Adoranten

ÅRSSKRIFT 1999 FÖR

Scandinavian Society for Prehistoric Art

Tanums Hällristningsmuseum Underslös

Dette skrift er et indlæg i **Adoranten**, 1999, fra side 47 til side 59.
Indlægget er forfattet af *Knud V. Valbjørn*, Hjortspringbådens Laug.

Det er formateret specielt til Medlemsmappen.

Boats, ca. 400 B.C., from the Litsleby panel, Tanum, Sweden. After Tanum Hällristningsmuseum.

"Rock Carving Ship" Sails Again.

The Hjortspring Boat, Reconstructed.

Introduction

In a little bog on the island of Als in southern Denmark a boat was excavated in 1922. The boat was named "The Hjortspring Boat" after the name of the bog. Along with the boat a huge amount of weaponry and some utensils were excavated.
The story of the find is a dramatic series of incidences interweaving warfare of antiquity into that of modern times.
In 1915 during the First World War, the manager of the museum at Sønderborg Castle, Jens Raben, was in hospital in Sønderborg, wounded. (At that time the island of Als together with the rest of Slesvig was part of Germany). Raben's room mate, a farmer by the name of Jørgen Petersen, also wounded, told Raben that he in 1885 helped digging peat in a little bog by the name Hjortspring. A wooden plank with a length of 8 m. was found. The plank was dried and burned. During digging they were bothered by a fair amount of spearheads. Those spearheads were thrown away.
Jens Raben was shocked by the story, and as soon as the two men were released from the hospital, they went to the owner of the bog. Raben persuaded him to stop digging more peat. Remembering the peace treaty after Denmark's war with Prussia and Austria in 1864, where Denmark not only lost Slesvig-Holsten but also the excavated Nydamboat (from 300 A.D.), no serious attempt was done to analyse the bog.
The Versaille Treaty called for a referendum that brought the northern part of Slesvig including Als back under Danish sovereignty in 1920**.** The very same year Raben wrote to The National Museum in Copenhagen, telling the story. The museum became interested and arranged for an excavation, which took place in 1921-22. The excavation was lead by Gustav Rosenberg, a conservator from the museum.

During the twenties the find was preserved and analysed.
The boat was an 18 m long plank boat, formed by five wide lime wood planks that were sewn together with organic materials. The boat did have remains of horns, two in each end, like the horns so well known from the rock carving ships in Scandinavia. There were ten thwarts, giving room for twenty oarsmen, or rather for twenty men using paddles.
The boat was documented by the Norwegian ships architect Frederik Johannessen in 1931**.** (G. Rosenberg, p. 92 and attachment lll).
The preservation of the wood showed to be disastrously bad and after having been on display for two decades, the wood was re-preserved in 1987 and the remains of the boat (36%) are again on display at The National Museum in Copenhagen in a manner that shows the elegant lines of the boat.

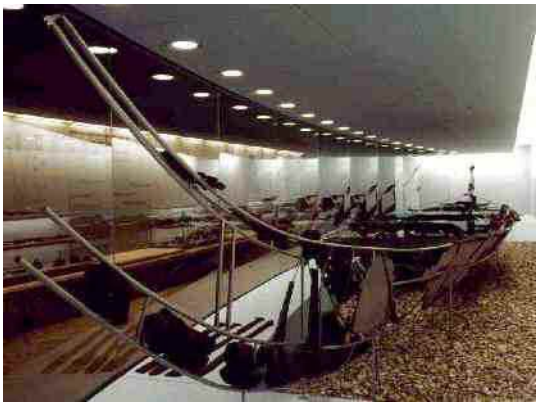

Fig. 1: The Hjortspring Boat on Display in The National Museum in Copenhagen. (Nationalmuseets Arbejdsmark 1989).

Apart from the boat 170 spearheads were excavated (some with remains of the shaft still fastened), together with 15 swords, 60 shields, the remains of what is interpreted as 15-20 mail coats and several pieces of utensils, fibulas and ceramics.
From the weapons and from the utensils, Rosenberg dated the find as being from the middle of the Celtic (Preroman) Iron Age. (Rosenberg, p.95).
An attempt to locate “fresh” wood in the bog was performed in 1987. A few pieces of wood were found and dated by C14 to be from 350-300 BC. (Rieck, p. 49).
Thus the Hjortspring Boat was landing on a beach of Als, while unknown artists were carving the ultimate ships of similar shape on rocks in Bohus Len in Sweden, give or take a hundred years.

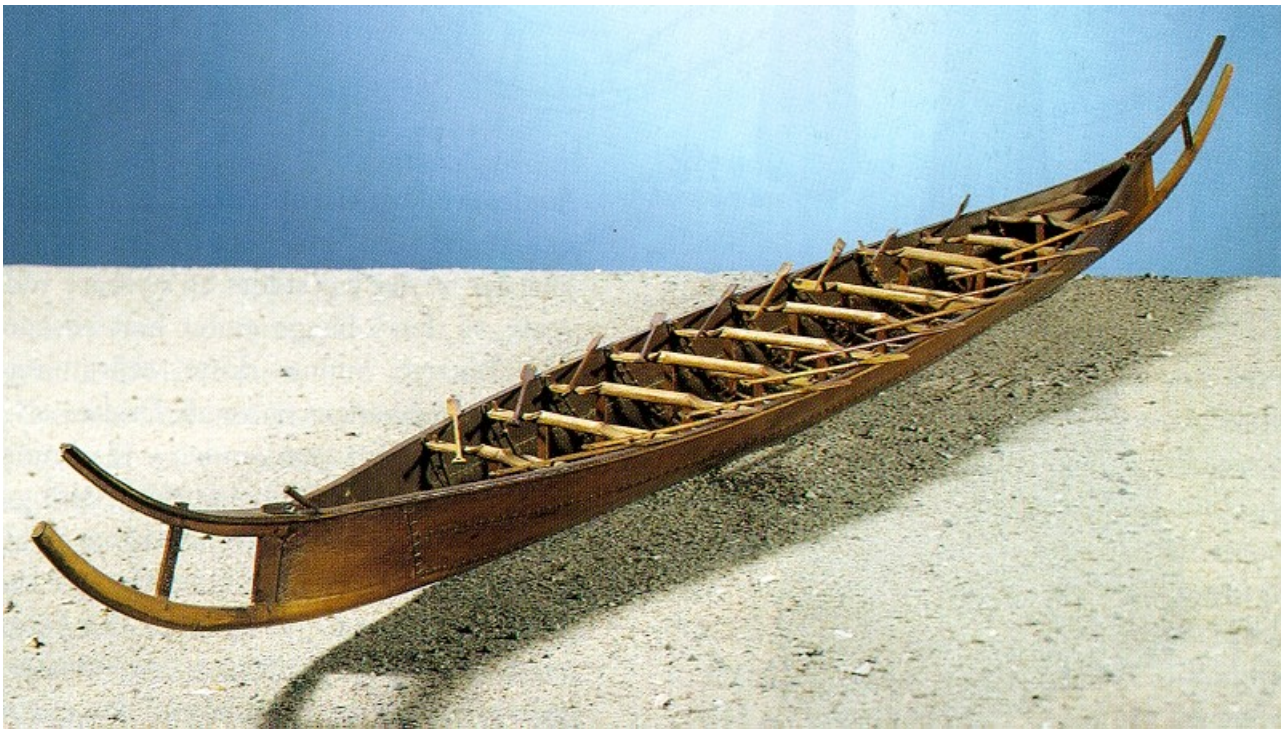

Fig. 2: A Model of the Boat. (Kaul,1988).

In accordance with C. Tacitus: “Germania”, 98 A.D. the boat and weaponry in the find are interpreted as being conquered from an enemy and offered to the gods.
The Hjortspring Find contains the oldest plank built boat in Scandinavia, the biggest amount of shields ever found in Europe, the oldest turned wooden artifacts in Northern Europe and, if interpreted correctly, the oldest and biggest find of mail coats ever found. All elements in the find have been sacrificed at the same event. (Kaul, 1988).

Back to the present. In 1991 a group of persons on the island of Als formed “Hjortspringbådens Laug”, “The Guild of the Hjortspringboat” with the purpose of spreading the knowledge of the boat more widely, and as a main task build a copy in full scale of the boat. The guild attracted persons with a wide variety of professional backgrounds and with diversified motives for joining the guild. (Historians, archaeologists, ship wrights and carpenters were absent in the member list).
The guild was organised in groups in accordance with said interests and professional backgrounds. Typically, a member participates in more than one group. The average age of the members is 55.
The last year of importance is 1999, the year, when the boat replica was launched.

The Philosophy

The objective was to build, test and display a full scale replica of the boat. As such a big undertaking will only take place every 25 years, if that often, the replica should represent the latest in understanding as to materials, design and manufacture of the boat. Furthermore as much information as possible should be produced and documented. All documentation should be made available to archaeological scientists from museums and universities. Without using these words, McGrail (1987, p.193) stresses the importance of such measures in order to justify the outlay of funds and effort to build a full scale replica.
Rosenberg and Johannessen (1937) and Rieck (1988) describe the boat as being very refined in design and finish. Our own initial studies convinced us, that we could never build the boat at the same speed as our predecessors, as they must have had the experience from building a long line of still more refined boats, surely in a ship yard. We could build a true copy, true in shape, surface smoothness, elasticity and weight, while time was our free parameter. So we did not produce any knowledge regarding Iron Age ship yard productivity. Neither did we prove which tools were used, although we feel that we have suggested likely designs.

The Reconstruction

It is outside the scope of this article to go into details with the boat design and the construction. A thorough description is found in the references. (Valbjørn et al, 1997).

The Basis

The main source for understanding the boat was the book “Hjortspringfundet” by G. Rosenberg (1937). The original drawing made by Johannessen was located in the archives of the National Museum. We used that as our base drawing. We also obtained copies of the sketches, which Johannessen made while studying the excavated parts of the boat, dated 1931. These sketches were made available to us from “The Institute for Archaeology” at the University in Oslo, Norway.
The display of the boat in The National Museum in Copenhagen, incorporating the latest interpretation of the find (Rieck 1988), was an important source as well.
Last but not least, we formed, what we named “Our Scientific Network”, a group of scientists and professionals, who received our documentation and willingly answered many of our questions during the boat building.

The Design

Johannessens drawing was used as data in a computer program. From this program the shapes, that was used by the building group, were printed out. The program was also the base for calculations of the hydrodynamic and the hydrostatic characteristics of the boat. Stress analysis used these data as well. (Fenger et al, 1997).

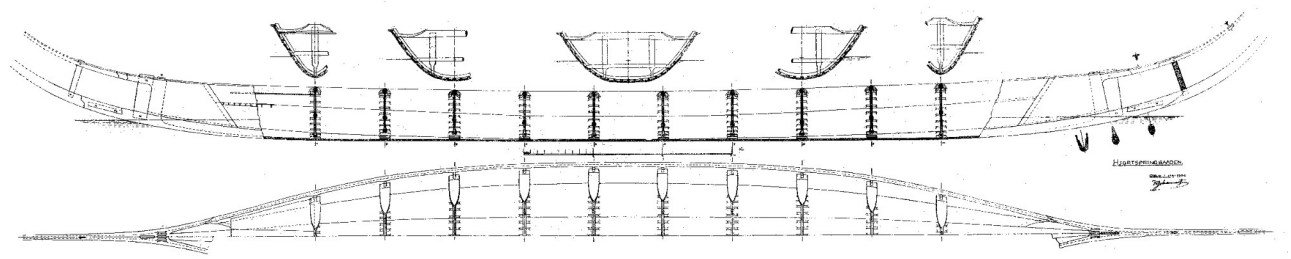

Fig. 3: The Drawing of F. Johannessen (Rosenberg,G 1937).

The design group performed also a series of tests regarding the stopping mechanism and the sewing seam strength.

The Ship Yard

The guild rented a former chicken farm, situated west of Nordborg, 600 meters from the cove named Dyvig, where the boat eventually was to be launched.

The Materials

The boat consists mainly of lime wood. In order to produce the 12 m long planks with a width of up to 60 cm., one had to find lime trees, with a diameter of at least 90 cm. at the root and with a height of 16 m. before the first branch appeared. The tree in question is Tilia parvifolia (cordata). Such big trees were not available in Western Europe.
At last the wood group identified a lime wood forest in Poland 100 km. south of Gdansk. The trees we got had an age of 130 years.
For the stem parts, the thwarts and the horns were used local lime trees (Tilia grandefolia). The other parts of the thwarts were hazel and ash. The locking plates were made of oak.
The sewing strings were produced from lime wood bast, while the stopping material was rolls of sheep wool, saturated in a mixture of ox tallow and linseed oil.
For surface treatment was used wood tar and linseed oil.

The Cutting Tools

The tool group studied finds of tools from the early Iron Age (few as they are) and started producing samples of the tools in a forge, to which we had access. These tools were then tested by the boat building group, who suggested changes. Through this cut and try method we refined the tools specifically with regards to the handles and the cutting edge angle.

The Training Period

While waiting for the big trunks, a training period was organised to develop and master the tools that are described above. Initial objects were paddles and thwarts. We then built a middle section of the boat to scale 1:1 with a length of 1.4 meter, thus containing two frame assembly. The third step was to build the prow from the peak to just after the first frame, a length of five meters. Apart from the training aspect the test pieces were valuable for studying the intricate parts of the boat, specifically with regards to assembly details.
The two test pieces have been on display in Munich, in the Viking Ship Hall in Roskilde, in the "Hjemsted" museum in Skærbæk and in several local exibitions.
The training period lasted until February 1994, when the large lime wood trunks arrived. A total of 1650 man hours were logged.

The Boat Building

By means of the tools the 12 tons of lime wood should be reduced to the five hundred kg, which was the weight of the boat. The three trunks were split into halves, each of which then reduced to a 60 cm wide, two cm thick plank of a length of 12-13 m.

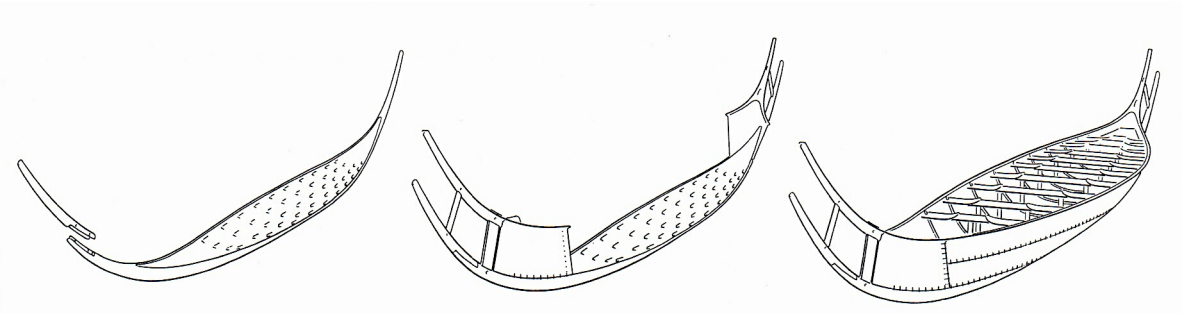

Fig. 4: Schematic Drawing of the Manufacture of the Hjortspring Boat (Kaul, 1988).

The two stem parts were carved from short trunks with a diameter of one m. While the lower horn, the keel horn, was connected to the keel plank, as well illustrated in the find, by means of a grove and feather assembly, the connection between the gunwale horn and the stem part was unknown. We decided to use a branch for the gunwale horn as well, also connected to the stem with a grove/feather assembly.

Fig. 5: The Keel Plank, the Middle Plank, the Stem Part and the Keel Horn Assembly.

The profile plates, that are shown on figure 5, were used to assure a symmetric form of the boat when bending the side and gunwale planks. (Our predecessors have probably used a system of sticks, lashed together.)
The profiles were eventually removed and the correct frame assemblies were inserted.
These frame assemblies are of an interesting design, strong, flexible and lightweight as they are.
The frame itself is a 30 mm hazel branch, that is lashed to a series of cleats, carved out as part of the planks. This frame pierces through the thwart in both ends, through a deck beam and through the lower end of two columns that support the thwart.
There is 1 m between each thwart.

Fig. 6: The Frame Assemblies Mounted in the Boat, Looking aft.

At each end on top of the stem pieces four cleats were carved out parallel to each other and in the direction of the boat. As a hypothesis they were used as a block for tightening a rope that acts as a trussing rope. (See fig. 6). The arrangement worked well during sailing. A few of rock carvings have indication of a similar rope.
10.000 man hours were logged during the building of the boat.

Other Parts of the Find

While the boat building group were occupied with the above, a group studied the weaponry and the utensils, that were part of the find. The group got access to the stores and to the display at The National Museum, and performed a series of measurements. These are documented in the Membership ledger. Half a dozen shields where carved and a score of different spear heads and a few swords were forged. Furthermore some of the wooden utensils were fabricated. The elegant wheel (Kaul, p.29) functioned well as weight in a hand spinning device.
The historic group studied the Celtic Iron Age and the culture at that time on the island and its surroundings as to house construction, clothing, farming etc. The major

goal was to establish from where the boat originated. They did not succeed in reaching this goal.
However, as a result of the study two members of the group wrote a book about their findings (Dreyer, V. and Valbjørn, B., 1999).
From the many bog corpses found in Denmark and south of the border, the group dressed five mannequins in replicas of the clothings, that were worn in the Celtic Iron Age.

Measuring

Although we used the drawings of Johannessen, the boat shape could not be expected to be as the drawing, so we decided to have the finished boat shape documented. As part of an agreement with The Centre for Maritime Archaeology at the National Museum in Roskilde, a measurement of the boat shape was performed in May 1999 lead by F. Hocker. The results are not yet documented.

Launching

May 29th, 1999 the boat was rolled out of the ship yard building and down to the cove of Dyvig for a first launching. Well down at the beach, twenty persons carried the boat into the water.

Fig. 7: The Hjortspring Boat About to Kiss the Water.

The boat was then directed to a floating pier close by. The draft of the boat was the expected 10 cm. Lying there along the pier, the boat was without any heeling. It was certainly not tight. Through many of the sewing holes water was entering. Ox tallow was pressed into all leakage's from the inside, and eventually the boat was declared seaworthy.
The crew entered the boat, thwart after thwart, until all twenty persons sat ready. And the boat sprang forward at the commando: "Heave away".
The boat was fast but unstable. The crew, however, learned quickly to counteract any heeling by means of moving their bodies. It was not found unsafe, except when entering and leaving the boat.

Baptising

A week later, on June 5, the official launching and baptising took place. This event was planned together with several organisations from the community, such as schools, scouts, choirs and orchestras. At 1400 hours the procession started from the ship yard, headed by an orchestra playing the lures from the Bronze Age. Then came the chief in an Iron Age dress with cloak, shield and spear. After a drummer came the boat, flanked by twenty oarsmen, also wearing Iron Age dresses and then fifty children in the same contemporary dresses. The goddess Nerthus, standing in a cart, drawn by four slaves, followed. She was escorted by twenty chanting priests, clad as in the Kivik rock carving.
The last element of the procession was a couple of hundred spectators with colourful umbrellas, as the rain poured down.
At the exact moment we entered the beach at the cove, where several thousand spectators were waiting, the rain stopped, probable due to the intense "sun worshipping" by the lures.
After some speeches from representative from The National Museum and local ship societies, the boat was carried out into the water and manned. The boat was then baptised by Nerthus and given the name **Tilia Alsie.**

Fig. 8: The Hjortspring Boat Sails Again.

The boat sailed along the coast for an hour accompanied by rounds of applause by the thousands of spectators that flanked the bay.
The boat was then carried ashore to be studied by the guests. The rest of the afternoon was spent eating steaks of wild boars, drinking mead and illustrating the art of wood carving and lime bast rope making.
It was a euphoric afternoon.

Sailing Tests

A part of the above mentioned agreement with the National Museum was the participation of said body in the sailing tests. In September 1999, a group of people from the Viking Ship Hall in Roskilde, lead by M. Winner, arrived and performed three days of tests together with half a dozen members from the guild. The tests are by no means finished, so new series of tests are planned in May 2000.
None of the participants had any prior experience in boat paddling.

1. Steering and manoeuvrability

The steering oar was lashed to the most aft frame, where it stuck up above the gunwale. (No indication from the find, as where to fix the oar, existed). It was

extremely difficult to steer the boat, with the oar in that position. Even with two oars, one at star board and one at port, the steering was not convincing.
The boat turned to either side eventually when paddling along, depending on the direction in relation to the wind. Loading the boat with 600 kg of ballast, thus obtaining a longer water line improved direction stability. The indicated fin aft at the bronze carving at the Rørby sword would certainly have helped.
Eventually, it was tried to lash the steering oar to the keel horn at its root and have the oar more or less vertical. The steering was then performed twisting the oar as it done in the Viking ships. In that position, the steering functioned well. A test using two oars, the second placed up front also lashed to the keel horn, gave convincing manoeuvrability. (In the Hjortspring Find there were found two steering oars, one in each end of the boat).

Fig. 9: The New Position of the Steering Oar.

At four knots the boat turned 90 degrees with a radius of 25 meters within 20 seconds.
At the same velocity the boat could be stopped within ten meters, using backwards paddling.

When paddling forward in one side and backwards in the other, the boat stopped and it revolved on the spot. Time for a whole turn was 1minut 23 seconds.
The boat could be moved sideways by means of the paddles.

2. Velocity

Fig. 10: Sailing at "Leisure".

Due to the lack of experience and strength of the crew, velocity was not impressive. A maximum of 5.1 knots were obtained over a distance of 300 m., when 16 paddlers were striking at 45 strokes pr. minute. A typical velocity was 4 knots when applying 35 strokes pr. minute over a distance of 1.100 m.
During the tests the wind had a velocity of between 5 and 10 m/s. The boat was very sensitive to wind. At downwind direction the velocity was 1 knot higher than at upwind. It is inconceivable that our predecessors did not use some sort of sail, when sailing downwind. A couple of cloaks stretched out between spear shafts would certainly give a knot or two extra. That will eventually be investigated.
The tests were only performed in the relative quiet waters in the cove, thus not giving any experience as to sailing in waves.

3. Load

As mentioned several tests were performed using a ballast of 600 kg. The ballast was placed between thwart 3-5 and 6-8. Also the boat was at times loaded with 25 persons giving a total displacement of 3 tons. The boat felt heavier but quite safe with an amble freeboard.

4. Stability

Manning the boat was a somewhat frightening experience. It certainly did not feel stable. The above mentioned ballast helped considerably. When sailing, the boat felt stable with and without ballast.

Lying at the pier the rightning moment was measured with the boat being empty, empty with 600 kg of ballast and with crew and ballast.

5. Hydraulic resistance

Towing the manned boat after a motorboat with a dynamometer inserted in the towing line we tried to measure the hydraulic resistance vs. speed. The test did fail and must be repeated using a longer tow and a heavier motorboat.
As above mentioned, the tests will continue in May 2000. Preliminary results with details may be found in the Member Ledger.(Chapter 8), and the final conclusions will eventually be presented at the 9th. International Symposium of Boats and Ships Archaeology in Venice in December 2000.

Documenting and Publishing

The philosophy of the guild is to document all our findings. The documentation is sent to all members of the guild, sketchy as it might be. Eventually we present detailed findings with conclusions in archaeological symposia's and magazines. It is furthermore our intention to write a book (in Danish) dealing with the whole process of designing, manufacturing and testing the boat.
Lastly we have in our agreement with The National Museum in Roskilde the intention of including our findings in a coming volume, dealing with the Hjortspring Boat, in the series : "Ships and Boats of the North".

Reflections on the Hjortspring Boat and Find

Manufacturing

McGrail suggests [...] that the work of shaping a boat could be divided into three typology elements: reducing, bending and adding. Applying this method, the manufacturing of the Hjortspring Boat has the following characteristic: Reducing was 85 %, bending less than 1 % and adding was 14-15%, when counting the hours used on the three different elements.
The technology of reducing, i.e. chipping away superfluous wood was by far the most time consuming effort. From that point of view the availability of iron and the technology of making and hardening steel must have given a dramatic increase in productivity in ship yards that built "rock carving" i.e. Hjortspring type boats compared with the productivity using flint and bronze tools.

Typology

The Hjortspring Boat is a self-contained shell with the frame systems inserted after the shell is formed, a design typical of Nordic ships. This design method and the use of extremely thin boards result in a high degree of flexibility and at the same time a very light construction. (The boat has a weight of 530 kg. meaning that it can be carried over land by the crew.).
The design and the extreme amount of weaponry in the find implies that the boat is a war ship (a war canoe), rather than a freight ship. The expected lack of ability to cope with high waves points towards the boat being basically a river and coastal vessel, rather than an "ocean" going all-weather boat. This does not imply, however, that the latter ships did not exist in the Bronze Age.
The shape of the boat below the water line is probably chosen in order to reduce the wetted area to a minimum, thereby achieving higher speeds rather than a higher degree of stability.
The analysis of the stress, the hydrodynamics and the sailing tests have not explained any functional use of the horns.
When the boat is seen from above (figure 3), one notices the concave shape at prow and stern, a shape that reduces the buoyancy considerably at both ends. To avoid that the boat breaks in the middle when having an evenly distributed load (the crew) and the main buoyancy being over the middle 6 m. of the boat, the trussing rope was introduced. The effect of this rope, when handling the boat ashore and in the water, has changed the hypothesis into a theory. It is, however, still not a proven fact, that such a rope was used.

The Bronze Age Ship Technology in Scandinavia. A Hypothesis

The major question in discussions regarding the Bronze Age ship technology during the whole of the last century has been: Skin or Wood. The "fight" between the two schools has been fierce, basically because no ships from the Bronze Age have been excavated, so no "proof" is available to support either stand. As "The absence of proof does not mean the proof of absence", the discussion has been based upon ethnographic evidence mainly, but with few references to the Hjortspring Boat.
As the Hjortspring Boat is dated just 150 years after the end of Scandinavian Bronze Age, and as the rock carvings show tens of thousands of ships with the same profile as the Hjortspring Boat, it is tempting to extrapolate backwards from this boat to the unknown Scandinavian Bronze Age boats.
During the lengthy period, which we used in the theoretical analysis and while building the replica of the Hjortspring Boat, hours and hours have been used to discuss the details, the how's and the whey's.

This brought the author to the conviction, that the preceding boats, that fathered the Hjortspring Boat, could very well have been skin boats. I may state that the technology of fastening the planks to each other by sewing was not the decisive argument. As a matter of fact sewing could just as well be called lacing or lashing, as the holes, through which the thread were piercing through the planks, were drilled beforehand. (Westerdahl, p.14).
In order to illustrate the hypothesis a skin boat was designed, having the same configuration and size as the Hjortspring Boat. The planks were substituted by five longitudinal rafters, a keel rafter, two side rafters and two gunwale rafters. The three first were lashed together at both ends over two meters representing the keel horns. The two gunwale rafters were lashed to each other at both ends also over two meters showing the gunwale horns. The rafters were shaping the boat hull just like the wooden boat.
A construction of triangular frames constituted the prow and stern.

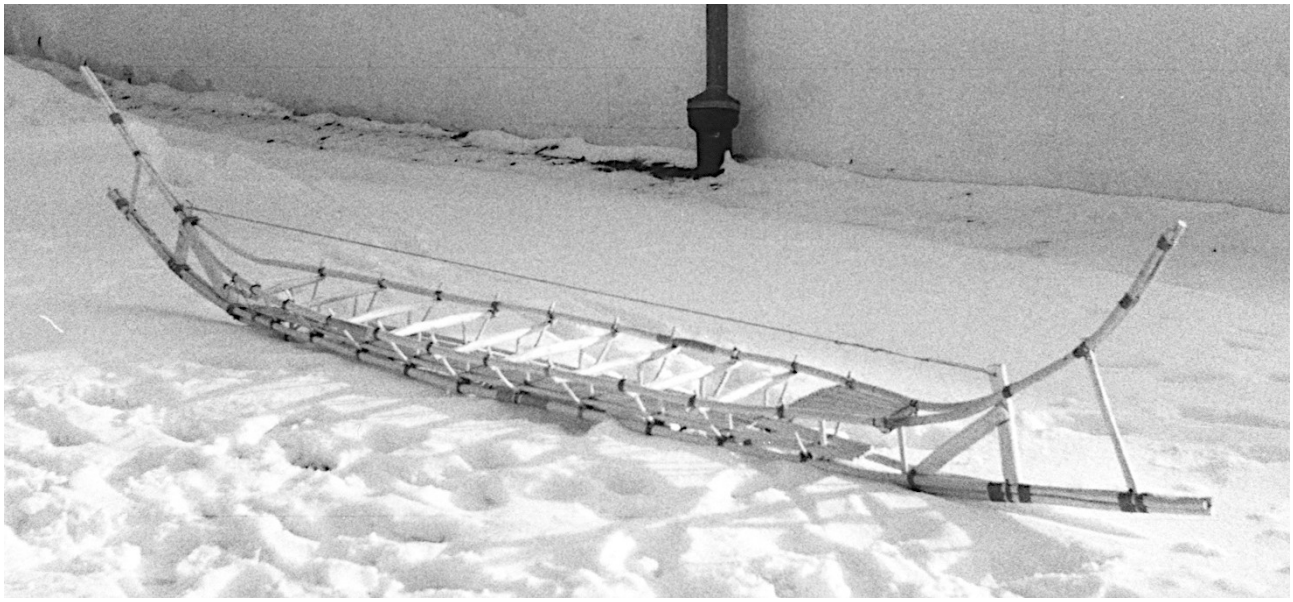

Fig. 11: The Structure of a "Hjortspring Boat" with Skin/Rafter Technology.
(Model, Scale 1:5)

The frames and thwarts were made just like the original frames although not as refined in order not to introduce excessive chipping away wood. The structure of the frame system could now be understood as transmitting the load from the weight of the crew down to the three lower rafters bending them outwards and thereby stretching the skin (the leather) to cope with the hydraulic pressure on the skin.
The skin of the boat was tanned ox leather. 31 square meters were necessary.
The rafters had a diameter of 100 mm, the frames 40 mm and the thickness of the leather 5 mm.

Calculation shows, that the resistance to bending was the same for both technologies while the resistance to twisting was 30% lower for the skin boat. The weight of the skin boat was 25% higher than that of the wooden boat.
A model in scale 1:5 was produced. The three elements of manufacture was dramatically altered in comparison with the Hjortspring Boat. As an estimation the reducing was 10% vs. 85% in the wooden boat, bending was 50% vs. 1% and adding 40% vs. 14%. Tanning the ox hides was not considered part of the ship building.

Fig. 12: The Hjortspring Boat in Skin Technology.
(Scale 1:5).

The design explains the horns, the concave shape of the bow and stern seen from above and the trussing rope. It illustrates how boats could have been built in middle and northern Scandinavia in the Bronze Age without ample access to high productive cutting tools (flint stone, bronze and steel).
The design work mentioned here is not fully documented nor published yet.

This design of a “Hjortspring” leather boat does not prove the technology of ships in the Bronze (and Stone) Age to be “Skin Boats”. It is at most a suggestion that the answer could be “Wood and Skin” in the Bronze Age. In modern times we have had sail, steam and diesel propulsion as well as wood and steel hulls simultaneously. A change of technology takes time, in antiquity probably many centuries, specifically within the conservative science and art of boat building. But typical of changes in

technology within boat building is, that the new technology boats often carry useless characteristics from the old technology.

Conclusion

The work of giving birth to a replica of the Hjortspring Boat has been extremely interesting from many points of view. It has been a interwoven effort of people with very different personalities, professions and skills. Tuesday and Thursday nights, week after week, year after year, the boat builders met to work together, discussing, rejecting, choosing and shaping all elements of the boat. The other groups met and worked separately with their part of the job.
Once a month all active members met to report on the status of their part of the project, to lay forward problems and receive comments or solutions from the meeting.
The support and interest from the community (organisations, funds and private persons) have been overwhelming.
The philosophy of documenting all findings was followed fairly well, although a few arms had to be twisted.
The major doubts regarding the produced boat in relation to the find are as follows: The stopping materials, being wool rolls saturated in ox tallow, does not explain the outside covering of the sewing seams by some sort of organic material, which is found. We should have investigated the use of resin. Secondly, Tilia Alsie had a 12 cm higher sheer than the drawing from Johannessen. This choice might have impeded the direction stability at low displacement (load).
We are convinced that the boat by no means was a “do it yourself” boat. The outline of the boat, the hydrodynamics, the refined details and the surface smoothness indicated that the boat must have been built in a professional ship yard in a line of still more refined boat.
The basic specification of the boat has been:

**“Build me a boat, capable of carrying at least 25 warriors,
it must be able to sail in quiet waters at speeds of no less than 7 knots,
it should be highly manoeuvrable and it should be so light that it could be carried over land by the crew”.**

Knud Vagn Valbjørn
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Denmark

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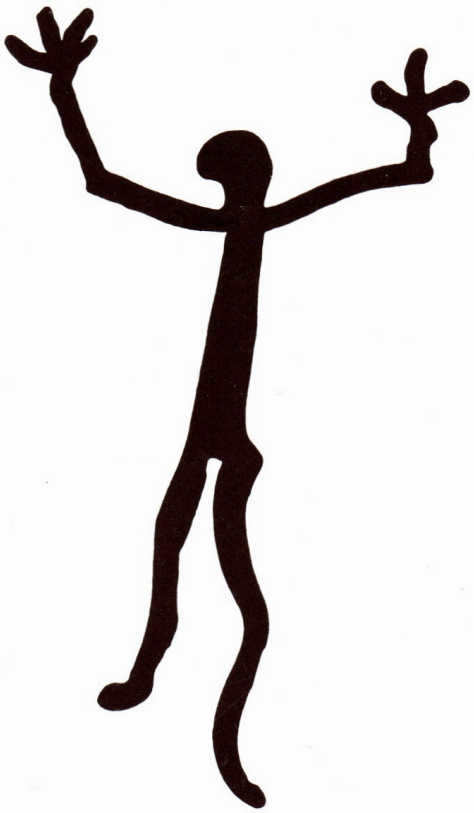

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