CHANGES IN TEXTURAL AND GEO-CHEMICAL FEATURES OF ALLUVIA IN THE WESTERN PART OF THE LUBLIN UPLAND OVER THE PAST 1000 YEARS

Wojciech Zgłobicki

Maria Curie-Sklodowska University, Department of Geology and Lithosphere Protection, Lublin, Poland

Magdalena Ryżak, Andrzej Bieganowski

Polish Academy of Sciences, Institute of Agrophysics, Lublin, Poland

Manuscript received: November 24, 2009
Revised version: February 21, 2011

Zgłobicki W., Ryżak M., Bieganowski A., 2011. Changes in textural and geo-chemical features of alluvia in the western part of the Lublin Upland over the past 1000 years. *Quaestiones Geographicae* 30(1), Bogucki Wydawnictwo Naukowe, Poznań, pp. 123–132, 6 Figs., 3 Tabs. ISBN 978-83-62662-39-5. ISSN 0137-477X. DOI 10.2478/v10117-011-0012-2.

Abstract. In the study the authors analysed the diversity of the textural indices and selected geo-chemical features of sediments that accumulated in the bottoms of valleys in the western part of the Lublin Upland over the past 1000 years. Detailed studies were performed for six profiles with known stratigraphy. The sediments studied varied little in terms of textural features, with a general trend for particle diameters to increase as the depth increased. The characteristics of the sediments indicate a significant role of material supply from the slope systems (mainly gullies) to the bottoms of river valleys. The heavy metal content was characterised by greater vertical variation. In most of the profiles, the youngest deposits were characterised by greater levels of Cd, Cu, Pb and Zn, with enrichment indexes at an average of 1.5–2.5. The observed diversity of the features of sediments, particularly the geo-chemical features, should be attributed to the effect of human activity in the area studied.

Keywords: alluvia, geochemistry of sediments, human impact, E Poland.

Wojciech Zgłobicki, Maria Curie-Sklodowska University, Department of Geology and Lithosphere Protection, Kraśnicka 2cd, 20-718 Lublin, Poland, e-mail: zglobek@hektor.umcs.lublin.pl

Introduction

The last 1000 years have been a period of fundamental changes in the environment of the western part of the Lublin Upland (Maruszczak 1988) as well as other parts of Poland (Klimek 1996). A marked increase in human pressure on the environment of the Lublin Region began in the 10th century. There was a tendency towards the stabilisation of settlement, and the number of archaeological findings dating back that period is significant. Progressing deforestation resulted in the increased dynamics of geomorphologic processes in slope systems. There was a clear increase in the intensity of gully erosion constituting the primary source of material supply to river valleys and fluvial systems (Maruszczak 1973, 1988; Jezierski 1981; Buraczyński 1989/1990; Superson *et al.* 2003). According to many authors, most of the present-day gullies have originated within the last 1000 years (Maruszczak 1973, Zgłobicki & Baran-Zgłobicka 2011). Factors conducive to dynamic morphogenetic processes in slope systems in the western part of the Lublin Upland include the occurrence of easily erodible loess formations, considerable relative relief, and a dense network of dry valleys. The processes mentioned above should also be reflected in the features of sediments filling the bottoms of river valleys in the western part of the Lublin Upland. The main objective of the study was to estimate changes in selected textural and geo-chemical parameters of deposits accumulated over the last 1000 years. The second important goal was to evaluate the human impact on those parameters.

Method and area of the study

The study focused on the valleys of four small rivers: the Bystra, Wyżnica, Kurówka and Bystrzyca (western part of the Lublin Upland). Six alluvial profiles were chosen for detailed analysis (Fig. 1). The profiles analysed were usually 200 cm thick, but in two cases their thickness was 400 and 500 cm. The vertical scope of the sediments under study depended on the structure of the profile. The bottoms of the profiles analysed usually consisted of peat layers or contained material available for radiocarbon dating. The continuous sediment cores were then divided into sections of 10 cm in length. 150 samples were analysed in terms of their textural and geochemical parameters. Based on radiocarbon dating results, the sediments in the profiles were divided into three groups: (a) sediments older than 1000 years; (b) sediments younger than 1000 years; (c) present-day sediments (0–10 cm) (Fig. 2).

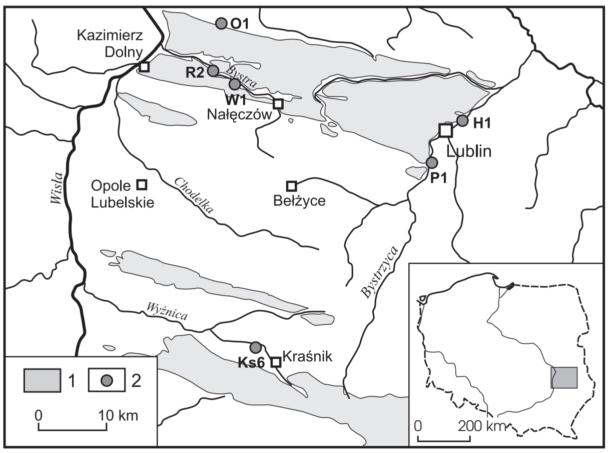

Fig. 1. Location of profiles studied
1 – loess covers, 2 – profiles studied

The particle size distribution was determined using a laser analyser, the Malvern Mastersizer 2000 (Institute of Agrophysics, PAS). The mineralisation of samples was conducted using nitrohydrochloric acid, according to the ISO 11466/2002 method. Zinc, cadmium, copper and lead were determined by means of ASA technique (Spectr AA 880 Varian, Analytical Laboratory, MCSU). Heavy metal content was determined in the < 0.2 mm fraction according to the methodology proposed for water sediments by Bojakowska and Sokołowska (1998).

The bedrock in the western part of the Lublin Upland is composed of lithologically varied

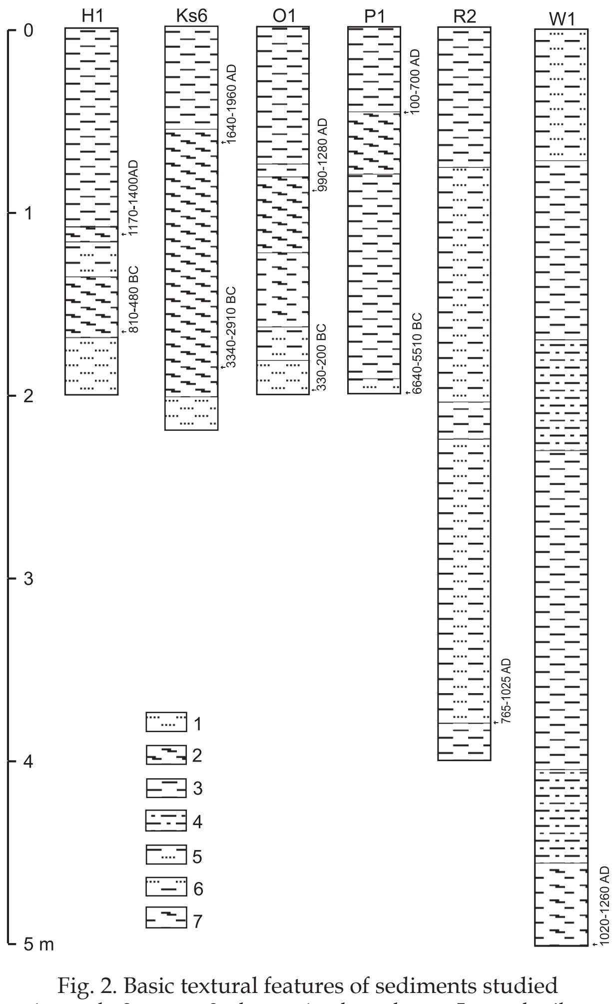

Fig. 2. Basic textural features of sediments studied
1 – sands, 2 – peats, 3 – loams, 4 – clayey loams, 5 – sandy silts, 6 – silty sands, 7 – organic-mineral sediments

carbonate and silica-carbonate rock layers dating back to the Upper Cretaceous and Palaeocene periods, covered with Tertiary and Quaternary formations. Quaternary deposits (glacial, fluvioglacial, periglacial and fluvial formations) have developed as sands, loams, clays and river gravels. In the Nałęczów Plateau and the Urzędów Hills patches of thicker loess covers occur. Loams, sands and peats occur in the bottoms of river valleys. Old river channels in the bottoms of valleys are relatively scarce due to their intensive filling with products of soil erosion within the catchment. The average depth of river channel incision into the flood plain ranges from 2 to 3 m.

The first more intensive anthropogenic changes in the environment of the western part of the Lublin Upland began with the appearance of agricultural Neolithic cultures. A particularly strong human impact was related with the Funnel Beaker Culture, 3700–2900 BC. Another increase in the pressure on the environment occurred in the early Middle Ages, between the 8th and 13th century (Hoczyk-Siwkowa 1999; Nogaj-Chachaj 2004). The 14th century saw the development of settlements under Magdeburg Law as well as the emergence of strip-fields with long strips of land stretching the bottoms of valleys towards the hilltops. It was then that the permanent deforestation of loess-covered areas began. The pattern of fields visibly affected the appearance and development of the gully systems. The final phase of intensified changes to the landscape, *i.e.* the reduction of forest areas and increase of arable lands, was related to the industrial revolution and took place in the 19th and 20th centuries (Maruszczak 1988).

Results

Characterisation of the profiles

Profile H1 is located within the flood plain of the Bystrzyca river valley, 20 m from the convex section of the river channel (downstream of Hajdów). At that point, the bottom of the valley is about 900 m wide, and the slopes of the valley, approx. 30–40 m in height, are asymmetrical: the left-hand slope is steep, while the right-hand one is very gentle. The upper part of the profile (0–105 cm) is composed of dark-grey loams, slightly clayey in the lower part. Underneath, two peat layers were found (105–110 cm and 135–170 cm), separated by a layer of medium sand. The bottom part of the profile (180–200 cm) is composed of fine sand (Fig. 2).

Profile Ks–6 lies in the bottom of the Wyżnica valley, approx. 10 m from the river channel. The upper part of the profile (0–55 cm) is composed of grey-brown loams, while sediments of a mineral-organic character occur in the bottom of this layer. The lower part (55–200 cm) consists of partially decomposed sedge-moss peat. The bottom of the profile (200–220 cm) contains grey-brown sand (Fig. 2).

Profile O–1 is located on the flood plain of Kurówka river, at a locality called Opoka, approx. 100 m from the active river channel. In the 19th and early 20th century a pond existed at the site. At present, the bottom of the valley is used as a meadow. The upper part of the profile (down to the level of 75 cm) is composed of grey-brown loams. Beneath those there is a layer of organic-mineral sediment overlying a layer of black well-decomposed peat (85–120 cm). The bottom part of the profile consists of dark-grey mineral-organic sediment (120–160 cm), and the bottom contains sandy loams (180–200 cm).

Profile P1 is located within the extensive bottom of the Bystrzyca river valley, near a locality called Prawiedniki, approx. 100 m west of the river channel. At this point the bottom of the valley is approx. 600 m wide; the right-hand bank of the valley is short and steep, while the left-hand one is long and gentle. In the top of the profile there is a grey-brown humus horizon underlain by grey loams and, further below, well-decomposed peats. The main part of the profile (75–200 cm) is composed of grey loams (slightly clayey), with local interbedding of black organic-mineral sediment (Fig. 2).

Profile R2 is located in the bottom of the Bystra river valley, in the vicinity of Rąblów. The profile is located 20 m from the river channel of the Bystra. The upper part of the profile, down to the level of 60 cm, consists of brown loams (colluvia). Further below (60–400 cm), there are grey sandy loams with local sandy interbeddings. The overall depth of the profile is 400 cm.

Profile W–1 is located within the flood plain of the Bystra, 10 m from the river channel. The sedi-

Table 1. Radiocarbon dating results (after Zgłobicki 2008)

Profile	Depth of sample [cm]	Material subject to dating	Code of sample	Calibrated age (95%)
H-1	110	peat	Gd-19035	50–420 AD
H-1	170	peat	Gd-12965	810–480 BC
Ks-6	70	peat	Gd-19037	1640–1960 AD
Ks-6	190	peat	Gd-12963	3340–2910 BC
O-1	90–95	peat	Gd-19036	990–1280 AD
O-1	195	wood	GdA-1017	330–200 BC
P-1	55–60	organic loam	Gd-16453	100–700 AD
P-1	200	wood	GdA-1018	5640–5510 BC
R-2	370	wood	Gd-17463	765–1025 AD
W-1	500	peat	Gd-19038	1020–1260 AD

ments analysed constitute fan sediments modelled by fluvial processes. The upper part of the profile (down to the level of 50 cm) is composed of black-grey (humus) and red-grey loams. Further below, down to the level of 300 cm, there are grey loams underlain by less compacted loams with organic and sandy interbedding. The lower part of the profile (450–480 cm) consists of black/dark-brown organic loams, while the bottom of the profile contains peats (Fig. 2).

Table 1 presents the chronology of the profiles analysed. The radiocarbon dating results indicate a considerable diversity of the sedimentation rate in the profiles under study. The thickness of sediments deposited over the past 1000 years has ranged from 50 to 500 cm, usually reaching 70–90 cm (Fig. 2).

Textural indices

During the past 1000 years, within the bottoms of the studied river valleys, there occurred the sedimentation of mineral deposits, *i.e.* loams, sandy silts and silty sands (the coarse silt fraction of 0.01–0.05 mm predominated, representing an average of 60% of particles). In the profiles studied, regularity was observed in the vertical distribution of the textural indices. However, the range of variation of the parameters analysed was small. Older sediments were characterised by a larger mean diameter of particles, from 2 to 4 Φ (sand), while in the upper parts of the profiles (younger than 1000 years) the mean diameter was 5–6 Φ, which is typical of loesses and loess colluvia (Fig. 3). A certain variation was also observed in the case of standard deviation (sorting index). In the lower part of the profiles the sorting was very weak (2–3), while in the younger sediments it was weak or very weak (1–3). Weak sorting corresponds to variable dynamics of the environment. It is characteristic of situations where the material was transported only on a short distance, and the areas of deposition are located close to the zones of sediment supply. Such a situation occurs, for example, in the case of slope sediments (Racinowski *et al.* 2001).

Geochemical indices

For the last 1000 years, increased heavy metal content in sediments was found in practically all profiles studied. The rate of increase in heavy metal concentration depended on the location of the profile relative to significant sources of contamination, mainly larger towns (see profiles H1, O1). Smaller changes were observed in the case of cadmium and zinc. In all profiles studied, the concentration of metals decreased with depth (Figs. 4 and 5). It should be emphasized that values clearly exceeding the geochemical background were obtained only in the case of samples from the surface horizons (0–10 cm). The coefficients of enrichment during the period under study (ratio of concentration in the top of the profile to that in the bottom dated within the last 1000 years) were

Table 2. Coefficients of sediment enrichment in heavy metals in the profiles studied (ratio of concentration in the top of the layer aged 1000 years to that in the bottom)

	H1	O1	Ks6	P1	R2	W1
Cd	1.9	2.3	2.0	-	-	-
Cu	2.6	1.8	10.1	2.0	1.5	1.4
Pb	2.2	1.5	3.2	1.4	2.5	3.1
Zn	1.6	0.7	2.2	1.5	1.4	2.4

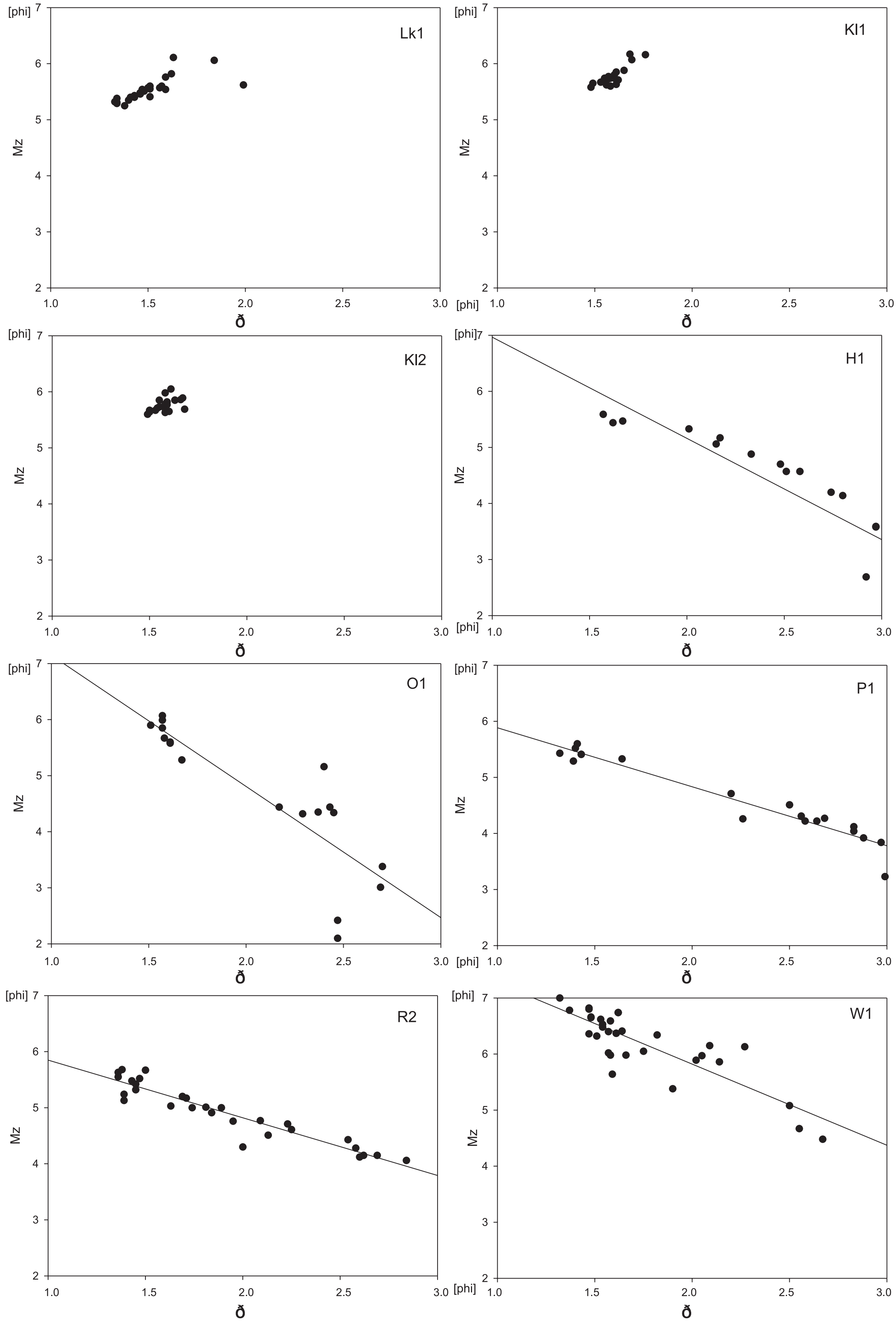

Fig. 3. Relationships between standard deviation and mean particle diameter
Lk1 – loess profile, Kl1, Kl2 – colluvial profiles (data after Zgłobicki 2008)

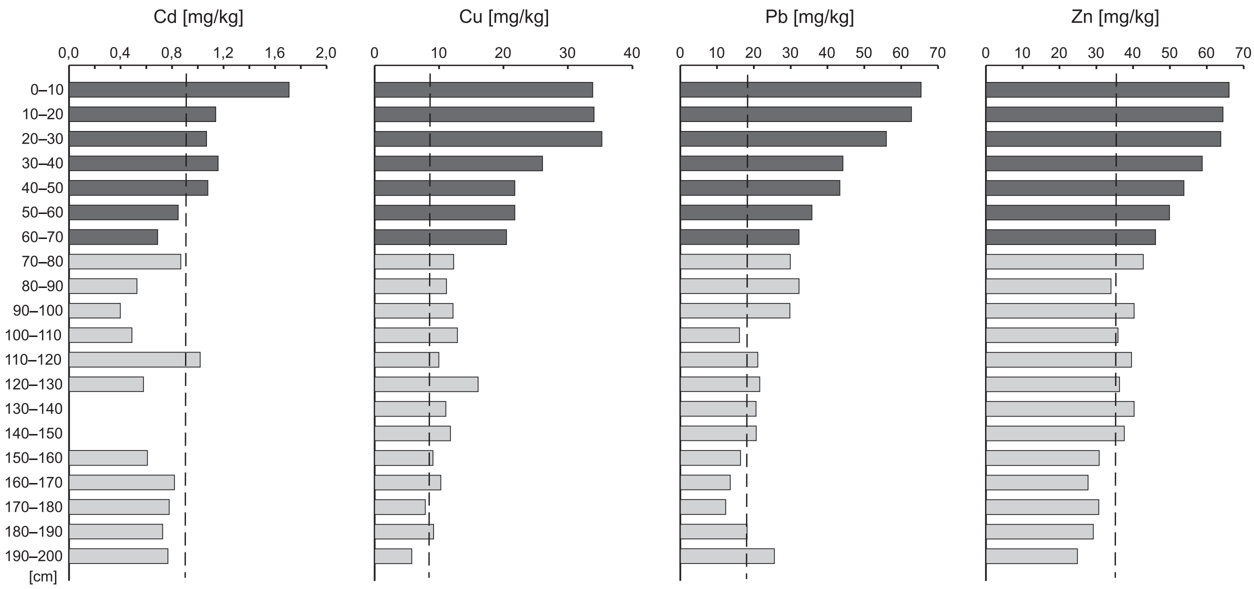

Fig. 4. Vertical variation in Cd, Cu, Pb and Zn concentration in profile H1 (the dashed line denotes the geochemical background values; the darker bars denote sediments aged up to 1000 years) (source data after Zgłobicki 2008)

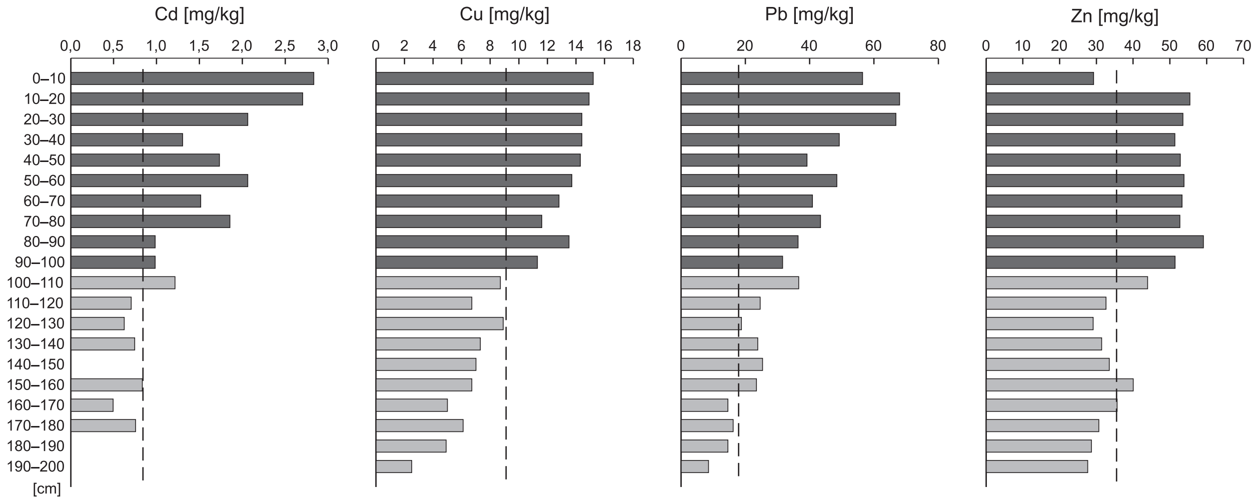

Fig. 5. Vertical variation in Cd, Cu, Pb and Zn concentration in profile O1 (the dashed line denotes the geochemical background values; the darker bars denote sediments aged up to 1000 years) (source data after Zgłobicki 2008)

as follows: Cd 1.9–2.3, Cu 1.4–2.6, Pb 1.4–3.1 and Zn 0.7–2.4 (Tab. 2). The coefficient was considerably higher (10) in the case of copper in profile Ks6. The heavy metal concentration in sediments older than 1000 years corresponded fairly well with values characteristic of the geochemical background (Figs. 4–5). The background values were adopted after Zgłobicki *et al.* (2011): Cd – 0.7 mg kg^{-1}, Cu – 9 mg kg^{-1}, Pb – 19 mg kg^{-1}, Zn – 35 mg kg^{-1}.

Discussion

In loess areas, sediments filling the bottoms of small river valleys have the character of massive loams (yellow loam sub-facies), usually referred to as young alluvial loam, loess alluvial loam, mineral alluvial loam (Śnieszko 1995, Michno 2004). They are formed by sediments related to fluvial accumulation as well as by colluvial-proluvial sediments. In view of the low lithological variation of those sediments, and given the relatively short-distance transport of the eroded ma-

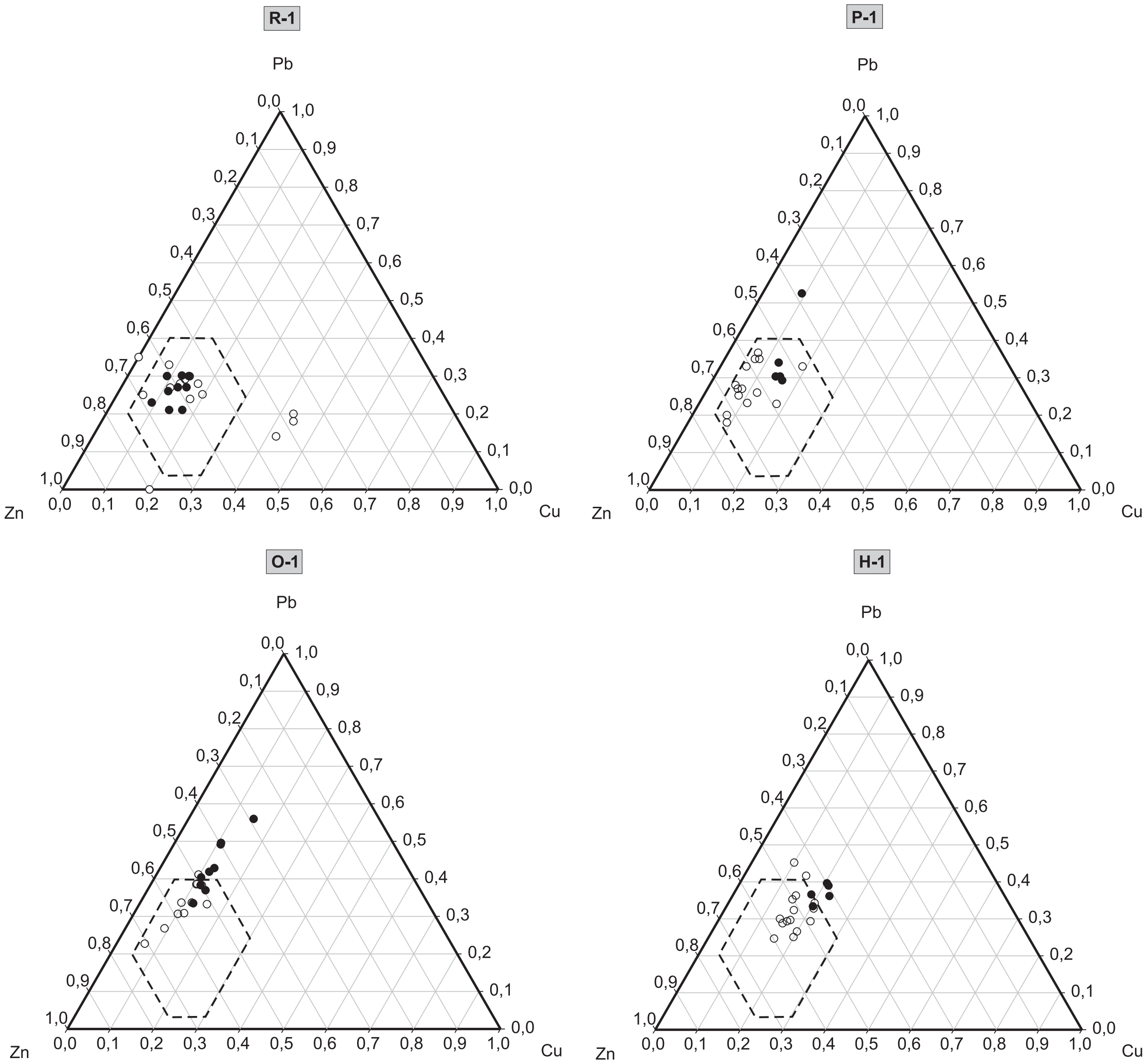

Fig. 6. Mutual relationships of Cu, Pb and Zn concentrations in four profiles (area within the dashed line denotes natural values; dark points relate to sediments aged up to 1000 years) (source data after Zgłobicki 2008)

terial, their genetic identification is difficult (Jezierski 1981). In his study on sediments filling the valley of the Sancygniówka river, Śnieszko (1985) goes as far as to state that the young alluvia are not a typical fluvial sediment as they have formed through an intensive supply of material from gullies developing within the catchment. It should also be stated that medium and fine-grained sands occur locally in the bottoms of larger river valleys intersecting areas with a greater diversity of cover formations in the western part of the Lublin Upland.

The relationships between standard deviation (sediment sorting) and mean diameter of particles in the profiles studied are characteristic of environments with varied dynamics of the force transporting the sediment (system I) (Mycielska-Dowgiałło 1995). An increase in the mean particle diameter is accompanied by a lower degree of sediment sorting. Such a system is primarily characteristic of fluvial sediments of the river channel facies. However, Twardy (2003) and Smolska (2005) found that it may also occur in proluvial sediments (alluvial fans of gullies). Michno (2004), on the other hand, obtained a completely different relationship – system II *sensu* Mycielska-Dowgiałło (1995) for the youngest alluvial sediments in the bottom of the Nidzica River, which

Table 3. Variation of averaged textural and geochemical parameters of alluvia of selected rivers in the western part of the Lublin Upland

Parameter	Contemporary alluvia	Alluvia aged up to 1000 years	Alluvia older than 1000 years
Mean particle diameter [Φ]	5.2	5.9	4.5
Sorting index	1.9	1.7	2.3
Cd content [mg/kg]	0.8	0.3	0.4
Cu content [mg/kg]	14.7	10.7	6.8
Pb content [mg/kg]	32.4	16.0	20.0
Zn content [mg/kg]	42.9	34.7	34.0

flows across loess areas. A decrease in the mean particle diameter was accompanied by a lower degree of sediment sorting. The above difference may result from the lack of typical gullies in the studied section of the Nidzica catchment.

The data obtained indicate that during the past 1000 years, the conditions of sedimentation on the flood plains of rivers have changed only slightly. It should be noted, however, that several profiles show that for the Bystra river valley the 11th century was the time when the type of sedimentation changed from organogenic (peats) to mineral (Superson & Zgłobicki 2005, Zgłobicki & Rodzik 2007). The sediments that filled the studied valleys during the past 1000 years generally have limited diversity, particularly in areas with compact loess covers (profile R2). A slight decrease in mean particle diameter and minimally better sorting may indicate a modification of the source of material supply to the fluvial systems. This fact results from the intensive supply of gully erosion products (proluvia), among which the silt fraction dominates, to the bottoms of the river valleys. Similar conclusions are suggested by the results of the analysis of relationships between standard deviation and mean particle diameter (Fig. 3). The significant role of sediments related to slope systems in the structure of the bottom of the Bystra river valley was noted by Jezierski (1981). Sediments of this type form a continuous cover extending across the entire bottom of the valley, and their thickness varies from 3.0 to 3.5 m. They have the character of covers of slope formations extending across the entire width of the valley, and of gully erosion sediments in the form of alluvial fans. Summing up the considerations above, it should be stated that, as in the case other regions, the changes in sediment features that have occurred during the past 1000 years should be attributed primarily to the effects of human activity (Kosmowska-Suffczyńska 1983, Śnieszko 1985, Michno 2004, Klimek *et al.* 2006).

So far, the issue of the effect of human activity on the geochemistry of alluvia has been taken up mainly in relation to industrial or urbanized areas (Klimek 1996, Hudson-Edwards *et al.* 1997, Swennen & Van der Sluys 2002, Ciszewski & Malik 2003, Szwarczewski 2003). Considerably fewer studies have been devoted to agricultural lands (Roguszczak 2003, Zgłobicki & Rodzik 2007, Zgłobicki 2008). The mean level of changes in the geochemical features, though clearly identifiable in the vertical profiles, was not significant in terms of absolute values (Tables 2, 3). The observed decrease in heavy metal content with depth is typical of river valleys subjected to human impact (Ciszewski 1991, Klimek 1996). In the case of some profiles younger than 1000 years, the relationships between the concentrations of those metals differed from those accepted as natural (Weng *et al.* 2003), which may indicate anthropogenic contamination (Fig. 6). An analysis of trends in the changes in heavy metal concentration in sediments in the western part of the Lublin Upland over the past 10 000 years indicates that contemporary heavy metal concentrations are between 2.5 (Pb) and 15 times (Cd) higher than in the 10th century. In the case of lead and cadmium, the background levels were exceeded around the 10th–11th century (Zgłobicki 2008).

Conclusions

1. Over the past 1000 years, in the bottoms of the valleys studied, intensive accumulation of sediments occurred, among which a major role was played by material originating from slope systems (mainly gullies and dry valleys).
2. The range of textural changes was not significant. Smaller particle sizes were observed in the youngest sediments, and the degree of sorting of particles in the profiles was very low.
3. The relationship between the mean particle diameter and the standard deviation indicates

sedimentation environments characterised by considerable variability.

4. In a vast majority of the profiles studied, increased heavy metal content was observed in the youngest sediments.
5. The degree of sediment enrichment in heavy metals over the past 1000 years was not very high as it ranged from 150 to 300%.
6. Human activity should be viewed as the primary factor responsible for the changes in the textural and geochemical parameters of the sediments studied.

References

Bojakowska I. & Sokołowska G., 1998. Geochemiczne klasy czystości osadów wodnych. *Przegląd Geologiczny* 46: 49–54.

Buraczyński J., 1989/1990. Rozwój wąwozów na Roztoczu Gorajskim w ostatnim tysiącleciu (Development of the gullies in the Goraj Roztocze during the last millenium). *Ann. UMCS*, B, 44/45: 95–104.

Ciszewski D., 1994. Rozprzestrzenienie metali ciężkich w osadach dennych rzeki Chechło. *Przegląd Geologiczny* 2: 116–121.

Ciszewski D. & Malik I., 2003. Zapis XX-wiecznej historii zanieczyszczenia Małej Panwi metalami ciężkimi w jej osadach (Sedimentary record of the Mała Panew River pollution with heavy metals in the 20th century (southern Poland). *Przegląd Geologiczny* 51: 142–147.

Hoczyk-Siwkowa S., 1999. Małopolska północno-wschodnia w VI–X wieku. Struktury osadnicze. Wydawnictwo UMCS, Lublin.

Hudson-Edwards K., Macklin M., Taylor M., 1997. Historic metal mining inputs to river sediment. *The Science of the Total Environment* 194/195: 437–445, DOI 10.1016/S0048-9697(96)05381-8.

Jezierski W., 1981. Rola deluwiów w kształtowaniu współczesnego dna doliny Bystrej (Płaskowyż Nałęczowski). *Biuletyn LTN* 23: 67–73.

Klimek K., 1996. Aluwia Rudy jako wskaźnik 1000-letniej degradacji Płaskowyżu Rybnickiego. In: A. Kostrzewski (ed.). *Geneza, litologia i stratygrafia utworów czwartorzędowych t. II, UAM Seria Geografia* 57: 155–166.

Klimek K., Lanczont M., Nogaj-Chachaj J., 2006. Historical deforestation as a cause of alluviation in small valleys, subcarpathian loess plateau, Poland. *Regional Environmental Change* 6: 52–61, DOI: 10.1007/s10113–005–0008-3.

Kosmowska-Suffczyńska D., 1983. Wpływ działalności ludzkiej na tempo przyrostu aluwiów dolinnych i zmian w krajobrazie na przykładzie Czyżówki (Wyżyna Sandomierska). *Prace i Studia Geograficzne* 4: 69–78.

Maruszczak H., 1973. Erozja wąwozowa we wschodniej części pasa wyżyn południowopolskich. *Zesz. Probl. Post. Nauk Roln*. 151: 15–30.

Maruszczak H., 1988. Zmiany środowiska przyrodniczego kraju w czasach historycznych. In: L. Starkel (ed.). *Przemiany środowiska geograficznego Polski.* Wszechnica Polskiej Akademii Nauk, 109–135.

Michno A., 2004. Transformacja doliny dolnej Nidzicy w holocenie. IGiGP UJ, Kraków.

Mycielska-Dowgiałło E., 1995. Wybrane cechy teksturalne osadów i ich wartość interpretacyjna. In: E. Mycielska-Dowgiałło, J. Rutkowski (eds). *Badania osadów czwartorzędowych. Wybrane metody i interpretacja wyników.* Warszawa: 29–105.

Nogaj-Chachaj J., 2004. O roli człowieka w przekształcaniu środowiska przyrodniczego w holocenie na Płaskowyżu Nałęczowskim. In: J. Libera, A. Zakościelna (eds). *Przez pradzieje i wczesne średniowiecze.* Wydawnictwo UMCS, Lublin, 63–72.

Racinowski R., Szczypek T. Wach J., 2001. *Prezentacja i interpretacja wyników badań uziarnienia osadów czwartorzędowych.* UŚ, Katowice.

Roguszczak D., 2003. Zapis działalności człowieka w chemizmie osadów wypełniających paleomeander Wieprzy (Changes of chemical properties in sediment of Wieprza palaeomeanders as a result of anthropogenic activity). In: J. M. Waga, K. Kocel (eds.). *Człowiek w środowisku przyrodniczym – zapis działalności*. Sosnowiec: 179–186.

Smolska E., 2005: *Znaczenie spłukiwania w modelowaniu stoków młodoglacjalnych (na przykładzie Pojezierza Suwalskiego)* (Slope wash processes in late glacial area on example of Suwałki lake district). WGiSR UW, Warszawa.

Superson J. Jezierski W., Król T., 2003. Wpływ deforestacji Płaskowyżu Nałęczowskiego na rozwój osadów dna doliny Bystrej (The influence of the deforestation of the Nałęczów Plateau on sediment development in the Bystra river valley floor). In: J. M. Waga, K. Kocel (eds.). *Człowiek w środowisku przyrodniczym – zapis działalności.* Sosnowiec: 207–212.

Superson J. & Zgłobicki W., 2005. Rozwój holoceńskich stożków napływowych w dolinie Bystrej (Płaskowyż Nałęczowski). In: A. Kotarba, K. Krzemień, J. Święchowicz (eds.). *Współczesna ewolucja rzeźby Polski.* VII Zjazd Geomorfologów Polskich, Kraków, 19–22 września 2005. Kraków, 423–429.

Swennen R. & Van der Sluys J., 2002. Anthropogenic impact on sediment composition and geochemistry in vertical overbank profiles of river alluvium from Belgium and Luxembourg. *Journal of Geochemical Exploration* 75: 93–105, DOI 10.1016/S0375-6742(02)00199-1.

Szwarczewski P., 2003. Wybrane geochemiczne i teksturalne cechy osadów w dolinie Utraty jako efekt działalności człowieka – współczesnej i w przeszłości (Selected geochemical and textural characteristics of deposits in the Utrata valley as a result of past and contemporary anthropogenic activity). *Prace i Studia Geograficzne* 33: 83–92.

Śnieszko Z., 1985. Paleogeografia holocenu w dolinie Sancygniówki. *Acta Geographica Lodziensia* 51.

Śnieszko Z., 1995. Ewolucja obszarów lessowych Wyżyn lessowych w czasie ostatnich 15 000 lat (The loess cover evolution during the last 15 000 years in Polish Uplands). *Prace Naukowe UŚ* 1496. Katowice.

Twardy J., 2003. Cechy sedymentologiczne neoholoceńskich osadów stokowych na Wyżynie Łódzkiej i ich wartość interpretacyjna (Sedimentologic properties of neoholocene slope deposits in the Łódź Region and their value for interpretation). *Prace i Studia Geograficzne* 33: 25–44.

Weng H.-X., Hang X.-M, Chen X.-H., Wu N.-Y., 2003. The stability of the relative content ratios of Cu, Pb, Zn in soils and sediment. *Environmental Geology* 45: 79–85, DOI 10.1007/s00254–003–0859-1 .

Zgłobicki W., 2008. *Geochemiczny zapis działalności człowieka w osadach stokowych i rzecznych* (Geochemical record of human activity in slope and river sediments). Wydawnictwo UMCS, Lublin.

Zgłobicki, W. & Baran-Zgłobicka B., 2011. Gullies as an indicator of human impact on loess landscape (Case study: North Western part of Lublin Upland, Poland). *Zeitschrift für Geomorphologie* 55, Suppl. 1: 119–137, DOI:10.1127/0372-8854/2011/0055S1–0042.

Zgłobicki W., Lata L., Plak A., Reszka M., 2011. Geochemical and statistical approach to evaluate background concentrations of Cd, Cu, Pb and Zn (case study: Eastern Poland). *Environmental Earth Sciences* 62: 347–355, DOI 10.1007/s12665–010–0529-z.

Zgłobicki W. & Rodzik J., 2007. Heavy metals in slope deposits of loess areas of the Lublin Upland (E Poland). *Catena* 71: 84–95, DOI 10.1016/j.catena.2006.10.008