International Journal of
Geohazards and Environment
http://ijge.camdemia.ca, ijge@camdemia.ca

IJGE 2016 **2**(**3**): 180-189

Available at http://ojs.library.dal.ca/ijge

Technical Notes

Modern and Late Holocene Flash Floods in the Silesian Upland (Southern Poland) Detected from Transformation of Periglacial Valleys: Case Study near Kromołów

Tomasz Kalicki*, Artur Zieliński, Paweł Przepióra, Sławomir Chwałek, Marcin Frączek,
Edyta Kłusakiewicz, Ireneusz Olszak, Łukasz Podrzycki
Department of Geomorphology, Geoarchaeology and Environmental Management,
Institute of Geography, The Jan Kochanowski University in Kielce,
ul. Świętokrzyska 15, 25-406 Kielce, Poland

Abstract: The examined area is located in southern Poland in the Silesian Upland. This northern Upper Silesia region is in the headwaters of the Warta river, a tributary of the Oder river. Some dry, fluvio-denudational valleys (dells) form a drainage pattern around Kromołów, which is a part of Zawiercie City. These dells, which were formed in periglacial conditions of the Pleistocene, are relict forms very typical of the Polish Uplands. These Pleistocene valleys were rejuvenated during the Holocene. A good example of this type of relief transformation is a small dry valley located near center of Kromołów. The first-phase of headward erosion reached upper section of this valley in the Subatlantic as documented by radiocarbon dating of a buried soil (2,570±80 BP, cal. 847 - 428 BC) preserved on the old valley bottom (terrace). Archaeological data from Archaeological Map of Poland (AZP) do not confirm prehistoric settlement in the study area. Incision of the valley floor could not be attributed to anthropogenic deforestation as the first settlements occurred within the last few hundred years. However, the absence of older archaeological sites might be caused by intensive soil erosion which could have destroyed them. Large scale soil erosion is confirmed by thick (about 3 m) series of deposits with fragments of 17 - 18 c. pottery accumulated in the middle section of the valley. Some members with fining upward sequence could be distinguished in this series. Then the older valley floor of trough was first covered with sediments of flash floods and subsequently cut by an ephemeral stream. Erosion to a depth of 3 - 4 meters and a length of almost 800 meters occurred in the middle section. This accumulation and incision was associated with flash floods which were the main morphogenetic factor of transformation of this valley type during the Holocene.

Keywords: periglacial valley, flash floods, relief, sediments, Subatlantic

1 Introduction

Flash floods, triggered by heavy rainfall, are one of the most significant natural hazards in Europe and other continents, causing serious risk to life and destruction of buildings and infrastructure (Baker et al 1988, Gaume et al 2009, Marchi et al 2010, Lóczy et al 2012).

The problems of the morphological and sedimentological consequences of catastrophic rainfall in different areas of Poland have been dealt with by many authors (e.g. Ziętara 1968, Rodzik 1984, Maruszczak 1986, Starkel 1986, Ciupa 1996a, b, Czyżowska 1996, Dwucet and Śnieżko 1996, Jóźwiak and Skrzypczak 1996, Zieliński 1998a, b, Gliński and Przesmycki 2011, Ballesteros-Cánovas et al 2015). Research is typically carried out immediately after the event

* Corresponding Author: Tomasz Kalicki, tomaszkalicki@ymail.com, Tel: +48 (125) 1281-6297

 DOI: 10.15273/ijge.2016.03.017

and describes the origin of the phenomenon and associated erosion and accumulation forms. In contrast, there is an acute shortage of studies that catalog the state of preservation of these forms a few or several years after a catastrophic event. Such studies would capture the role of extreme events in the modeling of relief under strong anthropogenic pressure, that is the case in most of Poland. Time, and especially present-day human activity, blurs geomorphological description of the effects of catastrophic rainfalls.

2 Aim of Studies and Methods

Questions relating to the preservation of forms and deposits of flash floods from May 1996 at Kromołów have become the subject of study (Kalicki et al 2014, 2015b). The results of the research capture the Holocene trends in the development of the Pleistocene fluvio-denudational valleys and the role of extreme processes in their transformation (Kalicki et al 2015a, c).

In the years 2014 - 2015, forms and cover created during a flash flood in 1996 were inventoried, and their state of preservation or transformation by man in the two fluvio-denudational valleys mapped. The basis for comparison is documentation that was made immediately after the catastrophic event (Zieliński 1997, 1998a, b). Archive materials registered by the inhabitants (photos, videos - more than 2 hrs.), and a series of interviews about the scale and course of this event was conducted.

During fieldwork in 2014 - 2015, a several of outcrops and drillings located in the eastern valley (Doły Żerkowskie) that was modeled during floods. Sediment samples were taken from the drill profiles for lithological, geochemical and dating analysis. Grain size analysis and Folk-Ward distribution parameters for each samples (GRANULOM program) were calculated. The pH measurement was performed using 1 N KCl pH meter Elmetron CX-551, and determination of elements by X-ray fluorescence spectrometry (XRF) mobile spectrometer BAS Delta. TL dating have been made in the Science-Teaching Laboratories Unit of Institute of Geography Jan Kochanowski University in Kielce and radiocarbon dating in Laboratory of Absolute Datings of M. Krąpiec (calibration OxCal v4.2.3).

Geoportal.gov.pl provided a detailed hypsometric map with shading. The program Quantum GIS 2.8.2-Wien through an embedded SAGA 2.1.2 (Terrain Analysis Morphometry tab) and using a Convergence index algorithm created a model of concentration of surface runoff. Convergence Index is a measure of the description of the relief in terms of surface runoff intensity. It is calculated on the basis of exposure of adjacent raster cells and can reach values from -100 to 100. A value of 100 has a top from which runoff takes place in all directions, the value -100 to the deepest point of the depression or a place to which each side water flows, while the value of 0 means the slope of uniform exposure. Based on Archaeological Maps of Poland (AZP 93-52) information was collected about the location and age of archaeological sites in the study area.

In 2015, field work was conducted in the neighboring northern valley, which built a number of hydrotechnical investments (dams and reservoirs, etc.) designed to capture floodwaters and prevent the devastating effects of flooding in the future.

3 Location

The study area is located in the headwaters of the Warta River in southern Poland in the Silesian Upland on the border of two geomorphological units: basin of Upper Warta and Prosna Valley and the Upper Jurassic cuesta of Cracow Upland (Częstochowa Plateau) in the east and Upper Triassic cuesta in the west (Gilewska 1972). There are two physic-geographical mesoregions of Upper Warta Depression and Czestochowa Upland (Kondracki 1994). Dry, fluvio-denudational dells form a drainage system. These dells, which have been formed in periglacial conditions of the Pleistocene, are relict forms very typical for Polish Uplands. These Pleistocene valleys were rejuvenated during the Holocene.

Kromołów (now a district of Zawiercie City) is a small town situated at an altitude of approx. 380 - 400 m a.s.l. in an erosion-denudational basin with ephemeral drainage, which consists of dry valleys and dells dissecting the surrounding structural hills height up to 460 m a.s.l. Average gradient of the slopes surrounding Kromołów is from 3 to 7°. Oxford marl and bedding limestones are covered by fluvioglacial sands of the Oder (Drenthe, Saale) glaciation with good permeability, and fragments of limestone.

In the Upper Silesian Coal Basin sub-surface Silurian rocks are overlain by Devonian or Triassic deposits, most frequently Lower (Lower Buntsandstein, Rot) and locally Middle Triassic (Ore-Bearing Dolomites). The boundary between the Silurian series and its sedimentary cover is marked by an angular discordance ranging from 3 - 14 m (Szymański and Teller 1998). At the bottom, the Silurian deposits either continuously pass down into the Ashgill carbonates or discordantly overlie Ordovician carbonates of various age and upper most Precambrian (Vendian)-Lower Cambrian (Szymański and Teller 1998). According to Detailed Geological Map of Poland in Kromołów Northeast area there are two units of limestone from the Upper Jurassic: older and younger Marl Limestones. The rest of the area is covered by the Quaternary Glaciofluvial Sands (Bednarek et al. 1978). On this substrate were formed brown rendzinas with a low carbonate content (0.3-0.5%) and a small amount of the skeleton (0-5%), dominated part of sand (up to 54%), mainly medium (up to 27% in the C level at a depth of 75 - 85 cm and up to 21% in the Ap level at depth 0 to 20 cm). Silt fraction reaches 36% and clayey part up to 28%. The pH of the soil (in KCl) ranges from 6.02 to 7.30. The area is deforested and used for agriculture. Direction of plowing on large is in accordance with the inclination of the slope (Figures. 1 & 2).

Climate Region of Silesia is defined by a transition between a warm maritime climate of Western Europe and the continental east. Over the region humid air masses from the Atlantic and very dry air masses from the continent clash. This results in high variability of weather from day to day and the significant diversity of the seasons in successive years. The climate of the region has - thanks to the influence of uplands and mountains, heavy, large variation in local climatic conditions. Annual rainfall in 1996 amounted to 640 mm (Paszyński and Niedźwiedź, 1991).

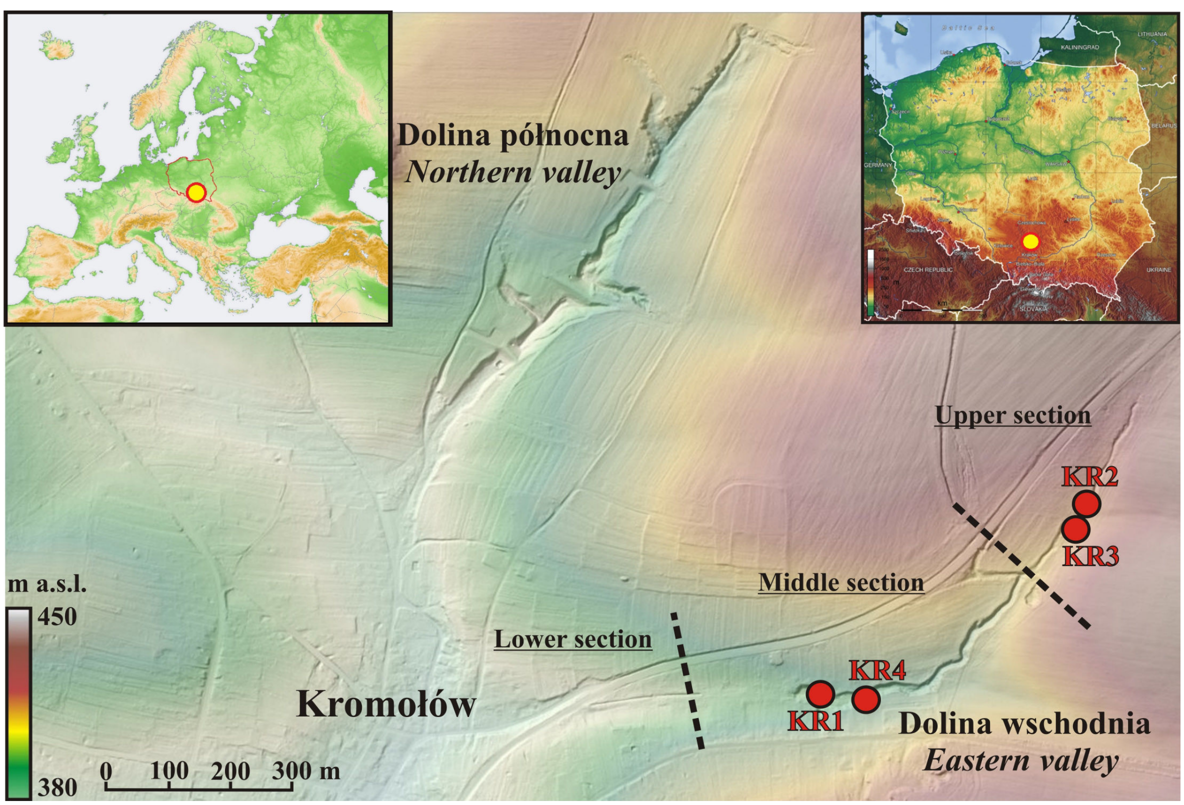

Figure 1. Location of research area and study profiles

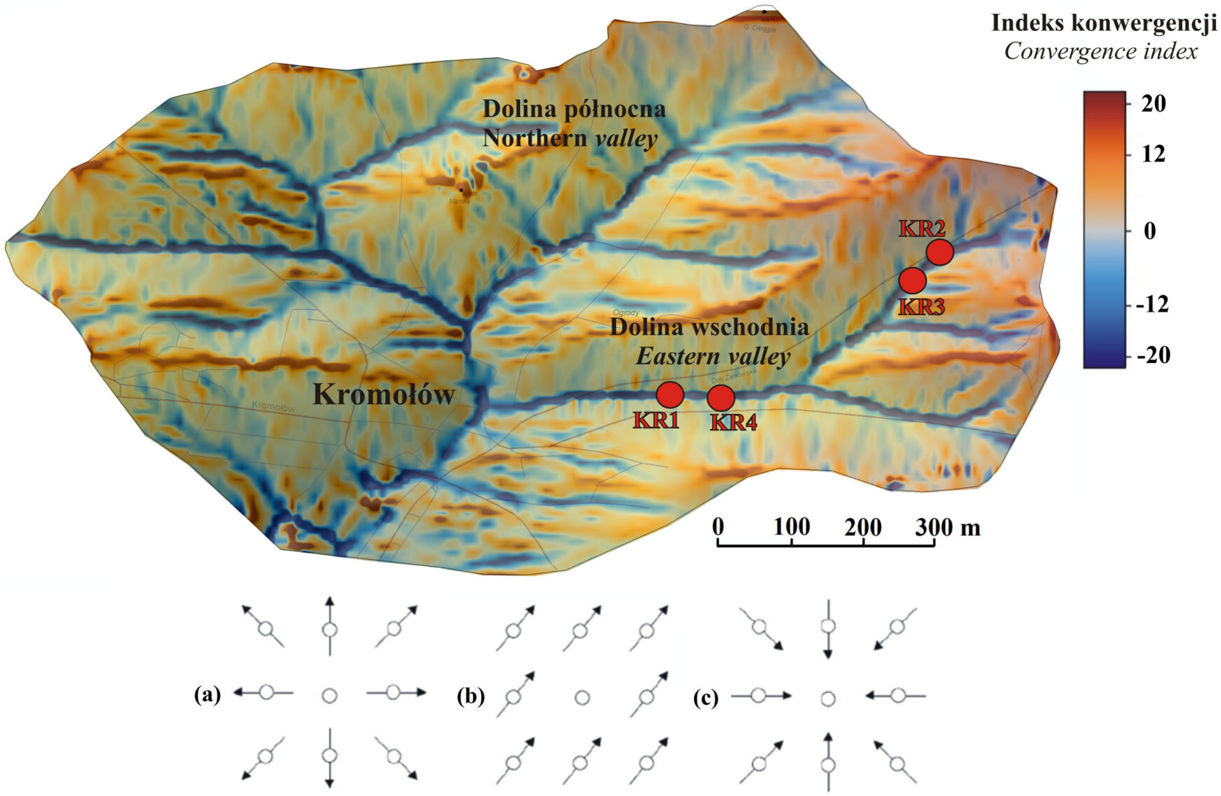

Figure 2. Convergence index model of Kromołów watershed. 1 - main roads, 2 - other roads, 3 – streets. The lower part of the figure shows the relationship between the convergence index value and the exposure of grid cells. The arrows indicate the direction of surface runoff. a - peak (convergence index value = 100); b - slope of uniform exposure (convergence index value = 0); c - the deepest point of the depression outflow (convergence index value = -100)

4 Flash Floods of 1996

1996 was the first year after a series of dry years, where the total annual rainfall was higher than the normal long-term (Cebulak and Niedźwiedź 1998). In some areas, such as the Cracow uplands, annual precipitation exceeded 125% of the long-term average. Compared to 1995 was recorded more local cases of torrential rainfalls focused mainly in May, 1996. Heavy rains reached catastrophic scale on May 15-18. In areas north of the Cracow thunderstorms occurred rapidly with heavy rainfall leading to flooding of many villages (Cebulak and Niedźwiedź 1998).

These floods occurred on May 14 and 17, 1996, and were caused by heavy rainfall, the size of which, based on data runoff from the meteorological station at Zawiercie few km from Kromołów, can be estimated at respectively 71 mm (2-hour's precipitation) and 57 mm (30 min's precipitation). Catastrophic rain storms were preceded by intense rains coupled with strong hailstorm on May 9, whose center was located 5 km south of Kromołów in the Ogrodzieniec region (serious damage including 200 ha of forests) and rainy day of May 13 (daily 20 mm) that water saturated surface layers of soil (Zieliński 1997, 1998a, b).

The effects of downpours in 1996 were observed within a radius of 12 - 15 km. In the fields there were traces of extensive surface water erosion, which turned into a network of rills, and then an ephemeral watercourse merging in the middle of the slope into a channel up to 7 m wide and 1.30 m depth and 1.2 km length. The catchment of the ephemeral watercourse, which drove the water to Kromołów, has an area of about 2.5 km^2. Liquefaction of the upper horizons of the soil resulted in leaching of the organic matter (C_{org} decrease in the Ap horizon from 1.9% to 1.2%) and particularly of the finest mineral fraction (loss of the clay fraction 5%) and carbonates (increase of carbonate content and higher pH7.53$_{(Kcl)}$ in sediments accumulated during the floods). Consequently, this has led to removal of the tillage horizon of the soil, with a thickness locally exceeding 25 cm. Calculations show that simply by creating the main channel, the flash flood had to remove about 4,000 m^3 of soil and about 6,100 m^3 of material from the area of 1.25 km^2. In the lower reach of the dry, fluvio-denudational valley, which was occupied by water flow during flash floods, an ephemeral creek was created.

5 Results

The studies focused on two dry valleys, east and north, where the outflow converges in the center of Kromołów. In both catchments the most intense processes of erosion and accumulation occurred in the floods of 1996. Both valleys experienced very distinct erosion, in the middle sections with depth reaching up to 5 m and width up to 10 m. This is clear evidence of the Holocene rejuvenation of these Pleistocene fluvio-denudational, periglacial valleys (dells).

In the eastern valley three sections of different slope and dominant morphogenetic processes during the catastrophic floods from 1996 year were formed: the upper (erosion to 1 m), middle (deepest cut and accumulation sandy bars) and lower ('fan like' accumulation) (Zieliński 1997, 1998a, b). In the upper and middle section 4 research profiles were established, two in each of them, in the bottom (KR2 and KR4) and the edge (KR3 and KR1) of the eroded channel. The lower section of the basin includes Kromołów. Mapping and analysis of sediments allow for comparison of these sections and the separation of the dominant morphogenetic processes.

5.1 Upper section

In this section erosion processes dominated during the formation of the 1996 flash flood. Cultivated fields on the slopes of the fluvio-denudational valleys formed extensive traces of surface erosion (washout about 7 cm soil layer on the area about 10 ha) and rill erosion, which focus along the mainstream runoff transformed in the valley bottom of the gully erosion (cut length 1.2 km, wide 7 m, depth 1.3 m). After the catastrophic events cultivated fields had to be reclaimed. Arable soil was eroded, the area was leveled and the Ap horizon as removed (Zieliński 1997, 1998a, b).

Today, there are no traces of both the processes of erosion on agricultural fields (furrows, rills etc.) and reclamation. Only the bottom of the basin was forested by almost 20 years dense scrub of trees and shrubs. The thalweg is cut by V-shaped ephemeral channel with a depth about 1.0 - 1.5 m, and channel edges are modified by soil creep as evidenced by the bending of tree trunks. Headward erosion causes further rejuvenation of the form. Profile KR2 was located on the 40 cm high rearward erosion scarp that shows that the bed is cut in the waste cover (loams with fragments of limestone up to 3 cm) (Figures. 1 & 3). The thalweg is overgrown and

Figure. 3. KR2 profile on erosional scarp in the ephemeral stream bed in the upper section. On the left site visual evidence of soil creep shown by bending of tree trunks (condition in 2014)

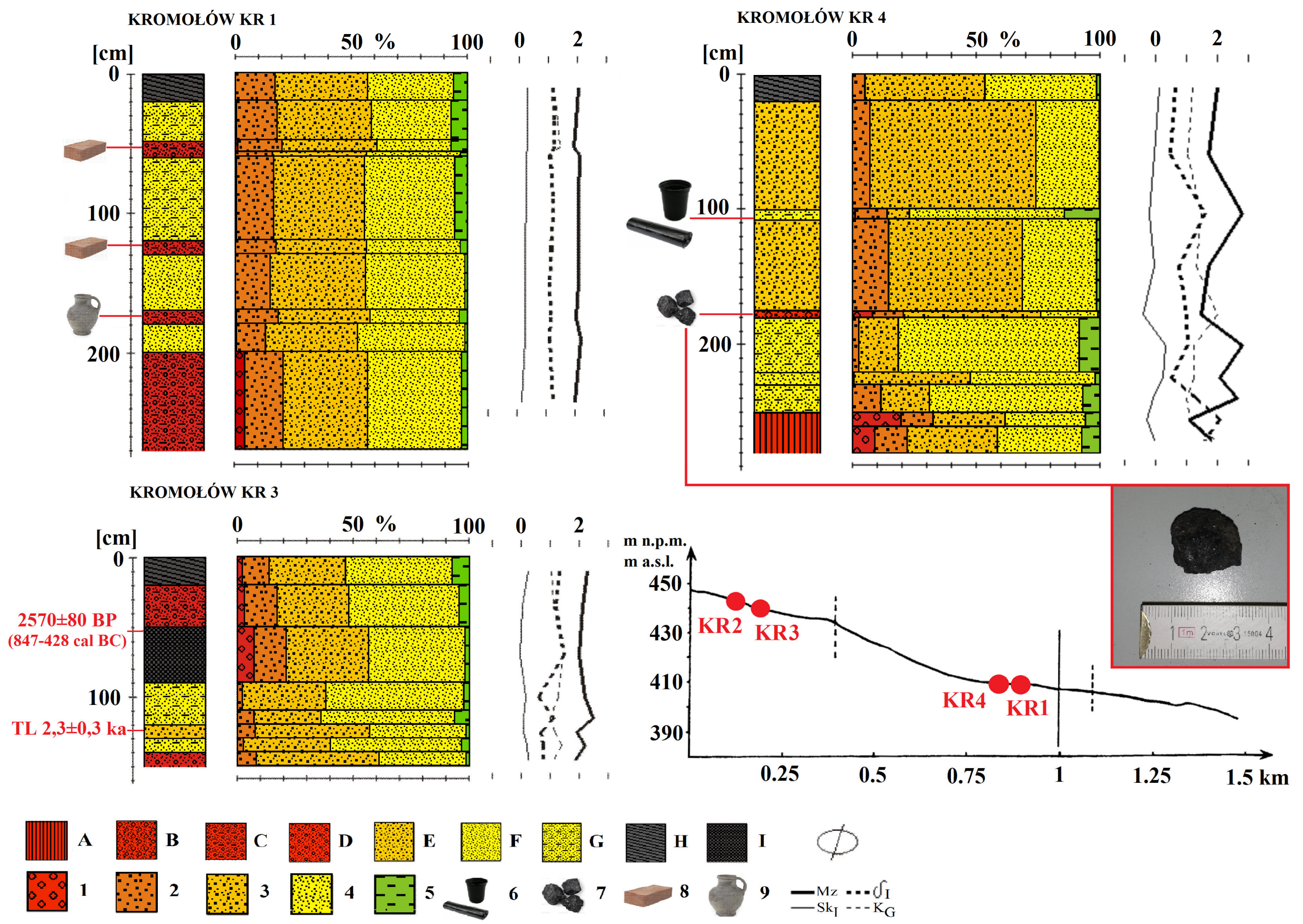

Figure 4. Longitudinal profile of eastern valley with location of study outcrops. Grain size composition and Folk-Ward's distribution parameters of deposits. 1 – weathering cover; 2 – sands with gravels; 3 – silty sands with gravels; 4 – sands with single gravels; 5 – medium sands; 6 - fine sands, 7 – silty sands; 8 – soils; 9 – buried soils; Fractions: 10 – gravel and rock fragment (below -1φ); 11 - coarse sand (-1 to 1φ), 12 - medium sand (1 - 2φ), 13 - fine sand (2 - 4φ), 14 – silt and clay (above 4φ); 15 – plastic garbage (pots, bags); 16 – coal fragments; 17 – brick fragments; 18 – pottery fragments; Folk-Ward's parameters: Mz – average diameter, δ_I – standard deviation, Sk_I – skewness, K_G – kurtosis

favors the presence of foxes, whose large population significantly affects the transformation of incised, dry riverbed dissecting the thalweg. Foxes create numerous and sizable zoogenic forms. Fox burrows dug into the edge of the channel facilitate bank erosion and promote the channel expansion, while the zoogenic mounds of deposits piled up against dens dam up and direct the stream. At the same time, it is a very large source of material that can be transported to lower-lying sections.

Alluvia of the valley bottom of this section is characterized by outcrop KR3, made near the profile KR2 in 1.5 m high edge of the ephemeral channel (Figures 1 & 4). In the lower part, loamy waste had a width of more than 17 m and depth 2-3 m and the accumulation of sediments reached 2 m. In contrast, at the foot of the slope water has left an extensive deluvial cover whose thickness reached 40 centimeters (Zieliński 1997, 1998a, b).

In KR3 profile on waste cover with fragments of limestone up to 20 - 30 cm occurs a series of sands (fine and medium sands, well and moderately sorted). It was TL dated at 2,300±300 ka (KIE-845). Above lies thick (about 40 cm), buried humus horizon (buried soil), whose the top was radiocarbon dated at 2,570±80 BP (847 - 428 cal BC) (MKL-2,252). Buried soil was covered by distinct coarser deposits (coarse sand 15-20%, gravel few percent) moderately sorted with the normal sequence (fining upward). This may indicate the one hand, the increase in flow dynamics (coarser deposits), while on one phase fossilized soil (normal sequence).

In KR1 and KR3 profiles are observed a significant accumulation of some trace elements and arsenic. It can be connected with pollution migration from Zawiercie area as metallurgy, mining center and also due to transport communication. Presence of Zn and Pb in profile may be caused by close vicinity of Zawiercie I, II Zn-Pb ore deposits. This dependence is visible the most in the case of the high concentration of As, Cu, Ni, Zn and Pb in KR3 profile and of Zn in KR1 profile, in topsoil especially. An increased content of mentioned metals in deeper levels is probably associated with the character of bedrock or elements moving into profiles. Those heavy metals contamination are detected to the 2.7 m depth in KR1 profile and 1.5 m in KR3 profile.

5.2 Middle section

This section with the largest average slope (2° 30') saw the deepest incision and the widest bank erosion during the flash flood. Sandy bars up to 2 m high were accumulated inside the cut and slightly sinuous bed (Zieliński 1997, 1998a, b) (Figure 5).

At present the bottom of periglacial, fluvio-denudational valley in this section is cut deep (up to 3 m), slightly sinuous, ephemeral bed with flat bottom, turf and partly forested (Figure 6). Within its well visible are accumulational bars from flash flood of 1996. Profile KR4 is located on this form (Figures 1 & 4). Sandy deposits with a thickness about 2.5 m lie on limestone waste cover. Within them we can distinguish three members. The lower member, probably older, make fine and medium sands involving the finer fraction up to 10%. Alternation of coarser and finer layers of sediments, well and moderately sorted suggests that they were deposited in two phases. Both higher members are made of coarser sediments (distinct domination of medium sands) and have a normal sequence (fining upward). Their accumulation refers to two flash floods of 1996. Fragments of coal were found in the gravely-sandy lag layer in the bottom of the middle member (depth 1.8 m), while pieces of plastic waste (fertilizer empty bags, pots) occur in its upper part (depth 1.0 m), which confirms a very young age of these deposits.

Figure 5. Sandy bar in middle section of the eastern valley accumulated during flash flood in 1996

Figure 6. Bed of ephemeral stream with vegetation cover in middle section of eastern valley (condition in 2014)

Profile KR1 has been made on about 3-meter high edge of the ephemeral channel dissecting the bottom of the fluvio-denudational valley and deposits fill the periglacial form (Figures 1 & 4). On loamy waste with limestone fragments lies a series of sands (varigrained sands, moderately sorted) with some sandy layers (3 - 10 cm thick) with limestone fragments size up to 2 - 30 cm. There are lag deposits at depths of 1.8, 1.3 and 0.6 m. In addition, in the lowest layer fragments of modern ceramic (17th - 18th c.), and in the two higher fragments of bricks were found. Data obtained from Archaeological Map of Poland (AZP) confirm the existence only a few archeological sites from this age in the study area. All this indicates that at first at least four phases of accretion of torrential alluvia occurred in the last centuries and then the thalweg was cut.

5.3 Lower section

In the lower section Kromołów accumulation reaches up to 0.5 m in thickness (Zieliński 1997, 1998a, b). These deposits were removed immediately after each flood wave and the evidence was destroyed. Only on the facades of houses along the Staromiejska street to this day are visible traces of the height (about 2 m) to which the flood wave rose.

In contrast to the eastern valley, where only the lower section is made of concrete channel, the north valley has been completely anthropogenically transformed over the last 20 years. In its middle section were built three large dams with retention reservoirs, which should effectively prevent the occurrence in this valley form of further flash flooding events.

6 Discussion and Conclusions

The Pleistocene fluvio-denudational valleys (dells) are typical of Polish Uplands, formed under periglacial conditions and modified during the Holocene. The transformation of the upper part of the eastern valley began in the beginning of Subatlantic, first through the sediment accretion in the bottom (TL dating 2,300±300 ka), and then through the incision caused by headward erosion, which is documented by the buried soil radiocarbon dated at 2570±80 BP, cal. 847 - 428 BC. Data obtained from Archaeological Map of Poland (AZP) does not confirm prehistoric settlements in the study area, but this could be due to the intense soil erosion. The proof of anthropogenic influences is in the thick (about 3 m) series of deposits with the fragments of the seventeenth and eighteenth century ceramics, which were found in the middle section of the valley. The structure and texture of these deposits indicates that they were accumulated in several phases during flash floods, which are a major morphogenetic factor in the Holocene. This is confirmed by results of erosion and accumulation processes of such events in 1996. Repeatability of these catastrophic events confirms previous and later flash floods that occurred here in 1912 and 2014, respectively.

After almost twenty years forms and deposits of flash floods from 1996 are preserved only in the middle section of the valley, while in the upper and lower ones all evidence has been anthropogenically removed. However, they document, very well the scale of catastrophic events. During duration of flash flood (a few hours) a thickness of 2 m may be accumulated. These accumulations are not redeposited or destroyed for decades, and they are only overgrown by vegetation.

Hydrotechnical investments (dams, reservoirs) built in the northern valley only partially protect against further flash floods in Kromołów. To guarantee the safety of the local people a similar investment should be made in the eastern valley.

Acknowledgments

We would like to express our sincere words of gratitude to all anonymous reviewers for their concerted efforts at assessment of manuscripts submitted to International Journal of Geohazards and Environment.

References

Baker, V.R., R. Craig Kochel and P.C. Patton, 1988. Flood Geomorphology. Wiley, Chichester.

Ballesteros-Cánovas, J.A., B. Czajka, K. Janecka, M. Lempa, R.J. Kaczka and M. Stoffel, 2015. Flash floods in the Tatra Mountain streams: frequency and triggers, Science of the Total Environment, **511**: 639 - 648.

Bednarek, J., H. Kaziuk and T. Zapaśnik, 1978. Szczegółowa Mapa Geologiczna Polski, Arkusz Ogrodzieniec, Wydawnictwa Geologiczne, Warszawa

Ciupa, T., 1996a. Geomorfologiczne Skutki Katastrofalnego Opadu Deszczu na Wyżynie Miechowskiej w Dniu 15 września 1995 r. Mat. Symp. Nauk. Budowa Geologiczna Niecki Nidziańskiej, Bocheniec. Oct 24 - 25, 1996.

WSP Kielce.
Ciupa, T., 1996b. Wpływ nawalnego opadu deszczu w dniu 15 września 1995 roku na przekształcenie rzeźby lessowej w górnej części zlewni Nidzicy (Wyżyna Miechowska). Prace Instytutu Geografii WSP w Kielcach, **1**: 185 - 195.
Cebulak, E. and Niedźwiedź T., 1998. Ekstremalne zjawiska opadowe w dorzeczu Górnej Wisły w latach 1995-1996. In: Starkel, L. (ed.), Geomorfologiczny i sedymentologiczny zapis lokalnych ulew. Dok. Geogr. 11. Polska Akademia Nauk., Wrocław
Czyżowska, E., 1996. Skutki geomorfologiczne i sedymentologiczne gwałtownej ulewy w dolinie Kalinki 15 września 1995 r. (Wyżyna Miechowska). Przeg. Geol., **44**(**8**): 813 - 816.
Dwucet, K. and Z. Śnieżko, 1996. Redepozycyjna transformacja lessów i gleb po gwałtownej ulewie 15 września 1995 r. na Wyżynie Miechowskiej. Przegl. Geol., **44**(**8**): 790 - 792.
Gaume, E., V. Bain, P. Bernardara, O. Newinger, M. Barbuc, A. Bateman, L. Blaškovičová, G. Blöschl, M. Borga, A. Dumitrescu, I. Daliakopoulos, J. Garcia, A. Irimescu, S. Kohnova, A. Koutroulis, L. Marchi, S. Matreata, V. Medina, E. Preciso, D. Sempere-Torres, G. Stancalie, J. Szolgay, I. Tsanis, D. Velasco and A. Viglione, 2009. A compilation of data on European flash foods. Journal of Hydrology, **367**(**1-2**): 70 - 78.
Gilewska, S., 1972. Wyżyny Śląsko-Małopolskie In: Klimaszewski, M. (ed), Geomorfologia Polski t. 2. PWN, Warszawa.
Gliński, P. And J. Przesmycki, 2011. Wpływ erozji wodnej na krajobraz. Teka Kom. Arch. Urb. Stud. Krajobr., OL PAN.
Jóźwiak, M. and A. Skrzypczak, 1996. Ocena erozji wodnej gleb w zlewni rzeki Kalinki na tle warunków przyrodniczo-gospodarczych. In: Józefaciuk, A. (ed), Ochrona agroekosystemów zagrożonych erozją, Wyd. IUNG Puławy.
Kalicki, T., A. Zieliński, P. Przepióra, Ł. Podrzycki and S. Chwałek, 2014. Morphology and sediments of flash flood near Kromołów (southern Poland) after 18 years. In: Uhlířová, H., J. Březina and V. Káňa (eds.), Kvarter. Sbornik abstrakt 20. Brno: 29p.
Kalicki, T., A. Zieliński, P. Przepióra, Ł. Podrzycki, S. Chwałek and M. Frączek, 2015a. Holocene Transformation of Periglacial Valleys of Polish Uplands: Case Study from Silesian Upland (S-Poland). Gradualism vs Catastrophism in Landscape Evolution, Extended Abstracts of Regional Conference IAG, July 2 - 4, 2015. Barnaul: 162p.
Kalicki, T., A. Zieliński, P. Przepióra, Ł. Podrzycki, S. Chwałek and M. Frączek, 2015b. Sediments and Morphology of Flash Flood near Kromołów (southern Poland) after 18 Years. Abstract and Programme Book of 2nd Disaster Risk Reduction Conference, October 15 - 16, 2015. Warszawa: 33p.
Kalicki, T., A. Zieliński, P. Przepióra, Ł. Podrzycki, S. Chwałek, M. Frączek and I. Olszak, 2015c, Holoceńskie zmiany cyklu erozyjno-akumulacyjnego koło Kromołowa (woj. śląskie) i ich wpływ na stopień zachowania stanowisk archeologicznych. Abstrakty XIX Śląskie Sympozjum Archeologiczne/International Conference, May 27 - 29, 2015. Wrocław: 12p.
Kondracki, J., 1994. Geografia Polski, Mezoregiony Fizyczno-Geograficzne. PWN, Warszawa: 364p.
Lóczy, D., S. Czigány and E. Pirkhoffer, 2012. Flash flood hazards. In: Kumarasamy M. (ed), Studies on Water Management Issues. Tech, Rijeka: 27 - 52p.
Marchi, L., M. Borga, E. Preciso and E. Gaume, 2010. Characterisation of selected extreme flash floods in Europe and implications for flood risk management. Journal of Hydrology, **394**(**1-2**): 118 - 133.
Maruszczak, H., 1986. Tendencje sekularne i zjawiska ekstremalne w rozwoju rzeźby małopolskich wyżyn lesowych w czasach historycznych. Czas. Geogr., **57**(**2**): 271 - 282.
Paszyński, J. and T. Niedźwiedź, 1991: Klimat. In: Starkel, L. (ed.), Geografia Polski. Środowisko przyrodnicze. Wyd. Naukowe PWN, Warszawa
Rodzik, J., 1984. Natężenie Współczesnej Denudacji w Silnie Urzeźbionym Terenie Lessowym w Okolicy Kazimierza Dolnego. Przewodnik Ogólnopolskiego Zjazdu PTG, Lublin 13-15.IX.1984, vol. **2**.

Starkel, L., 1986. Rola zjawisk ekstremalnych i procesów sekularnych w ewolucji rzeźby (na przykładzie fliszowych Karpat). Czas. Geogr., **57**(**2**): 203 - 213.

Szymański, B. and L. Teller, 1998. The Silurian stratigraphy of the Zawiercie-Żarki area (NE margin of the Upper Silesian Coal Basin). Ceological Quarterly, **42**(**2**): 183 - 200.

Zieliński, A., 1997. Katastrofalne Skutki Gwałtownych Opadów Deszczu w Okolicach Kromołowa (dzielnica Zawiercia) w Maju 1996 r. 46 Zjazd PTG, Rynia nad Zalewem Zegrzyńskim, Sept 18 - 21, 1997. 92 - 95p.

Zieliński, A., 1998a. Erozja gleb w rejonie Zawiercia spowodowana nawalnymi opadami burzowymi w maju 1996 roku. IV Zjazd Geomorfologów Polskich, UMCS, Lublin, June 3 - 6, 1998. 203 - 210p.

Zieliński, A., 1998b. Geomorfologiczne skutki zdarzeń powodziowych w okolicach Kromołowa w maju 1996 roku. In: Starkel, J. (ed.), Geomorfologiczny i Sedymentologiczny Zapis Lokalnych Ulew. Dok. Geogr. IGiPZ PAN, **11:** 39 - 44.

Ziętara, T., 1968. Rola Gwałtownych Ulew i Powodzi w Modelowaniu Rzeźby Beskidów, Prace Geogr. Inst. Geogr., PAN, **60**. Warszawa, Wyd. Geol.