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Reconstructing 2500 years of land use history on the Kemel Heath (Kemeler Heide), southern Rhenish Massif, Germany

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Abstract: The Kemel Heath (Kemeler Heide) in the Lower Taunus Mts. was used as a heath until the early 19th century. Today, it is the most densely wooded area of the German state Hesse (about 60 %). The history of the regional landscape and the land-use patterns of this area in the last 2500 years will be reconstructed by different methods and considering relicts, which have been preserved in the forest.

For reconstructing the former situation, three deserted agriculture areas with well recognizable field balks under forest were investigated for the first time by ^{14}C and OSL dating, sediment analysis and mapping. Furthermore, points of interest were the traces of Early Modern charcoal burning. For this purpose, we reconstructed the spectra of tree-species of the burned wood and dated it by ^{14}C. In addition, we dated the formation of two former slag heaps, of a medieval refuge castle, and calculated the sedimentation rate of a small colluvial filling of a slope depression that was deposited since the Roman times.

Regarding the results, there are clear traces of land use during the Iron Age and Roman Period, and strong impacts during the Middle Ages and the Early Modern Period. Thus, it is likely, that the deforestation in the investigated area was much higher during these periods than previously believed. Most of the field balks originate from the High Middle Ages. In contrast, during the Early Modern Period, the landscape was predominantly pastureland.

Die Rekonstruktion der Landnutzungsgeschichte während der letzten 2500 Jahre auf der Kemeler Heide im südlichen Rheinisches Schiefergebirge

Kurzfassung: Die Kemeler Heide im westlichen Hintertaunus ist heute Teil des größten zusammenhängenden Waldgebietes in Hessen mit einer Waldbedeckung von rund 60 %. Bis ins frühe 19. Jahrhundert wurde sie jedoch als Heide genutzt. Mit der vorliegenden Studie wird versucht, die regionale Landnutzungsgeschichte auf der Kemeler Heide mithilfe verschiedenartiger methodischer Ansätze zu rekonstruieren. Eine besondere Berücksichtigung erfahren dabei historische Relikte, die sich im Wald erhalten haben.

Zur Rekonstruktion früherer Landnutzungssysteme wurden hochmittelalterliche Ackerraine in drei verschiedenen Wüstungsfluren kartiert und im Hinblick auf ihre Sedimentzusammensetzung und ihr Alter untersucht. Die Datierung derartiger Ackerkolluvien erfolgte erstmals mit mehreren ^{14}C- und einer OSL-Datierung. Ein weiterer Schwerpunkt der Untersuchungen waren frühneuzeitliche Holzkohlemeilerplätze, anhand derer die Artenzusammensetzung der frühneuzeitlichen Wälder rekonstruiert werden konnte. Zusätzlich wurden auch zwei verschiedene Schlackenhalden als Hinterlassenschaften hochmittelalterlicher Eisenverhüttung datiert und die Ergebnisse mit den Sedimentationsraten einer kolluvialen Dellenfüllung verglichen.

Dabei konnte nachgewiesen werden, dass die anthropogene Landnutzung auf der Kemeler Heide spätestens während der Eisenzeit begann. Die stärksten Einflüsse erfolgten jedoch erst während des hohen Mittelalters und der frühen Neuzeit. Besonders im Hochmittelalter führte ausgedehnter Ackerbau dazu, dass der Waldanteil weitaus kleiner war als heute. Die meisten Ackerraine stammen daher aus dieser Periode. Während der Neuzeit wurde dagegen vermehrt Heidewirtschaft betrieben.

Keywords: *Field balks, charcoal burning, iron slag, deforestation, sedimentation rate, Rhenish Massif, Taunus Mts.*

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1 Introduction

1.1 Open questions

The Kemel Heath (*Kemeler Heide*; Fig. 1) is a historic area of around 60 km² in the Lower Taunus Mts. characterized by wide spread etchplains and deeply incised valleys at their edges (Hüser 1972). Today, about 60 % of the former heath area is forested (forest area of the community of Heidenrod; Hessisches Statistisches Landesamt 2008). However, historical reports confirm a large deforestation in the past (Ehmke 2003). So far, very little is known about the real proportion of the deforested area and land use intensity during different prehistoric and historic periods in this area.

In at least half of the wooded area of the Lower Taunus Mts., remains of former agriculture, such as field balks (Fig. 4) and clearance cairns are visible, which give evidence of an enhanced cropland area in the past. In most cases, the age of these relicts is quite unknown. In addition, there are frequently found kiln sites as relicts of former charcoal production for the local iron industry.

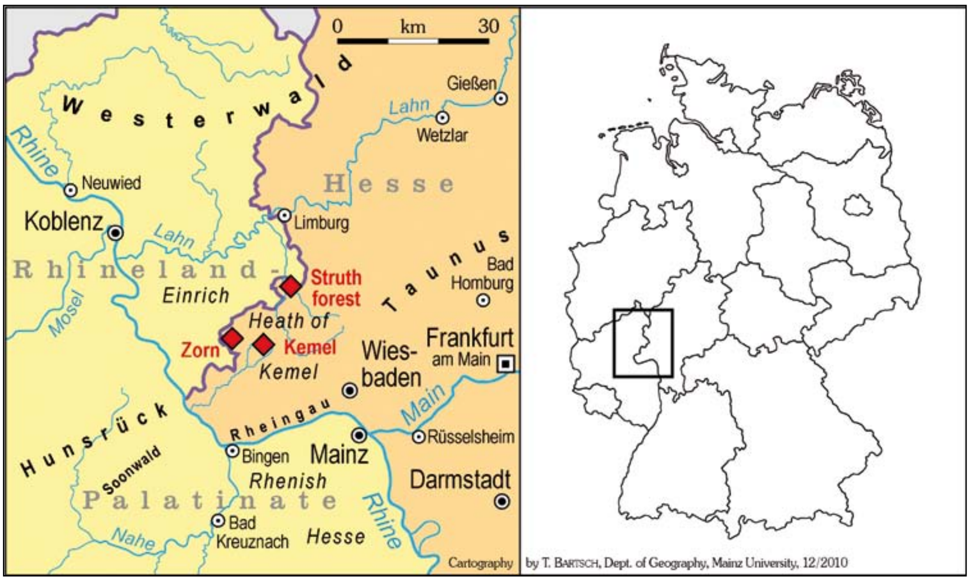

Fig. 1: Regional setting of the investigation area.

Abb. 1: Lage der Untersuchungsgebiete.

The special aim of this study is to create a chronological order of these remains for reconstructing the land-use distribution during specific periods and for comparing this with historical data: How old are the field balks and clearance cairns at selected locations, how are they structured and, in which way is it possible to date the concerning colluvial sediments? In which periods agricultural activities can be proven on the Kemel Heath? Furthermore, when the kiln sites were being used and which was the composition of the forests? Moreover, this study focuses on the consequences of former land-use. This was done by the investigation of the filling of a small valley the chronology of which was used to identify local soil erosion phases. The different sedimentation rates of the valley filling are given in mm/a.

We used a small valley filling for the chronological classification of local soil erosion phases (listed in mm/a), respectively by heavy rainfalls and a strengthened susceptibility on soil erosion by land-use.

Altogether, we investigated 7 forested locations in 3 different parts of the Kemel Heath by pedological analyses of selected soil profiles inside of field balks, datings of organic remains by AMS-^{14}C, one dating of Holocene colluvium by Optical Stimulated Luminescence (OSL) and by the anthracologic analyses of charcoals from kiln sites (Fig. 1):

a) 3 former field locations: In the Pfaffenwald forest (the term means "forest of pastors", in the past it was probably owned by the church), district of Heidenrod-Zorn (N 50°10'8.61", E 7°55'34.3"); in the Ohren-Forest (the term Ohren means the former presence of maple trees), district of Heidenrod-Niedermeilingen (N 50.1742°, E 7.9458°); in the Struth forest, district of Aarbergen-Kettenbach at the outside rim of the Kemel Heath (N 50.257°, E 8.065°).

b) 2 charcoal kiln sites: In the Pfaffenwald Forest, district of Heidenrod-Obermeilingen (N 50.167°, E 7.919°) and in the Reißbrühl forest, district of Heidenrod-Zorn (N 50.169°, E 7.930°; both are located on north-facing slopes which improves comparability).

c) 2 slag heaps: In the district of Zorn, five slag-heaps in the forests were found. Most of them are not located close to flowing waters, which may be a hint of a relatively high age (14th century and earlier; Geisthardt 1954). The first one we investigated is located a few meters beside the refuge castle (see below). Another one is located in the upper course of the small stream Rödelbach near Zorn (N 50.15829°, E 7.93905°).

d) 1 refuge castle in the district of Heidenrod- Zorn: The refuge castle *"Alte Schanz"* (N 50.1538°, E 7.9145°) is an 18m broad and 1.5-3m high, round earthwork in the Struthheck forest with a moat around. Von Cohausen (1879) assumed it to be a part of transition phase from Early to High Middle Ages.

e) The sediment sequence of the alluvial fan of a small valley near the village of Kemel, which included a Roman water well (N 50.1650°, E 8.0147°).

2 Regional setting and state of research

2.1 Physical conditions

The Kemel Heath belongs to the northern foreland of the Taunus mountain range. The altitudes range from 350 to 540m a.s.l. Its bedrock consists almost exclusively of mostly clayey Paleozoic metamorphs, which are completely weathered on the higher etchplain levels (Felix-Henningsen 1990). The bedrock on the slopes is comprehensively covered by loess-containing periglacial cover beds on the slopes typically of at least three different solifluction layers. This profile can be typically divided by the German concept of periglacial slope deposits into at least two, however, more often into three different solifluction layers (Semmel 1968, Kleber 1997, Völkel et al. 2002, Stolz & Grunert 2010, Semmel & Terhorst 2010). In the Kemel region, the cover-beds mostly consist of a loess containing upper layer and one or several basal layers, rich in debris. Additionally, at protected locations there are one or several loess containing intermediate layers. Common soil types on these sediments are cambisols, cambisol-luvisols, luvisols and podsolic cambisols. Due to the clayey weathered bedrock, several of these profiles show stagnic conditions. The annual precipitation rate is approx. 750 mm and the annual temperature is 8 °C (data from the climate station of Waldems-Steinfischbach, measuring period 1961-1990; DLR-RLP 2012).

2.2 Cultural history

Principally, the German Uplands can be divided into older and younger settled areas. The first ones, settled from prehistoric periods to the Early Middle Ages, are the loess-rich forelands of the mountain ranges, the tectonic depressions and the valleys of the large rivers, such as the Rhine (Born 1989). An exception is the village of Kemel. Its name without a suffix, respectively with the former suffix -aha, is of prehistoric age and probably of Celtic origin (Bach 1927). The settlement was located at the important "Hohe Straße" (*High Street*; connection between the old cities of Mainz and Koblenz) on the watershed between the Lahn and Rhine catchments. Along this probably prehistoric road, there are hundreds of grave mounds from the Iron Age. Due to their special construction some of them must be of Bronze Age. One example was been found in the district of Laufenselden (6 km S of Kemel; Kubach 1984). Basically, most of these grave mounds in the Lower Taunus are located along paths on the watersheds and typically arranged like cemeteries (Herrmann & Jockenhövel 1990, Behaghel 1949). However, prehistoric settlements are unknown in this area (Schwind 1984). Kubach (1984) believes that there is a finding gap in the Taunus Mts. Evidences of settlement activities for this period are located in the Rhine-Main lowland, the Basin of Neuwied and the adjacent early settled areas outside of the Taunus Mts.

Furthermore, the Romans had settled in the region between 10 and 260 AD and built up the Upper German-Raetian Limes. Its western part was probably constructed since 85 AD and crossed the prehistoric "Hohe Straße" near the village of Kemel (Baatz & Herrmann 2002). Roman forts on the Kemel Heath were located in Kemel and Holzhausen an der Haide. Several *villae rusticae* were only known from the southern Rhine-Main area.

From the Early Middle Ages (Merovingian Period) only some findings are known from the Basin of Nastätten (Neumayer 1993).

At the end of the 10th century AD, the region was ruled by the archbishops of Mainz, who started a colonization phase. In many upland regions of western Germany, the colonization of the High Middle Ages (*Hochmittelalterlicher Landesausbau*) started at the same time (Born 1989). Numerous settlements with the suffixes -roth, -schied and -hain are indicative of this period on the Kemel Heath (Bach 1927). In agriculture, the shifting cultivation including grassland and cropland phases (*Feld-Gras-Wechselwirtschaft*) was widely disseminated (Ehmke 2003, cf. Born 1989).

Bork et al. (1998) describe a change from the bread-eating to meat-eating people in Central Europe since the Late Middle Ages. Therefore, the term "heath" can be explained by a predominant use of pastureland, mostly for sheep in a sparsely wooded area during the Early Modern Period (since approx. 1500 AD; cf. Born 1989) up to the beginning of the 19th century. The main part of the heath was an area with common grazing rights for everyone's animals (*Allmende*). In most villages, there were many more sheep than inhabitants during the Early Modern Period (Stolz 2008).

The small town of Nastätten at the rim of the Kemel Heath was a center of wool weaving and textile fabrication since the 16th century, which was already mentioned in the 13th century (Spielmann 1926). During the 15th and 16th century, towels from Kemel heath and from the surrounding Nassau and Hesse territories were even traded by the powerful merchant family, Fugger, in Augsburg, Bavaria (Orth 1953).

At the same time, the region was also a center of iron production with a high consumption of charcoal.

The charcoal which was primarily needed for iron-smelting was produced in numerous charcoal kilns. For production, small round or oval leveled places on slopes or on plateaus were prepared by the charcoal-burners. On these places, the wood branches were stacked and covered by grass and earth material. As a result, inside of the kiln was a lack of oxygen, which prohibited quick burning. Only the volatile wood gases burned, which resulted the wood to become transformed into pure carbon. By the introduction of fossil coal after 1850 AD, charcoal burning was strongly declining; in the 20th century the profession became extinct (cf. Kortzfleisch 2008).

The main consumer of the charcoal from the Kemel Heath was the iron melt of Michelbach (10 km NNE of Kemel). It has been running since 1656. Charcoal has not been in use since 1856 (Stolz 2008, Geisthardt 1957). Maybe also the melt of Geroldstein in the Wisper valley (12 km SW of Kemel, worked from 1589 to 1634 AD) and the melt of Katzenelnbogen (14 km N of Kemel, worked from 1736 to 1840 AD; Geisthardt 1957, Herold 1974, Ehmke 2003) were consumers of the charcoal from the Kemel Heath. By 1677, the melt of Michelbach was forced to get its charcoal from the forests on the quartzite mountain range of the Taunus because of a severe lack of charcoal in its surroundings. In 1780, the iron melts of the Nassau-Idstein county employed 300–400 people only for the purpose of charcoal and wood transport (Geisthardt 1957: 169). The melt of Katzenelnbogen was temporarily shut down around 1810 because of the absence of charcoal (Herold 1974).

The few remaining forests were of great importance to the people. Harsh punishments were the consequences for the theft of wood, grass, green branches for cattle feed, leaf litter, charcoal, oak bark for tannery, and venison (Roedler 1910). The consequence of this overexploitation was in the neighbored Aar valley near Michelbach the formation and further development of more than 200 gully systems (Stolz & Grunert 2006, Stolz 2008). Similar situations are known from other parts of the Rhine-Main area (Moldenhauer et al. 2010, Semmel 1995, Bauer 1993).

Already in the beginning of the 18th century, landlords tried to draw a clear border between fields and forests by the enacting of special laws (Ehmke 2003, Kaltwasser 1991). Since 1815, the local Earls of Nassau (*Herzöge von Nassau*) started a reforestation campaign led by the forest scientist, Ludwig Hartig (Kuls 1951). In forest district of Bad Schwalbach (Kemel region) the forests increased from between 1816 and 1866 of 1670ha (Kaltwasser 1991). By 1926, only a few remains of the heath existed (Roedler 1926).

So far, there are no pollen data from the Kemel heath, but from the Usa Valley (40 km in the NE) and from the Lower Westerwald Mts. (40 km in the NW). Schmenkel (2001) evidenced in the Usa Valley a first significant increase of non-tree pollen during the iron age but sinking back in the Roman Period. However, cereal pollen could be first evidenced since Early Middle Ages. The largest proportion of non-tree pollen is proven for the High Middle Ages. Hildebrandt et al. (2001) confirm in the Westerwald a low level of beech pollen *(Fagus sylvatica*) and a moderate rise of grass pollen (*Poaceae)* during the High Middle Ages. This was followed by a reforestation phase during the Late Medieval destruction period from about 1320 AD, which affected especially the uplands in Central Europe (Hildebrandt 2004; Abel 1976). While this time the values of beech pollen in the Westerwald are more than tripled.

Concerning the intensity of soil erosion, Becker (2011) assumed a total rate of soil erosion since the Roman period of almost 1m, proven by the depth of an investigated Limes-ditch in the village of Kemel. Furthermore, three charcoal particles from the filling of the ditch were dated by ^{14}C to a period between 3rd and 6th century AD as indication for human activities and fire events.

In the neighboring upper course of the Aar valley, there is, however, no evidence of prehistoric or Roman floodplain deposits, although the Limes crosses the Aar valley in this area. First sedimentation could not have been proven until 1000 AD. In the lower course of the Aar the overbank fines are of earliest Bronze age, but the main part was deposited not until Early Modern period (Stolz 2011a; Stolz & Grunert 2008).

3 Results from other mountain areas

Increased soil erosion in Central Europe is primarily triggered by anthropogenic land-use or by climate (cf. Dikau et al. 2005; Bork et al. 1998). First anthropogenic triggered erosion events are known for the Neolithic Period in the early settled parts of Germany (Lang 2003; Dreibrodt 2010). However, the sedimentation of Holocene colluvia started during quite different periods, just like the temporal peaks of soil erosion and redeposit are varied (cf. Leopold & Völkel 2007, Wunderlich 2000, Dreibrodt & Bork 2005, Dotterweich et al. 2003, Bork et al. 1998, Semmel 1993, Bibus 1989). Including the results of Holocene German river activity, summarized by Hoffmann et al. (2008), the sediment fluxes until 2250 BC are mainly coupled to climate. Since a geomorphologic activity phase 1320–820 BC, the influence cannot clearly be related to climate but rather to anthropogenic influence.

In contrast, Mäckel et al. (2009) describe a very early beginning of anthropogenic influences on the landscape in low mountain ranges of the Central Black Forest and the Kaiserstuhl Mt. (Southwestern Germany; 250 km S of Kemel). By sedimentological investigations and pollen analyses, an anthropogenic influenced sedimentation of loamy river sediments and slope colluvia could be proven since Neolithic, even for the river valleys of the Black Forest. The highest sedimentation values in these valleys were detected during Iron Age and Late Middle Ages. These results become confirmed by Rösch & Tserendorj (2011) who detected a shrunken forest cover to less than 70% in the Northern Black Forest Mts. in the Iron Age. During the Roman period and the following Migration Period the forest cover rises again.

For the High Middle Ages Wolters (2007) described a clear rising of *Poaceae* pollen and a moderate shrinking of arboreal pollen for two spring mires near Johanniskreuz in the Palatinate Forest (95 km SSW of Kemel), a young settled region of SW-Germany in the Bunter Sandstone. Bork et al. (1998) assume that the biggest proportion of forest distribution in Germany within the last 1000 years is during this period. Mäckel et al. (2009) detected a gap in sedimentation within profiles of the Black Forest at the transition between Early and High Middle Ages followed by strong sedimentation of particular alluvial sediments from the Upper Rhine Rift to the watershed of the Black Forest.

However, very little is known about the real proportion of deforested areas and land use intensity during different periods in Central Europe. In many cases, there are indices for a stronger utilization of woods and forests during several historical periods (cf. Ludemann & Nelle 2002, Küster 2008). Another method reconstructing former forests is the anthracologic analysis of former kiln sites. Due to their investigations of charcoal samples from the Palatinate Forest Hildebrandt et al. (2007) described a strong overexploitation of the forests as consequence of charcoal burning and harvesting especially during the 18th century. In the central Black Forest, Ludemann (2008) indicated a main period of charcoal burning in the 16th and 17th century. Similar results are known from the Harz Mts. (northern Germany; Hillebrecht 1982).

Evidences indicating former cropping are field balks and clearance cairns known from different European mountain areas. In most cases, the age of these relicts is quite unknown. For some examples a formation during High Middle Ages is assumed (cf. Born 1961; Scharlau 1961).

4 Materials and methods

Many of the studied sites pits had to be dug with the help of an excavator. Several profiles were investigated according to the rules set by the German *Bodenkundliche Kartieranleitung* (Ad-hoc AG Boden 2005) and International Union of Soil Sciences (2006). Laboratory analyses were conducted according to Blume (2000). The parameters analyzed were grain size, pH, carbonate content, organic matter and heavy mineral content. The determination of heavy minerals was made by M. Guddat-Seipel, Bad Nauheim.

The presence of Laacher See tephra in the field was proven by rapid testing, which is a method that was employed by Sauer & Felix-Henningsen (2006): bringing the sample into contact with filter paper impregnated with a 0.1% solution of phenolphtaleine in ethanol and a 5% aqueous NaF solution.

Dateable fragments of charcoal were separated from colluvial sediments by an archaeobotanical elutriation procedure of five liters sediment per sample (c.f. Jacomet & Kreuz 1999). These samples were not taken in regular intervals, but rather with regard to genetic layers and soil horizons.

Another possibility to reconstruct former land-use is offered by the analysis of charcoal kiln sites. By this method it is possible to indicate the used and, in consequence, the availability of wood species in the surroundings of a kiln. The charcoals from two different kiln sites were taken by sieve with a mesh size of 10 mm. To avoid any contamination while sampling, the individual layers of charcoal containing soil sediment were removed in thin layers by a small spade and a spatula (Fig. 8). Because of the low sediment-thickness on the investigated kiln sites, the samples of at least 100 charcoal fragments were taken in only two different depths of the *Stübbewall* (Fig. 7). A further sample was taken on the surface in the center of the kiln site. Thereafter, the charcoals were identified under a reflected light microscope with a magnification range of 100 to 400x (Schweingruber 1990; cf. Hillebrecht 1982, Manske 1997, Hildebrandt et al. 2001, Ludemann & Nelle 2002, Hildebrandt et al. 2007, Kortzfleisch 2008, Ludemann 2008). For identification, it is necessary to look at the charcoal in radial, longitudinal and tangential sections. The relevant characteristics of wood anatomy are the distribution and the size of the pores, the vascular rays the presence of spiral thickenings and the pits inside of the pores. In most cases, it is only possible to identify the genus and not the precise tree species (Nelle & Schmidgall 2003). After the identification procedure, the fragments of every genus were counted to identify the number of units (the charcoals were not weighted; therefore, G/N values for the individual samples could not be calculated; cf. Nelle & Schmidgall 2003). Other parameters like the former diameter of the wood were not measured. Some of the charcoal fragments or woods were chosen for radiocarbon-dating at the Radiocarbon Laboratories of Erlangen University (Germany), Poznan University (Poland) and Beta Analytics (USA). With regard to these results, it should be noted that there are possible error sources. Fundamentally, charcoal fragments can be much older as the time of sediment production. Thus, it has to be considered that ^{14}C-datings give only minimum ages (*terminus post quem*). Furthermore, disturbances and a vertical displacement by past land-use or bioturbation are possible. However, the deeper the sediment is taken beneath the surface, the possibility of this error becomes smaller.

Additionally, one OSL (Optical Stimulated Luminescence) sample was dated at the Department of Geography of the Humboldt-University of Berlin. Within the interpretations of the results, it must be observed that ^{14}C and OSL ages are not exactly equivalent with historic data but rather only a statistical probability (cf. Geyh 2008).

5 Results

5.1 Former field balks in forests

Field balks on slopes and accumulations consisting of gathered stones and colluvium on flat ground (in some parts of Germany such small landforms are called *Ackerberge*; Fig. 4) occur frequently in the forests of the Kemel Heath. At three different locations, we opened pits by an excavator to a depth of 300 cm.

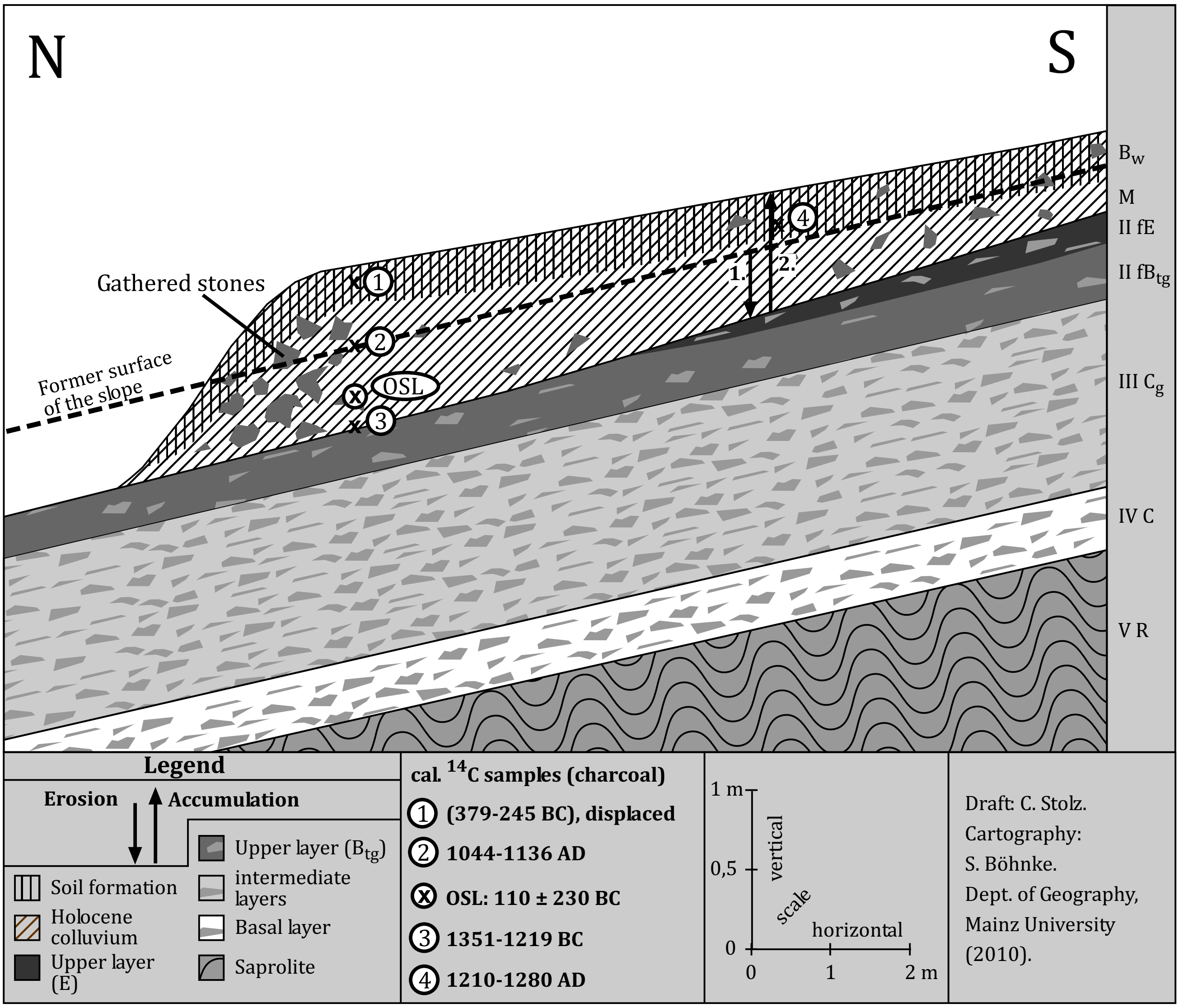

Fig. 2: Longitudinal section through the investigated field balk in the Pfaffenwald forest.

Abb. 2: Längsprofil durch den untersuchten Ackerrain im Pfaffenwald.

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5.1.1 Deserted fields in Pfaffenwald forest near the village of Zorn (N 50°10'8.61", E 7°55'34.3")

In the Pfaffenwald forest (Fig. 5), there are two well visible, as well as some indistinct field balks, forming long-striped field terraces on a north-exposed, 4–9° inclined slope. The recent forest consists of tall, 160 year old beeches.

In one of the balks, a pit was dug and another one 10 m upwards on the field terrace, in which a stone cluster (slates and quartzites) became visible within the balk (Fig. 2). Down to a depth of 100 cm, a Holocene colluvium has been accumulated by former agriculture. Its texture is very homogenous and clayey, because of its origin as an eroded soil (Tab. 1). The slightly brighter color of the uppermost 30 cm layer indicates an initial soil formation, while the texture and other parameters are inconspicuous. Underneath, the clay content rises and the soil aggregates are covered by well visible clay films indicating an eroded fossil Bt horizon, 33 cm thick (Tab. 1). The typically high contents of the heavy minerals augite, brown hornblende and titanite indicate the pumice of the event of Lake Laach. Thus, this layer represents the upper layer, which was active latest during Younger Dryas (cf. Semmel 2002; Tab. 2). The Holocene colluvium also contains the Lake Laach heavy minerals because of its origin from the eroded upper layer upslope.

Below the upper layer, two individual intermediate layers are deposited, which have a high content of skeleton (stones) and loess-like sediments. The typical heavy minerals of loess-like garnet and green hornblende are detectable (cf. Semmel 2002). The basal layer below only consists of lo-

Tab. 1: Sedimentological data of the field balk profile in the Pfaffenwald forest.

Tab. 1: Sedimentologische Daten zum Profil innerhalb des Ackerrains im Pfaffenwald.

Horizon/layer	Depth	gS	mS	fS	ffS	gU	mU	fU	T	Skeleton content	pH	Loss on ignition	Color	Charcoal
	cm	%	%	%	%	%	%	%	%	%		%	Munsell	mg/L
1 Bw/M (colluvium)	10-30	11,45	6,37	4,43	3,63	18,05	17,46	12,18	26,42	26,73	3,97	3,75	2,5Y-4/4	4,53
1 M (colluvium)	30-83	6,86	6,99	4,97	3,79	19,28	18,53	12,22	27,36	34,28	3,97	2,72	2,5Y-4/4	463,57
1 M (colluvium)	83-100	7,00	7,21	5,32	3,98	18,47	17,78	11,56	28,67	25,52	3,91	2,77	5Y/R-4/6	42,87
2 fBtg (upper layer)	100-125	3,80	8,43	6,12	4,07	17,94	16,55	11,59	31,51	9,89	3,88	2,86	5Y/R-4/6	23,40
1 fBtg (upper layer)	125-133	6,86	6,79	3,45	3,19	21,07	20,08	11,77	26,79	18,84	3,85	2,39	10YR-4/4	n.a.
3 Cg (interm. layer)	133-175	20,87	11,30	3,84	4,74	14,12	11,97	10,27	22,89	55,08	3,85	2,62	10YR-5/6	0,00
3 Cg (interm. layer)	175-218	16,67	11,08	4,79	7,61	13,31	12,62	12,79	21,14	51,32	3,79	2,79	10YR-5/6	n.a.
4 C (basal layer)	218-244	23,48	14,85	5,05	4,81	10,32	10,87	12,92	17,71	42,14	3,79	2,99	10YR-6/6	n.a.
5 R (weathered slates)	244-280	22,17	14,63	5,18	5,52	11,73	11,56	13,81	15,39	62,61	4,04	2,63	10YR-6/4	n.a.

M = Holocene colluvium, gS = course sand, mS = middle sand, fS = fine sand, ffS = finest sand, gU = course silt, mU = middle silt, fU = fine silt, T = clay

Tab. 2: Heavy mineral content of the field balk profile in the Pfaffenwald forest. (M = Holocene colluvium, UL = upper layer, IL = intermediate layer, BL = basal layer).

Tab. 2: Schwermineralgehalt des Ackerrain-Profils im Pfaffenwald (M = Kolluvium, UL = Hauptlage, IL = Mittellage, BL = Basislage).

Horizon/layer	Typical for	Bw/M	M	II fBtg, UL	II fBtg, UL	III Cg, IL	III Cg, IL
Depth [cm]	(Semmel 2002)	30-83	83-100	100-125	125-133	133-175	175-218
Augite	*pumice*	46	60	59	84	18	1
Epidote/zoisite		3	0	0	0	0	0
Garnet	*loess*	0	1	0	0	1	0
Green hornblende	*loess*	1	0	0	0	0	0
Brown hornblende	*pumice*	127	145	155	121	26	2
Titanite	*pumice*	42	34	32	25	2	0
Zircon		15	12	14	10	5	0
SUM		237	252	260	240	57	7

M = Holocene colluvium, UL = upper layer, IL = intermediate layer, BL = basal layer; analysis: M. Guddat-Seipel, Bad Nauheim.

cal debris. At a depth of 244 cm, the weathered Devonian bedrock is reached.

The colluvium was dated by three charcoals (^{14}C) and one OSL sample to the following ages (Tab. 5): 20 cm deep (cal. 379–245 BC, La Tène Period, Poz-36328), 53 cm depth (cal. 1044–1136 AD, High Middle Ages, Poz-36337), 83 cm (OSL: 110±230 BC, La Tène Period, HUB-0095) and 112.5 cm (cal. 1351–1219 BC, Bronze Age, Poz-36338).

A piece of charcoal from the field terrace above the balk was dated to: 28–50 cm, cal. 1210–1280 AD (Beta-294174; Fig. 2).

5.1.2 Deserted fields in the Ohren forest near the village of Niedermeilingen (N 50.1742°, E 7.9458°)

Likewise, in the Ohren forest traces of former agriculture were found. The location is relatively isolated at the rim of an old etchplain. There are several elongated low earthworks (*Ackerberge*, Fig. 4) with clearance cairns partly corresponding with each other by the right angle. They are formed by soil material fallen out during the turning of the plough at this place and also formed by clearance cairns.

A pit of 3m depth, dug by an excavator, revealed a structure consisting of gathered stones and a 71 cm thick layer of tarnished colored loess-like Holocene colluvium with an initial soil formation in the uppermost 30 cm (Fig. 3). Underneath follows the 29 cm thick remain of the upper layer with strong stagnic conditions and iron stains. The Btg horizon of a luvisol with visible clay films on the soil aggregates has been formed in both the upper and the intermediate layer (clay content 27–29 %). The colluvium consists of former material of the eroded upper layer. Both layers are containing typical heavy minerals of Lake Laach pumice (Tab. 4). In contrast, the only 25 cm thick intermediate layer below is nearly free of these minerals. The sandy basal layer (48 cm thick) is poor in skeleton (stone content) due to the bedrock of strongly weathered slates.

The colluvium only contains charcoal fragments (Tab. 3) which were dated at two different depths: 7–31 cm (cal. 919–999 AD, transition from Early to High Middle Ages, *Quercus spec.*, Poz-36339) and 50–71 cm (cal. 7–79 AD, early Roman Period, *Quercus spec.,* Poz-36340). Thus, the results are similar to those of Pfaffenwald forest (chapter 3.1).

5.1.3 Deserted fields in the Struth forest near the village of Kettenbach (N 50.257°, E 8.065°)

Eighteen km away from the two previously presented locations near Zorn, we investigated another wooded area at the rim of the Kemel Heath with deserted fields near the villages of Kettenbach and Hausen über Aar. There are two well visible field balks running parallel on a slightly inclined upper slope (3–9°; in western exposition; 265 m a.s.l.). A pit in the lowermost one revealed a 60 cm thick Holocene colluvium with an initial soil formation and charcoal content (Fig. 6). A covered luvisol had developed underneath. Its E-horizon located in the upper layer has been shortened by erosion. The Btg-horizon has been generated within the intermediate layer (clay content 33%). The whole profile is rich in loess and poor in skeleton (0–14%). Partly, the skeleton content consists of Oligocene-Miocene gravel (*Arenberger Fazies*; Müller 1973), which occurs on the adjacent plateau above.

A charcoal fragment taken from a depth of 45 cm, which was above the lowermost third of the colluvium, was dated at cal. 361–272 BC (La Tène Period; Erl-7539).

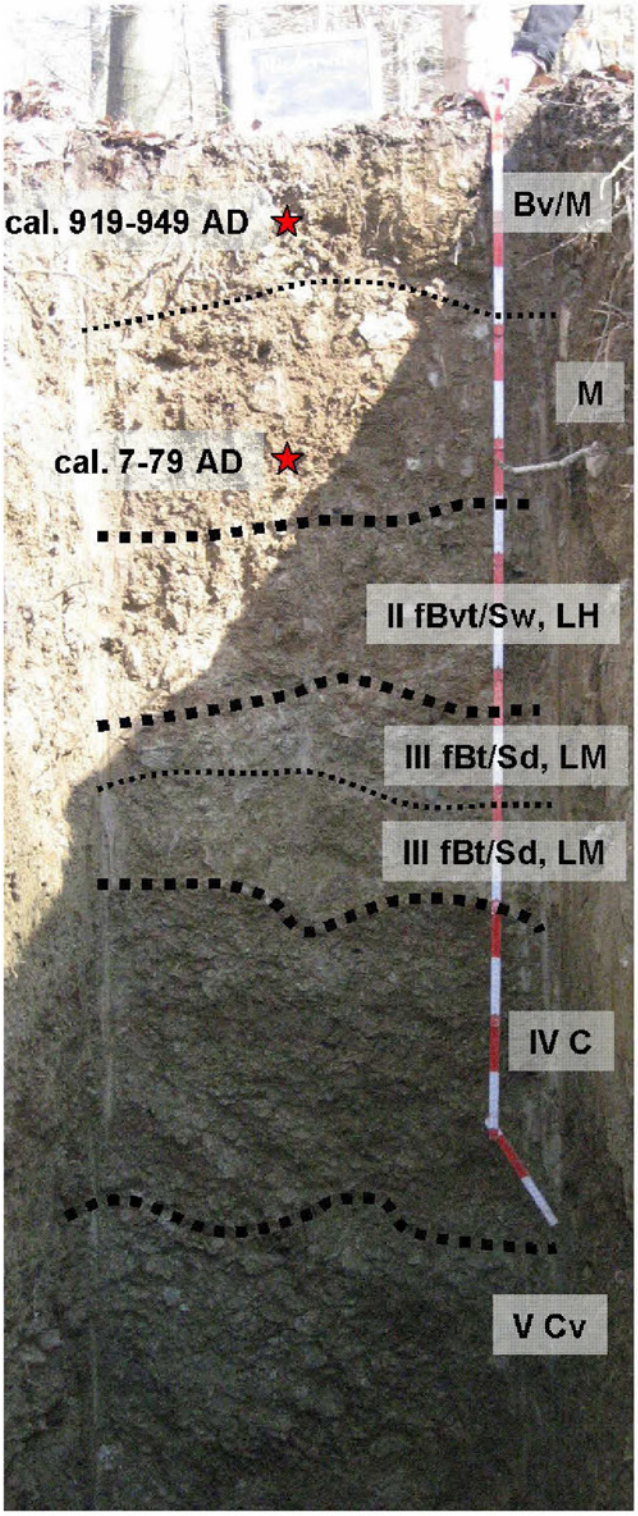

Fig. 3: The profile of Ohren forest with datings.

Abb. 3: Das Profil in der Waldabteilung Ohren mit Datierungen.

Table 3: Sedimentological data of the field balk-profile in Ohren forest.

Tab. 3: Sedimentologische Daten zum Profil innerhalb des Ackerberges in der Waldabteilung Ohren.

Horizon/layer	Depth	gS	mS	fS	ffS	gU	mU	fU	T	Skeleton content	pH	Loss on ignition	Colour	Charcoal
	cm	%	%	%	%	%	%	%	%	%		%	Munsell	mg/L
1 Bw/M [colluvium]	10-30	7,56	5,58	4,81	3,43	20,17	19,34	12,47	26,65	26,76	3,94	4,60	10YR-3/24	255,03
1 M [colluvium]	30-83	6,73	6,29	4,85	3,67	20,96	18,21	12,34	26,96	18,46	3,97	3,04	10YR-5/6	369,93
2 fBwtg [upper layer]	83-100	10,46	5,76	4,36	3,48	18,14	19,28	12,70	25,82	24,12	3,94	3,23	10YR-5/8	0,00
3 fBtg [interm. layer]	100-125	12,66	5,49	1,88	2,60	22,05	17,98	10,30	27,04	32,18	3,76	2,79	10YR-6/4	n.a.
3 fBtg [interm. layer]	125-133	7,79	5,21	1,86	2,71	26,11	17,26	9,58	29,47	15,55	3,77	2,56	10YR-5/6	0,00
4 C [basal layer]	133-175	19,41	9,02	4,14	8,24	16,76	13,44	11,75	17,25	2,30	3,66	2,13	10YR-4/6	n.a.
5 R [weathered slates]	175-218	37,04	16,21	5,35	6,38	11,01	6,44	4,69	12,89	71,97	3,81	2,64	10YR-4/4	n.a.
5 R [weathered slates]	218-244	37,11	18,00	5,69	6,97	9,19	7,06	5,31	10,69	72,21	3,70	3,16	10YR-2/1	n.a.
M = Holocene colluvium, gS = course sand, mS = middle sand, fS = fine sand, ffS = finest sand, gU = course silt, mU = middle silt, fU = fine silt, T = clay														

Horizon/layer	Typical for	M	M	II fBwtg UL	III fBtg IL
Depth [cm]		31-50	50-71	71-100	100-115
Augite	*pumice*	77	88	38	4
Epidote/zoisite		0	1	4	12
Garnet	*loess*	0	0	1	2
Green hornblende	*loess*	0	1	2	4
Brown hornblende	*pumice*	130	159	75	8
Titanite	*pumice*	49	50	16	1
Zircon		12	18	8	4
SUM		268	317	144	35

M = Holocene colluvium, UL = upper layer, IL = intermediate layer, BL = basal layer; analysis: M. Guddat-Seipel, Bad Nauheim.

Tab. 4: Heavy mineral content of the field balk profile in Ohren forest. (M = Holocene colluvium, UL = upper layer, IL = intermediate layer, BL = basal layer).

Tab. 4: Schwermineralgehalt des Ackerrain-Profils im Pfaffenwald (M = Kolluvium, UL = Hauptlage, IL = Mittellage, BL = Basislage).

5.2 Charcoal kiln sites

For the detailed investigation of kiln sites the complete forested area of Zorn was mapped (40 kiln sites; 0.11 sites/ha).

To investigate the influences of historical charcoal burning, we chose two different kiln sites, one in the Pfaffenwald and another one in the nearby Reißbrühl forest. From each of them, we took 83-130 pieces of charcoal by sieving top-down at different depths below the plane of the kiln (*Meilerplatte*; see Fig. 7) and from the bordering rim (*Stübbewall*).

The determination of tree species resulted only three different types (*Fagus sylvatica*, *Quercus spec.* and *Betula pendula*; Fig. 9) but in several compositions. Five charcoals were radiocarbon dated.

5.2.1 Dating and determination of tree species

The first investigated kiln site (N 50.167°, E 7.919°; 430 m a.s.l.) is actually located on the low inclined, NNW exposed slope of a small valley in a nearly pure, old beech forest (*Galio odorati Fagetum;* cf. Ellenberg 1996, Ludemann & Nelle 2002). The investigated one belongs to a group of 4 kiln sites in an area 130 m wide. Due to the hillside location of the kiln, it is plausible that the used wood originates from the forested upper slope. It is plausible that the origination area of the wood is wider on the slope above the kiln, because it was easier to carry the wood downslope (cf. Hildebrandt et al. 2007). After 100 m, the slope is bounded by the edge to the open fields. It is furthermore noticeable in this forest that there are several former field balks around the kiln sites. These belong to the investigated former farmland of the Pfaffenwald forest. The investigated kiln site is located exactly on one of these former field terraces.

The spectra of species at different depths of the kiln site-sediment are very homogenous and show nearly the same result as today (90% beech and 10% oak). The 3 datings are

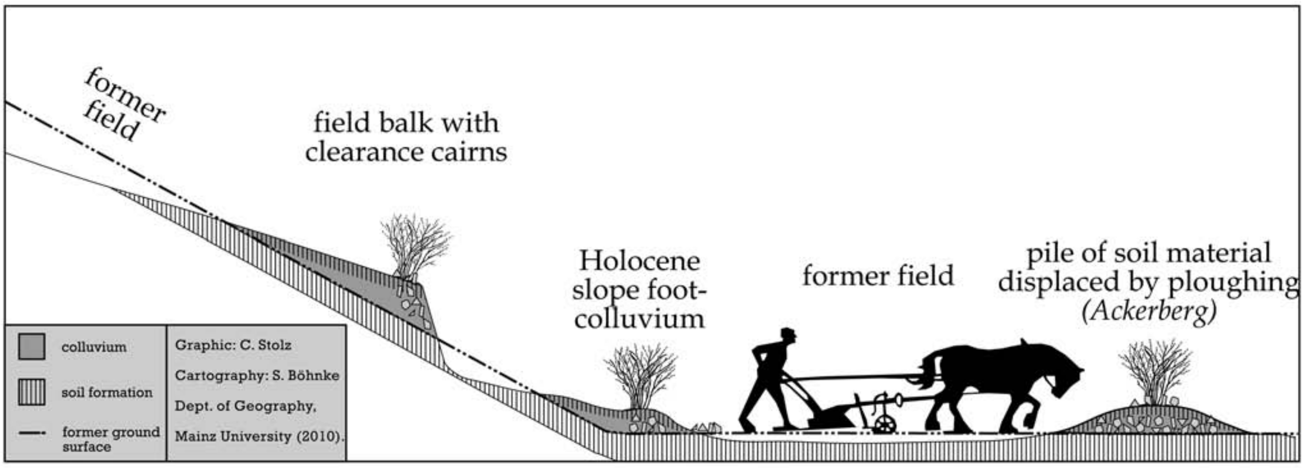

Fig. 4: Model of former field balks on a slope and an earthwork of soil material and gathered stones (Ackerberg) on a flat location under forest.
Abb. 4: Modell eines ehemaligen Ackerrains und eines Ackerberges, bestehend aus Bodenmaterial und Lesesteinen, in Hanglage.

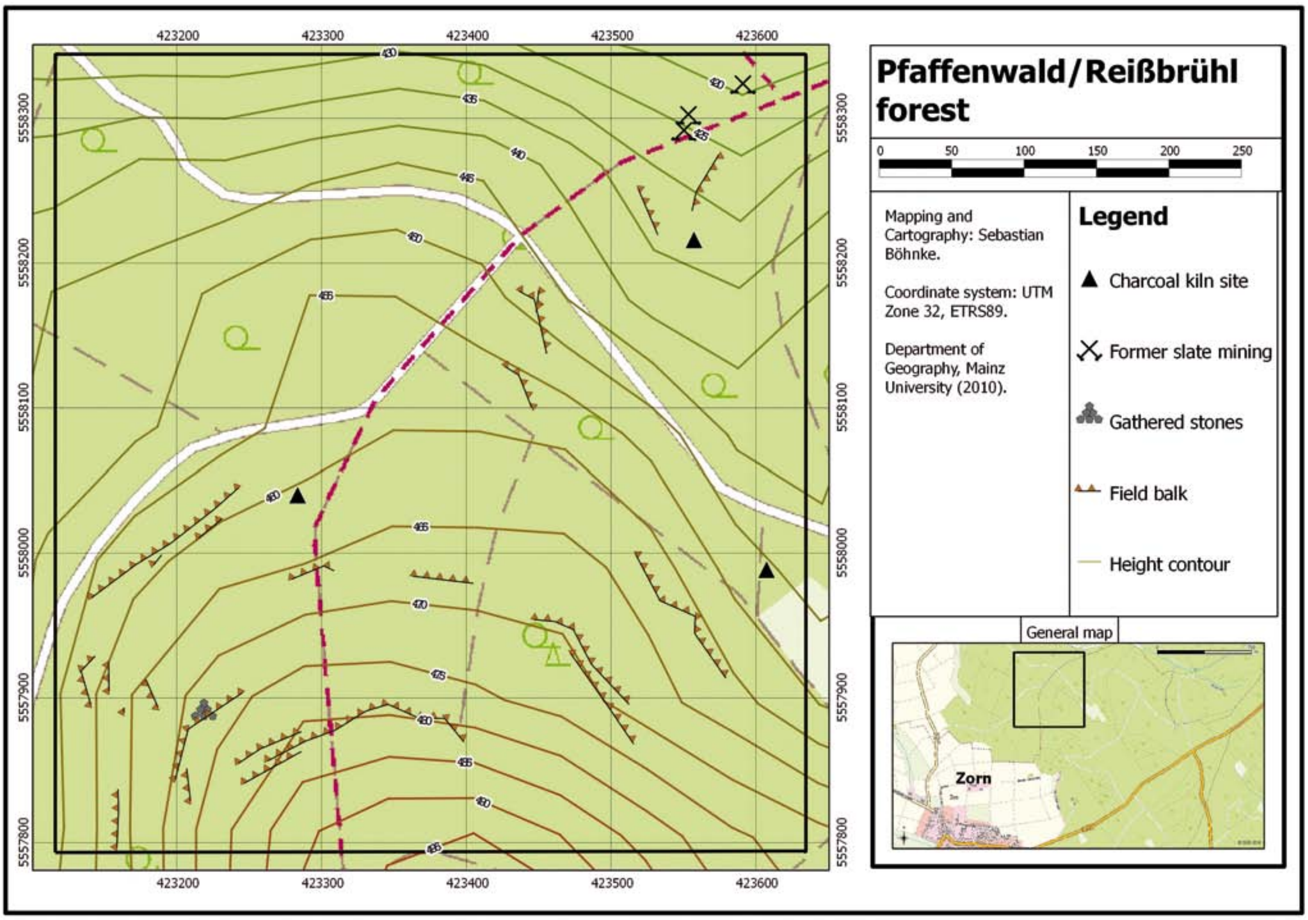

Fig. 5: Map section of the Zorn district with former field balks and charcoal kiln sites in forest.
Abb. 5: Kartenausschnitt der Gemarkung Zorn mit Ackerrainen und Meilerplätzen unter Wald.

indicative of the Early Modern Period: cal. 1712–1906 AD (*Fagus sylvatica*, Poz-36326), cal. 1654–1794 AD (*Quercus spec.*, Poz-36322) and cal. 1476–1604 AD (*Fagus sylvatica*, Poz-36321). However, the dated samples were not layered stratigraphic, because the sediment cover was obviously mixed between the individual burning sessions of the kiln or beyond. Thus, a detailed reporting about the forest history in the surrounding of the kiln site is only possible to a limited extend. However, it could be demonstrated that the kiln was used from the 16th to the 19th century.

The second one (N 50.169°, E 7.930°; 427 m a.s.l.) is located on a moderate inclined, NNE exposed lower slope within a small, wet spring-depression, covered by a forest with up to 160 year old beeches (result of a dendrochronological count) and some oaks. In the surrounding area of 450 m, there is no further evidence of kiln sites. The forested slope above the kiln is with a distance of 500 m to the top of the hill much larger. Eventually, the origin area of the used wood could have been much larger, too.

The spectra of species in the sampling depths of 0–13 cm

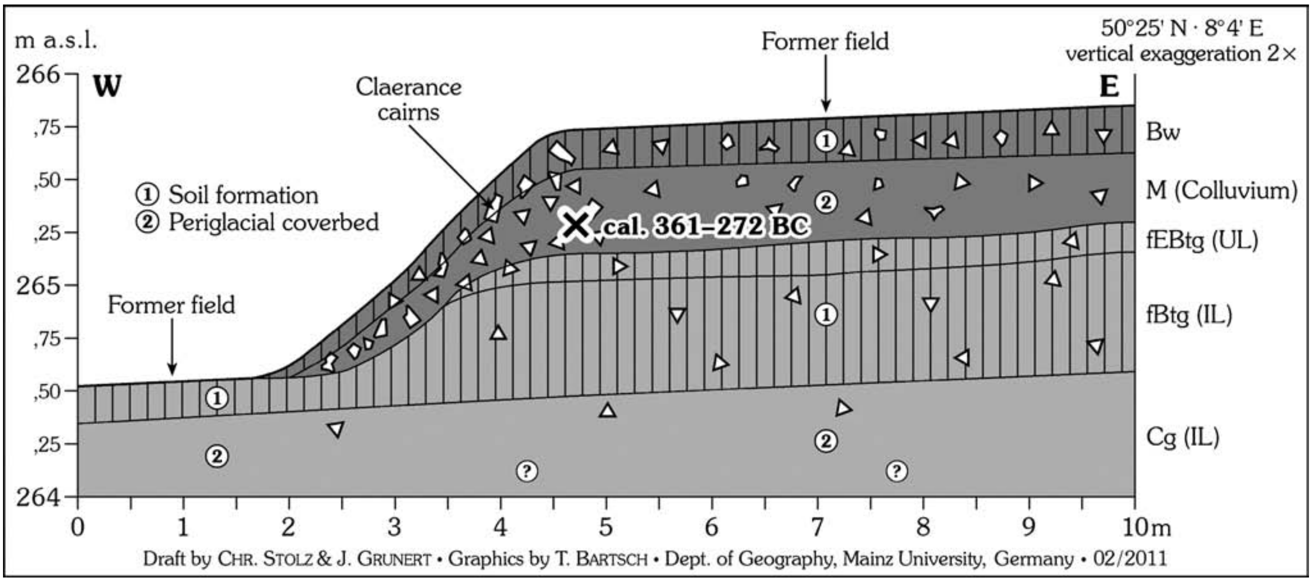

Fig. 6: Field balk in Struth forest, probably generated during Iron Age and later. For the parts of the profile marked with question marks there is no detailed information.

Abb. 6: Ein Ackerrain in der Waldabteilung Struth. Er geht vermutlich auf die Eisenzeit zurück. Für die mit Fragezeichen gekennzeichneten Profilbereiche liegen keine detaillierten Informationen vor.

and 13–25 cm of the *Stübbewall* were different (Fig. 8). The lower spectrum is dominated by beech (82%), followed by birch (13%, a tree which needs an exposure to the sunshine) and oak (5%). In the uppermost spectrum, beech is only 34% and birch is found in higher concentration (19%). Oak is the predominant species (47%) in this layer. Although the kiln site is located directly above the spring depression, there could not be proven any hydrophilic species like willows or alders. This indicates an origin of the used wood exclusively upslope of the kiln.

Dating of charcoal samples from the two presumably different layers gave exactly the same ages: cal. 1677–1921 AD (*Fagus sylvatica*, Poz-36323 and 36324). It is possible that the kiln was used for only a short period at the end of the 18th and beginning of the 19th century. However, the spectra of species in the different layers are quite different. Therefore, the lower charcoal sample could have been displaced by bioturbation or similar processes in the past.

5.3 The medieval refuge castle of Zorn with a neighboring slag heap

At the eastern rim of the castle (81° E), where it has been damaged by a modern stairway, we took a small portion of soil material from the lower part of the rampart (the permission from the local preservation authority was given). By the archaeobotanical elutriation procedure, a fragment of charcoal was eliminated, which was dated to cal. 900–970 AD (Poz-36343).

A charcoal sample of the slag heap, eliminated in the same way, was dated to cal. 1103–1203 AD (Poz-36341; High Middle Ages). An analysis of the slag by x-ray diffractometer resulted in residual iron contents of 36–49% and silicate contents of 9–25%.

A piece of charcoal of the other slag heap, which is located beside the small stream Rödelbach near Zorn (N 50.15829°, E 7.93905°) was dated to the similar age of cal. 1160–1260 AD (Beta-294172).

5.4 Calculation of sedimentation rates of a small alluvial fan near Kemel (N 50.1650°, E 8.0147°)

To calculate the local sedimentation rate from a single location on the Kemel Heath, we investigated an archaeological site, which included a Roman water well, stabilized by wood beams. It was located close to the former Roman castle of Kemel and, geomorphologically, on a small and flat alluvial fan, respectively a colluvial depression filling in the non-perennial upper course of the Aulbach and Wisper stream. The side walls of the well were supported by several sediment covered oak-wooden beams, which were dated dendrochronologically to 215 AD (information given by the Hessian Office of Monument Preservation).

The site was dug 384 cm into a sandy-silty, uppermost clayey, well-layered colluvial/alluvial sediment with a distinct content of skeleton (5–29%). Downwards 316 cm inside the well, the groundwater level was detected and the sediment is grey-reduced. Around 179 cm deep, it contains charcoal fragments; underneath, there are no organic remains. A charcoal fragment of 0–35 cm depth was dated to cal. 1160-1260 AD (High Middle Ages; Beta-294173), another piece of 35–55 cm to cal. 1080–1124 AD (High Middle Ages; Erl-8905) and a further piece of 140–163 cm to cal. 678–773 AD (Early Middle Ages; Erl-8906). Below this sample the top of the cover of the water-well was detected by archaeologists.

The soil samples downwards to 383 cm were analyzed concerning their content of heavy minerals. All samples contain the minerals augite, brown hornblende, titanite, green hornblende and garnet thus giving evidence of distinct contents of loess and the pumice of Lake Laach eruption of the Allerød Interstadial (cf. Stolz & Grunert 2006, Semmel 2002).

Summarized, the lower part of the profile (152–384 cm and deeper) had been already deposited when the Romans built the well in 215 AD. This can be assumed because of the lack of finds and charcoals in these sediments.

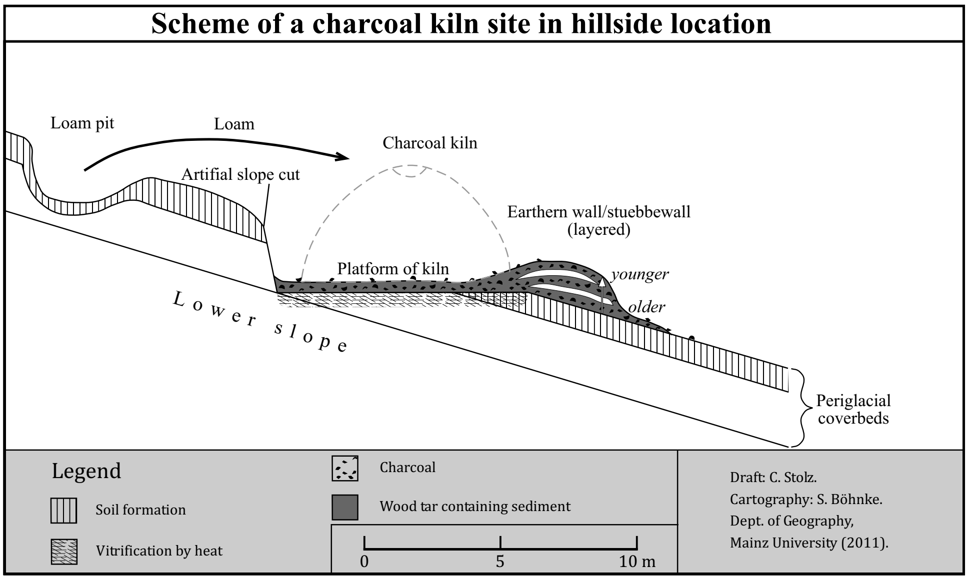

Fig. 7: Scheme of a charcoal kiln site in hillside location with loam pit.

Abb. 7: Schema eines Hangmeilerplatzes mit Lehmgrube zur Entnahme der Stübbe, mit der der Meiler verkleidet wird.

According to the ^{14}C-datings, it is possible to calculate approximate sedimentation rates for different periods. Therefore, it has to be considered that there are some uncertainties of this analysis concerning a subsequent displacement of charcoal samples: Between the 4th and 7th centuries AD, no traces of deposition have been found. After this period, the second part of the profile (152–45 cm depth) was deposited between approx. 725 and 1100 AD. This corresponds to a sedimentation rate of 2.8 mm/a (Fig. 10). The third part (45–20 cm depth) was deposited between approx. 1100 and 1210 (sedimentation rate of 2.3 mm/a). The upper part (20–0 cm depth) was deposited during the time after 1210 until today, corresponding with a much smaller rate of only 0.25 mm/a.

6 Discussion

The 16 datings of this study include 5 of Prehistoric and Roman periods (until 260 AD; cf. Baatz and Herrmann 2002), 1 of Early Middle Ages (approx. 400–1000 AD), 5 of High Middle Ages (approx. 1000–1320 AD) and 5 of Early Modern Age (approx. 1450–1850 AD; cf. Born 1989; Tab. 5). The presence of charcoal particles in the sediment archives concludes that in most cases, there is a certain amount of human influence on the landscape in the different periods. But it has to be considered that ^{14}C-datings give only minimum ages (*terminus post quem*). If a piece of charcoal is trapped within a sediment layer, the sediment must have been displaced after the formation time of the organic carbon of the charcoal.

6.1 Agriculture

This is proven by the uppermost sample (20 cm deep) within the field balk-profile in the Pfaffenwald forest, which was dated to an earlier time (cal. 379–245 BC, La Tène Period, Poz-36328) compared with the samples below. It could have been deposited for a long time (approx. 1300 years) on the soil surface upslope or within a colluvium when it was buried by the sediment. However, a vertical displacement by bioturbation could be also plausible. To clarify this, we additively used one OSL dating which confirmed the other

Fig. 8: Sampling of a charcoal kiln site in different layers.

Abb. 8: Die Beprobung eines Hangmeilerplatzes (Stübbewall) in verschiedenen Tiefen.

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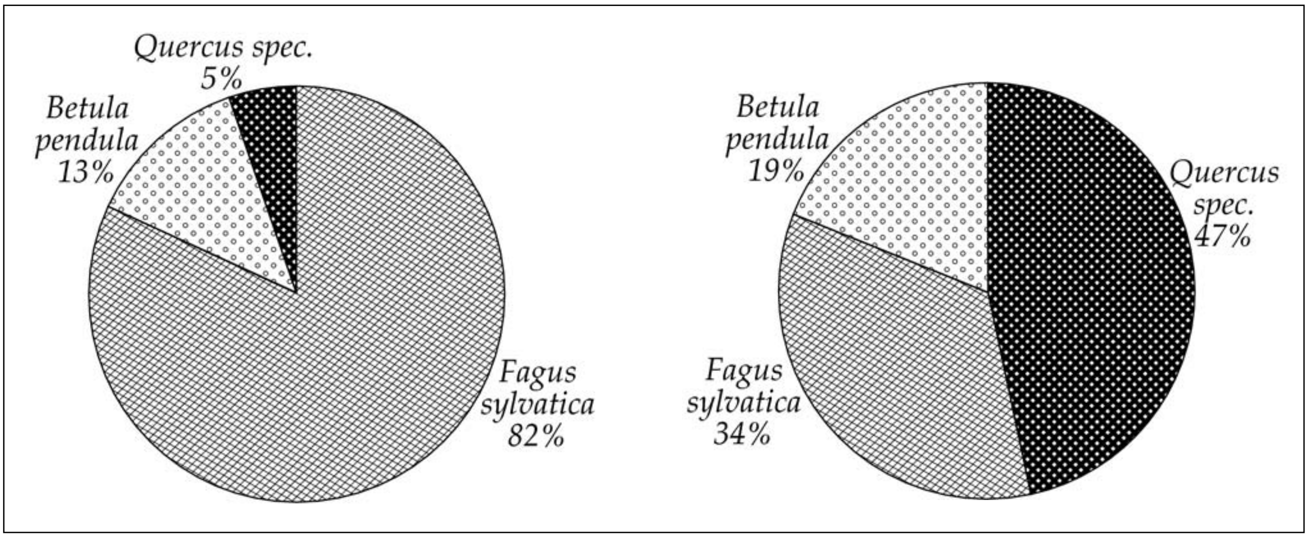

Fig. 9: Spectra of tree species at depths of 0–13 cm and 13–25 cm (kiln site 2).

Abb. 9: Baumartenspektrum in 0–13 und in 13–25 cm Tiefe (Meilerplatz 2).

[14]C-datings. Additionally, a piece of charcoal from the field terrace above the balk (28–50 cm deep) was dated to cal. 1210–1280 AD (Beta-294174). Unfortunately, archaeological findings were missing, which is typical for agrarian locations away from settlementsAs well as within the field balk-profiles in Pfaffenwald forest, in those of Ohren forest and Struth forest, we dated charcoals to prehistoric and Roman Periods. In consequence, at these locations the agriculture began before the arrival of the Romans (OSL: 340 BC-120 AD). Thus, the agriculture started during the Iron Age is proven for one location and it is likely so for the other two locations. In addition, based on the datings of Pfaffenwald and Ohren forests, it is also plausible that Roman agriculture existed for local supply of the border troops. Basically, we should know that fields were not so wide spread in that time as within Early Modern Periods or today. However, as non-favorable areas (North faced slopes) were cropped during that time and which are currently wooded. Thus, we also have to assume prehistoric agriculture in the actual cropped areas, too. Therefore, fields could have been more distributed than today. On the other hand, the forests must have been smaller. In contrast, prehistoric people might have preferred other locations than modern farmers, for example locations on plateaus or smooth slopes far away from recent settlements.

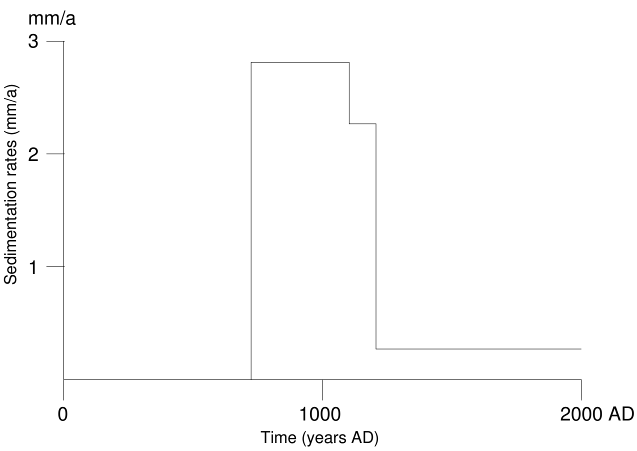

Fig. 10: Sedimentation rates in a small valley filling near Kemel.

Abb. 10: Unterschiedliche Sedimentationsraten im verfüllten Unterlauf eines Tälchens bei Kemel.

Within the field balks, dates from Early Middle Ages are missing. But the agriculture on these fields continued until the High Middle Ages. The covering of the terrace itself by colluvial sediments took place within the High Middle Ages. Maybe it was reactivated in this period. The presence of gathered stones within the colluvial sediments and the OSL age give a solid result. After the High Middle Ages, there is no further evidence of agriculture in the three investigated former field districts. Furthermore, due to the soil formation (luvisol) within the colluvium, a resting phase since High Middle Ages seems plausible (Fig. 2).

6.2 Charcoal burning

In the forests of the Zorn district (374ha), we found and mapped only 40 kiln sites (0.11 sites/ha). In a forest 15 km away near to the ironworks of Michelbach, we calculated 0.38–0.58 kiln sites per hectare (Stolz 2011b). In the mining region of the southern Harz Mts. von Kortzfleisch (2008) mapped 3.3 sites/ha. Therefore, charcoal burning was not so wide spread in the investigation area compared with other districts. However, in the cleared areas, charcoal burning was a frequent activity. Most of the mapped kiln sites have a diameter of 10–12 m. This indicates an origin within the period of massive charcoal burning of the 18th or 19th century in the Taunus Mts. (cf. Stolz 2011b, Hildebrandt et al. 2001). Basically, the investigated field balks in the Pfaffenwald forest must be older than the kiln sites, because kiln sites are located on the former field terraces using the leveled surface. By physical dating methods we could substantiate charcoal burning in the investigated area from the 16th century and increasing until the end of the 18th century.

The tree spectrum of the second investigated kiln site (Reißbrühl forest) taken from the lower layer of the charcoal containing sediment is dominated by *Quercus spec.* and *Betula pendula* (in total 66%). *Betula* is a typical pioneer

Tab. 5: ¹⁴C and OSL datings of this study.

Tab. 5: Aufstellung der in der vorliegenden Studie enthaltnen ¹⁴C- und OSL-Datierungen.

	No.	Type	Site	Depth [cm]	Material	¹⁴C Age [a BP]	Calibration or OSL age [a BC/AD]
1	Poz-36328	¹⁴C	Pfaffenwald forest	10-30	charcoal [field balk]	2260±35	379-245 BC
2	Poz-36337	¹⁴C	Pfaffenwald forest	30-83	charcoal, hardwood [field balk]	940±30	1044-1136 AD
3	HUB-0095	OSL	Pfaffenwald forest	83	basal colluvium [field balk]	-	110±230 BC
4	Poz-36338	¹⁴C	Pfaffenwald forest	100-125	charcoal, *Quercus* [field balk]	3015±35	1351-1219 BC
5	Beta-294174	¹⁴C	Pfaffenwald forest	28-55	charcoal, hardwood [colluvium from terraced field]	790±30	1210-1280 AD
6	Poz-36339	¹⁴C	Ohren forest	7-31	charcoal, *Quercus* [field balk]	1065±30	918-999 AD
7	Poz-36340	¹⁴C	Ohren forest	50-71	charcoal, *Quercus* [field balk]	1950±35	7-79 AD
8	Erl-7539	¹⁴C	Struth forest, Kettenbach	45	charcoal [field balk]	2205±56	361-272 BC
9	Poz-36321	¹⁴C	Kiln site 1, Zorn	0-8	charcoal, *Fagus* [kiln site]	360±30	1476-1604 AD
10	Poz-36322	¹⁴C	Kiln site 1, Zorn	8-17	charcoal, *Quercus* [kiln site]	220±30	1654-1794 AD
11	Poz-36326	¹⁴C	Kiln site 1, Zorn	30-48	charcoal, *Fagus* [kiln site]	85±30	1712-1906 AD
12	Poz-36323	¹⁴C	Kiln site 2	0-13	charcoal, *Fagus* [kiln site]	180±30	1677-1921 AD
13	Poz-36324	¹⁴C	Kiln site 2	13-25	charcoal, *Fagus* [kiln site]	180±30	1677-1921 AD
14	Poz-36343	¹⁴C	Refuge castle "Alte Schanz"	-	charcoal [artificial deposit]	1105±30	900-970 AD
15	Poz-36341	¹⁴C	Slag heap near the refuge castle	0-20	charcoal, *Fagus* [slag heap]	865±30	1103-1203 AD
16	Beta-294172	¹⁴C	Slag heap near the Rötelbach stream	0-15	charcoal, hardwood [slag heap]	850±30	1160-1260 AD
17	Erl-8905	¹⁴C	Kemel, site with Roman water well	35-55	charcoal [colluvium]	953±37	1080-1125 AD
18	Beta-294173	¹⁴C	Kemel, site with Roman water well	55-90	charcoal, half-ring porous hardwood [colluvium]	840±30	1160-1260 AD
19	Erl-8906	¹⁴C	Kemel, site with Roman water well	140-163	charcoal [colluvium]	1274±44	678-773 AD

tree species (Ludemann & Nelle 2002). The species are an indication for a bright, cleared forest with a high content of *Quercus spec.*, which was an important kind of timber (Ellenberg et al. 1991). While degradation processes, *Quercus spec.* and *Carpinus betulus* can be favored (Ludemann 2008). In the layer above, the content of *Quercus* and *Betula* has fallen (18%) and *Fagus* is the dominating species; however, the content of birch is still 13%. Today, there grow only few birches. However, the so-called Little Ice Age (Glaser 2008) cannot had direct influences to the detected changes in vegetation, because oaks *(Quercus robur)* are, in contrast to the beeches, counted among the slightly more thermophile deciduous trees (Ellenberg et al. 1991), however with a wider ecological range.

An eventual wood selection by the charcoal burners should not be considered. Ludemann (2008) demonstrated that charcoal burners during the Early Modern Period in the Black Forest used all available species and all thicknesses of wood.

6.3 Refuge castle and iron smelting

The refuge castle of Zorn, the neighboring slag heap and a further slag heap in the Rödelbach valley originate almost simultaneously from the High Middle Ages (10th to 12th century AD). Based on these findings, we also have to assume a high wood consumption around these small melts. Furthermore, the relatively high ferrous content of the slags indicates a low yield of iron due to a still primitive technology of iron-smelting. Nearly the same age we detected for the use of the deserted fields. The slag heaps, which are 2 of 5 samples from within the Zorn district, the castle and the field terraces give evidence of a wide spread, decentralized, agriculture, iron production and forest clearing in the district of Zorn during the High Middle Ages (cf. Stolz & Grunert 2008, Geisthardt 1954).

The dating of a charcoal fragment from inside the rampart of the refuge castle has to be regarded as an approximate value for a possible real age of the refuge castle As the charcoal was located inside the rampart, it must be older or of the same age as the castle. In consequence, the castle must originate from the 10th century or from a younger period.

6.4 Sediment sequences of the alluvial fan of Kemel

Within the alluvial fan profile of Kemel we calculated the highest sedimentation rate for the High Middle Ages, too. Direct climatic influences as a triggering factor are unlikely; in the contrary, however the local influence of anthropogenic triggered soil erosion in the small catchment of the depression was high (Thiemeyer et al. 2005). It must be expected that the accumulation of alluvial sediments probably was discontinuous, which means that it could have probably happened during heavy precipitation events in a more or less cleared landscape. Thus, the calculated sedimentation rates have to be considered as limited reference values for the susceptibility of soil erosion within the catchment.

The only dated charcoal from the Early Middle Ages (7th/8th century) is taken from this alluvial fan which is an important fact. The charcoal has been deposited directly above the Roman well. Thus, soil erosion rates during the Migration Period must have been reduced. Otherwise, the finding of Early Medieval charcoal supports the opinion of Becker (2011) concerning an increased human influence in Kemel in this period. Most likely, during Early Modern times the distribution of fields did not reach the level of the High Middle Ages. Instead, heathlands became predominant in the landscape. Therefore, the sedimentation rate within the fan profile of Kemel was shrinking again.

7 Conclusions

The agriculture on the Kemel Heath probably started during the La Tène or Roman Period. This conforms to the results of regional palynologic investigations. Since this time – interrupted during the Migration Period – to the High Middle Ages agriculture was intensified and non-favorable areas were cultivated. The spreading of fields increased up to 13th century and was shrinking again in favor of pastureland during the Early Modern Period. In the remaining cleared forests, charcoal burning was widespread, especially from 16th to the end of the 18th century. The consequences concerning forest degradation and changes in the composition of tree species could be evidenced due to the charcoals from two different kilns.

Of nearly the same age like the High Medieval agriculture are the slag relicts of decentralized iron melting and, probably, the refuge castle of Zorn next to the slags.

Although the sediment sequence of a small alluvial fan near Kemel is of very local character, we evidenced the highest deposition rate in its catchment for the High Middle Ages, too.

With this study, we evidenced the benefit of the application of several different methods to reconstruct former landscapes of different periods: Future studies have to investigate as much single relicts to get more representative information. Unfortunately, this was not possible due to limited financial resources.

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