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Improving temporal, chronological and transformational frameworks
2.1 Pre-industrial Charcoal Production in southern Brandenburg and its impact on the environment

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ABSTRACT

Due to modern lignite mining in southern Brandenburg and northern Saxony (East Germany), entire landscapes are being destroyed. In the area of the lignite extraction, the BLDAM (Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum) concurrently carries out large-scale archaeological surveys and excavations to study and document evidence of past land use by prehistoric and historic cultures. On the area of the Jänschwalder Heide (Lower Lusatia, southern Brandenburg) one of the largest archaeologically investigated charcoal production areas in Germany was discovered, demonstrating the great intensity of energy production in historical times. The charcoal was probably used in the nearby ironworks of Peitz, where bog iron ore was smelted since 1567. Meanwhile, remnants of more than 400 charcoal hearths are excavated. To charge those piles, large areas had to be cleared, which certainly had major consequences for the environment and the character of the landscape. At least for a while, the vegetation was completely absent on the deforested areas, which were used as farmland although the soils are very sandy and poor in nutrients. Wind-blown sediments covering the charcoal pile relicts prove that clearing and agricultural use has induced aeolian soil erosion and the remobilisation of Quaternary sands.

One of the main aims of the ongoing investigation is to build up a chronological framework of the former charcoal production. These findings have to be correlated with the major phases of the landscape dynamics, which are documented by the relicts of soil erosive landforms, human-induced aeolian sediments, and buried soils.
KEYWORDS

lignite mining, charcoal burning, Lower Lusatia, land-use history, anthropogenic impact

INTRODUCTION

Opencast lignite mining results in the total destruction of cultural landscapes and even small towns. Therefore, over the past years systematic archaeological research has been carried out in the opencast pits in Lower Lusatia (southern Brandenburg, Germany), prescribed by the regulations of the Brandenburgisches Denkmalschutzgesetz (BbgDschG). For the opencast pit Jänschwalde, it is expected that during the year 2010, an area of approximately 200 ha will be utilised (4 km length of the opencast pit and 500 m width of the excavated stripe). However, the large-scale impact of lignite extraction offers the opportunity for archaeologists to study landscape and settlement history as a whole instead of recording single findings and find spots.

During the archaeological investigations in the apron of the opencast mine Jänschwalde, presumably the largest charcoal production area in Central Europe, was detected (Rösler 2008). Meanwhile the remnants of more than 400 upright circular kilns have been prospected and excavated. The number of charcoal kilns suggests an immense impact on the environment caused by charcoal burning and related activities like logging.

In former times, charcoal burning was a widely distributed practice, carried out within forested parts of Europe (Groenewoudt 2005). Charburner was a respectable profession due to the importance of charcoal for energy supply and aggregates in pre-industrial production facilities like glass kilns, brickworks and iron works. This is also proven by the family names ‘Kohler’ or ‘Köhler’, which are common in Germany. In Central Europe, charcoal was mainly produced in the wooded low mountain ranges like the Erz Mountains, the Black Forest, the Vosges, the Jura Mountains, the Thuringian Forest, the Upper Palatinate Forest and the Bavarian Forest (e.g. Rösler 2008). Investigations by Groenewoudt (2005) show that charcoal burning was also carried out in the eastern part of the Netherlands, although the investigations in Jänschwalde suggest that former charcoal production in Lower Lusatia exceeds the charcoal production in the low mountain ranges. However, historical charcoal burning is not as well investigated as in other regions like the Netherlands (Groenewoudt 2005) or the Black Forest (Ludemann 2009).

In Brandenburg, the demand for charcoal resulted in a considerable development of charcoal burning. The earliest evidence of targeted charcoal burning in larger quantities in Lower Lusatia derives from the opencast pit Welzow-Süd. On the Wolkenberg, charcoal piles were found at the individual smelting furnace sites of a Germanic smelter centre (Lipsdorf 2001). The remains of pit kilns (German: Grubenmeiler) document the use of the oldest technique of traditional charcoal production (Lipsdorf 2001; Spazier 1999). From the 16th century onwards, charcoal hearths (German: Platzmeiler), were used. Charcoal burning for industrial use, particularly in smelters, is also known from several sites in Lower Lusatia, e.g. at Lauchhammerschlag near Altdöbern, where charcoal was produced for the iron work Lauchhammer, built in 1725 (Lipsdorf 2001).

First of all, this paper gives a résumé of the current state of research on historical charcoal burning in the Jänschwalde area (Lower Lusatia) which is mainly based on archaeological survey. Furthermore,
since 2010 the Research Group ‘Anthropogenic Landscape Development and Palaeoenvironmental Research’, the Chair of Geopedology and Landscape Development, the International Graduate School (all BTU Cottbus) and the BLDAM have jointly studied the environmental consequences of charcoal burning. The main objectives are to investigate the spatial extent of the affected area, to compile a chronology for charcoal burning, to study the effects of charcoal burning on the landscape (e.g. reactivation of aeolian dynamics, soil erosion, deforestation) and on soil physics and chemistry in matters of soil productivity. Therefore the research concept comprises four different scientific approaches: 1) an archaeological approach, 2) a pedological-geomorphological approach, 3) an archival research and 4) a GIS-based reconstruction of past environmental conditions and anthropogenic induced landscape change.

**STUDY AREA AND GEOGRAPHIC SETTING**

The study area Jänschwalde (opencast pit; 51°47´31N´´, 14°32´23´´E) is situated c. 10 km northeast of Cottbus (Lower Lusatia, southern Brandenburg, Germany) (fig. 1). Opencast mining started during the 1970s and the affected area is c. 6015 ha. The investigated charcoal production area lies within the opencast pit,

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**Figure 1. Location of the study area opencast pit Jänschwalde (Lower Lusatia, southern Brandenburg), situated c. 5 km northeast of Peitz.**
east of Peitz (fig. 1). In former times, this area was named ‘Königlicher-Taubendorfer Forst’ or ‘Tauerscher Forst’ and was in possession of the royal family (fig. 2).

Generally, Lower Lusatia is characterised by a continental climate with an annual mean air temperature between 8 and 9 °C and the temperature amplitude is about 18 °C. The annual precipitation sum ranges between 510 and 610 mm (Scholz 1962).

The landscape was formed by Pleistocene glaciations. The opencast pit Jänschwalde lies on the terrain in the border area of Old and Young drift (Lippstreu et al. 1994; Nowel 1995). The Hornoer plateau (up to 110 m a.s.l., fig. 2) is a relic of the ground moraine deposit of the Saale-complex (Cepek et al. 1994). It is a gentle undulated plain with elevations up to 110 m a.s.l. divided by basins at about 75 m a.s.l (Lippstreu et al. 1994). The near subsurface of the Hornoer plateau is built up by subglacial tills (i.e. ground moraine) as well as sandur and fluvio-glacial deposits, which were altered by periglacial geomorphological processes during the Weichselian. The plateau is in some extent bordered by the River Neiße in the east, and in the west by the broad plain of the Weichselian sandur, the so-called Taubendorfer Sander (Lippstreu et al. 1994). Directly to the south of the Hornoer plateau adjoins to the Baruther Urstromtal, which is filled up with meltwater deposits deriving from the Late Weichselian continental ice sheet (Brandenburger Stadium) (Lippstreu et al. 1994; Nowel 1995).

Figure 2. Overview of the location of prospected and excavated charcoal piles in the opencast pit Jänschwalde (state: 01.04.2010). The small rectangle marks the location of the large charcoal hearths assembly shown in Figure 4.
In addition, inland dune fields are present in the study area. Sedimentological, stratigraphical and pedological investigations were carried out in the dune field area in the apron of the opencast pit Jänschwalde, at the western border of the Düringsheide between the River Malxe in the west and the southern cape of the Horner plateau in the east (Poppschütz 2001). Postglacial landscape history studies in the region along the River Malxe between the villages Grötsch and Heinersbrück were carried out in connection with archaeological investigations (Stapel 2000 a, b, c; Bittmann 2000). Research on anthropogenic impact on the landscape during (pre-)historic times were for example conducted on V-shaped erosion valleys of the Horner plateau (opencast pit Jänschwalde) and on late medieval ridge and furrow in the opencast pit Cottbus-Nord (Woithe & Rösler 2001; Geldermacher et al. 2003; Woithe 2003; Bönisch 2005).

The dominant soils on the sandy-loamy ground moraines are cambisols, luvisols and podsols. The mainly poor soils are partly truncated by soil erosion. Buried soils are present under colluvial deposits on the slopes or below sand dunes. In depressions, wet lowlands and on the foot of the dunes iron- and iron-humus horizons may occur (Woithe 2003).

METHODS AND TECHNIQUES

The ongoing archaeological investigation aims to survey the cultural landscape as a whole. The systematic research comprises three stages of investigation: 1) prospection by site inspection and aerial photo analyses, 2) sondages (in stripes and in grids) and test trenches carried out manually and/or with an excavator, 3) open area excavations of selected areas which are especially likely to produce good results or to answer specific questions. The study area is surveyed with differential GPS (Global Positioning System). Additionally, airborne laser scanning maps, courtesy of the Vattenfall Europe Mining Group, are used for orientation, topographic information and mapping. For absolute age determination with radiocarbon and dendrochronological dating, charcoal samples are collected from buried agricultural soil horizons and the remnants of selected charcoal kilns.

ARCHAEOLOGICAL BACKGROUND OF THE OPENCAST PIT JÄNSCHWALDE

The excavations in the apron of the opencast pit Jänschwalde are yielding plenty of findings (fig. 3). Archaeological evidence of prehistoric settlement in the study area includes numerous Mesolithic chipping floors. For the Neolithic Period and the Early Bronze Age, burial grounds were found with arrowheads and flint dirks as grave goods (Rösler 2001). Furthermore, Bronze Age post buildings with granaries for cereals as well as graves were detected. Wells were found, which served as water supply on the Horner plateau (Bönisch 2004). In addition, a Germanic village from the 3rd and 4th century was excavated. The ground plans of the buildings, the wells, a cereal mill and much more, complete the picture of the way of living of the Germanic people in Lower Lusatia. Particularly interesting is the discovery of a forge for the production of ornaments, which was present within the settlement. In addition, fibulae were found, which were part of the period costume of the entombed dead persons on the graveyard nearby (Schultz 2008).
RESULTS AND DISCUSSION

Archaeological features of charcoal burning in the area of the opencast pit Jänschwalde

On the area of the opencast pit Jänschwalde, up to now, more than 400 remnants of circular upright hearths have been documented by prospection and excavation. The location and spatial distribution of the kiln sites is shown in Figure 2, which displays preliminary results. The majority of the charcoal piles are present in the former ‘Königlicher-Taubendorfer Forst’.

The remnants of the charcoal kilns are characterised by black, charcoal-bearing layers or by circular to oval surrounding or interrupted ditches, filled with charcoal. The ground plans of selected charcoal hearths are shown in Figure 4. The circular ditches were dug to extract the surrounding soils and substrates to cover and seal the stack. Following the lightning of the stack and the carbonisation and cooling down processes, the charcoal piles were opened with pokers and the ditches were backfilled with charcoal remains. The relicts of the charcoal hearths are clearly distinct as black circles present in the light sandy substrates (figs. 5, 6).

In addition, there are diverse finds of pits and post-settings, both inside and outside the circles. Particularly, single circular and trough-shaped pits are present with c. 1.5 to 1.9 m in diameter, which were
Figure 4. Large charcoal hearths assembly in the apron of the opencast pit Jänschwalde. The different circular ground plans are clearly distinct in the surrounding substrate by gray-coloured features and charcoal filling (drawing: M. Pingel). For the location of the large charcoal hearths assembly, see Figure 2.

Figure 5. Two overlapping ground plans of charcoal piles proving the multiple-shift usage of a charcoal burning site (photo: R. Piskorski).

Figure 6. Excavation of a charcoal pile (find spot 10, charcoal pile 2) buried under a 1m thick aeolian sediment. The covering by the dune sands indicates the remobilisation of Quaternary sands as a consequence of clearing for charcoal production (photo: H. Rösler).
filled with charcoal and sometimes with tar. These pits were found in different orientations directly in front of the circular ditches. Probably, these pits were used as pits to light the fire (German: *Zündfeuergruben*) or as pits to collect the tar (German: *Teerauffanggruben*). The overlapping ground plans of charcoal piles (see figs. 4, 5) prove the multiple-shift usage of a charcoal kiln site.

Concerning the age of the charcoal kilns, it is assumed that they have a medieval to modern age as suggested by the condition of the remains (Lipsdorf 2001). To date, only one charcoal kiln is absolutely dated by dendrochronological age determination. It was determined on a charcoal piece (pine) derived from the ditch of charcoal hearth 2 (find spot 10, fig. 6) dating to the year 1850 AD (Lab.-Nr. C44165), which fits well with the assumed age. It is presumed that not all the charcoal kilns are contemporaneous, but rather date from several centuries. Therefore, for further research more absolute age determinations are required.

The inner diameters of the charcoal kilns range from 3 to 20 m and they can be subdivided into three size classes: (a) small (3-8 m), (b) medium (8-14 m) and (c) large (14-20 m). The classification is preliminary based on the evaluation of one hundred ground plans. The majority of the charcoal hearths are large, with an inner diameter of up to 20 m. This result points at a production of charcoal in large quantities for industrial use. However, this has to be substantiated by further research. In contrast, the charcoal produced in the smaller hearths was possibly used by individuals for domestic application or by smaller craft producers.

Most probably the larger part of the charcoal produced in the study area was taken to the former ironwork Peitz nearby (Lipsdorf 2001). This smelter existed from the 16th century until 1858 (Lipsdorf 2001). Furthermore, there is evidence that the ironwork Peitz operated its own charcoal burning site, situated in the ‘Königlicher Taubendorfer Forst’, north-east of the ironwork. It is a fact that the ironwork was supplied with charcoal from the Großen Peitzer Heide. Prior to 1600, oak wood was used for charcoal production, and pine wood later on (Reichmuth 1986). So far, it is not clear if and to what extent the charcoal burning sites south-east of Peitz were also operated by the ironwork. At Peitz bog iron ore, a typical raw material of the lowlands in Brandenburg, was used for iron production. Today, the former mining sites are not visible in the landscape, because they are levelled by natural processes or filled.

For charcoal burning in upright circular kilns the site selection is crucial (Lipsdorf 2001). The considerations include the location (e.g. substrate, inclination of the ground surface) and the availability of wood and water. Concerning the location, a level surface and a loamy-sandy substrate are needed for the aeration of the stack during the charring process. In this respect, the charcoal burning area in the open-cast pit Jänschwalde offers ideal conditions. The investigations of charcoal hearths near Horno showed that they were situated on the slopes of the Hornoer plateau, which are dissected by V-shaped valleys caused by erosion. This suggests that hillside situations were preferred, probably because of the natural windbreak since the control of the oxygenation was the major difficulty. The charcoal hearths were mainly present on the flat footslope between 65 and 70 m a.s.l., extending over a linear line of 1.3 km length. The inclination of 20 to 30 cm from the centre of the stacks was ideal for the drainage of condensation water and tar and guaranteed more efficient oxygenation. The charcoal hearths sites were used repeatedly since a new setting meant both additional work and expense (Lipsdorf 2001). A further important precondition for the charcoal site selection was the availability of wood and the proximity to the wood resource. Therefore, prior to the beginning of charcoal burning, the presence of extended woodland is inferred. Investigation of the charcoal sites on the slopes of the Hornoer plateau showed that the majority of
the kilns were situated at the rim of the V-shaped erosion valleys and close to brooks, but the proximity of
the charcoal kiln sites to water supplies presumably played a secondary role in the site selection (Lipsdorf
2001).

Though the site selection for charcoal burning is important, as described in detail above, at this
stage the distribution of the charcoal hearths seems to be more related to the historic land tenure than to
distinct natural landscape units. This question is part of the ongoing research.

The effects of charcoal production on the environment in the area of the opencast pit Jänschwalde
Large quantities of wood are required for charcoal production. The computational model for a rough cal-
culation of the woodland consumption for one charcoal kiln is shown in Figure 7. It is based on data from
current forest management in Brandenburg (Frommhold 2010). Accordingly, a woodland consumption
of c. two hectares per stack is calculated, demonstrating the intensive utilisation of the woodland area.
Actually, the calculated numbers are extrapolations, and a transfer of this value to the entire charcoal pile
area is only possible with reservations. A more exact calculation of the woodland consumption is an es-
sential part of the ongoing research. Nevertheless, charcoal production and related activities must inevi-
tably have had tremendous consequences on the environment.

One of these consequences was the remobilisation of Quaternary sands, which was initiated by for-
est clearance. Quaternary sands are mainly present in the west of the study area, as Taubendorfer Sander
and south of the Hornoer Plateau in the Baruther Urstomtal, which maybe the source of the relocated
sands. The causal connection of clearing for charcoal production and wind erosion is for example proven
by the find of a charcoal pile (1850 AD, Lab.-Nr. C44165, dendrochronological age) buried below a c. 1m
thick aeolian sediment cover (Fig. 6). Furthermore, in the study area former ploughing horizons (fAp-

Figure 7. Computational model for the woodland consumption of one charcoal pile. For the
rough calculation the geometric shape of a truncated cone is used. The model is based on data
for pine from current forest management in Brandenburg (Frommhold 2010). The most frequent
ground plans found have an average inner diameter of 14m, therefore this diameter is used for
calculation.
buried by dune sediments are present. Radiocarbon dating ($^{14}$C-AMS) of charcoal particles from the fAp-horizon of the cross-section shown in Figure 8 resulted in an age of $970\pm 44$ a BP (989 AD-1162 AD, 2 Sigma, Erl-15502). Moreover, in the opencast pit Cottbus-Nord, ridge and furrow were found, also covered by aeolian sand. Based on ceramics found in the buried topsoil, the agricultural use is dated to the 15th to 16th century (Geldermacher et al. 2003). In conclusion, the investigations demonstrate a highly dynamic landscape caused by anthropogenic impact during the past centuries.

**DISCUSSION, CONCLUSIONS AND PROSPECTS**

The opencast pit Jänschwalde is probably the largest charcoal production area in Central Europe. Primarily, the excavations in the apron of the opencast pit Jänschwalde provide evidence for the use of upright circular kilns for charcoal burning. The large number, in total more the 400 charcoal hearths, and especially the occurrence of big charcoal kilns situated in the former ‘Königlicher-Taubendorfer Forst’ hints at the connection between industrial charcoal production and the ironwork Peitz. The ongoing excavations in the opencast pits south of Peitz supply further evidence of the interrelation with the ironwork. For example, in the opencast pit Cottbus-Nord, the stream that drove the water wheels and therefore the machines of the Hammerwerk (water-powered drop forge) is currently being investigated. This artificial channel of the River Spree is a brilliant engineering achievement.

Charcoal burning on such a large scale inevitably caused damage to the environment. One of the unintended results was the remobilisation of Quaternary sands by wind erosion, initiated by forest clearance. The sands went on to cover former agricultural soils and charcoal burning sites. This attests to
large-scale man-induced landscape change during past centuries. Besides the implications for the soils and landscape dynamics, by forest clearance, by charcoal burning and by the incorporation of charcoal fragments in the former top soils, the carbon cycle was also affected, at least on a regional scale. Finally, deforestation certainly had an impact on the water balance, which has not yet been investigated.

First of all, one of the main targets concerning further research in the opencast pit Jänschwalde is to establish a chronology for the land use history, especially for charcoal burning, based on absolute age determinations by dendrochronological and radiocarbon dating. Kiln site anthracology (analysis of wood charcoal) could supply complementary information on forest vegetation and woodland history.

With the continuation of the opencast pit Jänschwalde and passing the village of Grießen in a north-easterly direction, the archaeological work will concentrate on the Horner plateau and the adjacent western boundary areas. The time pressure caused by the mining activity in the apron of the opencast pit affords an effective strategy for the archaeological survey and for the accompanying geomorphological and pedological investigations. Concerning the latter, the issues are ideal for the application of modern, rapid and low-cost handheld techniques of soils and sediment analysis, e.g. handheld X-ray fluorescence (XRF) analyses. Finally, the results from the studies combined with the historic map analysis are combined and evaluated using a Geographic Information System (GIS) to reconstruct the dimension of charcoal burning and its impact on the environment.

In conclusion, the opencast pits in Lower Lusatia offer the outstanding opportunity for a comprehensive land use reconstruction. The large dimension of the area affected by lignite mining and the numerous outcrop situations caused by the lignite extraction provide an extraordinary insight into a complete landscape unit comprising geology, geomorphology, pedology and archaeology. This has created the opportunity for interdisciplinary cooperation between archaeologists, geographers, soil scientists and palaeobotanists, to the benefit of both the historical and natural sciences.

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