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Charcoal usage in medieval and modern times in the Harz Mountains Area, Central Germany: Wood selection and fast overexploitation of the woodlands

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ABSTRACT

Anthracological analysis is increasingly used to reconstruct natural and anthropogenic woodland dynamics. Here, we combine macro-charcoal records from charcoal production sites (kiln sites) with such from archaeological sites to elucidate past forest composition and its dependency on past fuel economy and human resource management.

The anthracological investigations of seven medieval smelting sites in the Harz Mountains provide detailed information about past fuel and woodland usage. First, the charcoal records allow for separation of chronological phases within the archaeological sites. Second, a selection of distinct wood species is identified for the different smelting activities (silver–copper-production). Third, in addition to reconstructing the human activities related to ore smelting, it remains possible to reconstruct the local vegetation in the surroundings of the former smelting sites.

The new anthracological investigations of kiln sites in the Harz Mountains focus on higher elevations (>600 mNN) and date to (early) modern times, showing a temporal and spatial shift of woodland exploitation to more remote, higher elevated areas. As expected, all typical taxa of the natural montane woodlands were used. Thus, local topographical conditions and natural woodland composition mainly regulate wood usage rather than human selection. *Picea abies* is the dominant species in all the records. However, surprisingly, local scale expansion of the montane beech woodland (Calamagrostio villosae-Fagetum) was identified, which reaches areas that today are fully covered by spruce woodland. Thus, the new results contradict the previously accepted assumption that the Harz Mountains above 750 mNN were covered by pure, natural stands of spruce until the 17th century. A recommendation for the woodland conservancy concept of the Harz national park, which includes tree planting to push woodland renaturalization is to add the planting of *Fagus* and *Acer* in elevations above 600 m.

1. Introduction

For thousands of years, human economy, particularly mining as well as ore processing has relied on wood and charcoal as the main source of fuel (Ludemann, 2010a,b). Besides the availability of ore, continuous charcoal supply was one of the preconditions for intensive smelting activity before the introduction of coal in the 19th century. The high wood demand for ore processing led to an intensive alteration of woodland over time, often resulting in a completely transformation of the natural woodland into a silviculture. Especially, charcoal production on kiln sites plays an important role and is one of the key activities for woodland usage in the central European low mountain ranges. Therefore, kiln sites can be found in high density in central European low mountain ranges (Hillebrecht, 1982; Ludemann and Nelle, 2002; Nölken, 2005; Ludemann, 2010c; Knapp et al., 2013). The anthracological analyses of such kiln sites combined with charcoal analyses on smelting sites and mining settlements provides detailed

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information about usage of the most important resource wood and allows insight into woodland exploitation by humans on a multi-century temporal scale.

Beside human resource management, kiln sites are additionally a valuable archive for woodland reconstruction (Bonhote and Vernet, 1988; Davasse, 1992; Ludemann, 1996; Ludemann and Britsch, 1997; Nelle, 2001). The common and long term vegetation history of central Europe (e.g. Firbas, 1949, 1952; Lang, 1994; Kalis et al., 2003) is well investigated by palynology, albeit due to the limitation of palynology (Gaillard et al., 2008a,b; Nelle et al., 2010) mostly with regional spatial resolution. Kiln site anthracology, however, offers additional information because it mirrors woodland composition on a local scale with special regard to site condition as well as stand structure (Ludemann, 2003; Nelle, 2003). From a methodological point of view when analysing charcoal from archaeological sites, there is generally the risk of a human filter due to potential wood selection for different purposes, sampling strategies or a natural filter by e.g. different taphonomic processes, which have to be considered when interpreting such charcoal assemblages (Nelle et al., 2010; Théry-Parisot et al., 2010). Moreover reconstruction of past usage of wood can rely on different sampling strategies as well as different purposes (Shackleton and Prins, 1992; Marston, 2009; Stöllner, 2010). Nevertheless, in the kiln site charcoal record from several low mountain ranges in western Europe only minor indications for species selection in terms of woodland resource availability were found (Bonhote and Vernet, 1988; Davasse, 1992, 2000; Ludemann, 1996; Ludemann and Britsch, 1997; Nelle, 2001; Ludemann and Nelle, 2002).

The low Harz Mountains were under the pronounced influence by humans since Roman times, mainly by mining activity and charcoal production for smelting purposes. More than 30,000 kiln sites and 2500 smelting sites are expected for the entire Harz reflecting the long and intensive mining history of the area (von Kortzfleisch, 2008). Thus, the Harz is ideal to investigate past wood and charcoal usage as a key resource for mining as well as to elucidate possible human bias in archaeological charcoal assemblages.

Due to the huge mining activity, the pre-mining woodland composition of the Harz cannot be reconstructed from the vegetation today. Especially, the distribution range of *Fagus sylvatica* and *Acer* sp. as well as the local scale interlocking between *Fagus* and *Picea* dominated woodland is of increased significance for the national park. Thus, further aims are a) to reconstruct medieval and Modern Times woodland composition to pursue basic information for woodland restoration as well as conservation policy on a local scale and b) to elucidate the extent of past woodland usage. Therefore, we analysed charcoal from different archives (kiln sites, smelting and settlement sites) from different timescales as well as altitudes in the Harz Mountains. This combined approach for the first time allows for a comparison between sites of charcoal production (kiln sites) and sites of charcoal consumption (e.g. smelting sites). Thus, we can follow two steps in the “chaîne opératoire” of past mining activities and their socio-environmental implications.

1.1. Study area and regional setting

The investigation area is the northwest part of the Harz Mountains (Fig. 1). The Harz is the northernmost low mountain range in Germany with an extension of approximately 30 × 90 km and towers above the North German lowland plain. Geographically, the Harz is subdivided into the Upper Harz (up to 700 m a.s.l), the High Harz (parts of the Upper Harz above 700 m a.s.l.) and the eastern Lower Harz (sloping area below 500 m a.s.l.).

The Harz is part of the Variscan orogen belt, and the northwest part consists mainly of Carboniferous greywacke, Devonian sandstone, shale and basaltic spilite as well as biotite granite. Around the Brocken pluton diorite-granodiorite occurs. Its highest mountain is Mt Brocken at 1142 m a.s.l. On the siliciclastics, nutrient poor soils developed (Karste et al., 2005). Furthermore, a great variety of ore deposits are found in the mountains and its foreland (Mohr, 1993). Besides the deposit of Rammelsberg with its sulphidic microcrystalline copper and lead/zinc ores, there are coarse sulphidic lead/silver ores from the ore dykes in the Upper Harz. A third kind of deposit are the red iron ores from the diabase range as well as the iron/manganese ores from the deposit at the Iberg. Due to its exposed northern position above the North German Plain, the climate of the Harz Mountains is markedly humid. Moreover, the low mountain range is characterized by a pronounced climate gradient between the colder western and the warmer eastern part (Glässer, 1994). Mean annual temperature increase from 4-5 °C–8.5 °C, while mean annual precipitation decrease from 1000 mm to 500 mm from west to east. Before the onset of mining activity, the vegetation of the Harz Mountains was mainly characterized by broad-leaved woodlands (Aceri-Fagetum and Luzulo-Fagetum) up to 700–800 m a.s.l., while above *Picea abies* became the dominant tree species. Today, the vegetation composition consists mostly of different anthropogenic *Picea*-forest and more natural *Picea*-woodland, depending on the soil conditions as well as the altitude (e.g. Calamagrostio villosea-Piceetum, Bazzanio-Piceetum, Piceo-Sorbetum). Overall, 85% of the Harz national park is covered by spruce, of which 60% stocks are on potentially natural deciduous forest sites (Karste et al., 2006).

1.2. Archaeological background

The various and comprehensive ore deposits of the Harz Mountains caused a long lasting human activity in terms of mining, ore smelting as well as charcoal production. Settlement history of the Harz foreland is dated to Neolithic times. In the Harz Mountains itself, human activity, with simple use of transit tracks, may start during the Bronze Age but is still questionable. Indications for Bronze Age and Iron Age mining activity were found in peat and sediment cores from the Harz foreland (Matschullat et al., 1997; Hettwer, 1999). Recently, Lehmann (2011) and Knapp et al. (2013) found indications for mining as well as landscape opening during the late Bronze Age. First archaeological evidence for smelting in the Harz foreland dates to 300 AD (Klappauf, 1985, 2003; Hettwer et al., 2003), while during the Migration period no signs for smelting activity can be found. Up to the 8th/9th century AD, no huge changes in the mining technology occurred, and smelting places operated close to the settlement areas in the Harz foreland avoiding the Upper Harz (Bartels et al., 2001; Alper, 2008). The year 968 AD marks the historic beginning of mining of the Rammelsberg ores, and the 13th century represented first intensive mining activities of the Upper Harz hydrothermal copper–zinc–lead dykes (Liessmann, 2011). The extensive mining and smelting activities during the Middle Ages culminated from 1050 to 1250 AD in all parts of the Lower and Upper Harz (Klappauf, 2000; Bartels et al., 2007). With the increase of the mining activity during the 12th and 13th century, the first permanent settlements in the Upper Harz were established (Hauptmeyer, 1992) and an increasing number of smelting sites up to 700 m a.s.l. can be found as well (Klappauf et al., 2008). While during the early Middle Ages smelting places were used seasonally, during the 12th and 13th century there was atransformation towards multi-phase smelting places.

During the 14th century, mining felt into a huge crisis leading to a nearly complete collapse of the first mining period (Hauptmayer, 1992; Steuer, 2000). After 1520, mining activity slightly increased, leading to the second mining period (Beug et al., 1999) with huge