

# Bringing it all together: a multi-method evaluation of Tanum 247:1

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## ABSTRACT

This paper presents the results of a photogrammetric survey of the rock art panel Tanum 247:1 in Kalleby, which revealed two entirely new boats and an additional partial human figure that were previously missed in a documentation history over 50 years long. Through the combined use of digital and traditional methods the results could be verified. It is therefore argued that collating documentations, both past and present, can help to create a better picture of Bronze Age rock art carvings. In addition to using new and traditional documentation methods together, panels should be recorded beyond what is known, both in terms of discovering unknown carvings, as well as creating better data for future researchers.

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## Introduction

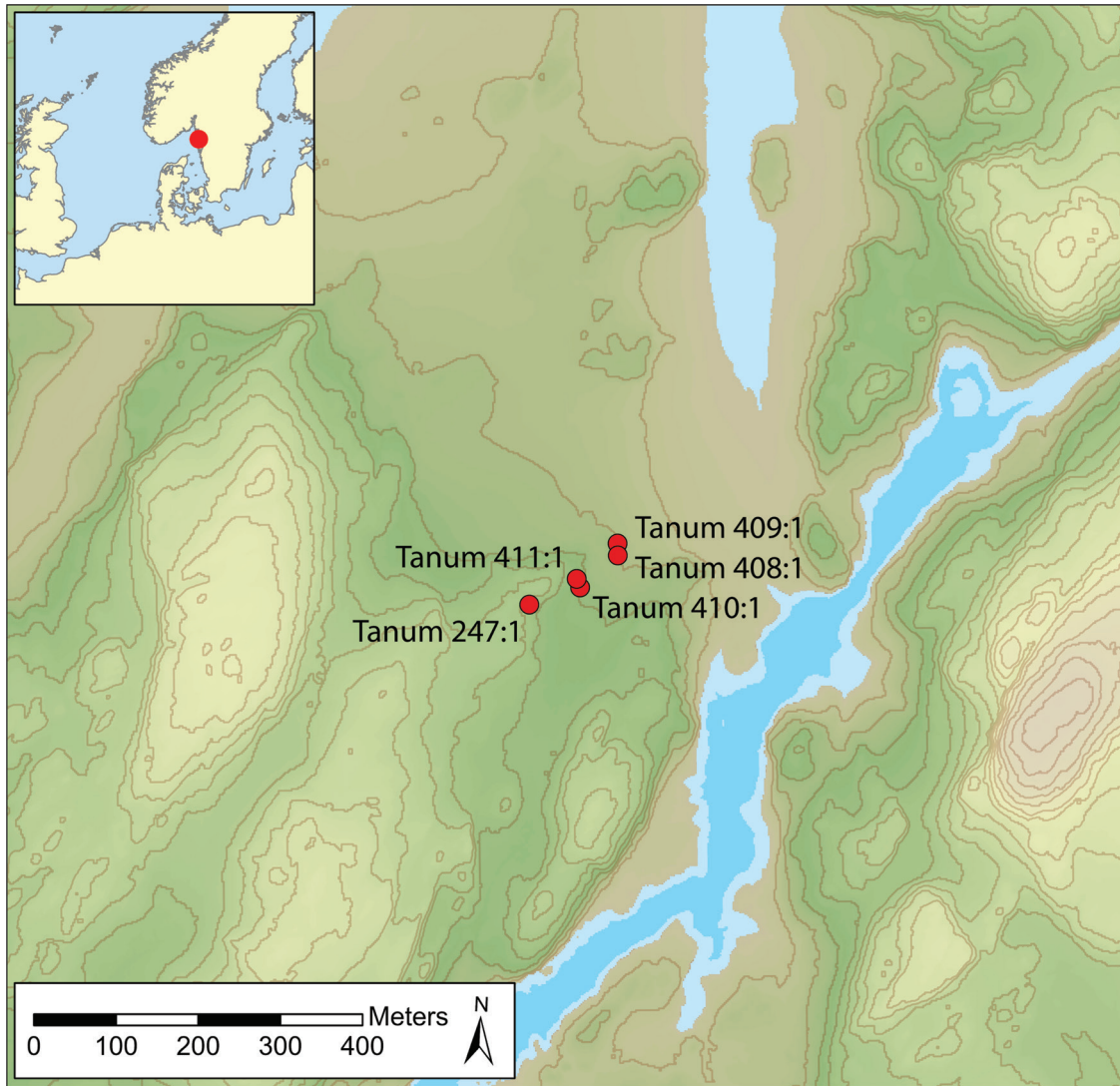
This paper focuses on a rock art panel in Kalleby (Tanum 247:1), upon which a photogrammetry survey revealed an entirely new boat that had previously been missed in over 50 years of documentation. The collection of 3D data using Structure from Motion (SfM) and Structured Light methodologies in Rock Art analysis has become a standard practice. However, rather than dismissing traditional methods of frottage and tracing, we want to demonstrate how both can fruitfully complement each other. Once 3D data has been recorded, there are a number of different ways in which the data can be processed and manipulated. Using a multi-method approach, including the traditional techniques, this paper examines how bringing the outputs of several documentation methods together may help to enhance the analysis and interpretation of rock art panels, including the discovery and verification of new carvings.

Kalleby is located in the UNESCO world heritage area in Tanum (Bohuslän, Sweden). The figurative Bronze Age rock art in Tanum was cre-

ated by engraving, or pecking, patterns into the exposed granite bedrock, perhaps using stone or antler tools from a period of 1700 BC, or even already during the Late Neolithic to around 300 BC (Bengtsson 2013; Goldhahn and Ling 2013). The vast majority of rock art images are abstract in the form of hundreds of thousands of cupmarks (Tvauri 1999). Recently, conclusive evidence has emerged that the cupmark tradition began in the Neolithic (Iversen, Thorsen and Andresen 2021). Most of the figurative carvings appear to relate to figures interpreted as warriors, boats, weapons, and animals, though there are a wealth of other types of carvings as well (Bertilsson, Horn and Ling 2021; Ling 2014; Nimura 2015). The Bohuslän area is home to around 1500 such panels (Ling 2014, 5).

New discoveries, evaluation, and quality control are important aspects of rock art research and documentation, as such the recorded data should be as error-free and extensive as possible (Nordbladh 1981). All methods have specific and different advantages and disadvantages, which means they can be used to evaluate the results of different record-





**Figure 1.** Map showing the locations of panels mentioned in this article (Base map: © Lantmäteriet).

ings of the same site. This paper seeks to utilise the results of digital and traditional visualisation methods to investigate how both can strengthen the interpretation of rock art sites and verify new discoveries. Furthermore, it is hoped that this case study advances best practice approaches to rock art investigation.

### **Site Description**

Tanum 247:1 is situated on the border of a field in Kalleby, and forms a roughly straight line with four other rock art panels, Tanum 408:1, 409:1, 410:1 and 411:1 (Figure 1), which were also recorded using SFM in the same field session. Tanum 247:1 is located roughly 45 m above the sea level making it one of the higher laying panels: they general-

ly seem to cluster around 18-25 m above the sea level. The panels in the area overlook a shallow valley which was likely dry, or perhaps a wetland during the Bronze Age. From higher points like Tanum 247:1, it may have been possible to see fjords that were a relatively short distance away.

The panel Tanum 247:1 was chosen as a case study because it was previously documented, as described below, but held high potential for a greater number of carvings than were previously known since it covered a large area, and was of a fairly uniform and high quality surface typically used for carving – although now lightly eroded. According to the national heritage database of Sweden (Fornsök), the panel measures 1.75 by 1.00 metres. It slopes down towards the east and descends at a fairly steady angle of 15 degrees. It is placed in an

area of planted forest and is bedded in with grass and moss. The bedrock onto which the panel was carved is primarily Bohus Granite and features a small segment at the top which is from a quartz or pegmatite dyke (Figure 2, Mark Peternell (Department of Earth Sciences, University of Gothenburg), Personal Communication, 2021)

### Previous Work

The rock art panel at Tanum 247:1 has previously been documented at least four times using traditional methods with varying results. The panel was inventoried in 1971 and described as having one ship, 1 metre long with a minimum of three 30 cm tall human figures, two cup marks - one above and one below the ship, and a 45 cm tall human figure at the bottom of the panel. The description mentions that the panel is highly eroded, a fact that every documenter has reaffirmed, and which can also be confirmed here (Fornsök).

The second documentation was made within the 1970s to 1980s by Torsten Högberg and was a frottage using industrial textile towels with blue carbon paper and no fixation. It was made of selected areas of the panel where rock art was recognized using a tactile survey (Figure 3a). The frottage clearly shows a boat that can be dated to period IV (Ling 2014, 105). Inside the boat there are a number of kneeling figures and potentially a lur blower, which could belong to period III, but they could also be later (Ling 2014, 103). There is also a larger figure above the boat, as well as one below which appears faintly and could point towards a Late Bronze Age dating. The strongly exaggerated calves, the curvilinear construction of the body, the belt-like empty space on the hips, and the weapon have been used as arguments for such a date (Fredell 2003, 2009), but recently new evidence has shown that the chronology of human figures may need to be reconsidered (Bertilsson 2015; Horn and Potter 2018; Ling and Bertilsson 2017). There appears to be a second boat over the cracked part of the panel, the dating of which is unclear. This second boat remained unrecognized in the original report, but was mentioned in a re-evaluation conducted in 2009 which will be discussed below.



Figure 2. An orthomosaic of the panel Tanum 247:1.

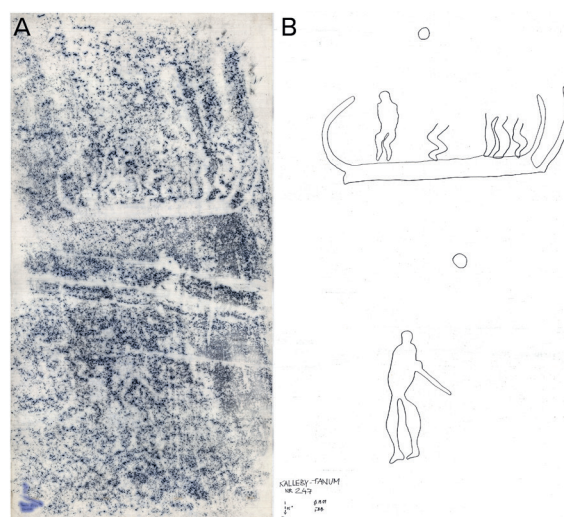
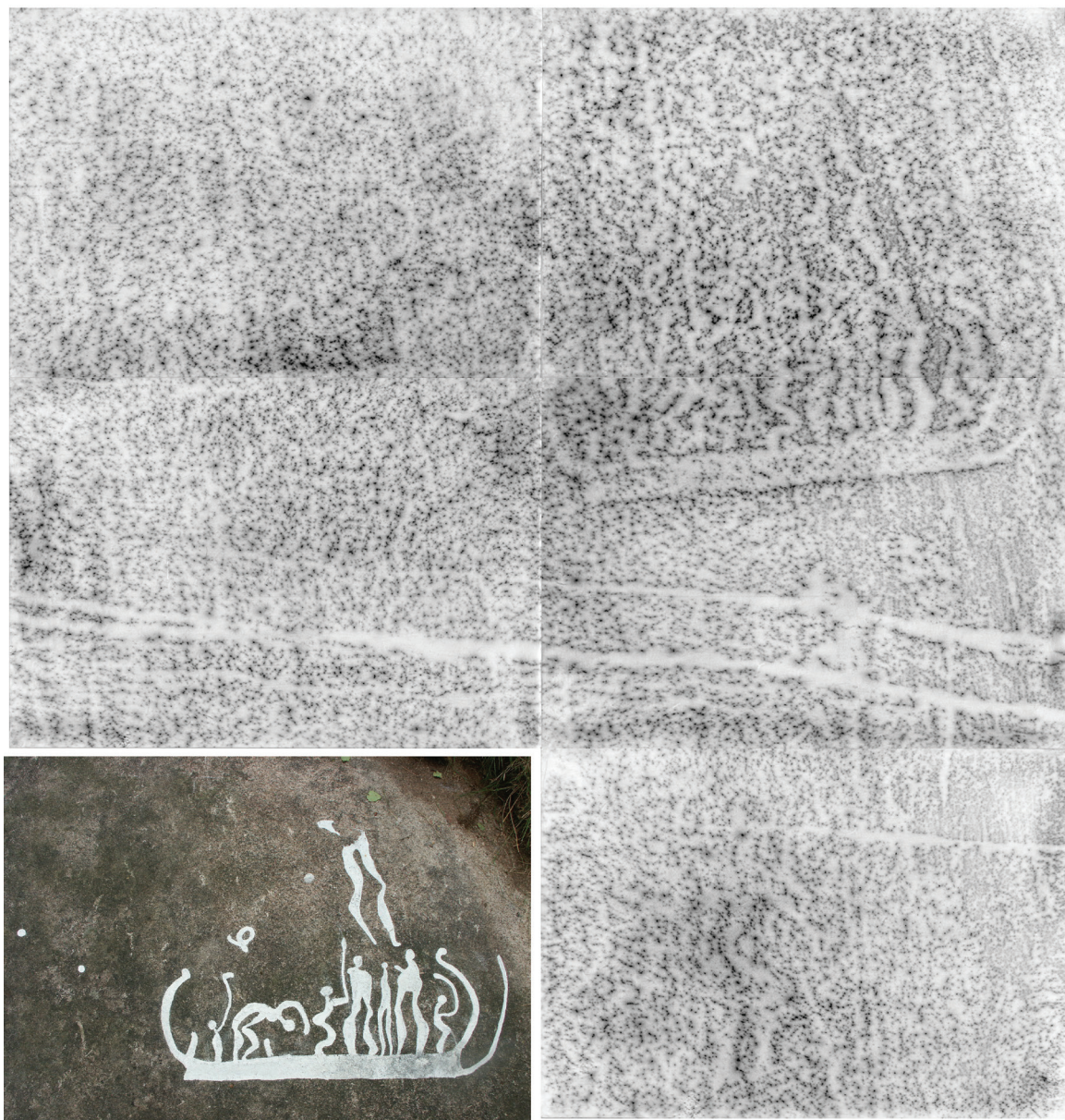


Figure 3. Frottage and tracing image of Tanum 247:1 by Torsten Högberg.

The third recording was a tracing taken in 1983 which missed some important features (Figure 3b). The legs of a number of the figures shown in the boat in the earlier frottage were present, but their bodies as well as the figure above the boat were



**Figure 4.** Frottage created by Tanums Hällristningsmuseum Underslös with photo of chalk painting created by Gerhard Milstreu, inset.

missing. It also shows a figure below the boat, but the exaggerated calves seem to be interpreted as thighs. The result lacks some key features on the prows of the boat which makes it seem like it dates to period III (Ling 2014, 105)

The photograph of a chalk painting by Gerhard Milstreu at Tanum 247:1 conducted in 2003 differs from the tracing from 1983. This documentation recognizes the boat with seven figures, including a lur blower. Furthermore, several cupmarks, a pair of legs with exaggerated calves above the boat, and a figure with exaggerated calves towards the bottom of the panel were recorded (Figure 4).

The most complete traditional documentation was created during the same field seminar as Milstreu's chalk painting in 2003. This shows the boat and the figures extremely well, and was used as the base point onto which the new results were overlaid. However, when this rubbing was conducted the lower left part of the panel was not documented, presumably because it was considered to be too eroded. A raking artificial light was used at night, and it was decided to only document areas where traces of carvings were visible.

## Documentation Method

The new recording was conducted during fieldwork in the summer of 2021. The panel was captured using standard photogrammetric documentation methods, including structure from motion, which are discussed elsewhere (Cobaz and Jagersand 2003; Green 2018; Horn and Potter 2018; Meijer 2016). The equipment used was a full frame Canon EOS R5 in manual mode and a Canon 28-70 mm RF lens shooting at 28 mm. The panel was largely shaded and there was also minimal wind, so shooting conditions were ideal. The panel was initially lightly cleaned and loose material was removed so that the full panel could be recorded. A total of 913 images were taken, all of which aligned successfully in Agisoft Metashape. All photographs were manually masked prior to alignment and checked for quality to minimize erroneous points. The model was then processed in the software using high settings and accuracy throughout for the best quality result.

For the analysis of the panel, a variety of visualization methods were used. Firstly, a Digital Elevation Map (DEM) was created in Agisoft Metashape, imported into ArcGIS Pro, and processed using the local relief modelling (LRM) methods outlined in Horn, Potter and Pitman (2019). It was processed with the focal statistics tool using cell sizes of 90 and 250 and then subtracted from the original DEM and given a standard deviation of 1.5 to highlight the carvings better. This produced two visualisations of the panel, each highlighting different features in different ways, which were then used for comparison when the final interpretation was drawn.

The 3D mesh that was created in Agisoft Metashape was then run through a visualization tool called Topographic visualization toolbox<sup>1</sup> (Horn et al. 2021). It was calculated using the full quality mesh with resolutions of 1, 10, 100, and 250. The best-looking output maps were selected for comparison.

The 3D mesh was then placed into a virtual reflectance transformation imaging (RTI) 'studio' created in Autodesk Maya, which moved the light with each frame and rendered out an image using a similar technique as described elsewhere (Goskar and Earle 2010; Goskar and Cripps 2011). These

were then calculated in RTI builder and compiled based on the principles laid out by Cultural Heritage Imaging (CHI) (Cultural Heritage Imaging 2013). The result was investigated in RTI viewer using the specular enhancement rendering mode from various angles. The 3D mesh was also investigated in Meshlab using the radiance scaling shader and a moving light in line with standard analysis methods for rock art (Díaz-Guardamino Uribe and Wheatley 2013; Jones et al. 2015).

## Comparative approach

Due to the erosion, some of the motifs were quite difficult to determine or were entirely missing from previous documentation attempts. In order to verify the results of the new documentation and to evaluate earlier findings, the output of a number of different visualisation techniques were overlaid, starting with the frottage created during the field seminar of Tanums Hällristningsmuseum in 2003, overlaying the LRM results. Older documentation like the frottage by Torsten Högberg was then used in the same manner. The tracing created by Gerhard Milstreu was used as a reference point, with the outlines from the LRM and Frottage being preferred as a baseline. The traditional recording methods were rectified to match the orientation and scale of the LRM in ArcGIS. These were then exported as TIFs and included in the analysis. The results from the methods were then compared using Adobe Illustrator. A final interpretation of the new 3D recording was drawn to create a better comparison.

Throughout the analysis and interpretative process, the orthophoto and textured 3D mesh created in Agisoft Metashape were consulted to make sure that natural features and damage were not misidentified as rock art. Once the initial investigation was completed using digital methods, we returned to the site and conducted a traditional rubbing on the surface that was covered by the 3D documentation to evaluate our findings (Figure 5).



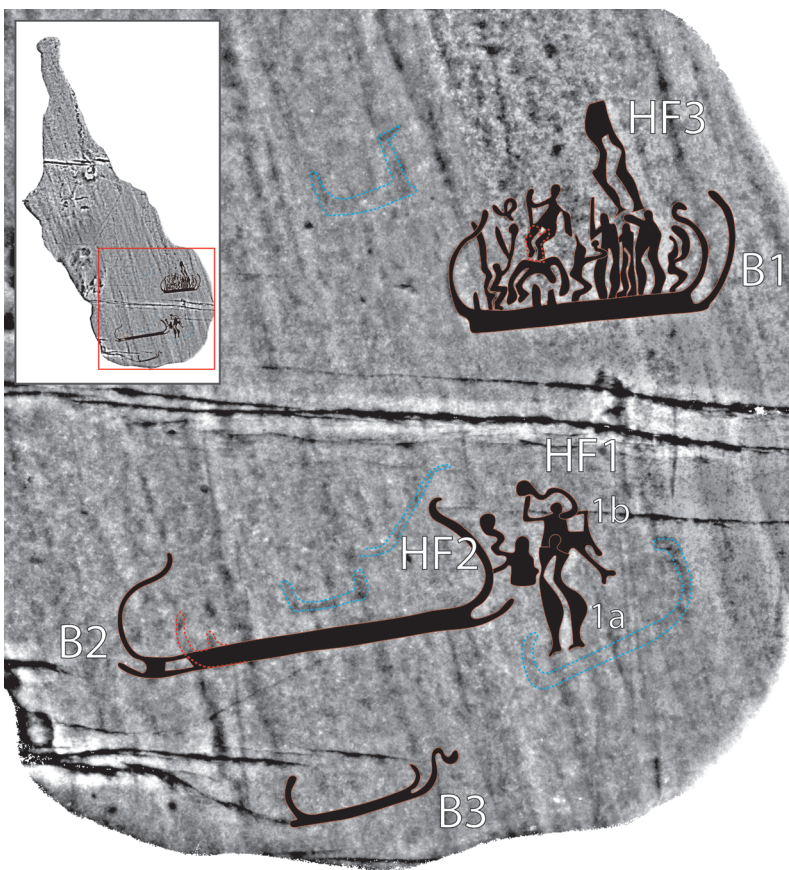
**Figure 5.** A frottage being produced at Tanum 247:1 (Photo: Ellen Meijer).

## Result

The LRM output provided the baseline for the interpretation as it produced a strong visualization of all the known features as well as new previously undiscovered images. The majority of the features were visible on the LRM directly, but we also utilised the results from the other methods to verify that what we were seeing was real, as well as to fine tune the results. The carvings are outlined in the figure below, and subsequently described.

Boat 1 (B1 on Figure 6) was updated by adding outward turned prows, suggesting that an Early Bronze Age boat was returned to and updated. The presumed addition on the prow becomes narrower where it meets the original prow, slots into the original carving, and the visualisation suggests that it is carved deeper, implying that it was created by another carver. This logic is also why other carvings in this paper are considered to be later additions (Horn and Potter 2018; Milstreu 2017). If the boat is considered prior to its update, then the prow design and the two Lur blowers may indicate a period III boat. The style of the stems after the update might be reminiscent of period IV or V. The boat features several other figures, three crouching, three standing. The deeper carved human figures may also be additions and it appears as though the prow may also have been extended. Although the rock above this carving is quite eroded, it was still possible using a combination of techniques to pick out the outlines of the figures.

Within the boat there appear to be two lur blowers, an acrobat, and at least five other anthropomorphic figures (Figure 7). There is potentially also



**Figure 6.** LRM view of the panel with interpretations marked. Motifs are labelled as they are described in the text. Red dotted lines indicated amendments to the carvings, or figures that are obscured by others. Light blue dotted lines denote features we felt might be present but were not sure enough about to confirm.

another figure hidden behind the acrobat. This, as well as the elevated figure whose legs are represented below the acrobat on the boat itself, suggest that some of the human figures were added later.

Boat 2 (B2 on Figure 6) features long outward curved stems, which can be compared to period V boats (Kaul 1998; Ling 2014, 105). The boat was originally a different length, or is intersected by another boat. The Late Bronze Age stem extensions seem to be updates to a boat that had much simpler stems, perhaps dating it to period III (Ling 2014, 105): an idea supported by the possible lack of crew on the ship. There is potentially at least one larger figure present in the middle of the boat which also seems to have been added later, but we were not certain enough to add it to our interpretation.

Boat 3 (B3 on Figure 6) is located below boat 2 on the panel and features outward curved stems which are elongated. There is no crew indicated on the ship. The stem design indicates a period V ship (Ling 2014, 105). However, given the observations so far, it may also be an updated earlier boat.

There are a number of other potential boats and features which may have been present, but they were heavily eroded, and it is not clear enough to be determined with any confidence whether it was in fact a feature, natural, or erosion/damage.

Human 1 (HF1 on figure 6) appears to be in fact two motifs superimposed on top of each other. The original figure (1a) is approximately half the height of the second figure (1b) and features exaggerated calves and a very short torso. Comparative examples of figures like this can be found on Tanum 410:1, approximately 65 metres away. The carving was later potentially extended, and a more anatomically correct version of the body was engraved. In its final form it features a sword sheath with a winged chape, which extends approximately from the head of the older figure (1a). The larger human (1b) appears to be holding a circular object and may also have a line going through its arm that curves round its head, which could be the representation of a lure, but the precise relationship is not certain. The larger figure may date to period V, as is often suggested based on the chape which resembles Central European examples (Fredell 2003, 2009). However, it is worth pointing out that the typological comparison is not an exact match (Pare 1991).

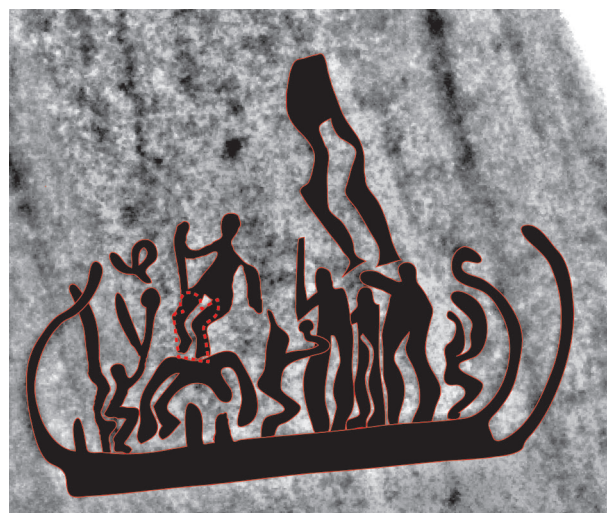


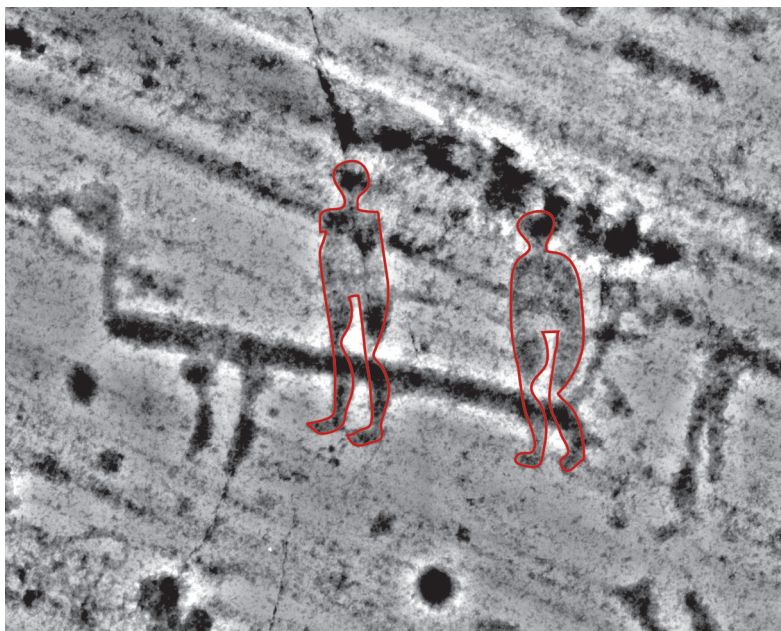
Figure 7. Detail image of Boat 1.

Human 2 (HF2 on Figure 6) is directly in front of human 1 and appears to be the same height as the original version (1a). It seems to only be the upper half of the figure and it seems to be holding something which could potentially be another lur. This figure is connected to the prow of boat 2.

Human 3 (HF3 in Figure 6) is located on top of boat 1 and seems to consist only of a pair of legs with exaggerated calves. It does not appear to have ever been completed, which is well-documented phenomenon in Scandinavian rock art (Fahlander 2021). However, the carving is also in a high erosion area, so it may have originally been a complete human body.

The boat originally mentioned in the inventory that was potentially visible on the original frottage was determined to most likely be natural damage or erosion, as although it appeared boat shaped in the original image, the panel itself did not hold a regular enough form to be considered rock art (Fig. 3a, 6). Part of B2 can be seen in the original frottage, to the left of the HF1, but it is extremely faint as the level of carbon that was laid down was lower in this area, suggesting that it was not an area of focus for the documenter.

Based on the observations in the older documentations, the new documentation using photogrammetry uncovered two boats (B2-3) and a partial human figure (HF2) that were previously unknown. The make-up of HF1 is also rather different than previously recorded.



**Figure 8.** Illustration showing the two similar figures from Tanum 410:1.

The greatest enhancement using multiple techniques combined was on B1, as described above, where greater distinction of the figures was able to be determined. Overlaying our documentation with earlier ones allowed us to enhance the details on the boat crew of B1 as well as HF1 and 3. In addition it was possible to show that the human above B1 and the acrobat superimpose an older human figure. Our results also demonstrate that there is still room for improvement in the future. New, yet to be discovered, evaluative techniques will perhaps be capable of enhancing the visibility of areas on the panel where we felt there might be something, but were unable to accurately depict them with any confidence.

## Discussion

There are four other panels in the local area which were also recorded using the same techniques. It is apparent that the carvings on Tanum 247:1 share similarities both in terms of the ship and figure design with Tanum 408:1, 409:1, 410:1 and 411:1, suggesting that some of the carvings were made contemporaneously, perhaps even by the same individuals. However, to establish this a more in-depth comparison is necessary.

There is also evidence of different carvers returning to the panel after generations and updating the images (Milstreu 2017). Two examples of this in particular are HF1 and B2. HF1 seems to be

composed of one smaller figure with a torso added at a later date to make the figure taller. There is a comparable example of the smaller figure found on Tanum 410, some 60 metres away (Figure 8), which suggests that perhaps these two figures were carved at roughly the same time period, and it was then later extended with extra equipment added (the sword sheath and the possible lur).

B2 was updated at least once and made to be longer than it originally was. This is seen by the fact that there is an old shallower prow extruding from within the middle of the ship. It shows yet another kind of way in which carvers in the past re-engaged with previously existing images in addition to those already identified (Bertilsson 2015; Horn and Potter 2018; Milstreu 2017). It may be possible that the elongation of the boat has to be seen within the same context as the elongation of the warrior. This process was previously observed, although in a different way, in Finntorp which is within 6.5 km of Kalleby (Horn and Potter 2018).

From the panel at Tanum 247, it would have been possible to see the water in the valley which was a fjord during the Bronze Age which connected the area to the sea. Within the surrounding area there is a cluster of rock art which all contains maritime elements including boats and humans – some of which are quite similar in terms of the motifs that were carved upon them. This could indicate that the area was a natural harbour or landing site,



which was potentially controlled by a local group. The local community may have carved the rock with symbols of maritime journeys and warriorhood during boat launching ceremonies, perhaps involving narratives of heroic journeys conducted by their ancestors which would also reaffirm their claim over this land (Horn 2019; Ling and Cornell 2017). It may well have demarcated the landscape and could have been used as such for a long period of time. At some point, carvers appear to have returned to the rock art sites and reemphasized and updated the boat images and the humans to make them fit better to changes in material culture and visual conventions with the aim to keep the images, narratives, and the memories linked to them relevant (Horn and Potter 2020).

Rock art and all of its potentially associated social functions, perhaps illustrating narratives, heroic stories, or myths, were important to the inhabitants of the Kalleby valley throughout the life cycles of the panels including making, viewing, adding, updating, and transforming images during the Bronze Age (Ranta et al. 2019; Redef, Skoglund, and Persson 2020). They were perhaps a relatively frequently used aspect of life not only as images, but as a practice tightly interwoven into the social fabric that people not only viewed, but also actively engaged with. Their meaning and presence were probably curated to keep them relevant to changing social, political, economic, and ideological circumstances. However, since this was based on older carvings their meaning may have been kept within the same frame of reference, i.e., boats and warriors, making existing images places of memory that helped to keep stability and social cohesion (Horn and Potter 2018, 2020).

## Conclusion

Using 3D documentation has revealed new carvings and unknown aspects of previously documented images in Tanum 247:1. However, it has also highlighted the need to evaluate these results with documentations derived from other methods. It was extremely useful to return to the site after the first data collection with SFM and create additional frottage sheets. This gave us the opportunity to confirm the results of the LRM and build

a stronger interpretation of what we were seeing on the screen. This suggests that the best way forward is to record new finds as extensively as possible using a combination of new and traditional methods. While older methods are clearly reductive, and some are even more interpretative than others, i.e., tracings, they all have a value in highlighting specific aspects of engraved surfaces. It is also necessary to document at different scales with the new methods i.e., from full panels to individual images as well as close-up approaches like macro-photogrammetry. Ultimately, we need to utilise as many methods as possible together, both traditional and new, to create a fuller picture of what is represented by the carvings.

It was clear from this exercise that regardless of which technique is used to evaluate the results, it is important to redocument entire panels, rather than collecting only what is known. In the future there will undoubtedly be better techniques than presented here, so it will be crucial that the results we create now are as complete as possible so that they can be of more use to future researchers.

As this case study has shown, this incorporation of all of the available methods led to the discovery of several new anthropomorphic figures, and potentially two new boats on a panel that has a documentation history spanning over five decades. The results showed that images were added over time, revisited, and extended or otherwise changed. Using the proposed approach may help us to understand just how important carvers were and how deeply engrained rock art and the making of rock art were in Bronze Age societies in southern Scandinavia.

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## Declaration of interest statement

There are no conflicts of interest to report.

## Notes

1 <https://tvt.dh.gu.se/>

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