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The Middle Pleistocene fluvial sequence at Uichteritz, central Germany: Chronological framework, paleoenvironmental history and early human presence during MIS 11

Abstract

The site of Uichteritz (Saxony-Anhalt, Germany) is a Quaternary gravel quarry hosting several Middle-Pleistocene fluvial units of the Saale River. This fluvial archive contains detailed information on (1) the timing of Middle Pleistocene fluvial aggradation and erosion periods in the region, (2) the driving forces for those alternations, as well as (3) early human presence indicated by the presence of Lower Paleolithic stone artefacts. Here we establish a luminescence-based numerical chronology at Uichteritz. Additionally, geophysical, sedimentological and micromorphological analyses were applied to obtain information on depositional and post-depositional processes of the fluvial sequence.

Our results point to several fluvial aggradation periods between ca. 420 and 180 ka. A first fluvial unit was deposited during the late Elsterian period, followed by formation of a Luvisol during MIS 11 and its fluvial reworking at the transition from MIS 11 to MIS 10 and/or during early MIS 10. These MIS 10/11 deposits, with an age of about 400 ka, also contain reworked Lower Paleolithic stone artefacts that document the initial appearance of humans in northwestern central Europe during MIS 11. After a period of fluvial incision during MIS 10, which was accompanied by a change in the course of the Saale River, several stacked fluvial sequences of the Saalian Main Terrace (SMT) formed between MIS 8 and MIS 6, mainly during cold climatic periods. Our age estimates confirm the correlation of the Elsterian ice advances with MIS 12, and the Saalian ice advances with later MIS 6.

1. Introduction

Fluvial sediment sequences are valuable archives that preserve information about how rivers responded to changes in climate, base level, tectonic impulses, and human impact (e.g., Vandenberghe, 2003; Lauer et al., 2011a; Bridgland et al., 2017; Cordier et al., 2012, 2017; Demoulin et al., 2017). Furthermore, fluvial archives are outstanding archives for the occurrence of early humans because of the preservation of Paleolithic artefacts within the fluvial sands and gravels (Laurat et al., 2004a; Bridgland, 2006; Bridgland and Westaway, 2014; Winsemann et al., 2015; Chauhan et al., 2017; Lauer and Weiss, 2018).

In central Europe, Middle Pleistocene sediments of the Saale River and its tributaries such as the Weiße Elster have been studied in detail during recent years (Meng and Wansa, 2005; Litt et al., 2007; Eissmann, 2002a, 2008; Junge et al., 2008). Although the fluvial architecture of several Middle Pleistocene sites is well known today, there is still a significant lack of chronological data that are crucial for chronostratigraphic correlations. Only recently, Lauer and Weiss (2018) systematically dated Middle Pleistocene fluvial sediments of the so-called Saalian Main Terrace (hereafter SMT) of the Weiße Elster River in the area south and west of the city of Leipzig (Leipzig lowlands; Fig. 1) using luminescence dating.

This work demonstrated several periods of fluvial aggradation between Marine Isotope Stages (MIS) 11/10 and 6. These fluvial units are separated by significant chronological hiatuses that are explained by erosion or a pause in fluvial activity. The results of this study showed that fluvial aggradation mainly occurred during cold stages or periods of cooling, hence during the shifts from interglacials or interstadials to glacials and stadials. Hence, the transition from stabilized landscapes with denser vegetation cover to phases of landscape activity with periglacial environments might have caused an increased supply of fluvial sand and gravel. Whereas a robust chronology is now available for Middle Pleistocene fluvial sediments of the Weiße Elster within the Leipzig basin, such data are still lacking for other fluvial archives of Middle Pleistocene age in the Saale River system. To better understand the link between fluvial aggradation and erosion in the Leipzig lowlands and regions located more up- or downstream, additional numerical dating is required.

The gravel pit of Uichteritz (Figs. 1 and 2), which is located near the city of Weißenfels (Saxony-Anhalt, Germany), is a key site to more thoroughly investigate the Middle Pleistocene fluvial litho-
and chronostratigraphy of the Saale River system. Here, several sandy to gravelly Middle Pleistocene fluvial units are present.

The site is situated within the typo-region for the Elsterian and Saalian glacial cycles (Junge, 1998; Litt et al., 2007; Eissmann, 1975, 2002a, 2008; Junge et al., 2008). Here, in proximity to the maximum extensions of the Middle Pleistocene Scandinavian ice-sheets, the gravel deposits of the Pleistocene Saale and Weiße Elster rivers interfinger with tills and meltwater deposits of the eponymous glacial cycles. Thus, the site also yields important additional information on the timing of the Middle Pleistocene ice advances of the Fennoscandian glaciers in Europe.

The lithological composition of the site was formerly studied in detail by Meng and Wansa (2005). They distinguished five main fluvial units below the proglacial lake deposits of the Zeitz phase (Drenthe stage) and placed these fluvial units into the early and late Elsterian glacial period. Within these Middle Pleistocene fluvial units, we (W.B.) recovered Lower Paleolithic stone artefacts during field surveys between 1996 and 2015. The initial part of this collection was described in Rudolph et al. (2005) and shows similarities to MIS 11 artefact assemblages (Lauer and Weiss, 2018) found in the gravel pit of Wallendorf/Schladebach (Saxony-Anhalt, Germany), ~20 km to the northeast (Laurat et al., 2004a). However, the Lower Paleolithic age of the Uichteritz assemblage is only based on artefact attributes and sedimentological-stratigraphical interpretations of the fluvial deposits (Meng and Wansa, 2005; Rudolph et al., 2005), not on numerical ages.

The aim of this study is to reinvestigate the Middle Pleistocene fluvial sediment sequence at Uichteritz by means of luminescence dating, geophysical prospection methods, soil micromorphology and sedimentological analyses. In doing so, we intended to further strengthen the chronostratigraphical framework for the Middle Pleistocene fluvial sediments of the Saale River and possible intercalated soil formation. This data will: (i) elucidate the driving forces of regional fluvial activity with aggradation, incision and/or soil formation during the Middle Pleistocene, (ii) provide additional minimum and maximum ages for the Middle Pleistocene maximum ice sheet extensions of the Fennoscandian glaciers, and (iii) make available supplementary data for the earliest human presence in northern central Europe.

2. Study area and site

The study region is located in central Germany, at the transition between the northern German Lowlands (Leipzig Basin) in the north and the mid-mountain belt in the south. Altitude varies between 100 and 200m.a.s.l. The region was covered by the Fennoscandian ice sheets three times: Two Elsterian ice advances occurred during MIS12 (N400 ka), and the most south-reaching Zeitz phase during the Drenthe stage of the Saalian glaciation took place during MIS6 (ca. 150 ka) (Litt et al., 2007). Figs. 1 and 2 show the ice marginal positions in the study area.

From the Holsteinian interglacial (around 400 ka) until the Drenthe stage (around 150 ka), extensive gravel bodies of the SMT were deposited by the regional rivers under mainly periglacial conditions (Eissmann, 2002a, 2002b; Junge et al., 2008). The SMT is a complex of several stacked terrace units formed during various Middle Pleistocene aggradation periods.

During the Weichselian glacial period the region was located south of the Fennoscandian ice sheets, but was shaped by periglacial processes such as solifluction and loess deposition (Eissmann, 2002a, 2002b; Lauer et al., 2014). Today, the recent surface is covered by Holocene black colored Chernozems and Phaeozems that developed in the current sub-continental climate with average annual temperatures between 8 and 9.5 °C and precipitation values ranging between ~500 and 600 mm/yr (von Suchodoletz et al., 2019).

The gravel pit of Uichteritz (51°12’28.31”N, 11°54’36.79”E; 120m. a. s.l.) is located ~2 km west of the city of Weißenfels (Saxony Anhalt, Germany). Fig. 3 describes the by Meng and Wansa (2005) established litho-stratigraphy of the site which is subdivided as follows:

- The base of the section is formed by claystones, siltstones and marls of Triassic (Buntsandstein) age.
The first Quaternary sediments consist of the Lower Gravel Unit (see also Supplementary Fig. 1). Based on the lack of Scandinavian rock components, the Lower Gravel Unit was interpreted as the result of fluvial activity of the Saale River prior to the first Elsterian ice coverage, i.e., into the early Elsterian period. During this time period the course of the Saale River followed the so-called Markröhlitz valley (Figs. 4 and 5). This Lower Gravel Unit was not exposed during the field campaigns of this study.

The Lower Gravel Unit was covered by the younger Middle and Upper Gravel Units, containing nordic flint and other Scandinavian rocks. The Middle and Upper Gravel Units are separated by intermediate fine-grained stillwater sediments, probably originating from an abandoned oxbow channel of the Saale River. Both units were interpreted to originate from a temperate climate phase of the late Elsterian period after glacier retreat. This assumption by Meng and Wansa (2005) is based on post-depositional weathering observed in the Middle Gravel Unit and the characteristic mollusc assemblage from all units capping the Lower Gravel Unit. The gravels from the Middle Gravel Unit contained the Lower Paleolithic artefacts (Fig. 3).

The late Elsterian fluvial deposits are overlain by proglacial silty to sandy lake deposits of the Saalian Zeitz-phase, that are covered by glacial till of that ice advance.

The top of the sequence is composed of Weichselian loess and loess derivatives, of which the uppermost part is overprinted by Holocene Chernozems/Phaeozems soil formation.

3. Methods and materials

3.1. Stratigraphy and field sampling

We studied three southern and four northern profiles (Supplementary Fig. 2) that were exposed by mining activities in between 2015 and 2018 and generated a composite profile. After describing the stratigraphies, six samples were taken for luminescence dating (three each from the southern and northern profiles). Furthermore, two samples were taken for lithological analyses from the northern sections (samples S11 and S12; Fig. 6) to enable a lithological correlation with the lithological units described in Meng and Wansa (2005). Additionally, 13 bulk samples were taken in 5 cm intervals from the northern sections for sedimentological analyses (magnetic susceptibility, carbonate content, organic carbon and pH value), and 4 block samples for micromorphological analyses (Fig. 6).

3.2. Geoelectrical measurements

To distinguish between different gravel units in a larger area, and thereby obtaining deeper insights into the buried fluvial architecture, geoelectrical soundings were conducted along a 315 m long transect at the eastern flank of the currently exposed sediments. The geoelectrical measurements were performed with a DC-GGA 30 system using a 3-electrodes configuration. The data points were located at distances between about 10–20 m, and the maximum range of the array was 163 m.

3.3. Luminescence dating

Luminescence samples were taken from sandy layers using light-proof steel tubes, and the samples for radionuclide measurements were taken at the same position.

3.3.1. Equivalent doses

Because the luminescence signal of K-feldspars saturates at much higher doses than that of quartz, feldspar is commonly the mineral of choice to date sediments beyond the last glacial-interglacial cycle (Buylaert et al., 2009; Buylaert et al., 2012b). Therefore, we prepared coarse-grained K-feldspars for dating.
The preferred grain size fraction (180–250 μm) was obtained by sieving. Subsequently, carbonates were removed using 15% HCl, followed by the destruction of organic matter using 30% H2O2. The feldspars were isolated by flotation (Miallier et al., 1983), followed by separation of the K-rich feldspars by density separation using sodiumpolytungstate at a density of 2.58 g/cm3. Finally, the K-feldspars were fixed on steel discs using silicon spray, producing 24 small (0.5 or 1 mm-sized) aliquots for each sample. The small aliquot size was chosen to identify whether there was insufficient bleaching.

To minimize the effect of anomalous fading (Wintle, 1973) and to allow the direct comparability with the luminescence ages of Lauer and Weiss (2018), we used the pIRIR290 approach (Thiel et al., 2011) where the luminescence signal is detected at elevated temperatures (here 290 °C) after depleting the IR50 signal. The different measurement steps are outlined in Table 1. To evaluate whether there is some fading even for the pIRIR290-signal, the g-values of six aliquots from sample L-Eva 1507 and of three aliquots from sample L-Eva 1506 were measured (Huntley and Lamothe, 2001).

To test the reproducibility of the pIRIR290-signal, dose recovery tests were conducted on samples L-Eva 1505, 1507 and 1508: eight aliquots from each sample were bleached under a solar lamp for 3 h. Subsequently, the remaining dose residuals were measured for 4 aliquots, and the other four aliquots were irradiated with a β-source with a dose close to the expected natural one to test how precise this dose could be recovered using the dating protocol in Table 1. To calculate the measured-to-given dose ratio, the residuals obtained were subtracted from each irradiated signal.

Luminescence measurements were conducted on a Risø TL/OSL DA-20 reader equipped with a 90Sr/90Y beta source (dose rate ~0.12 Gy/s). IR-diodes (~870 nm) were used for feldspar stimulation, and the IRSL signal was detected in the blue-violet wavelength range through a Schott BG-39 and Corning 7–59 filter combination. For final De-estimation, aliquots showing recycling ratios deviating >10% from unity and/or a recuperation of >5% were rejected.

3.3.2. Dosimetry
Concentrations of the radionuclides U, Th and K were measured on dried sample material using high resolution gamma spectrometry at the “Felsenkeller” laboratory in Dresden. Additionally, the in situ gamma dose rate contribution was measured at several luminescence sampling points (samples L-Eva 1506, 1507 and 1520) using a calibrated lanthanum bromide scintillation γ-detector (Inspector 1000 IN1KL-1, Canberra).

The internal potassium content of the K-feldspars was estimated for samples L-Eva 1505, 1506, 1507 and 1520 using microprobe analyses that were conducted at the Federal Institute for Geosciences and Natural Resources (BGR) in Hannover (Germany). Twenty grains were measured for each sample, and the K-mean values with their standard errors were used for age calculation. To account for dose rate attenuation by moisture, water content values of 15 ± 10% were estimated. An a-value of 0.11 ± 0.02 was used to address the alpha efficiency (Kreutzer et al., 2014), and dose rate conversion factors were taken from Guérin et al. (2011). The cosmic dose rate was calculated based on Prescott and Hutton (1994).

3.4. Sedimentological analyses
To trace potential soil formation in the fluvial sediments that leads to a decrease of carbonate contents and pH values but an increase of the values of organic carbon and magnetic susceptibility from bottom to top (von Suchodoletz et al., 2018), we carried out the following sedimentological analyses:

Carbonate contents were determined using the method of Scheibler: 1 to 10 g of material was filled into an Eijkelkamp Calcimeter apparatus, and 4 N hydrochloric acid was added continuously until the reaction ceased. Calculation of the carbonate content was based on the volume of CO2 produced during the reaction.
pH-values were measured with a pH-meter 196 (WTW): 20 g of sample material were mixed with 50 ml of 0.1M KCl, and pH was measured after 2 h of soaking.

Measurements of mass-specific (χ) and frequency dependent magnetic susceptibility (χ_{fd}) were performed using a Bartington MS3 magnetic susceptibility meter equipped with a MS2B dual frequency sensor. After softly grinding the material and densely packing it into plastic boxes, volume magnetic susceptibility (κ) was measured with low (0.465 kHz, κ_{(LF)}) and high (4.65 kHz, κ_{(HF)}) frequencies. Mass-specific magnetic susceptibility was obtained by relating κ_{(LF)} with the mass of the sample. Frequency dependent magnetic susceptibility indicates the presence of mineral grains at the single domain/superparamagnetic border (<30 nm) mostly formed by pedogenesis (Torrent et al., 2007), and was calculated using the formula:

\[ \chi_{fd} = \frac{\kappa_{(LF)} - \kappa_{(HF)}}{\kappa_{(LF)}} \times 100 \]

3.5. Micromorphology

We took four oriented, plastered block samples for micromorphological analysis at the northern section (Fig. 6) and five thin sections were prepared from these by T. Beckmann (Schwäpler-Lagesbüttel, Germany). Analysis of the thin sections was conducted with a petrographic microscope with a magnification of 20× to 200× using oblique incident (OIL), plane- (PPL) and cross-polarized light (XPL). Micromorphological descriptions follow established nomenclatures (Stoops, 2003; Stoops et al., 2010).

3.6. Stone artefact analysis

We (W.B.) recovered most of the 88 artefacts from the coarse gravel dump, which was a pile of the screened coarse gravel fraction produced by the mining company, containing mixed gravels of the Middle to the Upper Gravel Unit (Fig. 3) from the northern sections (Unit N-2, see below). Only four flakes and one notched tool were found in their original stratigraphic position within Unit N-2 (Fig. 7.8 and 7.4) of the northern sections (Middle Gravel Unit according to Meng and Wansa (2005)). All artefacts were measured and analyzed using a detailed attribute analysis explained in detail in Weiss (2015). Generally, only complete artefacts >20 mm were included into the analysis. Length, width and thickness were measured as maximum dimensions on flakes cores and tools. Angle measurements were obtained using a goniometer. Additional attributes are given and, if necessary, explained in Table 4. The analyses were performed using the open-source statistical software R (R Core Team, 2016). The 3d-scans of artefacts provided in Supplementary 3d Artefacts were scanned using an iPhone XS and the QLone application.

4. Results

4.1. Stratigraphy

During our investigations, we documented the following stratigraphy at Uichteritz:

1) Southern sections (125 m a.s.l., Fig. 6 and Supplementary Fig. 2): Gravelly fluvial units in these sections are characterized by mostly horizontally bedded gravels that are intercalated with partly cross-bedded sand layers. Unit S-1 at the bottom is mainly built by large, well-rounded gravels that are surrounded by a sandy matrix. Discordantly capping Unit S-2 contains smaller gravels compared with Unit S1 and these are intercalated with sand layers. Overlying this unit is Unit S-3, which is dominated by silty to clayey material, is interpreted as overbank deposits. At the top of the sequence, Unit S-4 is composed of sand-rich sediments with intercalated gravel beds (Fig. 6).

2) Northern sections (129 m a.s.l.; Figs. 6 and 8 and Supplementary Fig. 2): The northern sections show a higher topographic elevation than the southern ones. Unit N-1 shows mostly horizontally bedded, well-rounded gravels. The overlying Unit N-2 is gravelly to sandy with a
thickness of a few centimeters and shows a clay-rich matrix. It appears at an equal elevation in all northern sections. At the top, Unit N-3 partly caps the lower units discordantly and is dominated by sandy material.

All fluvial sediments investigated during this study contained optically visible nordic rock elements. Table 2 reports the results of the detailed lithological analyses conducted for samples S11 and S12 taken from Unit N-2 (northern profiles). Next to small amounts of nordic rocks (flint), the lithological spectra of both samples are mainly characterized by rocks representing the regional geology in the upstream areas. It is interesting to note that Triassic limestone is absent in the top of Unit N2, whereas the bottom part of contains 29% limestone. Permafrost features such as ice wedge casts were not observed in all investigated sediments.

Based on the lithological composition of our northern sections and the elevation, Unit N2 can be correlated with the so called Middle gravel unit (Fig. 3) of Meng and Wansa (2005) that hosts the Lower Paleolithic stone artefacts.

4.2. Geoelectrical measurements

Fig. 9 shows the results of the geoelectrical measurements. The visible resistivity variations allowed us to identify several sedimentary units. The basal Triassic claystones, siltstones and marls (Buntsandstein, solid rock) yielded resistivities of 40–260 Ohm * m. Within the overlying unconsolidated Quaternary sediments, layers with lower resistivities of 20–90 Ohm * m (blue colour in Fig. 9) were identified as silt- and clay-rich units, and those with higher resistivities of 120–2400 Ohm * m (yellow colour in Fig. 9) as gravel bodies. Consequently, two sediment bodies dominated by gravels could be identified: one preserved in the southern and central part of the outcrop, and the second found at a higher elevation in the northern part. Furthermore, a layer with intermediate resistivities of about 100 – 250 Ohm * m was identified, probably representing sands (light yellow in Fig. 9).

4.3. Luminescence dating

The following observations were made during our measurements, serving as bases for our luminescence age determinations: (i) The dose recovery tests (Fig. 10) of samples L-Eva 1505, 1506 and 1507 showed that all measured/to given dose ratios deviated <10% from unity; (ii) The measured pIRIR\textsubscript{290}-related g-values were at 0.3 ± 0.1 (L-Eva 1505) and 1.8±0.2 (L-Eva 1507). The observed g-values generally show the high signal stability of the pIRIR\textsubscript{290}-signal especially for the deposits of the north sections; (iii) The equivalent dose (De) distributions of the measured samples suggests that insufficient bleaching is not a relevant problem (Fig. 11; Table 3). The obtained overdispersions are all <30% and the Central Age Model (Galbraith et al., 1999) was used for final De-estimation; (iv) The measured internal potassium contents vary between 12.04 ± 0.2 and 12.24 ± 0.2%. For samples L-Eva 1794 and L-Eva 1795 that were not measured, the K-mean value of the other samples (12.1 ± 0.2%) was used; and (v) The pIRIR\textsubscript{290} luminescence ages obtained from the southern profiles vary between 284 ± 23 ka and 177 ± 10 ka, and those from the northern sections, containing the Lower Paleolithic artefacts between 415 ± 45 ka and 366 ± 30 ka. Table 3 summarizes the dosimetry and luminescence data.

4.4. Sedimentological analyses

Apart from an outlier in the lower part, from top to bottom the values of mass-specific magnetic susceptibility (χ) systematically decrease from 0.53 to 0.08*10^{-6} m\(^3\)/kg (Fig. 6). The same systematically decreasing trend is also visible for frequency dependent magnetic susceptibility (χ\textsubscript{fd}) where the values decrease from 9.3 % at the top to 2% at the bottom, and for organic carbon (C\textsubscript{org}) with values of 0.13 % at the top and 0.0 % at the bottom. An inverse systematically increasing trend
from top to bottom is shown by carbonate that shows values of 0.04 % at the top and increases to 1.7 % at the bottom, and by pH with values of 7.04 at the top and 7.88 at the bottom.

4.5. Micromorphology

The results of micromorphological analysis are illustrated in Figs. 12 and 13. The Lowermost Unit N-1 is only present at the very bottom of one thin section, UT 17-4 (Fig. 12A), over ~2 cm, and observations are therefore limited. Here, unit N-1 is dominantly composed of sand with frequent to common gravels. Sand grains are partly covered with clay coatings, and illuviated clay that forms bridges between the grains (gefuric and chitonic c/f-related distribution). The contact with the overlying unit N-2 in sample UT 17-4 is abrupt conformable.

Unit N-2 is represented in thin sections UT 17-1, UT 17-2 and the upper part of UT 17-4, and characterized by a strong increase in gravels and aggregates, which are rounded by translocation. All samples from Unit N-2 are gravel-supported and show a loamy matrix (Fig. 12B). The latter is composed of numerous (sub)rounded fragments of illuviated clay coatings, sand as well as silt grains (both dominantly quartz), and subrounded to rounded aggregates (Fig. 12C–H and 13A–D). The mostly limpid clay coatings are yellow to light brown and often microlaminated, representing several phases of clay illuviation during the formation of a Bt horizon. Most clay coatings are at least partially (sub)rounded, a few are deformed, exhibit internal fracturing and/or additional silty-clay coatings ('snowball' structure caused by accretion from rolling over a 'sticky' surface; (Rose et al., 2000)), showing they did not form in situ but were transported here. After deposition, iron and manganese oxides formed on some of the fragmented clay coatings (Fig. 13D). Only in two voids recently formed, undisturbed clay coatings were found (Fig. 13E–F), documenting very weak in situ clay illuviation. Similarly, we observed a few recent roots indicating post-depositional processes occurring in relation to the recent exposure of the profile section.

We identified two types of coatings on the gravels: (i) at least partial thin limpid clay coatings occurring on most gravels (Fig. 12F–H at the bottom of the grain), probably remnants of clay illuviation during the formation of the Bt horizon; and (ii) silty-clayey coatings overlying the clay coatings on common to few gravels. The latter are similar to the ‘snowball’ structure also present on the clay coating fragments (Fig. 12C–G on top of the grain) and indicate translocation of the gravels from the place of the Bt soil formation. Limestone gravels are present in the lower part of the thin section UT 17 1 as well as in thin section UT 17 2 and the upper part of UT 17 4, all containing Unit N-2. Limestones are dominantly to commonly affected by weathering in the form of calcium carbonate dissolution (Fig. 13A). In their direct surroundings secondary micritic calcite precipitated in the matrix and as coatings on the gravels (Fig. 13A). The matrix composition gradually changes in the lower part of thin section UT 17–4 compared to all other thin sections of Unit N-2. Here, the number of fragmented clay coatings decreases with depth, and instead small rounded aggregates and sand grains dominate the matrix. Rounding of the small aggregates demonstrates material translocation also for this part of Unit N-2.

Unit N-3 overlies Unit N-2 with an abrupt conformable contact and is represented in thin section UT 17-3. This unit is composed of well sorted sand with undisturbed clay coatings and bridges around/between sand grains (Fig. 13G–I), which we interpret as a post-depositional phase of soil formation (clay illuviation).

In summary, thin section analysis of four samples, UT 17 1 to 4, provided crucial insights into formation of the Units N-1, N-2 and the superimposing Unit N-3. The two sandy units, Unit N-3 and Unit N-1 exhibit only weak pedogenic overprinting in the form of clay illuviation. These two units bracket gravel Unit N-2, which has a loamy matrix that originated from intensive soil formation. This soil formation was not, however, preserved in situ, but instead reworked after its formation.

4.6. Stone artefact analysis
The 88 artefacts discovered were manufactured from Baltic flint that was transported to central Germany by the first Fennoscandian ice advance. Most artefacts were recovered out of their stratigraphic context from the mining company’s coarse gravel pile, containing gravels of the northern sections. The condition of their edges and ridges (Table 4) provides some information about their original stratigraphic context. Rolled and heavily rolled artefacts (41%) were affected by fluvial processes, and their surfaces were damaged and smoothed by water transport (or by water flow carrying sediment particles abrading the edges and dorsal ridges; see Supplementary 3d Artefacts, Ui_70). Thus, we can infer that these artefacts were redeposited within gravel bodies. Four flakes and one notched tool (Fig. 7.4 and 7.8 (Rudolph et al., 2005) were found within Unit N-2 (the Middle Gravel Unit after Meng and Wansa (2005)), and their displacement and final deposition might be correlated with erosion and subsequent accumulation of the interglacial soil sediments. The cause of heavy damage on some artefacts (17%) is not clear, as it could be caused by either post-depositional processes or mining activities. Finally, 41% (Table 2) of the artefacts were preserved in a fresh condition or showed only slight edge damage (Supplementary 3d Artefacts, Ui_62). We suggest that these better preserved artefacts were neither deposited in coarse gravels nor affected by intensive fluvial processes. Instead, they must have been preserved within rather fine-grained sediments, either in the form of lenses within the gravel bodies or within the oxbow destroyed some originally preserved artefact scatters. For instance, a flake and a core-on-flake show a comparable fresh preservation state, similar patination and raw material characteristics (Supplementary 3d Artefacts, Ui_61 and Ui_68). Therefore, we suggest that prior to the mining activities some artefacts might have been preserved in in situ clusters probably within the fine-grained sediments, whereas the rolled artefacts were potentially eroded from the former landscape and incorporated within the Middle gravel unit.

The median length of the cores measured in flaking direction was 55.1 mm (Fig. 7.1–7.3, Table 4, see also Supplementary 3d Artefacts, Ui_33 and Ui_24). The core margins are predominantly not modified or prepared, and the cores mainly retained the natural shape of the nodules. Unidirectional flaking of one exploitation or flaking surface dominated the blank production. This is confirmed by the dominance of unidirectional dorsal scar directions of the flakes (see below). The low number of flaked surfaces on the cores and the low number of flake scars point to a rather low exploitation of the cores. The median number of flakes obtained from each core was three (Fig. 7.1). Mostly natural surfaces (“primary surfaces”) served as striking platforms. Thirty percent of these were created by removing one large flake (Fig. 7.1–7.3), representing in some cases additional flaking surfaces on a core (Fig. 7.1 and 7.3). This constitutes a simple form of core preparation. A few cores (18%) showed a coarse preparation of the striking platform to control the flaking angle. The flakes (Fig. 7.4–7.6, Table 4) have a median length of 54.9 mm, and therefore match those of the cores. The observation that only few flakes were obtained from the cores is reinforced by the fact that a high percentage of flakes are cortical (25%, Table 4) or partial cortical (65%, Table 4) and that half of the flakes (Table 4) reveal a rather simple dorsal scar pattern with only one direction of the flake scars. The flake platforms also corroborate the observations made about the low striking platform preparation seen on the cores (see above). They are clearly dominated by platforms with primary surfaces (62%), followed by plain platforms (25%). The use of natural striking platforms resulted in less control of the flaking angle. This is evidenced by rather low exterior platform angles (EPA) of median 74°, compared to, for example, late Middle Paleolithic assemblages of central Europe (see e.g., Weiss et al., 2017). In the late Middle Paleolithic, prepared core methods are abundant, and the EPA was mostly between 80 and 90°. Furthermore, in Uichteritz no specific flake types were produced, as there is no clear dominance of a certain flake shape.

Only seven tools were recovered in Uichteritz (Fig. 7.7–7.10). The working edge is exclusively created by clactonian notches, generally only one on notched tools and up to four on the denticulates. In four cases, a back opposite the working edge was incorporated into the tool design. All tools but one were manufactured on natural pieces and not on flakes. Therefore, flakes did not play an important role for tool production. It is possible that flakes were mostly not modified and only used as simple
cutting tools. Similarly, it is possible that notched pieces were not tools per se, but instead cores for natural backed flakes.

Although an unknown part of the assemblage(s) is missing because of post-depositional processes and mining activities, we can conclude that the artefact assemblage from Uichteritz is characterized by simple flaking methods, with low rates of core preparation and nodule shaping to obtain a small number of flakes. No scrapers are present, and the tool assemblage consists exclusively of notched tools that are mainly manufactured on natural flint pieces.

5. Discussion

5.1. Robustness of luminescence ages

The pIRIR\textsubscript{290} based luminescence ages brought more light into the fluvial aggradation history at Uichteritz and the ages deliver important new information on the driving forces for fluvial activity of the Saale River. The pIRIR\textsubscript{290}-approach is interpreted to deliver a stable luminescence signal and it was demonstrated by previous publications that it provides a suitable tool to date back several 100 ka (Buylaert et al., 2012a, 2012b; Lauer and Weiss, 2018; Li et al., 2018). The measured g-values indicate that there might be some minor signal instability even for the pIRIR\textsubscript{290} signal, but the observed g-values might also be explained by a measurement artefact. Generally, a relevant age underestimation caused by anomalous fading is unlikely for samples from Uichteritz. The obtained De-overdispersions indicate that dose residuals might be low and insufficient bleaching is most likely not a relevant issue for most samples, especially because dose residuals are less relevant for Middle Pleistocene deposits if compared to Holocene or last glacial sediments. Nevertheless, the relatively high overdispersion of sample L-Eva 1795 (29%) might be explained by partly insufficient bleaching and the age of 415 ± 45 ka might be slightly overestimated.

5.2. Timing of Middle Pleistocene fluvial activity and periods of landscape stability

Several fluvial units of the Saalian Main Terrace (SMT) were deposited and preserved in the southern part of the Uichteritz gravel pit between 284 ± 23 ka and 177 ± 10 ka. Similar to observations from the Leipzig lowlands (Lauer and Weiss, 2018), fluvial aggradation mostly occurred during cold climatic periods. Increased fluvial aggradation activity was also described from several other central European rivers for the Middle- and Upper Pleistocene (e.g., Mol, 1997; Mol et al., 2000; Cordier et al., 2012; Van Huissteden et al., 2013; Lauer et al., 2010, 2011b, 2017). Nevertheless, the luminescence age of 210 ± 17 ka gives evidence for fluvial aggradation or reworking of formerly cold stage deposits also during warmer climatic conditions during MIS 7. Similar observations of fluvial reworking during warmer climatic periods were made by Cordier et al. (2014) in the Moselle catchment where several fluvial units could be allocated to MIS 5 substages on the basis of OSL dating.

The basal fluvial sediments in the southern part of the gravel pit correlate to MIS 8 (Lisiecki and Raymo, 2005), a period when the aggradation of fluvial sands and gravel was also observed in the Leipzig lowlands (Lauer and Weiss, 2018). Periods of fluvial aggradation during MIS 8 have also been documented from e.g., the Lower Thames (Bridgland, 2006) or from the Sarre valley (Cordier et al., 2012). The uppermost Middle Pleistocene sediments, stratigraphically preserved below till of the Saalian Zeitz-phase, yielded an age of 177 ± 10 ka. Similar ages were also obtained for the top part of Middle Pleistocene fluvial sediments in Zwenkau south of Leipzig (Lauer and Weiss, 2018). The cluster of ages obtained from the sandy and gravelly units of the northern sections does not allow us to clearly distinguish between different periods of fluvial aggradation, but the age estimates show that these were deposited around 400 ka ago, i.e., prior to those of the southern sections. Similar chronological data for fluvial aggradation, also in combination with the occurrence of Lower Paleolithic stone tools, are reported from the Somme catchment in northern France (Antoine et al., 2015).
The thin section analysis demonstrate that Unit N2 is characterized by reworked Bt-material of a Luvisol that must have formed during a warm climate period, most likely the Holsteinian interglacial. This is also supported by the lithological and sedimentological analyses. Sediment samples from the top and middle part of Unit N2 are fully decalcified and increasing values of magnetic susceptibility and TOC also underline former pedogenesis. Hence, at Uichteritz reworked warm stage deposits are preserved within Middle Pleistocene fluvial sediments that were mainly deposited during cold climatic conditions.

Preservation of interglacial sediments within fluvial successions is often restricted to sedimentary basins such as the Upper Rhine Graben (Gabriel et al., 2013). In such environments, the material from warm stages is often found as loamy sediments in floodplains. The preservation of Bt-material originating from a former stable landscape with intense soil formation is rare in Middle Pleistocene fluvial sediments, and therefore of high interest. Likewise, Meng and Wansa (2005) described soil formation in their exposed fluvial units, but correlated this with a pre-Holsteinian (late Elsterian) period. The Holsteinian interglacial was formerly described in the Saale-Unstrut area by findings of specific faunal remains such as forest rhino and elephant (Siegert and Weissermel, 1911; Mania, 1973). Additionally, intense Middle Pleistocene palaeosols preserved within loess-sections are documented from the study area (Haase et al., 1970; Mania and Altermann, 1970). However, all the above-mentioned sediments are lacking a robust chronological framework.

The lower part of the deposits exposed at the northern sections and below the reworked MIS 11 Bt-horizon (Unit N-1) most likely represents a late Elsterian period of fluvial activity of the Saale River, based on the occurrence of nordic rock elements (flint). The capping sediments, including the reworked Bt-material, can presumably be correlated with the initial formation period of the SMT at the transition from MIS 11 to MIS 10 and/or during an early stage of MIS 10. However, the error bars of the luminescence ages do not allow for a clearer age estimation as mentioned above.

### 5.3. Chronology of Middle Pleistocene Fennoscandian ice advances

The new age estimates from Uichteritz add greater detail to existing chronologies for the Middle Pleistocene ice advances into Germany (Roskosch et al., 2015; Lang et al., 2018; Lauer and Weiss, 2018) as all luminescence ages derive from deposits that are stratigraphically positioned between the (here eroded) Elsterian tills and the till of the Zeitz-phase (Drenthe stage). The ages from the northern sections further support a correlation of the Elsterian glacial with MIS 12 and consequently of the Holsteinian interglacial with MIS 11 (Sarnthein et al., 1986; Scourse et al., 1998; Nitychoruk et al., 2006; Scourse, 2006; Preece et al., 2007; Koutsodendris et al., 2012). This correlation suggests that the so-called Saalian glacial cycle included three distinct cold periods during MIS 10, 8 and 6 (Lisiecki and Raymo, 2005). In central Germany, there is no evidence for an ice coverage during MIS 10 or 8 thus far (Lang et al., 2018; Lauer and Weiss, 2018), only during MIS 6. A late MIS 6 luminescence age for the Saalian maximum ice sheet extension was also recently reported from SW Poland (Wiśniewski et al., 2019). This is in good agreement with the present study which shows that the Saalian ice coverage of the study area only corresponds to MIS 6. Additional chronological studies are needed to further understand the triggering factors for different degrees of ice sheet expansions during the Middle Pleistocene in northern central Europe.

### 5.4. Human occupation of northwestern central Europe starting at MIS 11

Based on the lithological composition (Table 2) of the fluvial units of the northern section, as well as on their topographic elevation, these deposits, especially Unit N-2, can be correlated with the Middle Gravel Unit of Meng and Wansa (2005). Since that gravel unit is connected to the occurrence of Lower Paleolithic artefacts (Rudolph et al., 2005) a minimum age of approximately 400 ka can be deduced for the latter. The reworked soil (fBt) material within the artefact-bearing fluvial unit also suggests that human occupation of the area took place under interglacial climate conditions.
The chronometric ages for the Lower Paleolithic artefacts from Uichteritz confirm the former finding by Lauer and Weiss (2018) that humans in northwestern central Europe, and specifically in central Germany, first appeared during the interglacial at MIS 11 (424–374 ka) (Lisiecki and Raymo, 2005) that directly followed the major inland glaciation of MIS 12. This is in line with a postulated onset of permanent population of Europe north of the Alps and the Pyrenees starting at 600–500 ka (Gamble, 1999; Roebroeks, 2001, 2005, 2006). However, it seems that the “archaeological onset” of permanent human occupation in northwestern central Europe started one interglacial later than in more southern regions but maybe traces of earlier human occupation have been eroded by the major MIS 12 inland glaciation.

Although only represented by a small number of artefacts, the assemblage characteristics of Uichteritz are comparable to the MIS 11 Lower Paleolithic site of Wallendorf/Schladebach (Laurat et al., 2004a, 2004b; Lauer and Weiss, 2018), about 20 km to the northeast. Flake types at both sites are variable in shape, and they were obtained from simple and multi-platform flake cores. However, both assemblages show a few prepared striking platforms on the cores and/or on flake platforms respectively, indicating a trend towards Middle Paleolithic blank production (Laurat et al., 2004a, 2004b; Lauer and Weiss, 2018) with higher control of the flaking angle. This technological change seems to have its onset within the first human populations in the area during MIS 11, and led to the prepared core blank production methods of the Middle Paleolithic starting around MIS 8 (Hérisson et al., 2016; van Baalen, 2017; Lauer and Weiss, 2018; Picin, 2018). This remained a stable adaptation (Gamble, 1999; Roebroeks, 2006) of (northern) European Neanderthals during the entire Middle Pleistocene and beyond. Regarding the tools, both Wallendorf/Schladebach and Uichteritz are dominated by notched tools and denticulates (Laurat et al., 2004a, 2004b). This similarity points to interglacial tool kits, as it has been experimentally shown (Weiss, 2016) that simple flakes, as well as notched tools and denticulates serve well as wood working tools in forested interglacial environments. However, it cannot be excluded that notched pieces were essentially cores for the production of natural backed flakes.

Bilzingsleben (Thuringia, Germany) is another site in central Germany that potentially dates to the MIS 11 interglacial (Mania et al., 1980; Mai et al., 1983; Mania and Weber, 1986; Weber, 1986; Mallick et al., 2001; Mallick and Frank, 2002; Pasda, 2012; Brasser, 2017). The site also yielded human cranial fossils as well as teeth (Vlček et al., 2002), which could not be attributed to a specific human species because of their fragmented nature (Hublin, 2009). Although the find layers of Bilzingsleben formed within interglacial deposits, inferred from the nature of travertine formation as well as faunal and plant remains (see citations above), the age attribution of Bilzingsleben is still not clear. Strong weathering of the travertine resulted in an open Uranium system that unfortunately led to unsuccessful attempts of 230Th/U dating on micro samples (Mallick and Frank, 2002). However, an age >300 ka for the site is likely, as U-series activity ratios yielded values close to the radioactive equilibrium (Mallick et al., 2001; Mallick and Frank, 2002).

Evidence of human presence in central Germany during MIS 11 (424 ka–374 ka) is scant, but Uichteritz, Wallendorf/Schladebach and possibly also Bilzingsleben constitute an expanding sample of sites that can be confidently dated to this period. The human traces at those sites indicate the start of a permanent human occupation of northwestern central Europe east of the Rhine Valley that was only interrupted by the extremely cold phases of the full glacial periods (Lauer and Weiss, 2018; Fig. 4).

Fig. 14 summarizes the main findings of the paper in previous studies (Meng and Wansa, 2005) in terms of periods of fluvial aggradation and incision, ice-coverage of the study area and early human presence in central Germany.

6. Conclusion

The chronostratigraphical data obtained at Uichteritz, combined with the results from micromorphology and sedimentary proxies provide important new information on the fluvial response of the Saale River system to climatic shifts. Furthermore, important additional information
on the timing of Middle Pleistocene ice advances of Fennoscandian glaciers as well as early human presence in the region can be deduced. The Middle Pleistocene landscape and Paleolithic occupation history in the area of Uichteritz can now be subdivided into the following periods:

- The early Elsterian period was characterized by the formation of the early Elsterian river terrace prior to about 450 ka. During that time, the Saale River drainage went through the Markröhlitz valley. The ice coverage of the study area during the Elsterian glacial cycle occurred during MIS 12 at around 450 ka, followed by a period of late Elsterian fluvial activity around the transition to the MIS 11 interglacial.

- During MIS 11, the landscape was stabilized, accompanied by the formation of a Luvisol. This period also correlates very likely with the appearance of first humans in the regions, as evidenced by the findings of Lower Paleolithic stone tools in the corresponding sediment units. During the transition from MIS 11 to the MIS 10 cold stage, the Luvisol was reworked and the Saale River incised into the previously deposited sand and gravel. This incision caused a rearrangement of the drainage system and a shift of the Saale River from the Markröhlitz valley to the recent river valley. In between MIS 8–MIS 6, several periods of fluvial aggradation were interrupted by periods of less fluvial activity or erosion. During this time, the stacked fluvial sequence of the Saalian main terrace was formed. During later MIS 6, the Fennoscandian glaciers again advanced and covered the study area as evidenced by the pro-glacial lake deposits as well as the Saalian till.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.geomorph.2019.107016.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Tables

#### Table 1

The steps of the applied pIRIR$_{290}$ luminescence protocol.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Give dose, $D_i \rightarrow$ irradiation of the sample</td>
</tr>
<tr>
<td>2</td>
<td>Preheat at 320 °C, 60 s</td>
</tr>
<tr>
<td>3</td>
<td>IR stimulation at 50 °C, 100 s</td>
</tr>
<tr>
<td>4</td>
<td>IR stimulation at 290 °C, 200 s</td>
</tr>
<tr>
<td>5</td>
<td>Give test dose, $D_t$ (irradiation of the sample)</td>
</tr>
<tr>
<td>6</td>
<td>Preheat at 320 °C, 60 s</td>
</tr>
<tr>
<td>7</td>
<td>IR stimulation at 50 °C, 100 s</td>
</tr>
<tr>
<td>8</td>
<td>IR stimulation at 290 °C, 200 s</td>
</tr>
</tbody>
</table>
**Table 2**

Lithological composition of the upper gravel Unit N2 (northern sections)(%).

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>S11</th>
<th>S12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total amount counted</td>
<td>726</td>
<td>648</td>
</tr>
<tr>
<td>Crystalline</td>
<td>1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Flint</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Porphyry</td>
<td>4.7</td>
<td>8.6</td>
</tr>
<tr>
<td>Triassic limestone</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Sandstone</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Quartzite</td>
<td>31.5</td>
<td>27.5</td>
</tr>
<tr>
<td>Slate, phyllite, greywacke, quartzite and schists</td>
<td>56.2</td>
<td>29.8</td>
</tr>
<tr>
<td>Chert</td>
<td>5.1</td>
<td>2</td>
</tr>
<tr>
<td>Hematite</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total (%)</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Table 3
Dosimetry data, equivalent doses and age estimates.

DR = dose rate, De = equivalent dose, CAM = Central Age Model, OD = overdispersion.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Location (N = north, S = south)</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>K (%)</th>
<th>$K_{int}$ (%)</th>
<th>$D_{R_{total}}$ (mGy/a)</th>
<th>De (CAM)</th>
<th>pIRIR$_{290}$ age (ka)</th>
<th>OD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-Eva 1506</td>
<td>S</td>
<td>1.0 ± 0.2</td>
<td>3.2 ± 0.2</td>
<td>1.3 ± 0.1</td>
<td>12.04 ± 0.13</td>
<td>2.32 ± 0.15</td>
<td>486 ± 23</td>
<td>210 ± 17</td>
<td>21</td>
</tr>
<tr>
<td>L-Eva 1507</td>
<td>S</td>
<td>1.7 ± 0.3</td>
<td>5.7 ± 0.4</td>
<td>2.6 ± 0.2</td>
<td>12.04 ± 0.18</td>
<td>3.85 ± 0.20</td>
<td>681 ± 19</td>
<td>177 ± 10</td>
<td>10</td>
</tr>
<tr>
<td>L-Eva 1520</td>
<td>S</td>
<td>1.6 ± 0.3</td>
<td>7.2 ± 0.5</td>
<td>1.6 ± 0.1</td>
<td>12.06 ± 0.14</td>
<td>2.90 ± 0.16</td>
<td>823 ± 47</td>
<td>284 ± 23</td>
<td>25</td>
</tr>
<tr>
<td>L-Eva 1505</td>
<td>N</td>
<td>0.8 ± 0.2</td>
<td>3.1 ± 0.2</td>
<td>1.5 ± 0.2</td>
<td>12.24 ± 0.14</td>
<td>2.36 ± 0.18</td>
<td>921 ± 24</td>
<td>390 ± 31</td>
<td>19</td>
</tr>
<tr>
<td>L-Eva 1794</td>
<td>N</td>
<td>0.8 ± 0.2</td>
<td>3.1 ± 0.2</td>
<td>1.6 ± 0.2</td>
<td>12.10 ± 0.20</td>
<td>2.47 ± 0.18</td>
<td>906 ± 31</td>
<td>366 ± 30</td>
<td>15</td>
</tr>
<tr>
<td>L-Eva 1795</td>
<td>N</td>
<td>1.23 ± 0.2</td>
<td>4.4 ± 0.3</td>
<td>1.2 ± 0.1</td>
<td>12.10 ± 0.20</td>
<td>2.33 ± 0.15</td>
<td>967 ± 82</td>
<td>415 ± 45</td>
<td>29</td>
</tr>
</tbody>
</table>
Table 4
Summarized results for the artefacts. Instead of “Cortex” the term “Primary Surface” is used here and refers to all types of natural surfaces, such as cortex, moraine cortex, natural cracks or frost fractured surfaces. EPA = Exterior Platform Angle, IPA = Interior Platform Angle. **Two cores are manufactured on flakes and counted as cores. ***A Plain striking platform on a core is characterized here by one large flake removal that shaped the striking platform (and results in “Plain-100%” platforms on the flakes), ****Primary Platform Preparation means that the platform was created by one flake scar or a plain natural surface, ****Aligned dorsal direction means that the dorsal scars have the same direction as the flake (ventral). This refers to unidirectional flaking.

<table>
<thead>
<tr>
<th>General Classification</th>
<th>n</th>
<th>n complete</th>
<th>Condition edges and ridges</th>
<th>Length in mm (median)</th>
<th>Width in mm (median)</th>
<th>Thickness in mm (median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cone</td>
<td>38*</td>
<td>33*</td>
<td>Fresh: 9 (12%),</td>
<td>55.1</td>
<td>61.2</td>
<td>35.8</td>
</tr>
<tr>
<td>Flake</td>
<td>43</td>
<td>32</td>
<td>Light.Damaged: 21 (29%),</td>
<td>54.9</td>
<td>42.7</td>
<td>18</td>
</tr>
<tr>
<td>Core tool</td>
<td>6</td>
<td>6</td>
<td>Heav.Damaged: 12 (17%),</td>
<td>59.2</td>
<td>36.05</td>
<td>24</td>
</tr>
<tr>
<td><strong>Flake tool</strong></td>
<td>1</td>
<td>1</td>
<td>Rolled: 14 (19%),</td>
<td>64.5</td>
<td>36.2</td>
<td>18.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>88</td>
<td>72</td>
<td></td>
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<table>
<thead>
<tr>
<th>Cores</th>
<th>Core shape</th>
<th>Number of flaking surfaces</th>
<th>Flaking directions on all flaking surfaces</th>
<th>Median number of flake scars</th>
<th>Amount of flaked surface</th>
<th>Striking platform preparation</th>
<th>Median flaking angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Natural: 26 (79%),</td>
<td>1: 25 (76%),</td>
<td>Unidirectional: 34 (76%),</td>
<td>3</td>
<td>10–30%: 17 (52%),</td>
<td>Primary Surface: 17 (52%),</td>
<td>81°</td>
</tr>
<tr>
<td></td>
<td>Irregular: 2 (6%),</td>
<td>2: 5 (15%),</td>
<td>Unidir. &amp; Lateral: 7 (16%),</td>
<td></td>
<td>40–60%: 14 (42%),</td>
<td>Plain**: 10 (30%),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Globular: 1 (3%),</td>
<td>3: 2 (6%),</td>
<td>Bidirectional: 3 (7%),</td>
<td></td>
<td>70–90%: 2 (6%),</td>
<td>Coarse Prep.: 6 (18%),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triangular: 1 (3%),</td>
<td>4: 1 (3%),</td>
<td>Concentric: 1 (2%)</td>
<td></td>
<td>100%: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prismatic: 1 (3%),</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oval: 2 (6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Flakes</th>
<th>Platform</th>
<th>EPA</th>
<th>IPA</th>
<th>Amount of cortex</th>
<th>Dorsal directions</th>
<th>Flake shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prim. Surf-0%: 20 (62%),</td>
<td>74°</td>
<td>117°</td>
<td>100%: 8 (25%),</td>
<td>0-Cortical: 8 (25%),</td>
<td>Convergent: 2 (6%),</td>
</tr>
<tr>
<td></td>
<td>Prim. Surf/Scars-40-60%: 1 (3%),</td>
<td></td>
<td></td>
<td>70–90%: 1 (3%),</td>
<td>1-Aligned****: 14 (44%),</td>
<td>Divergent: 8 (25%),</td>
</tr>
<tr>
<td></td>
<td>Plain-NA**: 2 (6%),</td>
<td></td>
<td></td>
<td>40–60%: 9 (28%),</td>
<td>1-Lateral: 2 (6%),</td>
<td>Div.-Conv.: 9 (28%),</td>
</tr>
<tr>
<td></td>
<td>Plain-100%**: 8 (25%),</td>
<td></td>
<td></td>
<td>10–30%: 11 (34%),</td>
<td>2-Aligned+Lat: 4 (12%),</td>
<td>Irregular: 5 (16%),</td>
</tr>
<tr>
<td></td>
<td>Crushed: 1 (3%)</td>
<td></td>
<td></td>
<td>0%: 3 (9%)</td>
<td>2-Bilateral: 3 (9%),</td>
<td>Parallel: 4 (12%),</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3-Concentric: 1 (3%),</td>
<td>Round: 4 (12%)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Tools</th>
<th>Tool type</th>
<th>Type back</th>
<th>Cross-section</th>
<th>Median angle notches</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>Count</th>
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<tbody>
<tr>
<td>Notch</td>
<td>5</td>
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<tr>
<td>None</td>
<td>2</td>
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<tr>
<td>Planoconvex</td>
<td>3</td>
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<tr>
<td>75°</td>
<td></td>
</tr>
<tr>
<td>Denticulate</td>
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<tr>
<td>Primary Surface</td>
<td>3</td>
</tr>
<tr>
<td>Irregular</td>
<td>3</td>
</tr>
<tr>
<td>Primary Surface + Retouch</td>
<td>1</td>
</tr>
<tr>
<td>Biconvex</td>
<td>1</td>
</tr>
<tr>
<td>Dorsal Scar/Core Edge</td>
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</tr>
</tbody>
</table>
**Figures**

**Figure 1**

Map of Central and Northern Germany showing the maximum ice-sheet extensions of Fennoscandian glaciers during the Elsterian, Saalian- and Weichselian glacial cycle. The ice-marginal positions are based on Ehlers and Gibbard (2004). The location of the gravel-pit Uichteritz is marked by the yellow dot. Uichteritz is located in the region where the terms “Elsterian” and “Saalian” glacial cycle were defined by the southernmost extension of Fennoscandian glaciers during the Middle Pleistocene. The ice sheets came up to the drainage area of the local rivers Elster and Saale (Litt et al., 2007). Based on recently published chronological data (Lauer and Weiss, 2018), the Elsterian glacial cycle can be correlated to MIS 12 and the Saalian glacial cycle spans the time period between MIS 10 – MIS 6.
Figure 2
Extension of the Middle Pleistocene Fennoscandian ice sheets in the study-area based on Eissmann (Eissmann, 2002a). The Zeitz phase defines the southermmost ice-sheet extension during the Saalian glacial cycle, and is correlated with the Drenthe-stage (Litt et al., 2007). In Central Germany, the Elsterian tills (Elster1 and 2) are separated from each other only by meltwater deposits but not by warm stage sediments, indicating that these two ice advances occurred within temporal proximity (Eissmann, 2002b; Hoffmann and Eissmann, 2004). The yellow dot marks the location of the gravel pit Uichteritz, and the green star the position of the artefact-bearing Middle Pleistocene fluvial units at Wallendorf/Schladebach (Laurat et al., 2004a, 2004b; Lauer and Weiss, 2018) often referred to in this study.
Figure 3
Composite profile of the Pleistocene deposits at Uichteritz following Meng and Wansa (2005). Also the stratigraphical position of Lower Paleolithic stone artefacts in the Middle gravel unit is shown (Rudolph et al., 2005).
Figure 4
Distribution of Pleistocene fluvial deposits in the study area following Meng and Wansa (2005). The Saalian Main Terrace (SMT) (Siegert and Weissermel, 1911) is defined by stacked fluvial units which are preserved between the tills of the Elsterian and Saalian glacial cycles (Eissmann, 2002b). The studied outcrop (yellow dot) is situated approximately 600 m west of the recent valley floor of the Saale river and the top of the here studied fluvial deposits are elevated about 40 m above the recent river level.
Figure 5
Digital elevation model of the study area (Landesamt für Landesvermessung und Datenverarbeitung Sachsen-Anhalt, Gen.-Nr. L VermGeo/A8-0354-2004-14). The Uichteritz gravel pit is shown in the western part of the map. The white rectangles mark the areas of the present study (NP: Northern profiles, SP: Southern profiles). The black rectangle marks the part of the gravel pit that was investigated by Meng and Wansa (2005). The pink dashed line at the eastern flank of the gravel pit outlines the geoelectrical ERT transect.
Figure 6
Composite profiles with luminescence ages of the exposed profiles in the northern and southern part of the Uichteritz gravel pit. In the northern sections, the intercalated clay-rich unit N-2 was additionally sampled for lithological, sedimentological and micromorphological analyses.
Figure 7
Lower Paleolithic flint artefacts from Uichteritz. 7.1a-b: core with two unidirectional flaking surfaces (11264:1:24), 7.2a-b: unidirectional core (11264:1:33), 7.3a-b: core with two unidirectional flaking surfaces (11264:1:12), 7.4: flake found within the Middle Gravel Unit (11264:1:23), 7.5: flake (11264:1:81), 7.6: flake from bi or three-directional core with a second preserved flaking surface at the distal end (11264:1:62), 7.7–7.10: notched tools, number 7.8 found within the Middle Gravel Unit (7.7 – 11264:1:21, 7.8 – 11264:1:19, 7.9 – 11264:1:5, 7.10 – 11264:1:35). Drawings: W. Bernhardt, scale: 2:3.
Figure 8
Picture from exposed north-section at Uichteritz. The profile is characterized by the intercalated Unit N-2 showing a clay-rich matrix. Supplementary Fig. 2 shows photographs of the other investigated sub-sections.
Figure 9
Results of geoelectric measurements. The geoelectrical resistivities allow to distinguish between several units of unconsolidated sediments. 2 main gravel beds (yellow colour) appear in different elevation, one in the northern and another one in the southern part of the gravel-pit. The subdivided sedimentary units (see previous chapter on stratigraphy) are marked as U N1-3 and U S 1-4.
**Figure 10**
Results of the dose recovery tests of samples L-Eva 1505, 1506 and 1507.
Figure 11
Equivalent dose (De) distribution of sample L-Eva 1507.

L-Eva 1507
OD = 10 %
De (CAM) = 681 ± 19 Gy
Figure 12

A-H: Micromorphological analysis of Unit N-2. A: MP (ppl) at the contact of Unit N-2 with the underlying Unit N-1. Rounded aggregates, sand and gravels dominate, but the characteristic fragmented clay coatings of Unit N-2 (Fig. 12 C-H) are absent. Scale at lower right 1 mm. B: Scan of thin section UT 17-1 containing Unit N-2. Unit N-2 is gravel supported with a loamy matrix. Red frames mark the position of the microphotos (MP) C-G. C: MP (in ppl) showing that fragmented, (sub)rounded clay coatings aggregates dominate the matrix. Note microlaminations in most of these clay aggregates. They represented relocated Bt- material of a Luvisol. Scale at lower right 1 mm. D: MP (ppl) with fragments of composite clay and clay silt coatings (purple circles). Note also their rounding, indicating transport/relocation from their place of formation. Scale at lower right 500 μm. 

E: MP (ppl) of the typical matrix composition in Unit N-2 with (sub)rounded fragments of clay coatings (purple arrows), sand, silt, brown aggregates and gravels. Scale at lower right 500 μm. F: MP ppl and G: crossed-polarized light (xpl) showing a flint gravel with a limpid clay coating at the bottom and ‘snowball’ silty clay coating on top. The red frame marks the position of Fig. 12 H. Scale at lower right 500 μm. H: MP (ppl) of the sequential coating of a gravel with limpid clay coating covered by a ‘snowball’ structure, which contains deformed clay illuviation coatings among others. Scale at lower right 200 μm.
Figure 13

A-I: Micromorphological analysis of sediment Unit N-1, Unit N-2 and Unit N-3. AMP (ppl) of limestone gravel in dissolution (orange circle) and micritic calcitic recrystallization in the matrix (orange arrows). Scale at lower right 500 μm. B (scale at lower right 500 μm) and C (scale at lower right 1mm): MPs (ppl) of rounded aggregates in sediment Unit N-2. Note that the rounded aggregates contain fragments of clay coatings (purple arrows) and larger fragment of clay coating with ‘snowball’ structure coating (red arrows). D: MP (ppl) showing iron and manganese oxide staining on fragmented clay coatings in Unit N-2. Scale at lower right 200 μm. E: MP ppl and F: xpl of undisturbed clay illuviation in Unit N-2, most likely of recent origin. Scale at lower right 500 μm G-I: MP (ppl) of Unit N-3 showing sand grains partly covered with clay coatings and interconnected by clay bridges between the grains. Scale at lower right 1 mm in G and H and 200 μm in I.
Reconstruction of the Middle Pleistocene landscape history in the study area of Uichteritz in relation to global climatic fluctuations (Lüthi et al., 2008). The red dots mark the luminescence age estimates obtained from the north sections, the blue dots the ages from the south sections. The numbers refer to the laboratory sample codes (L-Eva numbers, Table 3). The pIRIR\textsubscript{290} ages mark periods of Middle Pleistocene fluvial activity of the Saale river. The green numbers (right side) indicate important Middle Pleistocene events: 1 = fluvial aggradation of the early Elsterian terrace; 2 = Ice advances of the Fennoscandian glaciers during the Elsterian glacial cycle; 3 = fluvial aggradation of the late Elsterian terrace; 4 = First documented human appearance during MIS 11, soil formation; 5 and 6 = fluvial aggradation and incision of the Saale river at the transition from MIS 11 – MIS 10; 7, 8 and 9 = periods of fluvial aggradation or reworking (Saalian Main terrace) as evidenced by the luminescence ages; 10 = Ice advance during the Drenthe stage of the Saalian glacial cycle.