

History of deforestation in the vicinity of a village in Northern Masovia, Poland: An example of the possible old wood effect

Abstract

Anthropogenic activity changes the processes of erosion on slopes. The deforestation process is connected with the deposition of material at the foot of the slope. During this process, macro-charcoals from anthropogenic-induced fires are trapped in the sediments. This paper provides an analysis of charcoal counts and sediment characteristics and is supported by historical data analysis. During this study, a discrepancy between radiocarbon dating and historical data was revealed; a probable explanation is presented.

Keywords

Charcoals • colluvium • slope • Northern Masovia deforestation

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Introduction

Colluvial covers at the foot of slopes are very useful geoarchives for the reconstruction of the palaeoenvironment and its anthropogenic changes. Information about the environment is recorded in sediments and their sedimentological and geochemical properties. Types of sediments, the presence of soil horizons, the content of organic matter, and in-depth profiles of pieces of charcoal are a source of data about the past, which is characterized by high resolution in time, and medium-to-high resolution in space (Dotterweich 2008). This means that, although this kind of geoarchive is local, it represents high potential in the precise reconstruction of changes in time.

The main goal of colluvial research for landscape reconstruction is to reveal the beginning of the erosion processes on the slope. In central Europe, such studies were conducted in the German and Poland lowlands (e.g. Bork 1989; Sinkiewicz 1994; Sinkiewicz 1998; Dreibrodt & Bork 2005; Reis 2009; Dreibrodt, Lomax et al. 2010; Smolska & Szwarzewski 2014). The main objective of such studies was to detect palaeosoil horizons, which can be dated. Such horizons can help to reconstruct the shape of the landscape from before human activity. Following the deforestation of an area, the soil beneath the natural vegetation is buried by the eroded sediments. This is a natural consequence of deforestation as the vegetation cover stabilizes sediments on the slope.

The occurrence of macro-charcoals within sediments – in the form of continuous or dispersed layers – is particularly important. They confirm that fires occurred on the studied hillslope if the charcoal forms a clear layer, or that they occurred close to the slope if the charcoal is found in dispersed pieces. In humid continental climate conditions, large fires are mainly artificial and connected to human activity (such as the removal of natural vegetation for agricultural purposes). Charcoals can also provide information about species in the landscape that was burned (e.g. Figueiral 1995; Ntinou et al. 2013; Saulnier 2019; Mafferra,

Chiavazza & Roig Juñent 2019). The above-mentioned studies concerned mountainous areas exclusively and their authors provided full anthracological details. Another approach is to count the macro-charcoals as a fire proxy within a short range (up to 7 km) from the site (e.g. Whitlock & Larsen 2001; Mooney & Tinner 2011). This second approach is intended for organic and lake deposits; however, in our opinion, it can also be used for colluvial cover deposits resulting from soil erosion.

During the examination of the slope cover near Węgrzynowo (Northern Masovia, Poland), a charcoal layer was detected. It was dated and the charcoals were counted. The archaeological and historical background was also considered for this microregion. During these analyses, we found that the dates obtained by radiocarbon dating were not consistent with the historical analysis. The purpose of this article is to discuss and explain the discrepancies between the historical data and radiocarbon dating. The other objective is to present geomorphological and lithological arguments to indicate that deforestation took place in the vicinity of the village of Węgrzynowo in the 13th century.

Study area

The area of interest is located in Central Poland (Fig. 1), in the northern part of the Masovian Voivodship. It lies in the eastern part of the Ciechanowska glacial plateau, which is part of the North Masovian Lowland. The studied site is a gentle slope of 5100 metres with a mean drop of 2.8° to the Węgiełka river valley. The study area is located in the direct vicinity of the village of Węgrzynowo.

The slope developed in the Warthanian glacial tills and is, in some parts, covered by Warthanian fluvio-glacial sands. The river valley is filled by the Holocene fluvial sands interbedded with alluvial soils and mud (Michalska 1959). Contemporary soils on the

slope are Eutric Cambisols (leached brown soils). In the valley, Fluvisols cover the floodplain (USS Working Group WRB 2022).

Archaeological background

The immediate vicinity of the studied slope has been settled occasionally since the Bronze Age. Information about settlement activity is based on the Polish National Record of Archaeological Sites programme (Ministerstwo Kultury i Dziedzictwa Narodowego 2014) – from surface surveys only, not from excavation documentation. There are four sites dated to the Bronze Age in the range of 1.5 km around the studied slope. The sites consisted of 2–16 ceramic shreds found during the surface study. There are eight sites dated to the Iron Age. The number of shreds was in the range of 2–33. In the Early Mediaeval period, there was a fall in human activity in this area. During surface studies, only six sites from this period were identified. The shred count was from 2–7. In the Late Mediaeval period, together with the Early Modern period, six sites were identified with 2–27 ceramic shreds.

During the archive search, historical information about the local settlement activity was also identified. Information about settlements around the studied area during the historical period was found in a book by Borkiewicz-Celińska (1970). There were four villages located in the immediate vicinity of the studied slope in the Late Mediaeval period. The earliest mentioned was Chodup in 1230. The remaining three were settled before 1414: Węgrzynowo, Szczuki, and Szlasy-Łozino.

Material and Methods

The first step of the work was the identification of the surface sediments. To fulfil this task a cross-section of the slope was probed by shallow hand drills using a soil coring device (depth of up to 200 cm at the foot of the slope; sample collection in May 2015). Samples from the cores were taken for further laboratory analysis. Layers were determined macroscopically and were 1–10 cm thick.

Grain size analysis of the deposits from the footslope was conducted using the laser method on the Malvern Mastersizer 3000. Only the top 140 cm was analysed using this method, as the deeper sediments were deposited in thin layers and the samples from the core were too small for the analysis. Complementary to this method, sieve analysis was used for the particles above 0.5 mm. The results are presented in Figure 2 and were used to calculate the statistical features after Folk & Ward (1957). The soil texture was determined after the United States Department of Agriculture (2019).

Together with sedimentological analysis, the counts of macro-charcoals were provided. Following Mooney & Tinner (2011), the analysis concerned charcoals with a diameter greater than 100 μm . Samples of 1 cm^3 were taken from the core every 10 cm in depth. They were then put in a household "chlorine bleach" for 24 hours. After that, the samples were gently washed using 125 and 250 μm sieves. Later, the material from the sieve was transferred to a Petri dish and quantified in an aqueous solution under the microscope.

A probe from the profile was dated by radiocarbon dating. The conventional dating procedure was conducted in the Division of Geochronology and Environmental Isotopes, Silesian University of Technology (dating was provided in August of 2016; Pazdur et al. 2003; Tudyka et al. 2010). The results are presented with calibrated age (Reimer et al. 2013).

Results

The examined slope cover was collected at the foot of the gentle slope (Fig. 1). The cover is composed of clay loam and loam (Fig. 2). Only two layers are composed of different fractions: the level at 30–40 cm is enriched with gravel, and the floor part

of the drill is composed of sandy loam. The mean particle size is 2–6 Φ . In the top layer, it reaches 4–5 Φ . In the next layer, enriched in the gravel layer, it drops to 2 Φ . On the level at 50–100 cm, it increases to 5 Φ . The next layer (100–120 cm in depth) is characterized by a mean particle size of over 6 Φ . Below, in the thill section, the values of this index again drop to around 3 Φ . Sediments are characterized by very poor sorting, which slightly increases along with the depth.

In nearly the entire profile, skewness is marginally negative, which indicates the predominance of coarse grains. Only the layer enriched with the gravel and floor levels of the profile have positive skewness. Sediments of the profile are platikurtic, apart from the deepest layers, which are leptokurtic. This means that the layers are characterized by a rather wide range of fractions. Based on the above-mentioned analysis and organic matter content, we delineated the layer from the top of the drill up to 1.5 m in depth as colluvial sediment. Below, there are floodplain sediments (the palaeosol level).

The results of the macro-charcoal quantitative analysis show that there are several layers enriched in charcoals in the examined slope cover (Fig. 3). The range of the quantities is between 12 and 180 charcoals/ cm^3 . From the top of the profile, the values above 100 charcoals/ cm^3 are present up to a depth of 50 cm. In this layer, there is a distinct peak of 180 charcoals/ cm^3 in the layer at 30–40 cm in depth. The next layer is characterized by values between 12 and 65 charcoals/ cm^3 (50–125 cm in depth). On the level below 125 cm, the next peak – up to 127 charcoals/ cm^3 – appears at 147.5–152.5 cm. This enrichment ends at a depth of 155 cm. Below this level, there is a constant value of around 60 charcoals/ cm^3 .

The lower level of enrichment in macro-charcoals was radiocarbon dated. The result was 950–1220 AD (93.5%, 1015–1150 AD – 68.2%, GdS-3317).

Discussion

The main objective of this study was to determine how the slope cover is archiving the signs of deforestation in a microregion in the vicinity of Węgrzynowo. The trace of the landscape change in this example is the slope cover itself and the layer of charcoal enrichment. The colluvial cover is 1.5 m in thickness and records the erosion of the slope in the last eight centuries.

Soil erosion is very limited in forests (Teisseyre 1994). Previous studies show that colluvial sediment appears along with the deforestation of slopes and their cultivation (e.g. Bork 1989; Klimek 2003). Soil without plant protection is eroded even on gentle slopes as a result of surface slopewash. Due to this process, mainly fine sediment is eroded from the hillslope and transported to the footslope. On gentle hillslopes, rills are not created and soil particles are transported selectively – the coarsest particles are left on the slope and the finer ones are transported down to the base of the hillslope, and only sometimes further to the river. In addition, massive, homogeneous sediments with admixtures of gravel most likely indicate tillage translocation – the upper part of colluvial deposits, up to 100 cm deep. Such colluvial covers have been described and a scheme of soil redeposition elaborated (Sinkiewicz 1998; Lang & Hönscheidt 1999).

Colluvial deposit at the footslope usually covers peat, mud, or old soil developed before the colluviation on the valley bottom or depression. Organic matter under colluvial cover is radiocarbon dated, which indicates the age of the start of the colluvial cover development. Colluvial deposit is younger than fossil/buried soil or peat. This gap in time is very difficult to establish. Detailed archaeological evidence, sediment properties, and the morphological situation have been analysed in cases of discrepancies between the absolute age of sediments and the age of culture horizon by, for example, Bluszcz et al. 2007;

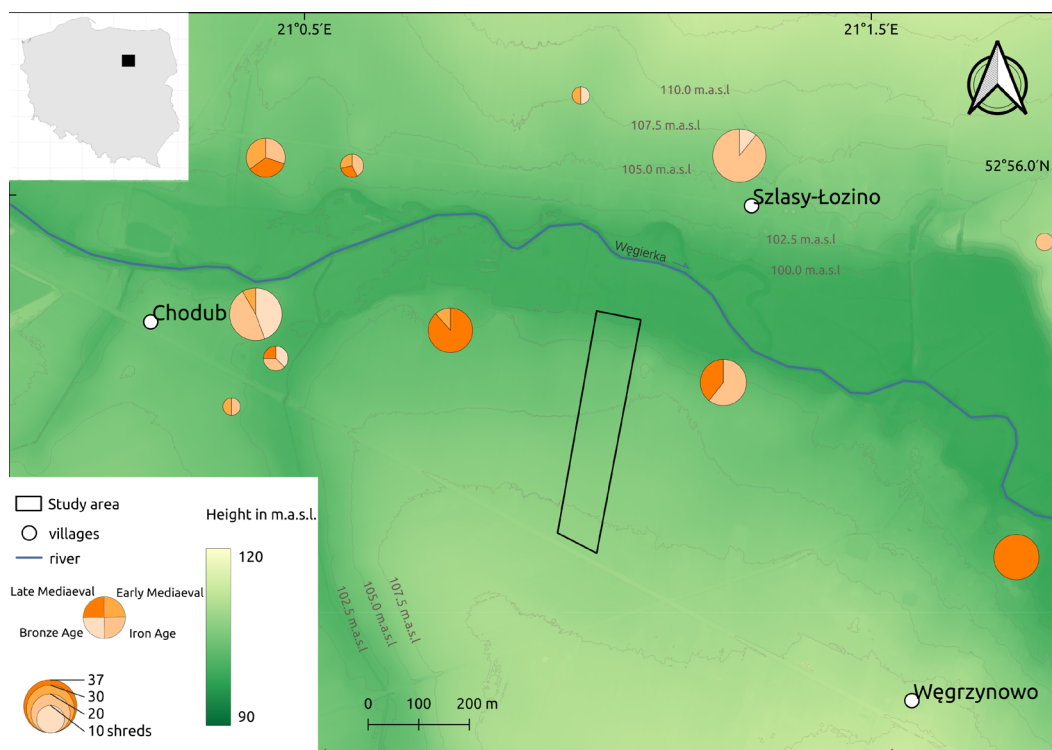


Figure 1. Location of the study area

Source: own elaboration based on dataset from Polish National Record of Archaeological Sites, Digital Elevation Model from Geoportal (2023), waterway from OpenStreetMap contributors (2023)

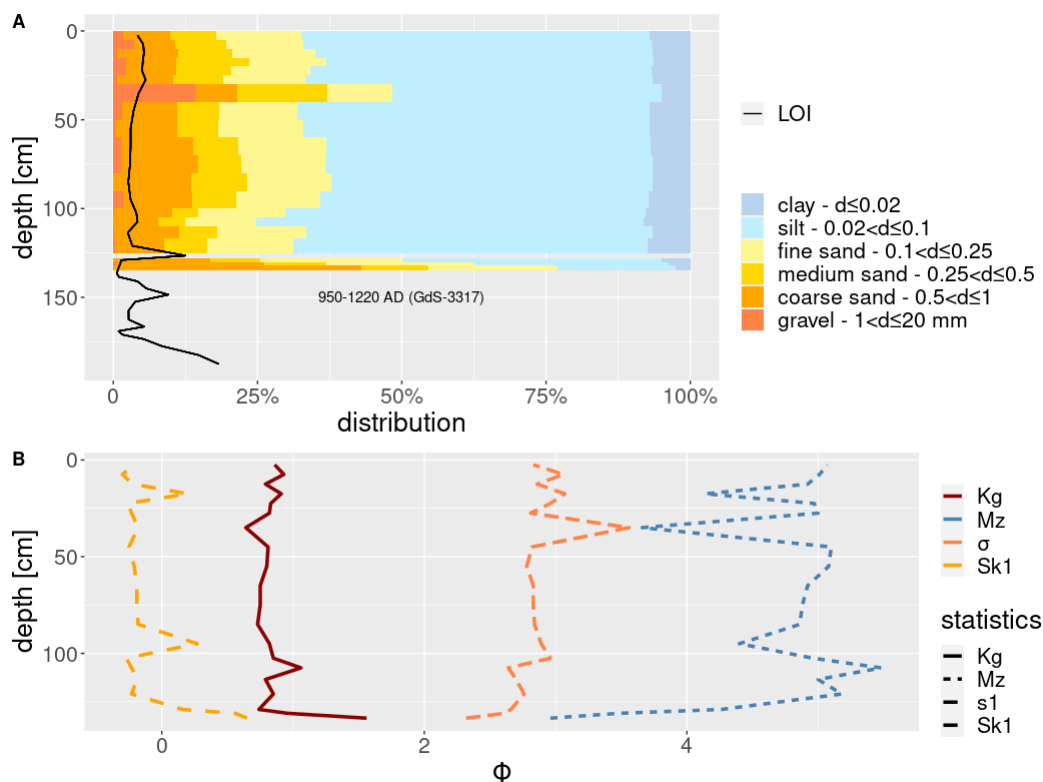


Figure 2. Grain size distribution and organic matter content – LOI (2A), grain size statistics (2B)

Source: own elaboration

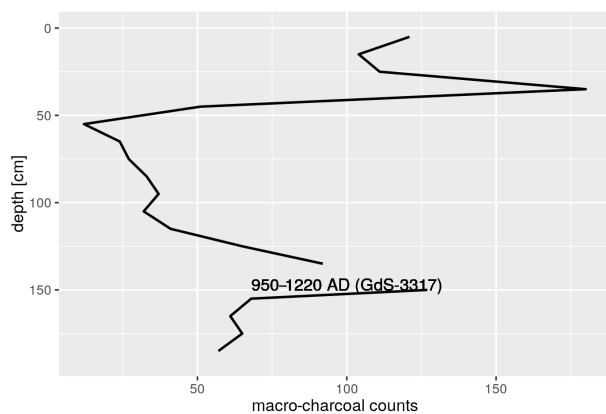


Figure 3. Counts of macro-charcoals in sediments

Source: own elaboration

Smolska 2011; Dreibrodt et al. 2010; Larsen et al. 2016; Henkner et al. 2018.

In the colluvial cover of Węgrzynowo, there are two layers enriched with charcoals. The first (around 150 cm below surface level), dated 950–1220 AD (GdS-3317), and the second (around 35 cm below surface level), not dated, but presumably connected with the later landscape transformation (early modern or industrial revolution period). Such enrichment in macro-charcoals should be connected with very local influence – up to 7 km, according to Whitlock & Larsen (2001). As Borkiewicz-Celińska (1970) wrote, there are three villages located in the immediate vicinity of the studied slope. One of them, Chodup, as previously mentioned, was first recorded in 1230 AD. However, the surrounding area was mentioned as Gdzew forest and was not settled, as this forested area was mostly parcellated between the 14th and 15th centuries (Borkiewicz-Celińska 1970).

The thill section of colluvial deposits has preserved lamination. Among these layers, there is one with higher organic matter content (125–128 cm in depth; over 10% organic matter). The depth of organic matter in thin layers below that (128–150 cm), which are 2–5 cm in thickness, is similar to that of floodplain

deposits. At the bottom of this transitional series, there is a layer containing macro-charcoals. It can be assumed that the change in the type of sediment occurred simultaneously with the deforestation of the area and the initial erosion of the soil. The eroded soil along with macro-charcoals reached the bottom of the valley and was deposited mainly in the foothill zone.

As seen above, the layer enriched with charcoals is dated as being older than the location of the village (radiocarbon date: 950–1220 AD, 95% confidence interval; and 1015–1160 AD, 68% confidence interval; first mention in documents probably connected with the location date – 1230 AD). In our opinion, the probable explanation for this could be the “old wood” effect (Geib 2008). The forest cover in this area was old, as the last landscape opening on a large scale was connected with the Iron Age (Borkiewicz-Celińska 1970).

Dead organic matter in such a landscape can make the dates “older” (Geib 2008; Olsen et al. 2013) due to prefire radiocarbon decay. Normally, when fresh wood is burned, the ratio of carbon isotopes is stable and known. When old organic matter, present in natural forests, is burned, the ratio of carbon isotopes is unknown and the content of radiocarbon C-14 is lower (due to decay).

Conclusion

Slope covers are a valuable source of information about the history of deforestation. As seen in this study, it is very precise in both spatial and temporal ranges. Together with historical source analysis, the impact of deforestation on village settlements and the surrounding environment can be tracked. For future analysis of the impact on the Chodup village location, the other surrounding slopes should be examined.

An example from the Węgrzynowo region confirms that the radiocarbon dating of the colluvial layers has its limitations. The dates obtained by this method should be carefully checked with other sources or dating methods.

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