Kaiser et al., 2012), representing a legacy of hydraulic energy production in medieval and modern Europe (Rynne, 2015).

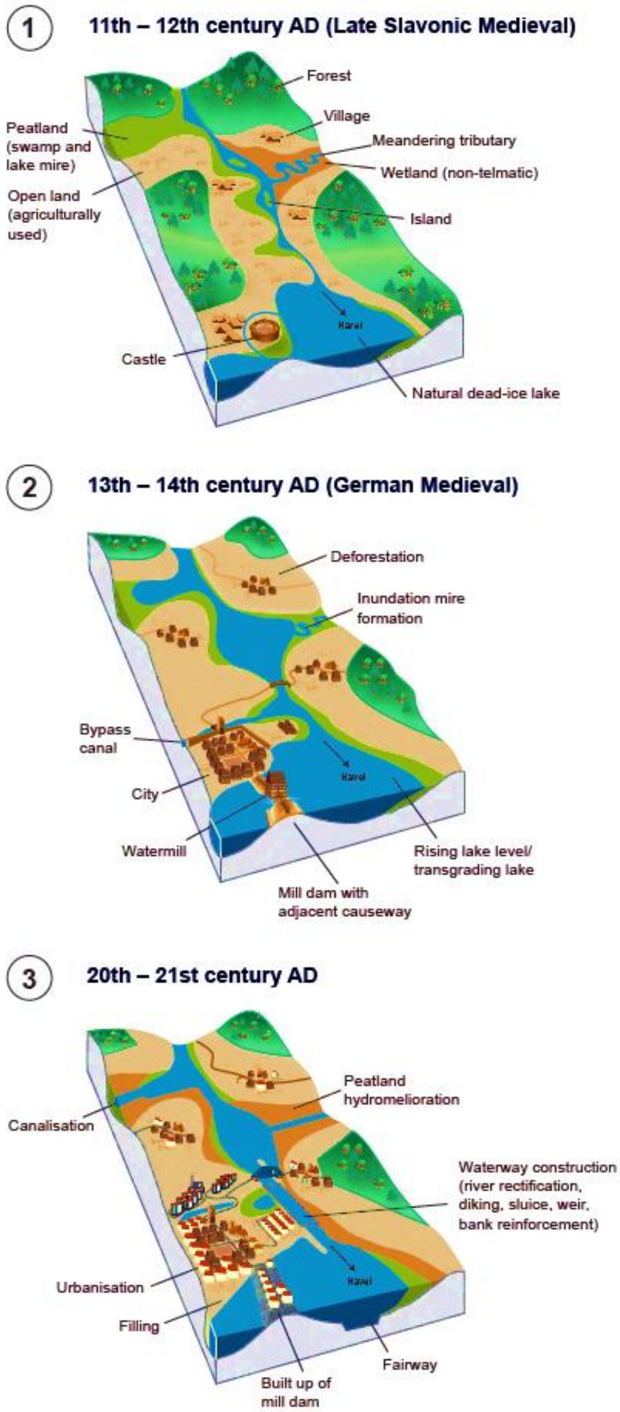

Fig. 1 Conceptual model showing selected hydrological, sedimentological, ecological and settlement changes in the middle river Havel valley caused by anthropogenic impoundment (mill damming).

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RIVER VALLEYS EVOLUTION AND MEN: A CASE STUDY FROM LOMAS DE LACHAY, PERU

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Lomas de Lachay region is located on the Central Coast of Peru, about 100 km north of Lima and ca. 10 km from the Pacific Ocean shore (Kalicki et al. 2014). It is situated on the first, low ridges of the Andes which reach about 1700 m a.s.l. During austral winter (May-October) thick clouds (*garúa)* form due to cold Humboldt Current which is flowing along western coast of South America. They deposit humidity on first ridges of the Andes which allows a peculiar ecosystem of *lomas* (fog oases) to develop. Presence of at least four types of *lomas* (shrubby *lomas,* cacti *lomas,* Bromeliacaeae *lomas*, herb *lomas*)are result of different amount of humidity which is associated with thickness, frequency and time of fog presence (Rundel et al 1998; Dillon et al. 2003). Lush vegetation of fog oases during wet season attracts animals like different species of birds, wild camelids (llama, guanaco), Andean deer and even pumas. During dry season the vegetation is scarce and number of animals is low. Fog oases' climate is also strongly influenced by El Niño episodes which are associated with torrential rains. Ecosystem of *lomas* strongly contrasts with dominant environmental conditions of the Peruvian coast which are characterized by extreme dryness, high temperature and lack of vegetation. Therefore, due to relatively rich natural resources, *lomas* were visited by men since the late Pleistocene (Engel 1987; Kalicki et al. 2014).

There are three main type of geosystems in the study area: coastal desert, proper *lomas* and mountain desert (Kalicki et al. 2014). Actually there are no permanent or seasonal rivers in the area, but prior to construction of extensive irrigation network in Quebrada Río Seco (Fig. 1) Río Seco river might have been a seasonal river because upper parts of its drainage basin are located high enough for seasonal rains to appear during the austral summer. The other principal river valley (Quebrada Doña María) does not reach this heights as its upper part of drainage basin is situated in Lomas de Lachay (Fig. 1). We found almost no traces of contemporary fluvial activity in coastal desert and *lomas* geosystems, except for one *huaico* (landslide) remains, very thin (few millimetres deep) layer of flood sediments on the point bar surface in middle section of Quebrada Doña María and some erosional cuts in upper parts of drainage of Quebrada Hato Viejo (Fig. 1), which belongs to Quebrada Río Seco system. They are all probably connected with El Niño episodes, especially last large episode from 1992-1993 AD. Paradoxically, there are many traces of fluvial activity in the mountain desert geosystem – in Quebrada Guayabito (Fig. 1) valley which is a part of Quebrada Río Seco system. Active alluvial plain of braided river, traces of landslides, terraces and lack of vegetation cover prove that during El Niño episodes catastrophic flash floods occur in the mountain desert geosystem due to torrential rains.

However, presence of large, deeply incised (several dozens to even few hundred meters deep) river valleys suggests existence of permanent or at least seasonal rivers in the past. Valley bottoms of Quebrada Río Seco, Quebrada Doña María as well as lower and middle section of Quebrada Hato Viejo are relatively wide (few hundred meters) and flat which suggests that lateral erosion occurred in the past. Also contrast between wide and flat valley bottoms of upper sections of lateral valleys in Quebrada Hato Viejo and Quebrada Doña María Hato Viejo and

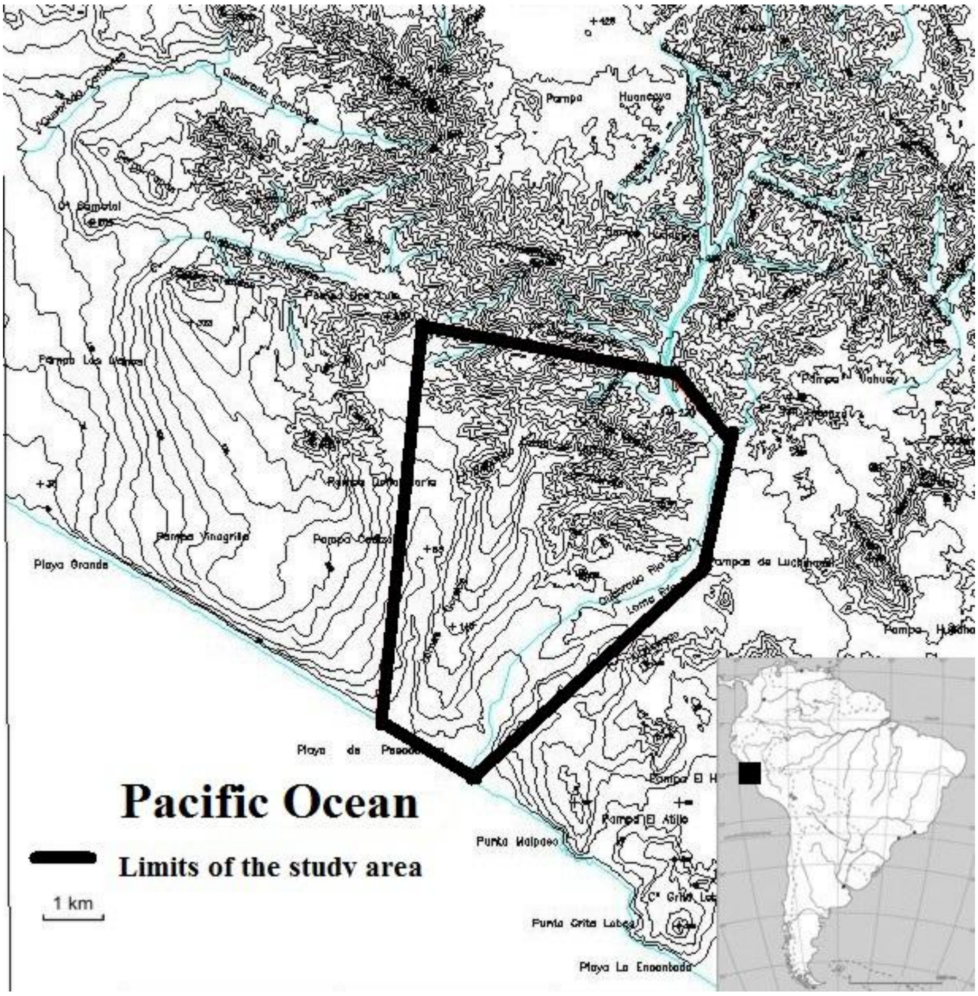

Fig. 1 Limits of the study area

their narrow, deeply incised lower sections indicates that relief of terrain was partially rejuvenated.

Basing on thermoluminescence dates of sediments from Río Seco valley and Quebrada Guayabito valley we suggest that principal features of morphology of the study area have developed during the Vistulian when there were active rivers as proved by presence of at least two generation of river terraces in Quebrada Río Seco drainage basin. It implies that precipitation was large enough to aliment permanent rivers during the last glaciation. It could be attributed either to more humid climate of Central Andes in general or to shift of climatic altitudinal zones downwards due to world-wide glacial sea recession. However, difference of height of successive generations of fluvial terraces (few-several meters high) is not as big as difference of height between successive generations of older planation surfaces which reaches several dozen meters. It might be interpreted as proof of long-term trend of precipitation decrease, although influence of tectonic uplift of the Andes was probably also considerable.

No traces of significant fluvial activity during Holocene were detected (Kalicki et al. 2014). Together with presence of large late Pleistocene and early Holocene sand covers, dunes which are located on the valley bottom of Quebrada Hato Viejo and Quebrada Doña María it suggest aridization of climate during Holocene. This long-term trend was probably quite stable and was briefly interrupted only by phases with increased El Niño frequency, which alimented springs and allowed development of permanent settlements in the Lomas de Lachay.

First phase of permanent settlements in Lomas de Lachay was associated with Playa Grande phase of Lima culture and basing on archaeological artefacts may be dated to 200-500 AD (Kalicki et al. 2014). By that time there must have been no permanent or seasonal rivers in Lomas de Lachay, because hundreds of agricultural terraces were built by Lima culture people in the valley bottoms of upper lateral valleys in Quebrada Doña María and Quebrada Hato Viejo. Construction of terraces in the bottom of small, lateral valleys is typical for dry climate (Brooks 1998). Remains of water reservoirs and wells also suggest that dry conditions were dominating in the Lima times. However, presence of structures designed to diminish speed of running water point towards relatively frequent flash-floods. Such dry conditions with common flash-floods are typical for periods with high El Niño frequency.

Second settlement phase with permanent habitation sites is connected with Inka culture and may be dated to 1450-1500 AD (Kalicki et al 2014). However, no traces of significant investments in agricultural infrastructure during that period were detected. It seems that subsistence economy relied on camelid (llama and alpaca herding), not on agriculture. It might be interpreted as sign of further climate aridization in Lomas de Lachay, so that despite of increased El Niño frequency water resources did not allow for the development of agriculture.

Both our environmental and archaeological research suggest a long-term trend towards aridization of climate in Lomas de Lachay, which supports proposed in literature (Lanning 1963; Engel 1970; Engel 1987; Rundel et al. 1998; Dillon et al. 2003) hypothesis of gradual *lomas* drying during Holocene due to environmental reasons. Main features of river valleys' morphology in the study area was created during late Pleistocene and during Holocene only minor changes occurred.

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CLIMATE AND BASE-LEVEL CONTROLLED FLUVIAL SYSTEM CHANGE AND INCISION DURING THE LAST GLACIAL–INTERGLACIAL TRANSITION, ROER RIVER, THE NETHERLANDS–WESTERN GERMANY

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The fluvial development of the Roer river, a tributary of the Meuse river, in the southeastern Netherlands and western Germany is presented for the Late Pleniglacial, Late Glacial and early Holocene periods. Reconstruction of fluvial style changes is based on geomorphological and sedimentological analysis. A chronostratigraphic framework is established by pollen analysis and optical dating. At the Pleniglacial to Late Glacial transition a system and channel pattern change occurred in the Roer valley from an aggrading braided to an incising meandering system. High meander migration rates have been established for the Late Glacial by optical dating. Strong fluvial dynamics was possibly related to the sandy nature of the subsoil and by the incision of the Meuse that resulted in a higher river gradient in the downstream part of the Roer valley. The Younger Dryas cooling is not clearly reflected by a fluvial system change in the Roer valley, indicating that the system responded differently compared to other nearby systems (Kasse et al., 1995, 2005; Janssen et al., 2012). An important incision phase and terrace formation was established at the Younger Dryas to early Holocene transition, probably related to forest recovery, reduced sediment supply and base-level lowering of the Meuse. This study shows a stepwise reduction in the number of channel courses in the Roer valley from a multi-channel braided system in the Pleniglacial, to a double meander-belt system in the Late Glacial and a single-channel meandering system in the early Holocene. The forcing factors of fluvial system change in the Roer valley are climate change (precipitation, permafrost and vegetation) and downstream base-level control by the Meuse.

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REFLECTION OF GEOLOGY, CLIMATE AND HUMAN IMPACT ON SMALL VALLEY FLOOR TOPOGRAPHY AND ALLUVIA STRUCTURE; SILESIAN UPLAND, SOUTHERN POLAND

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In Central Europe, between the Baltic Sea in the north (54^0 50'N) and northern foothills of the Sudetes and Carpathian Mts. in the south (50^0 00 N) there lies a part of the European Plain, 350-500km wide, stretching 6,000km from the Bay of Biscay in the west to the foothills of the Ural Mts. in the east. During the Pleistocene Central Europe was covered by Scandinavian ice sheet a few times, which left behind gravelly-sandy or loamy deposits. Moreover a number of older substratum elevations are identified within this zone. The Silesian Upland is situated in the southern part within this plain, where the western margin of older structures, covered by Quaternary deposits, slopes westward to the Odra valley and the Koźle Plain (Fig.1).

Fig. 4 The Bierawka catchment within the Koźle Plain

Situated on the northern foreland of the Moravian Gate, the western slope of Silesia Upland is dissected by the valleys of the upper Odra tributaries: Ruda, Bierawka and Kłodnica. In its older substratum lies the contact zone of the Moravian overthrust on the Upper Silesian coal basin. These structures coincide with the course of lineaments of the older substratum (Żeleźnikiewicz et al.2011, Buła ed.al. 2007). Some of them were re-activated as isostatic movements following the disintegration of the last Scandinavian ice-sheet in this region (Lewandowski 2015). This is reflected in the pattern of 1st order valleys dissecting the elevated parts as well as in varied thickness of Quaternary deposits in some sections of the valleys.

This part of Central Europe is situated within the temperate climatic zone, between the influence of advection of the Atlantic cyclones and the continental anticyclones. Here within a period of one or a few years occur very different weather conditions, reflected sometimes in sharp temperature differentiations, heavy summer rains or winter snowfalls. This part of the Silesia Upland receives 600-700mm of yearly precipitation. Between May and August the thunderstorms occurred on average 27 time per year (1949-1998). Mean temperature of the warmest month i.e. July is 14-15 °C, and the coldest month i.e. January falls within the range between -2°C to -4 °C. Snow cover occurs here 50 days/year on average (November-March), up to 70 days in the upper part of the Upland (Atlas of Climate..2000). The average number of days with temperatures □ 25 °C reaches 123.5 days/year. The lowest recorded temperature was -29.2 °C. (Chomicz 1977).

At the beginning of the Holocene, running water started to be the main factor transforming the Earth surface and biota dynamics. Coniferous and mixed forest succession adapted to different areas of climatic exposition, soils and groundwater properties. The valley floors were covered mostly by riparian vegetation.This vegetation cover had different resistance to human impact. In recent decades many researches' goal was to reconstruct the intensity of soil erosion and re-deposition processes as indicators of past human activity in the areas of different topography and climatic situation (Bork 1989, Boardman 2006, Helmng & Rubio 2006, Hauben 2012, Dotterweich 2013).

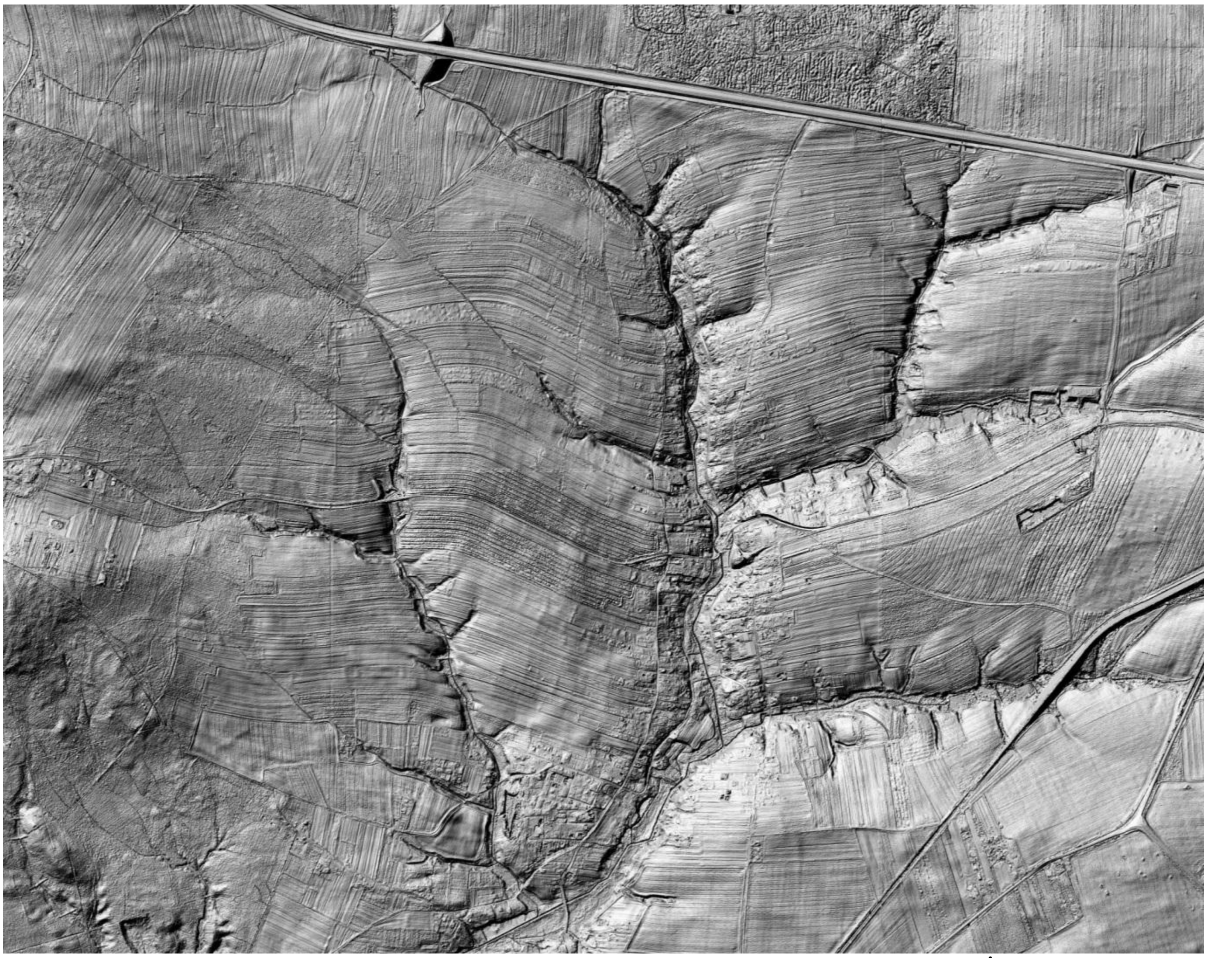

Fig. 5 LiDAR image of the upper part of the Bierawka catchment (Żernica)

The issue of reflection of natural environment and human impact on the topography of valley floor and alluvia structure present in the Bierawka valley represents very similar geomorphic properties to the neighbouring valleys draining the western margin of the Silesian Upland. The Bierawka catchment covers over 370km^2. Its source tributaries drain the elevation of mostly older substratum (300-310m a.s.l.). The lower valley course, with the gradient of 1.7-1.8 m/km, dissecting the Koźle Plain, is filled mostly with glacifluvial sandy deposits and younger alluvia. During the 20-year period (1951-1970) the average discharge of this river, 5km upstream the confluence to the Odra river (Grabówka gauge station), was over 3m^3/sec. However during years with intensive advection of wet air masses it can be even higher. As a result of heavy rainfalls recorded within the Bierawka catchment between 5th and 9th July 1997, which reached 201-220mm, the river discharge (Grabówka) reached 104m3/sec. It was 34 times greater than the mean yearly discharge. The specific run-off reached 286 l/sec/km^2 (Dubicki et al.1999).

Despite the fact that on the loess patches of the further west part of the Eastern Sudetes foreland there existed some Neolithic tribes' settlements, near the Odra valley the traces of Neolithic settlements from this period were found only on the Koźle Plain.During the Migration period in the upper OdraBasin occurred significant depopulation. Between 6th and 10th century the Slaviac tribes, migrating probably from the Russian Plain, started to settle the Upper Odra river basin. At first they settled a loess upland on the Eastern Sudetes' foreland

(Foltyn 1998). Later some of these tribes inhabited right-hand tributary catchments of the Odra river. Evidence of these settlement are confirmed bywell-preserved remnants of a stronghold of the Golensiszi /Gołęszyce tribe in Lubomia, 25km southward from the middle course of the Bierawka valley. This stronghold was destroyed probably between 8th and 9th (880) during the invasion of a Great Moravian king Svatopulk. In later centuries political alliances and economic relations caused this part of Upper Silesia to become a part of the Kingdom of Bohemiain1327. In the 12th and 13th centuries the process of agricultural colonization was developed. Within NE part of Bierawka catchment a dense network of source tributaries favoured settlement location as well as farm animalbreeding. These were those small tributaries of the Bierawka river that were predominantly of "warmexposure" i.e. of S or SW orientation. Such a localization facilitated access to groundwater sources not freezing even in extremely cold winters, when temperatures can drop below -29° C.

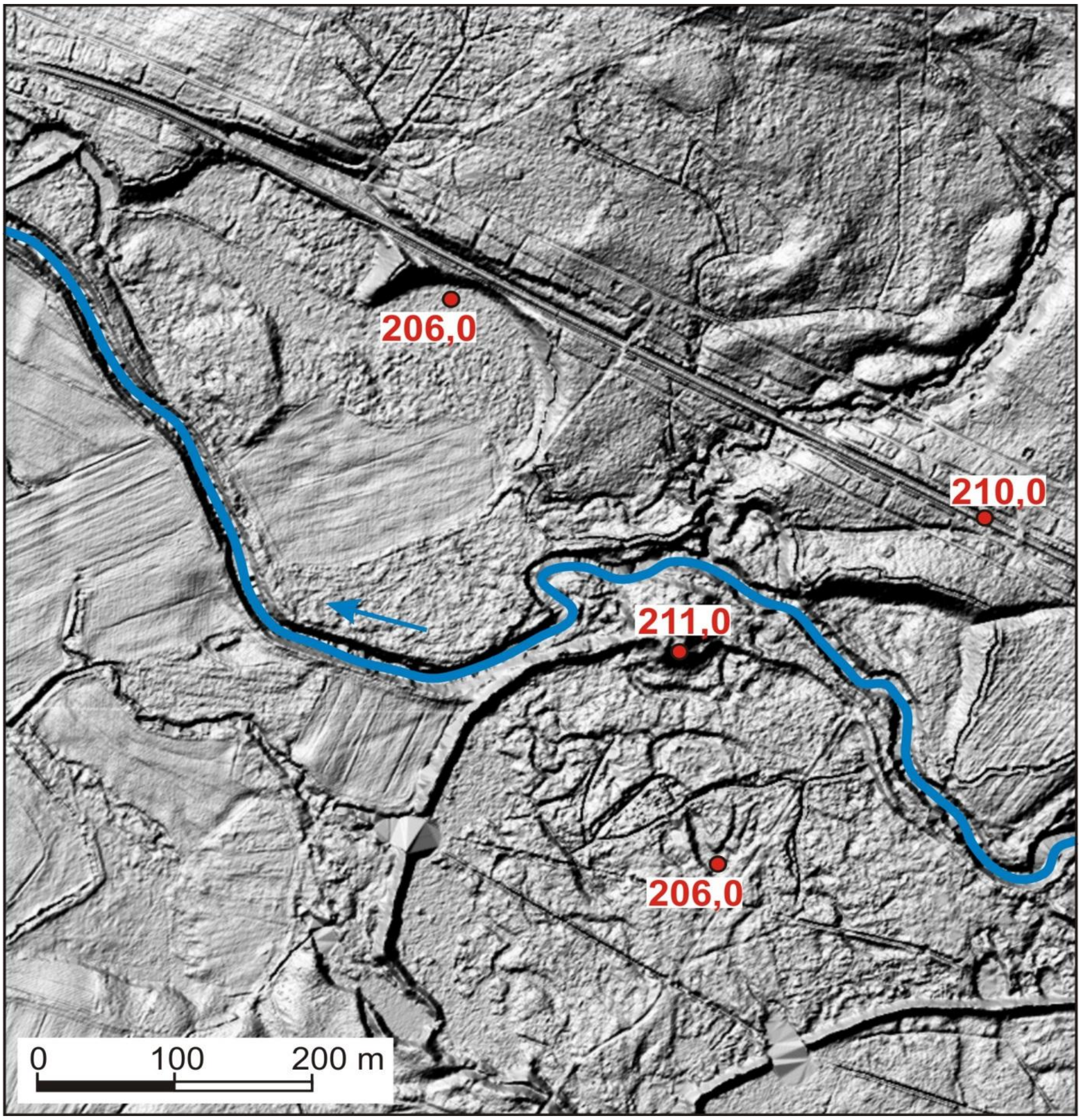

Fig. 6 LiDAR image of the Bierawka valley floor topography

In the Middle Ages harvest yield was low. Therefore to achieve economic self-sufficiently one farmers' family used a feud*/ łan (in Polish)* of land. The typical *łan zemsky*covered 7 hectares of farmland. Only a few farms could use 100ha which equals 1km^2. This caused successive forest clearance and an increase in croplands. During the second quarter of 14th century the population density in some regions of this part of theUpper Silesia reached 7-20 person/km^2 (Ładogórski 1955). Because new villages were usually founded along small streams, the soil tillage ran parallel to the valley side with an inclination of usually 10-40m/km. The improved primitive lister / *socha*to plough with cast of iron shape would turn the soil deeper and more effectively making these processesmuch easier. Moreover introduction of potato and later sugar-beet cultivation increased soil erosion. Therefore after some time the rainstorms or snow-melting waters formed the run-off trails, especially within the edges of small valley sides (Fig.2).

The middle section of the Bierawka valley is filled with fluvial deposits a few dozen meters thick. In its Tertiary substratum there occur the previously mentioned faults of the Moravia-Silesiaoverthrust, perpendicular to the valley direction, which may be responsible for the neotectonic activity. This section of the valley is overgrown with mixed forest, which "cover" the meso-topography of the valley floor,and has a backswamps topography or bogs drained by small streams. The engineering training of the main channel course increased its longitudinal slope which, in turn, caused the deepening of the channel (Fig. 3). Today it is accompanied by fragments of natural levee up to 1m high. In the two undercuts of the river banks, up to 3m high, there occur silts with fine sands intercalation and vertically standing trunks of alder (*Alnus glutinosa)* with the diameter of 10-15cm. The lowest of them have the roots above the mean water level of the channel and 1m above the channel bottom. The 14^C dating (MKL Lab. Kraków) indicated their age between 3670±40 and 3310±40 years BP. The younger ones, standing on a higher level, were dated at 1120±60 years BP.

This indicatesthat in this section of the Bierawka valley the alder swamp environment existed for over 2600 years or more. Even very slow subsidence of this area, not exceeding 1.0 mm/year, during 2-3 ka could result in the lowering of this area by 2-3m. The beginning of Early Medieval forest clearance transformed the hydrological regime of the Bierawka tributaries and resulted in slowly growing delivery of eroded soils from the catchment. This finds confirmation in the natural levee fragments in the higher part of the undercut alluvia sequences.

These levee sequences contain hard coal particles delivered from coal mine waste, which was started in this catchment in the first half of the 19th century.

Downstream the Bierawka valley course during the Pleistocene its channel crossed mostly forested sandy plain. Engineering correction of the Odra channel since the end of 18th century caused lowering of its water level. This resulted in a migration of vertical erosion upstream the Bierawka channel. In river bank undercuts there are visible vertical sequences of older alluvia,covered by younger alluvia, re-deposited during last centuries. Because of the higher specific gravity of quartz sand (2.65 g/cm3) and hard coal (1.69 g/cm3), during waning flood the quartz particles deposition precedes that of coal.

In other valleys of the western slope of the Silesian Upland there can be found sections of different valley floor topography. Such changes confirm the opinions concerning the still active neotectonic activity, especially in the zone of the Moravio-Silesian overthrust reactivated by the glaci-isostatic movements after the disintegration of the Scandinavian ice sheet 200 ky ago.

THE LATE GLACIAL AND HOLOCENE EVOLUTION OF UPPER KAMIENNA RIVER VALLEY

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The Late Glacial and Holocene transition is very characteristic period for Central Europe area when the climate changes were the most important factors of changes within river channels. They were connected mainly with the deepening of river valley, change of river regime, river channel conversion from braided to meandering, decrease of paleochannels size and increase of organic deposits accumulation. In the Holocene, especially in Subatlantic human activity have taken on importance increasingly. These regularities has been stated by Starkel (2001) and Kalicki (2006), and they are very good visible in case of Vistula river and its tributaries. Detailed geological and geomorphological research are being conducted among otherwithin upper part of Kamienna river valley.

Kamienna river which belongs to left-tributary of Vistula river has about 150 kilometers of length, and its catchment area reaches 2007,9 km^2. The river are using the tectonic conditions, therefore it has a characteristic longitudinal shape (Karaszewski 1985; Suligowski et al. 2009). Investiged section lies on the upper course of Kamienna river downstream of Skarżysko-Kamienna in Marcinków surroundings. It is connected with Mesozoic margin of the Holy Cross Mountains. The oldest deposits are from Lower Triassic (Suchedniów Plateau) and Lower Jurassic (Iłża Foreland). The valley is filled with Quaternary deposits which 20-30 m of thickness (Filonowicz 1979). They are mainly fluvioglacial sands and gravels of Oder glaciations. On this area two levels of Pleistocene terraces had developed – from Oder glaciations and Vistulian – and they are built from alluvia of braided river. On small surfaces a traces of aeolian processes could be observed as layers of dunes and windblow sands (Barwicka, Kalicki 2012, 2013). Holocene flood plain is characterized by very complicated architecture and it has created from overbank or channel deposits of meandering river. Within that form several alluvial bodies of different age are present.

Research conducted in Kamienna river valley include the dating of characteristic form, fluvial sedimentation studies and geochemical analysis within flood plain alluvia. Its formation are connected with lateral migration of meandering river (Barwicka, Kalicki 2012, 2013). An incision of flood plain had place in the Late Glacial and Holocene transition (9250±60 BP). Organic paleochannel fills has well preserved in Marcinków II/Kamienna 4 and Marcinków II/Kamienna 5 profiles. Meandering alluvia have a typical tendency of finning upward sequence, and it can be observed in cases of previous mentioned profiles, Marcinków III/Kamienna 2 and Marcinków I/Kamienna 3 profiles. An increase of fluvial activity in the Roman time is reflected by layers of subfossil trees in channel deposits. Two of them were aged on 2020±40 BP and 186-45 BC for Marcinków III site and Marcinków IV/Kamienna K7 profile, respectively. In Marcinków I site buried soil between thin layers of sandy loam were preserved. It was dated on 730±90 BP and it created by vertical accretion during floods events in Little Ice Age and also human activity in last centuries. The first geochemical research are showing a significant acidification of deposits. This tendency can be connected with a small amount of basic substance (mainly $CaCO_3$), acidifying influence of organic matter and also with an accumulation of iron compunds, visible in profiles as concrections and stains. Some layers of alluvia could be enriched in organic matter caused by outwashing from upper levels (Marcinków IV/Kamienna K7).

Human impact had a significant influence on changes within river valley. At the first time, anthropopressure were connected with mining and processing natural resources (hematite, chocolate flint) on Rydno Archaeological Reserve area, from the Late Paleolith to the declining of Neolith (Kardyś 2007). On the intensity of deforestation of Kamienna river surroundings, an ancient metallurgy of the Holy Cross Mountains region could had a strongly impact. Nowadays, along river channel numerous water-mills or its remains occur. In modern time these buildings caused the serious changes in channel morphology and in conditions of erosion, accumulation and transport processes. Other problems of Kamienna river valley concern mainly the relief transformation in connection withQuaternary sands mining and the presence of wastes as wild dumps.

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MAZOVIAN FLUVIAL AND LACUSTRINE SEDIMENTS OF THE CZYŻÓW COMPLEX BASED ON THE STUDY OF THE BEŁCHATÓW OUTCROP, CENTRAL POLAND

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In the long sequence of Pleistocene events of central Poland stored in the sediments of the Kleszczów Graben the Mazovian Interglacial limnic deposits are an important link (Baraniecka 1971). They belong to the Czyżów Formation (Complex) that in the lithostratigraphic profile of the middle part of the Kleszczów Graben − Bełchatów outcrop − includes fluvial sands and gravels, and among them limnic deposits formed as: gyttjas, silts clay and clays, silts and peats (cf.. Krzyszkowski, 1989, 1990, 1992, and Balwierz al., 2008; Allen and Krzyszkowski 2008). Palynological investigations of the Czyżów Formation organic deposits showed their affinity with the Mazovian Interglacial (Holsteinian; MIS 11).

Above the deposit of this formation there are glaciolacustrine (Ławki Fm.), glacial and glaciofluvial (Rogowiec Fm.), lacustrine (Aleksandrów Fm.), fluvial (Piaski and Widawka Fm.) and organogenic (Szerokie Fm.) deposits.

The deposits of the Mazovian Interglacial have been found in the middle part of the Kleszczów Graben. Profiles Kuców 9 & 10 were documented in 1994 by Dariusz Krzyszkowski, and currently they are developed by a team of authors. Analyzed sediments were lying in the middle part of the pit, at an altitude of 166−175 m a.s.l. (profile Kuców 9) and 175−205 m a.s.l. (profile Kuców 10), in the southern edge of the Kleszczów Graben. The Czyżów formation sediments have a characteristic color − silts are greenish and yellowish and sands, yellow-brownish or greenish. The 20-meter profile was also described as the Ławki Formation (Saalian, MIS6) − in the top, as well as Miocene and Pliocene sands and clays, as wide-radius synclines and anticlines − in the floor.

At the Kuców 9 site the fluvial and limnic lied in syncline depression, originated on the Pliocene top set, and at the Kuców 10 site those sediments filled the erosional, valley form. The Czyżów Formation bottom part had an accumulated (Kuców 9) or erosional contact (Kuców 10) with the Pliocene mixed colored clays. Top part of the Czyżów Formation deposits were covered by the Ławki Formation sandy gravels and gravels. The boundary between those formations had an erosional contact.

The described deposits lied shallow, as for the Kleszczów Graben, *ca* 20 m below the Bełchatów Plateau surface, but still in the lower, disturbed tectonic (structural) unit. This could be due to the position of the two profiles located above faults zones limiting the Kleszczów Graben.

In both profiles three fold divisions of the Czyżów Formation of an overall thickness of 13 m: the lower, strictly mineral (5.5 m), the middle, organic-mineral (2.5 m) and the upper, mineral (5 m). The middle part of the Kuców 9 was more expressive than the Kuców 10 site. Organic-mineral deposit was reported by pollen analysis (by M. Nita, unpublished). Mineral deposits were investigated by grain-size, mineralogical and by shape and roundness of the quartz grain analyses (by D. Krzyszkowski, partly unpublished).

On the poster the succession of facies in the profiles of the Kuców 9 & 10 has been showed, in deposits located in the marginal parts of the fossil river valley and palaeolake. In the floor were seen sands and gravels: *St*, *Sh* and *Sp*. In the middle member, sands *St/Sh* passed upwards in gyttja, silt and clay *Fm*, *FmC* and peat (*C*). On the roof *Sh* facies (pale yellow) dominate.

Palynological studies of sediments from the middle member suggests that the interglacial succession is not full. The upper part of the interglacial deposits are not preserved. Those small succession may be to the lower tundra phase, the Ist and IInd phases of the Mazovian Interglacial acc. to Szafer's classification (see Mojski 2005). The highest phase may be referred to the IIIrd phase of the warm period.

The results of mineralogical analysis showed differences between lithostratigraphic units. In the lower part, within the Pliocene sediments of Pleistocene ground/basement resistant minerals were dominating (staurolite − 30%, zircon − 40% and tourmalite − 30%). The fluvial sediments of the Czyżów formation a greater range of minerals has been reported (tourmalite − 20-40%, staurolite − 20-40%, cyanite − 10-20% and zircon −10-15%). However, in the upper part, covering interglacial deposits, the spectrum of heavy minerals for glacial sediment of the Ławki formation middle resistant minerals have been dominant (garnet − 40% and amphibole − 5%) over those more resistant to weathering (staurolite − 10%, tourmalite − 10% cyanite − 10% zircon − 5%).

Bottom part of the profile included trough, river deposits, above the limnic (delta), formed in several episodes. In the top generally sandy fluvial overbank facies have occurred.At the beginning of the Mazovian Interglacial, and maybe even at the end of the preceding glaciation occurred an accumulation of sand and gravel in the river environment. Then began lake and/or delta sedimentation, and then there was the activation of the river processes through periodic flooding of the valley bottom part. Hiatus covering the range from the Pliocene to the interglacial period, and especially the lack of tills from the South Polish Glaciations did not allow to specify the lithostratigraphic situation of the Czyżów Formation deposits in these profiles. While the results of the borehole 65/15 (Krzyszkowski 1989) indicate the presence of South Polish Glaciations clay (Elsterian). Thus, in the overall analysis necessary were comparisons with other fuller sites (eg. at the Radziechowice site; Borówko-Dłużakowa 1981).

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SEDIMENTS AND MORPHOLOGY OF THE CZARNA KONECKA RIVER VALLEY DOWNSTREAM OF STĄPORKÓW

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Study section of the Czarna Konecka river valley is located dowstream of Stąporków on Polish Uplands (Kalicki et. al. 2016). There is the Mesozoic margin of Holy Cross Mountains with Jurassic (Lias) sandstone (Żarnów series) in basement (Jurkiewicz 1968).

Within the valley can be divided high terrace (approx. 7.5 m) composed of sandy channel sediments of braided river (profile Czarna 5). Middle terrace (4.0-4.5 m above the river level) is erosion-accumulative in the east (profile Czarna 2) and accumulative in the west (profile Czarna 3) of study area. It has also been formed by braided river. Lower terrace (approx. 3.5 m) was already shaped by the meandering river. Along the river extend relatively narrow strips floodplain higher (2.0-2.5 m) and lower (0.5-1.0 m). Alluvia these two levels show a clear facial differentiation typical meandering river sediments. Lateral channel migration has created a meandering hill (profile Czarna 3) and a few Holocene cut-fill alluvial bodies. There are numerous subfossil tree trunks in both the channel sediments (profile Czarna 3) and abandoned channel fill (profile Czarna 4 and 1). One of this subfossil tree was ^{14}C dated at 1700±40 BP (MKL 2862) cal. 240-420 AD. It was fallen in the Late Roman period and it has accumulated on the limit between channel deposits and sandy bars in the first stage of abandonem channel filling. The fillings oxbow lakes (profiles Czarna 4 and 1) indicate distinct variation of sedimentation types, referring to changes in the frequency of flooding in the Holocene. One of this type change was ^{14}C dated at 630±60 BP (MKL 2861) cal. 1270-1420 AD when peats were covered with levee deposits (intercalations of sands and silts). It could be connected with a Medieval increase anthropogenic changes of drainage basin and valley floor but also with clustering of catastrophic events during the Little Ice Age. The data collected during Archaeological Map of Poland (Polish Archaeological Record) from the study section are few, only 4 points (traces of settlements) from the Stone Age. Two of them are located on the high terrace. The next two are already on the low terrace, which confirms indirectly probably its Lateglacial age. On this terrace developed Early Medieval and Medieval settlement, which indicates that the area was overflood in this period. However anthropogenic changes could triggered changes of sedimentation type on flood plain. Archaeological data indicate that the settlement entered the valley floor (flood plain) only in modern times.

In last centuries, the valley has been transformed anthropogenically as document cartographic and historical data. This led to theoccurrence of catastrophic event in 20th century, eg. floodafter breakthe dam and accumulation very coarse alluvium with artefacts downstream of drained lake. Present-day, the morphology of the river bed and the valley strongly influences the activity of beavers.

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HUMAN ACTIVITIES IN THE CZARNA KONECKA RIVER VALLEY DOWNSTREAM OF STĄPORKÓW

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The study area includes part of the Czarna Konecka river valley between the Janów and Wąsosz Stara Wieś. It is located within the northern margin of the Holy Cross Mountains, the area of the left bank of the Vistula river basin, 40 km north of Kielce.

Documented traces of human activity date back to the Paleolithic to the present. They are represented by archaeological finds, sedimentological and geomorphological records, cartographic and historical data and visible transformation of the area.

Medieval anthropogenic activities indicated in the geological structure of the floodplain. Found artifacts from past centuries attest to the functioning of the industry within the valley. Archival information documenting the catastrophic event caused by the damage of the dam reservoir. Present-day activities include the development of settlement pattern on the higher terrace, deforestation, hydrological and hydrotechnical changes, and interference with the natural discharge of the river.

"IT HAS ALWAYS BEEN THERE"… OR NOT? THE SCRIVIA RIVER PLANIMETRIC CHANGES DURING THE LAST 150 YEARS (NW ITALY)

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Thinking about the way an alluvial river works in a landscape, it's evident that channels are intrinsically mobile and that we are in front of an highly dynamic system. Anyway due to human activities fluvial forms and processes have often been modified and wonderful ecosystems have become run-down hydraulic pipelines (Sansoni, 1995), producing negative ecologic, geomorphologic and hydraulic effects (Piégay and Rinaldi, 2006).

Nonetheless, people are continuously asking for a traditional kind of river management interventions that aims at locking fluvial dynamics through, for instance, bank protection structures and gravel mining.

Nowadays it's evident that alternative ways must be tested to guarantee an effective and sustainable river management. Therefore a careful analysis of riverbed temporal changes is a prerequisite.

This paper illustrates the changes in Scrivia river floodplain reach (Piedmont, Italy) over the last 150 years and shows its recent evolutionary trend.

The Scrivia river basin spreads over 1000 km^2 and the main channel is about 90 km long. It flows northward from the Ligurian-Piedmontese Appennines, just North of Genova, to the Po river. It's one of the most important right tributaries of the Po river.

The study reach is about 40 km long and represents the whole floodplain reach.

Considering the main morphological features we can recognize three different segments: from headwater to Tortona (about 15 km), from Tortona to Castelnuovo Scrivia (about 10 km) and from Castelnuovo Scrivia to the Po river (about 15 km).

The former presents a very wide multi-thread riverbed, the second is wide and in general single-thread; the latter shows clearly a single channel and a narrow, sinuous and deep-incised riverbed with very low slope.

This work is based on a multitemporal GIS analysisusing the free and open source software Grass GIS and QGIS. The analyses are validated in the field by detailed field surveys.

We started considering six sets of georeferenced maps, aerial photos and ortophotos of different scales and of different years (1878, 1933, 1954, 1988, 2000 and 2012). The first three sets were georeferenced identifying Ground Control Points along both sides of the channel, external to and not too far from it; the other sets come from the National Geoportal WMS.

Subsequently, we manually digitized the river channel, considered as the portion of surface delimited by banks and sparsely covered by vegetation and with sand or gravel sediments,for each time series.

In order to perform a more detailed analysis we identified 10 reaches with homogeneous geomorphologic features.

A consistent GIS procedure was carried out to obtain automatically the channel centerline, the channel width (only from 1954-55) and the size of lateral migration comparing two consecutive periods, both of them referred to the progressive distance from the beginning of the upper reach to the Po river (Clerici et al., 2015).

Overlaying channel layers we also assessed channel variations and migrations between different years at reach scale and we outlined the historical channel shifting belt(Piégay et al., 2005).

Finally a set of 26 reference points were taken along both river banks in order to have a fixed reference system in space and time to refer to the channel changes of different dates (Clerici et al., 2015).

Concerning the channel width, the results show a considerable narrowing in the order of hundreds of meters, with peaks of about 400 meters in the first two segments going downstream, between the 1950s and the beginning of the 21st century, followed by a reversal trend noticed in 2012. The last segment was stable.

This temporal trend confirms the general tendency registered for several Italian water courses (Surian et al., 2009). This narrowing phase can mainly be related to agricultural activity, buildings and infrastructures that in the last fifty years got closer and closer to river banks, that are strictly fixed due to the construction of bank protection structures.

Channel migration from the first to the seventh reach shows few local shifts of the order of hundreds of meters that were noticed in particular between the 1930s and the 1950s; thereafter the migration is mainly related to the aforementioned general narrowing condition.

On the contrary considerable channel movements happened downstream Castelnuovo Scrivia, till the Po river. Here the most relevant shifts (some hundreds of meters) both eastward and westward are noticed till 1954. The highest values are registered from 1878 to 1933 in the last downstream reach, where the Scrivia-Po confluence shifted northeastward with a kilometric migration. From 1954 to 1988 there were minor shifts largely related to meander cutoffs; hereafter the riverbed was quite stable, underlining the role of bank protection structures in the last decades.

The analysis outlines the Scrivia river planimetric evolution during the last 150 years showing clearly the ancient river channels and their positions.

From maps it’s evident that “the river has not always been there” as people say asking for new defense structures and interventions; a great work of raising awareness about rivers is the first step to improve the relationship between rivers and citizens.

Nowadays a diffuse bank instability is registered along the whole Scrivia river floodplain reach and the river is enlarging in its historical shifting belt.

In the upper and middle segments we noticed relevant lateral erosion processes, mainly where there are no bank protection structures. In the lower segment the recurring collapse of lateral defenses indicates general vertical incision process followed by progressive lateral erosion.

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TECTONIC CONTROLS ON FLUVIAL LANDSCAPE DEVELOPMENT IN CENTRAL-EASTERN PORTUGAL: INSIGHTS FROM LONG PROFILE TRIBUTARY STREAM ANALYSES

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This study examines the long profiles of tributaries of the Tejo (Tagus) and Zêzere rivers in central eastern Portugal (West Iberia) in order to provide new insights into the patterns, timing and controls on drainage development during the Pleistocene to Holocene incision stage.

The long profiles were extracted from lower order tributary streams associated with the trunk drainage of the Tejo River and one main tributary, the Zêzere River (Fig. 1).These streams flow through a landscape strongly influenced by variations in bedrock lithology (mainly granites and metasediments), fault structures delimiting crustal blocks with distinct uplift rates, and a base-level lowering history (tectonic uplift / eustatic).

The long profiles of thetributaries of the Tejo and Zêzere rivers record a series of transient and permanent knickpoints. The permanent knickpoints have direct correlation with the bedrock strength, corresponding to the outcropping of very hard quartzites or to the transition from softer (slates/metagreywaques) to harder (granite) basement.

The analyzed streams/rivers record also an older transient knickpoint/knickzone separating: a) an upstream relict graded profile, with lower steepness and higher concavity, that reflects a long period of quasi-equilibrium conditions reached after the beginning of the incision stage; and b) a downstream reach displaying a rejuvenated long profile, with steeper gradient and lower concavity, particularly for the final segment, which is often convex (Fig. 2).

The rejuvenated reaches testify the upstream propagation of several incision waves that are the response of each stream to continuous or increasing crustal uplift and dominant periods of base-level lowering by the trunk drainages, coeval of low sea level conditions.

The long profiles and their morphological configurations enabled spatial and relative temporal patterns of incision to be quantified for each individual tributary stream. The incision values of streams flowing in uplifted blocks of the Portuguese Central Range (PCR) (ca.380-280 m) indicate differential uplift and are higher than the incision values of streams flowing on the adjacent South Portugal planation surface – the *Meseta*(ca. 200 m).

The normalized steepnessindex,calculated using the method of Wobus et al. (2006), proved to be sensitive to active tectonics, as lower k_{sn} values were found in relict graded profiles of streams located in less uplifted blocks, (e.g. Sertãstream in the PCR), or in those flowing through tectonic depressions.

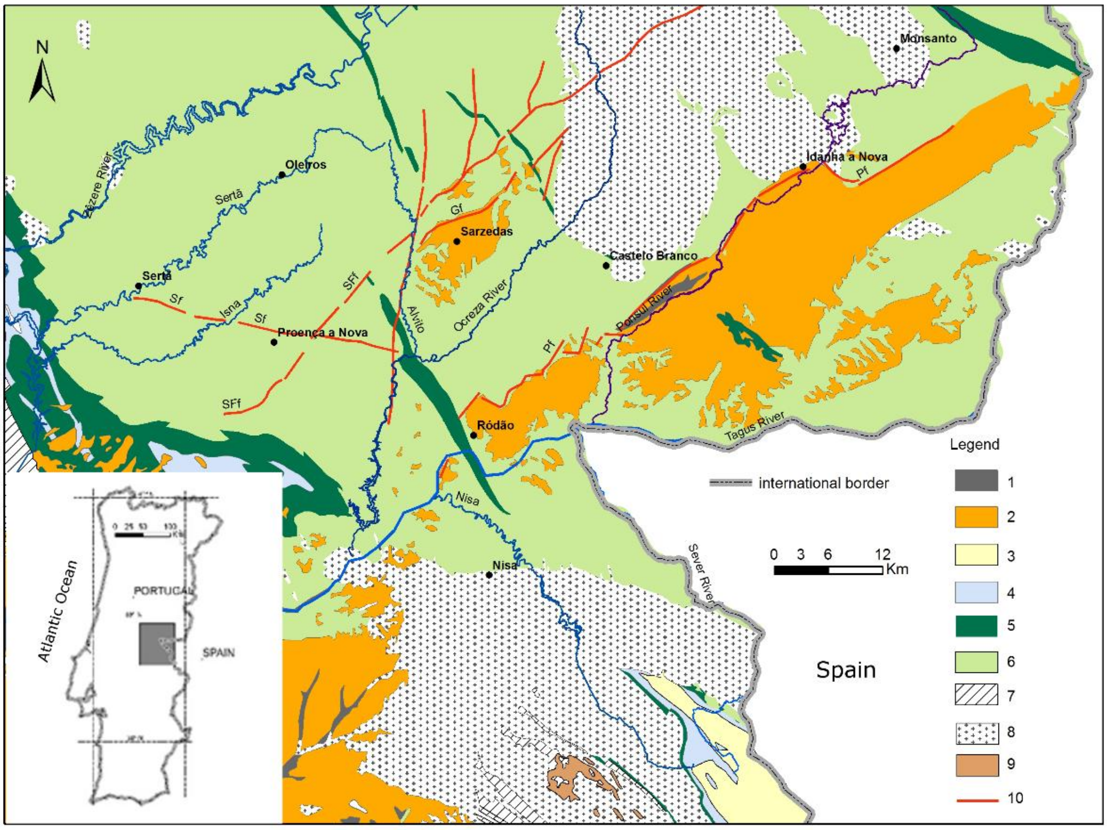

Fig. 1 Geological map of the study area. 1 – fluvial terraces (Pleistocene); 2 – sedimentary cover (Paleogene and Neogene); 3 – slates and metasandstones (Devonian); 4 – slates and quartzites (Silurian); 5 – quartzites (Ordovician); 6 – slates and metagreywackes (Precambrian to Cambrian); 7 – slates, metagreywackes and limestones (Precambrian); 8– granites and ortogneisses; 9 – diorites and gabros; 10 - fault. SFf – Sobreira Formosa fault; Sf – Sertã fault; Pf – Ponsul fault; Gf – Grade fault.

The differential uplift indicated by the distribution of the k_{sn} values and by the fluvial incision was likely accumulated on a few major faults, as the Sobreira Formosa fault (SFf), thus corroborating the tectonic activity of these faults.

Due to the fact that the relict graded profiles can be correlated with other geomorphic referencesdocumented in the study area, namely the T1 terrace of the Tagus River (with an age of ca. 1 Myr), the following incision rates can be estimated: a) for the studied streams located in uplifted blocks of the PCR, 0.38 m/kyr to 0.28 m/kyr; b) for the streams flowing on the South Portugal planation surface, 0.20 m/kyr.

The differential uplift inferred between crustal blocks in the study area corroborates the neotectonic activity of the bordering faults, which has been proposed in previous studies based upon less robust data.

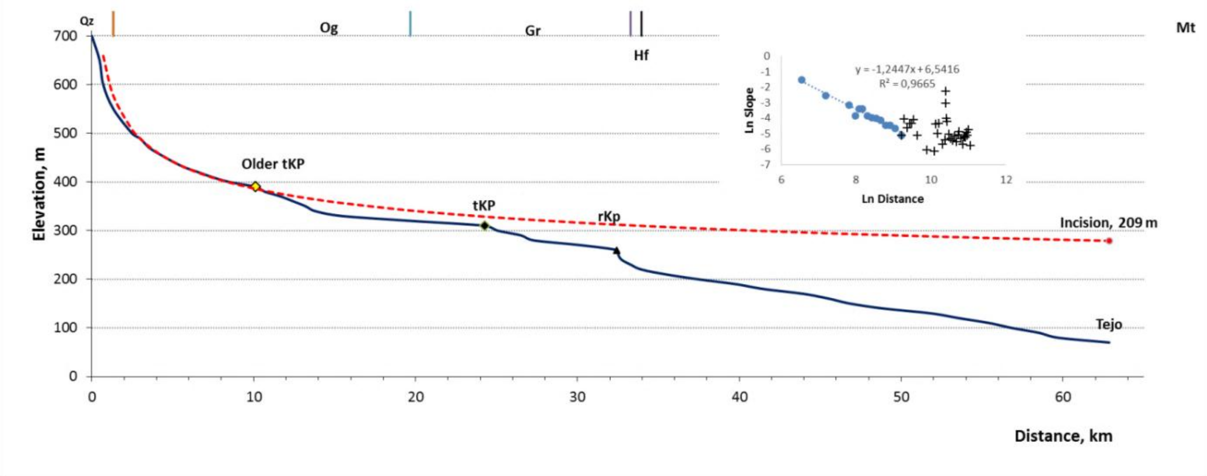

Fig. 2 Longitudinal profile of the Nisa stream a tributary of the Tejo River. Note the equilibrium relict profile upstream the older transient knickpoint (hatched line) and the downstream rejuvenated profile (continuous line). Legend: tKP – transient knickpoint;rKp – resistant knickpoint; Mt – schist and phyllite; Gr – granite; Hf – hornfels; Og – orthogneisse. In the inset Distance – Slope plots, fill circles correspond to the relict graded profile, crosses correspond to the rejuvenated profile located downstream the older transient knickpoint (tKP).

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RELIEF AND GEOLOGICAL STRUCTURE OF NIDA RIVER VALLEY NEAR WIŚLICA (POLISH UPLANDS)

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Wiślica is located in southern part of Nida Basin (Polish Uplands) in the Nida river valley, tributary of upper Vistula river. Due to the geomorphological regionalization this area belongs to Wiślica Funnel, depression located between two elevations Wodzisław Hummock and Pińczów Hummock (Gilewska 1972). It is a tectonic Solec trough, where the Cretaceous marls are covered with Miocene (Tortonian) rocks. In relief, the most important is the role of gypsum folded anticline and syncline in the course of the NW-SE. Karstic phenomena developed on gypsum. On the anticline lines were formed inversion karst basins occupied by swamps and bogs lying directly on the Cretaceous marls. On the syncline lines formed sink holes, dry karst valleys (eg. Skorocice) etc. (Flis 1954). Active karst phenomena also led to the changes of direction of hydrographic pattern. A number of geological and geomorphologic data indicates the existence young subsidence movements in the area of Wiślica Funnel (Gilewska 1972).

According to the data from Archaeological Map of Poland both slopes of the valley was densely settled in the Neolithic (Malęga et al. 2016a, b). However only a single Neolithic sites occur on the floodplain (4 sites) and on the border between the plain and upper terrace (3 sites). There were mainly settled gypsum domes which. constituted a favorable environment for settlement. Gypsum hill at Wiślica was settled since Neolithic. Later on one of these domes, directly at Wiślica, at the turn of 9th and 10th century A.D. was located a small fortified settlement, and in the 11th c. stronghold.

Within the flat valley floor in the cross-section is constructed fragment of the alluvial deposits and the passage referring to the karst processes.

Within the karst depression are organic sediments indicating organic sediments bottom. Not found within it no trace of the flow of the river. Probably there were lakes, due to the presence malacofauna. Now there is here with bog ponds.

In the segment fluvial are probably unevenly aged insert what could indicate several generations oxbow lakes preserved in morphology. Sediments is a simple sequence (Crushing deposits upwards), which may indicate the development of winding trough of Nida, at least in the last period of the evolution. At an earlier stage it was most likely to develop anastomosis, as evidenced by preserved on the floodplain oxbow lakes. The presence of fossil soil profile BD3 indicates phase shift rise madow cover.

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ALLUVIAL FANS: THEIR VALUE AS QUATERNARY FLUVIAL ARCHIVES

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The fluvial archive literature is dominated by research on river terraces with appropriate mention of adjacent environments such as lakes, yet despite comprising a significant (>88%) part of modern sedimentary basins, distributive fluvial systems, of which alluvial fans (>1km, <30km in scale) are a significant part, are neglected and tend to be discussed in separate literature.

Here we will examine the dynamic role of alluvial fans within the fluvial landscape and their interaction with river systems, highlighting the potential value of alluvial fans to the wider fluvial archive community. We will examine both thematic and geographical based benefits of alluvial fan research that can assist understanding of Quaternary fluvial archives. We will use field case studies that illustrate the interaction between alluvial fan and river terrace archives at Quaternary time-scales at different stages of landscape evolution. These are i) continuous mountain front fans interacting with a non incising but laterally eroding axial fluvial system; ii) fans which transition into fluvial terraces as sedimentary basins shift from net aggradation to net incision and iii) tributary-junction fans that develop predominantly within incising river valley systems.

We propose a simple conceptual model to summarise the dynamic role of alluvial fans within the Quaternary landscape context. The fans act as potential ‘buffers’ between hillslopes and river terrace records under ‘top down’ climate-driven high sediment supply and fan aggradation, and ‘couplers’ during periods of less sediment (in relation to water) discharge and fan incision. These dynamics will change with the addition of ‘bottom up’ controls such as main river incision, which will typically enhance the coupling effect of both systems.

DEVELOPMENT OF SAND-BEDDED MEANDERING RIVERS IN GLACIATED SOUTHERN ONTARIO

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Many studies of river floodplain sedimentology demonstrate their complexity and the need to simplify observations in the form of standard floodplain models. A field investigation was undertaken to test the applicability of the accepted sand-bedded river facies model developed by Miall (2010) to sand-bed rivers in southern Ontario. A challenge in southern Ontario is the influence of non-alluvial channel boundary materials such as glacial outwash sands, till, and glaciolacustrine clay (Fig. 1). The presence of these materials in some channel beds and banks, and entrenchment as these rivers approach the Lake Erie base level, suggest that these rivers are not in equilibrium and that recognized "models" may not always be appropriate at predicting channel behaviour (Thayer et al., 2016). Using data acquired from cross-sectional surveys, floodplain sampling and GPR, three primary floodplain subtypes are defined by the theories of channel pattern discrimination based on erosional and depositional processes, material types, and sinuosity-slope. To evaluate the effect glaciation has had on river channel morphology and lateral migration, slope-area analysis and constant stream power curves (with a power-law exponent of -0.4) are used to discriminate between glacially conditioned river reaches and expected planform morphologies.

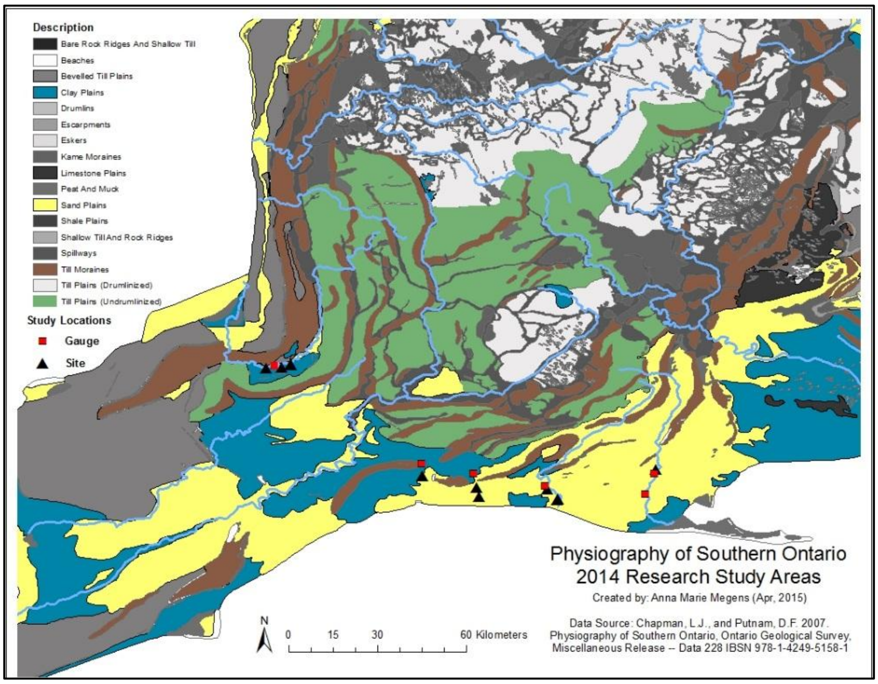

Fig. 1 Physiography and drainage network of southern Ontario, emphasizing sand plains, clay plains, till plains and till moraines relevant to the study area. Black triangles are study reaches. Data source: Chapman and Putnam (2007, digital release date).

An analysis of specific stream power versus drainage area demonstrates that 6 of the 9 studied reaches fit within the theoretical domain for meandering river floodplains (10-60 W m^{-2}). For the most part, meandering sand-bed rivers in southern Ontario reflect laterally stable river planforms, as defined by Nanson and Croake (1992). These rivers represent the medium energy, middle watershed floodplain subtype. Lower watershed, low-energy floodplains (< 5 W m^{-2}), also demonstrate laterally stable floodplains. Lateral instability is confined to upper-watershed, higher energy meandering river reaches (28 - 37 W m^{-2}), and relate to the semi-alluvial character of their channel boundaries.Upper-watershed river reaches are characterized by a hardpan silt-clay underlying ~1.5 m of gravel and vertically accreted alluvial sands accreting most recently at a rate of 6 mm a^{-1} (Fig. 2). These floodplains are dominated by abandoned channel accretion and vertical accretion radar facies (Fig. 3). Unique to this floodplain type, in the upper-watershed, are hyperbolic diffractions underlying abandoned channels and vertically accreted sediments. The elevation difference between the alluvial sedimentation zone and the water level (1.3 m) suggest that the river has incised into a material of glaciofluvial origin.

It has been observed that the physiographic regions defined by Chapman and Putnam (2007) have a complex effect on the river channel slope and specific stream power, sediment supply, style and rate of vertical and lateral accretion. Moreover, it has been observed that no single river, no matter what size, may pass through several physiographic regions affecting the processes and mechanisms of floodplain development at the reach scale. It is therefore proposed that several fluvial process domains exist in peninsular southern Ontario, which may explain why some river reaches conform to the expected meandering river facies model proposed by Miall (2010) and why others do not.

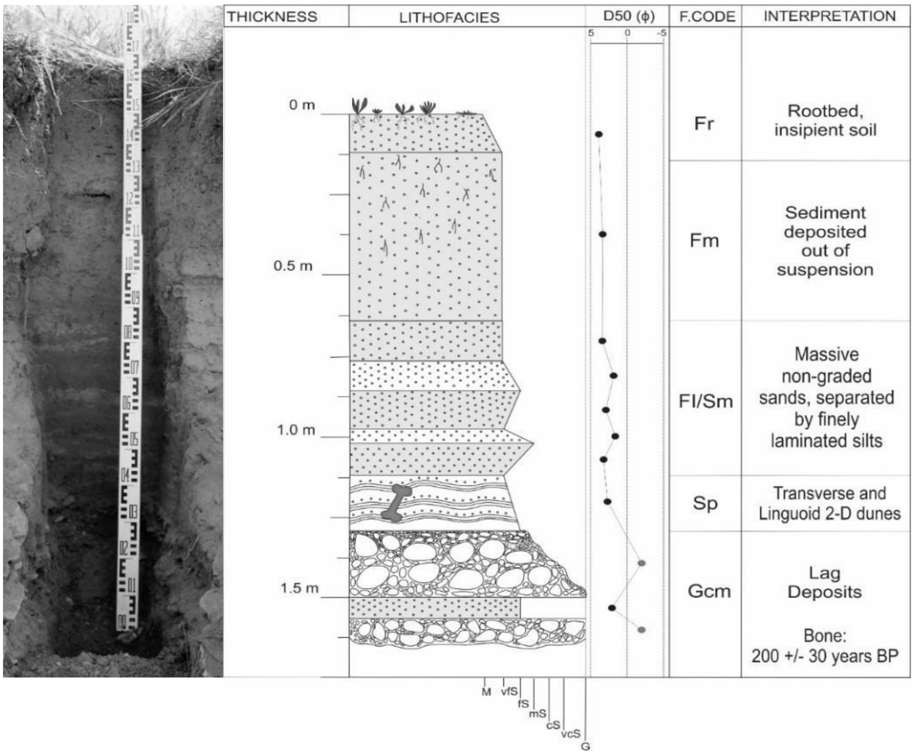

Fig. 2 Kettle Creek site 401 Sedlog, located near St. Thomas, ON; sediment collected upstream from the point-bar meander apex. The D_{50} markers indicated in red are those that required stitching of % vol and % mass grain-size measurements.

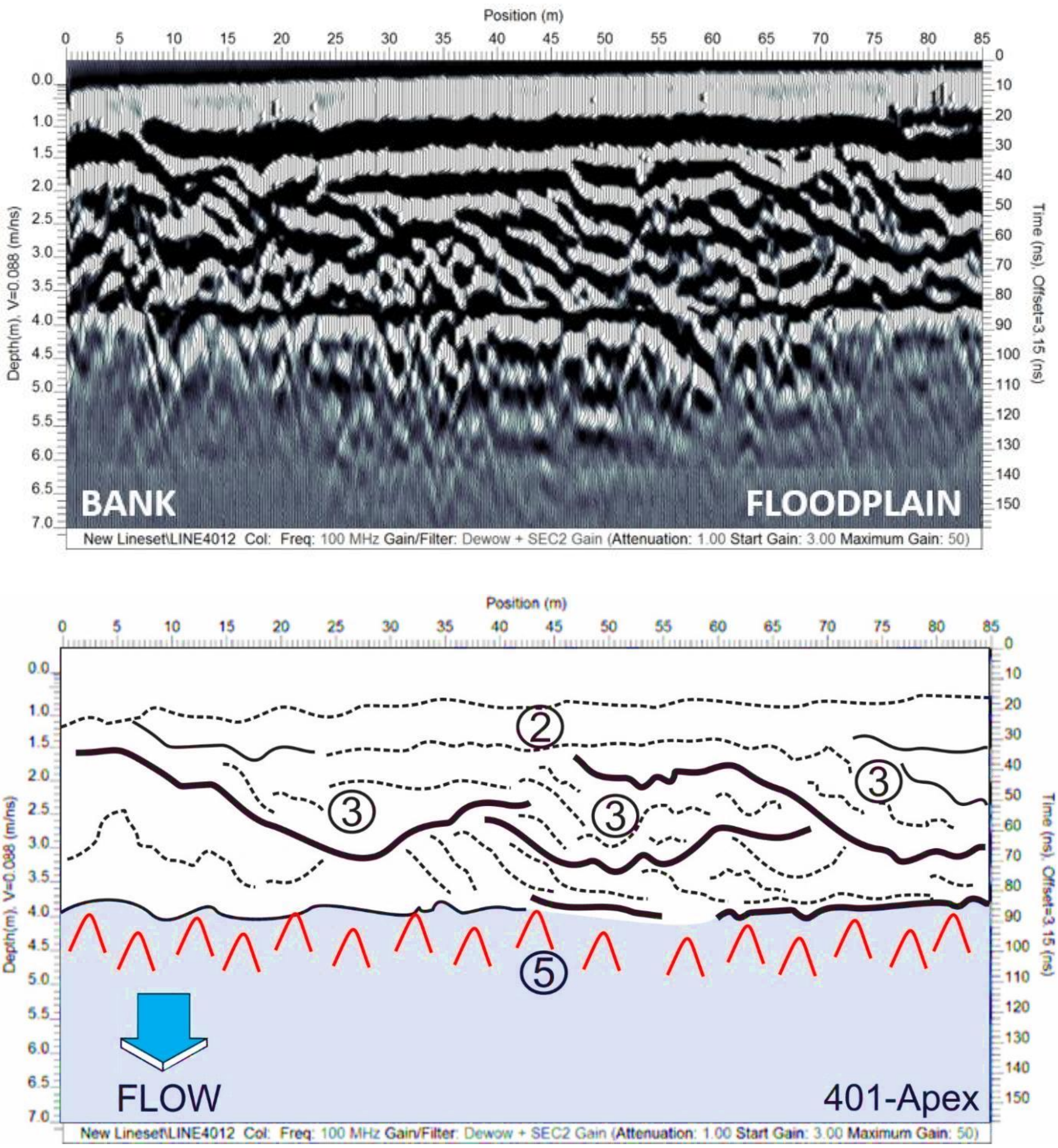

Fig. 3 Raw and interpreted GPR reflection survey collected at Kettle Creek site 401 near St. Thomas, ON. This profile was conducted perpendicular to flow at the apex of the meander bend. Unit 2 and 3 are vertically accreted and abandonded channel accretion deposits, repectively. Unit 5 is a coarse-grained till below the alluvial facies.

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GEOARCHAEOLOGICAL RECORDS OF HUMAN ACTIVITY REFLECTED IN FLUVIAL AND COLLUVIAL SEDIMENTS IN THE ANTHEMOUS VALLEY (GREECE)

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The paper concerns the results of geoarchaeological studies conducted under the Anthemous Valley Archaeological Project (Andreou et al. 2016) in Central Macedonia (Northern Greece).

The study area embraces the Anthemous river valley, located eastwards of Thessaloniki City, with the estuary in the Thermaikos Gulf. The valley has a flat bottom and asymmetrical slopes as a result of the geological structure and tectonic processes, very active in this region.

In archaeological terms, the area was settled already in the Middle Neolithic (5800/5600 BC). The intensity of habitation, sizes and types of sites are outstanding in comparison with the adjacent areas (especially during the Neolithic and the Bronze Age - Fig. 1).

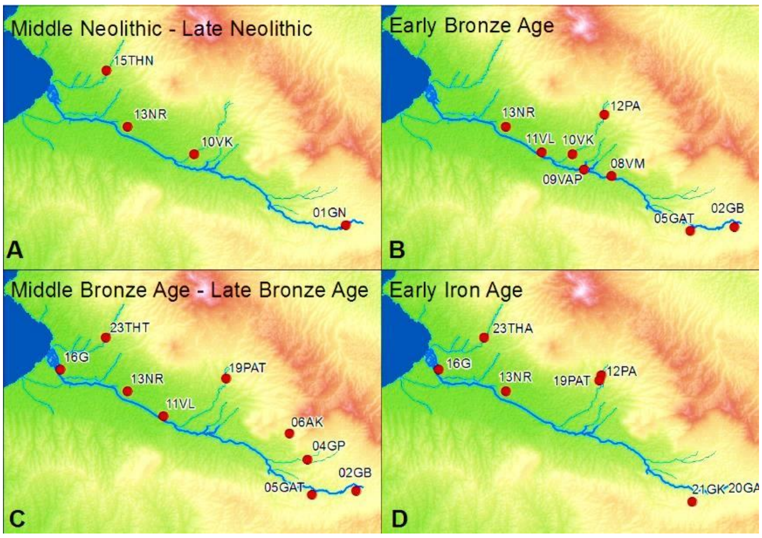

Fig. 1. Archaeological sites in the Anthemous Valley

Presently the Valley is occupied by agriculture and serves as a vegetable garden for Thessaloniki. The river channel is strengthened with concrete structures, with occasional water flows during precipitation periods.

The geoarchaeological surveys conducted since 2013 reveal highly diversified conditions obtaining in the Valley in the past. The situation is similar in the adjacent Thessaloniki Plain, which contains a record of many landscape changes in Northern Greece (cf. e.g. Ghilardi et al. 2008). Years of research have brought evidence of a high transformation rate of the Plain during the Holocene, from marine environments thorough glacioisostasy to limnic ones contributed by the Axios (Vardar) and Aliakmon rivers, to fluvial and finally, in the 20th century, to terrestrial conditions. The most prominent example is Pella - a former capital of the Macedonian Empire that during its time of greatness served as a sea port and presently lies well inland, app. 40 km from the coastline (Syrides et al. 2009). Such observations and perspectives motivated us to investigate the Anthemous Valley located on the opposite side of the Thermaikos Gulf.

The research in this area is conducted by a Polish-Greek team from Adam Mickiewicz University in Poznań and Aristotle University in Thessaloniki. The project has an interdisciplinary character and focuses on geoarchaeological investigation and prehistoric settlement in terms of palaeogeographical data. A general insight about the diversity of the sedimentary environments in the past, such as dynamic hydrological conditions or colluvial processes, was obtained as a result of hand drilling, geomorphological surveys and river profile documentation (Niebieszczański 2015). Special emphasis was placed on environmental and geomorphological changes around the tell site of Toumba Nea Raedestos, which is located in the bottom part of the lower basin of the Valley. This tell site was inhabited during a large part of the Neolithic (5800/5600 - 3300/3100 BC; Andreou et al. 2001:260) and the Bronze Age (3300/3100 - 1100 BC; Andreou et al. 2001:260) with a hiatus of the Late Neolithic in between and in further periods (including the Roman times).

In 2015 a geoarchaeological research began with the use of electrical resistivity tomography, taking cores with undisturbed sediment stratigraphy, laboratory analyses of samples, and archaeological and environmental dating methods including AMS ^{14}C. It was also possible to obtain palaeoenvironmental data extremely rare in the conditions of Northern Greece - a pollen profile reflecting the history of vegetation in the proximity of the Early Bronze Age site.

The research resulted in documenting a high diversity of landscape changes, especially considering water conditions around the tell in the past. Also recorded were sedimentological features related to stable water conditions in a small water body, river channels, as well as terrestrial (natural and anthropogenic) environments, including post-depositional processes (colluvial sediments) at the archaeological site (Fig. 2). Moreover, some evidence of tectonic processes was found in the form of a vertical displacement of layers related to antithetic faulting parallel to the main Anthemous Fault in the study area (Mountrakis et al. 2005).

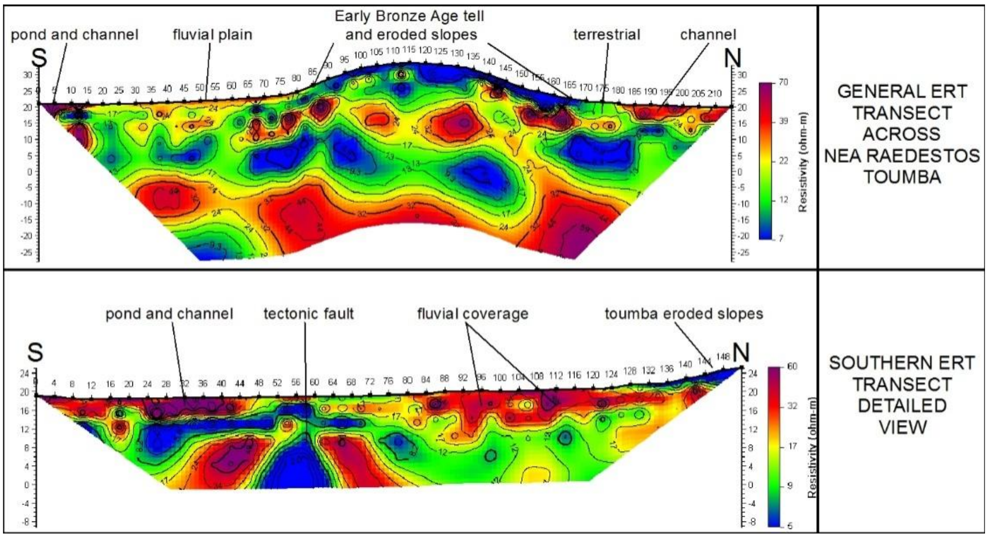

Fig. 2. Electrical resistivity tomography profiles in the Toumba Nea Raedestos area

Most of the presented processes and palaeoenvironmental features were set on a time scale thanks to a series of radiocarbon dating derived from both, eco- and artifacts. Moreover, several archaeological finds, such as sherds or stone tools, allowed relative dating of the deposition time.

To conclude, the paper seeks to present the effects of geoarchaeological investigations in the Anthemous Valley with special emphasis on micro-scale research in the area of Toumba Nea Raedestos and the results of environmental changes in relation to human occupation.

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FLUVIAL ARCHIVES WITHIN TECTONICALLY ACTIVE REGIONS DURING THE QUATERNARY, DUNAJEC BASIN, PODHALE, SOUTHERN POLAND

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Geomorphological studies and numerical dating of alluvial sediments were carried out in the northern part of the Carpathian orogen, in the uppermost reaches of the Dunajec basin, typified by the presence of laterally and vertically stacked alluvial deposits that form river terraces. Both uplifting tectonics and subsidence have influenced the modern landscape of the Dunajec basin. In the subsiding area of the intramontane Orawa-Nowy Targ Depression, river valleys are wide with a thick series of alluvial sediments deposited in alluvial fans and low river terraces. Along the uplifting sections of river courses, valleys are narrow and alluvial sediments are commonly preserved in several river terraces in a staircase system. The sediments usually consist of massive gravel with sand. Locally, these gravelly deposits are intercalated by thin layers of fine deposits occasionally enriched by organic matter.

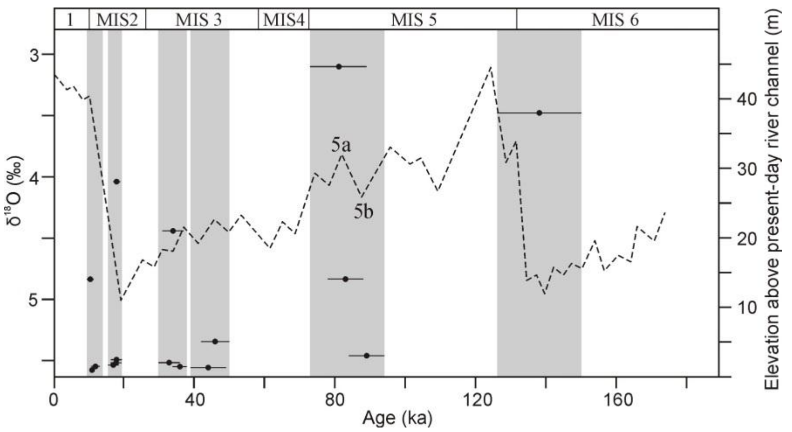

Fig. 1. Distribution of the luminescence ages (OSL and post-IR OSL). Each date is shown along with its uncertainty bar. Alluviation phases are shaded.

Age constraints of the alluvial sediments indicate several deposition episodes under various climate conditions. To date, we have documented six such episodes during the Late Pleistocene (Fig. 1), and another few during the Holocene (the latter are not presented herein). The Late Pleistocene alluvial sediments were deposited by gravelly river systems under both temperate and cold climate conditions. We documented three episodes of deposition of those sediments during temperate conditions and three episodes of deposition under cold climate conditions. Alluvial deposition (aggradation) during cold stages of the Pleistocene has been commonly accepted worldwide, whereas alluviation during temperate stages is increasingly recognized (e.g. Wagner et al., 2011; Stange et al., 2013). We have found, in the Białka Tatrzańska River valley, two episodes of aggradation during the last cold stage (MIS2) separated by river incision that led to the formation of two distinct river terraces. Our results indicate that the timing of alluviation at the foot of the Tatra Mountains needs to be reordered because the sediments had not in fact been deposited exclusively during glaciations as it was previously assumed (e.g. Watycha, 1976, 1977; Baumgart-Kotarba, 1983). Evolution of the fluvial system and terrace formation in the Carpathians were recently found to be more complex than the scenario one climate cycle=one terrace (Olszak, 2011; Olszak and Adamiec, 2016). Thus, the present results support those findings and challenge such increasingly out-of-date model of river terrace formation. Vertical and spatial distribution of the obtained ages imply diversified rates of river incision. This may be seen as a proxy of active uplifting in the region, outside of the Orawa-Nowy Targ Depression, where tectonic movements have been suggested along some tectonic faults (e.g. Baumgart-Kotarba, 1978; Pomianowski, 2003). That faulting most likely disturbed the hypsometric relationships between alluvial sediments, however, no evidence for fault-related vertical displacement of those sediments has been hitherto presented.

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SUBATLANTIC NATURAL ANDHISTORICAL CHANGESOF THEKAMIONKA CATCHMENT (SUCHEDNIÓW PLATAU)

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Kamionka catchment is located in the northern part of the Świętokrzyskie province (eastern Poland). This area is located on the Suchedniów Plateau, built from the Lower Triassic formations (sandstone). Valleys are filled with the Pleistocene fluvioglacial sediments (Oder glaciation), which is cut by Kamionka river. This area is situated in the historical Old Polish Industrial District. For this reason, this area has a rich history based on mining, smelting industries and processing of iron ore. Further industrial development of this region has led to significant changes in the morphology. Kamionkariver is a good example to show changes in sediments and morfology associated with human activitiesduring the Subatlantic. Similar studies have been conducted on many rivers in Central Europe (e.g. Kalicki 2006, Krupa 2013).

Rich deposits of iron ore contributed to the development of mining and following the iron industry in the Suchedniów area. Well-preserved changes in the morphology and in the fluvial sediments, which postindustrial traces (slags, charcoals) shows this very well.The Kamionka catchment adjacent to the terrains where in Roman ages was developed prehistoric metallurgy. The first historical references about the activities of the forges in Suchedniów, are from the Middle Ages (Piasta 2012). In those ages comes to the first anthropogenic transformation of the river. Those actions starts changes in water circulation in Kamionka drainage basin. Changes in this area have become better recognized through historical materials from the period of the nineteenth century by the old maps, documents and photographs. These materials allowed for accourate analysis of the changes made by the mining activity and industrial development. Many rivers of this region, also Kamionka was used as a source of energy for many blacksmith shop, workshops and even water mills (Kłusakiewicz et al. 2016). This is evidenced by the many traces left by establishments operating on the river bank (water reservoirs, raceway shafts). These traces have been confirmed by an extensive collection of photographs and maps from last centuries. This allowed to create a database, that show changes on the river, just like evolution of reservoirs, ponds and the riverbed itself. The information contained in them, explain many processes taking in Kamionka river. Those materials also allow to identify the causes, leading to specific changes of riverbed and anthropogenic forms created over the years. In the late nineteenth and early twentieth century, the forges were abandoned and were built watermills in their places, which used the existing infrastructure. This contributed to the behavior of many anthropogenic forms on the river. The twentieth century begins the development of the Central Industrial District. Become built and modernized the larger factories. There has become a large changes in morfology, which led to the disappearance of small streams and ponds (Piasta 2012, Przepióra et al. 2016). Regulation of the riverbed resulted in changing of the various parts of the river which had an impact on the type and size of the transported material (Przepióra et al.2016). Adjusting the riverbed and construction of large water reservoirs on the Kamionka, it has led to the emergence of catastrophic, anthropogenic floods. After rainfall and breaking the shaft of Suchedniów lake in 1974, flood wave was higher and stronger (Piasta 2012). The disappearance of the industry in the region has led to the renaturalisation of some parts of the river especially in the middle section of the Kamionka valley (Przepióra et al. 2013).

The twentieth century definitively ended activity of the forges but increasing level of urbanization, change many terrain forms. Currently, Kamionka is mainly regulated, but the disappearance of forges and later factories has contributed to changes in the water cycle of the river once more.

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EVOLUTION OF THE ALLUVIAL FANS OF THE LUO RIVER IN THE WEIHE BASIN, CENTRAL CHINA, CONTROLLED BY FAULTING AND CLIMATE CHANGE - A REEVALUATION OF THE PALEOGEOGRAPHICAL SETTING OF DALI MAN SITE

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The "Luyang Wetland" core is an important archive of climate change over the past 1 My in the northern part of the Weihe Basin. This paper analyzes the contribution of the Luo River to the sedimentary record. It is demonstrated that an alluvial fan of the Luo River contributed to the sedimentary archive until approximately 200-250 Ka. From this moment, the fan got incised and terraces were formed. A new alluvial fan was constructed further downstream, resulting in the disconnection of the Luo River from the "Luyang Wetland" core site.

The cause for these changes is the displacement of an intra-basinal fault. The faulting also resulted in folding structures (by faulting-forced folding), which caused increased relative subsidence, and thus increased sedimentation rates at the core site. Therefore, a complete sediment record in the "Luyang Wetland" was preserved, despite the disconnection from the Luo River.

A chronology of the fans and terraces was established using existing age control and additional U-series dating of mammal fossils and shells, and by correlation of the loess-palaeosol cover to marine isotope stages. The chronology shows that the main incision phases correspond to interglacial to glacial transitions.

Due to the incision, basal old parts of the oldest Luo River alluvial fan are exposed. One of these locations is the findspot of the famous Dali man. This study shows that the Dali man did not live on a river terrace as previously thought, but on an aggrading alluvial fan. He lived there during wet, glacial conditions.

CONTRASTED TERRACE SYSTEMS OF THE LOWER MOULOUYA VALLEY AS INDICATOR OF CRUSTAL DEFORMATION IN NE MOROCCO

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The Moulouya river has the largest catchment in Morocco and drains an area which is characterized by active crustal deformation during the Late Cenozoic due to the convergence between the African and Eurasian plates. As yet, its Pleistocene terrace sequence remains poorly documented. Our study focuses on the lowermost reach of the river in NE Morocco, which drains the Triffa sedimentary basin directly upstream of the estuary. New field observations, measurements and sedimentological data reveal contrasted fluvial environments on either side of a newly identified thrust zone, which disrupts the whole sedimentary basin and is associated with N–S compressive shortening in this region (Barcos et al., 2014). Long-lasting fluvial aggradation, materialized by ≥37 m-thick stacked fill terraces, and the development of a well-preserved terrace staircase, with (at least) three Pleistocene terrace levels, occur in the footwall and the hanging wall of the thrust, respectively. Same as for the Pleistocene terrace sediments of the middle Moulouya, a recurrent sedimentary pattern, characterized by fining-upward sequences was observed in the studied terrace profiles.

Assessing the rates of crustal deformation along this main thrust zone requires age estimations for these Pleistocene terrace deposits of the lower Moulouya on each side of the thrust. Samples for luminescence (OSL/IRSL), electron spin resonance (ESR, on quartz) and cosmogenic nuclide dating (^{26}Al/^{10}Be, burial dating) were collected in terrace deposits located both in the foot- and hanging walls. Sample preparation and analysis as well as age determination are in progress but preliminary ESR ages suggest deposition times during the Early Pleistocene.

The data mentioned above, soon integrated within a reliable chronological framework, agree well with morphometric indicators stating that the whole Moulouya catchment is at disequilibrium state (Barcos et al., 2014). This is confirmed by several knickpoints in its longitudinal profile. Late Cenozoic uplift associated with crustal shortening, which occurred in the lowermost reach of the river, may have both hindered profile rectification of the Moulouya and, at the same time, buffered the effects of long-term base-level changes due to eustatic sea-level variations.

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POTENTIALS AND PITFALLS OF DEPTH PROFILE (^{10}BE), BURIAL ISOCHRON (^{26}AL/^{10}BE) AND PALAEOMAGNTIC TECHNIQUES FOR DATING EARLY PLEISTOCENE TERRACE DEPOSITS OF THE MOSELLE VALLEY (GERMANY)

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Throughout the river network of the Rhenish Massif the so-called main terraces complex (MTC) forms the morphological transition between a wide upper palaeovalley and a deeply incised lower valley. The youngest level of this complex (YMT), directly located at the edge of the incised valley, represents a dominant geomorphic feature; it is often used as a reference level to identify the beginning of the main middle Pleistocene incision episode (Demoulin & Hallot, 2009). Although the main terraces are particularly well preserved in the lower Moselle valley, a questionable age of ca. 800 ka is assumed for the YMT, mainly based on the uncertain extrapolation of controversially interpreted palaeomagnetic data obtained in the Rhine valley.

In this study, we applied terrestrial cosmogenic nuclide (TCN) dating (^{10}Be/^{26}Al) and palaeomagnetic dating to Moselle fluvial sediments of the MTC. To unravel the spatio-temporal characteristics of the Pleistocene evolution of the valley, several sites along the lower Moselle were sampled following two distinct TCN dating strategies: depth profiles where the original terrace (palaeo-) surface is well preserved and did not experience a major post-depositional burial (e.g., loess cover); and the isochron technique,where the sediment thickness exceeds 4.5-5 m. One terrace deposit was sampled for both approaches (reference site). In addition, palaeomagnetic sampling was systematically performed in each terrace sampled for TCN measurements. The TCN dating techniques show contrasting results for our reference site. Three main issues are observed for the depth profile method: (i) an inability of the modeled profile to constrain the ^{10}Be concentration of the uppermost sample; (ii) an overestimated density value as model output; and (iii) a probable concentration steady state of the terrace deposits. By contrast, the isochron method yields a burial age estimate of 1.26 +0.29/-0.25 Ma, although one sample showed a depleted ^{26}Al/^{10}Be ratio, presumably related to a former burial episode. Moreover, a reverse-to-normal polarity change was recorded in the same terrace level. Given the burial age, it corresponds to the boundary between the reverse Matuyama chron and one of two normal subchrons in the 1.55-1.0 Ma time span, i.e., either Cobb Mountain (MIS 38) or Jaramillo (MIS 31). These results demonstrate the usefulness of cross-checking age information from independent methods, and also suggest that the MTC in the Moselle valley might be older than in the Rhine valley. This might imply a reexamination of the chronological framework of the terrace staircase in the main trunk.

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FLUVIAL TERRACES IN THE TOBALINA VALLEY, EBRO BASIN (N SPAIN)

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The Ebro catchment (north Spain) is the largest drainage system in the Iberian Peninsula. The catchment is divided into two geological units: The Upper Ebro Basin (UEB) and the Ebro Foreland Basin (EFB). The River Ebro terrace sequence has been defined across the UEB, but there is poor chronological control over it (Glez-Amuchástegui and Serrano, 1996, 2005; Gutiérrez and Serrano, 1998; Cano Flors, 2004; Soria-Jáuregui, 2013; Perucha *et al.*, 2015).

Situated on the UEB, the Tobalina valley is placed within the Villarcayo syncline and is surrounded by the Lahoz anticline (north) and the Obarenes thrust (south). These edges are made up of Cretaceous limestones and marls, whereas the Villarcayo syncline is composed of Tertiary conglomerates and sandstones. Glacis, fluvial tufas and fluvial terraces are preserved on top of the Tertiary bedrock (Glez-Amuchástegui and Serrano, 1996).

This investigation re-visits the Tobalina valley and focuses on fluvial terraces (Glez-Amuchástegui and Serrano, 1996). We use aerial photographs, geological maps and a recently available 5-m DEM to broadly identify these terraces. This information was later refined during fieldwork. Radiocarbon dating, Optically Stimulated Luminescence, and Uranium series were applied to obtain chronological information on fluvial deposits. Geomorphological, sedimentological, and chronological preliminary results demonstrate that the River Ebro terrace sequence in the Tobalina Valley is composed of seven terrace levels (T_1-T_7 from highest to lowest), ranging from 81 to 8-5 m above the modern channel. These features are evenly distributed across the study area but lower levels are more common than higher ones. There is a clear sedimentological difference between T_7 and the rest of terrace levels. Alluvium below T_7 is composed of fine-grained silts and sands, whereas higher levels are made up of coarse-grained sands and gravels, possibly indicating a change in sediment supply. Available chronology indicates that terrace T_2 dates back to MIS 6 and terrace level T_4 formed during MIS 4. Our main purpose is to present the last results of a multi-approach ongoing investigation that aspires to decipher the factor(s) governing Quaternary fluvial evolution in the UEB.

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ALLUVIAL FANS AND RIVER TERRACES AS RECORDERS OF VOLCANIC ISLAND DENUDATION

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Volcanic islands are important subaerial geomorphological features of the world's oceans, forming from plate motion over mantle hotspots. Such locations have received considerable attention from geologists interested in magmatic processes that reconstruct volcano development over geological timescales. However, geomorphological research is restricted to landslides associated with volcanic edifice collapse and marine terraces that develop around island margins. Alluvial fans and river terraces are common volcanic island features, yet little studied by the fluvial archive and volcanological communities despite their opportunities for providing insights into volcanic edifice evolution and their environmental change driving mechanisms (sediment supply and base-level change).

Here, we report preliminary findings of remote sensing, field mapping/survey and geochronological investigations into Quaternary alluvial fan and terrace development on two adjacent volcanic islands of the arid Cape Verde archipelago, offshore West Africa. Cape Verde has developed during Miocene-Recent volcanic activity linked to slow plate movement over a mantle hotspot. Santo Antão and São Vicente are the most NW islands. Santo Antão retains a clear geomorphological expression of a volcanic caldera complex, contrasting with the highly denuded São Vicente. Both comprise numerous alluvial fans and fluvial terraces (Fig. 1) that appear to be recording different stages of volcanic island erosion driven by variations in sediment supply and base-level variations. The islands are considered to be tectonically inactive and thus landscape development is likely to be controlled primarily by climate, climate-related sea-level change and the passive geological configuration of the volcanic island products (lava flows etc.).

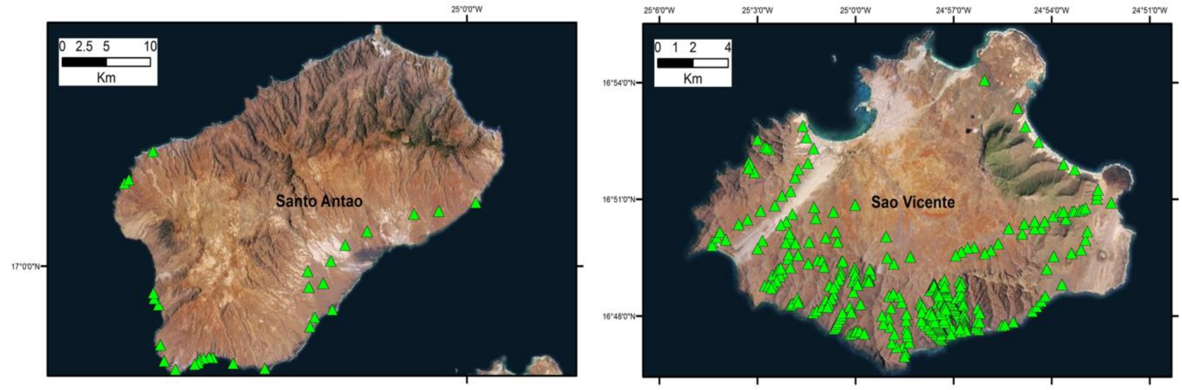

Fig.1 Alluvial fan distribution on Santo Antão and São Vicente islands, NW Cape Verde

Santo Antão comprises a limited number of large coalescent coastal alluvial fans restricted to the south side of the island. The largest fan (Pedrinha) is ~6km long and up to ~4km wide, covering an area of ~10km^2. It comprises an expansive single surface (Qf0), with a gradient of 0.03. Proximal fan areas are mantled by the Canudo Tephra (~220ka: Eiselle et al., 2015) which forms an important regional stratigraphic marker. We have sampled the Qf0 surface for cosmogenic He exposure dating on large (>0.5m) transported basalt boulders. Preliminary results yield age groupings of ~160-50ka (distal fan) and 20-10ka (proximal fan).

The fan surface is dissected by a series of ephemeral channels, revealing poorly sorted fluvial fan sediments interbedded with (undated) lava flows and an Argon dated tephra (193 ±23ka = Canudo Tephra?). Borehole logs reveal a 180m thick fan sediment-lava sequence suggesting prolonged coarse clastic fan sedimentation and volcanic activity along the southern island flanks. The fan surface is dissected by ephemeral channels. The main channel, the Ribeira das Patas, dissects the entire fan surface from the coast (~4m deep and ~ 200m wide in distal fan; ~60m deep and ~10m wide in proximal fan) and continues into a backfilled flank margin catchment area (30km^2; 1500m relief) with incision increasing up to 110m. The catchment infill reveals a series of inset fill terrace surfaces and lava flow channel infilling/damming.

São Vicente comprises extensive coastal and inland fans. These fans are small (up to 1.2km^2 and 1.8km long) and steep gradient (<0.08) forms that are fed from small (<1.3km^2) and low relief (<500m) backfilled catchment areas. All fans comprise up to two inset surfaces (Qf0 and Qf1) that show altitude, desert varnish, soils and sedimentological variability and relationships. Incision between fan surfaces displays proximal-distal variability but is typically <7m. Sections through the fan sediments reveals thin sediment bodies (several metres thick) with a dominance of debris flow processes. We have surveyed and mapped a selection of coastal and interior fans from different base level and caldera geology contexts to illustrate variations in fan form and development. Sampling for He cosmogenic exposure dating has targeted the Qf0 surface of the largest Santa Luzia coastal fan which builds over MIS7 and MIS 5 marine terraces in distal fan areas.

Preliminary interpretations suggest that the steep volcanic edifice morphology restricts coastal fan development around the island margins, inhibiting accommodation space for sedimentation and enhancing the likelihood of erosion through base-level fluctuations when fans do form. Flank collapse regions can modify the steep edifice margins, providing accommodation space, sediment supply and drainage routing conducive for fan building. Hydrothermal alteration of volcanic products appears to be a major control for island morphology and the distribution of inland alluvial fans. Santo Antão has limited alteration apart from a localised interior region where altered rocks have been exploited as part of catchment development during the building of the south island large coalescent fans (e.g. Pedrinha). These south island fans could also be occupying a former flank collapse area (hitherto unrecognised) based upon edifice morphology and offshore bathymetry. Here, sedimentation appears to be long lived (Middle Pleistocene and older) with the current surface abandonment and incision occurring in the Late Pleistocene in relation to climate related sediment supply and base-level change. São Vicente shows greater alteration resulting more widespread island interior erosion. The well-developed island interior valleys provide a morphological setting conducive for inland fan and terrace development. However, the thin sediment thicknesses and restricted terrace/fan surface altitudinal spacing suggests that sediment is routinely removed and resupplied, linked to a suppressed inland base level configuration decoupled from sea-level change and Quaternary climate-related variations in weathering and flood regime.

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GRAIN-SIZE CHARACTERISATION OF ALLUVIAL AND LACUSTRINE SEDIMENTS IN A LOESSIC SETTING

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Different modes of dust transport by the wind are, amongst others, expressed in terms of grain-size of aeolian deposits (Vandenberghe 2013). Three main loess populations of primary windblown origin may be defined according to their grain size (dominated by fine sand to very coarse silt, silt, and very fine silt to clay, respectively). Each of them reflects a specific aeolian process and transport conditions: fine sand to very coarse silt in saltation by local winds, silt in low suspension clouds by regional winds and very fine silt to clay in high suspension as background supply. After (primary) pure deposition by the wind, loess may also be affected by (secondary) post-depositional processes introducing properties that are useful to identify those secondary processes. Examples are settling of loess particles in a lacustrine setting and reworking by rivers or surface runoff. Those reworking processes leave their imprint not only on sedimentary structures as fine laminations, and occasional ripple structures and small-scaled cross-bedding, but also on the grain-size composition. Strikingly, the average primary loess grain-size characteristics are maintained in secondary loess deposits. However, they are more poorly sorted. In addition, the admixture of very fine-grained sediment (1-2 μm) is typical for settling in standing water in lakes of different origins and pools on floodplains. In contrast, addition of sediment that is coarser-grained than purely windblown loess characterizes higher energy conditions by slope processes or transport in flowing water. It follows that the grain-size distribution of a loess deposit, both primary windblown or secondary reworked, is an excellent proxy for the reconstruction of past processes of windblown transport, post-depositional processes and environmental conditions.

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GLACIAL AND INTERGLACIAL DEPOSITS IN THE SZCZERCÓW OUTCROP, IN THE WESTERN PART OF THE KLESZCZÓW GRABEN, CENTRAL POLAND

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The Kleszczów Graben, formed in the late Paleogene and Neogene, has become a place where there was an accumulation of sediments of considerable thickness. It was mostly filled by great thickness of the Miocene, Pliocene and Quaternary deposits. Here in the Miocene formed thick organic series, which have been converted into lignite. Coal mining (KWB Bełchatów) in the two quarries [Bełchatów (older) and Szczerców (younger)] also gave the possibility of penetration of Quaternary sediments. Those sediments in the lower and middle part of the geological profile are disturbed (Łękińsko Fm. − Stawek Fm.) and in the upper undisturbed (Chojny Fm. − Widawka Fm. and Szerokie Fm.).

Field studies carried out in 2010−2015 in the Szczerców outcrop, allowed the sampling and palynological tests (Kuszell and Iwanuś, 2012), petrographic and heavy minerals analysis (Król et al., 2007; Dobosz 2012) and radiocarbon data (Pazdur 2011, Michczyński, 2012). Additionally, a structural study of sediments was also made with malacological and anisotropy of magnetic susceptibility (AMS) analyses. The results and other previous studies and works (Wieczorek and Stoiński 2013) led the authors to the characteristics of Quaternary deposits (Wieczorek et al. 2015), which in turn contributed to, among others, a comparison to Quaternary sediments in the Bełchatów outcrop (Krzyszkowski 1992, 1995, 1996).

Field research in the Szczerców outcrop ran mainly on the first and second mining floor, all revealing the formations of Quaternary sediments formation and older sediments in selected formations. Least diagnosed bursts are the oldest glacial sediments, the Folwark and Kuców Formations, respectively Nidanian and Sanian. The Folwark Formation till and sand littered on the Neogene clays and sands (146−150 m a.s.l). Above them disturbed deposits of the Kuców Formation − sand, gravel, clay and till (140−170 m a.s.l.) have been diagnosed. Both sedimentary complexes were cut by faults. Within them distinguished were tills T1, T2a, T2, T2b (Krzyszkowski et al. 2015), formerly only tills T1, T2a, T2 were distinguished (see. Czerwonka and Krzyszkowski, 1992; Krzyszkowski, 1994).

In a similar elevation (145−155 m a.s.l.), south of the Chabielice fault (part of the Kleszczów Graben), were found fluvial, interglacial various-grain sands, white, most likely the Czyżów formation (Holsteinian). These fluvial sediment, for which the source were older ice sheets, or Neogene surface. In the sediments were found and described pieces of wood remnants (Myśkow et al., 2015). Till T3 of the Rokity Formation has not yet been found.

Tills (T4), glaciolacustrine and glaciofluvial sediments of the Ławki Formation (early Saalian, MIS 6) unaccordingly lie on the Mazovian Interglacial sediments (MIS 11). They widely occur and are at elevations of about 160−180 m a.s.l., disturbed in the upper part of the structural floor. Detailed studies were carried out for rhythmithe sediments (gray silts and black clays) with a thickness of up to 20−30 meters (Wachecka-Kotkowska et. al 2012).

So far the Chojny Formation sediments were not documented here, but they are well known from the nearby Bełchatów outcrop (Krzyszkowski 1992, 1996). The Rogowiec Formation (Late Saalian, MIS 6) represent glacial till T7 (Dobosz, 2012) and glaciofluvial sands that lie on the erosional pavement (elevation 179−182 m a.s.l.). Bottom tills, T5 and T6, familiar with the Bełchatów opencast mine are not described here. Above Rogowiec Formation deposits, also on the pavement or glaciofluvial series of, in the axis of the Krasówka valley lie the Aleksandrów Formation sediments: gyttja, peat and rhythmithe silt and clay (Eemian/Early Weichselian MIS 5e−d).

On the Aleksandrów, Rogowiec, Ławki and possibly Czyżów (?) formations unaccordingly lie sands of the Piaski formation (Vistulian), accumulated in periglacial conditions. On the eastern wall of the Szczerców outcrop between 2010 and 2012 a thick profile of this formation was documented. These fluvial deposits and river-deluvial surge at elevations of 160−180 m a.s.l. Two series were the Middle Plenivistulian silty-sands (*SFh*, *Sr*, *Sh*; segment e, b/c) and the Upper Plenivistulian sands *Sh*, with strong abrasion traces in the quartz grains. Such age-reference series were given by radiocarbon data (Pazdur, 2011; Michczyński, 2012), which indicate the Middle Plenivistulian (MIS 3; 47 ka BP) as the beginning of the filling of the valley and Upper Plenivistulian (MIS 2; 24 ka BP) crowning a fluvioperiglacial series (Wachecka-Kotkowska et al., 2014). Based on the analysis of the geomorphological study area it can be assumed that Krasówka, Krasowa and Nieciecz created a "valley" using post-Wartanian tunnel valleys and kettle holes (Wieczorek and Stoiński, 2013).

The thickest sand series within the Quaternary sediments in the Szczerców outcrop is the Plenivistulian. The Vistulian deposits are partly covered by deposits of the Widawka and Szerokie formations (Holocene). Holocene sediments mainly represent medium and fine sands and sandy silts, gray and brownish-gray, river and river-deluvial. They occur on the surface in the bottom of the Krasówka river valley, where the water flow periodically arises (at 178−180 m a.s.l.), the thickness in the area fluctuates around 2 m.

Part of the research was conducted during updating the Szczerców map sheet (735) of the Detailed Geological Map of Poland, scale 1:50 000. The work was carried out on request of the Minister of the Environment, and financed by the National Fund for Environmental Protection and Water Management.

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INTERLINKS OF FLUVIAL AND AEOLIAN PROCESSES IN A SEMI-ARID ENVIRONMENT RECORDED BY SEDIMENT SEQUENCE OF YELLOW RIVER TERRACE DURING LAST GLACIAL PERIOD

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Sediment sequences of last glacial terraces of theYellow River in semi-arid environment are composed of lower channel gravel and flood sand, a middle aeolian sand dune and upper laminar flood loam. These sediment sequences, dated by optical stimulated luminescence (OSL), recorded the link between fluvial and aeolian processes and their response to climate change. The channel gravel and flood sand deposited during cold periods (e.g. LGM). The river incised slightly during the transitions from cold to warm phases, and an aeolian dune developed over the coarse-grained cold-phase fluvial deposits. After that, the floodplain accumulation continued and floodloam covered the aeolian sand dunes during the (beginning of the) subsequent warm period. Sediment structure and grain-size analysis show the aeolian dunes were formed by the deflation of local fluvial sands, while the regional aeolian dust mainly provided the material for the thick floodloam units. The millennial-scale climate fluctuations related to the SE Asian monsoon system during the last glacial period were the driving forces for the interaction between fluvial and aeolian processes in this semi-arid environment, such as deflation of fluvial sands and the formation of aeolian dunes.

THE INTERNATIONAL 'DEBATE' ON FEEDBACKS BETWEEN CLIMATE AND LANDSCAPE EVOLUTION:IMPLICATIONS FOR FLAG

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Feedbacks between climate and landscape evolution are currently a 'hot' topic as researchers in diverse fields including glacial geomorphology are coming round to the view that multiple phases of vertical crustal motion, associated with long-timescale climate change, are recognizable in glaciated regions. This work is moving forward without regard for the fact that such phases of vertical crustal motion have been widely recognized for years in most regions, worldwide, from studies of long-timescale fluvial sequences. Thus, rather than discovering a new idea, the glacial community has rediscovered something that has been well known to the fluvial community for years, but is not according the latter community appropriate recognition, even though the fluvial evidence is typically far clearer than the glacial evidence that is now emerging.

On a related theme, FLAG discourse has, mercifully, hitherto largely remained free of 'contamination' by proponents of the 'stream power law' approach to the analysis of fluvial systems, which is underpinned by notions such as that long-profile gradients of rivers correlate with uplift rates and that – rather than being lithologically controlled – knickpoints propagate upstream as 'waves of erosion'. These concepts have led to the notion of 'continental-scale river profile inversion', i.e., the idea that one can 'invert' long profiles of major rivers (such as the Colorado in the western USA) for changes in uplift rates, knickpoints farther downstream being indicative of more recent changes. This approach to the analysis of fluvial systems has long-standing popularity among U.S. researchers and is starting to filter through into the outputs of FLAG, but can easily be shown to be wrong in principle.

The implications of both these developments for FLAG will be discussed.

TERRACE STYLES AND TIMING OF FLUVIAL TERRACE FORMATION IN THE WESER AND LEINE VALLEYS, NORTHERN GERMANY: RESPONSE OF THE RIVER SYSTEM TO CLIMATE CHANGE AND GLACIATION

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In glaciated continental basins accommodation space is not only controlled by tectonics and sea-level but also by the position of ice-sheets, which may act as a regional base-level for fluvial systems. Although the Pleistocene terrace record of major river systems in northwestern Europe has been investigated by many authors, relatively little attention has been paid to base-level changes related to glacier advance–retreat cycles and how these regional changes in base-level interacted with river catchment processes.

The drainage system of the study area developed during the Miocene. During the Pleistocene fluvial incision took place to a depth of 170 m, probably caused by a combination of tectonic uplift and increased erosion rates during climate cooling. A major change of the dynamic equilibrium occurred during the late Middle Pleistocene, when thick cut-and-fill terraces started to form. The depositional architecture of theseMiddle Pleistocene to Holocene fluvial terrace deposits has been reconstructed from outcrops and high-resolution shear-wave seismic profiles. The chronology is based on luminescence ages, ^{230}Th/U ages, ^{14}C ages and Middle Palaeolithic archaeological assemblages (Roskosch et al. 2015, Winsemann et al. 2015).

Climate was the dominant driver for river incision and aggradation, whereas the terrace style was controlled by base-level changes during ice-sheet growth and decayand river re-directions controlled by glacio-isostatic crustal movements.The repeated cut-and-fill cycles are confined within a stable buffer zone within which channels avulsed and cut and filled freely. The development of this stable buffer zone correlates with the onset of glaciation and periglacial climate condition in the study area.It probably persists until today and defined the available fluvial preservation space, the maximum depth of fluvial incision and the highest surface of aggradation (cf. Holbrook et al. 2006).

The Middle and Late Pleistocene fluvial sediments have been mainly deposited by gravelly to sandy braided river systems. The vertical stacking pattern of architectural elements within each terrace points to an increase in aggradation rates and a decrease in water discharge. During interglacials widespread soil formation took place. Interglacial/interstadial fluvial deposits consist of organic-rich floodplain deposits of a sandy braided river system (MIS 7c-a) and point-bar deposits of meandering river systems (MIS 5e). The latest change from braided to meandering channel patterns took place during the Bølling interstadial (~15 ka, Greenland interstadial GI-1) at the Late Pleniglacial to Late Glacial transition.

The Middle Pleistocene fluvial terraces are vertically stacked, requiring a high aggradation to degradation ratio. The increase in accommodation space is related to the onset of glaciation in northern central Europe (MIS 12). Ice-sheets and pro-glacial lakes acted as a regional base-level for the alluvial systems (Winsemann et al. 2015, 2016), leading to strong fluvial aggradation during phases of glacier advance (MIS 12 to MIS 6). In addition the post-Elsterian re-direction of the river systems may have led to a decrease in river gradients, a reduction of the stream power and transport capacity. A contemporaneous high sediment yield resulted from increased hill-slope erosion in the catchment area, where periglacial conditions established. Thickness variations of fluvial deposits along the river profiles were caused by local changes in accommodation space mainly caused by fault activity and subsurface salt solution.

At the beginning of the Late Pleistocene the terrace stacking pattern changed from vertical to lateral. The formation of laterally attached terraces points to a change of the aggradation to degradation ratio, which was probably related to a decrease in accommodation space during glacier retreat and a renewed river re-routing. The braided river systems were characterised by a high sinuosity, which may be a direct effect of an increased valley slope after deglaciation when channel lengthened and the river adjusted to the increased valley slope by increasing sinuosity. Major incision phases took place during MIS 5e, 5d, 5c, early MIS 4, early MIS 3 and at the beginning of the Lateglacial. These major phases of river incision and aggradation correspond well with those reported from many other river systems worldwide (e.g., Bridgland & Westaway, 2014). Up to nine Lateglacial and Holoceneterracing episodes can be distinguished, recording millennial-scale channel shifts, which might be related to major climatic variations.

The interplay of glacio-isostatic processes and the long-term tectonic uplift is difficult to estimate. The shorter-term glacio-isostatic movements may have controlled local degradation and aggradation rates but have not influenced the larger-scale terrace architecture. A major glacio-isostatic effect probably was the repeated re-direction of the River Weser and River Leine.

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CLIMATE CONTROL ON THE EVOLUTION OF LATE PLEISTOCENE ALLUVIAL FAN SYSTEMS IN NORTHWEST GERMANY

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During the Late Pleniglacial numerous alluvial fans formed on the southwestern slope of the Teutoburger Wald Mountains, south of the north German Lowlands. Records of Late Pleniglacial alluvial fans in central Europe are rare and luminescence dating is used to determine the timing of fan aggradation. In contrast to fluvial systems that commonly show a spatial delay between climate change and incision/aggradation (van Balen et al. 2010) the small alluvial-fan systems of the study area rapidly responded to climatic changes and therefore act as important terrestrial climate archive for this time span.

The onset of alluvial-fan deposition occurred at the end of MIS 3. Basal fine-grained alluvial-plain deposits have a luminescence age of 29.3±3.2 ka. These deposits are erosively overlain by distal or medial alluvial-fan deposits with luminescence ages of 25.4±3.6 to 18.7±1.9 ka (Roskosch et al. 2012). Strong fan progradation is attributed to an increase in water discharge and runoff rates from the catchment areas, which may be related to a period of higher humidity. The abundance of angular limestone and marlstone clasts indicate the erosion of colluvium, which was probably formed as frost debris during the previous stadial conditions.

The runoff-dominated distal to medial fans display three vertically stacked coarse-grained channel systems, separated by sandy sheet-flood deposits. The number of channels decreases upwards, whereas the aspect ratio of channels increases and intercalated sheet-flood deposits become more abundant (Meinsen et al. 2014).The stacking pattern and channel styles indicate an overall decrease in water and sediment supply with less sustained discharges and more sporadic runoffs from the catchment area, corresponding to an increasing aridity in central Europe during the Late Pleniglacial. Major phases of channel incision and fan aggradation may have been controlled by millennium-scale Dansgaard-Oeschger cycles.The incision of major channel systems may correspond to Greenland interstadials (GI-4 to GI-2; cf. Svensson et al. 2008) whereas the main aggradational phases probably occurred during the stadials, when the lack of vegetation led to an increased hillslope erosion and sediment supply. However, luminescence data are not precise enough to discriminate millennial-scale climate oscillations and an exact correlation with Greenland stadials or interstadials.

The alluvial-fan deposits are bounded by an erosion surface and are overlain by aeolian sand-sheets that were periodically affected by flash-floods. The luminescence ages range between 19.6±2.1 to 13.1±1.5 ka (Roskoschet al. 2012), recording a rapid increase in aridity at the end of the Late Pleniglacial. The occurrence of isolated channels, flash-floods and palaeosols within the aeolian sand-sheet deposits points to temporally wet conditions during the Lateglacial. Soil properties and micromorphological features are in accordance with the Lateglacial Finow soils (Meinsen et al. 2014).

The alluvial fan and aeolian sand-sheet deposits contain abundant soft-sediment deformation structures, which include closely spaced low-offset normal faults, ball-and-pillow structures, flame structures, sills and irregular sedimentary intrusions, dikes, and sand volcanoes (Brandes & Winsemann 2013). The formation of these soft-sediment deformation structures is probably related to a major earthquake along the Osning fault zone that occurred between 15.9±1.6 to 13.1±1.5 ka (Brandes et al. 2012). The association of soft-sediment deformation structures implies that it had a magnitude of at least 5.5 (Brandes & Winsemann

2013). Although we cannot completely rule out cryoturbation processes, we interpret these structures as seismically triggered, because i) the different soft-sediment deformation structures mainly indicate fluidization processes requiring strong hydraulic forces, which would not be expected in a mixed alluvial-aeolian environment, where the groundwater table is low and ii) there is a distinct variation of the soft-sediment deformation style parallel to the Osning fault zone.

However, we rule out tectonics as a major controlling factor for the evolution of the alluvial-fan systems, because fault scarps are rarely developed and preserved owing to the low slip rates along the Osning fault zone and there is evidence for only two seismic events in the study area during the last 32 ka. One occurred during the Lateglacial (Brandes et al. 2012) and one in the 17th century (Vogt & Grünthal 1994). Two seismic events do not seem enough to have had a significant impact on the sedimentary system, and it is therefore unlikely that fault scarps contributed considerably to the sediment production in the source area. In addition, climate changes and tectonic activity operate over different time scales. So far, the effect of glacio-isostatic adjustment has not been quantified in the study area. The reconstruction of Kiden et al. (2002) implies that the study area is located within the forebulge zone of the Late Pleistocene Scandinavian Ice Sheet. However, the small catchment area of the Late Pleniglacial fans makes it unlikely that glacio-isostatic adjustment had a major influence on differential base-level changes. Base-level changes caused by lake-level changes and river erosion can be also ruled out as a major controlling factor, as the fans do not toe out to lake shores or axial river systems.

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INCISION OF POLISH CAPATHIAN RIVERS DURING THE TWENTIETH CENTURY AND ITS IMPACT ON THE HYDRAULICS OF FLOOD FLOWS

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A loss of geomorphic dynamic equilibrium, manifestedby fast-progressing channel incision throughout the 20th century, has been documented for numerous rivers worldwide (Darby, Simon, 1999). In some cases, the tendency was ascribed to a single or dominating causal factor such as in-channel gravel mining, construction of a dam reservoir, channel regulation or catchment reforestation. More frequently though, the incision resulted from a range of factors limiting the availability of bed material for fluvial transport or increasing transport capacityof the river. In Polish Carpathian rivers, the 20th-century rapid channel incisionwas associated with increased river transport capacity resulting from channelization, a decrease in catchment sediment supply, that followed land-use changes in mountain areas, or intense in-channel gravel mining (Wyżga, 2008). River incision has often been identified on the basis of change in the vertical position of the channel bed, reconstructed from repeated surveys of channel cross-sections or a comparison of the elevation of contemporary channel bed with its position within the palaeochannels. However, this approach may lead to wrong recognition of incision as channel deepening may occur not only as a result of channel incision but also in the course of river metamorphosis. Proper recognition of the phenomenon and its impact on the hydraulics of flood flows is especially important for implementation of effective remedial measures to stop and reverse river tendency to incise. This study emphasizes the need to distinguish between incision and channeldeepening resulting from river metamorphosis induced by a change in sediment supply and investigates the impact of increasing river size and lateral channel stability on the hydraulic effects of channel incision in Polish Carpathian rivers.

Lowering of a channel bed is frequently reported as an indicator of river incision; however, a channel may deepen as a result of two different processes. First, bed lowering may occur due to river metamorphosis that is induced by a change from the bed-load to a suspended-load stream and leads to the transformation of the former wide, shallow and straight channel into a narrow, deep and sinuous one (Fig. 1A). If unconstricted, a river tends to adjust its channel to a reduced sediment supply through an increase in sinuosity and a reduction in channel slope with no significant change to channel conveyance and to the lateral and vertical extent offlood water on the valley floor at given discharges (Fig. 1A).

Channel incision occurs if a disrupted equilibrium between transport capacity of a river and its sediment load cannot be re-established through anincrease in channel sinuosity and the resultant reduction in channel slope. This situation is typical of channelized rivers with reinforced channel banks and watercourses flowing in narrow, especially V-shaped valleys. If adjustment of channel sinuosity is impossible, bed degradation induced by excess power of flood flows will increase channel conveyance and the increase will lead to the lowering of water stages and a reduction in the lateral extent of inundation of the valley floor at given discharges (Fig. 1B). Therefore, the lowering of water stages at given discharges rather than the lowering of the channel bed of a studied river should be considered an indicator of river incision.

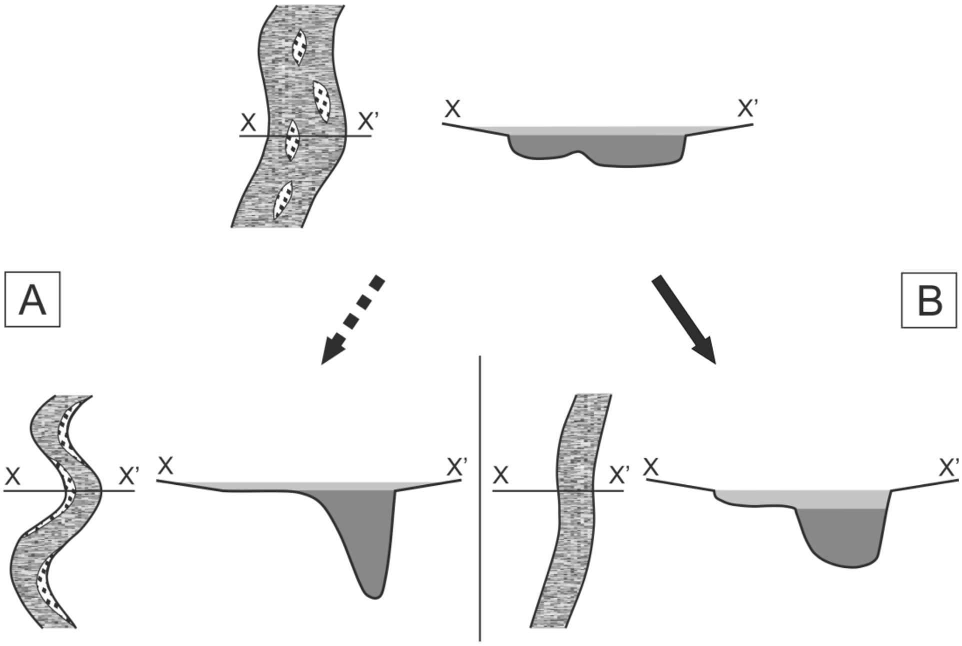

Fig. 1. Changes in channel geometry and the horizontal and vertical extent of floodwater resulting from a natural metamorphosis of a bed-load river into a suspended load one (A, dashed arrow) and from channelization-induced channel incision (B, full arrow). In the cross sections, in-channel water is indicated in dark blue and overbank water in light blue.

Carpathian tributaries to the Vistula started to incise in their lower and middle courses at around the turn of the 20th-century. The lowering of their minimum annual stages at water-gauge stations indicates that over the last century the rivers incised by 1.3-3.8 m inthese reaches. About 3 m or more of channel incision was recorded at half of the investigated gauging stations from these reaches and in many stations the incision was especially rapid in the second half of the century. In the second half of the century channel incision became also apparent inthe upper course of Carpathian tributaries to the Vistula and in their mountain tributaries. The hydrometric data indicate 0.5-2.8 m of channel incision, but at the majority of the gauging stations in these reaches the amount of incision was relatively low, ranging from 0.5 to 1.0 m.

Variability in the hydraulic importance of channel incision with increasing river size was analysed by comparing changes in the frequency of valley-floorinundation at gauging stations located along the 7th-order Dunajec River. Despite a lower absolute amount of channel incision inthe upper river course, here incision has increased channel conveyance and reduced the frequency of valley-floor inundation considerably more than in the lower course. Following channel incision by 0.37 m at the Kiry gauging station located in the upper river course, the stage which in 1962 was associated with a flow of 1.5-year recurrence interval in 1995 could be attained by the discharge 4.1 times greater, with a 16.3-year return period. In turn, the level inundated previously by a 5-year flood in 1995 could only be submerged by the discharge 2.8 times greater, with a 140-year recurrence interval. In contrast, at the Żabno station located in the lower course with about 200 times greater catchment size, the absolute amount of channel incision was greatest among the stations considered (2.8 m) but the effect of incision on channel conveyance and the frequency of valley-floor inundation was least significant. The stage, which in 1925 was associated with a 1.5-yearflow, in 1998 could be reached by the discharge 1.5 times greater, with a 2.1-year return period.The level inundated at the beginning of the analysed period by a 5-year flood, at its end would be attained by the discharge only 5% greater, which recurs every 5.5 years, on average.

Not only river size but also lateral stability/mobility of the channel accompanying river incision may affect its impact on the hydraulics of flood flows. Considerable differences in the degree of lateral channel stability during the 20th century occurred between low-energy rivers draining the eastern part of the Polish Carpathians and high-energy rivers from the western part (Wyżga, 2001). Low-energy rivers from the eastern part of the Polish Carpathians remained laterally stable during channel incision. This has resulted in substantial lowering of stages for low flood discharges and markedly smaller one for high-magnitude floods, whereas velocity of the flows conveyed over the highly elevated floodplains has decreased considerably. In high-energy rivers from the western part ofthe Polish Carpathians, alternation of incision of the regulated channel and lateral channel migration has led to the formation of incised meander belts, with substantially lowered stages for all flood discharges and increased velocity of the flows conveyed over the newly-formed, low-lying floodplains.

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MULTI-THREAD RIVERS IN THE POLISH CARPATHIANS: OCCURRENCE, DECLINE AND POSSIBILITIES FOR RESTORATION

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Multi-thread (braided) rivers are typified by the presence of interconnected channels separated by mid-channel bars or the islands forming as a result of vegetation encroachment on mid-channel bars. High gradients of channels and valley floors, high discharge variability, relatively low content of fine, cohesive sediments in the alluvial plain, coarse bed material and high sediment supply are environmental conditions that favour the development of braided channel pattern. Under natural conditions of the Holocene, island-braided channel pattern was typical of the rivers in the foreland of the Tatra Mountains and most likely also those draining the parts of the flysch Outer Carpathians underlain by thick-bedded sandstones complexes (Fig. 1). These braided channels formed in the rivers flowing through mostly non-cohesive floodplains and fed with coarse-grained material exceeding competence of the rivers.

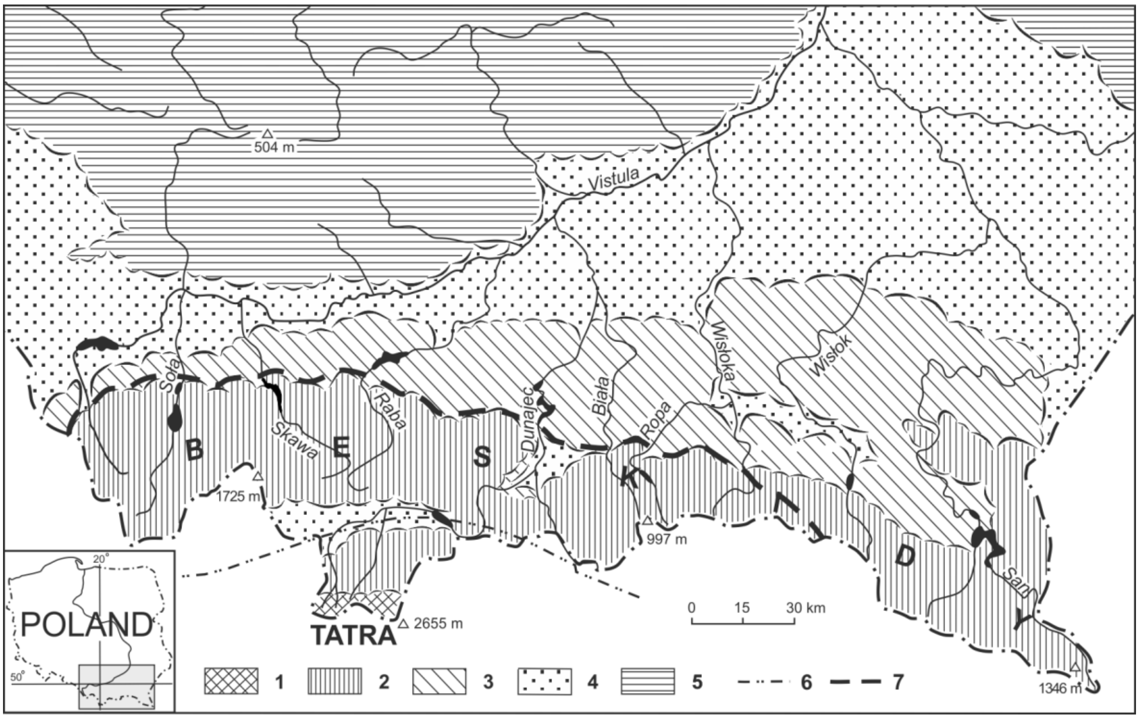

Fig. 1 Probable extent of the occurrence of multi-thread river morphology under natural conditions in the Holocene shown on the background of main physiographic elements of the Polish Carpathians. 1 – high mountains; 2 - mountains of intermediate and low height; 3 – foothills; 4 – intramontane and submontane basins; 5 – uplands; 6– geological boundary between the Inner and Outer Carpathians; 7 – northern limit of multi-thread morphology in Polish Carpathian rivers under natural conditions in the Holocene based on theoretical premises

Progressive deforestation of mountain catchments with the increasing area of cultivated hillslopes resulted in higher flood peaks and substantially increased sediment supply to river channels. Coupled with greater humidity of the final stages of the Little Ice

Age, this led to the transformation of the island-braided rivers into bar-braided ones; moreover, throughout the nineteenth century the braided channel morphology expanded downstream to the foreland river reaches (Wyżga, 1993). In turn, over the twentieth century the braided morphology nearly disappeared from Polish Carpathian rivers, mostly as a result of their channelization (Wyżga, 1993; Zawiejska, Wyżga, 2010). However, in river reaches outside the natural extent of multi-thread morphology in the Holocene, the disappearance of the multi-thread channel pattern reflected also adjustment of the rivers to a decrease in the intensity of sediment supply caused by land use changes, in-channel gravel mining and partitioning of the rivers with dam reservoirs (Wyżga, 2001). This is exemplified by the foothill reach of the Raba River where the multi-thread channel typical of the nineteenth century changed to a sinuous channel around he mid-twentieth century (Fig. 2). Subsequent channelization of these reaches, where rivers tended to increase their sinuosity in response to environmental changes (Fig. 2), induced rapid and deep channel incision (Wyżga, 2001).

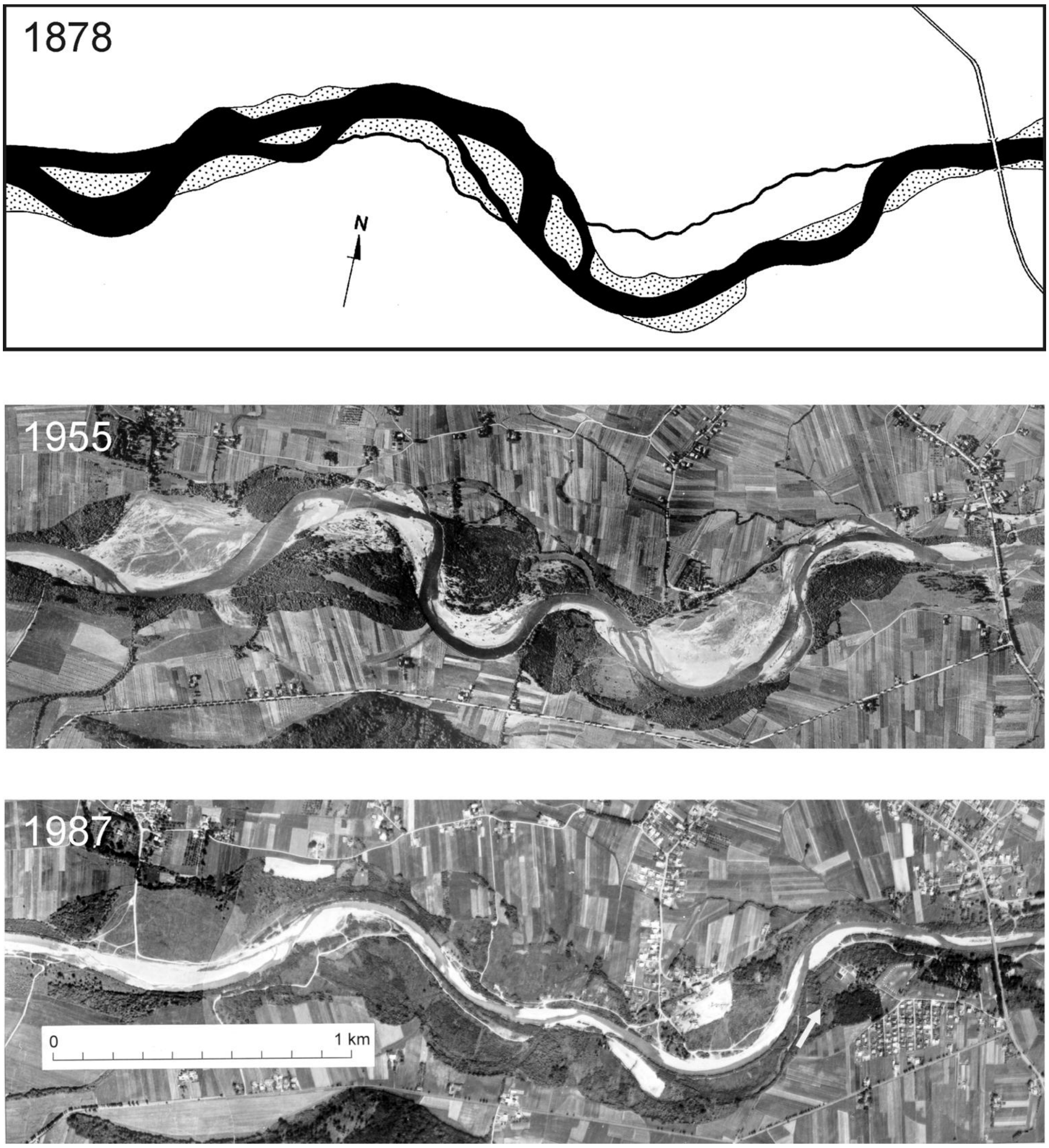

Fig. 2. Channel changes in the middle course of the Raba River between 1878 and 1987 as exemplified by the lower part of the Dobczyce-Gdów reach shown on a map from 1878 and aerial photos taken in 1955 and 1987.

Restoration of the multi-thread morphology of Polish Carpathian rivers would improve their ecological status and reduce flood hazard to their downstream reaches. However, environmental changes that occurred in the twentieth century in the river catchments and disruption of the continuity of sediment by dams limit the feasibility of the restoration of braided channel pattern in Polish Carpathian rivers to their reaches supporting such morphology under natural conditions of the Holocene.

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