DANIEL RICHTER · HARTMUT THIEME

ONE FIRST CHRONOMETRIC DATE FOR THE LOWER PALAEOLITHIC OCCUPATION AT SCHÖNINGEN 13 I

Since 1983 long-term archaeological excavations have been conducted in the area of the Schöningen brown-coal mine, which covers an area of about 6 km^2. During the course of the ongoing mining operation, an area of more than 400 000 m^2 has been excavated, with most sites dating from the Neolithic to the Iron Age (Thieme / Maier 1995, 107-187). Since 1992, several Lower Palaeolithic sites have been discovered in Middle Pleistocene interglacial sediments and partially excavated (Thieme et al. 1993; Thieme / Maier 1995, 57ff.; Thieme 2007a). The sediment layers of the Pleistocene exposures (up to 30 m thick) were permanently monitored, analysed (Mania 1995; 2007; Urban 1995; 2007) and archaeologically excavated. The oldest site Schöningen 13 I comprise flint artefacts and remains of fossil fauna, attributed to the earliest part of the Holsteinian complex. Based on palynological studies by Urban (1995) the Schöningen 12 site (at a stratigraphical higher position) contains sediments of the succeeding interglacial which was termed *Reinsdorf Interglacial.* Flint artefacts, a *Palaeoloxodon antiquus*-fauna and four wooden tools (interpreted as cleft hafts) were recovered. The layer Schöningen 13 II-4 is attributed to the same interglacial and interpreted as a horse hunting camp. In addition to the skeletal remains of at least 20 horses it yielded flint artefacts and eight wooden javelins. These implements are, up to now, the oldest-known completely preserved hunting weapons of humankind (Thieme 1997; 1999). The controversially (e. g. Jöris / Baales 2003) discussed age model for the Schöningen sequence is primarily based on geological observations (Mania 2007) as well as biostratigraphic results, which provide a relative age framework only and therefore need to be supported or refuted by reliable chronometric age determinations.

LOCATION AND STRATIGRAPHY OF SCHÖNINGEN

Schöningen is located about 100 km southeast of Hannover in the northern foreland of the Harz Mountains and at the south-eastern edge of the Triassic limestone ridge called the Elm. This area belongs to the northern region of the 70 km long sub-herzynic basin between Helmstedt and Staßfurt.

The oldest Pleistocene deposits in the mine are the sediments of the Elster Glaciations (**fig. 1**). Of great importance is a series of stratigraphically overlying sedimentological units and features, which were documented within the Schöningen sequence. They are interpreted as a series of six major erosional channels in the southern part of the open-cast mine (Thieme / Mania 1993; Mania 2007). These channels and their associated sediments were correlated in a model with a sequence of succeeding interglacial/glacial cycles. They were named Schöningen I-VI and, according to the age model represent the time from the Holsteinian to the Holocene. However, there is little chronometric data available and the correlations within the age model are debated. The channels (cycles) I-III contain limnic sediments in between deposits of the

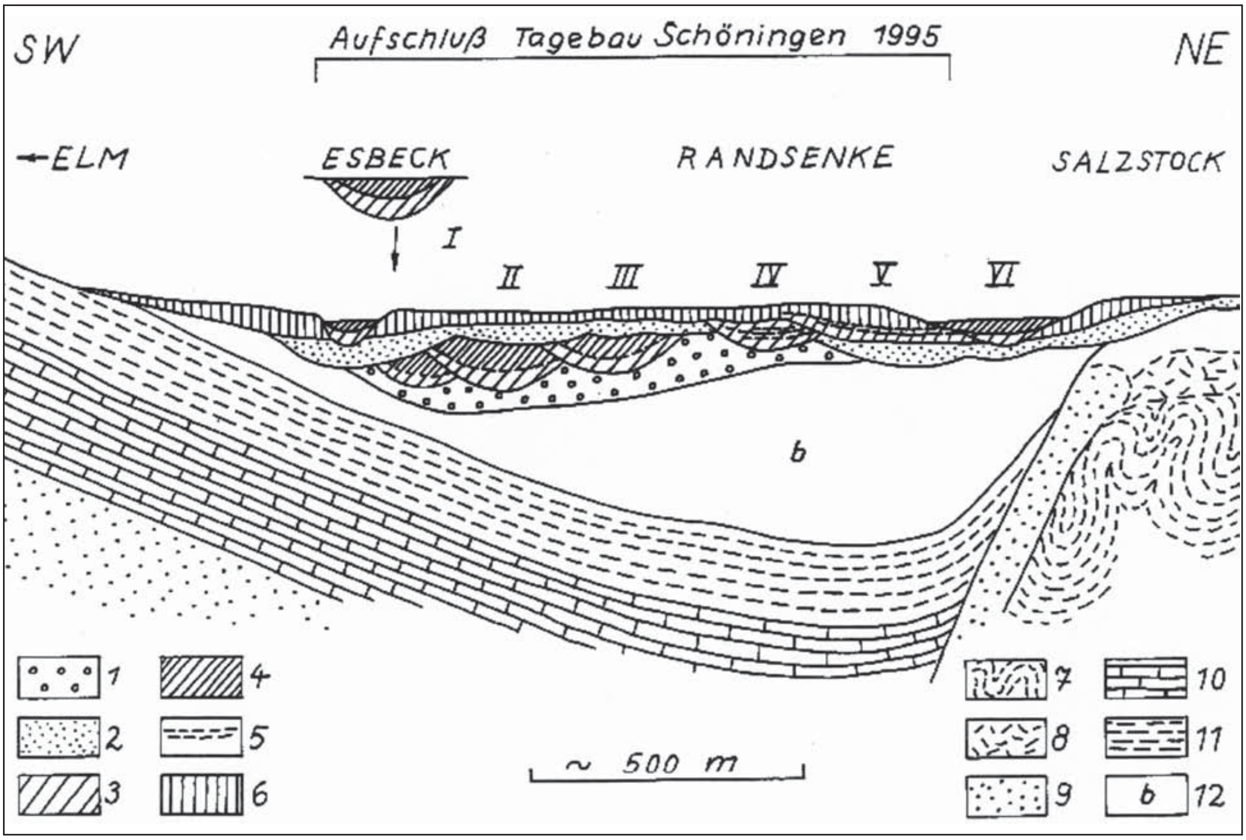

Fig. 1 Schematic section of the cyclic Quaternary sediment sequence in the depression along the Staßfurt-Helmstedter Salt Dome as exposed in the lignite mine of Schöningen. The scale of about 2 km between Cycle VI and the salt dome is compressed in this figure. The oldest interglacial sediments (Schöningen I) in the southern part of the pit probably belongs to the Holsteinian Interglacial. The sediments of the second channel (Schöningen II) are attributed to the »Reinsdorf Interglacial«. The Schöningen III channel is also older than the Saale glacial *sensu stricto* (Drenthe) and the cycle of Schöningen IV, younger than the Drenthe, contains an extensive double soil complex. The infill of channels Schöningen V and VI are correlated to the Eemian interglacial and the Holocene, respectively. – **1** Elsterian glacial deposits. – **2** Saalian glacial deposits. – **3** Lacustrine deposits. – **4** Limnic telmatic sequences. – **5** Soil complexes. – **6** Loess deposits. – **7** Evaporates (Zechstein). – **8** Gypsum cap rock. – **9** Buntsandstein. – **10** Triassic limestone (Muschelkalk). – **11** Triassic deposits (Keuper); **12** Tertiary deposits. – (After Mania 1995, fig. 24).

Elster and Saale glacials *sensu strictu* and cycle V, which is unequivocally attributed to the Eemian (MIS 5e) (**fig. 1**).

The oldest interglacial sediments (Schöningen I) probably belong to the Holsteinian Interglacial (**fig. 1**), but a palynological correlation of cycle I at Schöningen to profiles within the same mine which have yielded Holsteinian pollen assemblages is not securely established (Mania 2007). The Schöningen II channel is filled with sediments of the »Reinsdorf Interglacial« (Thieme et al. 1993) and the ensuing Fuhne cold stage. The »Reinsdorf Interglacial« is a biostratigraphically termed unit which is located between the Elster and Saale *sensu stricto.* While previously its vegetation history could not be correlated neither with the preceding Holsteinian nor the succeeding Schöningen III Interglacial (Urban 1995), the »Reinsdorf Interglacial« is now considered as a local variant of the Holsteinian (Urban / Sierralta, this volume; Bittmann, this volume). The Schöningen III Interglacial is believed to correlate with the Dömnitz Interglacial. The Schöningen IV channel is younger than the Saale glacial *sensu stricto* (Drenthe) and contains a double soil complex. The infill of the channels V and VI are correlated to the (last) Eemian Interglacial and the Holocene, respectively.

The age estimates for the Lower Palaeolithic sites of Schöningen are based on the reconstructed geological sequence, which is correlated by Mania (1998; 2006) to the generalized climatostratigraphy of Central Europe. This concept supposes a more or less uninterrupted complete sedimentological sequence with key sediments as clearly identified chronostratigraphic markers. Palynological data for the sediments directly above the Elsterian deposits in the »Südfeld« of the mine with its archaeological sites is not available yet and the attribution to the Holsteinian is tentative (Mania 2007). Age estimates for the Schöningen sequence are so far dependent on such attributions of deposits to pollen stages and their subsequent correlation to systems which can provide age estimates. The general correlation of the Holsteinian with MIS 11 (e. g. Ashton et al. 2008; Scource 2006) is questioned (Geyh / Müller 2005), because there is strong chronometric support to correlate the Holsteinian with MIS 9 (Gey / Müller 2007; Geyh / Krbetschek this volume). Such a discrepancy in the dating of terrestrial records and their attribution to MISs causes severe problems, especially when correlations to MISs are used to establish the age of sedimentary sequences. A recent stacking of oxygen isotope data was provided by Lisiecki / Raymo (2005), which can be assumed as a representative model of approximate age estimate for marine isotope stages (MIS), giving ~116-130 ka for MIS 5e, ~191-243 ka for MIS 7, ~300-337 ka for MIS 9 and ~374-424 for MIS 11. However, differences between the marine and the terrestrial record are known, e. g. the base of the Eemian interglacial appears to be about 6 ka younger than the base of MIS 5 (Shackelton et al. 2003). Therefore such marine frameworks can serve as references only. The reconstructed sequence of Schöningen is based on the interpretation of the sediments and channel fills to represent almost complete climatic cycles which allow generalized correlations of warm/cold indicating sediments, while other data might suggest a different scenario (e. g. Jöris / Baales 2003). However, in any age model it can not be assumed *a priori* that every inherent hiatus in sedimentation has been recognized and numerical age determinations are required for the verification of any model.

Fig. 2 Excavation of the Lower Palaeolithic site of Schöningen 13 I in July 1994 (x 408-409, y 29; c. 102 m NN). View of the exposed layer which contained some stone artefacts and faunal remains in between a thin layer of gravely sand with cobbles, just below a mud layer (on the whole several metres thick). – (Photo P. Pfarr).

THE SITE OF SCHÖNINGEN 13 I

The oldest evidence of human occupation at Schöningen, a lakeshore site, is located in sediments attributed to the earliest part of the Holsteinian complex (Channel Schöningen I; **fig. 1**). This Lower Palaeolithic site was discovered and partially excavated (120 m²) in 1994 (Thieme 1995; 2007b; **fig. 2**).

The archaeological material comprises flint artefacts, mostly small flakes and some notched flake tools. Some flints exhibit macroscopic signs of severe heating to high temperature. The few faunal remains are from steppe elephant (*Mammuthus trogontherii*), bovid, horse and red deer.

The small lithic assemblage does not allow a more specific attribution and is considered as Lower Palaeolithic from a technological and typological perspective. The stratigraphic position of the archaeological site of Schöningen 13 I at the beginning of the fifth climatic cycle (Mania 1998) indicates an age deep in the Mid-Pleistocene. The preliminary thermoluminescence age determination of a single burnt flint from this site yielded >400 ka BP (Richter 1998). This age was in general accordance with the proposed chronostratigraphic framework of the deposits consisting of the assumed quasi continuous cycle of channels representing the main Pleistocene climatic changes (Mania 1998). However, when considering the large 2σ-uncertainties the possible ages range from MIS 13 to MIS 9 (Richter 1998).

Thermoluminescence (TL) ages were obtained for the sediments from Schöningen 13 I with an experimental approach by Karelin (1997). TL measurements on quartz from the sediments of Schöningen 12 B2 (Reinsdorf Interglacial, cycle II-2) yielded an age of 247 ± 61 ka, while for layer Schöningen 12 C1 (Reinsdorf Interglacial) the same method obtained 359 ± 66 ka. Samples from Schöningen C2 yielded 288 ± 76 ka with TL on quartz and 255 ± 55 ka with Infrared Stimulated Luminescence (IRSL) on the feldspar extract (Karelin 1997). The sediments of the archaeological layer of Schöningen 13 I were dated with TL to 345 ± 52 ka on the quartz and 344 ± 81 ka on the feldspar component (Karelin 1997). Statistically all these results agree and bridge three interglacial periods. However, several of these dates were obtained with a novel technique, which are difficult to verify and therefore have to be considered with caution untill this technique is validated. Moreover, the TL ages (Karelin 1997) were calculated using the lower present day water content (groundwater level is nowadays below due to mining activities albeit water saturation of the sediments must be assumed in Schöningen for the entire burial time due to the preservation of organic materials, like the javelins.As a result these luminescence ages can represent minimum estimates only.

While chronometric information is needed for the geological stratigraphy, it is desirable to obtain such dating for prehistoric events which can be related to human activities. The luminescence methods mentioned above allow the determination of the time of sediment deposition, which might have happened considerably later than the Palaeolithic occupation. However, due to the antiquity of the deposits time deviation is very likely negligible. This also applies to TL dating of heated flint from Schöningen 13 I. The analysis of the site is ongoing and no specific spatial patterns or evident structures were observed during the excavation. Therefore it cannot be shown that the thermal alterations of flints from the find layer were due to past human activities and the heating could have been caused by a natural fire. The flint artefacts were recovered in sediments (**fig. 2**) together with naturally fractured flint. It is even not always possible to unequivocally differentiate between a natural piece and an artefact. Not any unequivocal artefact with clear signs of heat alteration has been identified so far. However, the nature of the deposit (sandy/gravel) and its location at a shore are not consistent with environments being frequently exposed to fire and the occurrence of a natural fire has to be considered as unlikely. In any case, the time difference between a natural and an anthropogenic fire and/or occupation seems to be negligible for a site of such antiquity. Furthermore, the unworked flints do not show any signs of having been exposed to the surface for periods significantly longer than the artefacts; in fact both find categories have relatively sharp edges. One such heated flint was previously dated with thermoluminescence (Richter 1998). The initial TL age of this sample was considered as a minimum age because of the use of an extrapolation procedure and not taking into account the supralinearity correction (Richter 1998). Moreover, the analysis was based on a less well founded γ-dosimetry from Karelin (1997), which was obtained on sediment from a location at some distance from the origin of the heated flint sample. Furthermore, the sediment of the find layer at that location contained less gravels compared to the reported origin of the flint samples. This measurement is therefore not representative for the γ-dose rate for this study. New *in situ* measurements with dosimeters and portable equipment, as well as laboratory γ-spectrometry are presented here. The TL age of Richter (1998) is replaced here with a revised TL-age where the palaeodose is determined with a more appropriate procedure (slide), the γ-dosimetry is based on new dosimetric measurements with α-Al_2O_3:C dosimeters and the water saturation capacity of the sediment is measured and considered in the age calculation.

PRINCIPLE OF THERMOLUMINESCENCE DATING

Thermoluminescence (TL) dating of heated flint artefacts is a well established method to date especially Middle Palaeolithic archaeological sites (e. g. Valladas 1988; Mercier 1991; Richter 2010).The age of the past human activity of lighting a fire can be directly determined.

TL dating is based on the accumulation of electrons in excited states in the crystal lattice caused by omnipresent ionizing radiation. The resulting metastable states are quantitatively measured by thermoluminescence analysis and provide the radiation dose the sample has received since the last zeroing (heating), e. g. by fire when all initial excited states were eliminated. Only such metastable stages are considered, which have a life time of at least an order of magnitude longer than the age to be determined. If the rates of all ionizing radiation sources (dose rate) at the sample position are known, an age can be calculated.

Dosimetric dating presumes constant dose rates over the entire burial time. In flint TL dating only the inner part of a sample is considered, comprising of the internal (α and β) and external (γ and cosmic) dose rates only (Richter 2007). The stability of the internal dose rates is not contested over the time range of interest because all part of a sample showing macroscopical traces of geochemical alterations, like patination, are discarded. The constancy of the external γ-dose rate from the surrounding sediment in the recent past can be verified, e. g. by HpGe γ-ray spectrometry. Ancient (repeated) occurrences of disequilibria between the members of the uranium decay chain cannot be excluded by such analysis. However, the lack of such is usually interpreted as indication that the decay chains have always been in secular equilibrium and the external γ-dose rate is thus assumed to have been stable over the entire burial period.

HpGe γ-ray spectrometry does allow the analysis of the small particles of the sediments only. But sediment layers in archaeological sites often contain larger pieces of rocks. HpGe γ-ray spectrometry on sediment samples in the laboratory may therefore not be representative for the actual radiation conditions at the sampling spot (Schwarcz 1994). Therefore the external γ-dose of such »lumpy« sites is preferentially measured with dosemeters buried at least 30 cm deep into the profiles (Richter 2007). Flint samples are removed from their context by excavation and the external γ-dose rate therefore can not be measured at exactly the sample's position any more. Therefore measurements in positions considered as representative of the samples' geometries have to be performed. In order to approach a good estimate of the external γ-dose, several positions next to the samples' locations are measured and the average result is used for the age calculation. As a result the individual TL ages may be too young or too old and a larger range of ages is obtained because of the use of a mean external γ-dose rate for all samples, which is not necessarily the correct one for each sample. In consequence individual TL age results do not necessarily represent the true age of their last heating or of an occupation. This also explains the common observation of a large variability of TL age results for a given layer, which is *a priori* assumed to represent a more or less single event of a time length which can not be resolved by any chronometric dating method.

tube	natural moisture (%)	water saturation (%)	correction factor for »dry« γ-dose-rate	correction factor for »present moisture« γ-dose-rate
13 I-2	11	14	0.85	0.97
13 I-3	14	18	0.82	0.95
13 I-4	12	17	0.81	0.96
average	12	16	0.83	0.96

Tab. 1 Moisture measurements in the laboratory and γ-dose-rate correction factors for water saturation.

However, the positions for dosimeters are chosen randomly and their individual geometries are unknown because they are inserted 30 cm deep into the sediment profiles. The latter applies to the independently and randomly chosen flint samples for dating as well. A precise and reliable TL age can be obtained only from a large number of samples and where the average external γ-dose rate was obtained with a large number of dosimeters. This implies that the heating took place within a reasonably short time interval and at the same time for all samples. The latter is generally assumed for Palaeolithic sites, which commonly represent palimpsests accumulated in time periods too short to be of significant relevance for the interpretation. It is therefore only the TL-dating of several samples from a Palaeolithic layer which can provide a good age estimate of the heating and thus the occupation of a site. Results on few or single samples – as in this case – can provide only a rough age estimate.

DOSIMETRY FOR SCHÖNINGEN 13/I

Based on HpGe γ-ray spectrometry, which are indicating the recent absence of disequilibria of the U- as well as the Th-decay chain, the long-term stability of the external γ-dose rate from the surrounding sediment of the flint samples from Schöningen 13 I was assumed. Here, only the external γ-dose needs to be taken into account because the flint sample was stripped off the parts affected by α and β radiation from the sediment. The preservation of organic material suggests that the majority of the sequence of Schöningen was located below the water table for most of its burial time. Therefore any present dosimetric measurement of the sediments need to be corrected for water saturation of the sediments, and the water saturation capacity had to be estimated as a further improvement of the estimation of the effective external γ-dose-rate. Several sediment samples in steel tubes of about 10 cm diameter and 20 cm lengths were taken from the profiles in order to measure the sediment moisture. After weighing the sample for its present moisture, the tube was filled up with water (any surplus water removed) and weighted again. After several weeks of storage at 70 °C the dry weight was determined and the ratios of the weights provided the natural and water saturation content (**tab. 1**). The present day »as is« γ-doses as measured *in situ* by portable γ-ray spectrometry or dosemeters, or in the laboratory by HpGe γ-ray spectrometry of dried sediment material, were corrected for water saturation conditions. Correction followed Aitken (1985) and not Aitken / Xie (1990) because the external γ-dose had to be corrected for the size and shape of the flint sample (effective external γ-dose rate after Valladas 1985).
In the field two portable γ-ray spectrometers were employed, both equipped with NaI crystals of different sizes. The Target NanoSpec is a multiple channel equipment while the Harwell spectrometer can discriminate only four channels. Therefore the latter provides less resolution and is more prone to temperature-dependent drift. The average factors (**tab. 1**) to correct for water saturation conditions were employed (**tab. 2**).

equipment	position	present *in situ* γ-dose rate (µGy a^{-1})	water-saturation corrected γ-dose rate (µGy a^{-1})
Nutmaq-Harwell 4-channel	1	921 ± 120	884
Nutmaq-Harwell 4-channel	2	944 ± 120	906
NanoSpec 2x2« NaI(Tl)	3	620 ± 43	595
NanoSpec 2x2« NaI(Tl)	4	610 ± 53	586

Tab. 2 Field measurements of the γ-dose rate using portable NaI γ-ray spectrometers.

dosimeter	»as is« *in situ* γ-dose rate (µGy a^{-1})	water saturation corrected γ-dose rate (µGy a^{-1})	± (%)
S-11	758	728	4
S-12	702	673	4
S-15	883	848	5
S-16	683	656	5
S-17	611	586	2
S-19	629	603	8
S-20	674	647	2
average		**678**	**13***

Tab. 3 Results of α-Al_2O_3:C dosimeter measurements corrected for water saturation. – * Standard deviation of dose rates.

More reliable results for γ-dose rates of heterogeneous sediments can be obtained by dosimeters which were placed into the sediment body for one year. The accuracy of using this type of material was recently shown (Richter et al. 2010). A total of 10 α-Al_2O_3:C dosimeters were implanted in sediment profiles at depths of about 40 cm in order to compensate for the sloping profiles and obtain a 4π-geometry. The γ-dose rate results from the α-Al_2O_3:C dosimeters are given in **table 3** (two were lost and one failed the analysis).

The results from these different methods of measuring the external γ-dose rate vary considerably by a factor of two. Not surprisingly, the laboratory HpGe γ-ray spectrometry on dry sediment provided the largest dose rates (dry 1051 µGy a^{-1} and water-saturation corrected 872 µGy a^{-1}) because it did not take into account neither the contribution of the larger sediment components (gravel and small boulders) nor from the sediment layers above and below of the find horizon. This result is therefore not representative for the actual γ-dose rate in the sediment body. The *in situ* dose rates measured with the portable equipment are considerably lower and differ to quite an extend as well. However, they were recorded in different years and in different seasons, therefore some variation is expected. The results of the Nutmaq-Harwell are less reliable than those of the NanoSpec due to its low resolution and the potential temperature drift problem.

The γ-dose rates measured by the dosimeters are considered as the most reliable measurement of the external γ-dose rate, especially as they also provide the opportunity to record the spatial variation. The average value of 678 µGy a^{-1} (**tab. 3**) lies within the range of the results of the portable equipment and was used in age calculation. An increased uncertainty of 15% was used in order to compensate for unaccounted effects.

The water saturation of three geological, and therefore certainly unheated, flint samples was experimentally determined as <0.01$\%_{weight}$ after 1 month of immersion in water. While heated flint is probably more porous than unheated one, it is assumed that the attenuation of ionizing radiation by water within the sample is negligible. The internal dose rate of 141 ± 9 µGy a^{-1} was calculated from the specific activities of the radioisotopes of the flint sample obtained by neutron activation analysis (NAA), taking into account its sensitivity to α-radiation (**tab. 4**). The internal dose rate is considered as temporally constant

U (ppb)	640	± 60
Th (ppb)	123	± 10
K (ppm)	472	± 23
b-value	0.65	± 0.1
effective internal dose rate (µGy a^{-1})	141	± 9
effective external dose rate (µGy a^{-1})	713	± 96
palaeodose (Gy)	402	± 17
age (ka)	470	± 60

Tab. 4 Results (1-σ) of Neutron Activation Analysis and thermoluminescence measurements of sample Schon-1. The effective external dose rate takes into account the shape and weight of the sample (after Valladas 1985) and the effective internal dose rate the sensitivity of the sample to α-radiation.

since burial as only unaltered parts of the sample were used.

The cosmic dose rate of 76 µGy a^{-1} (at 57 78 445 N, 44 30 825 E and 100 m a.s.l.) was taken from tables by Prescott / Stephan (1982), Barbouti / Rastin (1983) and Prescott / Hutton (1994) for an estimated total sediment cover of 20 m prior to excavation, which is assumed to have accumulated constantly after burial of the sample. However, the TL-age result is not significantly affected for varying thicknesses between 10 and 50 m.

THERMOLUMINESCENCE MEASUREMENTS AND RESULTS

Only one heated flint sample (Schon-1) from the screening of the sediments was available for TL analysis. The outer 2 mm surface of the sample was removed with a water cooled low speed saw and carefully crushed in a hydraulic press. Carbonates were removed with HCl (10%) after crushing and/or heating. The exterior as well as the interior material of the flint sample were investigated by the TL heating plateau test after Aitken (1985) in order to determine if the prehistoric heating was sufficient to fully erase the TL signal to allow TL dating analysis. The TL signal is increased by an additional irradiation in the laboratory and its ratio to the natural TL signal is constant (heating plateau) over the peak temperature range between 350 and 390 °C (**fig. 3**), providing evidence for the past full erasure of the TL signal. Between 6 and 12 aliquots were used for each of the 6-7 dose points for the additive as well as for the regenerated dose curve, where the grains for the latter were heated to 360 °C for 90 min in air. This procedure is supposed to induce the least TL sensitivity changes. Thermoluminescence was detected with an »EMI 9236QA« photomultiplier of a Daybreak 1150 system. Schott BG25 and HA3 filters restricted the detection to the UV-blue wavelength band at a heating rate of 5 °C min^{-1} to 450 °C. In order to base the TL analysis only on the most stable (experimentally determined) energy range and to obtain a more precise result the integral of the TL signals in analysis were defined as the overlapping range in temperature of the heating- and the D_E-plateau (360-390 °C). Irradiations were performed with an external calibrated $^{90}Y/^{90}Sr$ β-source. The alpha sensitivity (b-value) after Bowman / Huntley (1984) of 0.65 ± 0.1 (**tab. 4**) was determined by comparing the luminescence response of zeroed (heated in air to 500 °C for 30 min) 4-11 µm fine grain material to single doses from alpha and beta irradiation for 6 aliquots each.

Because the luminescence signal of the sample is at the onset of saturation, we here use a technique similar to the »Australian Slide Method« (Prescott et al. 1993) which is different to the technique used for the same sample in Richter (1998). The new palaeodose was obtained by a multi-aliquot-additive-regeneration (MAAR) slide protocol (Valladas / Gillot 1978; Mercier 1991; 1992) on the 90-160 µm fraction. The additive and regenerated TL data are best approximated by quadratic functions (**fig. 4**). Thereafter, the regeneration growth curve is scaled and shifted along the dose axis (Sanzelle et al. 1996) until the best fit with the additive growth curve is obtained. A constant ratio of the additive TL-signal to the TL-signal of the shifted regenerated curve is a measure of the similarity of the two dose response curves and used as a verification of the appropriateness of the approach (slide) used (after Mercier, 1991). The shift is the palaeodose and was found to be 402 ± 17 Gy (**tab. 4**). Based on the described measured parameters and assump-

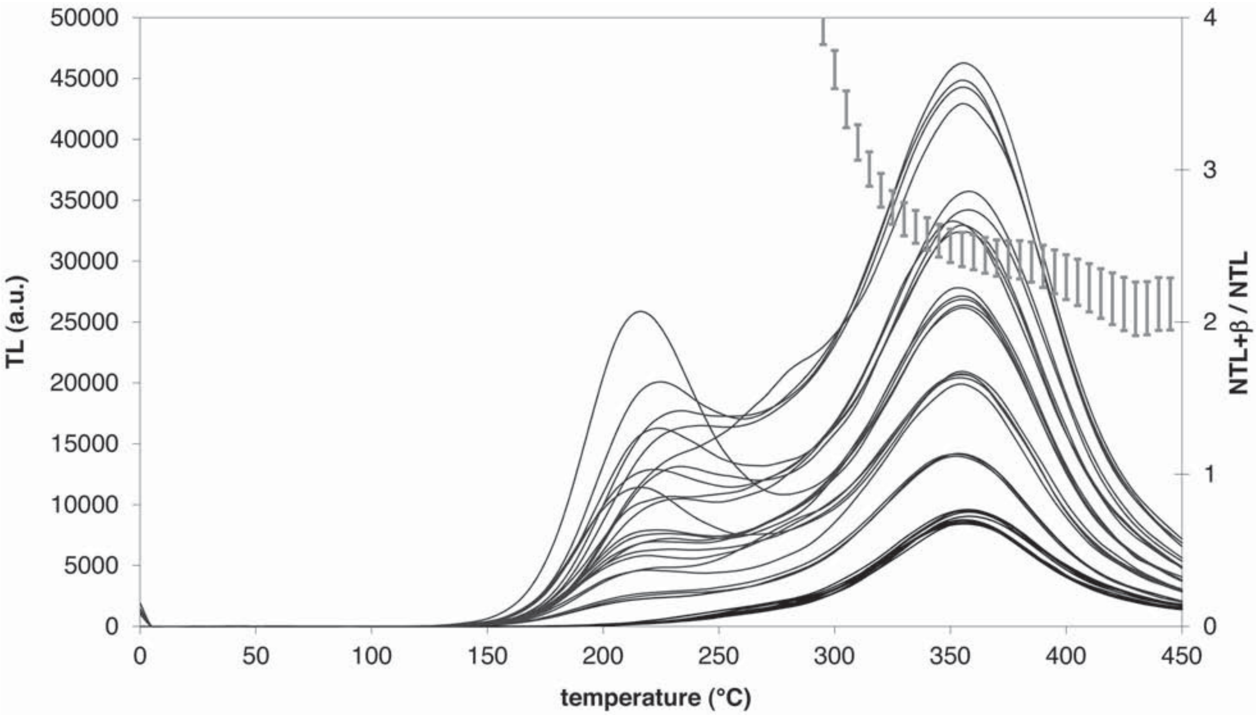

Fig. 3 Additive thermoluminescence glow curves and heating plateau (350-390 °C) of sample Schon-1. – (Illustration D. Richter).

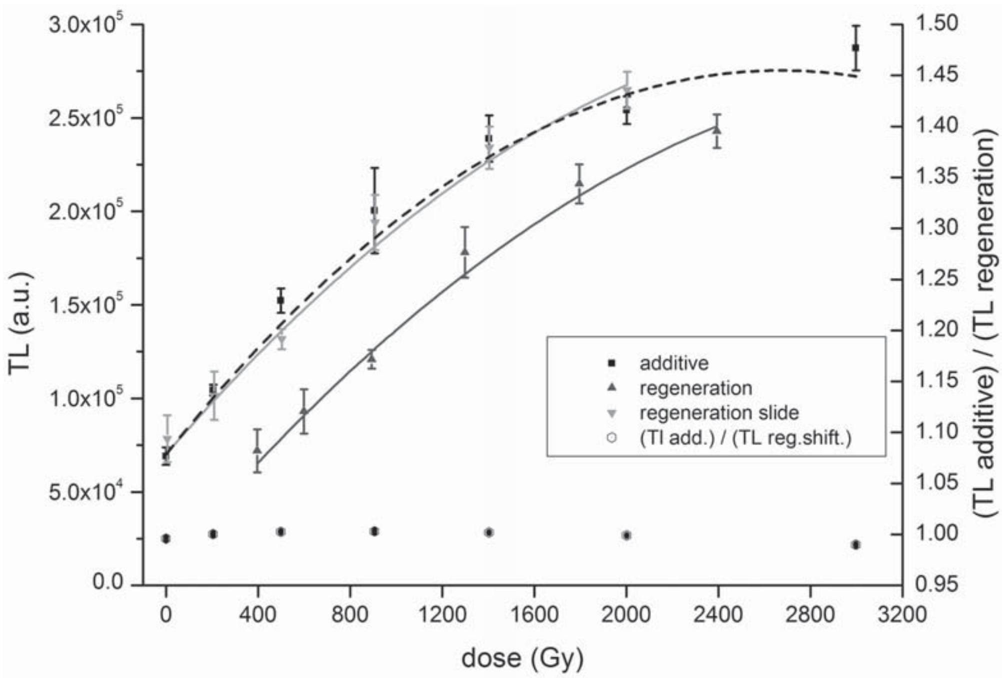

Fig. 4 TL gowth curves (polynomial fit) of additive (alpha contribution subtracted; hatched line), regeneration (dark grey line) and shifted (light grey line) regeneration (scaled) of the flint sample Schon-1. The constant TL-ratios (polygon) of the additive to shifted regeneration growth curve at the positions of the additive doses is a measure of the similarity (»*homothétie*« after Mercier 1991) of the two growth curves. – (Illustration D. Richter).

tions a new TL-age estimate for sample Schon-1 of 470 ± 60 ka is calculated following Aitken (1985), which replaces the previous estimate by Richter (1998; **fig. 4**).

DISCUSSION AND CONCLUSIONS

Due to the low internal dose rate of TL age of 470 ± 60 ka for sample Schon-1 is heavily dependent on the external γ-dose rate. The mean value of the external γ-dose rate may deviate considerably from the appropriate actual value for this particular sample. In order to illustrate the influence of the γ-dose rate on a single sample, the possible age range is calculated, based on the maximum and minimum dose rate as measured by the dosemeters (**tab. 3**). A minimum age for sample Schon-1 of 400 ± 50 ka is found, while the maximum age would be 520 ± 60 ka. However, only the TL-dating of more samples will give a better age estimate for the site of Schöningen 13 I. In spite of its singularity and wide range this result is the best age estimate available for this Lower Palaeolithic site. The age fits into the palaeoclimatological and biostratigraphical age model for the sequence of Schöningen of Thieme / Mania (1993) and Mania (1998; 2006), and is in general agreement with the TL ages on the sedimentation of the find layer of Schöningen 13 I using an experimental approach (Karelin 1997). Such an agreement cannot be used as an argument for the general validity of this particular approach, especially as this singular TL result allows other interpretations as well because of its large uncertainties. Because of its singularity, the given age for sample Schon-1 is not sufficient for a discussion of the chronostratigraphy of Schöningen At a level of 95% probability the single TL age for Schöningen 13 I comprises marine isotope stages (MIS) 10 to MIS 15, or MIS 9 to MIS 16 if the minimum and maximum ranges (which are based on the range of the dosimeter readings) are considered (MIS after Lisiecki / Raymo 2005) This first TL age estimate for the Lower Palaeolithic site Schöningen 13 I (cycle I) may also serve as a maximum age estimate for the overlying layer with the javelins of Schöningen 13 II-4 (Reinsdorf Interglacial, Schöningen cycle II; **fig. 2**).

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ZUSAMMENFASSUNG / ABSTRACT

Ein erstes chronometrisches Datum für die altpaläolithische Besiedlung von Schöningen 13 I
Eine singuläre Thermolumineszenzdatierung (TL) eines erhitzten Feuersteins aus der Fundstelle Schöningen 13 I (Zyklus I) wird vorgestellt. Es kann nicht unterschieden werden, ob die Erhitzung auf natürliche oder menschliche Faktoren zurückzuführen ist. Eine zeitliche Differenz einer natürlichen Erhitzung zur menschlichen Besiedlung ist bei dem mittelpleistozänen Alter der Fundstelle jedoch unerheblich. Bei Betrachtung der Extremwerte der externen γ-Dosisraten ist eine Korrelation dieses singulären Ergebnisses von Schöningen 13 I mit der marinen Isotopenstufe (MIS) 9 genauso möglich wie mit MIS 16. Mehr TL-Datierungen sind notwendig um das Alter von Schöningen 13 I durch Bestimmung eines Mittelwertes präziser zu bestimmen. Diese einzelne Altersabschätzung kann ebenfalls als Maximalalter der Speere von Schöningen 13 II-4 (Zyklus II) im Hangenden gewertet werden.

One first chronometric date for the Lower Palaeolithic occupation at Schöningen 13 I
One thermoluminescence (TL) age is presented from a single heated flint collected at the archaeological site of Schöningen 13 I (Cycle I). Although the fire cannot unequivocally attributed to human activities, any time difference between a natural fire and the human occupation is negligible for a site of such an antiquity. The site can be correlated by this single chronometric date as young as MIS 9 and as old as MIS 16, based on the extreme values of the external γ-dosimetry. More data is needed to allow a proper dating of the site by calculating an average TL-age. This data is also considered as a maximum age estimate for Schöningen 13 II-4 (Cycle II), which yielded the oldest javelins in human history.