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Reviewed Article:

The Construction of a Bronze Age Longhouse Model in Dwelling-byre Style using Experimental Archaeological Techniques

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Longhouses built using earth-fast post technique belong to the most important and most successful house types of middle European prehistory. The footprints of these structures, in

various styles, are identifiable from the very beginning of the Neolithic period up to the Middle Ages, and sometimes up to early modern times. The history of longhouses is closely connected with a settled, agricultural structured society. The subsistence of their inhabitants was usually based on a special form of mixed economy, whereby the cultivation of grain, vegetables and fruits played an important role along with the breeding of animals such as cows, sheep, goats, and pigs. This mixed economy insured the guaranteed survival of the farmers during troubled times such as animal epidemics and crop failures. Since the Bronze Age period, these longhouses were often used as dwelling-byres, where people and animals lived side by side with each other although the archaeological evidence is not always obvious. For researchers and archaeologists this house type is readily identifiable, because the earth-fast posts were often dug over one meter deep in the ground and therefore we can spot them in our excavations even when the original soil level of the past has already been destroyed by erosion (See Figure 1).

> From our experimental approach in constructing a full scale model of a longhouse we believe that the people in the Bronze Age must have had a complex system of numbers and data for linear measurements to manage such house building challenges. During the Bronze Age, either round or split wood was used for building purposes, which could be worked over very precisely to rectangular forms of beams, planks and boards.

A new longhouse model in Hitzacker

The town of Hitzacker is situated adjacent to the river Elbe in the district Lüchow-Dannenberg, east of Lower Saxony. The discovery of wide Bronze Age settlement structures in Hitzacker in the 1980s led to the founding of a Bronze Age open air museum called AZH - Archaeological Center Hitzacker. Along with other archaeological models of Bronze Age architecture, three Longhouses were the main attractions of the institution and were also focal points of the educational programs. The destruction of one Longhouse by arson in 2008 was a great loss. Fortunately, the damage was covered by fire insurance. Thus, a new building was planned. The team for Experimental Archaeology of the Vienna Institute for Archaeological Science (VIAS) of the University of Vienna was commissioned to build the new Longhouse model[1] . The archaeoexperimental working group had experience with Bronze Age technology from other projects (Lobisser, 2004; 2008). The actual building was located in the very center of the museum, near to the burned longhouse which is partly still standing, allowing observations of further decay of the structure (See Figure 2).

Archaeological background for a new start

The idea was to re-interpret a house foundation of the archaeological excavations from Hitzacker and to build a fourth full scale model. By building the house new questions may be answered concerning the eastern end of the building, inner

sections of the house, and the construction of the walls especially the discovered positions of foundation trenches on the wall. There were further interests about the development of different elements of woodworking and joints, finding out more about the technical possibilities in the Bronze Age and prove the durability of different materials. During the practical work we tried to find new solutions for construction details which have not been shown in the three models built before. Of course, all the woodworking elements should be discussed according to Bronze Age technologies.

Prior to the commencement of the building phase, we studied and analysed other European archaeological sites of Bronze Age, where due to special soil conditions the organic materials (e.g. wood) were preserved. For example, we would like to mention the findings from the Bronze Age salt mines of Hallstatt in Austria (Barth and Lobisser, 2002,), the findings of Fiavé-Carera in Italy (Perini, 1987), as well as the archaeological sources of Zug-Sumpf in Switzerland (Seifert, 1996). But there is also evidence of wood preservation in the wider surroundings of Hitzacker. In Rodenkirchen-Hahnenknooper Mühle in the district Wesermarsch the complete ground plan of a Bronze Age house could be documented due to the moist soil which preserved the under ends of alder posts (Strahl, 2004; 2005). Since the building of the last house model in 1996, new information has been derived from the latest excavations, especially of a younger Bronze Age house of Alt-Wendischthun (Assendorp, 2010). All three older longhouse models in Hitzacker showed round ends at both sides. In the Alt-Wendischthun there was evidence for a straight house end at the eastern side. Other documented Bronze Age ground plans of houses like Klein-Bünstorf (Keuneke and Schwieger,1943) and Benzigerode (Brauer, 2005) show similar straight eastern side endings of houses. On a closer look, our ground plan from Hitzacker showed comparable traces of post holes on both sides of a modern soil disturbance. Therefore, it was a challenge for us to construct the new model with a straight end in the east. We also found references for a subdivision of the inner two rooms with a passage way in between. In the east of the structure there was an open activity area still lying preserved under the roof (See Figure 3).

Selection of wood species

For the building wood to be used in our new model, we tried to find wood species that might have been used during the Bronze Age. Local evidence indicated the use of alder from Rodenkirchen, which is surrounded by alder-ash dominated wetland forests. But is alder an ideal wood for use in construction? Considering that people in Bronze Age, like museum chiefs today, desired long lasting houses, we assume that, if available, people used oak especially for the construction of earth-fast posts. There was oak in the Bronze Age forests near Hitzacker. Oak has a very high concentration of tanning acids and is therefore more resistant against wood pests of all kind than other tree species. This effect is even stronger when the trunks are cut down in winter time, and when the sapwood of the under parts of the posts is removed and the surface becomes hardened by fire. Due to these findings we

constructed the new house model in Hitzacker using mostly oak wood. According to archaeobotanic data there were nearly no conifer tree species in the forests at that time, except some occasional pines (Lesemann,1969). Therefore, we used ash wood in the construction of the roof truss (See Figure 4).

Activities on the building site

Where necessary, the building location was flattened with additional earth material. We then[2] started to determine the exact positions of the single posts according to the archaeological ground plan using strings, poles and tape measures. Each post position was marked with a stake. It is likely that the Bronze Age people must have proceeded in a similar manner. Obviously, they were able to conceptualize a ground plan according to their needs and traditions, to sketch it in some way, to communicate the plans to others and to put it into action in a 1:1 scale. Bearing in mind the correct number of trunks in suitable dimensions had to be prepared and brought to the site we came to the conclusion, that people in the Bronze Age must have had a complex system of numbers in terms of calculation and a determined measurement for length. By digging the pits for the posts with a depth between 90 and 120 cm we used Bronze Age-style wooden spades. It took us about 90 minutes for the bigger pits to be dug (See Figure 5).

Timber framing of the main construction

The five earthfast ridge posts of the axial centre line had diameters up to 35 cm, were about 7 m long and showed natural grown forks at their tap ends. With bronze blades the forked ends were worked over to a round form matching the diameters of the ridge purlins. The blades, which turned out to be well suited for this purpose, were hafted as axes in knee-grown handles. At their butt ends the trunks were barked and hardened in fire. How could people in former times accomplish the erection of the heavy trunks of up to 600 kg or more? We assume, that they might have had some kind of a simple hoist. On our building site we used a moveable three-leg-hoist, built of 8 m long stems that were bound together at their tops. A deflection roller coupled with a strong rope which was guided helped us to pull the forked ends of the posts upwards. For security reasons we used a metal rope. But there is archaeological evidence for a strong load rope with a diameter of about 4 cm found in the Bronze Age salt mines in Hallstatt in Austria (Löcker and Reschreiter, 1998). Concerning the deflection roller, we have archaeological evidence from an Iron Age site in Fellbach-Schmiden, where a wooden object was found, that could have been used in a similar way (Plank,1985) (See Figure 6).

To fix the erected upright posts the open pits were refilled with earth and compacted. The ridge posts were positioned in a way whereby the forks were in a line. Subsequently the ridge beams were placed into the recesses. At their ends we jointed the beams by splayed scarfs and rope bindings. The wall posts were set up by hand. At their upper ends we carved

rectangular tenons using bronze chisels. On the eaves beams we worked out matching mortices on the right positions. Then the heavy wall purlins were put on the wall posts using our hoist. The external wall construction and the ridge posts were strengthened by 8 transverse beams of a truss-frame. Similar to anchor beams those heavy trunks were set crosswise on the eaves beams with single notched joints. To attain adjusted connections the notches were marked with our wooden compasses following the forms of the wall eaves. The half round recesses were cut out with bronze axes. It took us about 70 minutes to work out the bigger half-round cogs with a length of 29 cm and a depth of 15 cm. Three of the crossbeams were set on the positions of the assumed transversal internal walls and connected with the inner post rows by mortice and tenon joints. At a later stage, the crossbeams built the basis for a massive wood ceiling in the eastern part of the house partly made of split planks and of round logs, which were nailed down with wooden pegs. Thus, the attic storey can be used for storage (See Figures 7 and 8).

The assembly of the roof truss

The rafters were put on in pairs with distances between them from 1m to 1.5 m with their tap ends upwards. After a roof overhang of about 60 cm, their butt ends were fixed to the eaves beams with birds-mouthed joints, which we put in half round recesses with horizontal sharp edges. Here we worked with axes, chisels and adzes. Especially adzes were perfect for this purpose. At their upper ends the rafters were fitted to the ridge beam by single notched joints and lashings. The battens were made of little ash stems with lengths of up to 6 m. To fix them we notched the rafters every 50 cm and bound the lath in the notches. The best method was to make those rope bindings loose and to turn them tight with little wooden sticks, which we fixed afterwards. In total we put on more than 700 m of battens which formed 12 rows. The plane of the roof measured more than 300 square meters and for acquisition reasons we assumed that in the Bronze Age roofs of this size were probably made of reed. Modern reed coverings are mostly steep with roof pitches of more than 45 degrees to guaranty a long-lasting utilization (Schrader, 1998). We chose a roof pitch of about 50 degrees. Our reed material was approximately 2 m long and was brought up in bundles that were fixed row by row with hazel sticks bound to the laths. The bundles were then opened and the reed stalks could be distributed regularly by hand forming a constant layer with a thickness of 30 cm (See Figures 9 and 10).

Three methods of building walls

We built the walls up to 2 m high and therefore the new model was completely different in appearance from the old models, where the roofs are nearly touching the soil. The idea was that with higher walls one can use the inner parts of the house much better and it also helps to keep the walls dryer. Concerning the wall construction, we had some evidence of posts which were situated very close to each other in the western part of the archaeological house. Therefore, we constructed the wall like a palisade with the gaps in between filled with clay. To

join the vertical wall logs to the roof plates we fixed them with oblique wooden pegs. The holes for the pegs were worked out with a small bronze chisel. The pegs were split out of straight grown oak and carved with bronze knives. Where there was no direct archaeological evidence we constructed the walls in two other variations. We interpreted the common function of the foundation trenches as drainage for rain water. The amount of water coming down to the eaves from a roof which is bigger than 300 m² during a thunderstorm or while thawing is enormous and people in the Bronze Age surely had to protect the inside of the house from this flood. For this reason, we embedded horizontal beams into all the other wall trenches and they have been a perfect barrier against surface water. In the middle of the house and in the eastern gable we used wattle and daub for the superstructure. The vertical sticks of these walls were pushed into holes on the upper sides of the buried planks, which prevents the loam plaster from soaking up water from the soil. The vertical sticks beside the posts were additionally mounted with little wooden pegs. The peg holes were made using a bow drill with a bronze point, which we formed after an ethnological model from Morocco. Homer mentions a bow drill in his Odyssey and we assumed that the drills in the Bronze Age were constructed that way (Odyssey, 9.384). The infills of the walls were woven with willow rods. With regards to the loam plaster, we got the opportunity to use different compositions of clay and organic material and different techniques of bringing up the loam render to the walls. The walls of the smaller room at the eastern part of the house were made with horizontal laid split planks of oak. To fix those planks we carved vertical grooves on the sides of the earth-fast wall posts using bronze chisels, and thus the planks could be inserted with their conical ends. To smoothen the edges and to fit the planks together our drawing knife of bronze was very helpful (Speck, 1989). The gaps in between were filled with clay (See Figures 11 and 12).

Our suggestion for Bronze Age doors

The doors were fixed in separate door frames similar to the ones known by ethnological parallels from Mongolian tents (Roná-Tas, 1989). We think that these door frames bring advantages pertaining to common stability and place management. With the additional frames the doors can be opened up to 180 degrees towards the inner side of the house. The frames are independent from the house construction and can therefore easily be taken out for possible repair work in the future. We built the door frames out of quartered timbers. The construction elements were smoothed with bronze adzes and stuck together with mortice and tenon joints additionally fixed with wooden pegs. In total, we built five doors: two normal ones, two double leaf doors and one so called “Klöndör”; where two door leaves are mounted one over the other and can be moved independently. The planks were radially split from straight grown oak. Afterwards the raw pieces, with a triangular cross-section, were formed into rectangular boards using bronze adzes. To avoid warps we used levelling laths to mark straight forms. It was a full one-day work for one person to hew such a board. Here we also conducted an experiment - to shaft a small bronze blade like a plane, and this resulted in

smooth wooden surfaces. Of course, we cannot prove that planes were common tools at that time, but from a technological viewpoint it would have been possible. The prepared boards were connected with conical planks of trapezoidal cross-sections, which were inserted crosswise in well matched grooves and fixed with wooden pegs. To join the edges of the boards we used different techniques like oblique gaps, tongue and groove connections, or rebates. There is good archaeological evidence for rebates from a Bronze Age cistern in Switzerland (Rageth, 1985). The finished door leaves can be moved over round pivots on their corners, which are guided by round holes in the heads and the sills of the door frames. Each door may be locked with different variations of wooden bolt mechanisms (See Figures 13 and 14).

Summary

Our new building was erected as a semi-aisled longhouse in the sense of a dwelling-byre, which is 28 m long, almost 7 m wide and more than 6 m high. The whole construction consists of earth-fast posts to carry the ridge beam and posts for the roof plates of the side walls. The roof was constructed as a symmetric saddle-roof with a complete hipped end in apside-style in the west. At the eastern end there is a straight gable with its ridge covering an open but roofed area forming a porch. Our research indicated that the inner part of the house was divided into two rooms with a 160 cm wide passageway in between. The external wall construction and the ridge posts are strengthened by 8 transverse beams of a truss-frame. These beams are the basis for carrying a plank ceiling at the eastern part of the house. The whole frame is the foundation for the rafters and the laths for the roof. The plane of the roof measures more than 300 square meters and is made of reed. The carpentry work on our full-scale-model had been done partly with replicas of Bronze Age tools. This approach helped us to understand more about the use of the specialised tool types. Function and capabilities of the implements could be reflected and proved. Our aim was that the full scale house model in Hitzacker reflected wood connection elements and tool marks in line with the technical background of a Bronze Age reality. We tried to use the bronze blades in different ways by changing the handle types. Our toolkit included axes, adzes, draw knives, different types of knives and chisels, gouges, drills, and marking awls. We came to the conclusion that the so called Bronze Age axe blades are multifunctional and could be used alternatively as axes, adzes, chisels etc. We also tried to find out which necessary tools were mostly made of organic material, like mallets, compasses, levelling laths, transport rolls, hoists, wedges or levers (See Figures 15 and 16).

From our experimental approach in constructing a full scale model of a longhouse we believe that the people in the Bronze Age must have had a complex system of numbers and data for linear measurements to manage such house building challenges. During the Bronze Age, either round or split wood was used for building purposes, which could be worked over very precisely to rectangular forms of beams, planks and boards. Along with simple joints with

natural grown wood forms like forks, rope bindings, recesses and notches they also used developed wood connection techniques like mortice and tenon joints, scarf joints, single notched joints, slots, grooves, pivots, wooden pegs, and rebates. Some of the archaeological findings show us the good technical options quite clearly, for example the findings of wooden wheels (Höneisen, 1989; Fansa et al., 2004.).

This special type of longhouse seems to fit quite well for the climatic situation of the region. The roundly palisade-like wall protects the building on its western side where the bad weather normally affects. While at the eastern side an open and dry working place is offered right were the morning sun could be seen to rise. We can be sure that the whole structure was a multi-purpose building. Yet, further research is required to determine what the inner parts of the house were used for. We put forward a theory: we assume that the dwelling section of the house may have been in the western part of the bigger room, well preserved by the massive log walls. Therefore, here we laid a wooden floor with a fire place in front. The middle area could have been used as byre. Maybe here there were stall rows like in Rodenkirchen. The room in the east may have functioned as a service section or a workshop with the open but roofed activity area adjacent. The big attic storey may have been used for storage for resources such as raw materials, foodstuffs or hay for the animals. The accurate documentation of our reconstruction work using authentic techniques enables us to give an estimate of the effort that must have been spent on a dwelling-byre building in the Bronze Age. The transport of the heavy trunks from the forest to the settlement may have been carried out using domesticated animals like cattle. We estimate, that a group of about 30 people could build up a longhouse like this within a two-month period, including all the material preparation work. Therefore, a rural settlement population in the Bronze Age should have been able to erect such a building within one or two years alongside conducting daily farm work (See Figures 17 and 18).

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2 Following persons joined the experimental team of VIAS: Oskar Bauer, Dilek Cetin-Draskovits, Kurt Hofinger, Michael Jagl, Gerald Karlovits, Tabea Krah, Maria Linke, Arnold Lobisser, Wolfgang Lobisser, Julia Nekovitsch (†), Bernhard Pichler, Myriam Urtz und Arved Zürn.

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ancient technology
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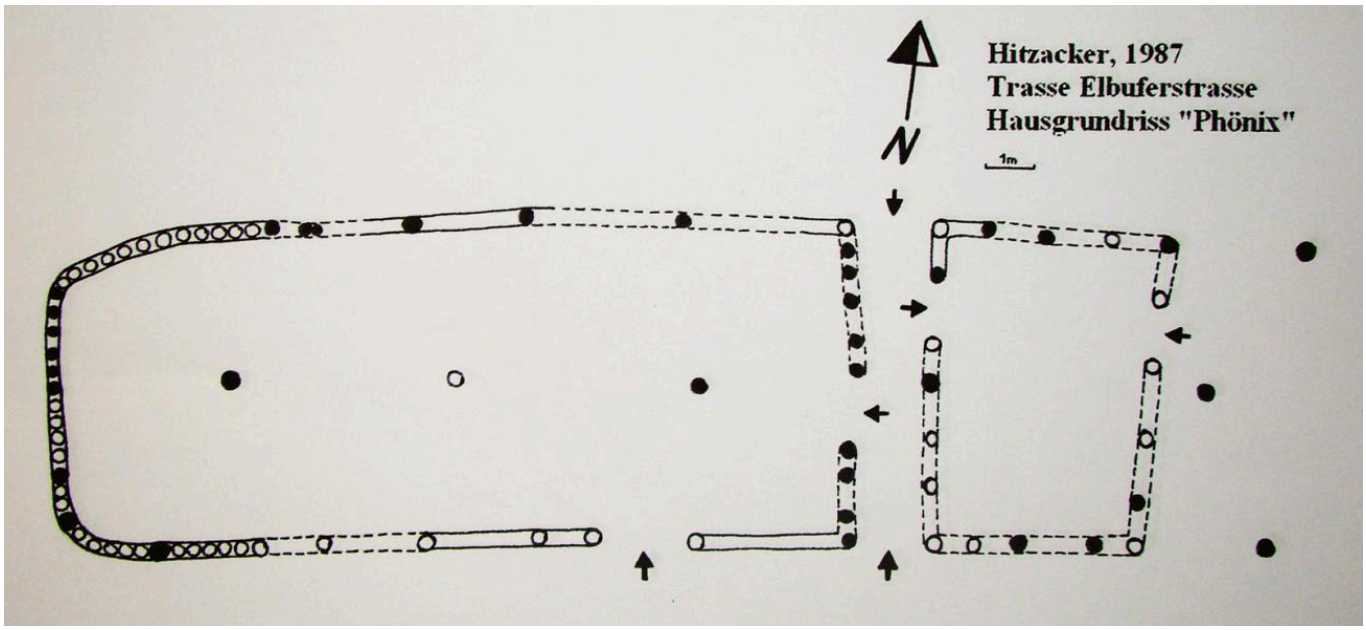

FIG 1. GROUND PLAN SKETCH OF THE LONGHOUSE: THE BLACK PAINTED POSTS WERE DOCUMENTED AT THE EXCAVATION IN HITZACKER IN 1987; THE OTHER POSTS WERE PLACED ACCORDING TO THE HOUSE FROM BLECKEDE ALT-WENDISCHTHUN. COPYRIGHT: WOLFGANG LOBISSER

FIG 2. REMAKES OF BRONZE AGE TOOLS THAT WERE USED TO BUILD THE NEW LONGHOUSE MODEL: AXES, ADZES, CHISELS, CARVING KNIVES, DRAWING KNIVES, DRILLS, HAMMERS, GOUGES, COMPASSES, AND AWLS. COPYRIGHT: WOLFGANG LOBISSER

FIG 3. THE FORKED GROWN TAP ENDS OF THE EARTH FAST RIDGE POSTS WERE ADAPTED TO THE FORM OF THE PURLINS WITH BRONZE AGE AXES ATTACHED TO THE ANGLED HANDLES. COPYRIGHT: WOLFGANG LOBISSER

FIG 4. BRONZE CHISELS WERE WELL SUITED TO CARVE RECTANGULAR TENONS ON THE UPPER ENDS OF THE EXTERNAL WALL POSTS WHICH ALLOWED US TO PUT ON THE EAVES BEAMS. COPYRIGHT: WOLFGANG LOBISSER

FIG 5. VIEW FROM THE SOUTH-EAST: THE RIDGE BEAMS AND THE EAVES BEAMS ARE PUT ON THE EARTH FAST POSTS WITH A THREE LEG HOIST, WHICH CAN BE SEEN IN THE BACKGROUND ON THE LEFT SIDE. COPYRIGHT: WOLFGANG LOBISSER

FIG 6. THE STRENGTHENING TRANSVERSAL ANCHOR BEAMS WERE FIXED ON THE EAVES BEAMS WITH SO CALLED SINGLE NOTCHED JOINTS; THE HALF ROUND RECESSES WERE HEWN OUT WITH HEAVY BRONZE AXES. COPYRIGHT: WOLFGANG LOBISSER

FIG 7. VIEW FROM THE SOUTH: THE GABLED ROOF OF THE TIMBER BUILDING IS GENTLY CURVED; IN FRONT ON THE LEFT SIDE WE SEE THE REMAINS OF THE BURNED HOUSE. COPYRIGHT: WOLFGANG LOBISSER

FIG 8. THE RAFTERS WERE FIXED ON THE EAVES BEAMS WITH SO CALLED BIRDSMOUTHED JOINTS, WHICH WERE WORKED OUT WITH BRONZE BLADES HAFTED AS ADZES. COPYRIGHT: WOLFGANG LOBISSER

FIG 9. THE BATTENS WERE BOUND ON THE RAFTERS USING ROPE BINDINGS. COPYRIGHT: WOLFGANG LOBISSER

FIG 10. ACCORDING TO EXCAVATION DATA THE WALL AT THE WESTERN END OF THE HOUSE WAS CONSTRUCTED WITH VERTICAL ROUND LOGS; THE GAPS WERE FILLED WITH CLAY. COPYRIGHT: WOLFGANG LOBISSER

FIG 11. OUR PROPOSAL FOR A BRONZE AGE BOW DRILL WAS INSPIRED BY AN ETHNOLOGICAL IMPLEMENT FROM MOROCCO. COPYRIGHT: WOLFGANG LOBISSER

FIG 12. IN THE MIDDLE PART OF THE HOUSE THE WALL INFILLS WERE WOVEN WITH WILLOW RODS IN WATTLE AND DAUB STYLE. COPYRIGHT: WOLFGANG LOBISSER

FIG 13. THE RECTANGULAR BOARDS OF THE DOORS WERE FIXED TOGETHER WITH CONICAL PLANKS OF TRAPEZE-FORMED CROSS-SECTION, WHICH WERE INSERTED CROSSWISE IN WELL MATCHED GROOVES AND FIXED WITH WOODEN PEGS. COPYRIGHT: WOLFGANG LOBISSER

FIG 14. THE TWO LEAVES OF THE DOOR ARE MOUNTED IN A DOOR FRAME AND CAN BE LOCKED WITH A WOODEN BOLT MECHANISM. COPYRIGHT: WOLFGANG LOBISSER

FIG 15. A BIRD´S-EYE VIEW DURING THE WORK ON THE REED ROOF. COPYRIGHT: WOLFGANG LOBISSER

FIG 16. CONCERNING THE LOAM PLASTER WE USED DIFFERENT COMPOSITIONS OF CLAY AND DIFFERENT TECHNIQUES OF BRINGING UP THE LOAM TO THE WICKER WORK WALLS. COPYRIGHT: WOLFGANG LOBISSER

FIG 17. WE ASSUME THAT THE DWELLING SECTION WAS IN THE WESTERN PART OF THE HOUSE; THEREFORE, HERE WE BUILT AN ELEVATED FIRE PLACE IN FRONT OF A WOODEN FLOOR. COPYRIGHT: WOLFGANG LOBISSER

FIG 18. THE LONGHOUSE WITH THE ROOF FINISHED; IN THE EAST THERE IS AN OPEN BUT ROOFED ACTIVITY AREA; PLEASE NOTICE OUR SUGGESTION FOR A WINDOW IN THE OAK PLANK WALL. COPYRIGHT: WOLFGANG LOBISSER