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Arrowhead Collecting On The Web

Readers will remember Vittorio Brizzi's previous article about Bronze Age arrowheads in Northern Italy published in the December 2011 edition. He is the Professor of Experimental Archaeology at the University of Ferrara in northeastern Italy. He has performed extensive studies into the tools and weapons found with the "Ice Man" whose mummified body was discovered in 1991, high up in the Alps along the border between Italy and Austria. In May and June of 2012, his home area was hit by several large earthquakes. You can read his email correspondence about those events on page 16.

"Otzi, During His Last 24 To 48 Hours Was Probably Involved In A Really Awful Battle For Survival. Not Against The Natural Elements But Against His Fellow Men."

by Vittorio Brizzi & Alice Brizzi

Hundreds of mummified figures have been found throughout the world. Some of them were as old as the Iceman, but none was discovered in his exact circumstances. Almost all of these mummies had arranged burials in which the mummification process was carried out by man or brought about by particular climatic or environmental conditions. These burials, in fact, tell us a great deal about a mummified person, and give us extremely interesting facts about its physiology, biology and genetics. But most of all, these details are important to give us evidence of ritual or religious procedures which, in turn, can relate to specific social or cultural characteristics.

In the last few years several theories have been formulated about the death of the Iceman. Some of those, made recently by reputable scientists, are strongly against the scientific evidence discovered to this date. One of the most off base theories is without doubt the one which postulates a "ritual burial." As in any scientific debate, all assumptions are considered, until certainty and facts prove otherwise.

What is certain is that this late theory of a "ritual burial" is quite hard to digest. Primarily because the scenario of an escape in which a running battle to the death occurred fits the forensic evidence which has been discovered.

Figure 2. *Chest x-ray of the Iceman: first radiography of the arrowhead.*

Figure 1. *The Otzaler Alp mountain, the red circle is the site of the Iceman, located just 60 meters inside Italian territory, outside Austrian land. He was found here in 1991, on the glacier.*

This evidence has been studied, its understanding has matured, and today this story of a conflict, flight and subsequent death high on the mountain is quite difficult to dismantle.

This article will examine some of the components of this scenario, relating to the documentary evidence of the arrowhead found eleven years ago in the Iceman's left shoulder, and some aspects of the "material culture" of Copper Age artefacts like stone arrowheads.

Ötzi, in fact, is a 5,200-year-old photograph. His particular distinctiveness is that he was frozen deep in time physically along with objects of his relevant daily lifestyle. Those numerous functional artefacts found near his body allow us some room to conjecture about how he lived, his habits and even his personality. All of this, part of an enormous Copper Age culture scan, yields much information. Thanks to earlier archaeological excavations and recent scientific studies, we now have been given a rare insight to comprehensively reconstruct a chain of knowledge and events to understand the last days of the Iceman's ("Ötzi" as he has been nicknamed) life.

Ötzi, during his last 24 to 48 hours was probably involved in a really awful battle for survival.

This was not against nature, but against his fellow men.

His wounds, apart from the arrow head in his shoulder, stand witness: the cuts on his hand and forearm; the bruises on his back and the blood from more than four different men on his

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knife, jacket and the point of a broken arrow which he carried with him in his quiver.

There were few certainties in this case, and it would be difficult not to lose oneself in fantasy.

Ötzi's shoulder wound, it would be fair to suggest, might well have been the mortal blow, even though it is well known that in certain cases people struck by a flying projectile can survive for a long time. One example of this is Kennewick Man, dated back 9,200 years ago in Washington state, who had a spear point embedded in his pelvic[2] bone; the stone fragment was surrounded by regrown bone tissue … evidence that he survived. Another example is that of a woman, 11,000 years ago, from the Grotta di San Teodoro, in Sicily, who had remnants of a stone projectile stuck in her side … she survived the wound for a long time. Once again the regrown bone tissue bears this out.

My own hunting experience using prehistoric equipment, and that of other bow hunters with whom I am in contact, could be useful to understand some aspects of the battle in which Otzi was involved, but only up to a certain point … I've never been involved in a real battle between humans, and modern reference works are scarce about the topic of archery-based conflict.

The impression which I get from the wound and the penetration of the arrow, compared with examples of similar situations in wildlife, is that the injury could have been (or become) fatal, even if the times and circumstances as they are known today are unable to support an absolutely positive verdict.

In our case the facts are these: The arrow penetrated the jacket material at the left shoulder, smashed the shoulder blade, stopping a few centimetres from a lung. The forensic observation[3] proves that the arrow shaft was removed before death and no parts of it remain in situ.

By removing the shaft of the arrow, its head must have been slightly retracted to such a position where the barbs securely caught in the tissue and, eventually, the arrowhead separated from the now missing shaft. This also

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Figure 3. *CAT SCAN of the Iceman shows the arrowhead embedded in his left shoulder.*

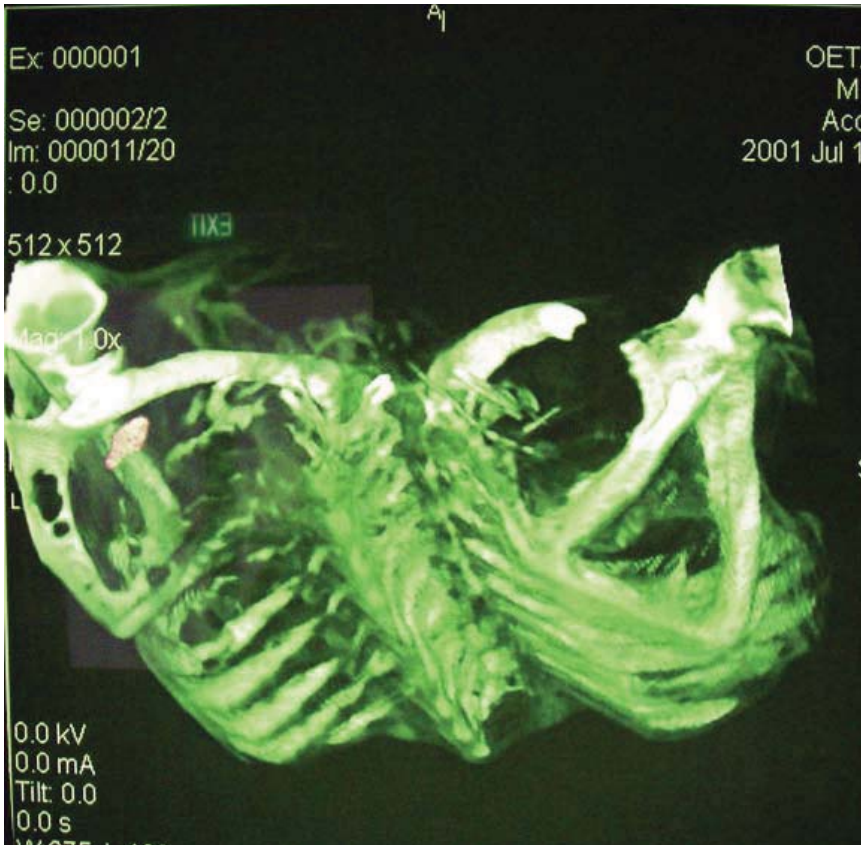

Figure 4. *3D view of the arrowhead.*

indicates that the Iceman was at this time in a semi up right position, similar to the one in which his corpse was found in 1991 on the glacier. The outer end of the shooting channel is currently obstructed by the prominently right-bending left arm.

Since the slightly more ventrally positioned subclavian vein can be clearly identified, this also proves that the lacerated more dorsal vessel must be the subclavian artery. Major symptoms often include massive active bleeding, expanding haematoma and shock-related cardiac arrest. Certainly this wound was very painful, worsened by a heavy bleeding coupled with a progressive weakness.

The Murderous Arrow Head

Of the arrow shaft that killed Ötzi nothing is present except for the small flint arrowhead, first discovered by Gostner's x-ray in Bolzano. The arrow point was subsequently rebuilt with a rapid prototyping process based on a three-dimensional tomography (CAT-SCAN). Naturally x-rays pass undisturbed through organic materials, so it is quite impossible to know how much organic material may still be attached to the arrow head. (***Figures 1, 2, 3***) From the pictures of the reconstruction I made it is easy to notice how the prototype process made point is lacking in details; it measures 2.1cm long by 1.7 wide. (***Figures 5, 6***)

I almost forgot to say that those reports, showing the amazing details of Ötzi's archery accessories, may suggest a sub-alpine cultural tradition. This conclusion is possible because the arrow heads fitted to the only two complete arrows in the quiver (supposing of course that these arrows are Ötzi's own and not collected during the anxious flight of his running battle) belong to a style of point used on the southern alpine slopes (Remedello Culture, ***Figure 7***) and are not north Tyrolean arrow heads from the mountain cultures.

Moreover, the arrow head in the Iceman's shoulder, even if shorter, is of the same type. Archaeological evidence shows that the ancient Austrians (of the Cham and Altheim Culture, ***Figure 8***) preferred flat-bottomed or slightly curved triangular arrowheads minus a central stem.

Figure 5. *The arrowhead rebuilt by a rapid prototyping process based on three-dimensional tomography CAT-SCAN.*

Figure 6. *The flint replica by the author.*

Figure 7. *"Classical" arrowheads of the Remedello Culture, author's replicas.*

This characteristic shape, both cultural and functional[1], clearly identifies the arrow head and allows the gory incident which happened to Ötzi to be recorded as the result of a clash or disagreement between people from the slopes of the Southern Alps. On the other hand, investigating the food remains eaten by Ötzi, we understand with reasonable accuracy his route which began from the Valley Venosta, continued in direction of the present artificial lake of Vernago, and then along the Tisental (the valley of Tisa), as far as Giogo di Tisa. The murder scene was then on the crest between the Punta di Finale and the Hauslabjoch, which mark the borders between the northern and southern slopes of the Otzaler Alp mountain range (***Figure 1***).

Figure 8. *Cham & Altheim Culture arrowheads, author's replicas.*

This tells us in all probability that Ötzi's attackers were proto-Italic men. If the arrows in the whole quiver, those fitted with arrow heads, were owned by our man, he may come from the same ethnic background. Having said that, the doubt about the small arrow head remains; at this point we still have many uncertainties.

We are sure just about one thing: The

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arrow head is really quite small, yet it penetrated 50mm (2") of cloth and smashed the left shoulder blade. We don't know if the arrow may have also passed through other cloth or fabrics and what additional damage the impact might have caused.

And here is the doubt: Was it a "last chance" attempt, shot from a strong bow and arrow weapon system fit for a real warrior or perhaps from a light bow made for a less imposing "weedy" man? (Might this suggest a theory about an angry lover?)

The size and the form of this arrow head was the result of a corrective adjustment to allow its re-use.

In other words, the arrow head formed a portion of a set of archery equipment similar to that used by Ötzi.

The reader should make note of this fact: The relative power of the propulsion unit of a bow and arrow hunting system allows a solitary hunter (or, for that matter, one who tracks game with fellow hunters) to shoot an arrow effectively at short to medium range, both for accuracy and body-damaging impact. This helps in the retrieval of bigger game, by not giving prey a chance to run away with a lesser wound.

Figure 9. *Comparison between Iceman's shoulder arrowhead (bottom right) and "usual" arrowheads found in burial sites of the Remedello Culture.*

Up to now, everything seems to make sense: I would never dream of going off to hunt large game (like the black bear, the European red deer or the big alpine Stambecco – Capra Ibex) with a

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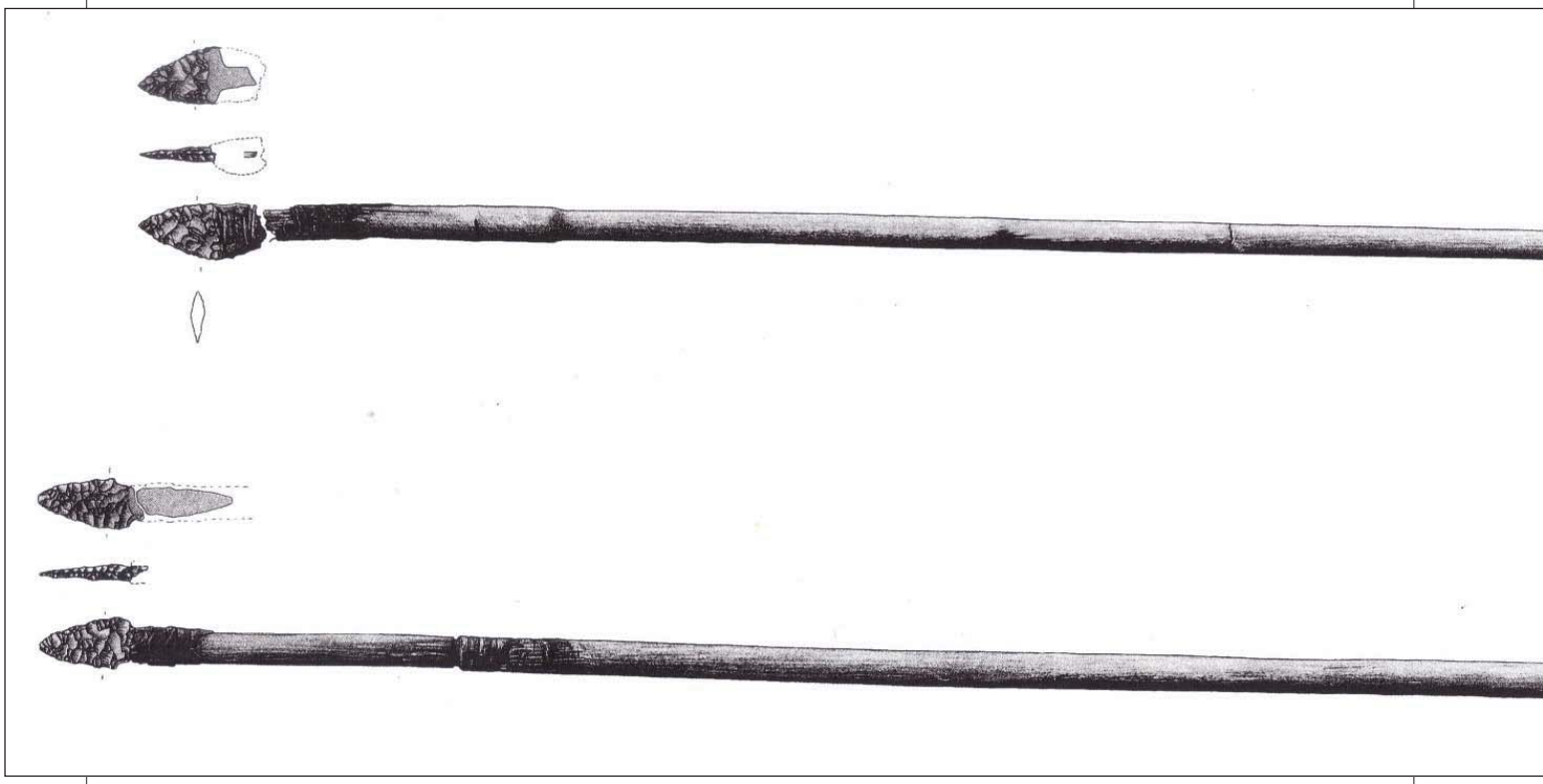
Figure 10. *Otzi carried a 14-arrow quiver -- a dozen rough-hewn Viburnum (Viburnum lantana) shafts, each with a single incision for the arrow head, and two complete but broken shafts. One of these was entirely made of Viburnum; the other was a composite, with a Cornel (Cornus mas) foreshaft which was armed with the arrow head.*



bow weaker than 70 pounds and with arrows lighter than those found in Ötzi's quiver.

What means the term "last chance"?

Accounts reveal eye witnesses telling how, in emergency situations, hunters emptied their quivers against a target. As a good hunter, the archer carries many arrows on his shoulders, among them different style and weight arrows, some intended for large and some for small game. When in deep need, having already shot his most appropriate arrows, he may be driven to empty his quiver, even using those intended for different game.

In Denmark, near lake Vig, they found a very beautiful Mesolithic aurochs or urus rib (Bos Primigenius) with a trapezoidal arrow point struck in it (the classical transversal cutting edge, a trapezius with the bigger side corresponding to the impact edge)[4] .

It is easy to imagine how that poor bison, already wounded by the other arrows and about to be killed like a bull full of banderillas or barbed darts, felt when this extra arrow hit him. In theory, it was not meant for him. The hunter had certainly targeted him, firing every available arrow. I would probably have done exactly the same thing with a wounded and very angry bison in the middle of the water, not worrying about the "how".

My opinion that the Iceman's arrow head was the result of a "repair job" after previous use stems from the fact that its base dimension are very close to those of the others, which in other aspects are longer in form, more like new, unused points.

As far as I know, "new" arrow heads with a design which could be contained in a square (I mean the "body" of the arrow head without the stem) have almost never been found in burial sites; instead, in burial sites you find many unused arrow heads with an isosceles triangle shape base twice or more the body length.

On the other hand, reshaped and reworked arrowheads which are now shorter in their linear dimension are common enough in the shallow ground surfaces where, presumably, they were witness to multiple hunting and/or fighting episodes; the tips being re-sharpened after impact damage, while the base would not need repair as often.

Comparing the reproduction arrow heads (***Figure 9***) to those in Ötzi's equipment (see ***Figure 10***) you can see at once that the base or tang length is more or less similar, while the "live" area length is almost doubled. As you can see in the photo of my reconstruction, the length is not bad.

The one thing common to all three of the original arrow heads I think is the system of re-utilisation, which is evident from the similarity of the finishing retouches and the obvious signs of impact (this assumption of damage from actual use impact is backed up by blood traces found in two of the items from the quiver, see below).

The shoulder arrowhead from the Iceman's body could be characteristic of the more advanced re-utilization process. The reshaping naturally concerns not just the arrow's point but its shoulders, too, which may suffer damage when the arrow enters its target.

In many hunting scenarios this has

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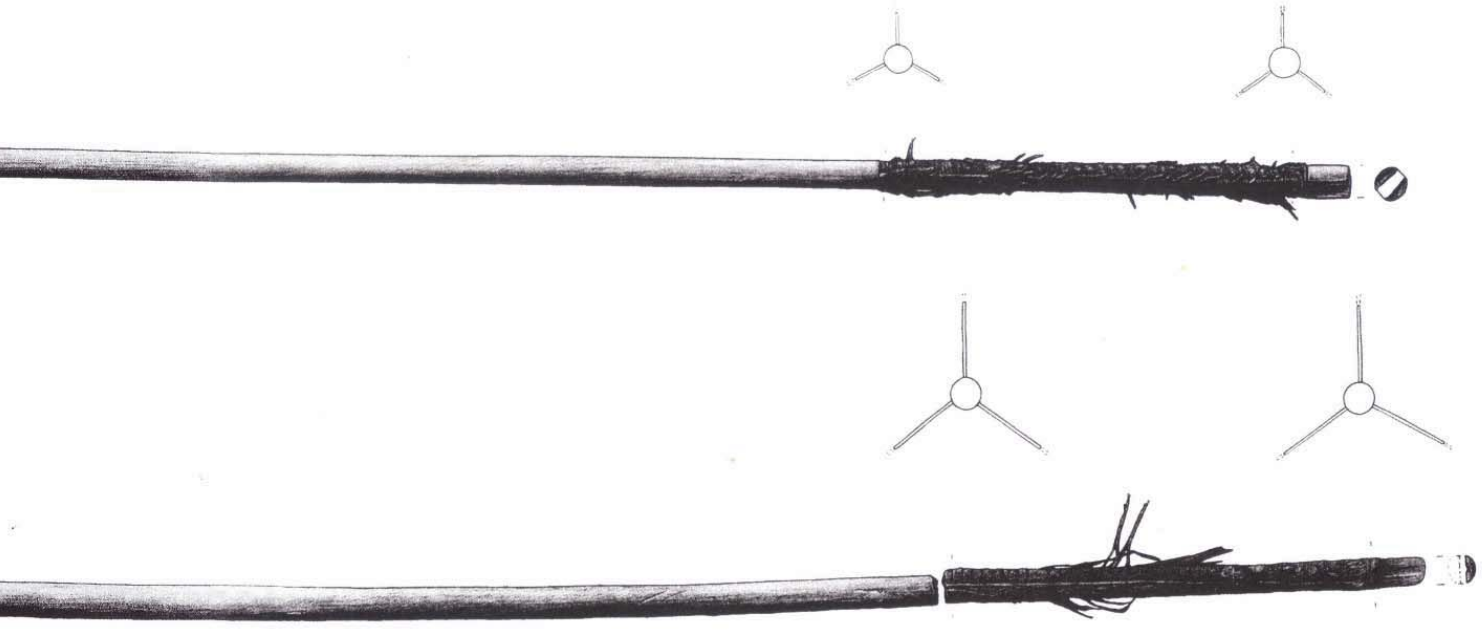

happened to my arrowheads. I have had to reshape the arrow head's edge and even make some stronger adjustments to arrows which were damaged when they missed their targets or even arrows which hit their targets but lost their wholeness in the impact.

During these very hurried situations (I had neither the time nor the equipment to hand) I have often adjusted the arrow head by simply supporting my work on a tree trunk as a support and using a deer antler tip to reshape the damaged arrowhead by pressure flaking (see Ötzi's pressure flaking tool in ***Figure 11***). Up to a certain limit, it is possible to continue reshaping a damaged arrow head without compromising the arrow's ballistic performances, but when the "live area" length of the point becomes smaller than its width, the arrow becomes "downgraded". Personally, I re-use these arrows for hunting small game (and winged game, replacing the tail feathers with three having bigger surface, so that their penetration capability is less than needed for big game.

The Arrows In Ötzi's Quiver

Now, regarding the arrows in Ötzi's quiver, I refer to the undamaged ones (with attached points) which are the most powerful you can have at your disposition … the complete arrow weighs about 900-1000 grains each (***Figure 10***).

Based on the current knowledge you can just imagine a very powerful weapon system with a bow boasting 38 to 45 kg tension, worthy of an English bowman during the Hundred Years' War!

This is quite different from Arm Paulsen's thought, who has tried to reproduce Ötzi's unfinished bow, supposing it to be a standard version bow from that civilization. I prefer to consider Ötzi's bow shaft as a makeshift temporary weapon, a transitory prototype, an incomplete expedient destined for use in an emergency (due to the on-going fight and the lack of time to prepare himself with effective equipment).

Without going into too many theoretical considerations, the large number of his arrows, their length and diameter were also more suitable to a very strong bow. In 2006 I published a study[5] about this topic, and in 2011 I began a research program[6]. Starting from these facts, dimensions and weights, the kinetic energy calculation (and that of momentum) from the arrow is a straight forward process. You can then calculate the draw of the bow which has discharged these arrows with reasonable accuracy.

Figure 11. *The Iceman's retouching tool (antler tine hafted in Tilia wood handle).*

Figure 12. *The little flint Dagger in the Iceman's equipment. The blade is a clear example of Remedello side notched typology (V. Brizzi--S. Iacopini replica).*

Ötzi carried a 14-arrow quiver … with a dozen rough-hewn Viburnum Lantana shafts (each with a single incision for the arrow head) and two complete but broken shafts (***Figure 10***). One of these was entirely made of a single shaft of Viburnum. The other was a composite, with a Cornel (Cornus mas) fore shaft, which was armed with the arrow head. Some say that the additions of such extensions were made in order to re-use a shaft which had been previously broken in its last 10 cm. I rather believe it was the intentional first design for the arrow, rather than an attempt at repair. Evidence of creating such a two-stage missile (the fore shaft) is well noted in numerous primitive societies.

The last two arrows were also different: Helicoidal or flattened spiral feathering, fastened to the shaft with birch-bark glue and reinforced with a wrapping of lamb's hair, one of them in a right helical twist, the other one in a left helical twist. This was supposed by Arm Paulsen, (the first re-constructor of Ötzi's personal archery effects), to have been produced by two different people; one of them right-handed, the other, left-handed.

At a first glance, this explanation appears perfectly reasonable.

Then, one day, I scanned through the arrows that I normally use for hunting, and I found the same thing. A number of arrows, made a long time ago by

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someone whom I don't clearly remember, in an old goatskin quiver … some were right-wing feathered arrows and some with left-wing feathers. This means that the binding process itself is absolutely insignificant, just as it does not matter whether the spiral is to the left or to the right side. It depends only on where you want to start the binding, if from the nock or from the opposite direction further down the shaft. Anyway, this doesn't mean that the two arrows could not have been made by two different people. Other colleagues interested in primitive archery confirmed my theory.

The arrowheads found equipping the arrows in the quiver were part of two shafts broken in several places. On closer examination, the breaks did not seem to me to be the result of a fall (the other non-feathered shafts seemed to be intact and were in the majority) rather, this suggests that the arrows had been repaired several times. The analysis of blood traces present up to 50cm from the tip would seem to confirm this.

Their most recent shot at a target resulted in a miss, with the impact producing breaks upon which work was planned in an effort to recycle the valuable bits. They could even have been fired arrows that missed our fleeing man, which were quickly collected by him for re-use (Ötzi only had unfinished equipment, but kept with him all the necessary tools for their rebuilding and assembly).

The arrowheads which we are talking about are of the Remedello type, and show clear signs of corrective retouching. One of these (the one engaged in the Cornel fore shaft) is fractured in the shank, which has an abnormal magnitude (visible from the X-ray, still connected within the shaft). We can suppose that it was originally of considerable size and mass.

On the other hand, a rod of viburnum 1 cm (a little over 3/8") in diameter and 90cm (35.4") long weighs from 60 to 70 grams (about 1000 grains, including the arrowhead, the birch-bark mastic and the feathers and binders) and would require, from a ballistic point of view, a tip considerably heavy to have a dynamic center of gravity moved forward enough. This is for stability in the air and the penetration coefficient.

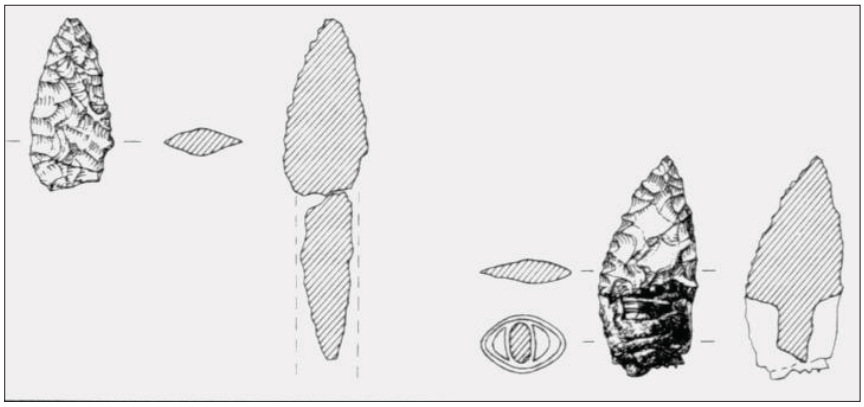

Figure 13. *Profile of Arrowheads found in the Iceman's quiver.*

Forensic Analysis Af The Arrow With Foreshaft.

Some close observation, from Loy 1994 preliminary reports[7]:

This arrow shaft is the only one that shows extensive modification and decoration. It was a compound arrow consisting of both a shaft and foreshaft. The shaft has an intermittent spiral pattem of darkened stripes. The fletching is attached with string binding and the same black pitch compound used as a hafting resin.

The foreshaft is inserted into a cylindrical hole made in the distal end of the shaft. The outer surface of the shaft at the area of foreshaft insertion was carved into a shallow depression completely around the shaft. When the foreshaft was inserted into the shaft, this depression was bound with string and covered with the black pitch. Traces of the string wrapping pattern are evidenced by remnants of the pitch; only one small piece of the string and a remnant fragment of the pitch are currently attached to the distal end of the foreshaft. The foreshaft has a compound geometry which, at the joining with the shaft is circular and at the joining with the arrowpoint is rectangular in cross-section. The tang of the arrowpoint was inserted into a groove, lashed with string and coated with pitch. The foreshaft and shaft were tested with the Hemastix to determine the origins of discoloured patches and larger areas, and to in vestigate the origin of the spiral pattem. In addition, a series of tests were made along the length of the whole shaft to in vestigate the possible maximum penetration of the shaft into a prey animal. Very strong reactions were noted on both the foreshaft (4+) and 4 cm proximal from the end of the shaft/foreshaft join (3+); tests taken near the midpoint of the shaft yielded reactions of 2+. From the midpoint of the shaft to a point 13.5 cm from the broken proximal end gave reactions of 1+. Testing the difference in reaction of the spiral discoloured band and adjacent clear areas yielded a reaction of 1+ in both samples. I conclude that the maximum penetration was up to 1/2 the length of the arrow and that there is a background of blood deposition on the remaining rear 1/2 of the arrow most likely reflecting handling (with bloody hands) during the removal of the arrow from the (human) prey.

The dark spiral decorative pattern did not give elevated Hemastix reactions (not greater than a score of 1), nor did the dark areas appear similar microscopically with any of the bloody areas on other parts of the shaft/foreshaft. This spiral pattern of light and dark bands was most likely produced by wrapping the shaft with a narrow piece of leather or plant material and exposing the whole of the shaft to dense smoke. Such a treatment would leave the observed spiral pattern after the wrapping is removed. Examination of the darkened areas with very high magnification might reveal traces of carbon (fly ash, soot) within the fabric of the woody tissue. Wrapping and smoking of arrow shafts for decorative purposes is a widespread practice in many parts of the world.

This point was recovered from the quiver separately from the shaft and

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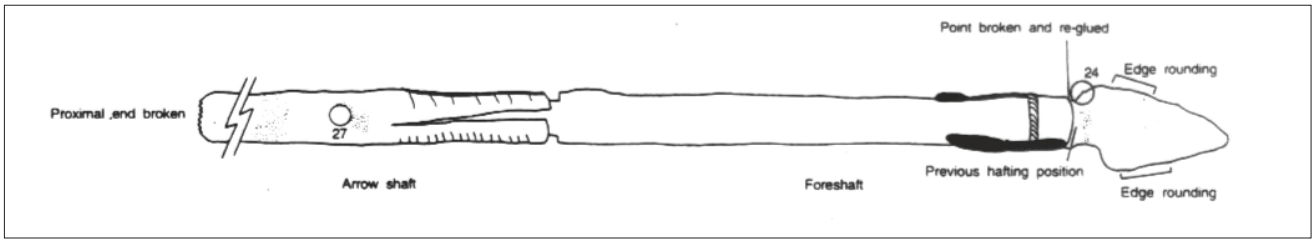

Figure 14. *The Foreshaft with its assembly components for the composite arrow.*

has been glued back into its original position during conservation, a fact which makes it difficult to observe the morphology of the break. However even without being able to see the entire break clearly, the geometry of the break is consistent with experimental evidence suggesting a high energy impact along the axis of the arrow shaft as opposed to a low energy break (dropping, damage during pressure retouching). The arrow point was separated from a long tang section still remaining in the fore shaft.

The tip has been damaged by impact with a hard, but yielding material shown by a bending-type snap fracture. In addition there has been the removal of a "burin-like" flake from the area of the snap fracture. Residues were observed in the scar of the snap fracture, but not in the scar area of the burin-like flake removal. This indicates two separate episodes of impact tip-damage. There is pronounced edge rounding on one edge (from roughly the midpoint to the base) suggesting a long period of use had elapsed since its manufacture.

The residues observed include hair fragments embedded in both the hafting pitch and in protein residues on the point surface. The residues on the point surface have parallel striae visible near the tip which are aligned with the long axis of the point. The residues are thicker over the proximal 2/3 of the point than in the forward 1/3. Muscle tissue was observed near the base. The residues were very thick near the base and the thickest zone corresponds to the location of a previous hafting position. Blood residue was visible in the area between the surface of the point and the inner surface of the hafting wood. A single Hemastix test was made which returned a reaction of 1+. The surface was very hydrophobic and comparisons made before and after the test indicate that very little residue was actually removed and tested. When removing residue from the basal thick deposits (Sample #24) more liquid was used and a longer soaking time was allowed. The subsequent liquid sample was viscous and reddish brown, consistent with experience removing thick blood residues from other archaeological tools (for example see Loy 1993).

Associated with the mix of residues at the base of the point were small grains of angular mineral sand and silt. Also observed was one plant spicule (trichome) consistent in shape and size with those found on the Scraper of the Iceman. The sand particles on the surface but not incorporated within the residue, and the striations within the residue near the tip suggest direct contact with soil, probably at the time of the breakage, ie. the last use. The phytolith could have come from a variety of activities, too many in fact to make any useful inference at this time.

Arrowhead Without Foreshaft

This arrow point was not hafted into a foreshaft, but directly into an arrow shaft. The breakage point was near the proximal end of the tang. The arrow point is still wrapped in pitch covered "string" and includes the forward portion of the arrow shaft. Some of the pitch has been removed on both sides revealing the string wrapping. A previous hafting line is evidenced by a buildup of residue just forward of the present haft. The geometry of the broken surface at the tang reflects a high energy rotational impact break. Sand grains are impacted into residues near the haft, in step fracture scars which are oriented to face toward the tip, and under and in the wooden shaft at the haft itself. There is impact damage to a small area of one edge near the tip.

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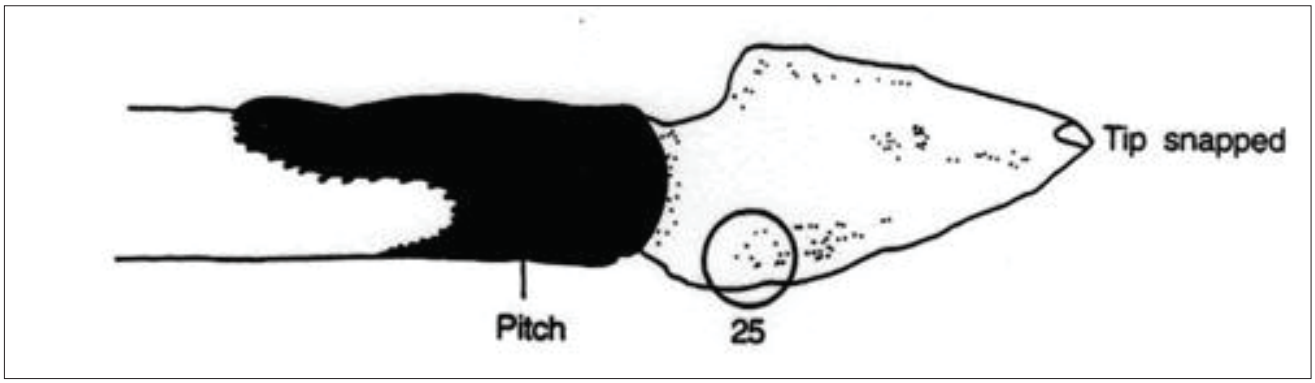

Figure 15. *The Arrowhead with foreshaft showing sampled locations (circle with number) designated Face B, side (edge) B uppermost; black area is extensive pitch deposit, note the tip has been snapped.*

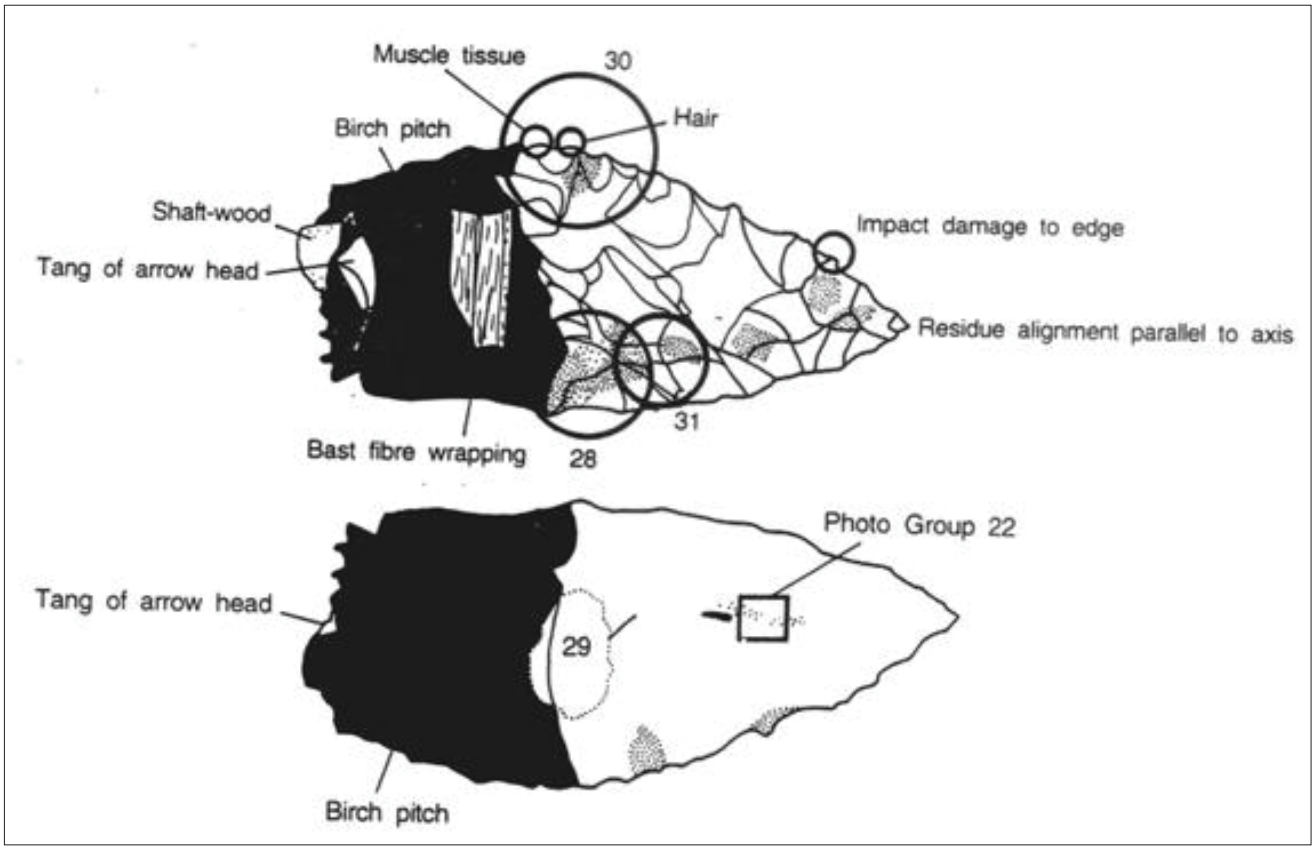

Figure 16. *The single shaft Arrowhead.*

Residues include hairs on both surfaces which are embedded in blood residues. Only one hair had the scale pattern well preserved, the remaining hairs were abraded and/or the cuticular scale pattern was obscured. The residues are very thick in some places (> 20 μm) and have a dark brown/black appearance, similar to the pitch used in hafting. Hemastix reactions of this thick deposit yield 4+ reactions, and thus the colour reflects a very thick blood residue rather than pitch. Striated muscle tissue is preserved in residue near the base of the arrow point. Near the tip there is dragging and smearing of the residue parallel to the axis of the point.

Abrasion of cuticular scale patterns in hairs is not uncommonly observed in prehistoric residues; I had previously thought this to be due to abrasion by movement of the soil against the tool during the burial period. Although the cause of the abrasion seen here cannot be unambiguously determined, it is clearly not a soil abrasion effect given burial in ice and the storage of the broken point in the quiver. The abrasion could have came from either a secondary effect of the point hitting the ground when it broke, from quiver wear during its use life, or simply long use.

Important is the presence of clearly identifiable red blood cells almost at the midpoint of one face (Figure 16, lower, boxed area). The cells are classic in shape (circular, biconcave) and have no nucleus. Some cells appear (without staining) to be nucleated and I guess that they are probably circulating "white" cells (eg., lymphocites, macrophages).

Notes and Bibliography

[1] "functional": the hafting system of a triangular tip is much weaker than to a stemmed (or notched) hafting system but can be a functional response to the need to remain stuck in the target, leaving free the shaft and to promote the bleeding of the wound.

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[5] Baugh D., Brizzi V., Baker T, 2006, Otzi's Bow, *The Society of Primitive Technologies Bulletin* #31. Spring 2006

[6] Brizzi V., Pedrotti A., Loi. C., 2011: *Looking for an experimental frame of reference for the Otzi's bow*, 3rd International Congress of Experimental Archaeology (Banyoles, 17-19 October 2011),

[7] T.H. Loy Analysis of the Artefacts of the Ice Man of Hauslabjoch: Microscopy and Residue Analysis, Mainz, Innsburck: Forschunginstitut für Alpine Vorzeit, Leopold-Franzens Universität. (Manuscript on File). August 1994