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

IJGE 2016 2(3): 190-207
Available at http://ojs.library.dal.ca/ijge

Technical Notes

# The Role of Catastrophic Events in Slope Transformation of the Forecarpathians During the Subboreal-Subatlantic: A Case Study of the Archaeological Site Brzezie 26 Near Cracow (Southern Poland)

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**Abstract**: The early Lusatian (about 1,300 - 1,100 BC) site in Brzezie 26 is located in the Niepołomice-Bielcza Upland, on the watershed undercut by a fluvio-denudational dry valley (dellen). Erosional relief on the Miocene clay is covered with the Quaternary loess. Luvisol (lessive soil) within the top layer of loess, on which the settlement was located, was covered with loess colluvium, with varying thickness (0.2 - 2.0 m). The colluvium could be distinguished in two members of different age, and accumulated in different sedimentological regime. The lower member, without clear sedimentological massive structures, lies on the "Neolithic-early Lusatian pottery pavement" within the top layer of luvisol. This member might have formed during the climatic phase dated to 3,200 - 3,000 BP, with clustering of catastrophic events well recognized in the upper Vistula basin and in the whole Central Europe. The upper member, with a small number of the early Lusatian, Medieval and early Modern pottery fragments, and very clear sedimentological structures, accumulated very quickly, probably during the Little Ice Age. The study results confirm that the biggest changes in loess relief in the upland occurred during the Subatlantic.

**Keywords**: Lusatian culture, Niepołomice-Bielcza Upland, colluvia, catastrophic events, geoarchaeology, middle bronze age

## 1 Introduction

### 1.1 Location and site description

The sites 1 & 26 at Brzezie was located within the Niepołomice-Bielcza Upland, which in terms of the physico-geographical regionalization of Poland is a part of the Sandomierz Basin, within the Forecarpathian Province (Czeppe and German 1979, 1980). With regard to the geomorphological regionalization, it is the Wieliczka-Gdów Upland, being a part of the mesoregion of the Eastern Forecarpathian Uplands and the macroregion of the Sandomierz Basin (Klimaszewski 1972) (Figure 1).

The geological basement of the site consisted of folded sediments of the Miocene clays of the Gdów Bay (Gradziński 1955), a considerable part of which was covered with thicker series of the Vistulian loess (Bluszcz and Pietrzak 2001) (Figure 2).

The upland relief of the area in question (low foothills) has Tertiary foundations. Hills and uplands, separated by valleys of small rivers, formed in the Quaternary, mostly through sheet wash, piping, leaching, landslide and creep, deflation and aeolian accumulation (loess), as well as fluvial erosion and accumulation at the

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DOI: 10.15273/ijge.2016.03.018

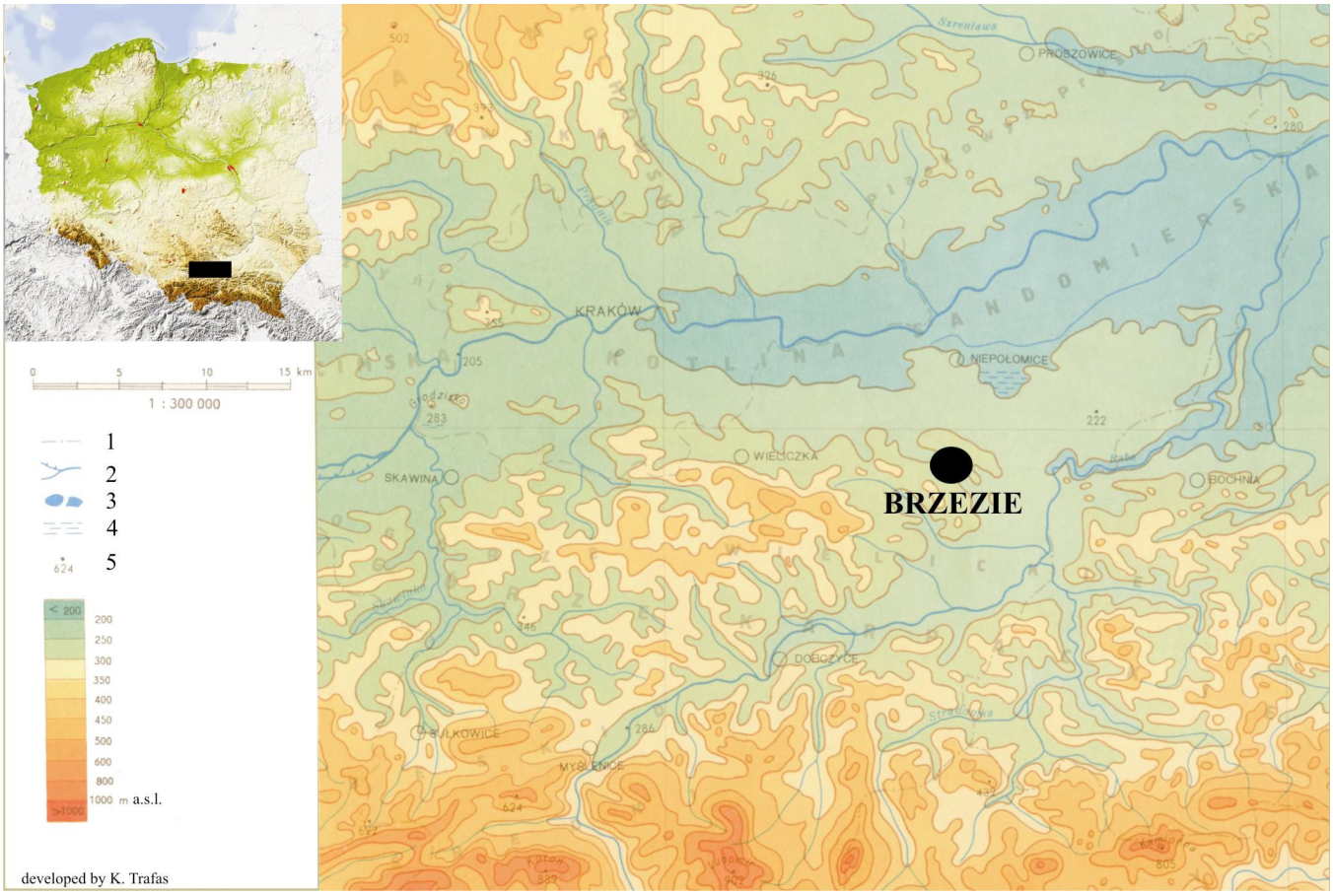


Figure 1. Location of research area (Atlas Województwa Miejskiego Krakowskiego 1979). 1 – voiewodship border, 2 – rivers and channels, 3 – lakes and ponds, 4 – bogs, 5 – height

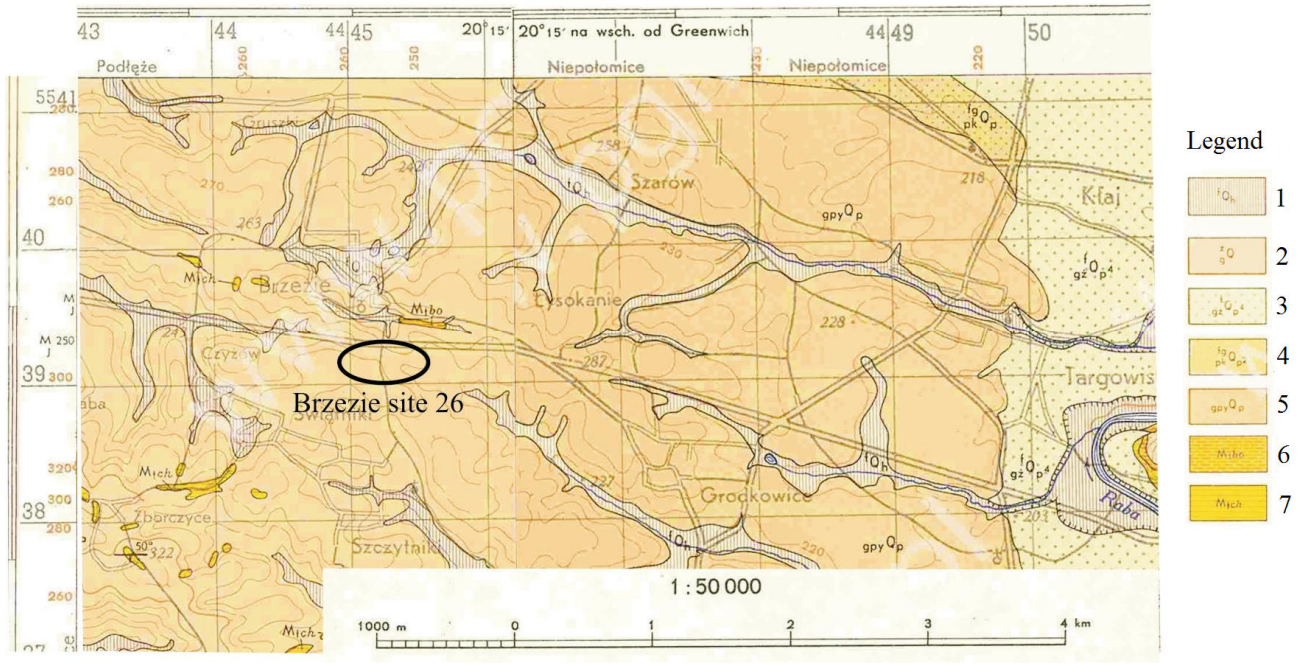


Figure 2. Detailed geological map of the area site 26 in Brzezie. 1 – Holocene alluvia of flood plain (gravels, sands, silts), 2 – Quaternary weathering cover, 3 – Vistulian alluvia of terraces (gravels and loams), 4 – San II glaciation - fluvioglacial sands, 5 – Quaternary loess-like deposits, 6 – Miocene sands (Bogucice and Rajsko strata), 7 – Miocene clays (Chodenice strata)

bottoms of the valleys (Tyczyńska and Chmielowiec 1988). In Forecarpathian valleys thicker series of silts and sands, older than the late Vistulian, formed the fossil terrace of the Podłężanka river and filled up the Serafa valley (Kalicki 1997). These series had been cut through as early as in the younger Pleniglacial, as proved by the paleobotanical dating from organic sediments of the Podłężanka valley (Nalepka 1991, 1994), and radiocarbon dating of sediments from the bottom of the Vistula valley – 13,260 BP in Pleszów and 13,200 BP on the alluvial fan of the Serafa river (Kalicki 1992a, 1997). An intense erosion in Forecarpathian basins of that time, connected with the low erosion base of the deep cut Vistula river bed, allowed the rivers to shape sandy alluvial fans overlapping with gravelly and sandy alluvia of the braided Vistula river (e.g. alluvial fan of the Serafa river) (Kalicki 1997).

In small Forecarpathian valleys we only find the records of the Late Glacial climatic fluctuations, whereas no such records for the period of full afforestation in the Eoholocene (Preboreal-Boreal) and Mesoholocene (Atlantic) have been reported. Warmer periods (e.g. Bölling, Alleröd and Eoholocene), with more abundant vegetation, were the phases when the transformation processes stabilized in both, basins and alluvial fans, and when the organic sediments formed. In cooler periods (the Older and Younger Dryas), with poorer vegetation, clastic sediments accumulated on the alluvial fan of the Serafa river (deposits older than 11,950 - 11,830 BP and a member from the period between 11,460 and 8,750 BP), and on the peat bog in the Podłężanka valley (a member from the period between 11,610 and 9,180 BP) (Kalicki 1997). In the Younger Dryas, which is hardly legible in pollen diagrams (Nalepka 1994), on the alluvial fan of the Serafa river a successive coarsening of sediments took place, followed by two simple sequences of alluvium accumulation. The relief transformations of that period were recorded not only for small, but also for large fluvial systems. Distinctive traces of the river pattern changes and the channel braided alluvium formation in the Younger Dryas can be encountered in the Vistula valley (Kalicki 1991, 1992a, 1992b), whereas the intensification of fluvial process in the Younger Dryas was responsible for coarsening of the levee sediments of the Vistula river, or interrupting the accumulation of organic deposits in abandoned channels (Kalicki 1996b). An intense accumulation of overbank sediments of that time (older than 9,850±210 BP) was also recorded in the Raba river mouth (Alexandrowicz and Wyżga 1992). The region of the Niepołomice-Bielcza Upland had been penetrated by human communities since the Paleolithic, which is finely confirmed by the recent findings (e.g. Kalicki et al. 2006, Wilczyński 2009).

The site lay on the watershed separating the basin of the Podłężanka river, a right-bank tributary of the Vistula river, from the catchment of a nameless stream, a left-bank tributary of the Raba river running through Łężkowice (Figure 3). It was situated in a pass, at a height of ca. 270 m a.s.l., between the Ugór hill (290 m a.s.l) to the north, and a lower hill to the south (ca. 278 m a.s.l.). Presently, the steep slope descending from the northern elevation to the col is cut by a trench dug out for the Kraków-Tarnów road construction. The trenches covered the col, and the higher part of a large fluvio-denudational dry valley (a dellen) to the west, which belongs to the Podłężanka river basin. Dry, fluvio-denudational valleys (dellen) have been formed in periglacial conditions of the Pleistocene, and are relict forms typical for Polish Uplands with loess cover.

### 1.2 History of research

Archaeological field surveys in the region of the Niepołomice-Bielcza Upland have been conducted since the 1950's. In 1954, M. Gedl discovered a settlement of the Radial-Decorated Pottery (Baden culture) and the Lusatian cultures in Brzezie 1 (Bielenin 1957), while one year later K. Bielenin carried out excavations in the northwestern part of the settlement, on the Ugór hill (Bielenin 1957). These investigations were continued by M. Godłowska in the years 1965, 1967 and 1969. The excavations revealed relics of a large settlement of the Baden culture and traces of the Lusatian settlement (Bielenin 1957, Godłowska 1969, 1970). In the course of the verifying field survey, carried out by Wichman

and Naglik (1992) on the opposite hill, relics of the Lusatian settlement dated to the Period III of the Bronze Age were discovered, referred to as the site 26 in Brzezie. In 2004, the site was explored within rescue excavations associated with the modernization of the route E4 between Targowisko and Wieliczka. The investigations covered an area of 2,370 m$^2$, located to the south of the site Brzezie 1, and to the northwest of the site Brzezie 26. The trenches founded formed a belt with a length of 260 m and a maximum width of 18 m (Kalicki and Czerniak 2014, 2015) (Figure 3).

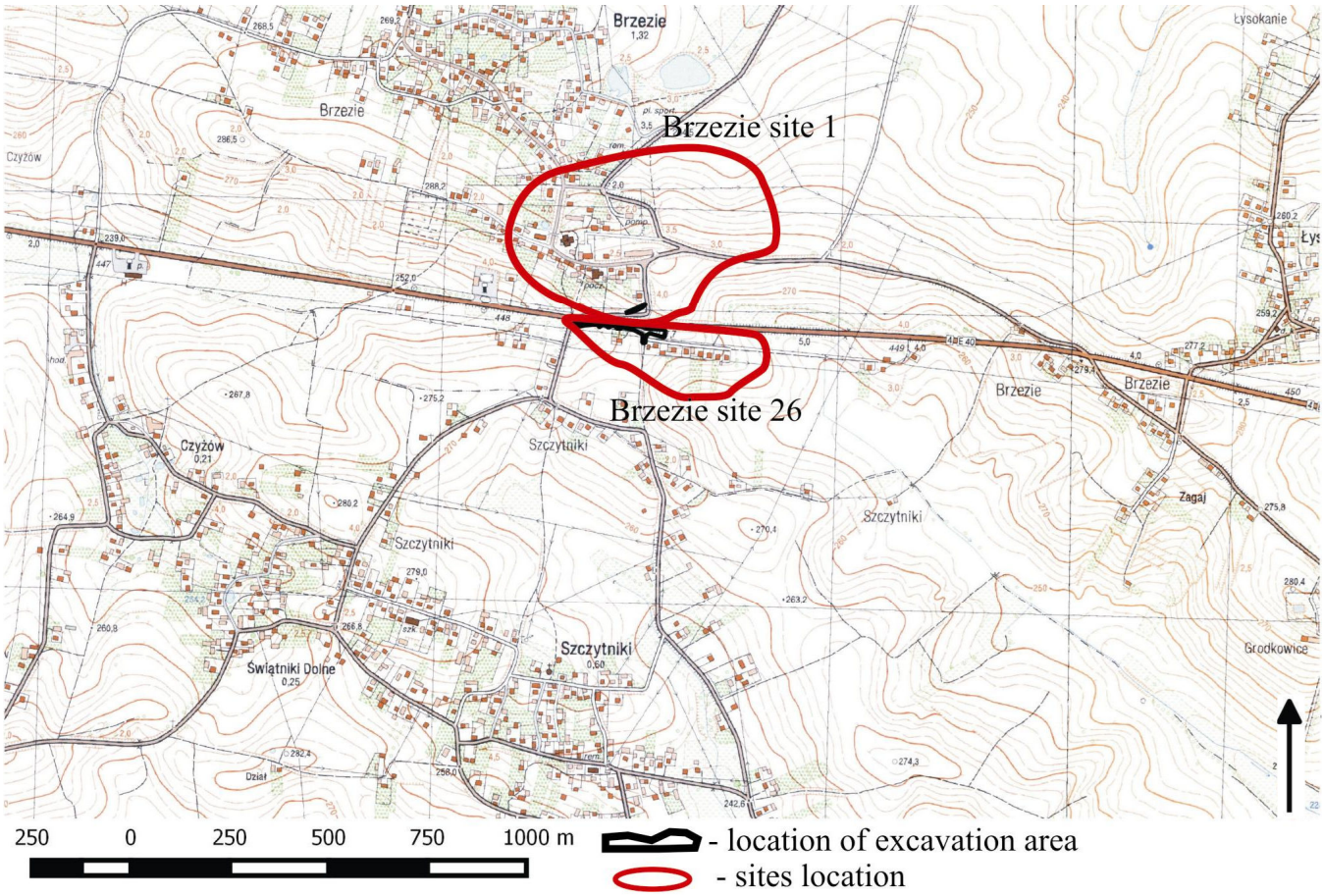


Figure 3. Location of archaeological sites 1 and 26 in Brzezie

### 1.3 Aim of studies

The studies were carried out within the project named "Interakcja człowiek-środowisko na obszarze Działów Niepołomicko-Bielczańskich w holocenie" (The man-environment interaction in the Niepołomice-Bielcza Upland in the Holocene), executed in connection with the construction of the motorway A4 between Cracow and Bochnia. The motorway construction was preceded by wide-spread rescue excavations conducted by the Cracow Team for Archaeological Supervision of Motorway Construction, based in Cracow. In the course of the investigations a great number of abundant complexes of a settlement and sepulchral nature were discovered. This created an opportunity to undertake interdisciplinary, comprehensive studies on the human-environment relationship in prehistory. The project covered the Forecarpathian fragment of the Sandomierz Basin, which is relatively poorly recognized in terms of its paleography, in contrast to the uplands located to the north of Cracow (e.g. Alexandrowicz 1997), or the upper Vistula basin downstream of Cracow (e.g. Kalicki 1991, 2006).

The project aimed to recreate elements of the natural environment under conditions of the

changing climate and escalating anthropogenic pressure. The investigations focused on the identification of the impact of climatic conditions on the changes in geographical environment and human economy at particular stages of its development. The paleographical reconstruction was based on recognition of archaeological sites in association with the relief and geological profiles. Such an approach allowed the investigators to make an attempt to correlate certain types of landforms with settlement preferences in the period since the Neolithic until the early Modern Times. The paleographical analysis was performed to reveal the records of human activity in sediments and identify the impact of human communities on the local natural environment. Thanks to this, it was possible to determine the nature and extent of anthropogenic transformations in the environment, related to a deforestation of lands from agricultural, grazing and construction activity, an increase in soil erosion, and a role of "normal" (secular) and catastrophic morphogenetic processes in the relief transformation (Kalicki and Czerniak 2014, 2015). The site presented in this paper is the first so thoroughly elaborated within the project in question.

### 1.4 Methods

The present work synthesizes results of most recent research at the Brzezie 26 site and Niepołomice-Bielcza Upland. The study included geomorphological mapping on the 1:10,000 scale of site surrounding (*study off site*), as well as geological, sedimentological and pedological analysis of deposits from the archaeological outcrops and trenches on site (*study on site)*. Grain size analyses were made using laser method made by Malvern instrument. Sedimentation parameters were calculated using Folk-Ward formula.

The excavation started from the foundation of the measurement grid and the location point for height measurements. Exploration began with the removal of humus layer and present day embankment (approximately 40 - 60 cm), using excavators working under the supervision of archaeologist. Unveiled level was called level B. Cleaning the level, exploration of successive layers with a thickness of 10 - 20 cm done by hand, documenting each level photographically and drawing to scale 1:20 and 1:50 were completed. For the following levels of exploration there were used next letters of the alphabet on the level of B to Z. The artefacts from mechanical layers were documented graphically, on each of the areas separately, within the certain stratigraphic layer. Accumulation layers and profiles of the trenches were drawn and documented photographically. The cross profiles explained the stratigraphy of the discovered layers. Photographic documentation and drawing at 1:20 scale were completed. Then they explored the mechanical layers with a thickness of 10 cm. From each feature and from each stratigraphic layer around the objects approximately a liter sample of sediments was taken to make palaeobotanical or physico-chemical or granulometric research. Excavations were carried out according to the guidelines of Cracow Team for Archaeological Supervision of Motorway Construction based in Cracow.

## 2 Results

### 2.1 Geoarchaeological results

Sediments uncovered in the trenches corresponded closely with the site topography. Above the fossil soil there lay loess colluvium, varying in thickness. Luvisol with poorly distinctive bleached horizon developed on loess (grain size typical for Polish loess), most likely of the Vistulian age. In both, the loess background and other soil layers, there were visible cracks caused by desiccation, filled up with yellow-grey silts.

Within colluvium two members were distinguished, varying in terms of their age of formation and sedimentation regime (Figure 4). The lower member, without distinctive sedimentation structures, consisted of several layers of variable colors, referring to the color of the layer that eroded on the elevation and was deposited in a form of colluvia. Depending on the primary material, which could have been humus (A), eluvial (E) or illuvial (B) horizon of the soil, the color of colluvium was brown-black, light brown or rusty. They formed in a few stages, and

the rate of accumulation must have been relatively slow since the post-depositional processes destroyed the sedimentation structures. The lower member had a thickness of ca. 1 m in the central part of the main trench, and it decreased southward. Within this member, in the central part of the trench, there were few fragments of the Neolithic pottery and over 2,500 fragments of pottery dated to the Period III of the Bronze Age, 54 elaborated stones and daub. The prehistoric material was mostly encountered on the limit between the luvisol and the lower colluvial member.

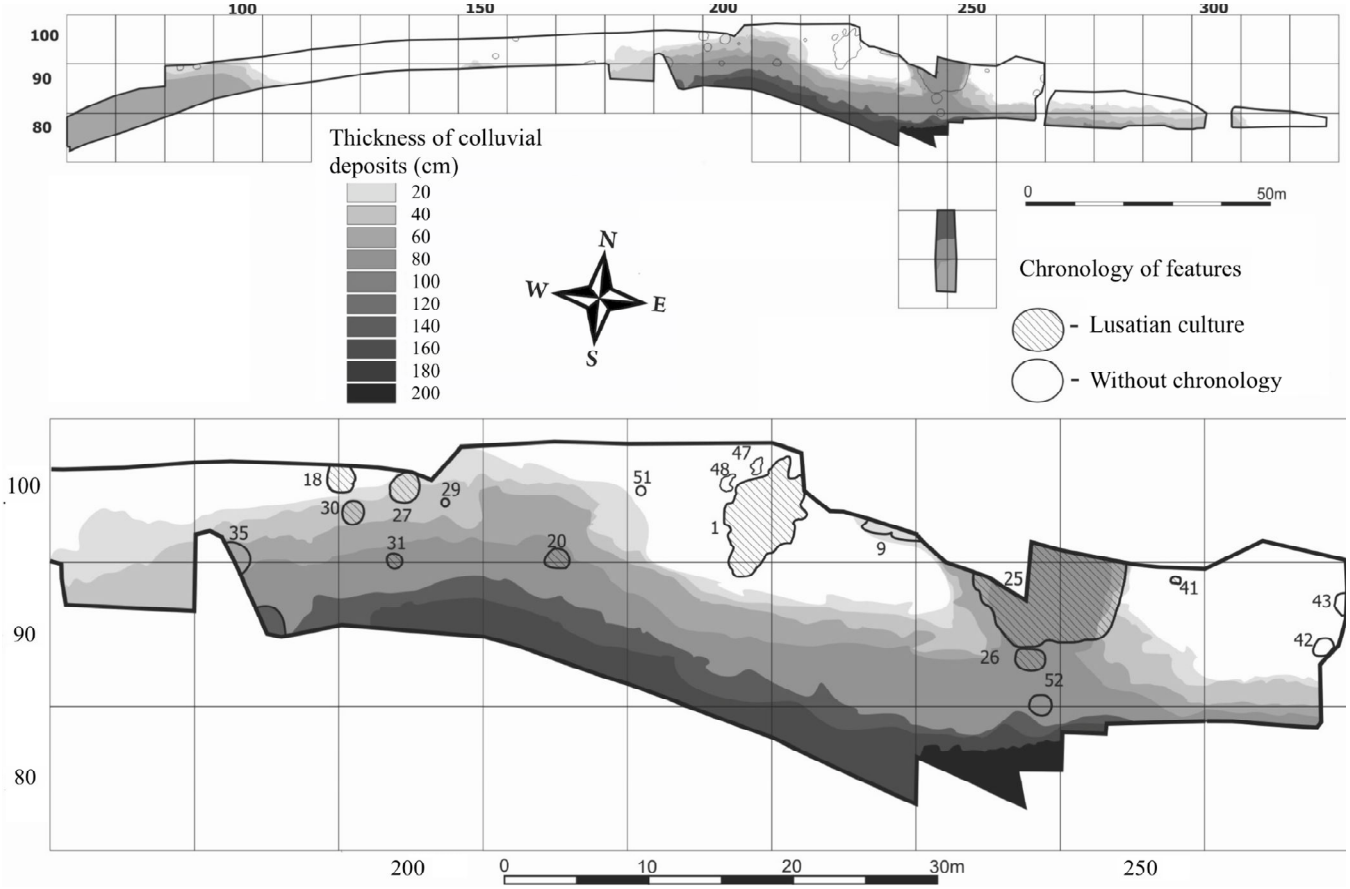


Figure 4. Plan of the site 26 in Brzezie with distribution of the features and thickness of colluvial deposits (drew by R. Czerniak)

Sedimentation structures within the upper member of colluvium were well-preserved and clearly visible, which indicated rapid accumulation. This member contained loess intrusions that might have occurred due to erosion of the basement (C horizon of soil) within the northern elevation. In its lower part there was a small number of fragments of pottery dated to the Period III of the Bronze Age (3,300 - 3,100 BP), while in the upper part few potsherds from the Middle Ages and early Modern Times were found.

Most of the features became noticeable after the colluvium had been explored. Only few objects, nos. 10, 19, 30 and 41, were recorded as soon as the humus layer was removed (Figure 3). The latter also concerns the object no. 1 from the site Brzezie 1.

In the main trench, oriented along the east-west axis, luvisol was covered with loess colluvium, with varying thickness. In its central part the thickness reached nearly 2 m (ca. 1.8 m) (Figs. 5 & 6), while in its western part, where the spring of the fluvio-denudational dry valley was located, it decreased to ca. 20 - 30 cm. To the south, the layer of colluvium clearly divided into two parts. The total thickness of colluvium

reached nearly 2 m, and this was additionally covered with ca. one-meter mound. The inclination of the top of the buried soil, as well as successive colluvial members, indicated that they were transported from the northern elevation (Figure 5).

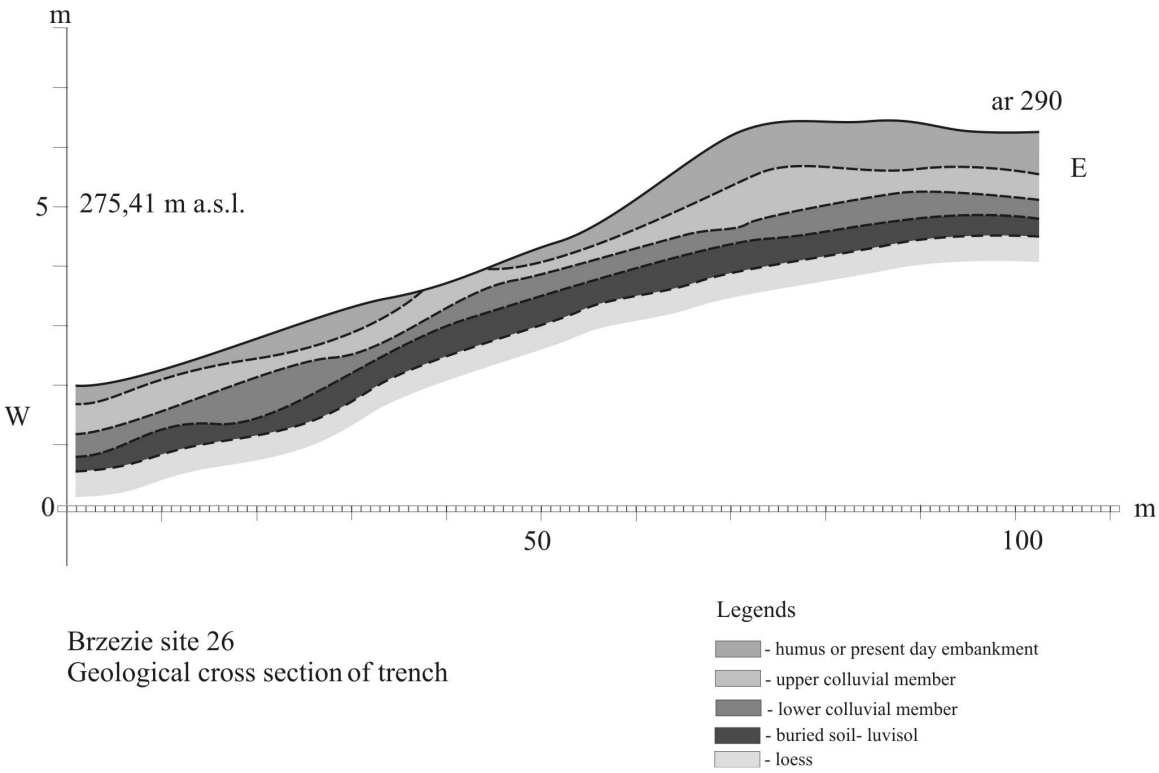


Figure 5. Geological section across the site Brzezie 26 (drew by R. Czerniak)

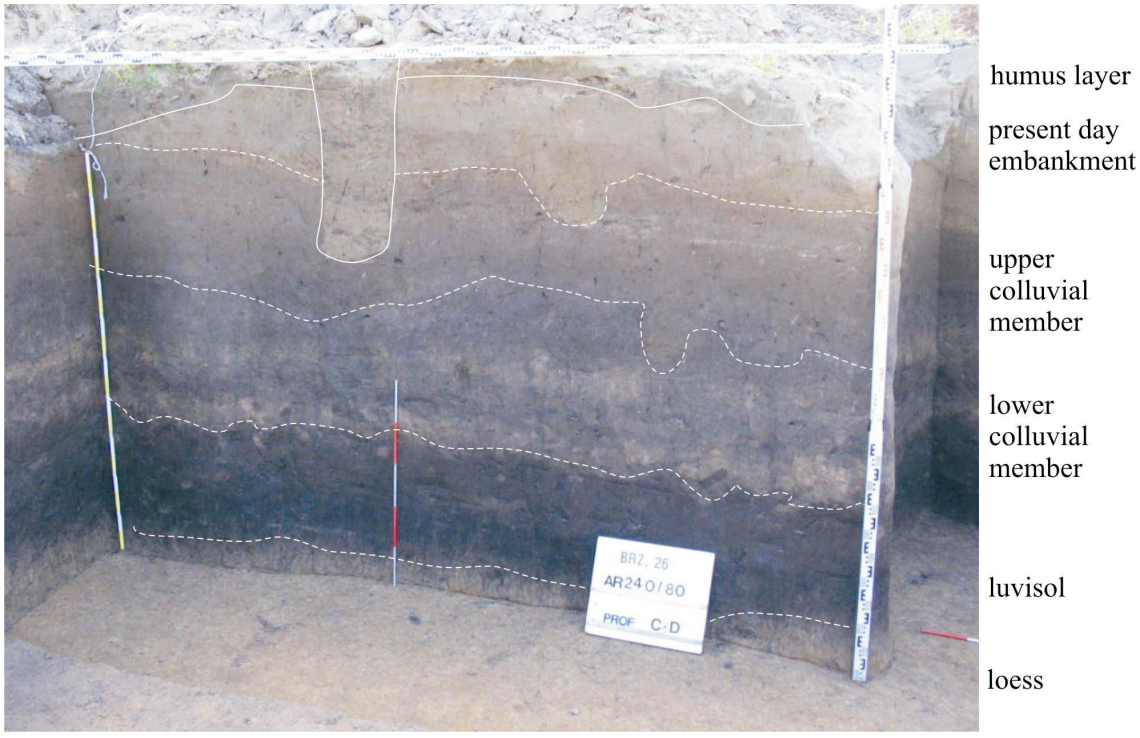


Figure 6. Geological profile from site 26 in Brzezie (are 240/80 south-wall of trench). (photo by R. Czerniak)

Archaeological artifacts and features were encountered almost exclusively in the central part of the main trench, thus in the area where the luvisol was covered with a thicker layer of colluvium. The humus layer of this soil contained only few fragments of pottery, which might have been due to erosional-accumulative and zoogenic processes.

In the western part of the site the prehistoric features were preserved only if they had been dug into the illuvial horizon, whereas the shallower objects were completely destroyed due to erosion processes in the spring part of the fluvio-denudational dry valley. A half of the artifacts were found within the features, the other half lay in colluvium, which clearly indicated that they were redeposited and relocated with sediments from the northern elevation. The concentration of prehistoric material in colluvium was varied; the greatest on the erosion boundary between the luvisol top and the colluvium bottom.

At the site under scrutiny spatial distribution of the prehistoric material was also diversified. Artifacts concentrated in the regions where the colluvial layers were the thickest, i.e. within the areas 190-260/100-80 and 240-250/50-60. The maximum concentration of prehistoric relics was recorded within the belt of area 240-250, in particular, above the outline of the clay pit no. 25 and in its surroundings. A similar situation, though on a smaller scale, was encountered near the clay pit no. 1 (Figure 3). On the slope below the clay pit no. 1, close to utility pits within the areas 190-200/90-100 (Figure 3), another concentration of redeposited artifacts was discovered.

An interesting observation was made within the areas 240/80 and 240-250/50-60 (Figure 3), where on the top of luvisol a series of concentrations of artifacts, including daub, were recorded. Those concentrations have been preserved fragmentarily, destroyed by erosion processes, and scattered over the area of ca. 2 m$^2$. This also confirmed that in the period between 3,300 and 3,100 BP the surface of the luvisol was the ground level.

## 2.2 Archaeological results

In the course of the excavations 62 permanent features were revealed, including 4 natural structures, 10 pits, 10 postholes and 3 clay pits (with 35 “clay quarries” holes) (Figure 4). The assemblage of portable artifacts consist of 5,600 specimens. Most were pottery pieces (5,200 artifacts) (Figs. 7 & 9) and 4 weaving weights. Stone artifacts were the second most numerous (140 pieces with traces of use) (Figure 8). There were much fewer flint artifacts (4 examples). The

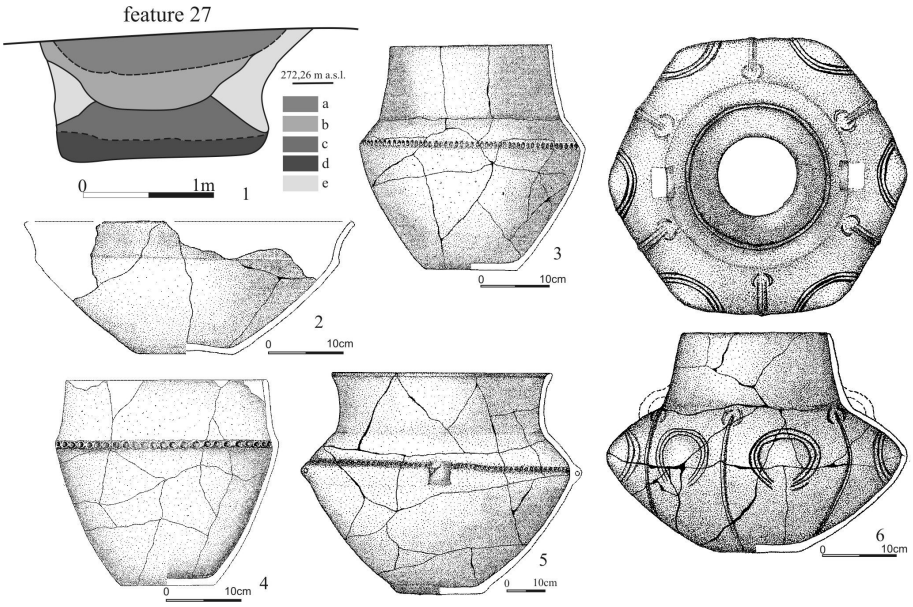


Figure 7. Brzezie site 26, example of the clay vessels from storage pit (feature 27). (drew by R. Czerniak, S. Skubisz), a – dark grey, b – light brown, c – dark brown, d – black, e – dark yellow


Figure 8. Brzezie site 26, example of the querns (1 – feat 27, 2 – feat 18) and grinders (3, 4 – lower colluvial member, 5, 6 – feat 53) (photo by R. Czerniak)


Figure 9. Brzezie site 26, example of the pottery fragments from lower colluvial member (drew by Skubisz, S. and O. Suchan-Czerniak)

collection was completed by an iron arrowhead. Moreover, there were discovered relics of a settlement dated to the Neolithic: the LPC (a fragment of a vessel from the feature no. 60), and the FBC (four flint artifacts); to the Bronze Age: left by a community related to the earliest phase of the Lusatian culture in the region of Cracow, and scarce traces of the early Medieval settlement (an arrowhead and a fragment of pottery). The most intense settlement in this part of the site was recorded for the Bronze Age. Due to the alignment of the trenches, founded within a long, narrow belt of the southern access road leading to a footbridge, and within a drain of the northern access road, the exploration conducted there revealed only a small fragment of a large, open settlement of the Lusatian culture. The center of the settlement could have been either on the slope of the northern elevation, surrounding the area under investigation, or within the belt devastated by the Tarnów road (Figure 2). The latter may be evidenced by the occurrence of colluvial sediments of significant thickness, the lower of which contained a great number of prehistoric materials. The excavations revealed nine utility pits and two clay pits with artifacts of the Lusatian culture. Other features (five utility pits, clay pit no. 9 and postholes) did not contain any artifacts (Figure 4). Based on the alignment of the features encountered in the investigated part of the site, two functional zones of the settlement were distinguished: a production zone with three clay pits (feat 1, 9, 25, 47, 48) and a residential zone with storage pits: trapeze (feat 18, 27, 30)- and hollow-shaped objects (feat 20, 29, 31, 35).

The Lusatian pottery materials from the site preserved mainly fragments. Only 34 forms were possible to reconstruct. The classification has been based on these forms or those in which the greater part was reconstructed. The terminology occurring in present elaboration is based on works of Gedl (1982). In the collection of pottery pieces from Brzezie there have been distinguished following types of pots: vases or amphoras with conical or cylindrical necks (Figure7: 4, 3 & 6), jugs and mugs, bowls – mainly three pieces bowls with S shaped profile (Figs. 7:2 & 9:11), rarely two piece bowls with the rim folded inside, pots with gentle profile (Figure 9: 12), big pots like vessels with flaring necks and through-shapes vessels (Figure 7: 5). A relatively small proportion of the pottery was ornamented. Only four groups of ornamentation have been distinguished by a manner of making. Group I consists of vessels, probably amphoraes or jugs ornamented with broad vertical or arched engraved lines with knobs placed of the maximum girth of the body (Figure 7: 6). Group II encompasses vessels with engraved lines, mainly vertical or diagonal in lower part of pottery, frequently accompanied with small oval or lenticular pits on the shoulders of this motif (Figure 9: 1, 3, 5, 7, 10 & 11) Group III consists of vessels decorated with finger impressions on its walls (Figure 7: 4) or applied band (Figs. 7: 3 & 9: 11). This motif has been often recorded on vases and bowls where accompanied with line motive covering their lower parts (Figure 9: 1 & 5). Group IV includes vessels, probably bowls, with finger on the rims (Figure 9: 2 & 3). Stone tools were divided into a grinding tools, grinders and querns (Figure 8).

The most interesting, in terms of chronology of the artifacts discovered there, was the residential zone, where three trapeze-shaped features were found (feat 18, 30, 27). One of them (object no. 27) delivered 17 forms of vessels, a great majority of which has not been reconstructed. (Figure 7) An analysis of the prehistoric material, obtained at the sites 1 and 26 in Brzezie, proved an existence of one large settlement of an open type, established by the Lusatian community (Czerniak 2007). Based on the results of the comparative analysis performed for the pottery collected at the site, including well-dated artifacts from graves and utility pits, a conclusion was drawn that the material in question displayed traits typical of the earliest assemblages of the Lusatian culture in the region of Cracow, dated to the Period III of the Bronze Age. Therefore, it seems presumably that the settlement in Brzezie was founded by the Lusatian community that migrated from Silesia during the Period III of the Bronze Age (possibly, in the $HA_1$ period). The prehistoric materials gathered at the settlement in question may be counted to the oldest phase of the Cracow sub-group of the Silesian group of the Lusatian

culture, referred to as the Iwanowice-Wysyłek phase, and synchronized with the phases IIb and IIc of the cemetery in Kietrz (Gedl 1982). A great number of stone artifacts, such as grinding stones and querns, indicated that the community inhabiting the site under analysis was engaged probably in farming activity (Czerniak 2007).

## 3 Discussion and Conclusions

The aforementioned results of the geoarchaeological investigations, conducted at the site Brzezie 26, fall in well with the general picture of the relief transformation of the Niepołomice-Bielcza Upland within the Holocene and the role of human communities in these changes.

An increased fluvial activity in the Holocene phases, clearly visible along the entire Vistula reach downstream of Cracow (Kalicki 1991, 1996a, 2006), did not leave its mark in small Forecarpathian valleys (Kalicki 1997). In the Eoholocene and Mesoholocene there were no significant changes of the accumulation type in the alluvial fan and at the bottom of the Serafa valley. This might have been due to a small deforestation scale for those basins in the Neolithic. Simultaneously, the data collected from the low zone of the Drwień creek indicated that large floods, at the turn of the Boreal and Atlantic, were flooding the entire bottom of the Vistula river valley, causing changes of the sedimentation type in both, backswamps (8,890±120 BP), as well as paleochannels below the opposite edge of the floodplain (Nowa Huta - 8,860±160 BP; Kalicki 1992b, 1997). However, these floods did not reach the Serafa alluvial fan, situated slightly higher; moreover, floods of the Serafa river must have been insignificant since it did not hinder the accumulation of organic sediments on the alluvial fan in that period (8,750 - 7,570 BP). Lower parts of the Serafa alluvial fan was covered with overbank deposits of the Vistula river no sooner than in the Atlantic. Organic sediments accumulated in this region (profile OK1) were overlaid with overbank deposits at the end of the successive phase of the intensified activity of the Vistula river (5,970±120 BP), after the avulsion of the channel, close to the valley of the Drwień creek (comp. with Kalicki 1992b, Kalicki and Zernickaya 1995, Kalicki 2006). The above-quoted examples perfectly match and confirm the scheme of the intensified activity phase, developed for river valleys with wide floodplains (Kalicki 1996a, 2006).

Changes in morphogenetic processes forming the Niepołomice-Bielcza Upland occurred no sooner than farming and breeding communities entered this region, which essentially affected the natural environment (Valde-Nowak 1988). The anthropogenic deforestation and agricultural reclamation of loess and sandy areas in the Neoholocene stimulated erosion processes on the slopes, and almost completely changed the type of sedimentation in small valleys (Kalicki 1997).

Archeological sites discovered in the region in question were dated since ca. 5,400-5,300 BC (Atlantic), i.e. since the loess areas in Little Poland became inhabited by the Linear Band Pottery communities, introducing the model of farming economy, until the early Modern Times and contemporary human activity (e.g. Dzięgielewski et al 2004, 2008, Rauch-Włodarska et al 2005, 2007, Włodarski et al 2006, Kalicki et al 2006, 2015, Drobniewicz et al 2008, Kalicki and Tyniec 2008, 2009, Tyniec and Kalicki 2009, Kalicki 2014, 2015).

However, the site in Kraków-Kosocice, dated to ca. 5,200 - 4,800 BP, proved that human groups settled not only the loess areas, but they also entered less fertile, sandy soils. Burning up forests, and uncovering sandy slopes and watershed areas induced denudation and erosion processes. At first erosion did not affect the watershed areas, however, the following phase of cooling and wetting of the climate, at the turn of the Atlantic and Subboreal (Kalicki 1991), which was also associated with short-lasting rainfalls forming flash floods in small basins, led to the development of a fluvio-denudational dry valley, the spring of which reached the watershed area. Within this dry valley, the artifacts were deposited at shallow depths, in colluvia, or they were laid directly on the ground surface (Drobniewicz et al 2008).

A precise dating of the colluvial cover at the site Kraków-Kosocice was not possible;

nevertheless it was a great example showing the mechanism of erosion and accumulation processes developed on the slopes. The sediments, altogether with prehistoric material, were washed down the gentle slopes and accumulated within fluvio-denudational dry valleys, on the slope flattening, where the secondary concentrations of the artifacts formed. Finer fraction of sediments, containing tiny artifacts, were most likely transported as far as to the bottoms of the valleys and the river channels. The fluvial system was also supplied by the material eroded from steeper slopes (Drobniewicz et al 2008).

At the site Brzezie 26, situated on loess area, a small number of the Eneolithic (about 4,000 - 2,400 BC) artifacts, co-occurring with specimens of the Bronze Age in sediments filling up the fluvio-denudational dry valley, indicated that despite the existence of a wide-spread settlement of the Radial Decorated Pottery culture on the Ugór hill and its slopes, the erosion processes showed a very insignificant activity in this period (Czerniak 2007, Kalicki and Czerniak 2010, 2014, 2015). The results of the geoarchaeological investigations indicated significant changes in the relief of the site under scrutiny in the Subatlantic. What is particularly noteworthy is the development of the thicker (up to 2 m at certain spots), two-part colluvial cover. Each of the distinguished members accumulated in a different sedimentation regime (Figure 10).

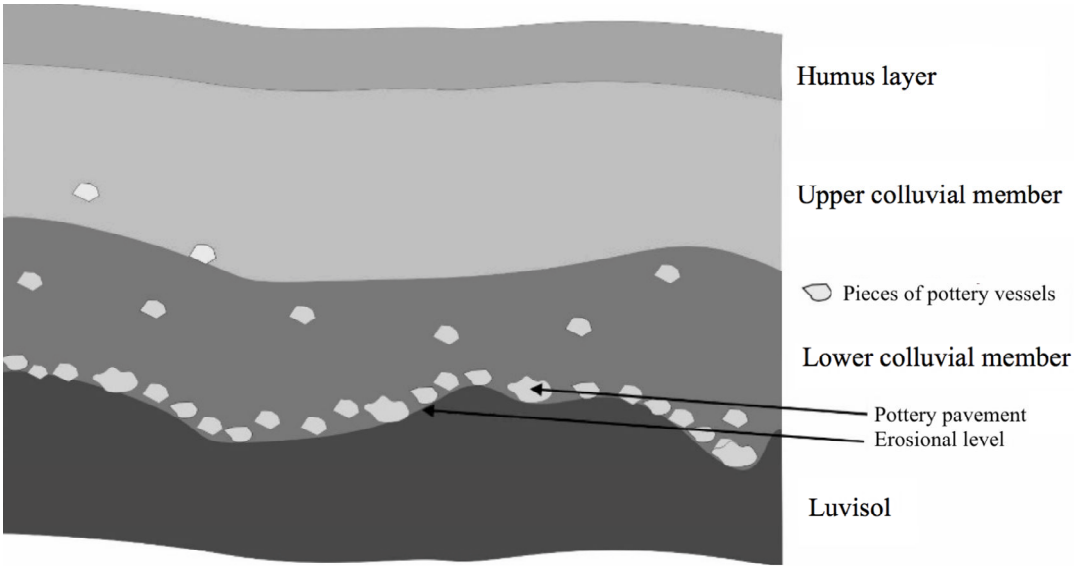


Figure 10. Schematic stratigraphy of sediments at the site 26 in Brzezie (drew by R. Czerniak)

It was the changes in the natural environment related to the early Lusatian population that initialized the erosion. The changes were also enhanced by the climatic fluctuation (3,200-3,000 BP), which is well-dated and documented in the Vistula valley in the region of Cracow, and left its mark in a great number of river valleys in Central Europe (Kalicki 2006). The cooling of the climate caused an increase in the activity of fluvial systems of various order. Detailed data analyses this type of climatic fluctuation i.e. phase of the Roman time (see Kalicki 2006, Dobrzańska and Kalicki 2015) show clustering catastrophic events in different geoecosystems – often and big flash floods in small valleys and dry fluvio-denudational valleys. The results of the investigations conducted at the sites 1 and 26 at Brzezie showed that this was the time when the slope erosion started as well. Large fragments of pottery and the concentration of artifacts, dated to the Neolithic, Bronze Age and older periods, lying on the erosion surface in the top of the buried soil ("artifact pavement"), indicated that they were redeposited there during one erosion-

accumulation event (flash flood). The emergence of the "artifact pavement" might have also been stimulated by the erosional destruction of the initial ground level (erosional rills in the top of luvisol). From this horizon silt fraction of sediments were washed out, and the artifacts, which primarily lay on the ground surface, got more concentrated, forming a secondary accumulation on the erosion base level. Relocation of such big artifacts was possible only due to the rill erosion that developed on the slopes of the dry valley. The distance of transportation in this first event must have been relatively small because many of pottery fragments in the upper part of the fluvio-denudational dry valley ware able to fit in each other and reconstruct schapes. Later on, the "artifact pavement" was covered with the older colluvial member, which accumulated during a few phases. This is confirmed by an occurrence of several layers of varying colors related to the color of the level that eroded on the elevation and formed colluvia. The artifacts encountered in those upper layers were significantly less numerous and scattered, which supported the hypothesis of relocation of most of the Bronze Age artifacts simultaneously, within a single episode, and their redeposition on the erosion surface.

At the same time (after 3,300±30 BP cal. 1,670 - 1,500 BC), the first phase of formation of an alluvial fan at the site in Targowisko took place (Kalicki et al 2006, Kalicki 2014, 2015), which coincided, on one hand, with the foundation of two, independent, contemporaneous settlements separated with a wide-spread cemetery, on the other hand, with a considerable cooling and wetting of the climate (Kalicki 1991, 2006). This was marked in a pollen diagram from the site in Targowisko-Przedewsie with an increase in the share of *Picea*, *Salix* and *Alnus* in the composition of forest biocenoses, as well as a boost in vegetation typical of humid habitats, and an increase in a number of ponds on a peat bog in the paleochannel. This was also the period when evident pollen indicators of farming lands (seeds of crops and their weeds), pastures, ruderal plants and open areas emerged (Kalicki 2014). The anthropogenic changes under conditions of the climatic fluctuation, and possibly, increased frequency of extreme events, as in the case of the Roman phase (comp. with Kalicki 2006), initialized the formation of new erosion valleys (gullies), at the openings of which torrential fans developed.

The data collected in the course of geomorphological mapping of a fragment of the Niepołomice-Bielcza Upland indicated a significant role of human communities in transformation in the natural environment of this region in the Subatlantic, e.g. initializing denudational processes on the slopes of the gullies (Starkel 1960). The latest data has fully confirmed this. In fact, the accumulation of the alluvial fan in Targowisko stopped in the early Roman Period before 1,915±30 BP cal. 20 - 140 AD, when a small settlement of the Puchów culture had diminished. The soil erosion and the formation of the alluvial fan continued after 600±30 BP cal. 1,290 - 1,410 AD, thus after a village in Targowisko had been founded, the oldest phase of which was archeologically dated from the second half of the 12$^{th}$ until the 13$^{th}$ century. This dating was confirmed by the historical records, which mentioned the date of 1,198. However, one must keep in mind that the human activity developed under conditions of the Little Ice Age with very numerous catastrophic events, the beginning of which was dated to ca. 1,350. In the Middle Ages and early Modern Times the edge zone of the headland in Targowisko lowered, leaving only "traces" of the original archaeological features (Kalicki 2014, 2015, Kalicki et al 2015). The same dating was determined for the transformation of this type that affected an edge of a loess terrace of the Vistula river in Kraków-Wyciąże, where the series of loess colluvia was younger than 415±50 BP, cal. 1,410 - 1,640 AD (Kalicki et al 2005). At the site in Zofipole colluvia, containing the Roman artifacts, were probably of similar age (Dobrzańska et al 2013).

In the Middle Ages and early Modern Times, at the sites 1 and 26 in Brzezie, the younger member of colluvia formed, with the Medieval and early Modern artifacts scattered within it, and sedimentological structures preserved. Most

probably, it accumulated fast and rapidly, no sooner than in the Little Ice Age, when the frequency of extreme events related to rainfalls increased.

At the bottoms of small valleys at the site Brzezie 20, two general fluvial accumulation phases were distinguished – one dated to the early Middle Ages, the other one to the late Middle Ages and early Modern Times. The early Medieval settlement, functioning there between the 8th and the beginning of the 9th century, was abandoned due to an increase in rate of sedimentation at the valley bottom. This could have been caused by a deforestation of large area and a development of soil erosion processes in the upper part of the basin (Kalicki and Tyniec 2008, 2009, Tyniec and Kalicki 2009). Speeding up of the sedimentation processes might have also been stimulated by the climatic fluctuation, dated in the Vistula valley in the region of Cracow to the 9th - 11th century (Kalicki 2006), characterized by an increased frequency of extreme events, or so-called flash floods at the site under scrutiny. In the neighboring Wiśnicz Upland, an intense filling up of the bottoms of small valleys was dated to the Roman Period and the last centuries (315±35 BP) (Kalicki and Pietrzak 1999, 2004, Bluszcz and Pietrzak 2001).

The transformations on slopes, in fluvio-denudational valleys and valleys of small rivers were responsible for changing of the type of sedimentation in the Forecarpathian valleys. In the Podłężanka valley, within the travertine, the first interbedding of organic overbank deposits was recorded as early as in ca. 6,750±50 BP, whereas in the upper layers, an organic interbedding within overbank deposits was dated to ca. 1,090±40 BP (Alexandrowicz and Chmielowiec 1992). In the lower part of this valley the amount of mineral substance in peat bogs increased gradually, which ultimately led to covering the peats in valley bottom with organic loams. In the Roman Period, at the site in Podłężówka great floods were recorded, causing changes in the morphology of the floodplain and stimulating transformations of the sedimentation type within it (Dzięgielewski et al 2004, 2008).

Simultaneously, at the mouths of Forecarpathian valleys an intense accumulation of alluvial fans took place, the sediments of which varied essentially from the deposits formed in the Eoholocene and Mesoholocene (Kalicki 1997). Entering of the sediments of the young alluvial fan into the Late Glacial backswamp was also encountered at the mouth of the nearby Uszwica river valley (Gębica 1995). Unfortunately, due to strong anthropogenic pressure the records of the young Holocene climate fluctuations are unreadable in sediments of those young alluvial fans (Kalicki 1997).

The results of the investigations conducted at the site in Brzezie 26 and the comparative analysis presented in this paper indicate that the strongest relief transformations, concerning both, river valleys and slopes within the Niepołomice-Bielcza Upland, and in the neighboring regions, occurred no sooner than in the Subatlantic. Essential changes in the functioning of the natural environment took place after the Lusatian communities entered this region, which launched the soil erosion. However, this happened in the climate-determined phase with a higher frequency of extreme events. A similar coincidence of natural and anthropogenic factors was recorded in the region under scrutiny in the Little Ice Age. This supports the general conclusions drawn by Kalicki (2006), that the Neoholocene was also the period, when the phases with intensified fluvial activity were related to the climate fluctuations and clustering of extreme events, while the anthropogenic factor was responsible for the escalation of the scale of certain phenomena, e.g. slope erosion, and strengthening the response of the natural environment to the climatic impulse.

Dry, fluvio-denudational valleys (dellen) that 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. The valley floor was first covered with sediments of flash floods and subsequently cut by ephemeral stream (Kalicki and Pietrzak 1999, 2004). This accumulation and incision was associated with flash floods which were the main morphogenetic factor of transformation of this valley type in Polish Uplands (comp. Kalicki et al 2016) and Forecarpathian area during the Holocene.

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