The Shaman and the Infant: The Mesolithic Double Burial from Bad Dürrenberg, Germany

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Zusammenfassung

Die Schamanin und der Säugling: Die mesolithische Doppelbestattung aus Bad Dürrenberg, Deutschland

Die 1934 bei Bauarbeiten im Kurpark von Bad Dürrenberg, Saalekreis, entdeckte Doppelbestattung einer erwachsenen Frau und eines Säuglings gehört zu den herausragenden Grabbefunden des Mesolithikums in Mitteleuropa. Trotz der widrigen Fundumstände und der Bergung des Fundes durch Laien mit Unterstützung eines Restaurators konnte eine Vielzahl der zahlreichen Beigaben und der Skelettreste geborgen werden. Die außergewöhnliche Ausstattung der in sitzender Haltung bestatteten Frau mit einem Säugling umfasst neben Silexartefakten und Felsgesteingeräten auch Knochen- und Geweihartefakte, ein Rötelstück, zahlreiche Tierknochen einschließlich der Panzer von mindestens drei Sumpfschildkröten und teilweise durchbohrte Tierzähne. Zusammen mit einem schädelechten Rehgeweih und ursprünglich sechs zum Teil durchbohrten Eberhauern stellen diese Funde wahrscheinlich einen Kopf-/Körperschmuck dar. Das Grab wird aufgrund seiner Ausstattung als Bestattung einer Schamanin gedeutet. Verschiedene pathologische Befunde an den Frontzähnen und Anomalien der Halswirbelsäule sowie der Schädelbasis unterstützen diese Interpretation.

Nachgrabungen an der Fundstelle im Zuge der Vorbereitungen der Landesgartenschau 2024 ergaben nicht nur neue Erkenntnisse zur Deponierung und Positionierung der Körper, sondern erbrachten eine Vielzahl von Neufunden, die eindeutig dem Grab zugerechnet werden können. Neben durchbohrten Tierzähnen, Faunenresten und Steinartefakten konnte auch eine große Anzahl von menschlichen Skelettresten geborgen werden. Vor allem das nur teilweise erhaltene Skelett eines Säuglings konnte ergänzt werden. Die Entdeckung des Felsenbeines ermöglichte auch bei diesem Individuum eine genetische Analyse. Im Ergebnis zeigt sich, dass es sich um einen Jungen handelt, der nicht der Sohn der Schamanin ist, sondern im 4. oder 5. Grad mit ihr verwandt ist.

Summary

The double burial of an adult woman and an infant, discovered in 1934 during construction works at the spa gardens of Bad Dürrenberg, Saalekreis district, is regarded as one of the outstanding burial finds of the Mesolithic in Central Europe. Despite the unfavourable circumstances of the find and the recovery by lay people with the assistance of a conservator, a large number of the many grave goods and skeletal remains could be rescued. The unusual equipment of the woman with an infant, who was buried in a seated position, comprises flint artefacts and solid rock tools, but also bone and antler artefacts, a piece of red ochre, a number of animal bones including the shell of at least three terrapins and partly pierced animal teeth. Together with real deer antlers and originally six partly pierced boar's tusks these finds are probably head/body ornaments. Due to its grave goods the burial is interpreted as that of a shaman. Several pathological finds on the anterior teeth and anomalies of the cervical vertebrae and the skull base support this interpretation.

Subsequent excavations at the site as part of the preparations for the State Garden Exhibition 2024 brought not only new revelations about the deposition and positioning of the body to light, but also revealed a multitude of new finds, which could be clearly attributed to the burial. Beside of pierced animal teeth, remains of fauna, lithic artefacts and a large amount of human skeletal remains could also be recovered. But especially the only partially preserved skeleton of an infant could be added to. The discovery of the petrosal enabled a genetic analysis at this individual. The result showed that it is a boy, who is not the son of the shaman, but is 4th or 5th degree related to her.

Site and find history

The burial site from Bad Dürrenberg, Saalekreis district, was discovered when digging a trench for a water pipe in the spa gardens of Bad Dürrenberg on 4 May 1934. The burial was found in a central location in the spa gardens about 80 m east of the current edge of the slope to the Saale (Fig. 1). The grave was partially uncovered with the help of local historians and reported to the »Landesanstalt für Vorgeschichte« in Halle. The restorer, W. Henning, recovered the burial and the grave goods after some objects had already been removed from the grave by the construction work and the lay researchers involved (Bicker 1936). In addition, a two-page report and a documentation sketch were made by W. Henning in plan and section (Find spot archive, LDA Halle, ID 1955, OA Bad Dürrenberg). Beyond that, no photographs were taken, nor was it precisely recorded how exactly the skeletal remains had lain in the grave or where the individual grave goods had been located. Only a curved posture with a clearly higher skull and upper arms positioned obliquely upwards was noted, indicat-

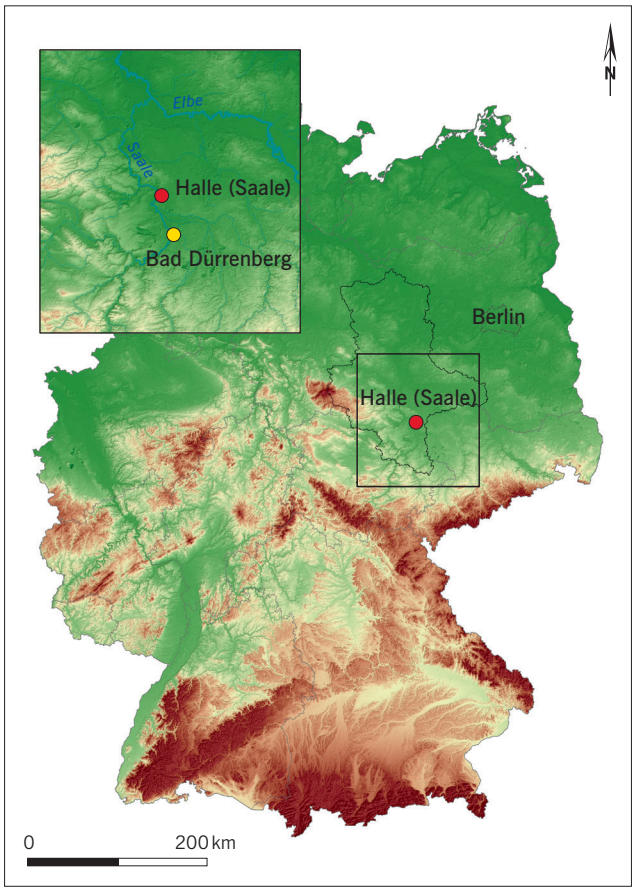

Fig. 1 Location of the Bad Dürrenberg, Saalekreis district, burial close to the Saale River.

Abb. 1 *Fundort des Grabes von Bad Dürrenberg, Saalekreis, in der Nähe des Flusses Saale.*

ing a seated position (Bicker 1936, 60). According to the documentation, the orientation of the burial pit was east-north-east–west-south-west, the skull is said to have been facing south. The burial pit was 90 x 55 cm and not very large. The soil of the lower 30 cm of the grave-pit was apparently strongly interspersed with red ochre, which is clearly visible not only on the skeletal remains but also on the objects found in the grave. During the excavation, the skeletal remains of an infant were also identified. Based on the skull fragment mentioned in the report of Henning, which lay between the thighs of the buried adult, the position of the infant was reconstructed (Bicker 1936, 60). The position of the grave goods remains largely unclear, only the stone axe below the right upper arm is explicitly mentioned in Henning's report.

Grave goods

The grave at Bad Dürrenberg contains an unusual number of grave goods for the Mesolithic period (Fig. 2). The few graves from this period in Central Germany known so far contain either no or only a few objects; these grave goods are mostly flint artefacts. Thus, not only the quantity of objects, but also their composition, is remarkable in the grave of Bad Dürrenberg[1].

One of the central objects are the antlers of a roebuck, which was about 2 years old (Fig. 3). These show a few signs of modern damage, which most likely originated during the recovery process; however, older fractures are also apparent. The older breakage pattern could be associated with a deliberate dressing of the piece. Around the base of the antlers, there are numerous traces of cuts from de-fleshing or skinning. A total of six boar tooth lamellae were discovered of which the only two pierced specimens were most likely located in the neck area of the woman in the grave. The lamellae were made from longitudinally split canines and show evidence of polishing and rounding, as well as traces of their manufacture. One piece has a total of four perforations, three at the base and one at the tip. While the base was damaged recently, the hole at the tip was made in prehistoric times. A pierced fragment of a hyoid bone from a wild boar was also found, along with six pierced incisors from wild boar, which show clear signs of wear. Further pierced animal teeth could be assigned to aurochs and bison. A total of 33 incisors and three canines were identified, half of which have pierced roots. Another 16 incisors and two canines come from red deer and do not show any perforations. Also from red deer is a metatarsal that has been split lengthwise, with signs of wear at the tip. In this spot, especially on the inner side, a strong red ochre adhesion is visible, which could match a piece of red ochre that shows signs of wear. Other bone implements are present including awl-like implements, two of which were made from metatarsal bones of red deer and three others were obtained from metatarsal and metacarpal bones from roe deer. The pieces show polishing and rounding and reveal traces of manufacture. There is also a pierced implement obtained from a heavily reworked antler base of a red deer.

In addition to bone artefacts, several flint artefacts were also found. These include two flakes, seven blades and a piece of debris. In addition, there are 29 microliths and two microlithic flakes, which were discovered after the recovery of the finds in a right humerus of a crane that had been prepared to serve as a container. In addition to these flint implements four ground stone artifacts were found in the grave at Bad Dürrenberg. Among these is a flat axe which, as mentioned above, is thought to have been deposited below the buried person's right humerus. The piece is almost completely polished and for many years had been classified as a chronological reference to the transition between Mesolithic and Neolithic (Geupel 1977), or originally even belonging to the Neolithic (Bicker 1936). Since several dated polished rock axes from the Mesolithic are now available (Fischer et al. 2009; Little et al. 2017; Gramsch 2021), this can no longer be used as an argument against an earlier Mesolithic date (see below for the absolute dating of the human and animal skeletal remains from the grave). In addition, an oval flat and a triangular stone pebble are present. The pieces show polish-

1 Bicker 1936; Geupel 1977; Teichert/Teichert 1977; Grünberg et al. 2016, 296–323; Dietl et al. in press.

Skeletal element	Lab Number	^{14}C date in BP	Calibrated years BC 1σ range	Calibrated years BC 2σ range
Homo, Femur	BLN-2130	7580 ± 80	6564–6271	6593–6246
Homo, Femur	BLN-2221	7730 ± 80	6638–6476	6768–6423
Homo, Costa	OxA-29229	5643 ± 30	4536–4409	4543–4368
Homo, Costa	OxA-3136	7930 ± 90	7032–6689	7060–6599
Homo, Fibula	OxA-31090	8012 ± 40	7050–6829	7062–6706
Capreolus, Mandibula	OxA-31091	7906 ± 37	6903–6654	7032–6647
Capreolus, Scapula	OxA-31093	8006 ± 37	7048–6830	7059–6706
Emys orb., Carpapace	OxA-31092	8335 ± 40	7480–7346	7524–7195

Tab. 1 Overview of available radiocarbon dates.

Tab. 1 *Übersicht über die verfügbaren Radiokarbondaten.*

ing, impact marks and other signs of use. Next to these is a percussion stone with clear fields of scars, polishes, and traces of red ochre.

In addition to the bone artefacts and the tooth ornaments, which originate from the main hunted fauna of the Mesolithic (wild boar, roe deer, red deer and aurochs, or bison), there are isolated bone fragments from the grave context that can be interpreted as grave goods. These include an unmodified thoracic vertebra fragment and a metacarpal bone of the roe deer. The roe deer is additionally represented by three lower jaw halves from at least two animals, an isolated incisor and three scapula fragments, also from at least two animals. Only the lower jaw halves show modifications and the fracture patterns clearly indicate that they were smashed when fresh as there are no traces of cutting. In addition, a hock bone from a beaver and a shoulder blade from a hedgehog are present, together with various small and very small bone fragments that could not be determined in more detail. One of the indeterminate fragments shows signs of cutting. Besides the already mentioned humerus of a crane, which served as a container for microliths, a tibiotarsus bone from a crane is present but does not show any modifications. A total of 120 fragments of river mussels of various species with ochre residues attached to them were also found in the tomb. In addition, 64 fragments of at least three shells of the European pond turtle comprise material from the original find in the 1930s. Traces of modification in the form of scratches and cuts on the inside of the carapaces indicate that they were cleaned of adhering soft tissue and that the dorsal vertebrae, which are fused to the inside of the carapace, were also removed. This, together with the absence of other skeletal elements and fragments of the abdominal carapace, indicates that only the carapaces were given as grave goods.

Dating

The controversial discussion about the chronology of the grave was mainly ignited by the existence and the secure grave affiliation of the polished flat axe (see Geupel 1977), which led to a first conventional ^{14}C dating in 1979. The humerus, femur and tibia of the right side of the body were taken as sample material, but only the femur was used for the two dating procedures (laboratory protocol Berlin)[2], the other two skeletal elements of the sampling have since been lost.

Table 1 summarizes the results of the various absolute dating efforts made to date. While the conventionally measured ^{14}C-dates of the Berlin laboratory appear too young in comparison with the dates from Oxford (OxA-3136, 31090–31093), and are outdated from today's point of view, the two solid dates of the human remains together with the two roe deer dates according to the sum calculation in the range of 2σ (95 % probability) result in a time horizon of 7000–6800 cal BC for the grave of Bad Dürrenberg. The grave of Bad Dürrenberg thus dates to the early Atlantic in terms of climate history.

The human skeletal remains

The human skeletal remains of the double burial were examined several times[3]. The anthropological age-at-death and sex determinations yield the remains of a 30–40 year-old woman and a 6–8 month-old infant, whose sex could not be determined as the decisive traits are not developed at this age. Ongoing investigations as part of the follow-up investigation of the site have retrieved further skeletal remains of the two individuals from the grave at Bad Dürrenberg. In addition to the completion of the skeletal remains, especially of the infant skeleton, a re-evaluation of the pathological findings noted in the past is also being undertaken. The 30–40 year-old woman was a gracile person with a body height of about 1.55 m, typical for the period. Remarkable about her skeleton is the absence of distinct muscle attachments, especially on the lower extremities, which are commonly found in hunter-gatherers. Slight signs of wear on the spine (spondylosis deformans) in the area of the lumbar and thoracic vertebrae indicate a certain physical strain in the area of the trunk.

At the base of the skull there is an anomaly at the edge of the great occipital hole (foramen magnum), in the form of a small constriction. This area, which has already been consid-

2 Thanks to Dr. J. Gresky, DAI Berlin, for researching the original dating protocols.

3 Heberer 1936; Grimm 1957; Orschiedt 1999; Porr/Alt 2006.

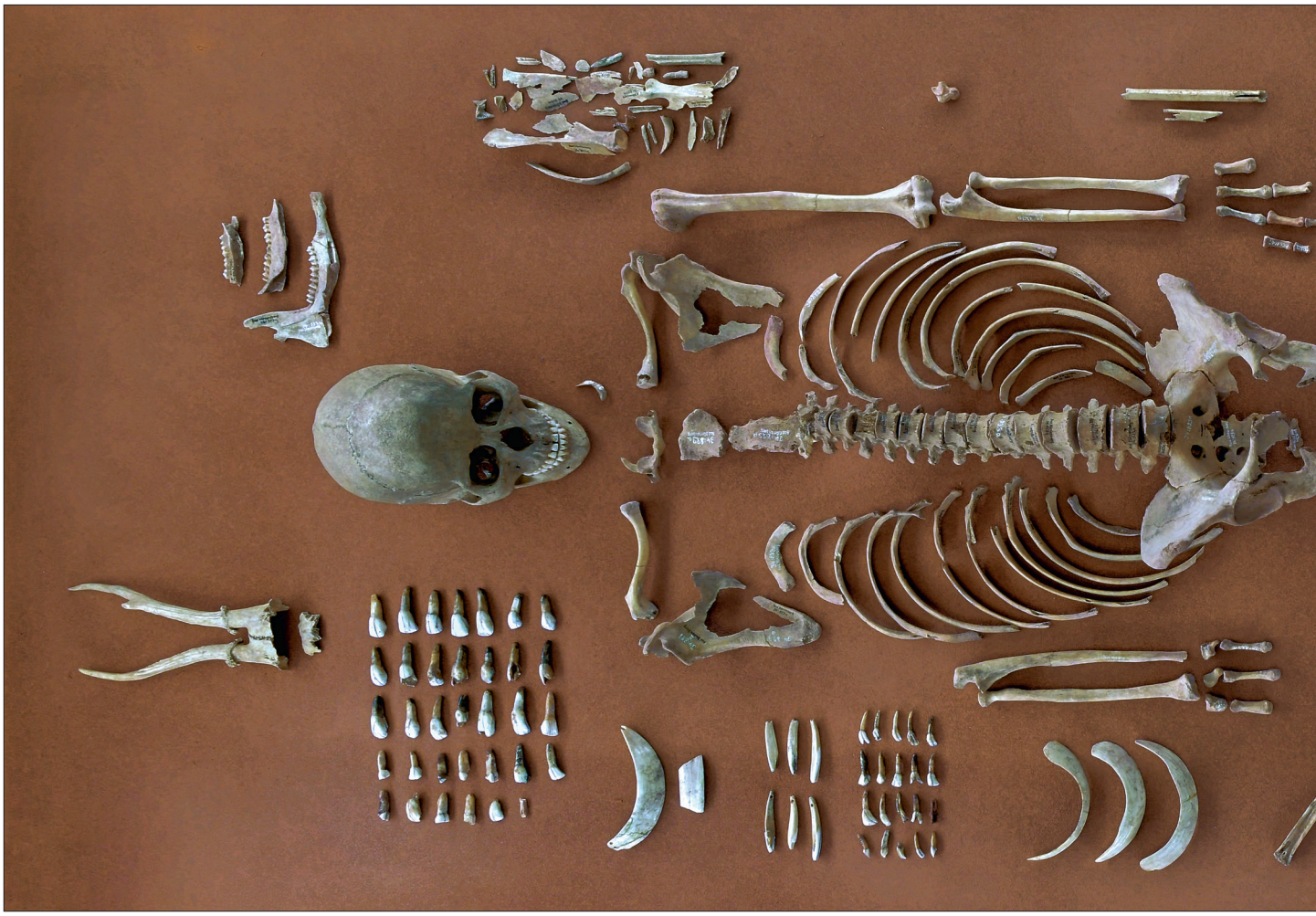

Fig. 2 Display of finds from the 1934 excavation at the State Museum of Prehistory Saxony-Anhalt.

Abb. 2 *Ausstellung der Funde von der Ausgrabung im Jahr 1934 im Landesmuseum für Vorgeschichte Sachsen-Anhalt.*

ered evidence of decapitation, is the imprint of an abnormally developed blood vessel (Orschiedt 1999, 128 f.). The first cervical vertebra is incompletely formed due to a congenital growth defect and has only reached 40 % of the arch. The rounded end of the vertebral arch corresponds to the previously observed defect at the large occipital hole (Fig. 4). In this context, the hypothesis was formulated that a pinching of the blood vessel with various sequelae appears possible with a corresponding head posture (Porr/Alt 2006). The discovery of the 2nd cervical vertebra among the finds of the re-excavation could be confirmation of this. This vertebra also shows an anomaly, which is limited to the vertebral process in the form of a protruding bone clasp. This makes a blockage of one of the blood vessels leading to the brain plausible. This can be caused intentionally by adopting a certain head posture. The consequences are unlikely to have been serious or hazardous to the person's health. However, it is conceivable that a nystagmus, i. e., an involuntary movement of the eyeballs, could be caused by the blockage of a blood vessel. This unusual feature might have been perceived as uncanny and when initiated on purpose may have reinforced or even justified her role as a shaman.

Another peculiarity is a conspicuous tooth abrasion in the area of the upper central incisors (Orschiedt 1999, 128). This abrasion, which only affects the two anterior teeth and whose specific orientation towards the palate is referred to as the LSAMAT phenomenon (Lingual Surface Attrition of the Maxillary Anterior Teeth), has so far been demonstrated several times and in different temporal and geographical contexts (Fig. 5). A cause of this specific kind of abrasion is not known, but is usually interpreted as the use of the anterior teeth as tools or as a »third hand« (Alt/Pichler 1998, 399; Porr/Alt 2006, 400–402). In this context, the fact that the nerve cavity of both teeth is opened seems unexplained. Usually, secondary dentine is formed in the nerve cavity during tooth grinding, which protects the nerve from exposure should the tooth grinding reach this area. In this case, the grinding must have occurred so quickly that the corresponding process could no longer be initiated. Bacteria could then penetrate through the exposed nerve cavity to the root of the tooth and cause inflammation. Traces of this apical process can be seen on the maxilla. What activities may have caused the opening of the nerve cavity will be the subject of future investigations.

The re-excavation of the site

In the run-up to the opening of the State Garden Show in the spa gardens of Bad Dürrenberg, originally scheduled for 2022,

extensive construction measures were planned for renovation and redesign. Against this background, the opportunity arose for a follow-up investigation of the site where the so-called »Shaman of Bad Dürrenberg« was found. A first search excavation led to the localization of the pipe trench that had originally led to the discovery of the grave in 1934. Traces of red ochre in the uppermost layer filling the trench gave a first indication of the correct location of the grave. However, an expected visible disturbance outside the pipe trench as evidence of the excavation of 1934 was missing. An alternative explanation, which suggests that the original uncovering and salvage was not carried out from above, but deliberately from within the pipe trench, thus appeared conceivable and with it the possibility of preserving the areas of the burial pit lying above the buried female and child. The excavation of the pipe trench over a length of 5 m revealed a pronounced disturbance of the soil profile in the expected location of the burial pit, which was interpreted as an indication of the intervention carried out in 1934 to recover the finds. In addition, the fill in/back material contained accumulations of red ochre along the entire length of the worked section and numerous finds with colour adhesions that corresponded to those of the known find inventory. These were concisely concentrated in the area of the disturbance recorded in the trench profiles. Besides numerous faunal and human skeletal remains and flint artefacts, the pierced animal teeth deserve special mention. The total area of the postulated burial pit on both sides of the pipe trench was recovered in the form of 2 blocks in order to process it under workshop conditions (Fig. 6).

Already during the excavation in the field, it became apparent that the upper layers of the burial pit defied a purely visual recording. By uncovering the recovered blocks, the structure of the burial pit could finally be documented. An upper part with a trough-shaped profile could be distinguished from a shaft-like lower part. In the lower part, the remains of a rectangular construction were found, the north-eastern corner of which was still preserved at a height of about 20 cm. Wooden imprints indicate a wattle-like construction with steep walls, which was lined with clay and backfilled with clay towards the wall of the burial pit (Fig. 7). Its base corresponds in shape and orientation to the »burial pit« recorded in 1934. Thus, it was not the burial pit itself that was documented at the time, but rather its chamber-like installation in which the skeletons and the grave inventory were located.

As already mentioned, besides numerous faunal and archaeological objects the new finds also contained a number of human skeletal remains. In addition to hand and foot bones and rib fragments, also vertebrae and vertebral fragments could be assigned to the adult female. The skeletal remains of the infant, which was only incompletely recovered in 1934, could be complemented substantially. However, due to the highly fragmentary preservation, this work has not yet been completed. The most important new finding with regard to

Fig. 3 (left page) Roe deer antler, perforated and unperforated teeth of aurochs/bison, red deer and wild boar.

Abb. 3 (linke Seite) *Rehgeweih, durchlochte und ungelochte Zähne von Aurochsen/Bison, Rothirsch und Wildschwein.*

Fig. 4 Anomaly of the skull base and incomplete formation of the atlas bone.

Abb. 4 *Anomalie der Schädelbasis und unvollständige Ausbildung des ersten Halswirbels.*

Fig. 5 Abrasion of the upper central incisors with open pulp chamber.

Abb. 5 *Abnutzung des oberen mittleren Schneidezahns mit offener Zahnmarkkammer.*

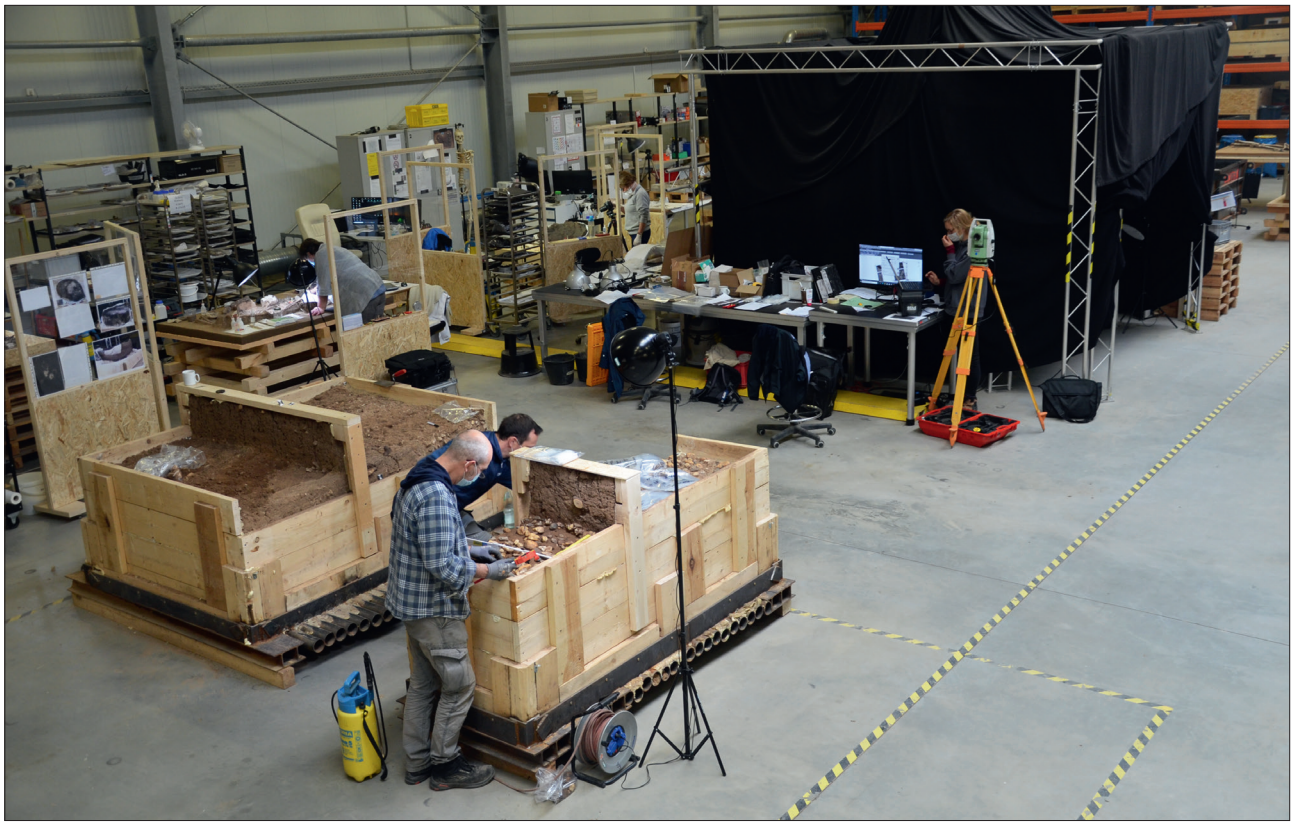

Fig. 6 The two removed blocks containing the remains of the burial pit during excavation at the State Office for Heritage Management and Archaeology Saxony-Anhalt.

Abb. 6 *Die zwei geborgenen Blöcke, die die Überreste der Grabgrube enthielten, während der Ausgrabung des Landesamtes für Denkmalpflege und Archäologie Sachsen-Anhalt.*

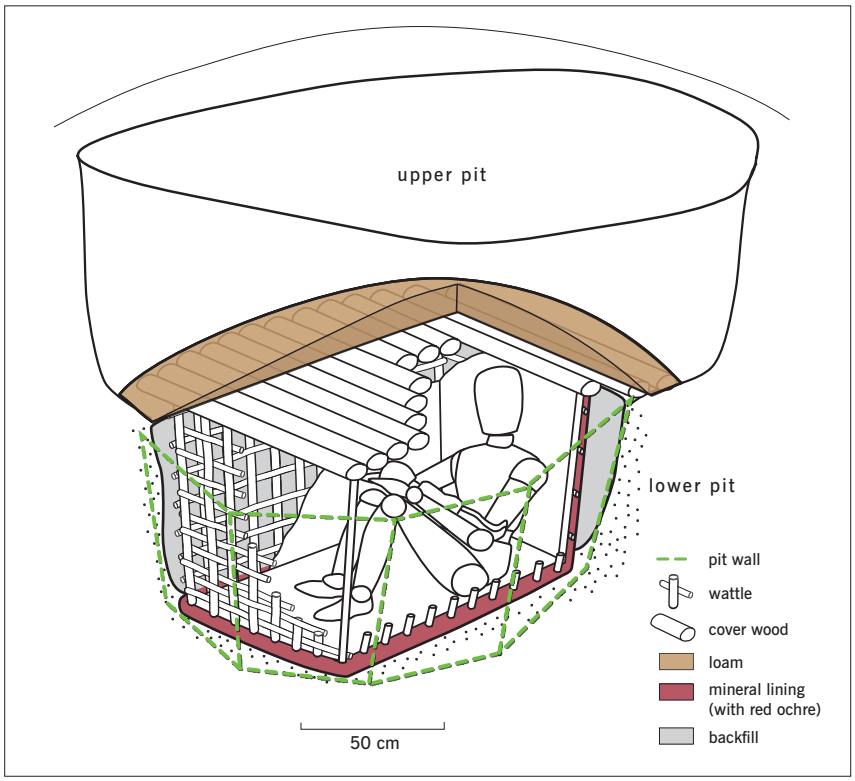

Fig. 7 The reconstruction of the burial pit, which has a basket-like structure in which the bodies of the shaman and the infant were deposited in a sitting position.

Abb. 7 *Die Rekonstruktion der Grabgrube, die eine korbähnliche Struktur hatte, in die die Körper der Schamanin und des Säuglings in sitzender Position plaziert wurden.*

the preservation of the child was certainly a pars petrosa (petrous bone), which for the first time made a genetic examination of this individual possible.

Genetic results from the genome-era

The first attempts to retrieve ancient human DNA from the burials at Bad Dürrenberg were made in 2003–2006 together with colleagues from the Department of Anthropology at the Johannes Gutenberg University of Mainz. For this purpose, one of the authors (W. H.) collected samples from the compact bone of the left femur and a tooth (33) of the adult female, as well as sample of the femur of the child. At that time, ancient DNA studies were still in their infancy and the classical PCR-based method were used. The retrieval of authentic ancient human DNA, free of modern-day contamination and thus not delivering false-positive results, was often met with skepticism, and any results had to withstand scrutiny (Willerslev/Cooper 2005). Following the strict criteria for replication and authentication of the results, several hundred base pairs of the hypervariable region of the human mitochondrial genome from the adult female could be retrieved. These results, attributing the Bad Dürrenberg individual to mitochondrial haplogroup U4, were published in 2009, alongside a number of hunter-gatherer individuals from Europe (Bramanti et al. 2009). The fact that nearly all hunter-gatherer individuals known at the time belonged to haplogroup U, which was considered on the oldest maternal lineages in Europe (Richards et al. 2000), and different from the lineages commonly found in early European farmers from the Neolithic period, lend support to the antiquity and the credibility of the results.

The revolutionary breakthroughs in Next Generation Sequencing methodologies and associated Bioinformatics emerging in 2005 also propelled ancient DNA research into unprecedented spheres, and it soon became possible to generate complete genomes from prehistoric humans (Metzker 2010). In combination with refined methods to extract DNA and avoid contamination, and the realization that the petrous portion that forms the solid bone capsule around the human hearing apparatus preserves the highest amount of endogenous human DNA (Pinhasi et al. 2015), this revolution also led to the idea to revisit the ›shaman lady‹ in order to generate genomic data. First, another piece of long bone was tested, but yielded only very limited results. In the same year, her petrous bone was sampled using a minimally invasive method by drilling from the base of the skull to preserve the fully intact skull. At this time, given the refined methods at hand, re-sampling of the infant skeleton was also considered, but deemed not justifiable, given the highly fragmentary nature of the skeletal remains. However, the bone powder from the female's petrous bone proved to be a treasure trove for ancient DNA analyses. Genetic sexing quickly confirmed her as a biological female, but this came no longer as a surprise. Fast forward a few years, the first genome-wide data from the adult female was published (Rivollat et al. 2020) and a complete genome with 13X coverage soon thereafter (Childebayeva et al. 2022).

With the availability of genome data from several thousands of modern and now also from prehistoric and historic human genomes, it is possible to reconstruct a genetic history of many regions of the world. The genomic ancestry profile of the ›shaman lady‹ falls squarely within several dozen other Mesolithic hunter-gatherer individuals from central and western Europe, a profile which is commonly coined »Western (European) Hunter-Gatherer ancestry« or »WHG« ancestry (Lazaridis et al. 2014; Fu et al. 2016; Posth et al. 2023). This ancestry emerged from south/southeastern parts

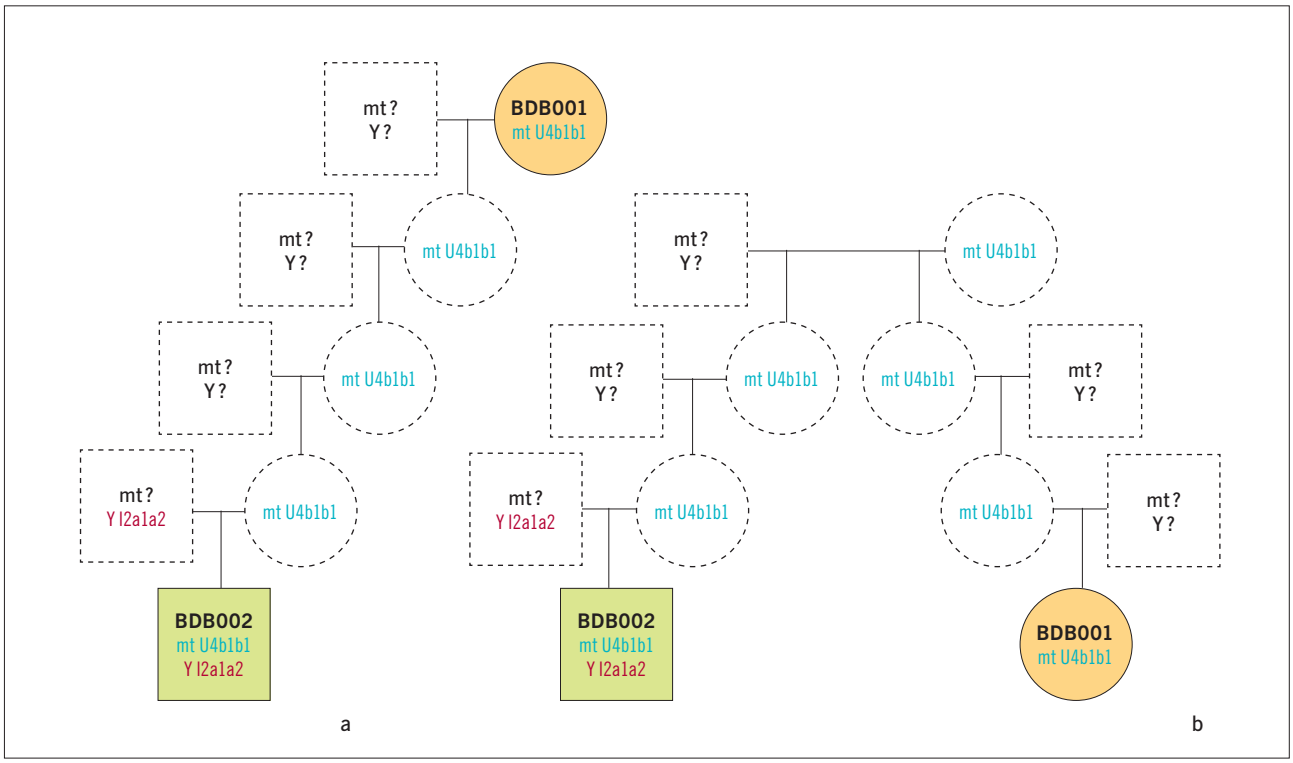

Fig. 8a–b Ilustration of two possible relationship scenarios between the adult female (BDB001) and the boy (BDB002) from Bad Dürrenberg. a 4th degree generational descent on the mother's side (5th would be another generation added); b alternative constellation of a 5th degree relationship in which both individuals could have overlapped during their lifetime. Of note, slight balancing variations in the number of generations on each side of this pedigree are also possible. Circles and squares depict genetic females and males, respectively. Blank symbols with dashed outline represent unsampled relatives; mt mitochondrial haplotype; Y Y-chromosomal haplotype.

Abb. 8a–b *Darstellung von zwei möglichen Verwandtschaftsszenarien zwischen der erwachsenen Frau (BDB001) and dem Jungen (BDB002) aus Bad Dürrenberg. a Abstammung 4. Grades mütterlicherseits (5. Grades wäre eine weitere Generation zugefügt); b alternative Konstellation einer Verwandtschaft 5. Grades in der beide Individuen zeitgleich gelebt haben. Leicht abgewandelte Alternativen in der Anzahl der Generationen auf beiden Seiten dieses Stammbaums sind auch möglich. Kreise und Quadrate stellen jeweils genetische Frauen und Männer dar. Leere Symbole mit gestrichelter Umrandung repräsentieren nicht beprobte Verwandte; mt mitochondrialer Haplotyp; Y Y-chromosomaler Haplotyp.*

of Europe during the Epipaleolithic and was soon replacing the prevailing Magdalenian-associated ancestry in post-LGM Europe to then become the predominant type of genomic ancestry during the early Holocene in western/central Europe, as the naming suggests. Eastern Europe was home to a related but distinguishable form of ancestry (Eastern European Hunter-Gatherer ancestry; EHG), and both mixed in a longitudinal region of overlap stretching from Scandinavia to the Baltics and from the Ukrainian forest steppe to the Middle Danube region. Her mitochondrial genome could also be completed, which not only confirmed the PCR-based findings from early studies, but also refined the haplotype call to lineage U4b1b1.

Having the complete genome sequence data from a person allows the exploration of any gene of interest for which the function is known or the association is established reasonably well. This also includes genes that encode the phenotypic appearance, which are not the primary interest of population geneticists given the connotations associated with skin, hair and eye colour. However, having the opportunity to know what prehistoric individuals looked like is critical in order to generate reconstruction for the purpose of museal illustration. In fact, the numerous life-like illustrations by K. Schauer form an integral part of the State Museum of Prehistory in Halle and especially the portrait of the ›shaman lady‹ has appealed to a large number of visitors since the opening of the second part of the permanent exhibition in 2004. Thus, it was important to update the portrait with the current genetic findings. Indeed, the phenotypic variants analyzed in the Bad Dürrenberg genome inform us that the shaman had a relatively dark skin complexion, dark, straight hair and blue eyes. This combination was quite common among hunter-gatherer individuals from Western Europe and the shaman lady shared this appearance with contemporaneous Mesolithic individuals from sites such as Loschbour, Mullerthal (Luxembourg), La Braña, Asturias (Spain), or Cheddar Man in Somerset (Britain)[4].

However, one of the most pressing questions that could not be answered, even with a complete genome at hand, was whether she was the mother of the infant, related to the child in any way, or perhaps not related at all. The answer to this would require genomic data from the child for direct comparison in order to look for shared portions of the genome, as would be expected in the case of closely related individuals. The sensational retrieval of the petrous bone(s) during the re-examination of the original find spot finally opened up

4 Lazaridis et al. 2014; Olalde et al. 2014; Mathieson et al. 2015; Brace et al. 2019.

this unique opportunity. And indeed, the genetic analysis of the well-preserved petrous provided the long-awaited answer. The genome-wide data from the child show that it also carries the same genetic ancestry, so undoubtedly belongs to the same time period and thus highly relevant to the burial context described above (unpublished data). Further, genetic sexing revealed that the skeletal remains of the infant belong to a boy.

Using established methods (Monroy Kuhn et al. 2018) that can detect biological relatedness in ancient DNA data reliably up to the second degree, resulted in the surprising finding that both individuals are not closely related in the first degree, i. e., they are not mother and son, or siblings. A 2nd degree relationship could also be excluded, which means that an aunt-nephew or grandmother-grandson relationship can also be ruled out.

However, since high-quality data from both individuals, and especially from the female was available, we could also employ a newly developed method[5], which scans the genome data for the presence, amount, and length of tracts in the genome that are shared by two individuals, so-called identity-by-descent (IBD) tracts. This method, optimized to deal with missing data, as is common in fragmented ancient DNA, allows the detection of biological higher degree relatedness, and with reservations, up to the 10th degree. Concerning the two Bad Dürrenberg individuals, we found that the number and length distribution of identify-by-descent tracts that are shared between the pair is equivalent to genetic relatedness of the 4th or 5th degree. This degree of relatedness could be equivalent to 4 or 5 generations apart, assuming a direct line, which would make the adult female the potential great-great-(great)-grandmother of the boy.

However, the relationship does not necessarily have to be in the direct line, which means that the pair could also be 1st cousins, once or twice removed, or 2nd cousins, or the female could be the great-grand-aunt of the boy. Given that both share the same mitochondrial haplogroup means that a direct generational relationship of 4th or 5th degree on the mother's side is indeed possible, and also limits the number of alternative constellations to relationships on the maternal side of the family.

Figure 8 illustrates two possible scenarios: a) a generational relationship, which renders it rather unlikely that the female would have known about the existence of her great-great-(great)-grandson due to the temporal gap of at least 60–80 years, and b) an alternative 5th degree constellation on the maternal side, in which both might have overlapped during their lifetime, and in which she (or any of the parental ancestors of both) might have known about her kin relation to the boy.

The petrous bone of the boy now also allows a direct ^{14}C dating of the child burial. Analyses are currently underway, applying a sensitive new method that is also minimally invasive. The date holds the potential not only to lend support to one of the two relatedness constellations, but also will further corroborate the temporal framework of the burial context.

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5 ancIBD; <https://pypi.org/project/ancIBD/> (22.03.2023); Ringbauer et al. 2023.

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