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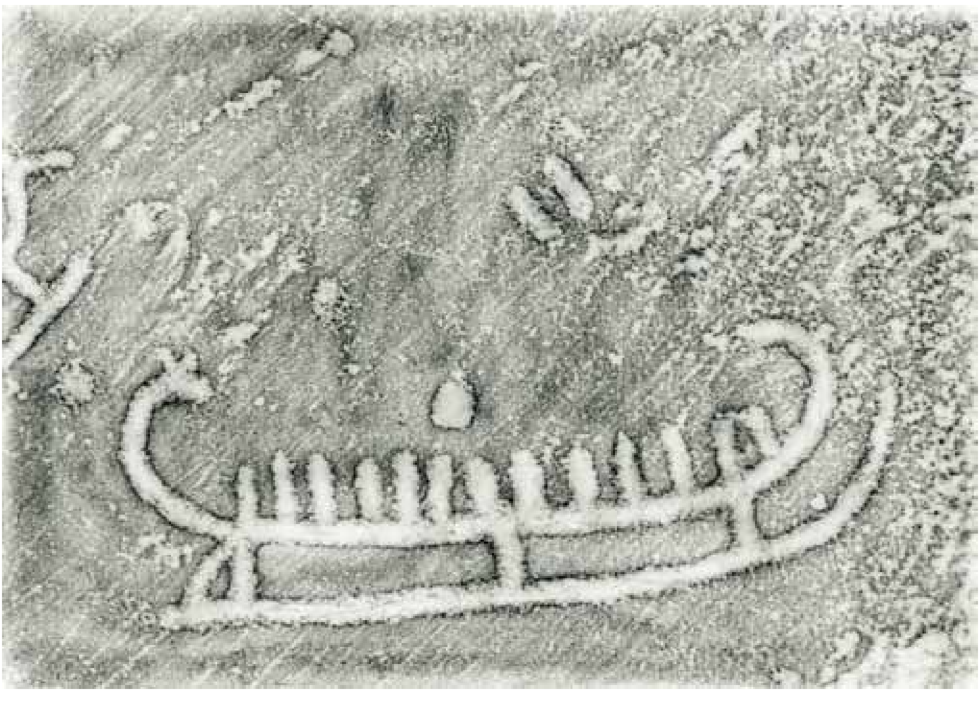
Photogrammetric scanning of rock carvings

Introduction

Today many rock carvings are in a poor state of preservation due to environmental and climatic changes. Sadly they will maybe fade away in the future. Therefore future scientists will not be able to study the carvings in the field, instead they will have to base their investigations on documentation. It is therefore important to document the carvings as thoroughly and realistically as possible.

A problem with the most common documentation methods, such as *tracing* and *rubbing* (figure 1), is that they present carvings in a flat, two-dimensional view, (*2D*), which means simply the length and the width. The documentation omits informa-

Figure 1: Rubbing of a shipmotive from Brastad 5 (photo: Mette Rabitz).



tion such as the topography of the rock, the depth of the carvings, pecking marks and the carving techniques. Such details are very valuable and should be registered, documented and presented! These details generate a more realistic view of the carvings and the rock which they are placed upon, and by documenting this, the science of rock art can be developed and create new questions for future research. This will make it possible for future scientists to rely on documentation, which will give a better understanding and experience of the carvings since maybe they will not be able to study the carvings anymore due to erosion!

In my masters thesis (Rabitz 2013) in Prehistoric Archaeology, I evaluated and analyzed some 2D- and 3D-documentation methods, which have been in use in South Scandinavia. I also did some experiments with the 3D-method, *photogrammetry*, in order to document rock carvings in *Bohuslän* and *Østfold*. This article will only focus on photogrammetry, and only few of the case studies will be presented here. The complete thesis is available on: www.metterabitz.dk which also has information about other methods and a blog about fieldwork.

Photogrammetry

In the field of rock carvings, some panels have been 3D-documented with *laserscanning* and *white-light scanning*. The results are very realistic, and it is also possible to study the microstructure concerning pecking marks. Even though the results are promising there are some limitations with using these methods. Both laser- and white-light scanning use heavy equipment, and need huge amounts of power, for instance car batteries. -Many carvings are not situated near roads, and sometimes one has to hike or climb to some panels (Bertilsson & Magnusson 2000, Johansson & Magnusson 2004). Using the equipment also needs technical experts concerning data-collection and also in the later study of the data. The study also needs huge servers, which have to process the data for hours or possibly a week.

In the car- and building industry another 3D-method has been used, *photogrammetry*. With photogrammetry one can develop 3D-models based upon photos. The method documents objects almost as precise as laser- and white-light scanning, but only needs a camera and eventually some photo equipment when gathering data. The technique consists of a pair of photos, a stereo-pair, which means that the object is photographed twice, but seen from slightly different angles. The different perspectives of a stereo-pair give the opportunity for a 3D-presentation of the object (Walford).

The photos are processed through photogrammetric software. There are both freeware and some softwares which are a little more expensive. The quality is definitely better with the more expensive softwares. I used a canadian software from *EOS* called *PhotoModeler Scanner*. This software can be processed on a consumer computer

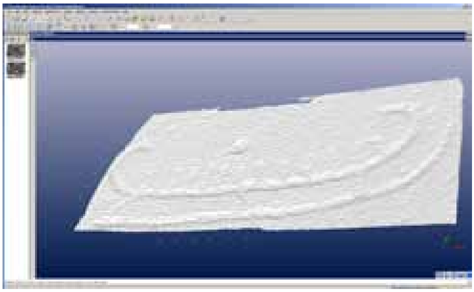
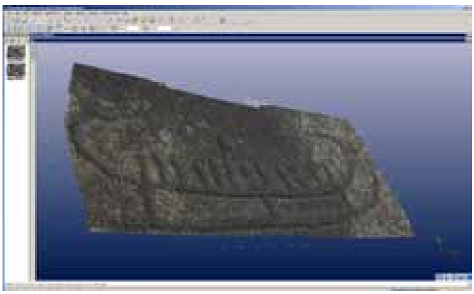


Figure 2: Screenshot of 3D-model from Brastad 5, shaded view. Note that the two pictures to the left were the amounts needed to create the 3D-model (photo: Mette Rabitz)

Figure 3: 3D-model presented with texture (photo: Mette Rabitz).



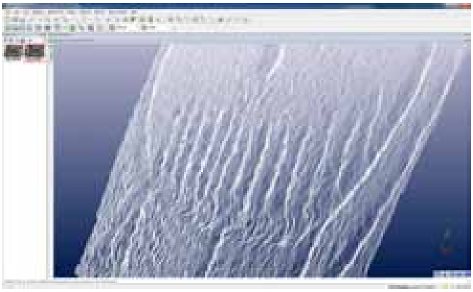


Figure 4: Screenshot of 3D-model of shipmotive from Brastad 5 presented in dotted view (photo: Mette Rabitz).

in a few hours, and it is somehow easy to work with, and does not need technical experts. Even though the photogrammetric software is costly, it is still a much cheaper solution than the laser- and white-light scanning, where one would have to get service for the equipment every now and then + hiring special servers to process data and technical experts.

The finished 3D-model can be shown in a fine meshed *pointcloud*, in which one can study the microstructure of the carving, for instance pecking marks, but it is possibly also a nice way to study the process of degradation. It is also possible to measure the carving down to millimeters on the 3D-model. In order to measure, the use of target points is needed, when taking the pictures. In order to make the software know your camera, the first step is to calibrate the camera.

When collecting data in the field it is as usual when taking photos: a good and even balance of light, but not too much sunshine. In contrast to tracing and rubbing, photogrammetry does not need a dry surface. But small depressions with water should be emptied, since the water will reflect images, which are mirrored from the surroundings, and these will confuse the photogrammetric software. If the rock surface is too wet in combination with the light shining too much, this will not give a good documentation. When taking the pictures, it is also important that things do not change from picture to picture. For instance vegetation which moves in the wind, or flying insects will change the pictures, and should be avoided in pictures.

After collecting the data, the photos are processed in the software. The software will analyze the pictures in order to detect common points in between the photos, and creates a cloud of all the points –the object

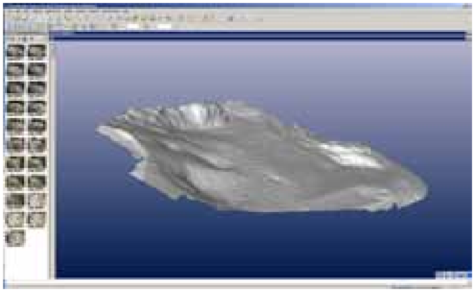


Figure 5: Screenshot of topography, Finntorp T-184:1 (photo: Mette Rabitz).

Figure 6: Data-collection at Post-Hornes with the use of targetpoints (photo: Mette Rabitz).

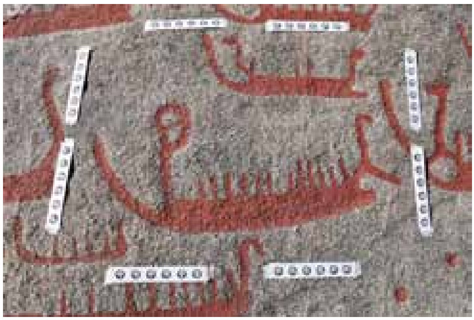
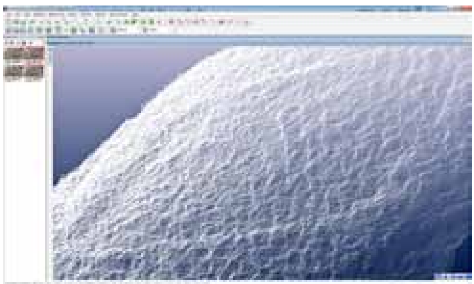


Figure 7: Close-up of the stem of a ship from Post-Horness (photo: Mette Rabitz)



is now presented in a fine meshed point-cloud. Now it is possible to generate a 3D-model, which can be presented in a *shaded* view, one colour with shade-effects (figure 2); with *texture*, with realistic colours from the photos (figure 3); and in a *dotted view*, where it is possible to study the microstructure (figure 4).

Cases

The *Finntorp*-panel (T-184:1), from the Swedish World-heritage area of *Tanum*, was interesting to document because of the placing of the carvings in a special topography. The rock slopes down into a long depression, which could look like a small creek, where shipmotives have been carved on both sides. The rock also has three oval depressions, almost like small lakes. It is not possible to present these details with the use of rubbing or tracing, which was why I wanted to test if photogrammetry could document such contextual elements. The result can be seen on figure 5, and at: www.metterabitz.dk the 3D-model has been animated, so it is possible to study the rock from many angles. My first intention was to present the topography and the placement of the carvings. But in order to do this, a 3D-model of every carving should be made, and stitched together with the 3D-model of the topography, which would take too much time concerning the time-schedule of the fieldwork. Alternatively one could have placed a rubbing of the whole panel upon the 3D-model of the topography, but then the rubbing and the collecting of data for photogrammetry should have had some fixed points in common. Another solution could be to paint the carvings with non-permanent paint, before taking the pictures for the 3D-model of the topography.

To reach the panel, one needs to take a steep walk through the forest. In the middle of the forest with a sloping topography, there is a rock coming up, upon which the panel is situated. It was therefore nice to only have to bring the camera and photo equipment in order to document this panel.

Post-Hornes III from the Norwegian rock carving area of *Østfold*, has permanently painted rock carvings. Some of the painted details differ from Martstranders tracing from 1943 (Marstrander 1963), and it has been discussed if they are wrongly painted, or if Marstrander has not seen them. At figure 6 the left stem of the ship is a circle

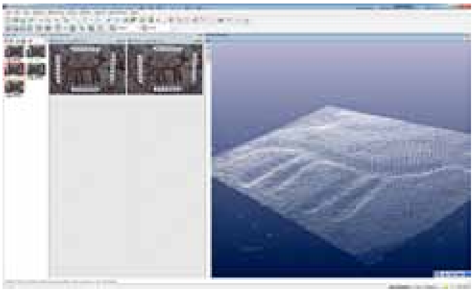


Figure 9: 3D-model of a horse from Brastad 1 (photo: Mette Rabitz).

Figure 8: 3D-model in colourspectre, which show different levels. Blue is the deepest level, while pink is the highest (photo: Mette Rabitz).

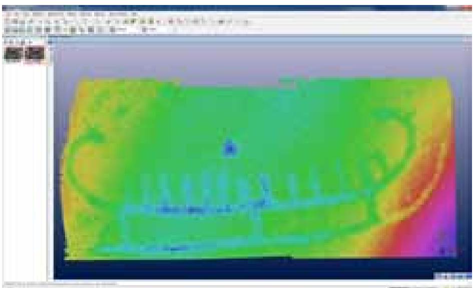
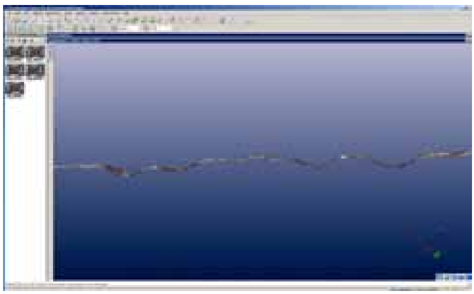


Figure 10: Virtual cut-through of the legs of the horse seen at figure 9 (photo: Mette Rabitz).



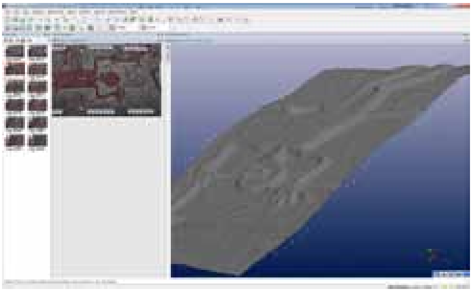


Figure 11: 3D-model of "the shoemaker from Backa Brastad" seen from the other way around (photo: Mette Rabitz).

with a line going through it. This detail was documented by Marstrander as a stem with an s-shape. The 3D-model of this detail showed the detail slightly different (figure 7), as a circle which was more deeply carved inside. The reason for painting the stem as a circle with a line going through it is possibly due to a slightly higher point inside the circle.

At *Brastad 5*, from the southern part of Swedish *Bohuslän*, I investigated a shipmotive. It looked nice and evenly carved both on the rubbing (figure 1), and on the 3D-model (figure 2-4). By looking at the motive in a colourspectre in the programme, which presents different levels in colours, it was also clear that the ship were not evenly carved (figure 8). This colourspectre is also useful in order to present updated carvings, such as the small ears added to the left stem. An inward stem with ears can be dated to the Bronze Age period III, according to Flemming Kauls' ship chronology (Kaul 1998). But as the ears are somehow differently carved, they could have been added later. So this means that the ship with inward stems instead can be dated to period I or II, which would make the ship some one hundred years older.

At *Brastad 1*, also known as *"the shoemaker from Backa Brastad"*, some carvings are more deeply carved than others, for instance the shoemaker and a little horse on a ship (figure 9). The horse looks evenly carved, but with a virtual cut-through, the leveling of the legs seem odd (figure 10). Two legs are not as deeply carved. Were the legs not finished, or was it on purpose in order to symbolize something? The head of the shoemaker consists of a deep ring, in which the inside is in a higher level. -A 3D-model of this is a good way to visualize such detail (figure 11).

Evaluation

In order to document as many panels as possible it is important to use a fast but effective method. During the experiments with photogrammetry it became clear that the method is useful concerning effectiveness and use of time. The method results in good documentations of the topography and of the carvings. If the rock surface is very smooth, and the carvings not very deep, it will be necessary to also document with another method. In such a situation photogrammetry and rubbing would complement each other well. A great potential of photogrammetry is also that in contrast to laser- and white light-scanning, it can be used on consumer computers, and by archaeologists and other scientist, and does not need educated experts. Presenting a 3D-model in realistic colours will also make the documentation useful for biologists in order to study the vegetation of algaes and lichens, or geologists could study the condition and preservation of the rock in general, but also in the microstructure. Presenting rocks in 3D would also reach a greater audience, for instance if a student in one part of the world wanted to study rock carvings from another part of the world, but were unable to travel there, it would be useful for him to at least study a 3D-model, which gives a better impression than a photo. 3D-documentation could also be a good way to document other archaeological objects, or useful in excavation in order to present a profile or document the excavation of a burial.

If the data has been collected, there are then a range of possibilities of what to do with the data. One could animate the 3D-models, as is available on the above mentioned website. The 3D-model could also be presented with a turn-tool, so the viewer can twist and turn the 3D-model around, in order to study the object from different angles.

In the future, it would be interesting if scientists focused on updating carvings or differences in level, like the legs from Brastad 1. Was there there a difference in body parts in order to symbolize something? Another question could be concerning the carving-process, were some details not finished?

In the science of rune stones (Åhfeldt 2002) some promising results have been made in order to detect differences in the techniques of carving. By studying the microstructure of the rock carvings it could also be interesting to study pecking marks in order to understand the carving-process, the tools, and possible changes in the carving technique.

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