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Reviewed Article:

The Arrow Quiver of the Iceman Reconstruction Attempts and the Special Significance of the Fur Material

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In 1991, the sensational discovery of a male mummy, thawing from the ice, was made on the Tisenjoch in the Ötztal Alps, near the Austrian-Italian border. The deceased man lived about 5300 years ago at the end of the Neolithic Age and is commonly known as *Ötzi* in German-speaking countries. The site also contained many well-preserved accompanying items and equipment. Most of the found objects have a good state of preservation and are invaluable to

archaeology. The entire equipment of the glacier mummy generally attests to a "high level of craftsmanship and extraordinary technological and material knowledge" (Reitmaier, 2014, p.29; Ruß-Popa 2016, p.164).

The Iceman and his Equipment

> Among the finds of the Tisenjoch complex are many objects made of animal skin. Most of these items are garments. The most important artefact made of animal skin which is not part of the clothing is the almost completely preserved quiver for the arrow.

Regarding the materials and manufacturing techniques, extensive scientific investigations, as well as reconstruction attempts within the last thirty years, have succeeded in capturing many of the finds. (Barth, 2003; Goedecker-Ciolek, 1992; Goubitz, Van Driel-Murray and van Waateringe, 2001; Junkmanns, 2001; Klek, 2012; Rast-Eicher, 2009; Reichert, 2000; 2001; Reitmaier, 2014; Teržan, 1994; Wierer et al., 2018). However, there are still some objects in the ice mummy collection whose function or technical reconstruction have not yet been conclusively clarified (Reitmaier, 2014, p.29). Among which the arrow quiver should be counted (See Figure 1).

The Quiver

Among the finds of the Tisenjoch complex are many objects made of animal skin. Most of these items are garments. The most important artefact made of animal skin which is not part of the clothing is the almost completely preserved quiver for the arrows (See Figure 1a). This quiver is among the best-preserved items of the entire complex (Egg and Spindler, 2009, p.104) It essentially consists of three parts. The main part is the elongated, tubular storage place for the arrows. A separate closure or wing flap is attached transversely to its opening. To stiffen the quiver, a stick was fixed lengthwise to the main part. Several separate leather straps were used for stiffening, underlay and assembling the individual parts. A special carrying strap or evidence that points to such a strap could not be discovered. It is therefore assumed that the quiver may have been attached to the back carrier found with the body, or was worn on the hip (Egg and Spindler, 2009, p.104; Junkmanns, et al., 2019, p.295). On the main part and the transverse flap there remain a few tufts of hair, which is why it is assumed that the quiver must have originally consisted of fur and not depilated leather (Egg and Spindler, 2009, p.104).

The quiver has received relatively little attention and is even neglected in some treaties on the Iceman's equipment (Goedecker-Ciolek, 1992; Ruß-Popa, 2018, pp.163-164) To the best of the author's knowledge, there are no publications regarding reconstruction attempts. Among Living History performers, hobbyists, and traditional archers however, the construction methods are occasionally discussed in great detail, although with a wide variety of authenticity. (FlintMetz, 2013; Neal, 2011; Stöter, 2013). The author was commissioned for the first time in 2019 by the Museum of Prehistory in Zug, (Switzerland) for a reconstruction of

the quiver. This aroused a special interest in the object. Already the first approach showed that the biggest challenge lay in the use of the necessary fur material. Furthermore, the stiffening rod and the transverse flap leave some questions unanswered.

The Fur Material – Chronological Outline of the Analysis on the Original and its Significance for Reconstruction

Over the decades, the identification of the animal skin materials in the complex from Tisenjoch has presented a particular challenge for science, Which is also true of the quiver. The last investigations on the object date back to 2016 and leave some questions unanswered, as will be explained in this article.

In regard to the species from which the fur material of the quiver could originate, there have been different analytical results over the years. Some confusion was caused by terminology, open questions regarding sampling, and different interpretations of the results.

The following are the various analytical results for the identification of the skin material undertaken between 1992 and 2016. Based on initial optical investigations of hair remains in the find complex, deer or goat-like animals (*capra*) were suggested (Wittig and Wortmann, 1992, 274ff).

Markus Egg, head of the restorer's workshop at the Roman Germanic Central Museum (RGZM) in Mainzpostulated , along with Egg (1992, p.39) that it must be the skin of a caprid, i.e. a goat-like animal. Further optical examinations by Groenman-van Waateringen of hair and the pore structure of the skin's surface were summarized in an English-language article, put forward chamois (*rupicapra rupicapra*), ibex (*capra ibex*)or roe deer (*capreolus capreolus*). Information on where exactly on the quiver these observations were made is not given (Groenman-van Waateringen, 1992, p.126). The subsequent German publication on the clothing and equipment of the Ötztal mummy by Markus Egg and Konrad Spindler (2009) refers to the publication by Groenmann-van Waateringen but obviously makes a mistake in translation, with the term roe deer being reduced to deer [*Hirsch* in German] (Egg and Spindler, 2009, p.104).

However, the term deer represents a deviation from the above results, as it also includes the red deer (*cervus elaphus*) and the fallow deer (*dama dama*). This inaccuracy regarding the species is then carried into other German language publications, which all postulate the hide coming from a deer [*Hirsch*]. (Junkmanns, et al., 2019, p.293; Kamper, 2020, p.42; Püntener and Moss, 2010, p.316). The determination of these inaccuracies should not be regarded as criticism, because such terminological confusion is common in literature also regarding other species. For example, the species *alces alces* is referred to as *moose* in American English but is called *elk* in British English. However, the term *elk* in American English refers to the Wapiti

deer (*cervus canadensis*). Nevertheless, the unambiguous identification of the species is crucial for reconstruction of artefacts, as laid out below.

Two further analyses on the skin material of the quiver followed, which used complex scientific approaches. In 2012, sequences of hair samples from various parts of equipment of the Ötztal mummy were analyzed. For the quiver, this study concluded that the skin of the transverse closing flap must have come from a bovid (Hollemeyer, et al., 2012, p.1735). The authors describe both in the text and on a drawing where on the quiver, the corresponding sample was taken. This sampling spot features the most significant remaining cluster of hair on the entire quiver. Interestingly, this result has hardly prevailed in literature. A further investigation of the fur and leather objects of the glacier mummy was undertaken in 2016. Based on DNA analyses of skin material, the authors concluded that the quiver was constructed from the hide of a roe deer (*capreolus capreolus*). Where on the quiver the samples were taken is unfortunately not mentioned in the article. After the first attempt of the author to reconstruct the quiver, it became apparent that this analysis result raises some questions. As a result, it became necessary to find out where exactly on the quiver the samples for the DNA analyses were taken because, after all, the object consists of two separate main parts and several individual straps.

After intensive research at the Archaeological Museum in Bolzano, where the finds of the Tisenjoch are housed and at EURAC (Institute for Mummies and the Iceman, Bolzano), both of which were involved in the above study, it was possible to identify the sampled skin pieces. The sampling was, in fact, not carried out directly on the quiver itself but on an assembly of three separate leather strips, which are assigned to the quiver (communication with Mr. Maixner EURAC, and Mr. Kaufmann, Museum Bolzano). These pieces are listed in the online catalogue of cultural assets of Tyrol (inventory number I.6b) with over a dozen other fur and leather remains, which belong to the Tisenjoch complex. However, nothing more is known about these three leather or fur strips that goes beyond the short description in the online catalogue.

However, the quiver's salvage report states that "various scraps of leather and fur" were seized on site and in the immediate vicinity of the quiver (Egg and Spindler, 2009, p.40). It is possible that these are the three strips mentioned. From a purely visual point of view, the pieces fit perfectly to the damaged upper end of the main part in terms of their length and shape. However, the restoration report on the quiver (worksheet number WB_1991_0119), which is kept in the archives of the RGMZ where the finds were treated in the early 90s, does not contain any notes regarding the assignment of the skin strips to a specific place on the quiver. Upon request, Professor Dr. Markus Egg, then head of the restoration workshop and Dr. Goedecker-Ciolek, the former restorer, were kind enough to share their memories and knowledge regarding the assignment of the strips with the author. It was pointed out that they could probably be assigned to the damaged elongated part of the opening and thus to

the main part of the quiver (Egg, pers. comm.), but at the time there was no clear evidence of a direct connection to the quiver, and it was also not clear whether or not this damage had occurred during Ötzi's lifetime (Goedecker-Ciolek, personal comm.). Furthermore, the archaeologist Jürgen Junkmanns, an expert in prehistoric bow construction who also dealt with the archery equipment of the glacier mummy, assumes that the mouth of the quiver had already thawed out before the salvage and thus that the damage stems from this phase (Junkmanns 2019, 293). This assumption is probably based on the excavation history of the object, in which the quiver was recovered carefully without additional damage (Egg and Spindler, 2009, p.39). Regarding the reconstructions described in this article the author has, despite the uncertainties mentioned above, remained with the assumption, that the skin material of the main part is from a roe deer. When attempting an authentic reconstruction, it is of immense importance to know which species to start from, as the skins of even-toed ungulates differ dramatically between species, with characteristics such as size and thickness of the skin being particularly varied. But the quality, color and density of the coat is also affected. Significant differences can occur even within the same species. The fur material is of crucial importance for the construction of the quiver, as it is not only an important factor in terms of construction and appearance, but may even influence the socio-cultural significance and classification of the object, which could therefore extend beyond a purely functional container for arrows. A Roe Deer Skin Quiver? – Many unsolved questions

The assumption that the fur material of the main part is the skin of a roe deer, leads to a number of questions and interesting topics in the course of an attempted reconstruction. Thus reconstructive archeology can help to shed light on certain aspects that remain unnoticed by scientific analysis and statements derived from it.

When working with animal skins, even once the species has been determined, further questions automatically arise. This includes the distinction between summer and winter coats (See Figure 2), a factor affecting all wild mammals found within temperate latitudes and further north. These two coat types differ, triggered by the change of season, in terms of density, structure, length and coloring of the coat. There is also an inverse relationship in terms of hair coat and thickness of the skin (dermis).

In summer the coat is thinner, and the skin is thicker. This corresponds to an inverse relationship in winter. The skin of animals that are in the so-called moulting period, i.e. in the transition period between the extreme seasons of summer and winter, usually suffers from hair loss and is at best suited for the production of leather, i.e. skin from which the hair has been removed.

These distinctions are lacking in the above-mentioned scientific studies.

There are some remains of hair on the quiver itself. These are concentrated at a location at the outer top of the transverse flap and at the top end of the body. A few hairs are preserved

under the strips of skin that run through the transverse flap, where they are clamped and thus protected against loss. These hair remnants can be examined more closely using photos which were kindly made available to the author from the archives of the RGZM in Mainz, Germany, and the museum in Bolzano (See Figure 3).

Regarding questions about the quality of the hair and skin material, the author was lucky enough to consult with two other experts on prehistoric leather finds, archaeologists Dr. Theresa Kamper and Dr. Gabriella Ruß-Popa.

The reddish-brown coloring of the remaining hair at the mouth of the main part of the quiver indicates the summer fur of a roe deer. This assumption is also supported by the fact that the curves of the straps, under which hair remains, are not very pronounced. Long and thick winter hair would have provided a correspondingly larger curvature here. Also, the reversal ratio mentioned above can be taken as an indicator that the main part of the quiver was made from a summer coat. After all, it seems impractical to make an article of daily use out of a thin-skinned winter hide when arrows with sharp-edged points are to be transported. However, the species *capreolus* poses fundamentally special challenges for a reconstruction of the quiver. Of all animal species considered so far, the roe deer offers the smallest body size and thus also provides the smallest skin area to work with. Since the main part of the quiver consists of a single part and has a length of about 90 centimeters (Egg 2009, 104), this is a problematic feature.

First tests in a tannery with more than a dozen roe deer skins showed that none was long enough to place the pattern as shown by Spindler and Egg (2009). This may be due to the fact that around 50% of roe deer shot in German-speaking countries areyoung (Ophoven, 2005, p.18). Another factor is that the neck area of commercially tanned hide usually only remains partially intact. It can therefore be assumed that the Iceman must have used the skin of a large, adult deer, presumably that of a buck.

The head-torso length (KRL) of recent roe deer in Germany is given as a maximum of 135 centimeters (Ophoven, 2005, p.16; Richarz, 2003, p.164) (See Figures 4 and 5).

The fact that there are also size variations within the species *capreolus* is shown by the fact that, for example, Austrian roe deer are considered medium-sized to large in a Central European comparison and reach a KRL of up to 140 centimeters (www.jagdfakten.at; Schmitzberger, 2009, p.68; Von Lehmann, 1976, p.76). The sub form *capreolus pygargus,* (Siberian roe deer), whose maximum KRL is given as up to 150 centimeters also indicates variance (specify wiki details as of February 2022).

So far, however, only data from recent, Central European deer have been considered.

But what is known about the roe deer during the lifetime of the man from the Tisenjoch?

The Roe Deer in the Neolithic

For the time of the glacier mummy, basically, two questions arise regarding the species *capreolus.* First might be size variability in roe deer populations between today and the end of the Neolithic and second, the frequency of deer bones in archaeological inventories, which might help indicate the importance of the species as a resource for humans.

According to the archaeozoologist Karlheinz Steppan (personal comm.), there is very little osteometric data for roe deer, since they were relatively scarce in the Neolithic and were therefore rarely killed (see also Boessneck, 1956; Lippert, 1992; Schibler, 1980; Steppan, 2003).

For the much more frequently used red deer, on the other hand, there are concrete indications of individuals that are larger than the corresponding recent comparative populations (Lippert, 1992, p.164; Steppan, 2003, p.113). Some authors, therefore, assume that a general decrease in size can also be assumed for *capreolus* since the Neolithic. Using data from Austria, Schmitzberger calculates a size difference of 5% (Schmitzberger, 2009, p.68)

Regarding the role of deer as human prey, it can be stated that the importance of wild animals generally declined sharply during the Neolithic, while the use of domestic animals was on the rise. For the Neolithic of Switzerland, for example, 80-90% domestic animal remains are documented in osseous inventories (Hafner and Suter, 2003, pp.25,56). Such numbers are of course subject to regional and periodic fluctuations and occasionally experience a temporary reversal, but the trend towards domestic animal use is clear. The situation regarding hunting in the region of the Iceman is contradictory on an initial review of data. For inner-Alpine locations, an increased proportion of wild animals is generally recorded in the inventories (Hafner and Suter, 2003, p.62; Reitmaier, 2014, p.31). On the other hand, the homeland of *Ötzi* is in the Vischgau, which can probably already be assigned the role of a granary in the Chalcolithic (Egg and Spindler, 2009, p.173; Festi, 2011, p.367). The archaeological site of Latsch in the Vischgau has archaeological horizons contemporaneous with the Iceman and is regarded as potential origin for him. It holds extremely few bones from wild animals among its almost 300 identifiable osseous fragments. There are some red deer remainsand one piece from a brown bear. This suggests that hunting played only a minor role, and the roe deer seems to disappear into insignificance in this scenario.

In summary, it can be said that a comprehensive evaluation of archaeozoological data from the corresponding geographical areas could provide more information about the socio-cultural position *capreolus* played in the environment of the glacier mummy.

This would make it possible to assign the use of the skin of a full-grown roebuck for an arrow case to a corresponding value. Hypothetically, apart from its practical purpose it could, due to

its material nature, be rated as a trophy like the cap made of bearskin.

The Reconstruction

Initial Animal Skin Preparation

In addition to the question of the animal species, the identification of initial skin preparation options is of essential interest for an authentic reproduction. The preparation and further processing of animal skins is an important technological complex, although the methods used are difficult to grasp archaeologically for prehistory, since they generally leave hardly any traces in the ground. For the late Neolithic in the Alps, however, there are actual artefact finds made of leather and fur. These include the accompanying finds of the Iceman and objects from an Alpine pass in Switzerland, the Schnidejoch. Parts of leather leggings and a shoe were secured there (Suter, Hafner and Glauser, 2005, p.512).

Objects from both sites were used to gain insights into the processing, i.e. tanning, of animal skins during the Neolithic.

The results are very complex. They indicate a possible treatment with smoke (Waateringe, 1992, 120ff; Goubitz van Driel, van Waateringe, 2001, p.37). The use of various animal or vegetable fats also seems likely (Lang, 2009, 211ff; Püntener and Moss, 2010, p.318; Spangenberg, et al., 2010, p.13). A possible combination of fats with various minerals and clays is also discussed (Lang, 2009, 211ff; Püntener and Moss, 2010, p.318; Klek, 2019b, 106ff). The incorporation of vegetable tanning agents (tannins) could be substantiated at least for the Schnidejoch artifacts (Spangenberg, et al., 2010, p.13).

For the first reconstruction (quiver 1) a commercially tanned deer skin was used.

However, for reasons already mentioned and since the treatment of fresh skin has a major impact on its later properties, the hide for the second reconstruction (quiver 2) was prepared by the author himself. The author has twenty years of experience in processing animal skins using prehistoric and traditional methods (Klek, 2019a). In the context of this article, the steps involved in tanning are not described in detail.

The fresh skin of an adult roebuck (*capreolus capreolus*) was used, which was shot in October, i.e. still in its reddish summer coat (See Figure 6). Stretching the hide in a frame during the tanning process ensures that the hide retains its maximum size after tanning and lies as flat as possible (See Figure 7).

A type of combination tanning was used for the treatment, which appeared plausible according to the above analyses. After fleshing, the skin was soaked in oak bark brew for eight days. After lashing into the frame, an aqueous grease solution was worked in several

times. This consisted of a mixture of sheep brains with some linseed oil. Subsequent smoking completed the process (See Figure 8).

The Pattern of the Main Part

The publication of the RGMZ (Egg and Spindler, 2009) includes technical drawings of all objects as separate leaflets. For the quiver, a pattern of the main part has also been included on a scale of 1:2 (Appendix 8). However, at the author's discretion, this drawing requires numerical modifications before it can be used as a direct cutting template. About two to two and a half centimeters of material must be added with respect to the width of the main part. This assessment is based on two facts. After the first reconstruction of the quiver (quiver 1) with the direct transfer of the drawings as a pattern, a surprisingly narrow quiver was created. Although this corresponds to the photographs of the original in its top view, it seems to offer too little volume or space for the 14 arrows and arrow blanks, as well as the other objects found in the quiver. An assessment of the computed tomographic X-rays of the quiver (1991) provided information in this regard.

The X-rays were originally taken to determine the contents of the quiver during the restoration, which contained two cords and several antler tips in addition to the arrows. But on closer inspection, they provide even more information. The photographs, which show the cross-section of the quiver at various points, indicate a correspondingly larger internal volume of the main part based on longitudinal bulges (Egg and Spindler, 2009, p.103). In the case of the technical drawings, the width dimensions of a simple top view were probably used as if the object lay completely flat, like a folded piece of paper. This led to a reduced result in terms of width (Egg and Spindler, 2009, Appendix 8). The calculated increase in width may appear small, but practically it makes a not insignificant difference (See Figure 9).

The same x-rays of the cross-sections can also be used to help decide the orientation of the fur for the main body (see below). The five exposures show a clear decrease in the thickness of the hide material from the base of the quiver towards the mouth over a length of about 39 centimeters. There are no further X-rays for the remaining length. Regarding the placement of the pattern on the hide, it can be taken for granted that it needs to be placed longitudinally, as this is the only way to achieve the necessary material length.

A single, large skin is required for the main part of the quiver, the surface value of which is used to the maximum in terms of length. This fact adds to the special position of the quiver within the finds complex. All other objects made of leather and fur, such as shoes, leggings, coats, belt, loincloths and hats, are made up of various individual segments, some of which are very small, in order to obtain the desired shape. Another remarkable aspect of the quiver is that the entire piece used for the main part does not have a hole, which would indicate a deadly injury to the animal. However, since the cutting pattern covers a considerable part of the entire hide surface, one can only speculate how the prey was killed.

Hits by projectiles such as arrows or spears are out of the question, at least in the area occupied by the pattern.

The orientation of the pattern on the hide raises the question of whether the quiver was oriented with the opening towards the animal's head or vice versa. Both variants have certain challenges (See Figure 10).

Variant A (See Figure 11) seems the most plausible. However, an above-average sized hide is needed. The slightly skewed placement of the pattern seems necessary to maximize length utilization. The course of the hair would essentially be oriented downward from the opening and to the side. During the practical use of the quiver, this could facilitate the drainage of rainwater and thus improve the protection of the quiver's contents from moisture. On the other hand, in the case of the longitudinal closing flap, which is formed by the skin of the neck, the hair would run in the direction of the mouth, which tends to cause a build-up of moisture in this area during rain. If one assumes that the longitudinal flap, which is not completely preserved in the original, reached to the strap below the muzzle to be knotted there, the deer must have been skinned along the entire neck and up to the head to achieve the necessary length.

With variant A1, a slightly smaller skin can be utilized, since the rectangular piece to which the transverse flap is attached is angled. However, this would lead to a bulge at the narrow connection point to the main part due to the compression of the skin material. After examining the photographs of the original, this effect hardly seems to exist.

Variant B, on the other hand, places the opening towards the rear of the animal. However, this requires sufficient material width in the neck area and a carcass skinned up to the hooves for the longitudinal flap. The water drainage on the longitudinal flap would be improved but impaired on the main part. The results of the thickness investigation on the computer tomographic images would most likely correlate with this variant.

When examining the remaining tuft of hair on the main part, which is located at the outermost end of the rectangular piece of the mouth, one can see that the course points away from the mouth, which would correspond to variant B or A1.

Another argument for variant B is that the skin of the deer is particularly thick in the neck area. Technically, it would make sense to use such a spot for the location of the quiver where the sharp arrowheads are.

The following refers to problems with the variants in Figure 11 indicated by the corresponding points:

A Point 1	The length is not sufficient, except for a particularly large hide.

A Point 2	Scratches on the original at this point speak in favor of such a placement. These could indicate intensive scraping of the skin on the neck during tanning, because the skin is particularly thick here.
A1 Point 1	At this thin point, the skin would bulge a little when it is placed in position. This should be recognizable on the original.
A1 Point 2	This positioning could provide a structural explanation why the transversal flap was attached separately. The hide lacks the necessary material to cut the flap directly from the deer skin.
B Point 1	Here the entire leg would have to be skinned to guarantee a sufficient length.
B Point 2	As with model A, there is no technical need to add a separate transverse flap in this case, as there is sufficient material available.
B Point 3	The skin of the neck never lays completely flat on any hide, which means that the entire width cannot be used, thus making a very large hide necessary.

The Wing Flap

The wing or transverse flap is a characteristic part of the quiver and is attached as a separate element with leather straps using the running stitch technique to an extension protruding from the main part. The flap is completely preserved and shows only minor damage and missing pieces. According to the analyzes of hair samples, the piece of skin is from a bovid (Hollemeyer, et al., 2012, p.1735). The remaining hairs, like those of the main part, appear to be reddish-brown in color. In both reconstructions, roe deer skin was also used for the transverse flap.

The flap is used to horizontally close the mouth of the quiver. Attaching it separately raises some questions. The skin material of the main part could also have been brought into the same shape with a simple cut. The fact that this did not happen could indicate that the skin of the main part either did not have enough surface area in that particular place, or that the cut-out was intentional in order to add a flap which, for socio-cultural or functional reasons, should derive from another species.

The meaning or function of the straps, which pull through the flap using the running stitch technique, have not been clarified. Their function as decorative elements cannot be ruled out. However, it should be remembered that with a hair-on hide they are hardly visible when the flap is closed. Another possibility is that the straps were used to pull the flap into a slight concave curvature giving the arrow fletching additional protection.

The Tools Used

It is not known whether the Tisenjoch man manufactured his own quiver. Equally unknown are the tools used to carry out this work.

Consequently, it cannot be assumed that the tools found on the body were used.

However, there is evidence that the tools carried were used at least on parts of the equipment. The axe, for example, left marks on the bow blank. The flint tools may have been used to make arrows, trim arrow feathers, and cut grass. (Egg and Spindler, 2009, pp.108,99). Regarding the making of the quiver, Egg noted that the flint drill may have been used to create the groove in the stiffening hazel stick, as its tip fits right into that groove (Egg and Spindler, 2009, p.107). In any case, it was decided to attempt the manufacturing of quiver 2 exclusively with replicas of the tools which the Iceman carried. The reconstruction showed that the man from the Tisenjoch had all the types of tools with him that are necessary to manufacture or repair a quiver.

A flint knife, a flint drill, a small flint blade and a bone awl were used, all pieces were of comparable morphology to the originals.

The tools proved to be sufficiently functional for the necessary work steps. However, the small flint blade became blunt due to the high stress and had to be replaced with a fresh one. The distal end of the bone awl was wrapped in leather to protect the hand.

It also proved to be rather short for optimal power transmission when piercing the hide. The flint drill was used when processing the wooden stick. Drilling the holes was tedious and the continuous rotation proved particularly tiring on the wrists. A leather wrapping was also necessary to protect the fingers from the sharp edges. The tip of the drill broke off once and had to be retouched by pressure flaking (See Figure 12)

The Wooden Stick

The material of the stiffening stick of the quiver has been identified as hazel (c*orylus avellana*) (Egg and Spindler, 1992, p.39).

The debarked stick is about 92 centimeters long and about 1.4 centimeters thick (Egg, 2009, p.104; Junkmanns, et al., 2019, p.293). It is cut longer than the leather of the quiver and protrudes about 4.5 centimeters beyond the lower end of it. The stronger end of the stick is at the bottom. A deep, V-shaped notch runs its entire length. Only the last centimeters of the lower end remain unprocessed. There are 20 holes in this groove, about 4.7 centimeters apart (Egg and Spindler, 2009, p.107).

A suitable, straight hazel rod is easy to find. Many hazel bushes have suitable shoots. The slightly curved lower end of the stick is a typical characteristic of these shoots.

It indicates that this end was cut where a first thin side shoot usually branches off. Such a sapling can be easily notched and broken off with the flint knife. Clean debarking is done with

the small blade. Since fresh wood is easier to work with than dried wood, it was decided to put the groove in immediately but let the stick dry prior to drilling the holes.

(See Figure 13, 14 and 15)

The small flint blade also proved very effective for cutting the V-shaped notch along the entire length of the stick. By working evenly with the knife-like tool, a groove can be gradually deepened and widened, whereby long, thin fibers can be removed. Working on knots is a bit more difficult. The groove was deepened down to the marrow, as can be seen on X-rays of the original (Egg, 1992, p.46). The stick was then dried at room temperature for three days without drying cracks.

After drying, the groove was given its final shape with the silex drill. The drill was pulled back and forth through the depression with long, scraping movements.

To prevent the wood from extensive fraying, the holes were drilled when it was dry. Due to the signs of abrasion visible on the original, the holes were drilled from the groove (Egg and Spindler, 2009, color plate 8). Drilling was tedious and the drill point broke off once and had to be reshaped by pressure flaking.

Two questions arise regarding the hazel stick. Why was it provided with a groove and holes? From the ethnology of North America, for example, quivers made of fur and leather are known, which are reinforced by comparable sticks. However, these remained unworked but were also tied to the quiver with leather thongs (Laubin, 1980, p.131).

On the other hand, the groove and the holes represent a decisive weakening of the stick. This is apparent by the fact that the stick broke during the Iceman's lifetime in two places, each time at a hole. In this context, the choice of wood can also be questioned. Why did the man from the Tisenjoch use hazel and not a more stable material such as dogwood (*cornus*)? He was familiar with its properties, as evidenced by the fore shaft of one of his arrows, which is manufactured from *cornus.* (Egg and Spindler, 2009, p.112).

(See Figures 16, 17 and 18)

The Construction Method (Quiver 2)

Cutting the hide after drawing the pattern can be achieved in a few minutes. The flint blade is ideal for cutting leather. Flat leather thongs were used to connect the sticks to the main part. One or two knots on these leather thongs can be distinguished on the original, so it can be assumed that there were at least two separate straps (Egg and Spindler, 2009, enclosures 7 and 8) Assembling the quiver must begin at the bottom. According to Egg, this part of the quiver was sewn together with an overcasting stitch from the hairless side, the so-called flesh side (Egg and Spindler, 2009, p.104). After that, the builder turned the skin inside out and

continued his work. The overcasting stitch is the predominant form of sewing and assembling of all the Iceman's clothing. However, the overcast stitch, when turned inside out, leads to a completely different stitch pattern than is visible on the original (Egg and Spindler, 2009, Enclosure 6), therefore the builder of the quiver must have used a different type of stitch. The stitch that corresponds to the original is the so-called baseball stitch. The variant used on the bottom of the quiver thus represents a third and previously undocumented type of joining for the equipment of the Tisenjoch mummy (See Figure 19).

The reason for the preference of the baseball stitch for the bottom of the quiver can be explained speculatively by the fact that it leads to a widening of the seam and thus provides a little more volume at the bottom of the quiver (See Figure 20).

The attachment of the stick, which at the same time represents the assembly of the main part, is carried out from the lower end in the direction of the opening. While tying, the edges of the skin are pulled into the notch of the hazel rod. An anomaly occurs after hole 11. This is where the first strap ends or is torn off. A new piece was tied on. However, as a result, only the skin was tied together with four stitches, but not connected to the stick, as with the other holes. So, two holes in the stick were left out. It is not clear whether this was a repair or an intentional action. When the main part is fully connected to the stick, the wing flap can be attached. On the other hand, it is also possible to connect the wing flap to the main part first. The tacking of the flap to the main part, as well as the underlaying and threading of it with the separate leather strips, is readily reproducible due to the good condition of the original and the detailed representation of the technical drawings (Egg and Spindler, 2009, Appendix) (See Figures 21 and 22).

Work step	Quiver 1	Quiver 2
Tanning	-	480 min
Preparing stick	110 min	210 min
Assembling main part	65 min	60 min
Horizontal flap	95 min	120 min

TABLE 1. DURATION OF THE VARIOUS WORK STEPS. THIS EMPIRICAL DATA CAN ONLY BE UNDERSTOOD AS APPROXIMATE VALUES. FOR QUIVER 1 A METAL KNIFE, DRILL AND AWL WERE UTILIZED.

Outlook and Discussion

The quiver from Tisenjoch represents a very interesting object within the collection. The final identification of the skin material on the main part is, as explained in the article, of imminent importance for the object. Further direct sampling of this part would therefore be important and desirable. Less invasive methods, which could manage with smaller tissue samples, are available today (Maixner, personal comm.). The construction and function of the stick and the

transverse flap should also be examined more closely in further practical tests, in order to get to the bottom of the remaining mysteries.

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(re)construction
skin or leather

Country Italy

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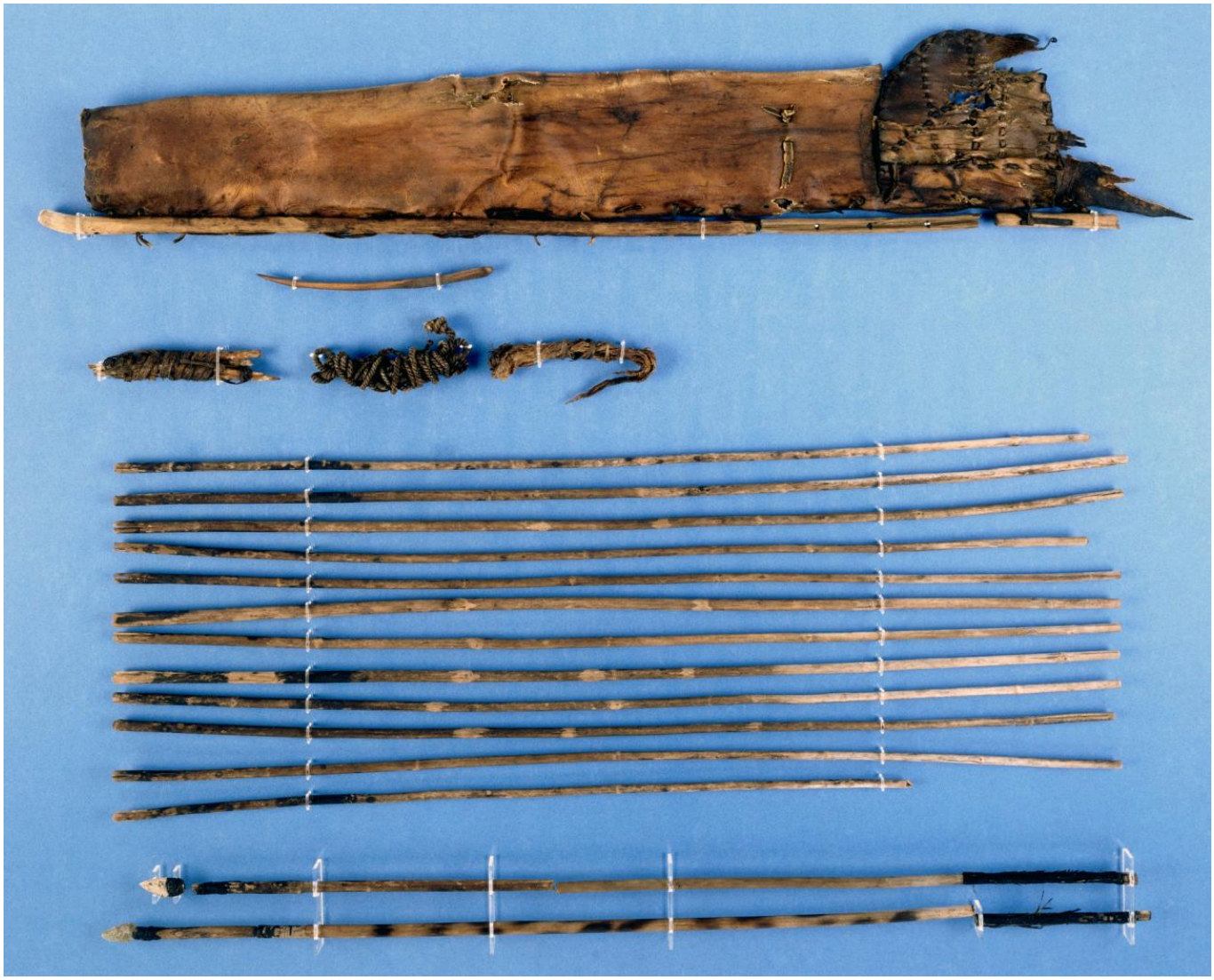

FIG 1. THE QUIVER AND ITS CONTENTS. PERMISSION BY RGMZ (MAINZ). PHOTOGRAPHER: DÖRTE CHRISTIN BEEK. DIA. NR.: CD_1995_0157

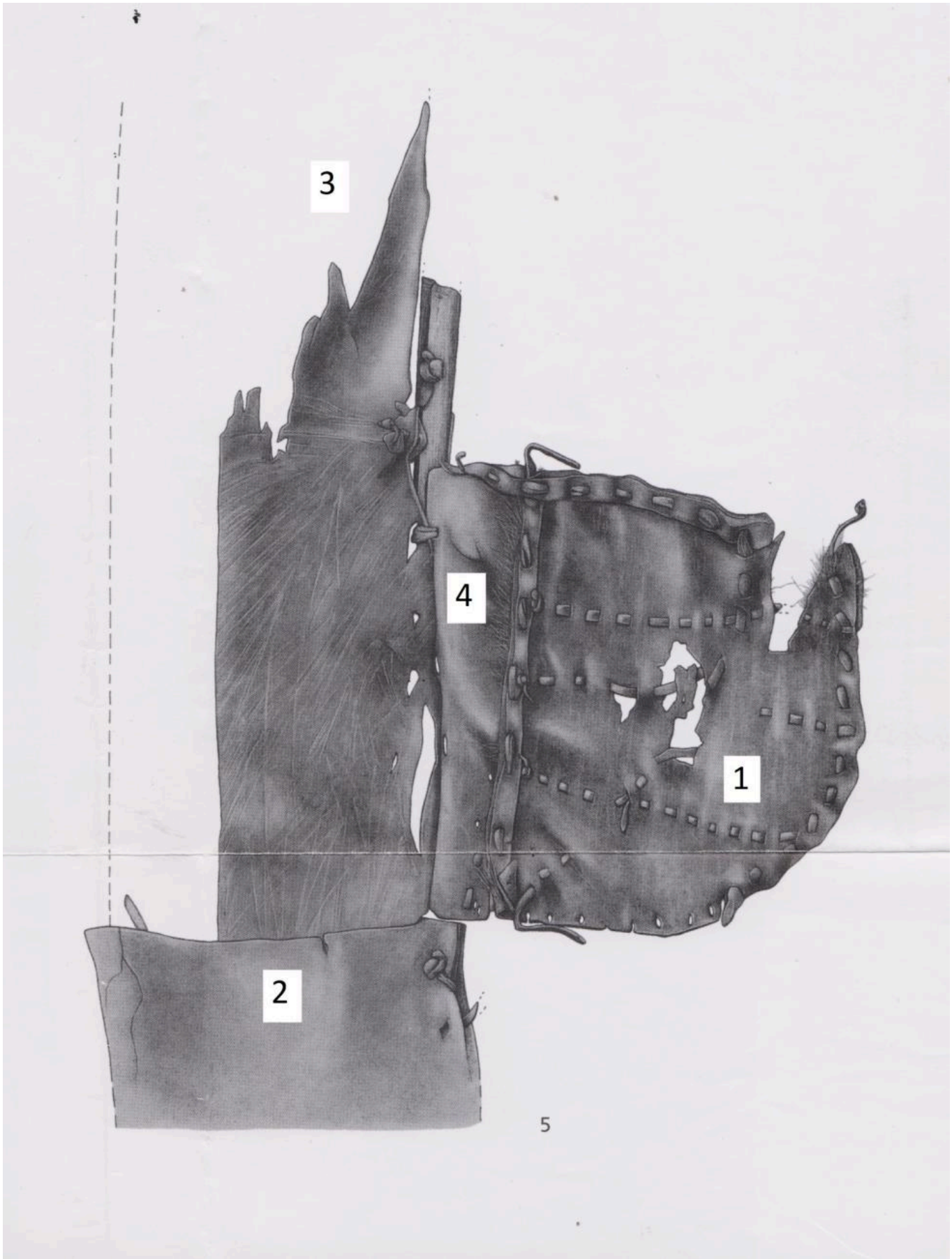

FIG 1A. TECHNICAL DRAWING OF THE OPENING AREA. VISIBLE HERE ARE THE DETAILS OF THE TRANSVERSE FLAP (1), AS WELL AS THE REMAINING CONTINUATION OF THE MAIN PART (2), WHICH WAS MOST LIKELY TURNED OVER THE TRANSVERSE FLAP AS A CLOSURE. PART OF THIS DAMAGED LONGITUDINAL FLAP (3) COULD HAVE BEEN THE FUR STRIPES, WHICH WERE SAMPLED IN 2016. ALSO RECOGNIZABLE IS THE ELONGATED RECTANGULAR PIECE (4) OF THE MAIN PART TO WHICH THE TRANSVERSE FLAP IS ATTACHED. PERMISSION BY RGZM, MONOGRAPHIEN,

BAND 77, APPENDIX 7 (2009) (DRAWING BY ANDREAS BLAICKNER/MICHAEL SCHICK, INSTITUT FÜR ARCHÄOLOGIEN, LEOPOLD-FRANZENS-UNIVERSITÄT INSBRUCK)

FIG 2. SAMPLES OF WINTER HAIR (ABOVE) AND SUMMER HAIR (BELOW) OF THE ROE DEER. THE DIFFERENCES ARE CLEARLY RECOGNIZABLE IN TERMS OF COLOR, STRUCTURE, AND LENGTH OF THE HAIR. PHOTO BY MARKUS KLEK

FIG 3. UPPER PART OF THE QUIVER. VISIBLE IS THE REMAINING HAIR AT THE END OF THE MAIN BODY AND ON THE FLAP. PERMISSION BY RGZM (MAINZ). PHOTOGRAPHER DÖRTE CHRISTIN BEEK. DIA. NR.: CD_1993_0134(DETAIL)

FIG 4. FIRST BASIC REPRODUCTION OF THE QUIVER FOR THE PEDAGOGICAL DEPARTMENT OF THE MUSEUM OF ARCHAEOLOGY IN ZUG, SWITZERLAND (QUIVER 1)

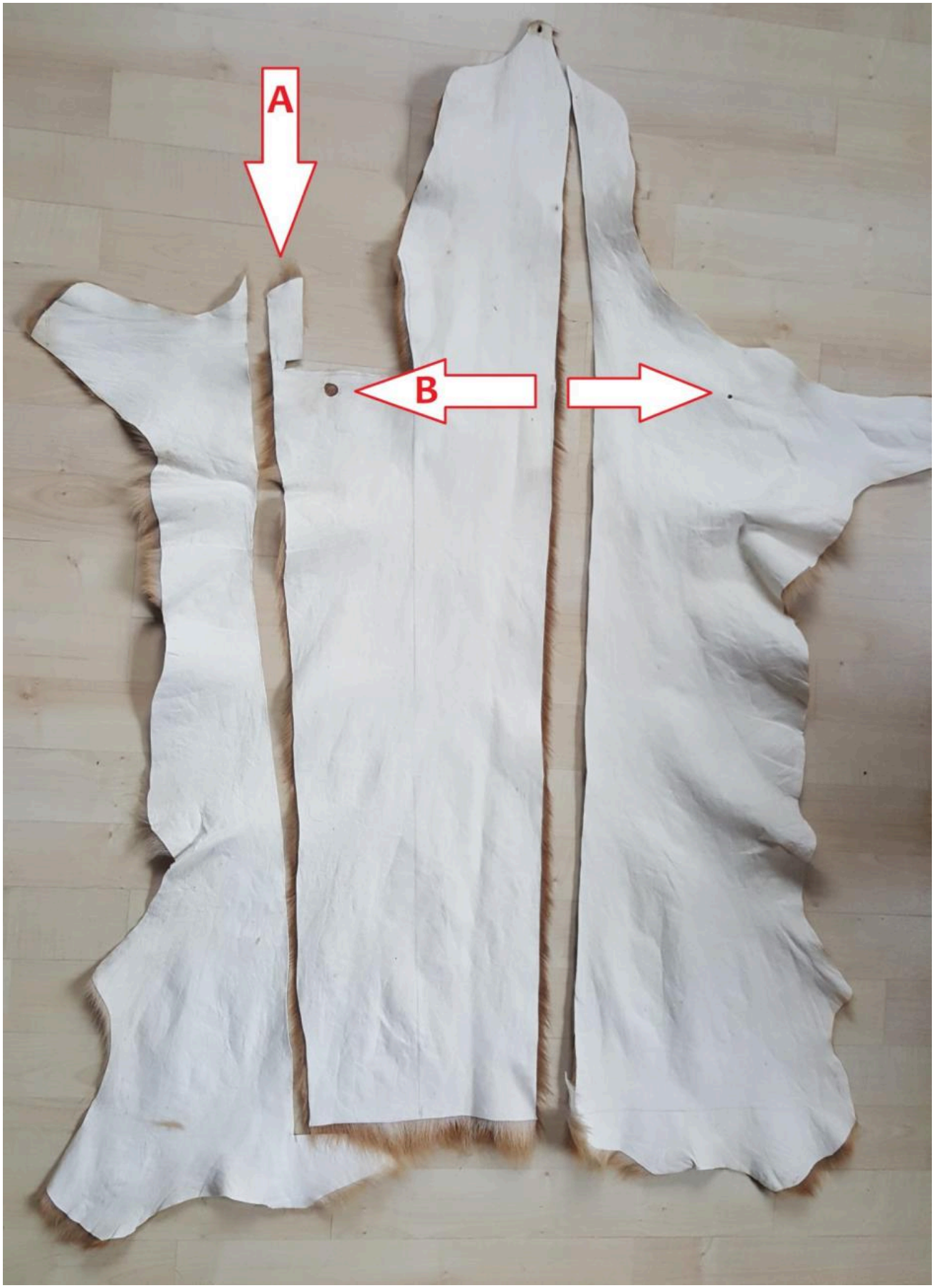

FIG 5. THE LARGE ROE DEER SUMMER HIDE FOR QUIVER 1 AFTER CUTTING. A PIECE OF HIDE HAD TO BE ATTACHED AT THE MARKED POINT (A) TO MATCH THE DIMENSIONS OF THE ORIGINAL. THE ARROWS (B) MARK THE BULLET ENTRY AND EXIT HOLES. PHOTO BY MARKUS KLEK

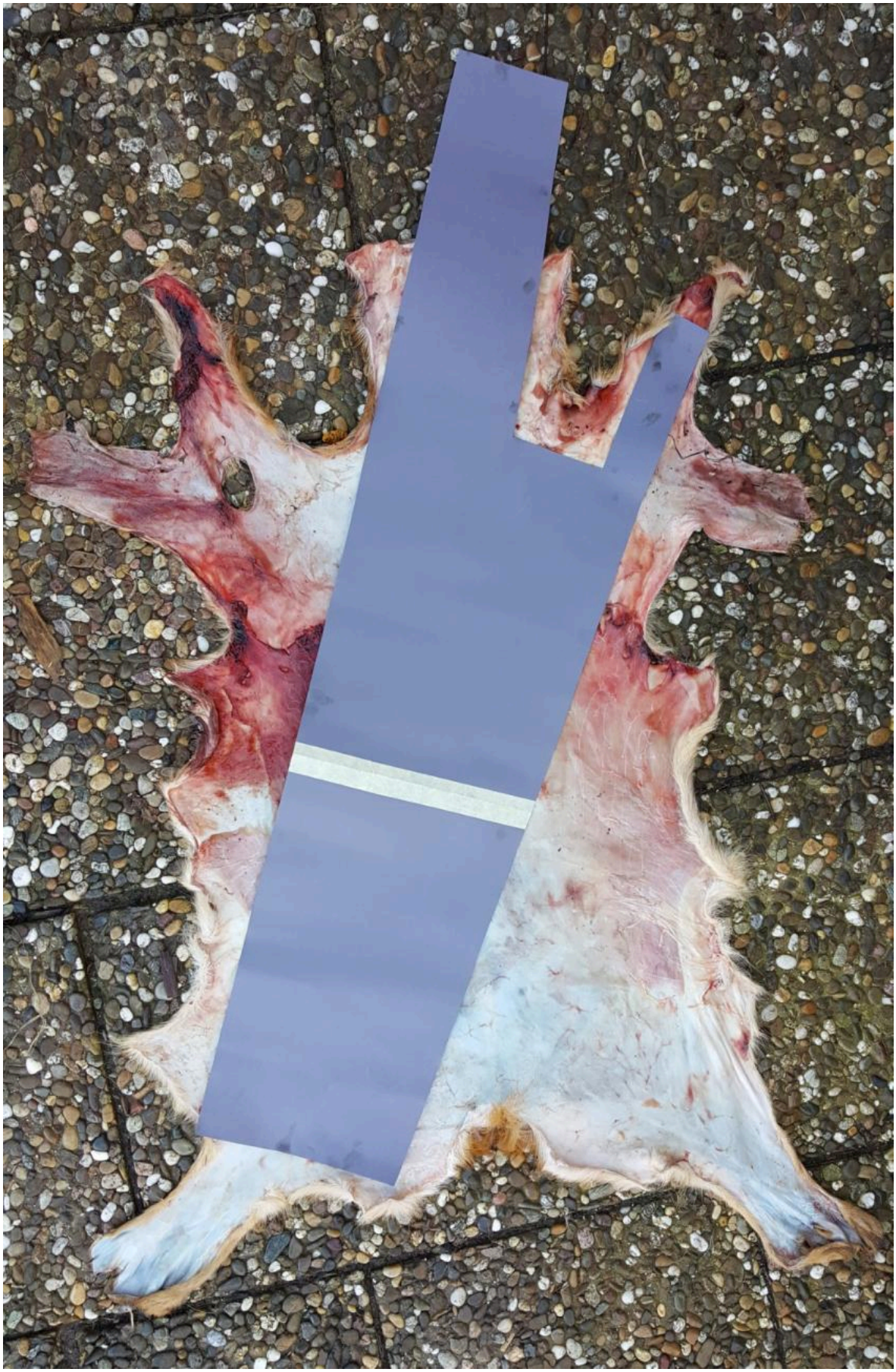

FIG 6. PATTERN FOR QUIVER 2 PLACED ON THE FRESH UNPROCESSED DEER SKIN. PHOTO BY MARKUS KLEK

FIG 7. THE AUTHOR'S WORKSHOP. THE DRIED DEER SKIN IN THE FRAME AFTER AN INITIAL TREATMENT WITH OAK BARK EXTRACT, VISIBLE AT THE LEFT. PHOTO BY MARKUS KLEK

FIG 8. WORKING IN THE FAT SOLUTION. PHOTO BY MARKUS KLEK

FIG 9. CREATION OF THE PATTERN. AN ENLARGED SCAN OF THE TECHNICAL DRAWING (EGG, APPENDIX 8) WAS PLACED ON RIGID CARDBOARD. THE CALCULATED 2.5 CENTIMETERS ARE THEN ADDED TO THE WIDTH. PHOTO BY MARKUS KLEK

FIG 10. PLACEMENT OF THE PATTERN ON THE HIDE. TYING IN A FRAME MAKES IT POSSIBLE TO GAIN MAXIMUM SIZE BUT REDUCES THE THICKNESS OF THE MATERIAL. PHOTO BY MARKUS KLEK

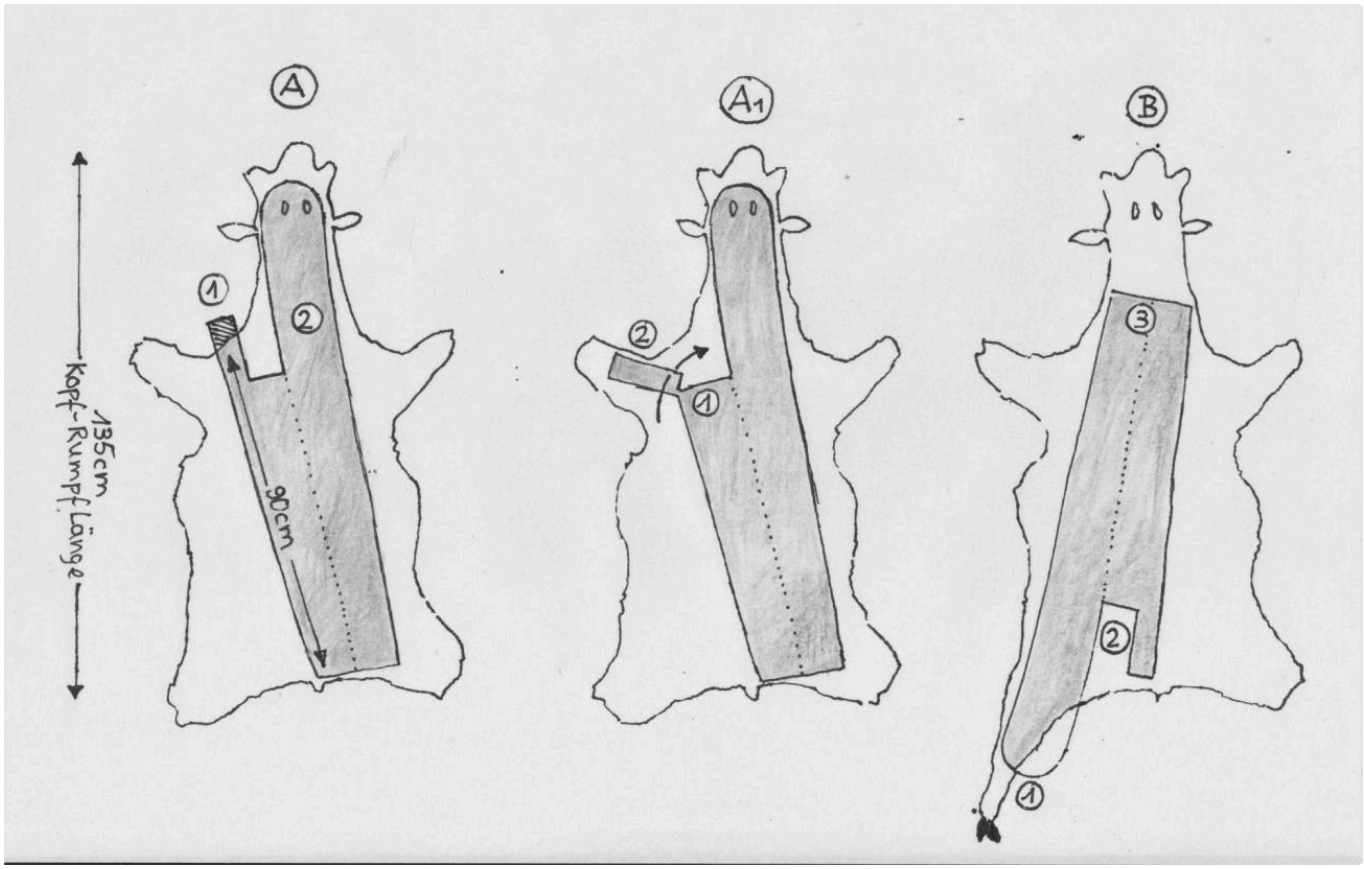

FIG 11. GRAPHIC DRAWING OF THE PATTERN VARIANTS. PHOTO BY MARKUS KLEK

FIG 12. TOOLS USED BY THE AUTHOR. PHOTO BY MARKUS KLEK

FIG 13. CUTTING THE STICK WITH THE SILEX KNIFE. CONSIDER FLINT FOR SILEX. PHOTO BY MARKUS KLEK

FIG 14. CUTTING THE GROOVE WITH THE SILEX BLADELET. PHOTO BY MARKUS KLEK

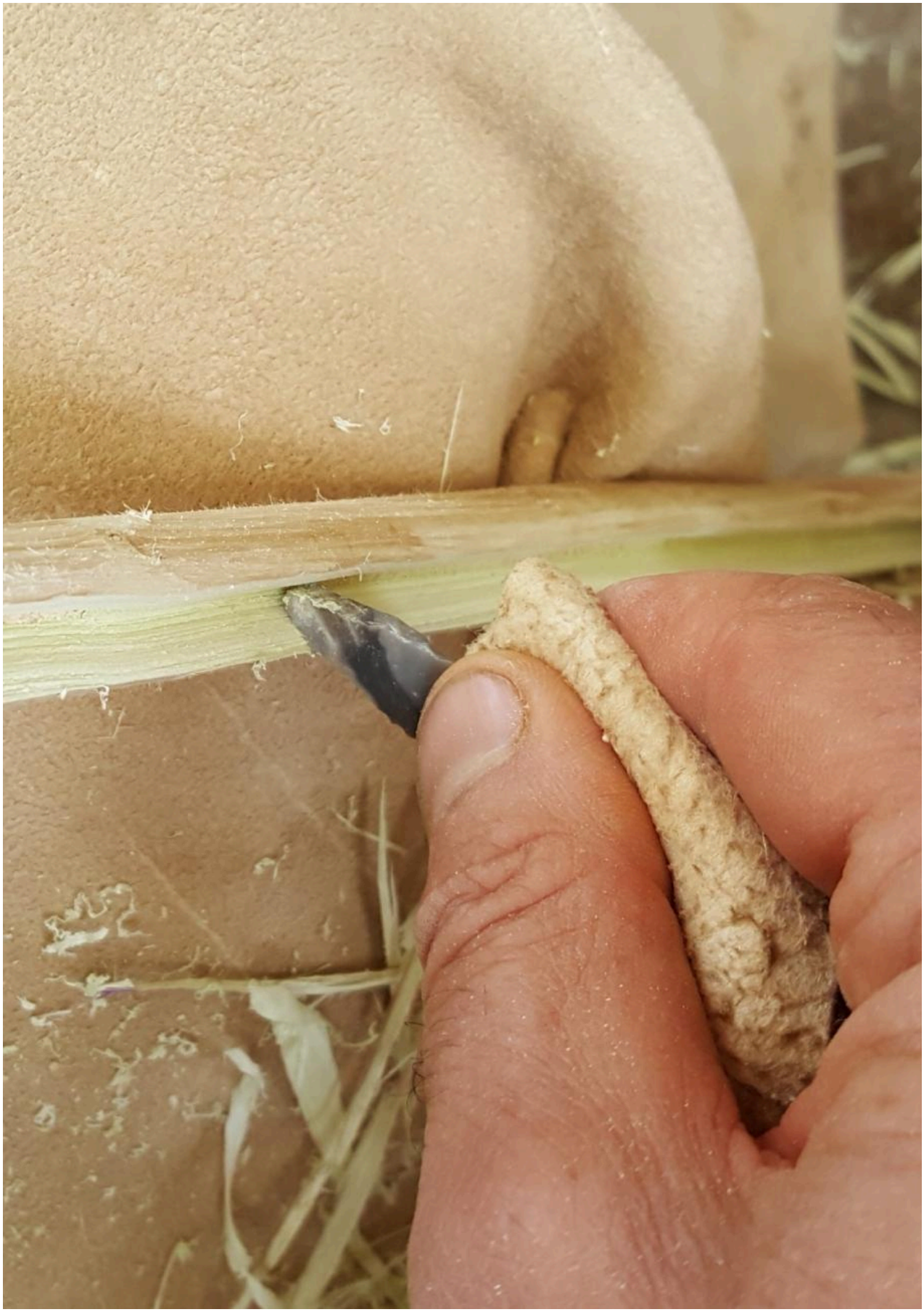

FIG 15. DEEPENING THE GROOVE WITH THE SILEX DRILL. PHOTO BY MARKUS KLEK

FIG 16. DRILLING THE HOLES WITH THE SILEX DRILL. THE GRIP PART IS WRAPPED WITH A PIECE OF LEATHER FOR BETTER HANDLING. PHOTO BY MARKUS KLEK

FIG 17. CUTTING THE PATTERN FROM THE HIDE WITH THE BLADELET. PHOTO BY MARKUS KLEK

FIG 18. DETAILED VIEW OF THE MOUTH OF A PLAINS INDIAN QUIVER. REPRODUCTION BY THE AUTHOR. VISIBLE IS THE UNPROCESSED, STIFFENING STICK, WHICH IS CONNECTED TO THE QUIVER BY A SPIRALING LEATHER THONG. PHOTO BY MARKUS KLEK

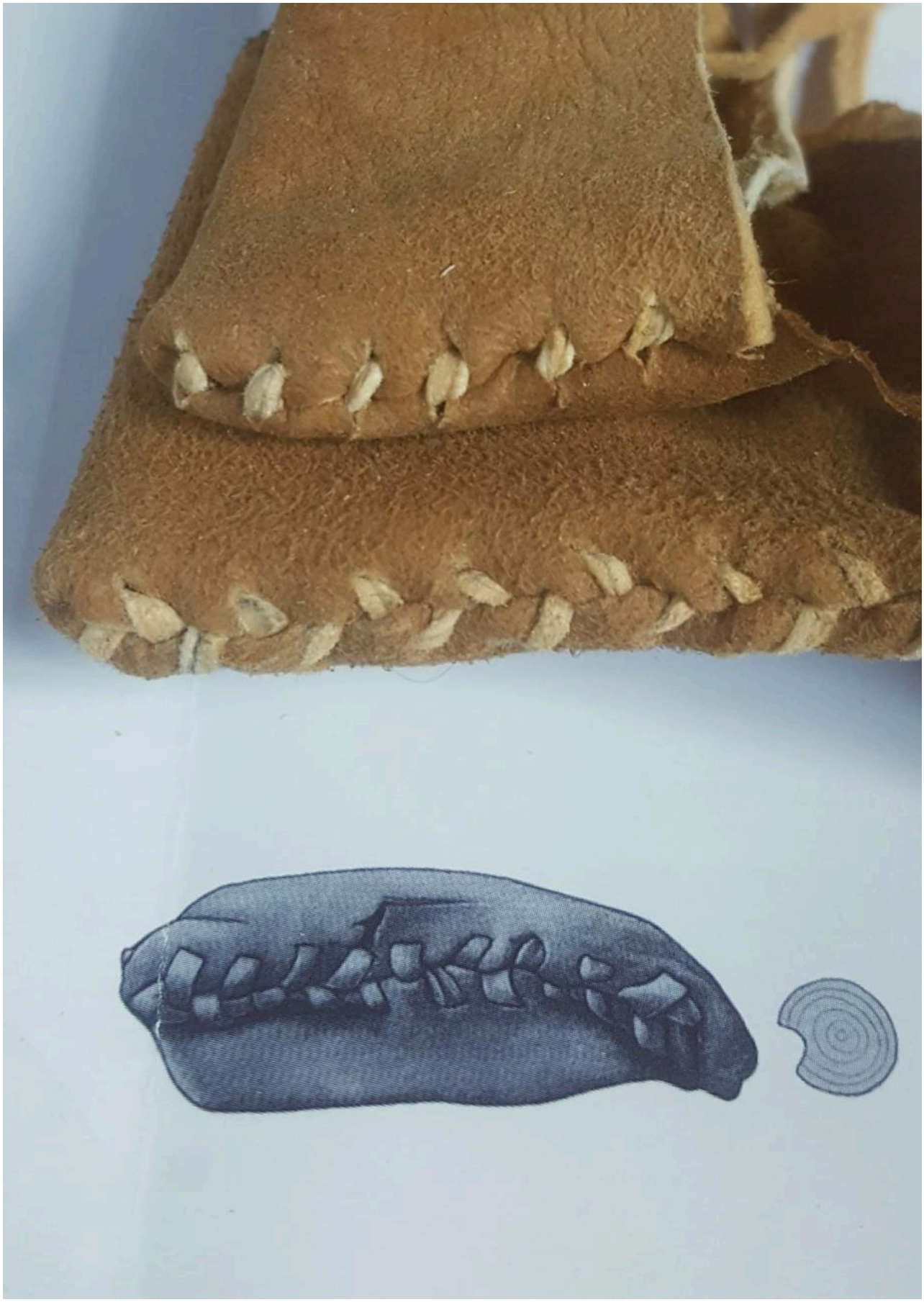

FIG 19. THE WAY THE BOTTOM OF THE QUIVER IS STITCHED TOGETHER INDICATES THE USE OF THE BASEBALL STITCH. AT THE BOTTOM, THE ORIGINAL IS REPRESENTED GRAPHICALLY (EGG 2009, APPENDIX 6). ABOVE, A COMPARABLE, EXPERIMENTAL SEAM IS SHOWN USING THE BASEBALL STITCH. ON TOP IS THE CORRESPONDING RESULT OF THE OVERCASTING TECHNIQUE. PHOTO BY MARKUS KLEK

FIG 20. LACING THE STICK TO THE MAIN PART OF THE QUIVER. PHOTO BY MARKUS KLEK

FIG 21. FINISHED WING FLAP. PHOTO BY MARKUS KLEK

FIG 22. FINISHED RECONSTRUCTION. QUIVER 2. PHOTO BY MARKUS KLEK