# Every picture in its place

## – A spatial analysis of rock art in Tjust using GIS

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Abstract

Rock art is the closest we have to a written language from the Bronze age. The different motifs make us wonder what stories they tell us, what they are representing and why they were even made in the first place. The focus of this thesis is on the placement of rock art motifs on the panel and by using digital techniques like photogrammetry and GIS, the spatial relation between different motifs is examined. Do certain motifs have a predetermined place on the panel, and how do the panel, cosmological beliefs, and people, who interacted with rock art then, affected the placement of motifs?

To study this, ten rock art panels were chosen from Gamleby parish in Tjust in eastern Småland. Tjust is well-known for being a landscape filled with remnants from the Bronze age, and it constitutes the rock art richest area in Småland. Spatiality and digital technology were the theories and practices used for studying the placement of rock art motifs. By treating the panel as a topographical landscape and look at density, distance, slope and topography, it’s possible to study rock art in relation to the rock panel.

What this study shows is that motifs are concentrated in certain parts of the panels, with small differentiations between individual motifs, and that the panels’ texture, including cracks and striations, could possibly have been affecting the way motifs were placed on the panels.

Key words: rock art, Bronze age, spatiality, Tjust, GIS, photogrammetry

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# 1. Introduction

This thesis is going to focus on the placement of rock art motifs on the rock art panel. By using 3D documentation and GIS, the spatial relation between different rock art motifs will be studied to see if there is a pattern between different types of rock art motifs and if certain motifs are found in the same part of the panel on many different panels. The rock art panels chosen for this study are located in Tjust in eastern Småland in Sweden. Even though Småland contains many rock art sites, it still hasn't been one of the most popular areas when it comes to rock art research. Tjust is an archaeological area known for its Bronze age landscape and for being one of the most well-known rock art areas in Småland. This thesis will not focus on all the rock art sites in the entire Tjust area, but the focus will be on a selection of panels in Gamleby parish which is one of the richest parishes in Tjust when it comes to rock art.

The focus of this study will be on the spatial distribution of rock art motifs on the panels. Spatiality will therefore be discussed in the theoretical part of this thesis. The landscape as well as surrounding settlements and burials where these panels are located will not be analysed further, but the panels' location in the landscape will be mentioned and their connection to the old shoreline. If there is a relationship between their location and specific motif combinations, it will be brought up. The carving process and how these figures were made will not be included either. Cosmology and phenomenology will be two perspectives used during the main discussion. Even though they will not be the main focus of this thesis, since the focus will be on the motifs' placement, different combinations of motifs and distances between them, it might still be of interest to include these two perspectives and discuss them in combination with the results of the analysis of the panels.

One way for archaeology to better understand past societies and people's experiences of the world around them and how they saw it and lived in it, is to study rock art. During a time when there was no written language, the rock art gives us a glimpse of what past people found important to portrait on the rock panels in the landscape. The motifs they chose to carve onto the rocks give us a glimpse of what ancient people found valuable and important to show others, and how these motifs are representing something more than just what meets the eye (Chippindale & Nash 2004a).

The rock art motifs have been studied from many different perspectives, for instance from a cosmological, religious and a semiotic perspective (Kaul 1998; Skoglund, Persson & Cabak Rédei 2020). Rock art have been studied as material objects with focus on materiality (Fahlander 2017), its relation to and placement in the landscape (Chippindale & Nash 2004b and when it comes to the rock art panel, they have been studied from a phenomenological point of view and how people might have moved between them in the landscape (Tilley 2004a, 2008). It has also been suggested that the panel could represent a sort of map of either the landscape where the panel is situated (Helskog 2004; Nash 2011) or where different sceneries are taking place (Cabak Rédei, Skoglund & Persson 2019).

What has not been studied as much is the placement of the different rock art motifs on the actual panel. Even though studies have been made about the panel's texture and colour as something that might have influenced the placement of certain motifs (Jones 2006), not many studies have been made about the underlying choices of placing motifs on different parts of the panel. We understand that rock art motifs possessed symbolic and cultural meaning, and by making some motifs bigger than other, or certain parts of the motif bigger than other, it sent out a message to people observing it (Goldhahn 2009, pp. 34 – 44; Skoglund, Persson & Cabak Rédei 2020). But could it be that motifs had a predetermined place depending on what kind of motif it was? And can this be traced on other panels as well?

## 1.1 Purpose and aim

The aim of this thesis is to assess the limits and potentials of using digital techniques when studying rock art. With the use of photogrammetry, I will document a number of rock art panels in Tjust in Småland, create 3D models in Agisoft Metashape, and then import the models into a GIS to study the placement, distance and relationship between rock art motifs on the different rock art panels. My purpose is to see if rock art motifs are placed in a similar way on several different rock art panels and if there's possible to see a common pattern between them. To discuss the reason why the motifs are carved where they are, spatial, cosmological and phenomenological approaches will be used.

## 1.2 Questions

1. How can digital techniques be used to study the placement of rock art motifs?
    - Where are the different motifs placed on the panel?
    - What relation do they have to other motifs and the panel itself?
    - What similarities and dissimilarities can be found between the panels?

2. In what way might symbology, an observer and the panel itself have influenced the placement of the motifs?

## 1.3 Background

The Bronze age is known for its monumental burial mounds, the import of bronze and the creation of objects of high skills in craftmanship and with ritual and religious meaning. Another thing that is well known from the Scandinavian Bronze age is the rock art. Even though the making and use of rock art reaches its peak in the Bronze age, it started long before the earliest part of the Bronze age (Jensen 2002).

The oldest rock art in Scandinavia can probably be dated to the Mesolithic and the hunter-gatherer societies who lived in the middle and northern Scandinavia. The most common motifs were hunting game like elks and bears, both painted, polished and deeply carved (Burenhult

1999a, pp. 216 – 217). Another type of carvings which also occurs during the Mesolithic are cupmarks. They can be found on top of the roof block of south Scandinavian megalithic tombs. In western Europe, cupmarks are found on the walls inside the megalithic tombs, which also makes the dating of the cupmarks to the Mesolithic more precise (Burenhult 1999b, pp. 311 – 312). About 2000 years later, another figurative motif saw the light of day, the ship. But the ships were not the only motif to be carved on the rock panels and boulders in the landscape. There were also different kinds of animals, humans carrying weapons and wearing garments, footprints, chariots and sun figures (Jensen 2002, pp. 489 – 491). The Scandinavian rock art is most concentrated in Østfold, Rogaland and Vestfold in Norway, along the Swedish west coast from Gothenburg to the Oslofjord, the Scanian east coast, Småland, Bohuslän and Östergötland in Sweden and Bornholm in Demnark (Jensen 2002, p. 80).

The close relation between rock art and water is evident, because most rock art can be found close to the past shoreline. Depending on where in the landscape these rock art locales were situated, the composition of motifs changed. Closer to water, the ship is overrepresented and in the inland areas, footprints, chariots and cupmarks are the most common motifs (Jensen 2002, pp. 489 – 491).

## 1.4 The Bronze age cosmology

Without a written language to carry on their history, stories, myths, legends and cosmological beliefs, the people of the Scandinavian Bronze age had to transfer their knowledge to other people through songs and storytelling. Some of these oral transmissions, which might have been taken place during certain ceremonies and rituals, also might have included the making of rock art. Rock art can therefore be seen as a social and ritual medium for carrying on knowledge between different groups of people (Goldhahn, Wikell, Broström & Ihrestam 2012). Three of the rock art motifs from the Bronze age are especially important if we want to get a glimpse of what people during this time thought about their world cosmology. The horse, the ship and the sun (Goldhahn et al. 2012; Kaul 1998).

The ship during the bronze age had a symbolic, but also important, meaning for people. To be able to bring home copper and tin to produce bronze, owning a ship was crucial and it also gave the owner of the ship political and social power (Kaul 1998, p. 84). The ship as a symbol can be found on bronze items like razors, neck-rings, knives and tweezers, as rock art (Kaul 1998), and as ship shaped graves and ship settings (Skoglund 2008). What's also very interesting is the similarity between the shapes of the razors and the shape of the ship's stern or prow. Some of these razors with the shape of a ship also consists of a horse's head decorating the handle of the razor (Kaul 1998).

The sun can be depicted as a round circle with either a dot or knob in its centre or as double- or triple rings (Kaul 1998). A circle with a cross in it can also be interpreted as a sun, but also as a wagon wheel, it's then referred to as a wheel cross (Jensen 2002, pp. 273 – 288). Together with the horse and the ship, they constitute a holy trinity. According to Kaul (1998) people in

Scandinavia during the Bronze age worshipped the sun, and the rock art and objects can tell how important the sun was for past people. One of the most well-known items when it comes to religion in the Bronze age is the Chariot of the Sun, which was found in Trundholm Mose in Sjælland, Denmark. It consists of a horse dragging a sun disc on a chariot. One of the sides of the sun disc are covered in gold and the other side is dark. When the horse is facing right, the gold-covered side is visible and the dark one is not. The fact that the horse's direction from left to right also corresponds to the direction of the travel of the sun, the sun disc dragged by the horse might represent the belief that the horse was dragging the sun during the day, over the sky from east to west. In the evening, at sunset, the sun landed on a ship which sailed down to the underworld during the night and then up with the sunrise where the horse could continue the transportation of the sun. Other animals like snakes, birds and fishes, were also part of the transportation of the sun. The ship could also transport the sun during the day. When we look at the rock art ships in combination with suns, some of the ships are facing left and some of them are facing right. This is explained by Kaul that ships facing right are day ships, and ships facing left are night ships. This is due to the sun's travel from east to west during the day, meaning left to right, and from west to east during the night, meaning right to left. This cycle, which doesn't have a beginning or end, may symbolise life and death and the cycle of the seasons (Kaul 1998).

This circle of eternity might be, according to Goldhahn (1999) a representation of rebirth and reincarnation. His interpretation of the rock art panels found inside the Sagaholm mound in Jönköping, and the relation between the burial ritual and the rock carvings, is that the ship isn't just sailing with the sun as its only companion, it also brought with it the souls of the dead. When the ship reached east and the sun rose, the souls also arose from the dead and was reborn again (Goldhahn 1999). Kaul, on the other hand, rather wants to see the souls as becoming a part of the travel and part of the mission of transporting the sun through day and night. In this way, the soul becomes a part of the Bronze age cosmology after its death (Kaul 2005).

The ship is here the main actor in the Bronze age cosmology and religion. But what about places where the ship is almost absent? According to Skoglund (2006) the sun cosmology during the Bronze age changes character depending on different regions. In Kronoberg county in the Småland inland, the most prominent motifs are footprints, and ships are nowhere to be found. The sun cosmology in this area is explained from the rock carvings in Ör, by the fact that the sun is travelling alone during the day and then during the night the sun is transported by the horse and the snake. Here the big number of footprints, representing living people, might be interpreted as being part of the ritual and becoming part of the sun myth (Skoglund 2006).

## 1.5 Rituals

One reason why people carved out figures in rocks, boulder and panels might have been due to ritual practices or different ceremonies. The carvings could have been made in association to naming-, death-, funerary- or transition ceremonies. These transition ceremonies might for example have been ceremonies when someone went from a child to adult or apprentice to master. Maybe these ceremonies were held when children were born, during hunting, harvesting, slaughtering, environmental catastrophes, war and for curing sickness. Maybe they even used it for cursing or killing another human being. The important aspect of this is to consider rock art carving as a part of the rituals and not the aim of the rituals (Goldhahn et al. 2012).

Skoglund (2013) is discussing rock art footprints with focus on dress and nakedness in a ritual context. He takes the example of the Kivik mound in Scania and points out that the human figures on the slabs are both naked and dressed which could have been a part of the death ritual for the dead person. He then relates this to the study of footprints on a rock art panel in Järrestad in south east Sweden, which can be interpreted as both being dressed and naked feet. He draws the conclusion that nakedness and dress were used in rituals as an expression of one's social identity and to express authority and rank. The fact that footprints in rock art are depicted as real sized feet in the sizes of younger individuals could also indicate that making copies of your foot or feet onto the panel is relating to ritualisation and creation of personal identities (Skoglund 2013). The footprint may also have acted as a guide for people where to stand during ceremonies. Here the orientation of the footprints in relation to the view over the landscape, the sun and the rock's topography may have played an important role (Skoglund, Nimura & Bradley 2017).

Now and then, stone have played an important role for people. It is not just used for its durability when building grave mounds and raising gravestones, but also for its magical and mythical properties. Within animistic societies in southern Africa and northern Australia, societies who believe everything in nature has a soul, the rocks and mountains in the landscape are seen as homes for fantastic creatures and animals. Rock art sites, and especially the rock art panel, is like a wall between the outer world, our own world, and the inner world, the world of the supernatural, and is used as a medium for portraying the creatures living inside the rock (Taçon & Ouzman 2004).

Robert J. Wallis (2009) discusses the two rock art sites Ilkley Moor in Yorkshire, England and the Kilmartin Valley in Argyll, Scotland. According to Wallis, rock art sites were sacred places in the landscape. The rock surface where motifs were carved, was seen as a barrier between this world and the other, therefore people made rock art in honour of the non-human spirits dwelling there on the other side. They also returned to the rock art site to make sacrifices and other types of rituals. The offering of food and fluids running across the panel and down into cracks and fissures where perhaps passing the border between our world and the otherness (Wallis 2009). Kristiansen (2005) are discussing the same meaning of rock art locales in relation to settlements and graves and points out that rock art sites are located in the borderlands between these two. Therefore, rock art sites might have worked as cross borders between worlds, like a door between our world and the other (Kristiansen 2005).

Rock art was not just used as a part of the ritual practice during the Bronze age. The rock art itself can also show us what these rituals actually looked like. Bredarör in Kivik, is a grave cairn dated to circa 1400 – 1300 BC. Inside the cairn, the dead person was put in a stone cist and on these stone slabs which constitutes the cist, rock art has been carved. The pictures represent horses, animal sacrifices, dancing humans wearing bird masks, musicians, fire rituals and a human driving a war chariot. There are also more humans who are escorted to another room or tent. These carvings have been interpreted as scenes showing how the burial ritual was performed. Even though the dead person is invisible on the slabs we still get a glimpse and an idea of how people buried him or her and how the cairn was constructed (Goldhahn 2005a; 2006a). Rituals associated to activities like fishing and hunting, or rituals performed as a celebration to seasonal changes can also be told through the rock art. According to Knut Helskog (2004) the changes in nature during seasons are pictured as animals with or without antlers or with or without moose calves (Helskog 2004). The connection between nature, landscape and the rock art site is clear. The connection between rock art and the surrounding landscape, like the orientation of footprints according to the overview of the landscape (Skoglund, Nimura & Bradley 2017), and the placement between the zones of the living and the dead (Kristiansen 2005) proves that the rock art sites' location in the landscape play an important role.

## 1.6 Body and mind

People's intentions for carving out figures in the rocks in the landscape are something we try to understand. What people thought then might differ a lot from what we think today, meaning that all we can do is trying to reconstruct what people thought and how they used their material culture. When it comes to rock art, we need to study rock art, not just from a symbolic or iconic point of view, but also from a phenomenological perspective where we study the movements of our bodies and how we experience with our senses when entering a rock art locale or facing a rock art panel (Tilley 2004b). The phenomenological approach can be questioned though, since one person's experience doesn't mean that everyone experiences the same landscape in the same way. Fleming is criticising the way the phenomenological approach tends to make the most imaginative interpretations of the past landscape, through field walking for example, without having any evidence of their interpretations more than their own personal experiences (Fleming 2006). It is also problematic to think that past humans experienced the landscape the same way as we do today. Past people moved, lived and were constantly surrounded by their landscape. We visit it when we want to, which creates a romanticised picture of the landscape. Therefore, we can't look at landscape through a modern human being's perspective and claim that past people experienced it the same way (Johnson 2012). It would also be wrong to think that the landscape would look the same today as it did during the Bronze age. The landscape is not static but changes due to declining and rising sea level and climate changes, which also affects the vegetation. What we can do to reconstruct past landscapes, is to use paleoenvironmental data from pollen-, plant macrofossils- and insect samples. It will give us information about what was growing and living there and how wet or dry the area was (Chapman 2006, pp. 113 – 116).

Interacting with the landscape, buildings and people around us with all senses, even our body, creates memories of what we experienced which also make us remember what it felt like the next time we encounter it again. All these experiences, memories and activities we conduct in the landscape are also a part of creating our social identities (Tilley 2006). We often talk about how we affect objects and materials, but what we also need to bear in mind when studying rock art is how the pictures affect us. Rock art is not just representations of cosmology and symbology, they are also a combination of an artefact and a practice. Rock art possesses materiality and by that it possesses the possibility to affect people (Fahlander 2017). While moving through the landscape, you're not just experiencing the visual landscape but also its lightness, darkness, sounds, smell and taste. To be able to see the rock carvings from a better perspective, sometimes you need to climb up or down the rock and move from one side of the panel to the other. You might have to move in circles to see all the motifs from its right angle, turn your head from side to side, follow the direction of the motifs diagonally and sit down or stand on your toes to be able to see. Maybe you need to touch the stone or ground for support or to better feel the surface of the rock art. Everything you use your senses for, is helping you to experience the landscape and rock art locale (Tilley 2004a; 2008).

Movement between rock art locales in the landscape are discussed by Jones (2006) who points out that rock art motifs on standing stones in Kilmartin in Argyll, Scotland, were situated along certain routes through the landscape, directing the movement through the valley. These stones are situated in the landscape as nods which connect relationships and networks between different sites (Jones 2006). Another example is Tilley (2006) who brings up the rock art area Vingen in Norway and discusses the movement between rock art sites and how the landscape is experienced while moving in the same direction as the moving red deer depicted on the steep rocks (Tilley 2008)

When studying rock art, first and foremost we use our eyes to look at the panel to distinguish what kind of motifs there are and how many of them there are. But as Skoglund, Persson and Cabak Rédei (2020) are pointing out, one of the other important senses we need to use when studying rock art is touch. They discuss the multisensory interaction between the rock art panel and the observer meaning that past people created and carved these images in a way for people to interact with the rock surface with both sight and touch. For example, vertical panels can contain bigger motifs, so that you can see them from a distance, but on a horizontal panel, the motifs are automatically smaller, which means to be able to study them, you need to kneel in front of the panel, maybe bend forward and use your hands for support and use your fingertips to trace the images. Maybe some motifs were meant to be better experienced by touch than sight under conditions when the observer couldn't see the images clearly or if the observer had bad sight. One example is chariots which can be depicted from more than one perspective where the wheels are depicted from the side and the rest of the chariot from a bird perspective (Skoglund, Persson & Cabak Rédei 2020).

To summarize this chapter, making rock art could have been a part of carrying on knowledge about the world and what people believed in (Goldhahn et al. 2012). It was part of ceremonies and rituals of different kinds and the making of certain motifs could've been a part of creating and expressing a person's social identity, authority and rank (Skoglund 2013). The rock art site and panel have a special magical meaning. The rock art sites are usually placed in between the settlements and the burials (Kristiansen 2015) and in some cultures, the panel is seen as a barrier or a door between our world and another world (Taçon & Ouzman 2004). The ship, sun and horse play an important part of the cosmological belief of life, death and the afterlife, and the ship can be seen as a transporter of the sun (Kaul 1998) or the souls of the dead (Goldhahn 1999). The orientation of the ship might be due to the sun's travel across the sky and the underworld, and depending on the ship's direction on the panel, it could be either a day ship or a night ship (Kaul 1998). In regions where ships are absent, the footprint might have worked as a replacer for the ship (Skoglund 2006). Rock art sites have a deep connection to its surrounding landscape and are often found in specific locations between the settlements and the burial grounds (Kristiansen 2005). The panel's topography, view over the landscape and the position of the sun may have affected the placement and orientation of the rock art motifs as well (Skoglund, Nimura & Bradley 2017). To experience the landscape through a phenomenological point of view gives us an understanding of how people in the past moved between places in the landscape (Jones 2006; Tilley 2004b). Rock art affects us and the way we experience it with our bodies (Tilley 2004a; 2008) and by touch (Skoglund, Persson & Cabak Rédei 2020), but we cannot ignore the fact that our experience and interpretation will always be affected by our own modern worldview (Johnson 2012).

# 2. Theoretical perspective

## 2.1 Predigital methods of rock art studies

At the very beginning of rock art documentation, which in northern Scandinavia began in the beginning of the 17th century (Goldhahn 2006b), before digital cameras, computers and internet, documentation of rock art was made by drawing or painting the panel and rock art figures (Bertilsson 2015). Photography was introduced for documenting rock art around 1900. During the years, the most used techniques have been night photography, frottage and tracing (Goldhahn 2005b). Night photography, conducted during nights and evenings, uses an artificial light source to light the panel from an oblique angle, which creates shadows where the surface is irregular and by that, the figures become more visible (Horn, Pitman & Potter 2019). Using frottage, also called rubbing, means that the person or persons first of all study the panel to figure out where the different figures are. After finding the rock art figures, sheets of paper are placed on top of the panel and the motifs. Using carbon paper around a soft sponge, the area is rubbed by the carbon draped sponge and all the hard areas like edges and elevated parts, are painted. The depressions from both motifs and natural cracks or fissures of the panel is not coloured in as much, which creates differences between the hard and the soft areas. After the panel has been rubbed, the paper sheets are fixed by rubbing the frottage with grass. Tracing works in a similar way. After discussing and interpreting which lines constitute figures and which lines constitute natural cracks, the lines are coloured in using chalk or chalk paint. After that, the panel is covered with plastic sheets to transcribe the painted lines from the panel to the plastic sheets (Horn, Ling, Bertilsson & Potter 2018, p. 83).

The main problem with these techniques is their inability to show depth. Even though frottage shows less pigmentation over the shallow areas, the ability to show how deep the shallow parts are and document this third dimension, makes these traditional techniques insufficient to give us a realistic picture of the rock carvings (Horn et al. 2018; Horn, Pitman & Potter (2019). According to Goldhahn (2005b), the problem with older documentations of rock art is what the documentation excludes, which is the surrounding landscape, the panel's texture, natural features and slope. This creates a two-dimensional picture of rock art which does not depict reality (Goldhahn 2005b).

Even though these techniques give us a more detailed and accurate picture of the rock art than drawings do, they are still affected by the interpretations made by the person in the field, and each person might have their own interpretation about which lines are natural and which ones are human made (Horn et al 2018; Horn, Pitman & Potter 2019). The problem with the more traditional techniques when it comes to documenting rock art, is that each time a panel was documented, there were different results each time. And, since the focus most of the time has been on the motifs, the rock panel is almost forgotten in older documentation of rock art, which means a big part of the rock art's context is invisible (Meijer & Dodd 2018). Besides the problem with objectivity and the lack of depth information, these techniques are also expensive and demands a lot of space for storage (Johansson & Magnusson 2004).

To document rock art by physically touching it, has both its advantages and disadvantages. The disadvantages with documenting rock art using older techniques like tracing and frottage is the need to kneel, sit or lie on the rock panel while documenting. Depending on how much you need to move, you might cause damage to the rock surface and the images. Intense cleaning of the panel using chemical and mechanical cleanings is necessary for these sort of documenting techniques, which also causes damage to the panel (Horn et al. 2018). Even though these more traditional documentation techniques have many drawbacks, they do have something that digital techniques are lacking. The possibility to get close to the panel and make physical contact with it (Meijer & Dodd). Objects possess materiality, the capacity to affect us as we can affect them. Objects have a history and go through things just like humans do. It is when we engage with the objects through bodily interactions that we create a bond between us and them. When studying archaeological objects, getting in touch with the objects makes us experience it in a certain way (Olsen 2010). With digital techniques we are getting further away from the panel, which means that we no longer have physical contact with it. We lose the skills to read the surface and study the texture of the panel and its figures up close (Meijer & Dodd 2018).

Rock arts placement in the landscape and their visibility can be studied using GIS, but they have also been studied with more traditional fieldwork techniques. Bradley, Harding, Rippon and Mathews (1993) have been studying rock art sites and the visibility from them in Galloway, Northumbria and Mid Argyll in Britain through fieldwork, where they compared the view from rock art sites with the view from other sites in the landscape. The study used two groups of control samples. One group of samples taken from the overall topography in the landscape and another group of samples taken in the surroundings of the carved rocks. These samples showed a big difference of the view. In Galloway it was big contrasts when it came to the view at distances of 500 metre and from 500 metres up to 5 kilometres from both the rock art site and the random spots in the landscape. From 5 kilometres the view was almost the same. From the rock art site, within these two distance bands, the view was much wider than from the random samples, between 1,2 and 1,3 times the width than the random samples (Bradley 1997; Bradley, Harding, Rippon & Mathews 1993). Skoglund, Nimura and Bradley (2017) are discussing the rock panel's topography where they study the orientation and placement of footprints on panels in Järrestad in Scania and Boglösa in Uppland in Sweden. By studying two separate panels' footprints, their orientation and the view from them, they come to the conclusion that the footprints' placement and orientation could be affected by the direction towards the sea and the slope of the rock, not just the position of the sun which has been stated before. The rock panel's cracks and fissures also seemed to frame the footprints and the footprints seem to have been placed parallel to these natural features of the rock (Skoglund, Nimura & Bradley 2017).

## 2.2 Spatiality

Landscape archaeology has since the 1990s undergone a dramatic change in how we look at the landscape and how people used it in history. For a long time, modern western conceptions of humans and landscape was the normative way of looking at landscape where landscape has been seen as a backdrop where people lived and acted, and depending on the activities taking place there, landscape could be divided into two parts. Spaces and places. The places are seen as the sites where people lived and acted. To be able to get to all the different places, people needed to move between them through the so called spaces, areas that people didn't use or acted within. Space and place have therefore been seen as meaningless and meaningful parts of the landscape, the object and the subject (Chapman 2006; Thomas 2001), the natural and the cultural, or the quantified and the qualitative (Lock 2009). This is a very problematic way of looking at and studying landscape and how people used their landscape, since landscape becomes alienated, de-humanized, distanced and objectified (Thomas 2001). It also tends to separate the landscape into different zones depending on how important they were for people and how much meaning it contained (Ingold 1993; Tilley 2004b). This dichotomy separates the landscape between lively and lifeless things (Wallis 2009). Instead of studying the landscape from a site-based perspective, we should rather study the continuative use of the entire landscape and analyse the physical, cultural, social and political relationships across the entire landscape on many different scales (Campana 2018, pp. 31 – 42).

Spatiality means the way people use and structure their landscape for cultural, economic and social reasons. It's about how we as humans organize ourselves in the world and in place (David & Thomas 2010). Space can be manipulated and by that we can construct space and the world to fit our agenda and purposes. Studying spatiality in archaeology, means to interpret archaeological activity in the present and relate it to past human activity and experience. With help of spatial models, excavation plans and distribution maps we make representations of how past people used their space and material culture and how the spatial and social relationships between the physical and mental parts of the landscape look like (Lock 2009). Gillings (2012) is discussing the role of affordances and points out that we should not only study the physical relationship between people and the landscape, or certain elements in the landscape, but also the meaning certain landscape elements possessed to people and how this relationship, affordance, between the two were affecting the way people experienced the landscape (Gillings 2012).

Spatial analysis of archaeological material is one of the important ways to understand and get a glimpse of the organization of past societies and cultures and their relationship to their surrounding environment and landscape. The way these societies were structured is closely associated with the spread of artefacts and architecture (Seibert 2006). Within archaeology, the landscape has been studied to find new archaeological sites with the help of distribution of visible artefacts or remnants. By mapping the distribution of human activity, a spatial pattern can be made and used to find new sites in the landscape. Even place names, cartographic material, paleoenvironmental data and historical documents can be of good help to picture the way the landscape looked like and was used by past societies. Influential factors like watercourses and topography also need to be considered when interpreting the way people moved within the landscape (Chapman 2006, pp. 39 – 40). The distribution of artefacts, buildings, or places of activity are usually visualized as dots spread across an area. Depending on the number of dots, their distribution pattern and the closeness between them, interpretations can be made about how people used their space. If many dots, representing deposits of raw material, are clustered this could for example mean that these clusters are representing a manufacturing area. The disadvantage of this approach is that since we want to find patterns which explain what we see, sometimes we create patterns that may not be there (Wheatly & Gillings 2002, pp. 113 – 132).

The way of studying the landscape and the spreading of artefacts and innovations and how they and people moved across the landscape is to study the network between people and places. These places where the same artefacts or innovations can be found are seen as dots connected by lines where these lines represent movement, connections or relationships between people. Network analysis can also be used to study social and cultural borders, maritime contacts and interregional connections (Brughman 2013). Usually, these patterns are focused on similarities between places, but it can also be a combination between similarities and dissimilarities which connect different places and people together. Another important thing to bear in mind is that topography may affect people's movement in the landscape. Even though two dots are close to each other, it still might have been difficult or less cost effective to move between these two dots due to the topography (Östborn & Gerding 2014).

## 2.3 Rock art and spatiality

One of the weaknesses when studying spatial patterns of material objects is the uncertainty if the place the object is found, is the same place the object was used. Objects may switch owner, it may be moved due to human or non-human events, deposited in one place then reused by someone else and moved to another place. Objects aren't fixed. Rock art, on the other hand, are fixed, both in macro- and micro scale. The rock art site remains fixed in the landscape, the rock or panel are fixed at the site and the rock figures are fixed on the panel. The ground level, vegetation and the quality of both the rock and the figures might change through time, but it's not going anywhere (Chippindale & Nash 2004a, p. 10).

Spatial patterns can be studied in different scales. According to Chippindale (2004), rock art can be studied in a kilometre, metre, centimetre and millimetre scale. The kilometre scale deals with the rock art site in the broader landscape. It focuses on the distribution of rock art sites or panels in the landscape, where they are found, their connection with each other and to other elements of the landscape, for example topography. The metre scale focuses on the motifs' placement and the relationship between the motifs and the panel. By studying rock art in centimetre scale, the size and form of the motifs are in focus. Even the chronology of different motifs. In the smallest scale, the millimetre, the creation of the carved or painted motif is studied, for example which tools that were used and how the figures were carved (Chippindale 2004).

The spatial distribution of rock art sites in the landscape can be studied to see where in the landscape rock art were made depending on topography and different landscape elements. Rock art in northern Scandinavia is usually found close to where the shoreline once was, meaning they were placed close to water (Helskog 1999). Some rock art sites which were not placed close to the sea, were still placed close to other water sources, for example wetlands and bogs, which is the case in Askum parish in Bohuslän, Sweden (Bengtsson 2004). In relation to burials and settlements, rock art in Tjust is found between the settlements and the hunting grounds, where the hunting grounds can be seen as foreign areas and the settlements as non-foreign areas. Between these two types of areas, the burials are found, and in relation to the burials are the rock art panels. They are still connected to the settlement unit, but also close to the borderland between the known and unknown (Goldhahn et al. 2012). The distribution of different complex motifs and their topographic location in Britain has also been studied by Bradley who demonstrates that the more complex motifs are found on more prominent places in the landscape with a wide view over the landscape, both inland and coastlines (Bradley 1997).

The rock art panel itself has long been seen as a static, neutral and blank surface where rock art figures where carved in different forms and sizes. The problem with this thinking is that the panel's impact on the creation of the figures becomes almost non-existent. According to Jones (2006), the rock art panel's appearance, colour, texture and shape impacted the way rock art figures were placed and carved on the panel. With the example of Kilmartin in Scotland, rock art is found on rocks and panels with already existing texture including cracks, fissures, cavities and lines due to the latest glacial period. Some figures were placed in between the cracks and some were connected with the rocks natural texture which connect the rock and the carved figure together as one. (Jones 2006). The same phenomenon is found in Val Camonica where many of the rock art motifs have been carved in relation to the panels natural texture, some motifs even include the panels' cracks in its art (Nash 2011). In Slagsta in Sweden, rock art motifs depicting half-finished carved ships are found in close relation to natural cracks and glacial striations. The ships are carved as they are coming out of the cracks and striations, which can be interpretated as this half-finished work was a conscious decision by the artisan to show movement and the link between different motifs and the panel's texture (Goldhahn 2005b). The rock's natural features as a part of the rock art are also brought up by Keyser and Poetschat (2004) who show that the shape of the rock was used for the shape of different parts of animals painted on the rock. (Keyser & Poetschat 2004). In Järrestad in Sweden, fossil waves created over 500 million years ago is covering many of the rock art panels. When studying the figures and the rock's morphology together, new meaning is created (Tilley 2004a, pp. 147 – 184).

Some interpretations of the rock art panel suggest that the panel can be seen as a map of either the landscape's topography or events taking place in the landscape. Aspeberget 12 in Bohuslän has been studied from a cartosemiotic perspective, meaning that the panel has been studied as a map of a journey. The different motifs' chronology and placement on the panel in relation to already existing motifs is interpreted to show different expressions of social practices. One example from this study is the oldest phase of the panel, where bulls are depicted beside a ship. These bulls are interpreted to enter the ship, which means the artisan might have wanted to show the viewer that the ship was on land and not at sea. They also might have wanted to use the bulls as a metaphor for a longer journey by boat where the bulls represent food which was taken on board the ship. A journey can also have been depicted by the group of ships, chronologically dating to the same time period, which are sailing in the same direction across the panel like a fleet (Cabak Rédei, Skoglund & Persson 2019). Helskog (2004) is also considering the rock art panels in Alta in Norway, Nämforsen in Sweden and at the river Vyg in Russia, as representations of the topographical landscape. By studying the motifs depicting humans and different animals in combination with the topography of the panel, where cavities collecting water during rainfall represent lakes and elevations represent mountains, the panel works as a map which shows how the animals were moving through the landscape during breeding and hunting (Helskog 2004). Arcá (2004) is also interpreting the rock art panels with its rock art in Val Camonica and Mount Bego in the Alps as being overviews of the landscape below the panels' topographical location. The panel shows topographical patterns of the landscape where people used the landscape for cultivation and livestock. The patterns are depicted as geometrical modules carved onto the panels as rectangular, round or irregular forms, with grids, lines or dot-pecked surfaces inside (Arcá 2004).

## 2.4 Rock art and digital archaeology

Since computers started to become a more common part of everyday life, its development has impacted not just society, but also the archaeological profession. The development of digital techniques has made it possible for archaeologists to work with the past by measuring, calculating, collecting data and creating realistic 3D models of both places and objects (Zubrow 2006, p. 9). Within archaeology, GIS was first used in the 1980s and has since then been an important part of the study of landscape archaeology, spatial data and the study of visibility, networks and spatial patterns of objects and sites (Chapman 2006; Conolly & Lake 2006).

There are many reasons why the need of effective, more accurate, complete and non-invasive documentation techniques of rock art have been important. The main reason is that rock art is damaged by environmental factors and human interactions, which risks the loss of information for future research. (Horn et al. 2018). One example is the Altai mountains in Russia, where the rock art is suffering from natural erosion by wind, water and cycles of freezing and thawing. This erosion causes damage like cracks, flakes peeling of the rock and pieces of the rock surface falling off. The rock art in Altai is also damaged due the human interaction like tourism pressure and researchers using invasive documentation techniques like tracing and rubbing. Tourism have resulted in vandalism like graffiti, littering and chemical damages on the panels. Some parts of the panels have also been removed and stolen (Plets, Verhoeven, Cheremisin, Plets, Bourgeois, Stichelbaut, Gheyle & De Reu 2012). For us to be able to study these endangered rock art sites in the future, we need to document them as complete and close to the original, with as little human error, as possible (Horn et al. 2018). Meijer and Dodd (2018) mean that since not everyone is able to go out in the field and study the rock art in situ, we need to rely on already existing documentation. The problem with these already existing older documentation results is that they aren't uniform. They show different representations of the same panel depending on the documenter. The authors emphasize the importance of realistic and informative documentation of rock art for research now and in the future. They also mean that the interpretation of the panel shouldn't be done only by the documenters, but also by other people. This is because the interpretation will be biased by the people who has documented the panel, since they have already been interpreting and had a biased opinion in the field. By including other people, the panel will have more interpretations and will be interpreted more accurately (Meijer & Dodd 2018). However, different results using different techniques, from different documenters don't have to be a negative thing, since different persons documentations of the same panel may generate different details. This helps to generate new perspectives and information about rock art and the surface of the panel. Even though digital techniques are said to be objective, the documentation is always a question of personal decisions and interpretations. It is impossible to delete subjectivity and claim that this or that documentation technique is absolute and completely objective. It will always be a reproduction of the original panel (Goldhahn 2006b, pp. 81 - 82).

3D documentations include Reflectance Transformation Imaging (RTI), Structure from Motion (SfM) and Optical Laser Scanning (OLS). These techniques have many advantages. They have minimal physical contact with the panel which helps to preserve the panel. It records everything on the panel, including cracks and natural features of the stone, which minimises human bias in the documentation phase and gives an accurate overview of the panel, even though interpretations are made later in the process. It is possible to document large areas in a minimum of time, without being too many persons working with the documentation at once. Last but not least, these techniques allow us to document depth and study the differences in depth across the panel. Even though these techniques facilitate the documentation process, they do also have some disadvantages. They are limited when it comes to certain areas in the open environment, where both strong winds and direct sunlight can be detrimental to the technique and cause blurry images with the SfM technique. Working and processing larger SfM files demands both time and a strong computer. The laser scanners are also expensive, which may not be the best choice for a smaller project (Horn et al. 2018), but they can acquire a huge amount of data in a short period of time and can also give a more accurate and detailed 3D model than if you use pictures which might contain more mismatches and missing parts of the object you photograph (Remondino, Guarnieri & Vettore 2005). Nowadays, one of the easiest and less expensive ways to create 3D models, is by using a regular digital camera for photogrammetry which takes pictures in high resolution. You will be able to make 3D models for a lower cost and sometimes in even higher resolution than with laser scanning (Powlesland 2016, pp. 17-18, 21).

Using 3D techniques when studying rock art can generate more information about rock art, than what older techniques may do. One example is the rock art site at Nämforsen in Ångermanland, Sweden. One study has focused on the weapon figures which are depicting axes, both individual and wielded by humans. After documenting four panels, using digital photography and SfM technology, new information came to light about the axes' appearance, which turned out to be a completely different type of axes than previously thought. This proves that 3D documentation can help to generate new information about dating, interpretation and understanding of the rock art in Nämforsen (Bertilsson 2018). Another example where 3D documentation has generated information and details that were no longer visible on the panel in real life is the documentation of rock art in the Altai mountains. By using Structure from Motion, over 300 panels were documented and after processing, details that were invisible on the panel due to destruction, appeared on the finished 3D models of the panels (Plets et al. 2012).

The combination of photogrammetry and GIS has been used by Jalandoni and Kottermair (2017) in Bontoc in Philippines. The authors suggest that to be able to study the panels motifs placement on the panel, we need to treat the panel as a micro topography. By doing so, we can apply GIS tools like DEM models and Hillshade to enhance the rock art motifs and study its topography in centimetre and millimetre scale. The study was successful because it was cost effective, it helped to enhance the rock art and more than twice as many motifs were identified and the results were also stored in a spatially linked database which enables spatial analysis (Jalandoni & Kottermair 2018).

Another study where GIS has been applied to 3D rock art data is a study conducted in Tanum between 2014 and 2018, where rock art was documented using Structure from motion and laser scanning. The data was used to make 3D models and DEM models, which were analysed and processed in a GIS. Through the analysis, more figures were discovered than previously documented, the texture were enhanced and superimpositions between different motifs were discovered. The new information about the carvings' superimpositions opens for new discussions about the carvings' chronology. According to the authors, this way of working with 3D models can be applied to other 3D models with small depth surfaces, not just rock art but other types of objects and materials from different time periods (Horn, Pitman & Potter 2019).

This chapter has presented traditional and digital documentation techniques and their advantages and disadvantages. The main problems with the more traditional techniques like frottage and tracing are their inability to be accurate, show depth (Horn et al. 2018; Meijer & Dodd 2018) and exclude information regarding the panel's texture, surrounding landscape and natural features and slopes (Goldhahn 2005b). Even though there are no such thing as a completely objective documentation technique (Goldhahn 2006b) digital 3D documentation techniques like Reflectance Transformation Imaging, Structure from Motion, and Optical Laser Scanning are still more accurate and have the possibility to show depth and every little detail of the motifs and the panel (Horn et al. 2018). The chosen documentation technique for this thesis' study will be Structure from Motion, also called photogrammetry. Apart from being an easy way to document the panels in 3D using a digital camera (Powlesland 2016), it is also a non-invasive technique since you don't need much physical contact with the panel, and the results will show all the details of the panel and its texture (Horn et al. 2018).

Spatiality has been one of the theoretical perspectives introduced in this chapter. It's important not the treat the panel as a static or neutral blank canvas where rock art was carved but played an important role of where to place motifs depending on the panel's texture, colour, cracks and cavities (Goldhahn 2005b; Jones 2006; Nash 2011). Therefore, this study will focus on the panel as an active part witch also affected the placement of the rock art motifs in certain parts of the panels and in relation to the different natural features of the rock panel. The panels will also, after the 3D models have been made, be imported to a GIS. According to Jalandoni and Kottermair (2018), to be able to study the placement of the rock art motifs, we need to treat the panel as a micro topography and combine 3D documentation and different spatial tools in a GIS to study the panel's topography. It may also generate more details and motifs than are visible in real life (Horn, Pitman & Potter 2019; Jalandoni & Kottermair 2018).

# 3. Research history

## 3.1 Tjust in Småland

Tjust is located in eastern Småland (Fig. 1). Today the landscape consists of archipelago, with inlets and bays extending over miles. During the Bronze age, the sea level was between 8 – 12 metre higher than it is today, meaning that the landscape looked pretty much like it does today, only that the sea extended further into the mainland. Apart from the archipelago, Tjust could also be divided in a coastal- and forest zone during the Bronze age. People have lived in all three zones, but it’s in the coastal zones that we find the archaeological remains from them, and especially the rock art (Goldhahn et al. 2012).


Fig. 1 The study area marked out on the maps of Sweden and north eastern Småland. (Lantmäteriet 2021)

The rock art in Tjust was first discovered in 1634 when Johannes Haquini Rhezelius travelled to Öland and Småland to collect and register ancient monuments and heritage sites at the request of Johannes Bureus, Sweden's first national antiquarian at the Swedish National Heritage Board. When Rhezelius visited Tjust, he came across information about a rock art site in Gladhammar parish. He went there and documented the panel, which contained one footprint and two cupmarks. His documentation is one of the oldest rock art documentations of northern Europe (Goldhahn 2011; Goldhahn et al. 2012).

Not until the 1920, the rock art in Tjust was noticed again by the fisherman Johan Berg and his sons. For a few years, Berg and his sons found around ten rock art sites in Lofta, Gamleby and Törnsfall parishes. The information collected by Berg was then handed over to the archaeologist Harald Stale, who lived in Tjust and conducted several investigations regarding rock art in Tjust. After the inventory in the 1940s, twelve sites with rock art were known in Tjust. In the 1960s during the investigation of a bronze age cairn in Hjortekrog, rock art figures depicting 18 ships and one cupmark were discovered on the rock underneath the cairn. It became the third biggest found of rock art in a grave context in the northern Europe by that time (Goldhahn et al. 2012).

A few years after the discovery of the rock art underneath the cairn in Hjortekrog, one of the excavating archaeologists, Barbro Friberg, wrote a thesis about rock art in Tjust. In her thesis, which can be considered to be the first actual study regarding rock art in Tjust, she lists fourteen figurative rock art sites and discusses the chronology and meaning regarding the different rock art motifs (Friberg 1966). During the 1970s a few different inventories and documentation projects were taking place. Göran Burenhult was documenting about ten rock art sites in Tjust for his doctoral thesis (Burenhult 1973) and an inventory by Sven-Gunnar Broström and Boris Wredenmark, led by Åke Hyenstrand, took place in Tjust in 1978. During this inventory, sites with both figurative rock art and cupmarks were discovered and inventoried (Goldhahn et al. 2012).

Due to the destruction of rock art panels that came to light and became an important discussion during the following years, there was a need to document the level of damage of rock art sites. One project with the aim to document rock art motifs and its level of destruction and establish a project plan about how to best preserve the sites was the RANE project. The project focused on the eleven known rock art sites in Lofta socken in Tjust and was conducted between 2002 and 2005 by Kalmar county museum and the County administrative board in Kalmar (Schulze & Källström Alexandersson 2005). The project kept going until 2009, with the aim to document and establish preservation- and protection plans of all the known rock art sites in the province of Kalmar (Petersson 2009; Ring 2010). The latest project regarding documentation and inventory of rock art sites in Tjust, was started by Joakim Goldhahn and Linnaeus University in 2008 and continued until 2010. The project, named Bronze age rock art along the Baltic coast of Sweden (Bilder av ostkustens bronsålder), was successful due to the discovery of even more rock art sites. When the project started, only 30 sites containing 32 surfaces with figurative rock art were known in Tjust, when the project finished, there were about 200 sites, with a total amount of over 700 rock art surfaces (Goldhahn et al 2012). After the project was finished, new inventories and antiquarian valuation of rock art were made by Linnaeus university at Mem in

Casimirsborg in Gamleby parish at the request of the County administrative board in Kalmar. The purpose of this was to establish a project plan on how to best take care of the rock art sites in Casimirsborg for future uses of the area for public activities (Goldhahn & Ernfridsson 2015).

Tjust contains 20 parishes and half of these contain rock art. The parishes with the majority of the rock art sites are Gamleby, Lofta, Gladhammar and Törnsfall parishes. The most common motifs are cupmarks, ships and footprints (Goldhahn et al. 2012). In Gamleby parish, the total amount of rock art sites today is 421. 401 of these contain cupmarks, 49 contain ships and 28 out of these 421 contain footprints (Swedish National Heritage Board 2021). After the project Bronze Age rock art along the Baltic coast of Sweden was finished, the approximate number of ship motifs found and registered were more than 700, around 60% of all the figurative motifs in Tjust. Cupmarks are the most common rock art motif in Scandinavia, and in Tjust there are over 10 000 registered cupmarks. It's not clear what kind of meaning they possessed to people. Maybe they were made as a part of a fertility cult, as containers for sacrifices, part of fire rituals or rituals to induce rain or sun. Another interpretation is that cupmarks are forming constellations, that they were used as support for piles when mooring ships and that they might represent female genitalia, raindrops, suns, moons, grave mounds, or dead souls (Goldhahn et al. 2012). Many sites with figurative rock art are located close to graves, and they often contain ships, footprints and cupmarks. When approaching the burials, the rock art shows up, and the footprints seem to be oriented away from the burial ground in a vertical direction, while the ships are often placed in a horizontal direction (Goldhahn et al. 2012).

Some interesting finds from Tjust are found at Casimirsborg. One of these finds are a 10-metre-long rock panel with approximately 90 cupmarks, but some of these cupmarks are bigger than usual cupmarks. Some of them are up to 24 centimetre in diameter, a size of a plate (Broström 2011). Another interesting find is one of the many ship panels in Casimirsborg of which one 30-metre-long panel contains 101 ship carvings (Broström 2011; Broström & Ihrestam 2012). Also, two other interesting motifs are the suncarriage (RAÄ 650), found during the same time as the plate looking cupmarks and the ship panel (Broström 2011), and a panel which contain three human figures of which one is placed in an acrobatic position (RAÄ 469) (Goldhahn & Ernfridsson 2015). One of the most unique motifs found in Tjust are the frame figures. They consist of a rectangular shape with rounded corners and a midline. The two sections inside the frame figure contain a net of diagonal lines forming a fish bone pattern (Broström & Ihrestam 2010). The meaning of the frame figures has been discussed, but it's not sure what the figure is depicting, but it could be depicting some sort of fish net or some other sort of fishing equipment. One interpretation, when frame figures are depicted close to ships, is that the frame figures are nets used to catch the ship or are used for fishing from the ship (Hauptman Wahlgren 2002, pp. 84 – 85).

## 3.2 GIS surface analysis tool

In the analysis, several surface analysis tools will be used in a GIS. These tools are Hillshade, Buffer, Slope and Aspect. They will be further explained and described in this part. GIS is a software which capture and manipulate spatial data and this spatial data can then be managed, visualised and analysed in the form of digital maps (Conolly & Lake 2006).

The hillshade tool is used to create a grey scaled 3D representation of a raster surface. A light source representation, like a sun, is positioned using the azimuth and altitude properties to place this light source in a specific position. The altitude is the sun's angle above the horizon where 0 degrees indicated that the sun is on the horizon and 90 degrees indicates that the sun in its highest position, directly overhead. The azimuth is the suns relative position along the horizon measured clockwise, where 0 degrees indicated that the sun is shining from north, 90 degrees from east, 180 degrees from south and 270 degrees from west. From the sun's relative position, it will create a shaded image of the surface which will enhance the topography of the surface (Esri 2021a).

Buffer is a tool used to create buffer polygons around selected features from a vector file. The buffer can be used on points, polylines and polygons and can be used as two methods. To create a buffer zone on a two-dimensional plane surface, the Euclidean buffer is most suitable. To create a buffer zone on a curved surface, like large regions across the globe, the geodesic buffer is more suitable. The buffer distance is set by the user and can be measured in different units of measure (Esri 2021b).

The tool Slope us used to calculate the elevation change across a raster surface. The tool compares one cell's z-value to its neighbouring cells z-values, calculates the slope between these cells and by that it creates a map showing the value of these slopes. The lower the slope value is the flatter the terrain is, and the higher the slope value is the steeper the terrain is. The end result is a map showing the different levels of the surface's terrain level, the higher and the lower parts (Esri 2021c).

The last tool used in the analysis is the Aspect tool. Aspect calculates the downslope direction between a cell and its neighbouring cells on a raster surface. The value of each cell is indicating the compass direction and is measured clockwise from 0 degrees to 360 degrees. The cell is given the value north, northeast, east, southeast, south, southwest, west and northwest with associated colour and a value from 0 – 360. Flat surfaces are given the value of -1 and are grey. The aspect tool can be of good use when trying to identify flat land or calculate the solar illumination for a specific location in a region (Esri 2021d).

# 4. Method and Material

This chapter will present the methods and material used in this study. It will explain how the panels were selected and how they were documented in the field with help of a digital camera and photogrammetry. It will also explain how the final 3D models were made in Agisoft Metashape (Agisoft 2021) and how GIS was used to analyse the placement of the different motifs on the panels and the panels' topography. The different methods will also be discussed regarding their advantages and limitations, the source material used for this thesis, and an overview and description of the ten selected panels.

## 4.1 Data collection

Before the collection of data was made in the field, it was important to first select which panels that were going to be studied. The chosen geographical area was Gamleby parish in Småland, and according to the information found in the search engine Fornsök at the website of Swedish National Heritage Board, the total amount of rock art sites are 421 sites, but one site can contain more than one panel (Swedish National Heritage Board 2021). During the first selection, all panels which contained motifs like ships, footprints, ring motifs, humans, animals, spirals, ring crosses, cupmarks and frame figures were chosen. Panels with only cupmarks were not chosen. This is because there were so many panels with only cupmarks, and the lack of other sort of motifs would make these panels less suitable to analyse. The information regarding each chosen panel, a total number of 61 panels, were written down with information regarding their RAÄ number, size of the panel and what kind of motifs it contained. These 61 panels where then reduced to 30 panels. The criteria were that the panels needed to have two or more than two types of motifs and at least around ten motifs in total. The reason for this is because this study was going to focus on the relation between different motifs on the same panel, which made panels with only one type of motifs unsuitable. Also, the density of motifs was also going to be studied, which made it important to choose panels with a high number of motifs instead of panels with less than five motifs. The size of the panels ended up with panels with a size of at least 1 square metre. If the panel was too small, it generally contained too few motifs.

All information regarding the 30 panels were found in Fornsök (Swedish National Heritage Board 2021) and is listed in the Excel table (Fig. 2) in chapter 4.4. The table lists the panels RAÄ number, their size in square metre, their orientation, the number of motifs depicting ships, footprints, humans, animals, wheel crosses/ ring crosses, rings/ ring figures, spirals/ spiral figures, frame figures and cupmarks, the number of types and the number of motifs in total. In the Notes box, specific information was filled in if applicable.

The fieldwork was taking place in Gamleby parish in Tjust during two days in April. To photograph the panels, a digital camera, a Canon Eos 550d, was used. To be able to create a 3D model of each panel later on in the working process, photogrammetry was used when documenting the panels. The way photogrammetry, also called Structure from Motion, works is that images are taken with a camera with at least 60 – 70 % overlap. When the images have been taken, they are processed in a computer and the final results are a three-dimensional image of the entire surface in high resolution (Horn et al. 2018). Out of the 30 panels chosen for this study, only ten of them were found and documented. All ten panels were photographed moving slowly from side to side, and from top to bottom, this was to be sure to cover the entire surface of the panel. A yardstick was used as a scale bar, because it was necessary to have a scale for future work with the 3D models. Personal observations and calculations like the panels' locations, sizes and their orientations were also documented during the fieldwork. Since one of the thesis' approaches for studying the placement of rock art motifs is phenomenology and how to experience rock art through the interaction between the rock art panel and the moving body, it was useful to write down how the rock art panel and the site could be bodily experienced in the field, even though this is a personal experience and doesn't mean that everyone will experience it the same way.

When the panels had been documented it was time to build the 3D models. The software used for this was Agisoft Metashape (Agisoft 2021). To make each model, the process started by importing all the photos of the panel. The quality of the photos varied between the panels. Some panels's photos were all in very high quality, and some photos were in a quality lower than 0,5. Here a choice had to be made if the photos in low quality were necessary to use for building a model or not. If they were not, they were discarded. If the loss of these photos generated a model with holes or missing parts of the panel, they were included. The next step was the alignment of the photos. Every panel's photos were aligned on highest quality or high quality. This is because it was important that the final 3D models would be in best possible quality and also because the photos of two of the panels had accidentally been photographed with two different focal lengths which can complicate the alignment when this is done in lower quality. After the alignment, the cameras were optimized, and the dense clouds were built. To build the dense clouds, the Mild Depth Filtering was used in this process to make sure that the details of the panels would be as clear as possible. All models' denseclouds, except for one, were made in high quality. The panel with the dense cloud which couldn't be made in high quality was instead made in medium quality. This was because the model contained the biggest number of photos and the computer used for this process had problems with processing the data when making the dense cloud.

After the dense clouds were made, it was time to scale the models. Here the yardstick used in the field as a scale were included in the models, and all that needed to be done was to create two points, one on each side of the yardstick, create a scale bar between them and fill in the length between these two points. This part of the process gives the models their correct size, which were important for the future part of the analysis in the GIS. The models were also cleaned to give the model a more clearly shape. When taking photos of the panels, the background, vegetation and the like can be captured also on the photos. To get a better-looking model, it's good to clear away visual information which is not part of the panel itself. The next step was to create the meshes. After that, the colours were calibrated before the textures were made. The last part of this process was to export the model and the choice was made to export both the dense cloud as a DEM model, and the final mesh as an orthomosaic. The reason for this is that some of the motifs were not visible on the DEM model, because they were only visible as a discoloration on the panel. This means that to be able to identify all the motifs, it was necessary to use both the DEM model and the orthomosaic, and therefore all models were exported to these two file types.

After the 3D models had been exported it was time to start working in the GIS. The software used for this was ArcMap (Esri 2021e) and the first thing that needed to be done was to choose a base map of Sweden in ArcMap and then to import the orthomosaics and DEM-models. To move the models to their approximate location and rotate them to their correct position, the data management tool Shift and Rotate were used. To be able to see the texture of the panels and the motifs, the tool Hillshade was used to convert the DEM models to hillshade maps. When this was done, it was time to start working with, and identifying, the motifs. First, a polygon vector file was created for the panels, and all the panels were outlined. All figurative motifs and cracks were then divided into two separate polyline vector files, the cavities as a polygon vector file and the cupmarks as a point vector file. The motifs and features of the panels where then drawn in or point marked. Sine the figurative motifs were in different sizes and shapes, it was more accurate to outline them as polylines instead of marking them as points. The distance between the motifs would be more accurate if the distance was counted from the motif's outline and not from a point in the middle of the motif. The placement of different motifs on the panel is one of this thesis' main focuses, and to be able to tell the density of different motifs, a grid was placed on top of the panel using the tool Fishnet. First each panel were exported as an own vector file. This made it easier to structure and create an overview of each panel for the upcoming analysis where many different raster layers would be created for each panel. When creating the grid, you get to choose how many rows and columns you want and this was adapted after the shape of each panel. After the grids were created, the grids and the panels were intersected using the tool Intersect, which adapts the outline of the grid to the shape of the panel. In the attribute table, where all squares were listed, the total number of motifs was filled in, as well as the number of each motif type. Here the choice was made to only include the most common motifs in the density regarding certain type of motifs which were ships, footprints, cupmarks and ring figures including ring crosses. In the layers' properties and symbology, the panels were then visualised in graduated colours depending on the number of motifs in each square.

To study the relation between different motifs, the tool Buffer were used to create a 20-centimetre buffer zone around specific motifs. These motifs were ships, footprints, cupmarks, ring figures and ring crosses. These motif types were also the only motifs counted in the buffer zone, but cracks and cavities were also included. The different panels were studied individually working with one motif type at a time. For example, first a buffer zone was created around the ships on one of the panels. Each motif type that occurred inside the buffer zone or came in contact with the buffer zone were counted in, including cracks and cavitites. The total number of different motifs in relation to the ships' buffer zone on all panels were then used to create a pie diagram. This was then repeated to the four other groups of motifs.

The panel itself where also of interest to see if the rock art motifs were placed on the panel depending on its topography. For this the tool Slope was used which creates a map showing which part of the panels that are highest and lowest. This was used to visualise how the different motifs were placed across the panel and if they were found in the higher or lower topography.

The last tool used in ArcMap was Aspect which was used to analyse the downslope direction of the panel and to see if certain motifs were placed in specific parts of the panel depending on its downslope direction.

## 4.2 Equipment choice

The camera used for the documentation was a Canon Eos 550d. The reason why a digital camera was used, instead of a mobile camera, was because of the better quality of the photos taken with the digital camera. It was important that the photos turned out as detailed as possible, but at the same time, since studying the details of the carvings were not the main focus but rather the panel more in general, a camera of even better quality were not necessary. If the plan would've been to study the carved surface of each motif and how the artisan made the actual motif, maybe an even better camera would have been needed. Although the camera generated detailed pictures in good quality overall, the quality varied between some pictures taken of some of the panels and were not in as good quality as the rest. This is probably due to that some panels were photographed in bad light conditions, which can be a problem when using photogrammetry (Horn et al. 2018), and due to the difficulty with moving across or around some of the higher panels while taking the photos. Some of the panels also had smaller gaps and missing parts of the panel which also is a common drawback of photogrammetry (Remondino, Guarnieri & Vettore 2005) but it was still an easy way to document in 3D. One thing that affected the final result was the fact that not the entire panels were visible in the field, due to the coverage of moss, lichen and soil, which were impossible to clean with only a broom at hand. The visible part of the surface which was not completely covered with moss was therefore the part that was measured and documented.

The 3D models were made in Agisoft Metashape (Agisoft 2021). It is a software that I've been working in before, which made it easy to do the models, since the different steps and tools were already familiar. Aligning pictures when some pictures had a different focal length were no problem at all, as long as they were aligned on highest or high quality. However, the main drawback with processing large amount of SfM data is that it sometimes takes a long time, and it demands a strong computer (Horn et al. 2018). Some of the panels documented contained over 300 pictures, the biggest panel documented contained over 800 pictures, which made the processing take sometimes thirty to forty-five minutes.

Since one of the important parts of this study was spatiality, how the panels' surfaces have been affecting the placement of rock art motifs, and the spatial relation between different motifs, the panels were analysed using the GIS software ArcMap (Esri 2021). This way of studying the panel as if it was a landscape or a microtopography makes it possible to generate information that maybe wouldn't have been visible in the field (Jalandoni & Kottermair 2018). The density regarding rock art motifs on the panel and the density of certain types of motifs were analysed using the Fishnet tool to create a grid across the panels. The number of motifs in each square were counted and the result ended up with a density map with the squares in different colours depending on the number of motifs in each square. The Hillshade tool was used to enhance the panels' textures and to make the rock art motifs more visible by creating light and shadow across the panel. To find out how many of each motif type that were placed close to other motifs, a 20-centimetre zone around the motifs were created, using the Buffer tool. Then the motifs were counted, and the result could then be used to make a diagram showing how many of each motif that were closest to other motifs. Here cracks and cavities were included to the buffer zones as well, since the focus of this thesis also was to study the relation between the motifs and the panel's natural features and texture. The tools Slope and Aspect were also chosen to see if the panels natural topography and downslope direction had any connection to the placement of motifs and if there were any common patterns between the different panels.

Even though a GIS is a user-friendly software and can generate spatial information about archaeological data, depending on the information you put into the system and what questions you want the system to answer (Conolly & Lake 2006), it still has its limitations. One of these limitations is that the GIS software will always give a precise answer to the questions we ask and the analysis we want to do, but at the same time we can't be sure that this answer is correct. The lack of showing uncertainty in a GIS and the fact that the results or answers we get from a calculation in a GIS are biased by the information we provide the software, is problematic (Lock & Harris 1997 p. 6). The documentation of the panels and the choices made in the field regarding how much of the panels that could or should be documented, were later on affecting the results in the GIS regarding the density of motifs and where on the panels most of the motifs were found, which is an important aspect to bear in mind.

## 4.3 Source material

The source material used for this thesis were mostly books and articles, but websites like Fornsök at Swedish National Heritage Board (2021) for collecting information about the panels, were also used. The maps in chapter 3 were downloaded from Lanmäteritet (Lantmäteriet 2021) and the map used to show the old shoreline in chapter 5 was downloaded from SGU (Geological Survey of Sweden 2021) The books used were mostly loaned from the LUX-library at Lund University as physical copies, but books and articles available online were also used through the university's library website LUB Search. Material that couldn't be found through the library was loaned from other libraries through Libris.

A couple of literate sources have been of very good help when trying to identify the motifs on the panels during the analysis. These are one of the reports from the RANE project (Petersson 2009), Broströms and Ihrestams paper about ship panels in Casimirsborg (Broström & Ihrestam 2012), the report Hällristningar i Tjust: Måsebo / Dvärgstad i Gamleby socken (Broström, Ihrestam, Goldhahn & Wikell (2010) and a scientific and antiquarian report considering valuation and inventory of rock art at Mem in Casimirsborg (Goldhahn & Ernfridsson 2015).

There was no problem finding literature about rock art, since this is a well-researched topic and have been studied from many different perspectives. However, a problem regarding the literature was to find the reports regarding the project Bronze Age rock art along the Baltic coast of Sweden. A couple of reports regarding rock art inventory in Tjust were found, but they were most dealing with finds of cupmarks and not so much with panels with other types of motifs, with exception of one report which dealt with the two panels RAÄ 388:1 and 447:1. Most information about this project seem to be found in the book Västerviks historia (Nimhed & Palm 2012).

## 4.4 The panels

At the beginning the plan was to study 30 panels from Gamleby parish in Tjust. Unfortunately, due to problems with finding the panels in the field, only ten panels ended up being documented and studied. Information regarding the panels was collected through the search engine Fornsök (Swedish National Heritage Board 2021). In Fornsök you can search for information regarding all known archaeological sites and monuments in Sweden, including remains located on both land and under water. All you need is the site's RAÄ number and you have the possibility to find all the information about the site, its location and its level of protection (Swedish National Heritage Board 2019). The information of the 30 panels collected from Fornsök is compiled as an Excel table below (Fig. 2). The footprints in this study contain both fully pecked feet and outlined feet. The outlined feet are usually referred to as foot soles and the pecked one as footprints (Skoglund, Nimura & Bradley 2017). But for this study all foot images will be termed as footprints.

| RAÄ number | Orientation | Size ($m^2$) | Ship | Footprint | Human | Animal | Wheelcross/ringcross | Ring/ring figure | Spiral/spiral figure | "Ram" figure | Cupmark | **Amount of types** | **Amount of motifs** | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 252:1 | NNW-SSE | 11,4 | 20 | | | | | | | | 9 | 2 | **29** | |
| 653 | NW-SE | 1,98 | 14 | | | | | | | | 4 | 2 | **18** | |
| 612 | NNW-SSE | 33 | 15 | | 1 | | | | | | 3 | 3 | **19** | |
| 252:3 | NNW-SSE | 11,27 | 20 | | | 1 | | | | | 20 | 3 | **41** | |
| 618 | NNW-SSE | 1,44 | 1 | 4 | | | | | | | 11 | 3 | **16** | |
| 649 | NE-SW | 3,4 | 2 | | | | | | | 1 | 6 | 3 | **9** | |
| 650 | NW-SE | 20,02 | 15 | 1 | | | | 14 | | | | 3 | **30** | 1 suncarriage, 1 mantel figure |
| 652 | E-W | 2,4 | 4 | | | | | 2 | | | 13 | 3 | **19** | |
| 652 | N-S | 15,51 | 31 | | | 2 | | | | | 25 | 3 | **58** | |
| 552 | N-S | 3,84 | 4 | 3 | | | | 1 | | | | 3 | **8** | |
| 769 | X | 3,91 | 7 | | | | | | | 1 | 1 | 3 | **9** | |
| 80:2 | NW-SE | 11,61 | 1 | 2 | | | | | | | 20 | 3 | **23** | |
| 447:1 | X | 4,62 | 3 | 1 | | | | | | | 162 | 3 | **166** | |
| 429:1 | (ENE-WSW | 2,79 | | 2 | | | | | | 1 | 7 | 3 | **10** | |
| 388:1 | NNW-SSE | 7 | 7 | | | | | 1 | | | 96 | 3 | **104** | 1 stamp |
| 431:1 | X | 7,25 | | 2 | 1 | | | | | | 119 | 3 | **122** | |
| 380:1 | NNW-SSE | 5,28 | | 26 | | | 3 | | | | 25 | 3 | **54** | |
| 611 | NW-SE | 9,1 | 8 | 6 | | | | 2 | | | 8 | 4 | **24** | |
| 613 | NNW-SSE | 17,36 | 16 | 5 | | | | 5 | | | 4 | 4 | **30** | |
| 616 | NW-SE | 8,64 | 5 | 3 | | | | | 1 | | 6 | 4 | **15** | |
| 652 | E-W | 10,03 | 15 | 6 | | | | 6 | | | 90 | 4 | **117** | |
| 253:1 | NW-SE | 15,68 | 12 | 6 | | 2 | | | | | 223 | 4 | **243** | |
| 686 | ENE-WSW | 2,64 | 2 | | | 2 | | 2 | | | 26 | 4 | **32** | |
| 80:1 | N-S | 24,2 | 7 | 2 | | | | 1 | | | 74 | 4 | **84** | couple of legs?(footprints?) |
| 469 | NW-SE | 2,4 | 2 | 2 | 3 | 1 | | 2 | | | | 5 | **10** | |
| 615 | NW-SE | 23,36 | 74 | 1 | | | | 5 | | 1 | 10 | 5 | **93** | 2 axe figures |
| 616 | NW-SE | 19,78 | 11 | 1 | | | | 1 | | 1 | 86 | 5 | **100** | |
| 54:1 | NNW-SSE | 150 | 5 | 2 | 1 | | | 4 | | | 183 | 5 | **195** | |
| 649 | NW-SE | 18,15 | 99 | | 1 | 7 | | 1 | 1 | | 20 | 6 | **129** | |
| 652 | E-W | 16,12 | 49 | 2 | 1 | 4 | | 3 | | | 100 | 6 | **159** | |

Fig. 2 Table of the 30 panels.

The ten panels that will be analysed in chapter 5 will be described in more detail below, together with a table giving a better overview of the panels (Fig. 3). Almost all the panels contain fragments and scores, and some contained unidentifiable figures. They will be mentioned in the descriptions of the panels but not be included in the table or the analysis since they are unrecognizable figures. All the information about the panels is collected from the Swedish search engine Fornsök (Swedish National Heritage Board 2021).

## RAÄ

### 54:1

The panel is 15x10 m and contains 183 cupmarks, 5 ships, 1 human figure, 2 footprints, 4 ring figures, 4 fragments and 8 scores.

The ships are 53 – 111 cm and contain crew lines. Four of them are double lined types, one is a single lined type. The human figure is 16 cm and is standing inside one of the ships. The footprints are 23 – 30 cm long and 8 – 13 cm wide. One of them are outlined and one is fully pecked. The ring figures are 11 – 21 cm in diameter, three of them consists of a single ring with a cupmark inside, the fourth consists of three concentric rings with a cupmark inside. The cupmarks are 3 – 9 cm in diameter and 0,5 – 3,5 cm deep. Some cupmarks are connected with scores.

### 80:1

The panel is 5,5x4,4 m and contains 7 ships, 1 ring figure, a couple of legs (?), 5 fragments, 1 score and 74 cupmarks. The ships are 56 – 160 cm. Three of them are dubble lined types with crew lines and carved hull lines. The other four ships are single lined types, one of these have crew lines. The ring figure is 10 cm in diameter and consists of one single ring with a cupmark inside. The legs are 25 cm long. The cupmarks are 3 – 9 cm in diameter and 0,5 – 2 cm deep, one of them is connected with the score.

### 380:1

The panel is 3,3x1,6 m and contain 26 footprints, 3 ring crosses, 1 unidentifiable figure, 2 fully pecked surfaces, 16 fragments, 25 cupmarks and various dot-pecked surfaces. The feet are outlined and 12 – 23 cm long and 7 – 12 cm wide. Two of them have transverse lines underneath them and are carved together as one unit. The ring crosses are oval shaped, 1 – 18 cm long and 8- 17 cm wide. The unidentifiable figure is 10x5 cm. The fully pecked surfaces is 5 – 7 cm long and 3 cm wide, and the fragments are 3 – 23 cm long. The cupmarks are 2 – 11 cm in diameter and 0,5 – 3 cm deep.

## 388:1

The panel is 2,8x2,5 m and contain 7 ships, 1 ring, 1 stamp, 25 fragments, 96 cupmarks and 1 score. The ships are 25 – 38 cm long. One of them is a single lined type. Six of them are double lined types and three of these contain crew lines and two contain hull lines. The ring is 8 cm in diameter with a cross-line. The stamp is 7x6 cm. The fragments are 5 cm long. All cupmarks, except from one, are round shaped with a size between 2 – 5 cm in diameter and 0,5 – 2 cm depth. The other one is a more oval shape, 5x3 cm and 1 cm deep. Of all cupmarks, 25 of them are carved over cracks.

## 447:1

The rock art is carved on the top of a boulder, 2,2x2,1x0,9 m, the top of the boulder slopes to south. It contains 3 ships, 1 footprint, 2 fragments, 5 scores and 162 cupmarks. The ships are 32 – 42 cm long, two of them are double lined types, one of these with crew lines, and the third ship is a single lined type. The foot is 19x9 cm and outlined with a transverse line underneath the foot sole. The fragments are 18 – 25 cm long and the scores are 4 – 8 cm long. Some of the score are connected to cupmarks. The cupmarks are 1 – 6 cm in diameter and 0,5 – 1,5 cm deep.

## 469(A)

This site contains 4 panels, but only panel A will be studied.

The panel is 3x0,8 metre and contain 2 ships, 3 humans, 1 animal, 2 footprints, 2 ring figures, 9 fragments and various dot-pecked surfaces. The ships are 40 – 41 cm long, double lined types with crew lines and hull lines. The human figures are 15 – 19 cm long and fully pecked. One of them are carved in an acrobatic position. The animal is 10 cm long, line art with four legs. The footprints are outlined and 20 – 30 cm long and 7 – 10 cm wide. The ring figures are 4 – 10 cm in diameter and the fragments are 3 – 13 cm long.

## 612

The panel is 11x3 m and contains 15 ships, 1 human, 14 fully pecked surfaces, 33 polished surfaces, 1 dot-pecked surface, 9 fragments and 3 cupmarks. The ships are 17 – 61 cm long. One is a triple lined type with crew lines, eight are double lined types of which six contain crew lines. Four ships are of single lined type of which two contain crew lines. The last two ships are fully pecked. The human is 8 cm long and is standing inside one of the ships. The fully pecked surfaces are 4 – 66 cm long and 4 – 17 cm wide. The polished surfaces are 4 – 55 cm long and 4 – 29 cm wide. The dot pecked surface is 20x10 cm. The fragments are 4 – 21 cm long and the cupmarks are 2 – 4 cm in diameter and 0,5 cm deep.

## 650(E)

This site contained 10 panels, but only panel E will be studied.

The panel is 7,7x2,6 metre. It contains 15 ships, 14 ring figures, 1 footprint, 1 sun carriage, 1 mantle figure, 3 fully pecked surfaces, 19 fragments and various dot-pecked surfaces. The ships are 18 – 37 cm long. Nine of them are fully pecked. Three ships are double lined types of which one contains crew lines. The rest of the ships are single lined types. The ring figures and ring crosses are 6 – 19 cm in diameter. They consists of both fully pecked rings, single rings, and some rings with a net like surface inside. Two out of three ring crosses have double crosses. The footprint is 15x10 cm and outlined. The sun carriage is 83 – 38 cm and the mantle figure is 31x21 cm. The fully pecked surfaces are 5 – 13 cm long and 3 – 5 cm wide and the fragments are 3 – 19 cm long.

## 653

The panel is 3,3x0,6 m and contain 14 ships, 6 fragments, 1 unidentifiable figure and 4 cupmarks. The ships are 20 – 46 cm long. Seven of the ships are double lined types of which five contain crew lines of which one contain a horn blower. Six ships are single lined types of which five contain crew lines. The fourteenth ship is fully pecked with crew lines. The fragments are 6 – 13 cm long, the unidentifiable figure is 27x4 cm and the cupmarks are 1 – 3 cm in diameter and 0,5 cm deep.

## 769

The rock art is carved on a boulder. Most of the motifs are found on the vertical south-west side of the boulder, which will also be the side I will study.

The boulder contains 7 ships, 1 ram (frame) figure, 11 fragments and 1 cupmark. The ships are 11 – 35 cm long. Five of these are double lined types of which 3 contain crew lines of which one contain a horn blower. The other two are single lined types. The ram figure is 24x15 cm. The fragments are 2 – 20 cm long and the cupmark is 5 cm in diameter. The cupmark and three of the fragments are placed on the boulders south-east side and on top of the boulder. The cupmark will be included in the table down below (Fig. 5) but it will not be analysed since I will focus on the south-west side were most of the motifs are found.

| **RAÄ no.** | **Panel Orientation** | **Size (m)** | **Ship** | **Footprint** | **Human** | **Animal** | **Wheelcross/ ringcross** | **Ring / ring figure** | **Ram (frame) figure** | **Cupmark** | **Number of types** | **Number of motifs** | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **54:1** | NNW – SSE | 15x10 | 5 | 2 | 1 | | | 4 | | 183 | 5 | 195 | |
| **80:1** | N – S | 5,5x4,4 | 7 | 2 | | | | 1 | | 74 | 4 | 84 | Legs(?) |
| **380:1** | NNW – SSE | 3,3x1,6 | | 26 | | | 3 | | | 25 | 3 | 54 | |
| **388:1** | NNW – SSE | 2,8x2,5 | 7 | | | | | 1 | | 96 | 3 | 104 | Stamp |
| **447:1** | X | 2,2x2,1 x0,9 | 3 | 1 | | | | | | 162 | 3 | 166 | |
| **469 (A)** | NW – SE | 3x0,8 | 2 | 2 | 3 | 1 | | 2 | | | 5 | 10 | |
| **612** | NNW – SSE | 11x3 | 15 | | 1 | | | | | 3 | 3 | 19 | |
| **650 (E)** | NW – SE | 7,7x2,6 | 15 | 1 | | | 3 | 11 | | | 3 | 30 | suncarriage, mantel figure |
| **653** | NW – SW | 3,3x0,6 | 14 | | | | | | | 4 | 2 | 29 | |
| **769** | X | 2,3x1,7 x1,1 | 7 | | | | | | 1 | 1 | 3 | 9 | |

Fig. 3 The ten panels.

The map down below (Fig. 4) shows all the ten panels' geographical location, the shoreline today in light grey and the shoreline 3000 years ago in light blue. Panels that are located close to arable land today, were once located close to the shoreline. Many of the panels that are close to today's shoreline, were even closer to the shoreline 3000 years ago. The only exception is panels 612 and 380:1 which are placed more inland than the rest of the panels.

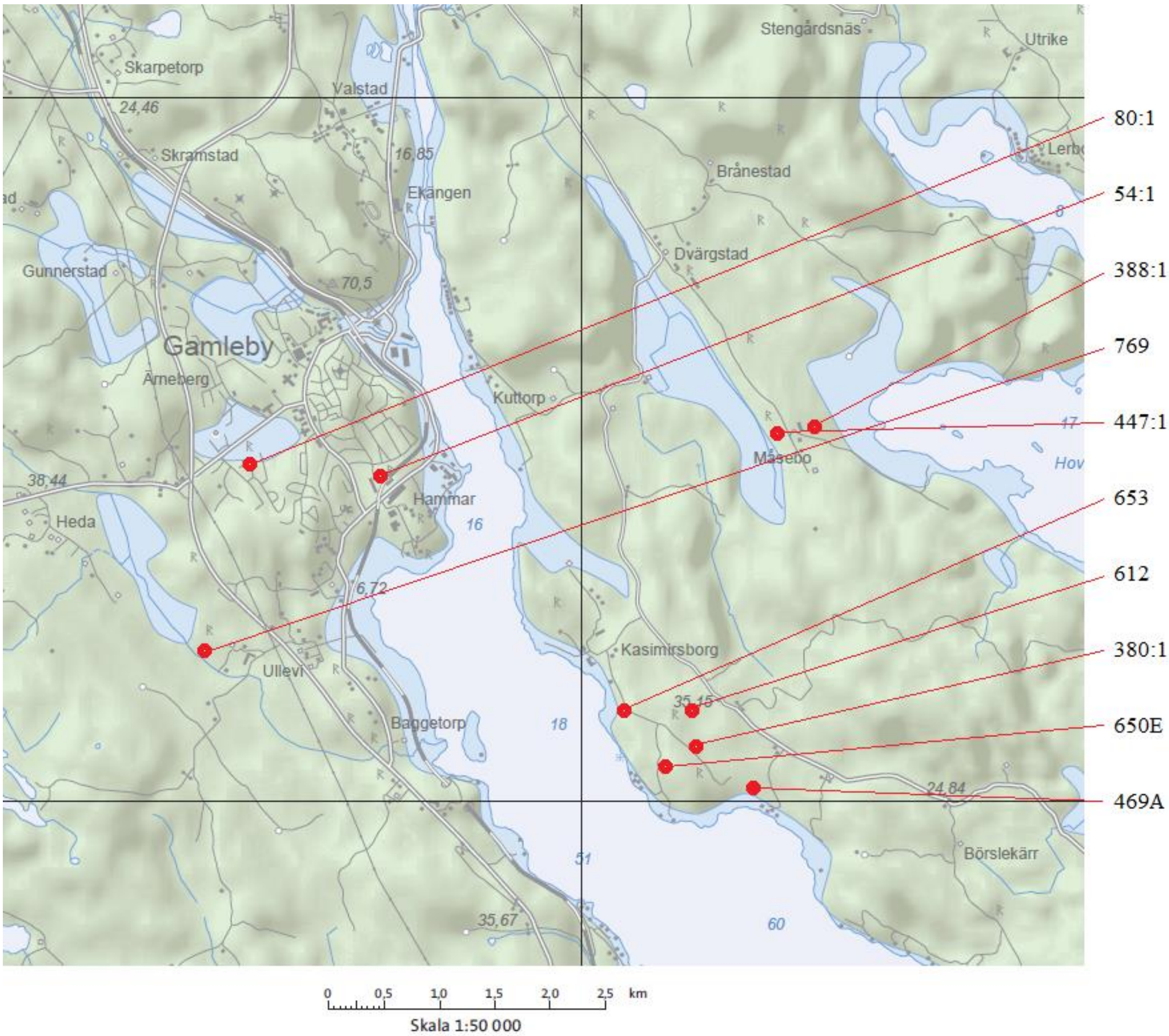


Fig. 4 The studied area with the shoreline 3000 years ago and the ten panels marked (SGU Geological Survey of Sweden 2021)

# 5. Analysis

In this chapter the analysis of the ten panels will be presented. The analysis is made in the GIS software ArcMap (Esri 2021e) and the tools used are Fishnet, Buffer, Hillshade, Slope and Aspect. In sub-chapter 5.1, the panels with their motifs, cracks and cavities are visualized as vector maps showing where on the panels the motifs are placed. In chapter 5.2 the density of motifs and the density of specific motifs are visualised as a grid, the fishnet tool has here been used, covering the panel with a graduating colour scheme showing which squares contain most and least number of motifs. This to find out if certain motifs are most concentrated on specific parts of the panels. In chapter 5.3 the tool buffer were used to create a polygon around specific motifs to show which motifs that are placed closest to other motifs. Here the most common motifs were chosen for the analysis. Cavities and cracks were included as features that were closely related to each specific motif. This part of the analysis will show if certain motifs appear closer to each other than other. The pie diagrams visualise how many of each motif that occur close to one specific motif.  For the next chapter, 5.4, the panels' texture is enhanced using the tool Hillshade. This tool was used during the identification of motifs for chapter 5.1, but it also enhanced striations and other textures of the surface which were of good help to see if motifs were placed in association with the panel's texture. Chapter 5.5 showing the panels' topography using the tool Slope. This tool was used to see if specific motifs and the motifs in general were placed on the steeper, sloping, or the lower parts of the panels. Lastly, chapter 5.6 will analyse the panels downslope direction. This to see if motifs were placed on certain down slope directions and which compass directions they in that case were facing.

Since not all the chosen panels were found in the field, some observations should be said about the 30 panels in general. If looking at the information collected and visualised in the Excel table in chapter 3.2 (Fig. 2), the most common figurative motif is, with no doubt, the ship. Ship carvings are present on all panels except from three. Footprints and rings/ ring figures are also common motifs. The panel with the biggest number of footprints is RAÄ 380:1, where 26 footprints are found. What's interesting is that this panel completely lacks the present of ships. A couple of other panels where ships are absent is consisting of footprints as well, though not in the same big amount as RAÄ 380:1. On panels with both ships and footprints, the ship is predominance in number. Both animals and humans occur on panels with both ships and feet, or panels with either ships or feet. Fifteen of all panels contain rings or ring figures, but just like with animals and humans, they occur on panels with both ships and footprints, or either ships or footprints. One of the panels at RAÄ 650 contain 14 rings/ ring figures, and it completely lacks cupmarks, which is the most common rock art carving of all carvings. Cupmarks occur on all panels, in more or less large numbers, except from three, but these three panels don't seem to have anything in common, more than the fact that the surface is used for other sorts of motifs. An interesting thing about the three wheel crosses, is that they are only found on one panel, the same panel with the 26 footprints (RAÄ 380:1). Two of the frame figures are found on panels with no footprints. One is found on a panel with footprints but no ships, and the last two are found on panels with both footprints and ships.

## 5.1 The motifs on the panels

This following section of the analysis will show all the ten panels (Fig. 6 – 15) and their composition of motifs which were identified in the GIS and with the help of reference pictures. Apart from motifs, the most prominent cracks on each panel were also marked out. The table down below (Fig. 5), is an upgraded version from the original table from chapter 3.2. The measurements and orientations of the panels are based on observations and calculations done in the field.

Overall, most of the motifs were found. One of the ships and two of the rings could not be found on panel 54:1 (Fig. 6), and it also lacked many of the cupmarks. 4 out of 7 ships on panel 80:1 (Fig. 7) were found, none of the footprints, neither the ring, nor all the cupmarks. With panel 380:1 (Fig. 8), 7 out of 26 footprints were found, as well as the wheel crosses and almost all cupmarks. One motif found was interpreted to be a ring. With panel 388:1 (Fig. 9), none of the ships were visible on the panel. One guess is that maybe this part of the panel was overgrown with moss and grass and was therefore not documented in the field. It was still possible to find 40 out of 96 cupmarks. Panel 447:1 (Fig. 10) should've contained 3 ships, but only 2 were identified, together with the footprint and 94 out of 162 cupmarks. 469A (Fig. 11) contained both ships, the 3 human figures and the animal. Only 1 out of 2 footprints were found and none of the rings/ringfigures.

Panel 612 (Fig. 12) is the only panel where the least number of motifs were found, only one possible ship and two cupmarks, where it originally should have been 15 ships, 1 human and 3 cupmarks. Due to its lack of motifs, the decision was made to not include it for further analysis, but a picture of it will still be included together with the rest of the panels down below. At panel 650E (Fig. 13), only 5 out of 15 ships were found, 1 wheel cross and only 3 rings out of 11. The footprint could not be identified, but the sun carriage and the mantle figure could be identified. Panel 653 (Fig. 14) only contained 6 out of 14 ships and 3 out of 4 cupmarks. Last but not least, panel 769 (Fig. 15) contained 3 out of 7 ships and the frame figure. The cupmark is, as explained in chapter 3.2, placed on a different side of the rock boulder and are therefore not visible on the analysed side.

| RAÄ no. | Panel Orientation | Size (m) | Ship | Footprint | Human | Animal | Wheelcross/ ringcross | Ring / ring figure | Ram (frame) figure | Cupmark | Number of types | Number of motifs | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **54:1** | NNW – SSE | 15x10 | 4 | 2 | 1 | | | 2 | | 105 | 5 | 114 | |
| **80:1** | NW – SE | 5x4 | 4 | | | | | | | 31 | 2 | 35 | |
| **380:1** | NNW – SSE | 4,3x3,2 | | 7 | | | 3 | 1 | | 23 | 4 | 38 | |
| **388:1** | NW – SE | 3x2,8 | | | | | | | | 40 | 1 | 40 | |
| **447:1** | SSW - NNE | 2,1x1,9 x0,8 | 2 | 1 | | | | | | 94 | 3 | 97 | |
| **469 (A)** | NW – SE | 1,6x1,8 | 2 | 1 | 3 | 1 | | | | | 4 | 7 | |
| **612** | NW – SE | 14x6 | 1 | | | | | | | 2 | 2 | 3 | |
| **650 (E)** | NW – SE | 7,5x1 | 5 | | | | 1 | 3 | | | 3 | 11 | +1 suncarriage, 1 mantle figure |
| **653** | NW – SW | 6x1 | 6 | | | | | | | 3 | 2 | 9 | |
| **769** | NW-SE | 1,8x1,6 x1 | 3 | | | | | | 1 | | 2 | 4 | |

Fig. 5. My upgraded table of the panels

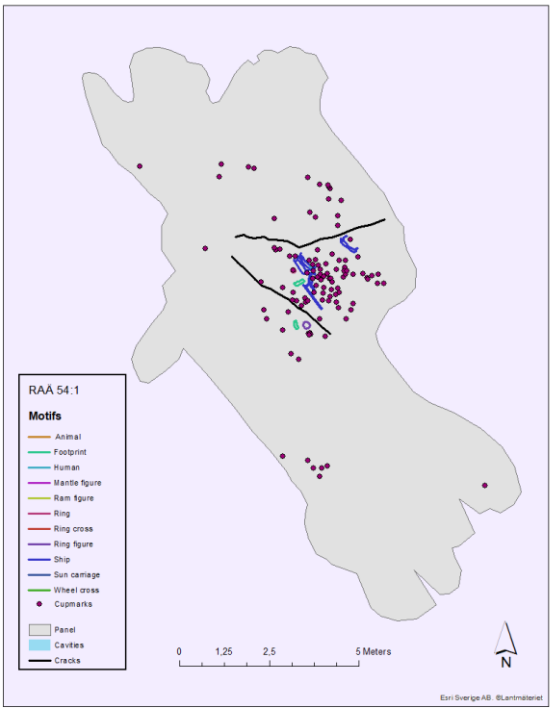


Fig. 6. Panel 54:1 with motifs and cracks.

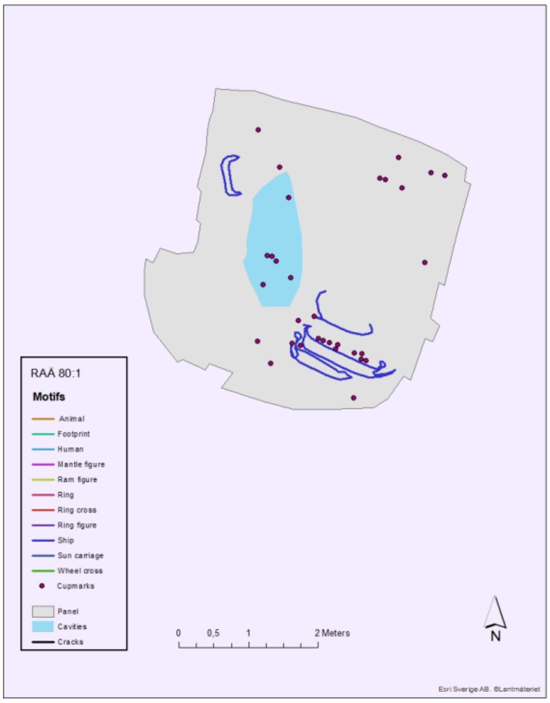


Fig. 7. Panel 80:1 with motifs and cavity.

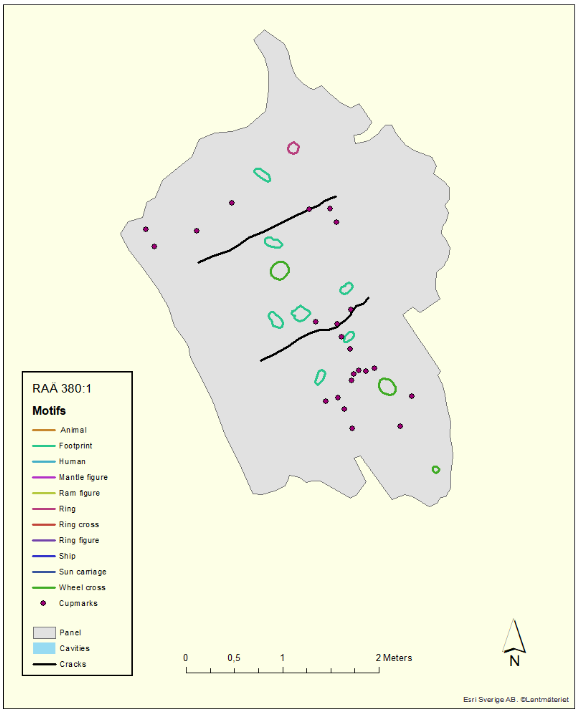


Fig. 8. Panel 380:1 with motifs and cracks.

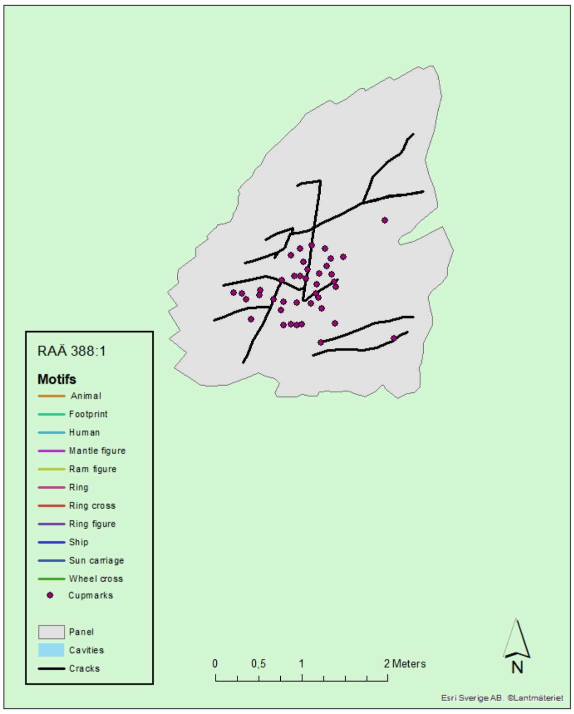


Fig. 9. Panel 388:1 with cupmarks and cracks.

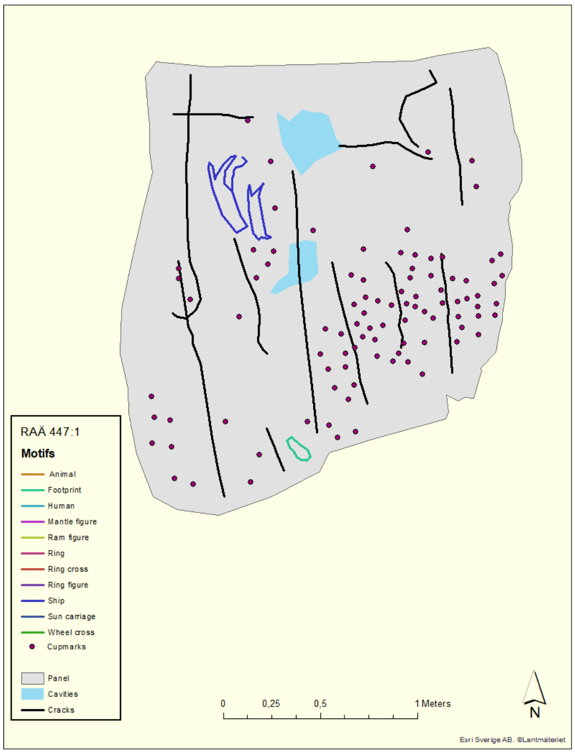


Fig. 10. Panel 447:1 with motifs, cracks and cavities.

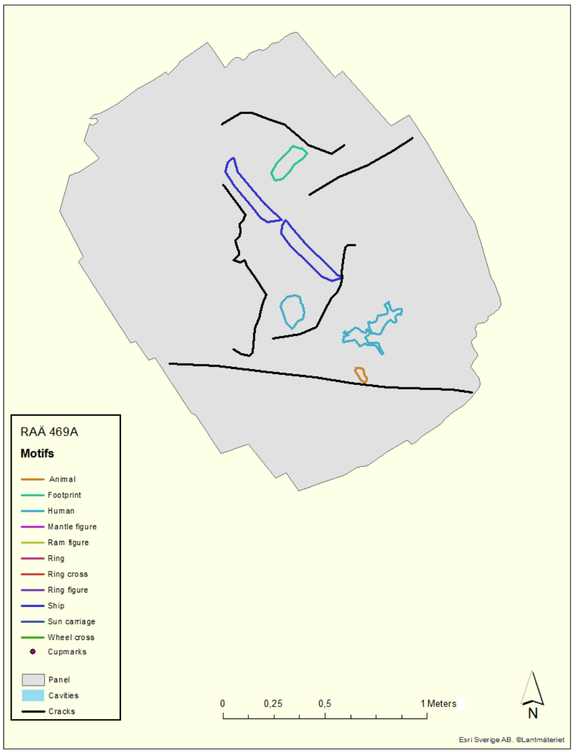


Fig. 11. Panel 469A with motifs and cracks.

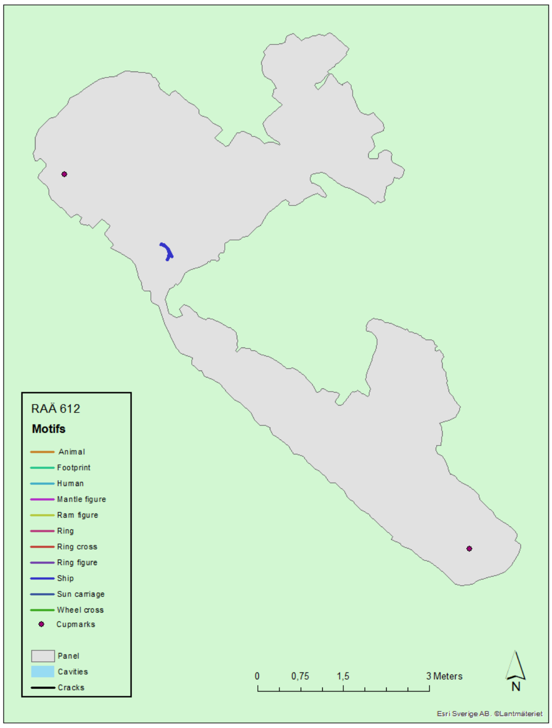


Fig. 12. Panel 612 with motifs.

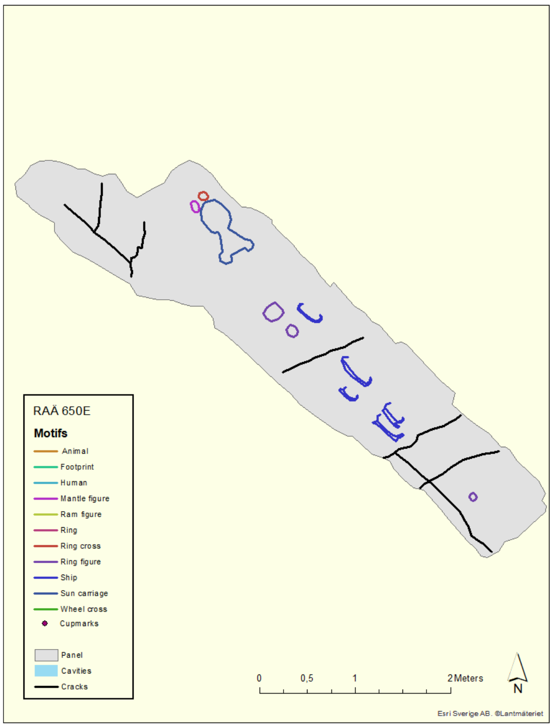


Fig. 13. Panel 650E with motifs and cracks.

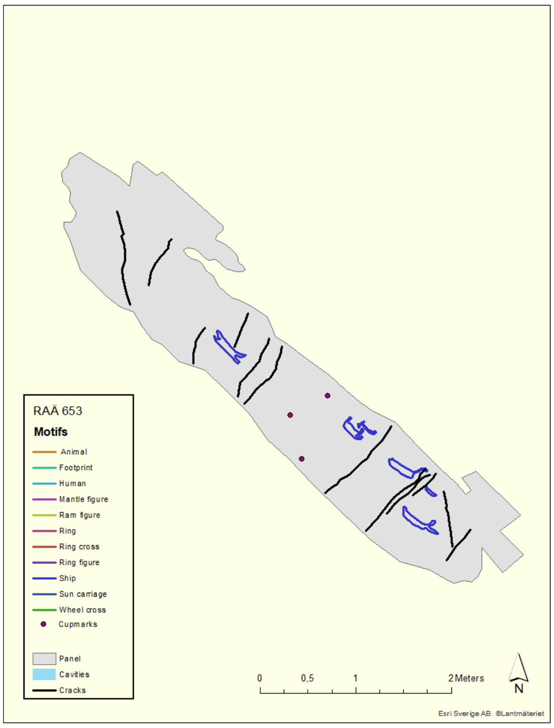


Fig. 14. Panel 653 with motifs and cracks.

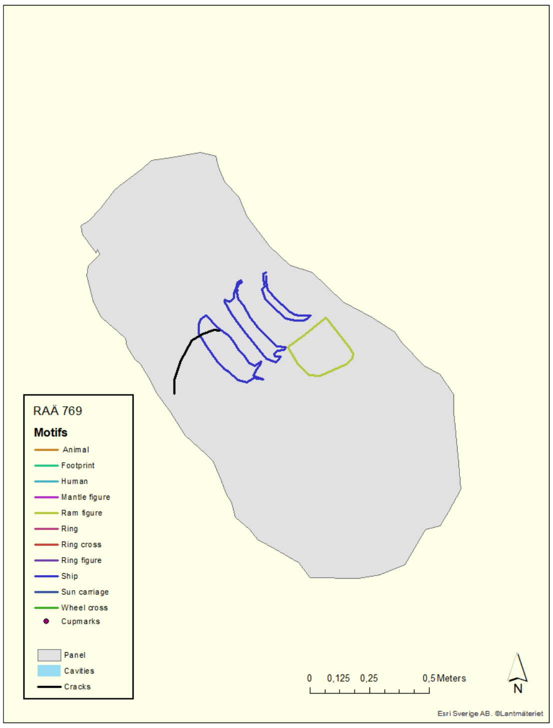


Fig. 15. Panel 769 with motifs and crack.

## 5.2 Density of motifs

Here follows the analysis regarding the density of motifs across the rock art panel. The choice was made to look at the density of all motifs together on each panel, but also look at the density of the most common motifs separately, which are ships, footprints, cupmarks and ring figures. Wheel crosses/ring crosses were included in the ring figure category, since there aren't so many motifs of each group, it would generate more information together as one group. Since one motif could belong to more than one square, the decision was made to include it in every square it showed up in, as long as it wasn't a too small part of the motif.

The following nine density maps (Fig. 16 – 24) show the density of all motifs on the panel. Panel 54:1 (Fig. 16) shows the highest concentration of motifs in the north eastern part and the middle part of the panel. Panel 650E (Fig. 22) is also showing a slightly more concentration in the north east part but is also concentrated in the middle part of the panel. The panels 80:1, 380:1, 447:1, 469A and 653 (Fig. 17, 18, 20, 21 and 23) are all showing the most concentration of motifs in the south eastern parts of the panels. 388:1 (Fig. 19) has its concentration of motifs in the southern and middle part of the panel. Panels 80:1 and 447:1 shows a distribution of motifs across the entire panel, while the motifs in 380:1 is distributed in a northwest direction. 469A and 653 also contain motifs in the middle part of the panel. 388:1 and 769 (Fig. 24) has the most concentration of motifs in the middle part of the panel.

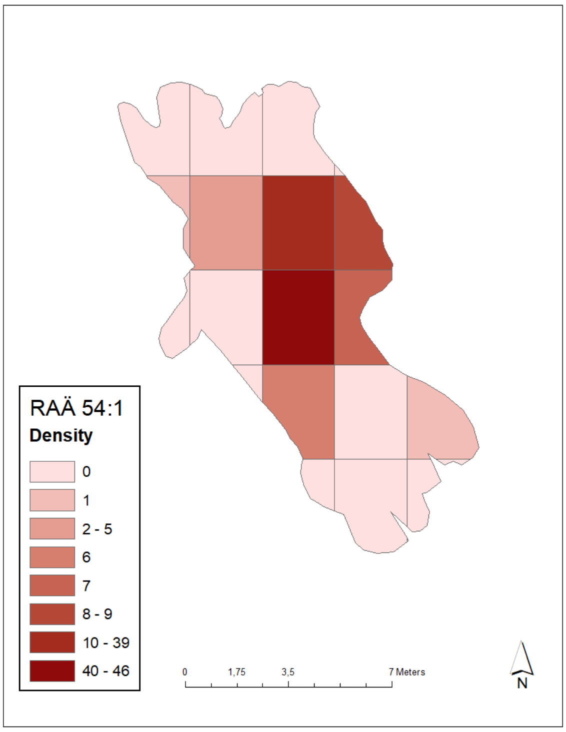


Fig. 16. Panel 54:1 and the density of motifs.

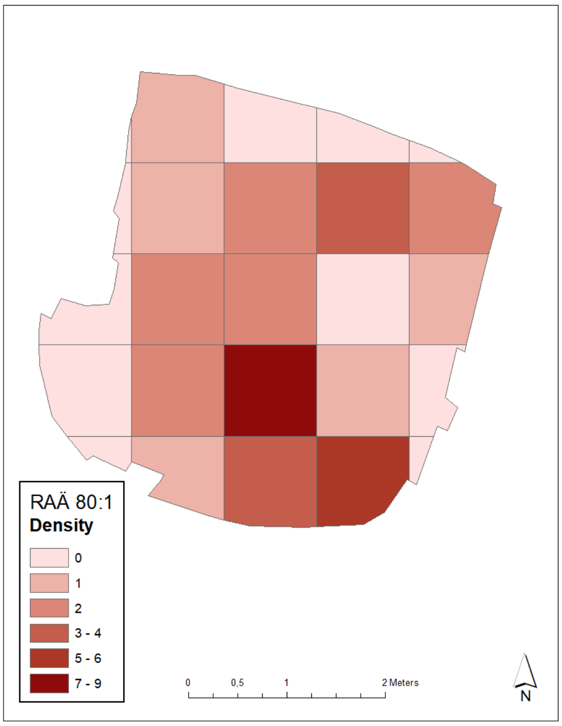


Fig. 17. Panel 80:1 and the density of motifs.

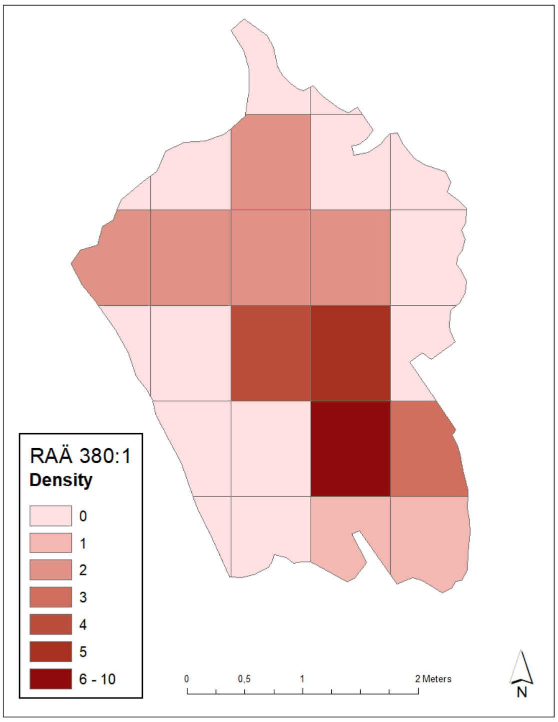


Fig. 18. Panel 380:1 and the density of motifs.

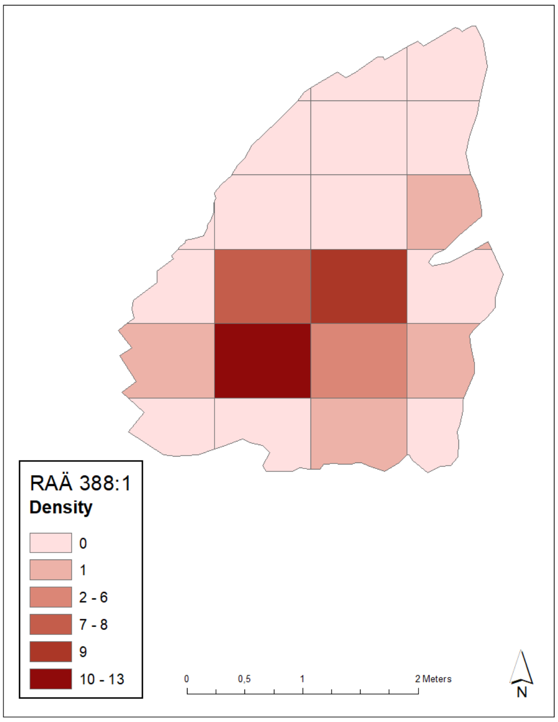


Fig. 19. Panel 388:1 and the density of motifs.

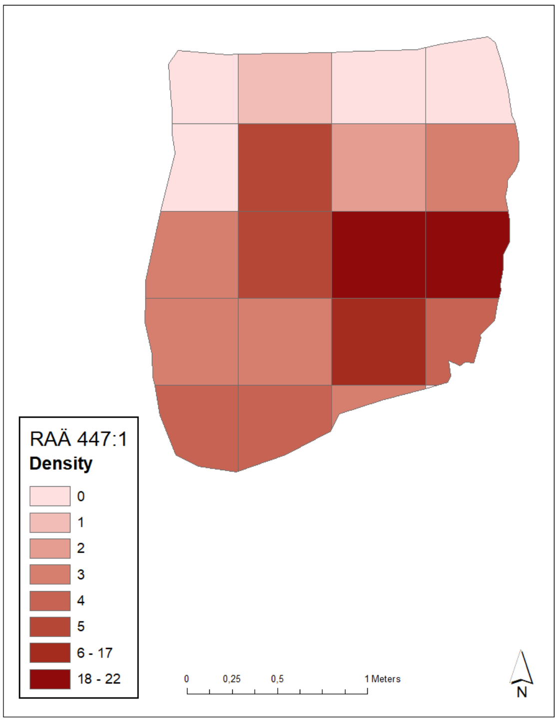


Fig. 20. Panel 447:1 and the density of motifs.

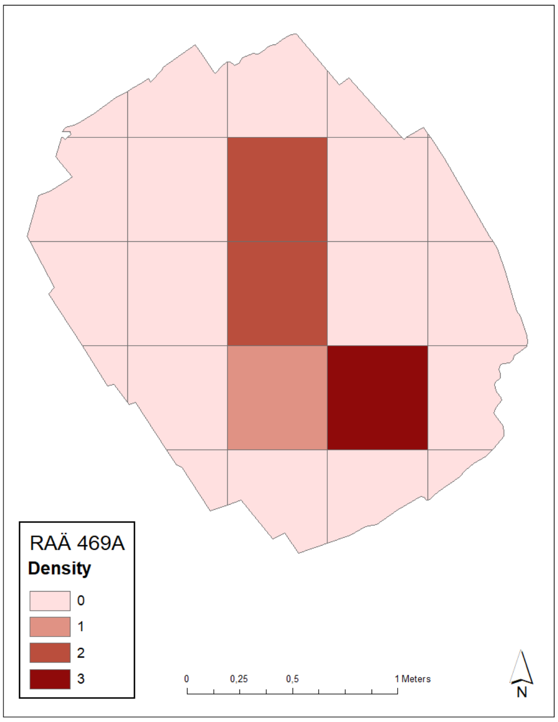


Fig. 21. Panel 469A and the density of motifs.

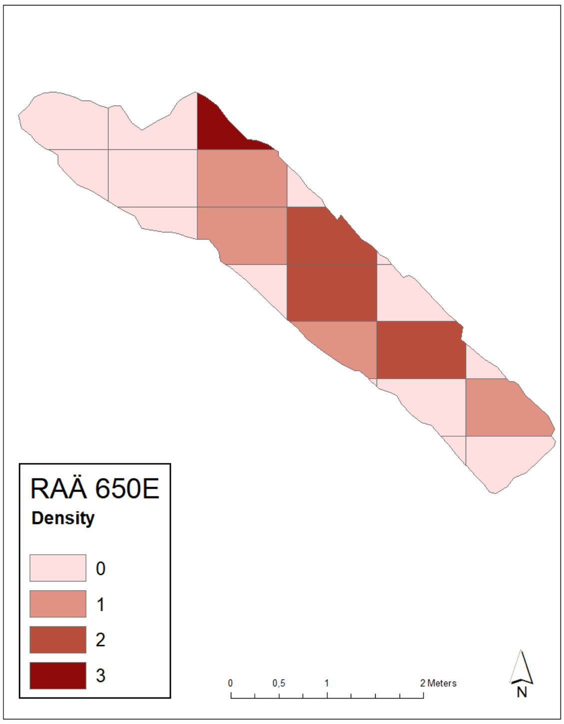


Fig. 22. Panel 650E and the density of motifs.

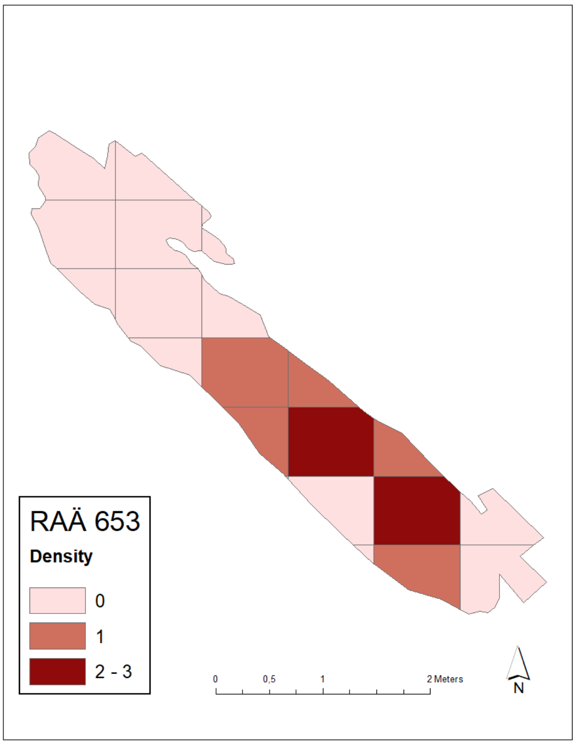


Fig. 23. Panel 653 and the density of motifs.

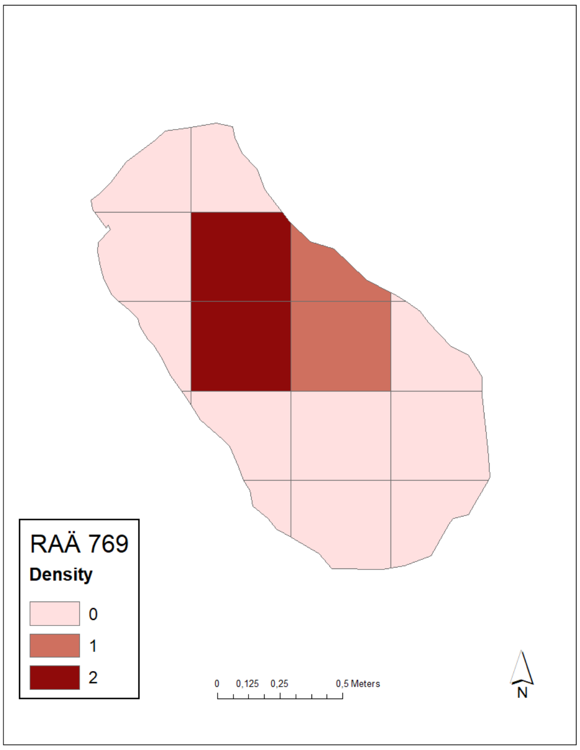


Fig. 24. Panel 769 and the density of motifs.

## Ships

The seven panels which contain ship motifs have their concentration on different parts of the panel. Most of the ships on panel 54:1 (Fig. 25) and 469A (Fig. 28) are placed in the north eastern part and in the middle of the panel. Ships on panel 80:1 (Fig. 26) are most concentrated in the southern part, and on panel 650E (Fig. 29) and 653 (Fig. 30) the ships are mostly concentrated in the south and south eastern part. The ships on panel 447:1 (Fig. 27) is concentrated in the north western part and on 769 (Fig. 31) in the middle of the panel.

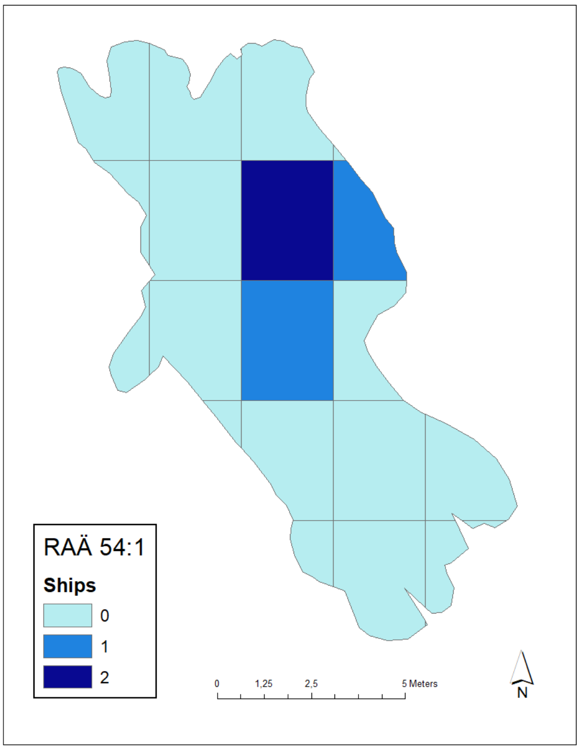


Fig. 25. Panel 54:1 and the density of ship motifs.

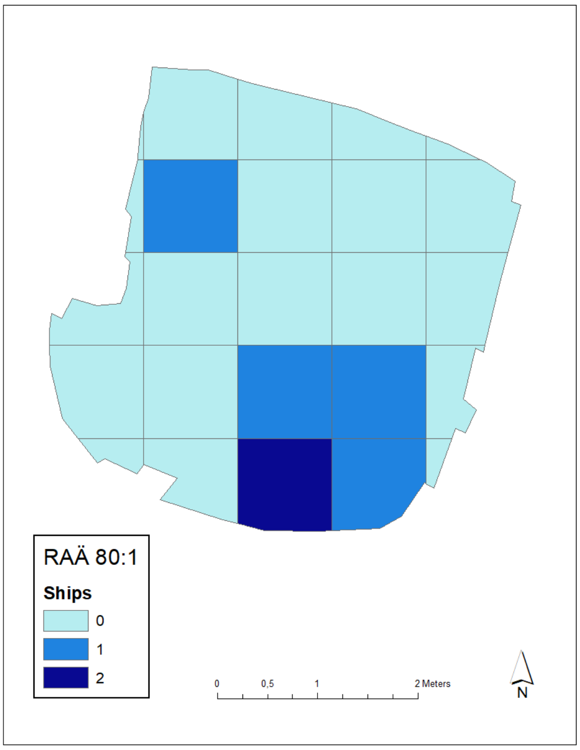


Fig. 26. Panel 80:1 and the density of ship motifs.

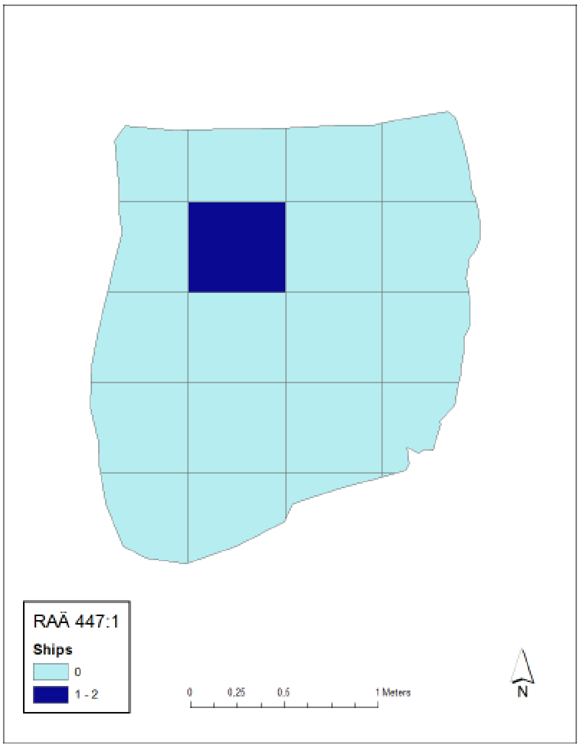


Fig. 27. Panel 447:1 and the density of ship motifs.

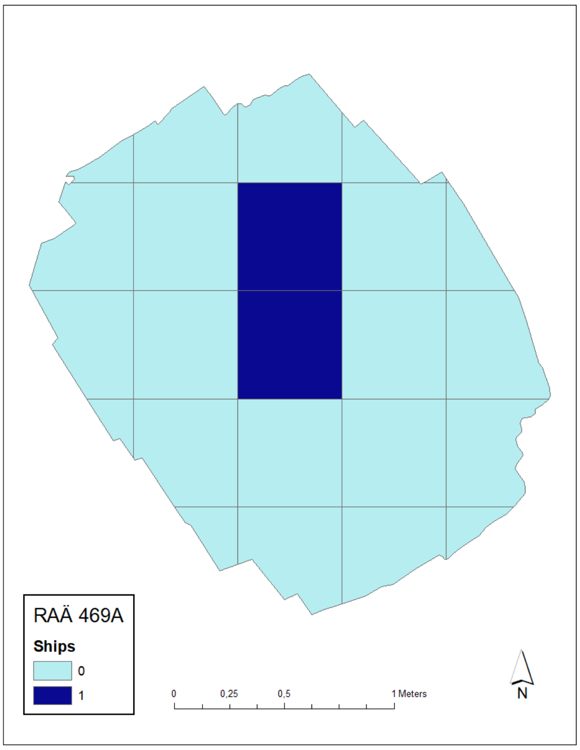


Fig. 28. Panel 469A and the density of ship motifs.

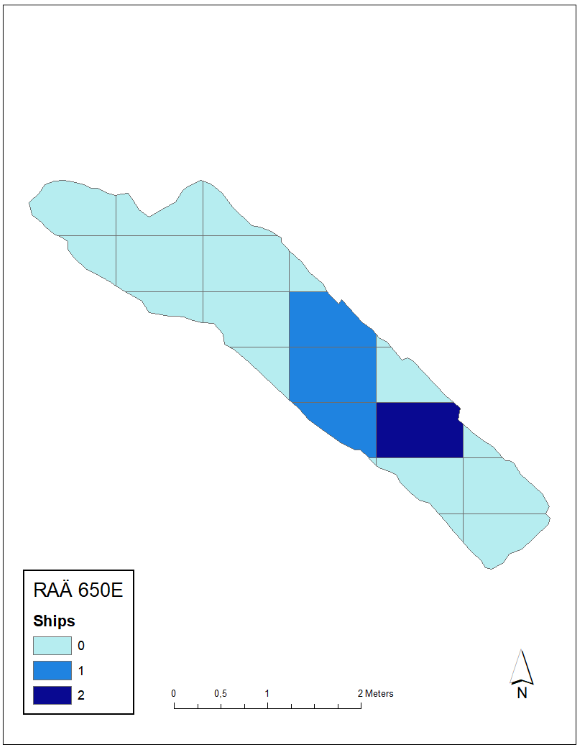


Fig. 29. Panel 650E and the density of ship motifs.

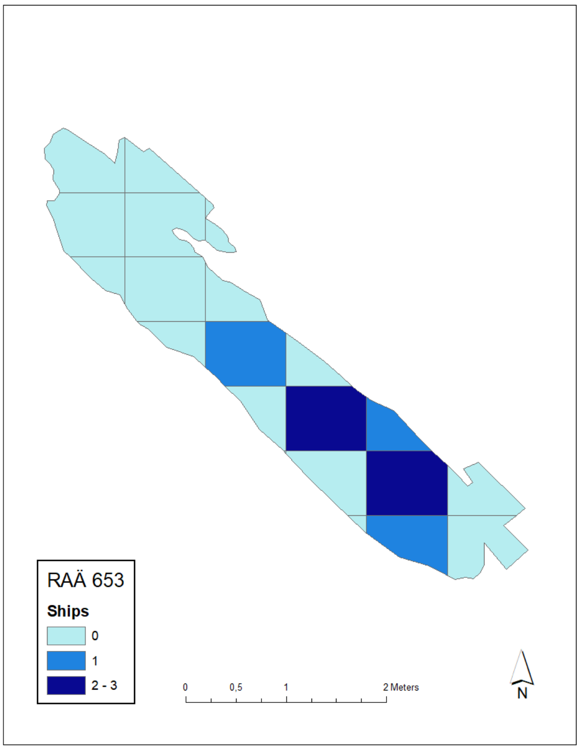


Fig 30. Panel 653 and the density of ship motifs.

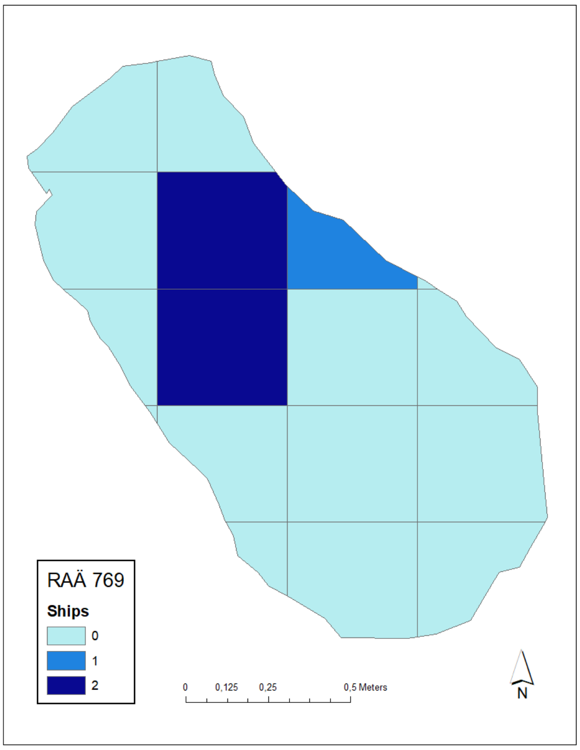


Fig. 31. Panel 769 and the density of ship motifs.

## Footprints

Out of the four panels which contained footprints, two of them, 54:1(Fig. 32) and 380:1 (Fig. 33), shows the highest concentration of footprints in the middle part of the panel. Footprints on panel 380:1 is also extending to the north and south, but still in the middle part of the panel. The footprint on 447:1 (Fig. 34) is placed in the southern part of the panel, and the footprint on 469A (Fig. 35) is placed more in the northern part.

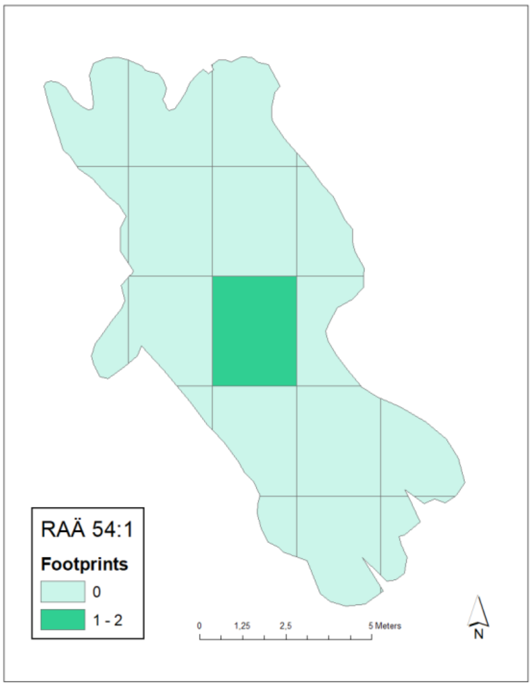


Fig. 32. Panel 54:1 and the density of footprint motifs.

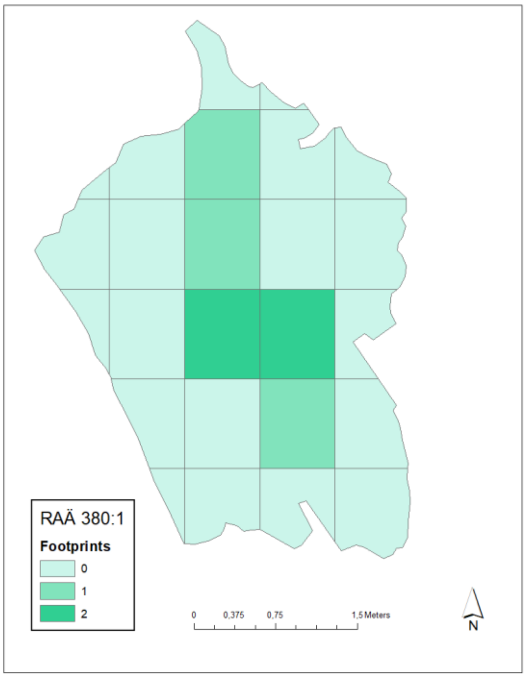


Fig. 33. Panel 380:1 and the density of footprint motifs.

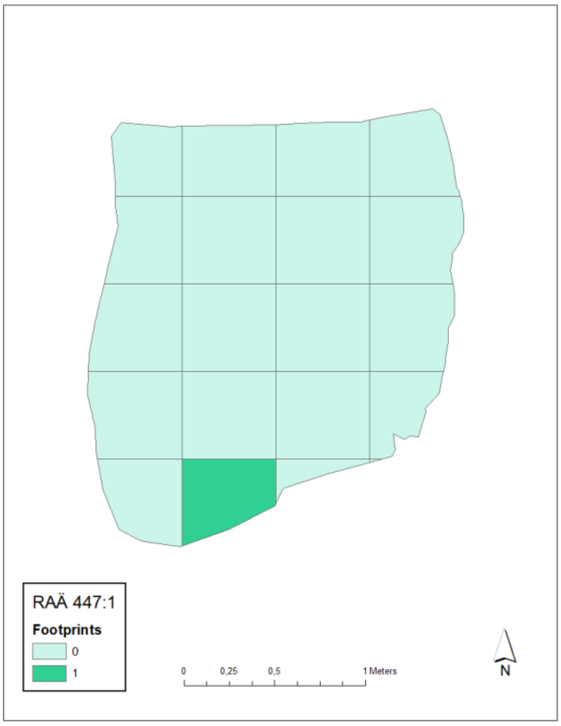


Fig. 34. Panel 447:1 and the density of footprint motifs.

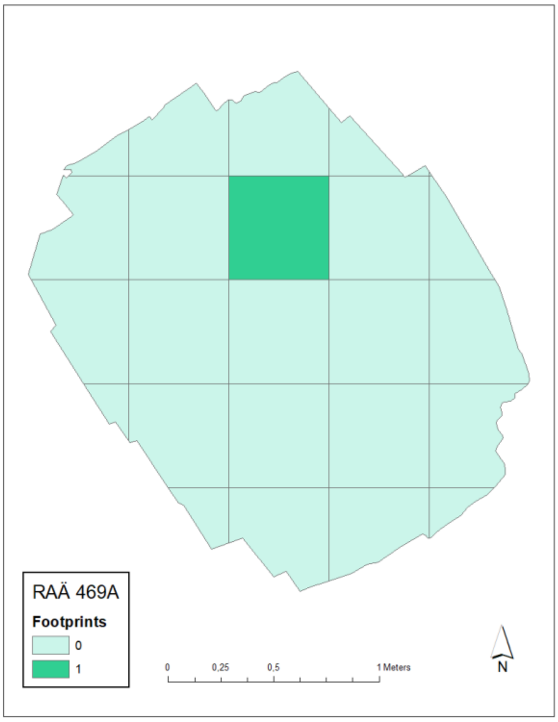


Fig. 35. Panel 469A and the density of footprint motifs.

## Cupmarks

Cupmarks were found on six panels and the cupmarks are spread out across the entire panel on almost all of them. Only panel 653 (Fig. 41) and its three cupmarks are placed in the middle part of the panel. Panel 54:1 (Fig. 36) has the highest concentration of cupmarks in the middle and eastern part of the panel. Panel 80:1, 380:1 and 388:1 (Fig. 37, 38 and 39), have the highest concentration in the southern part of the panel. On panel 447:1 (Fig. 40), most of the cupmarks are placed in the eastern part of the panel.

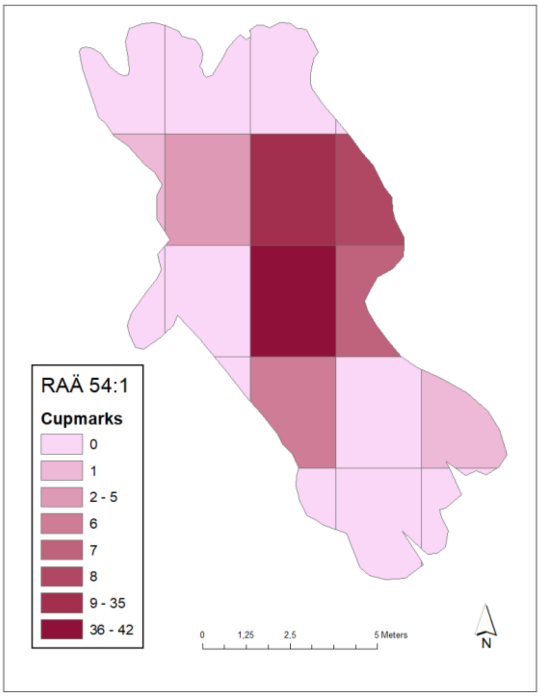


Fig. 36. Panel 54:1 and the density of cupmark motifs.

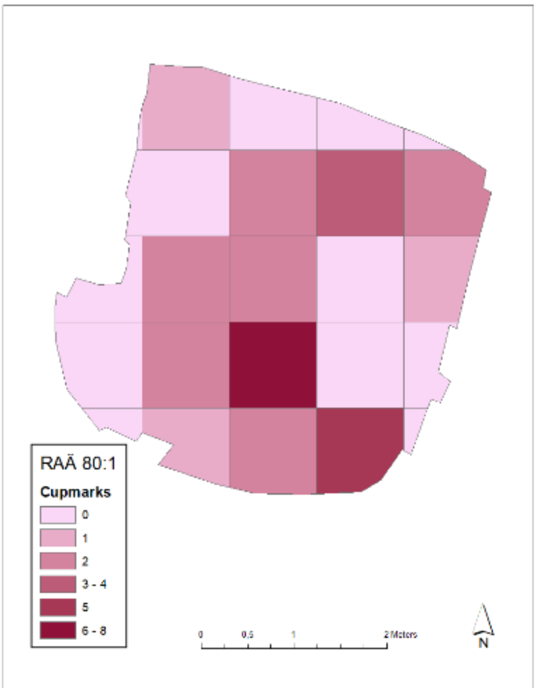


Fig. 37. Panel 80:1 and the density of cupmark motifs.

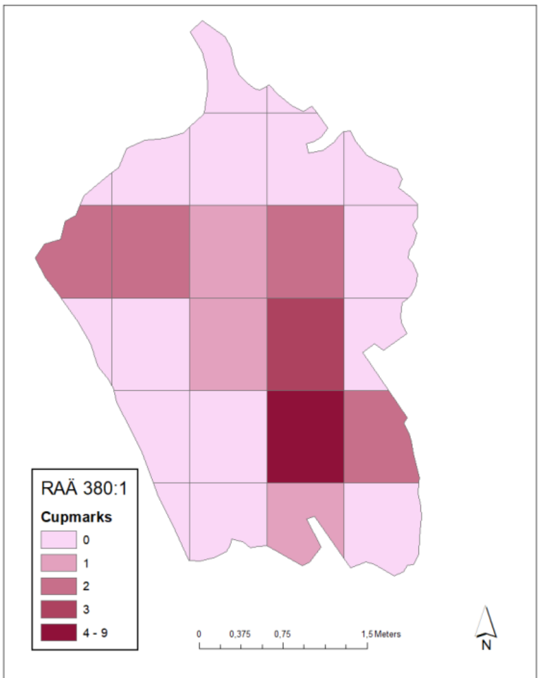


Fig. 38. Panel 380:1 and the density of cupmark motifs.

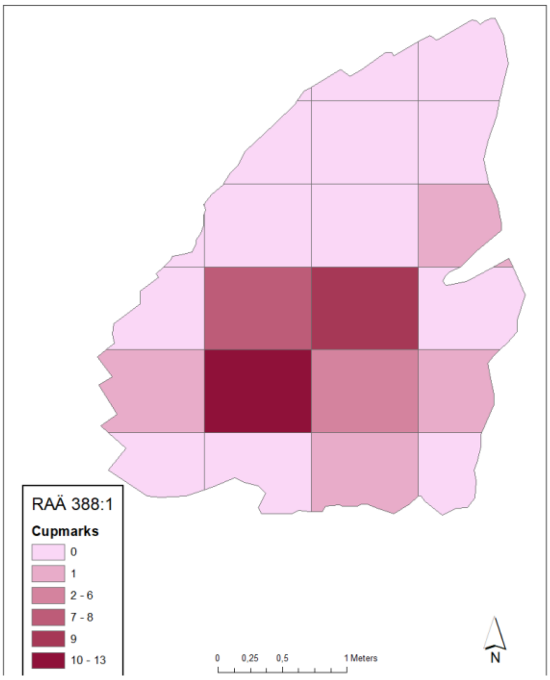


Fig. 39. Panel 388:1 and the density of cupmark motifs.

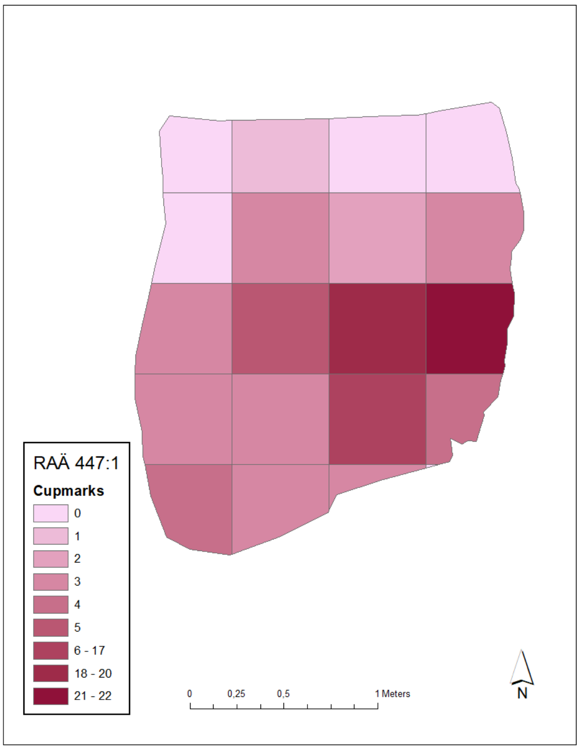


Fig. 40. Panel 447:1 and the density of cupmark motifs.

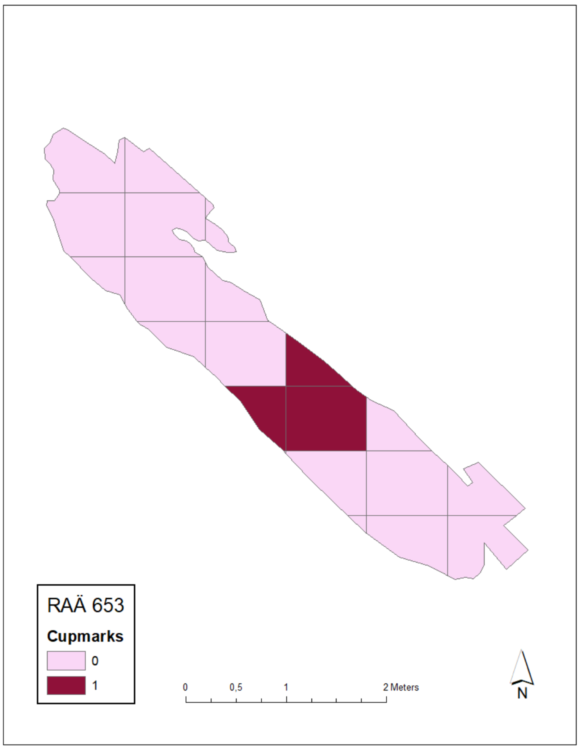


Fig. 41. Panel 653 and the density of cupmark motifs.

## Ring figures

On the three panels (Fig. 42 – 44) with ring figures, including both rings and ring/wheel crosses, the highest concentration of ring figures were similar. Ring figures are found in the middle part of all three panels. They also occur in the northern and south eastern parts of panel 380:1 (Fig. 43) and 650E (Fig. 44).

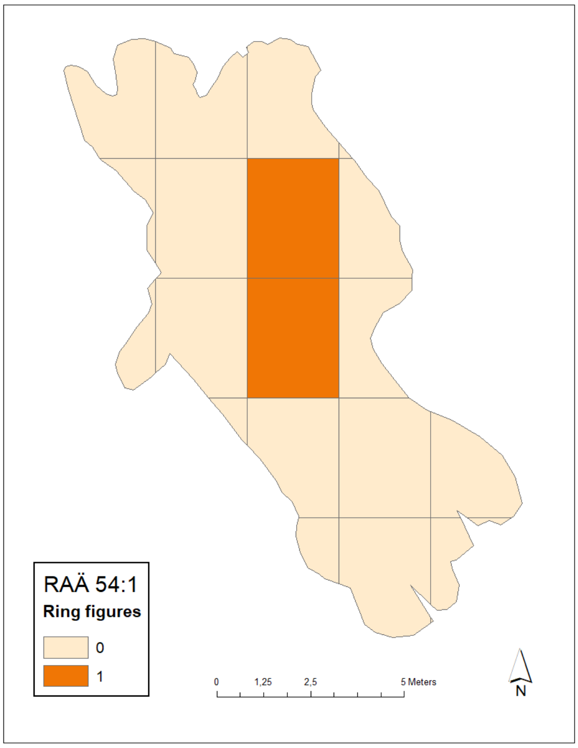


Fig. 42. Panel 54:1 and the density of ring figures.

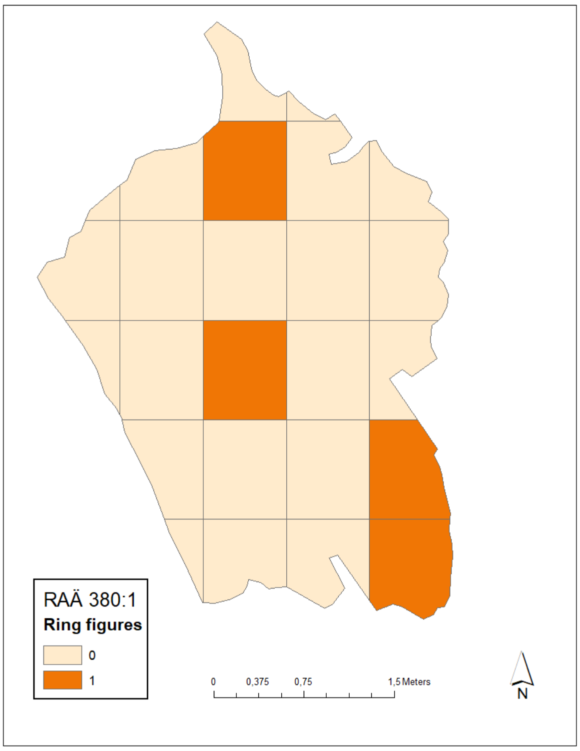


Fig. 43. Panel 380:1 and the density of ring figures.

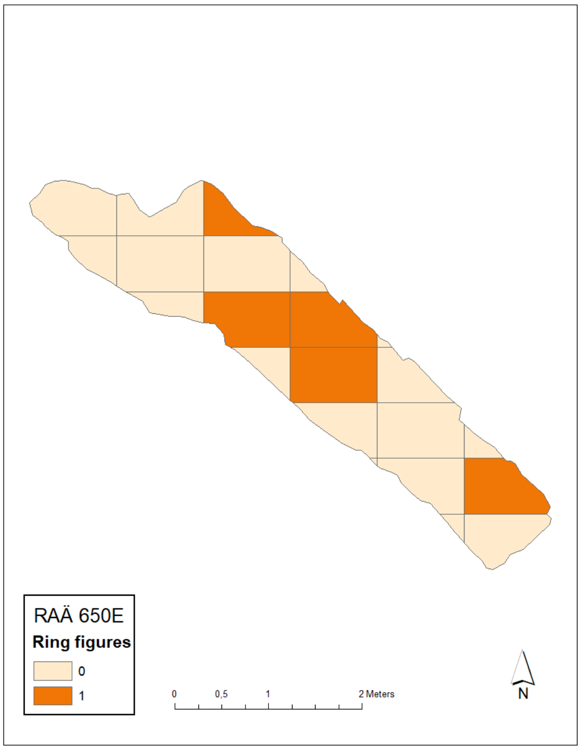


Fig. 44. Panel 650E and the density of ring figures.

## 5.3 Relation between motifs

The relation between different types of motifs, was analyzed by creating a buffer zone around the motifs. This was to see what kind of motifs that occurs in close relation to specific motifs. The distance was set on twenty centimeter and motifs that were most relevant to focus on were ships, footprints, cupmarks, ring figures and ring crosses. The motifs that were counted in were all motifs that were either inside the buffer zone or were connected in some part to it. The panels' cracks and cavities were also included, as elements that might be close to these selected motifs. The diagram shows the number of motifs that occurred closest to the selected motif.

First out are ships (Fig 45). The motif that occurred the most within the distance of 20 centimeter from a ship carving, were cupmarks. On second place comes cracks, followed by ring figures, cavities and the least common motifs were footprints.

Footprints (Fig. 46) were, just like ship carvings, closest to cupmarks and cracks. Three ships could be found within the twenty-centimeter zone, as well as one ring figure and one ring cross.

Cupmarks (Fig. 47) were closest to cracks and ships. The third most common motif was footprints followed by two ring figures, two cavities and one ring cross.

Ring figures (Fig. 48) and ring crosses (Fig. 49) were both closest to cupmarks, but the second closest motifs to the ring figures were cracks while the second and last motif closest to ring crosses were one footprint. Ring figures were also close to two ships and one footprint.

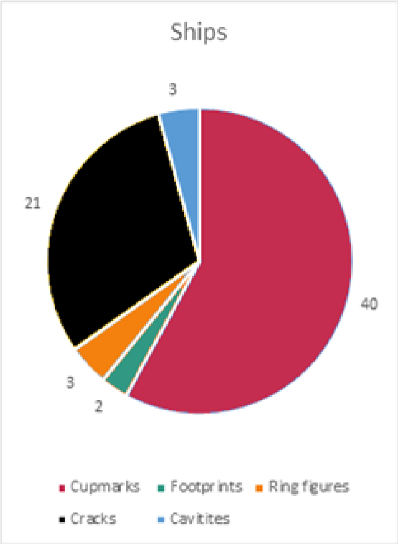


Fig. 45. The number of motifs closest to ship motifs

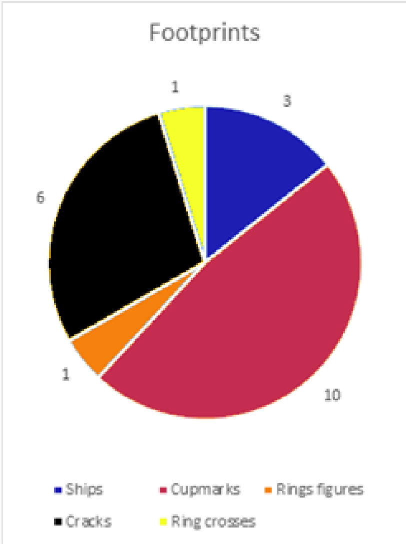


Fig. 46. The number of motifs closest to footprint motifs

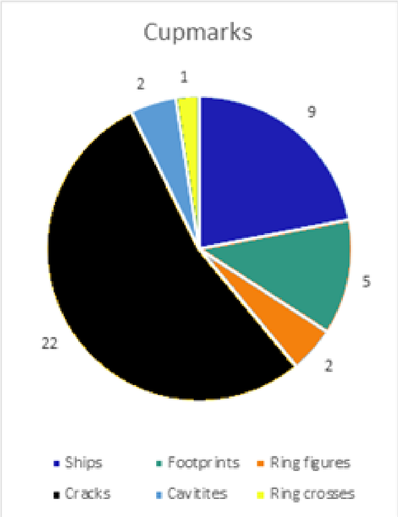


Fig. 47. The number of motifs closest to cupmarks

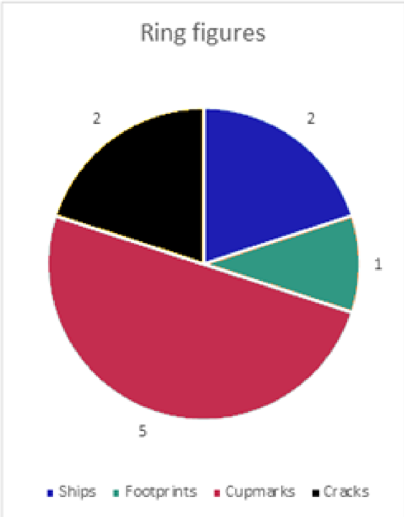


Fig. 48. The number of motifs closest to ring figures

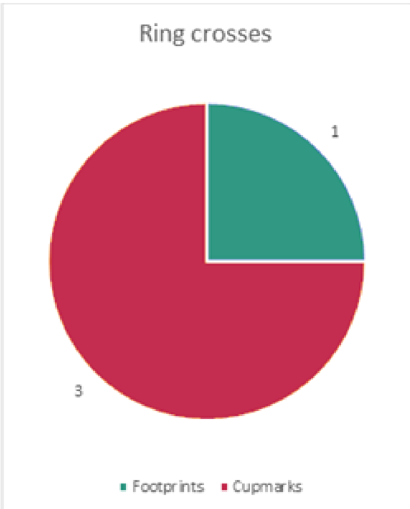


Fig. 49. The number of motifs closest to ring crosses

## 5.4 The texture of the panels

Many of the panels contain striations and cracks. The striations are mostly visible on panels 80:1, 380:1, 650E and 653 (Fig. 51, 52, 56 and 57). The striations have the same direction as the ships on panels 80:1, 650E and 653. On panel 380:1, the striations are mostly concentrated in the middle part of the panel in a south-west to north-east direction, the same part of the panel as the concentration of motifs. Cracks occur on almost all panels and the biggest ones are marked out on the motif maps in chapter 5.1. The motifs seem to have been placed in between two or more cracks, and some motifs like the ships on panel 447:1 (Fig. 54) are "sailing" in the same direction as the cracks. The only motifs that have been placed on top of cracks are cupmarks, especially on panels 380:1, 388:1 (Fig. 53) and 447:1.

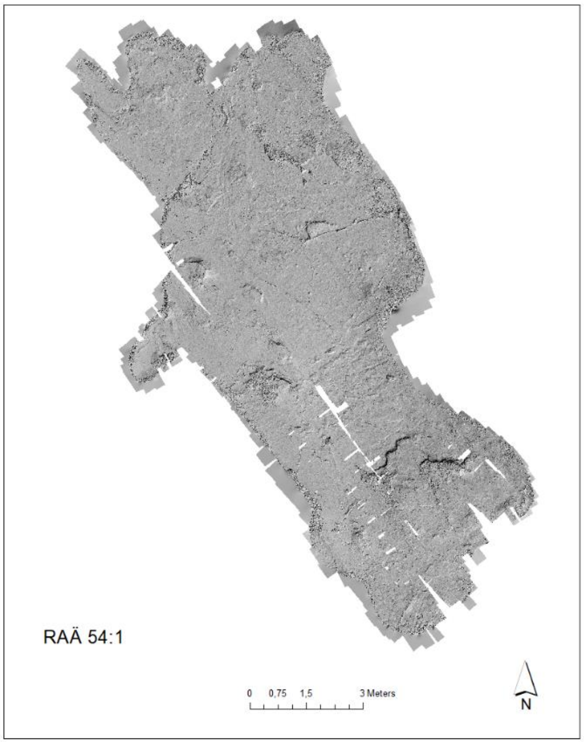


Fig. 50. The hillshade map of the texture of panel 54:1

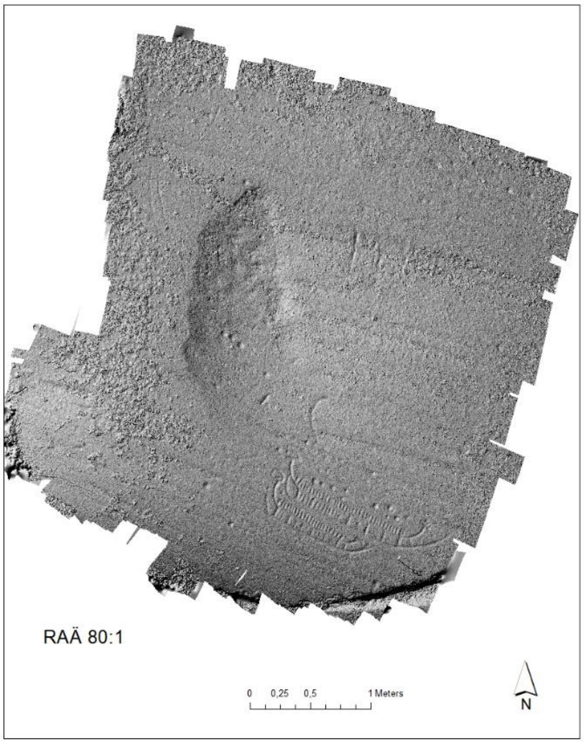


Fig. 51. The hillshade map of the texture of panel 80:1

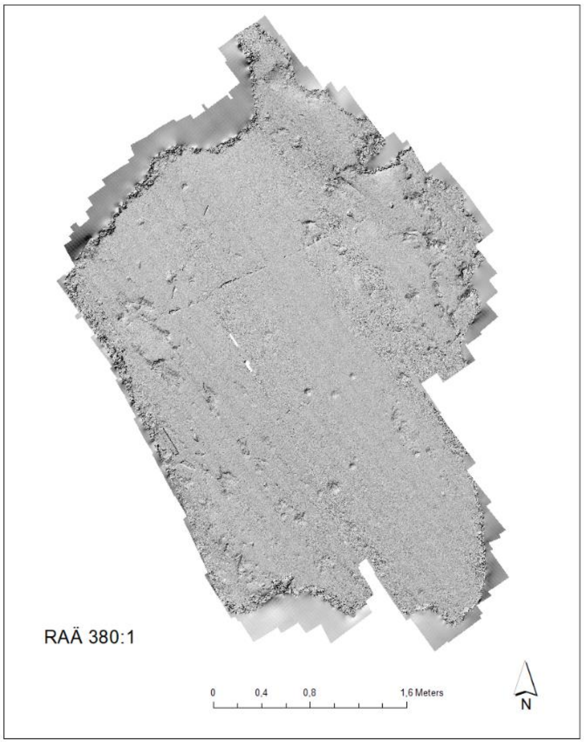


Fig. 52. The hillshade map of the texture of panel 380:1.

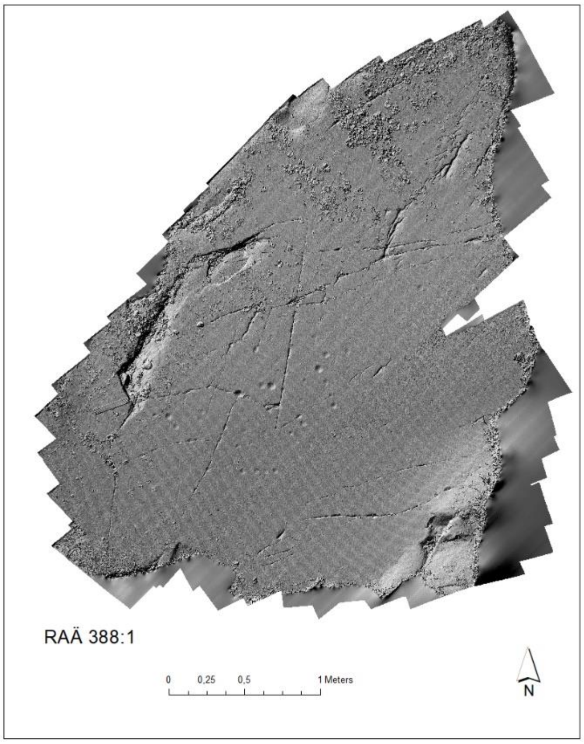


Fig. 53. The hillshade map of the texture of panel 388:1.

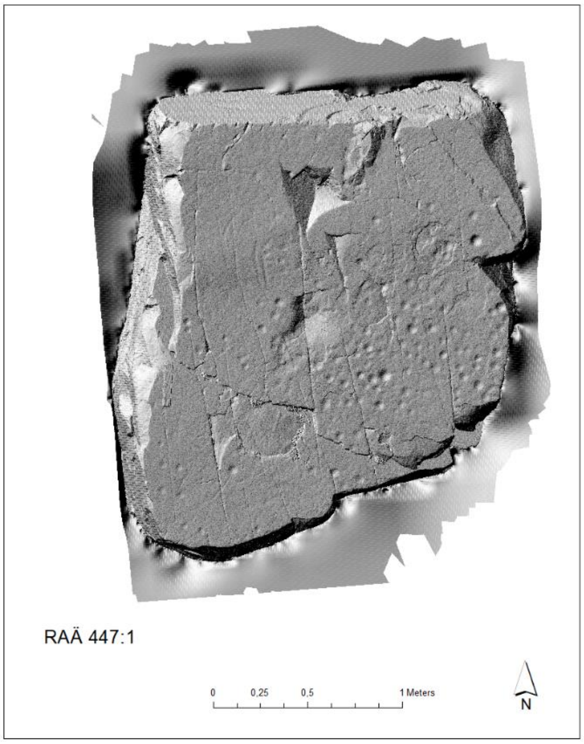


Fig. 54. The hillshade map of the texture of panel 447:1.

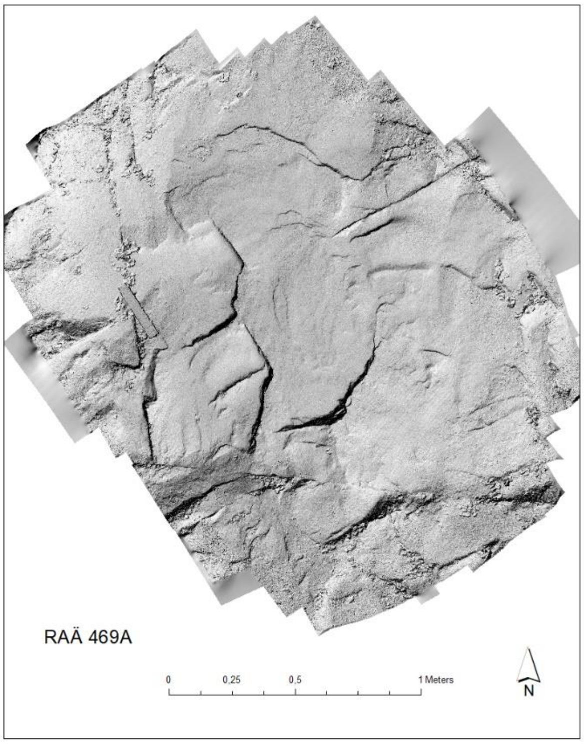


Fig. 55. The hillshade map of the texture of panel 469A.

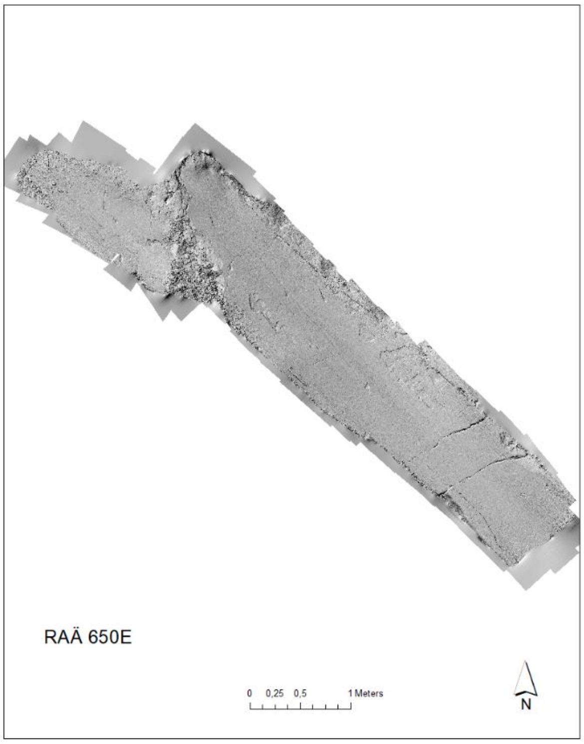


Fig. 56. The hillshade map of the texture of panel 650E.

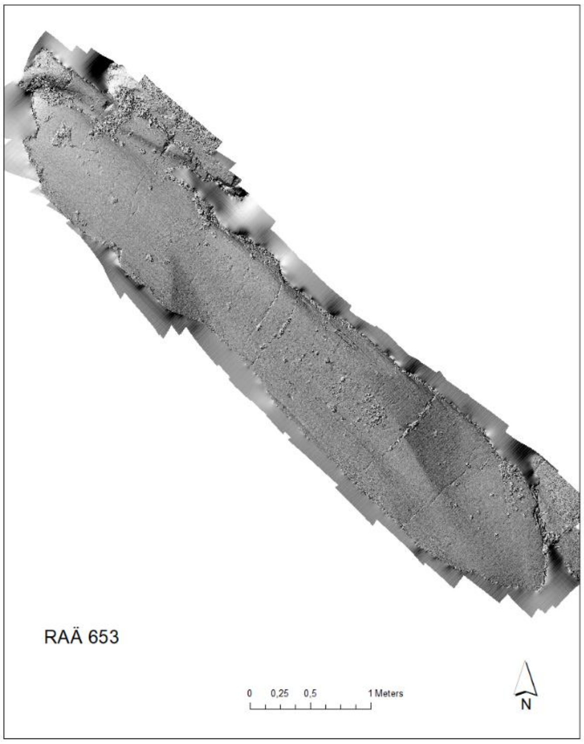


Fig. 57. The hillshade map of the texture of panel 653.

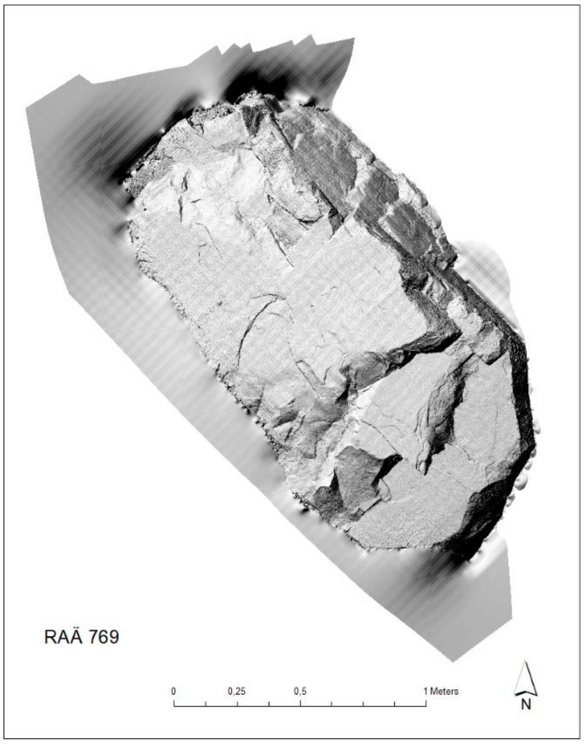


Fig. 58. The hillshade map of the texture of panel 769.

## 5.5 Slope

To see if the rock carving motifs were placed on certain higher or lower parts of the panel, I used the tool Slope in the GIS to create maps showing the elevation of the panels.

All the motifs seem to be placed on the higher parts of the panels, which is especially visible on panel 469A (Fig. 64) where the two ships are placed on the highest part of the panel. Other than that, the only motifs that seem to have been carved on a little bit lower topographical part of the panel are cupmarks on panel 80:1 (Fig. 60), two of the human figures and the animal on panel 469A, a couple of ring figures at panel 650E (Fig. 65), 2 – 3 of the ships in the south eastern part of panel 653 (Fig 66), and the ships and frame figure on panel 769 (Fig. 67).

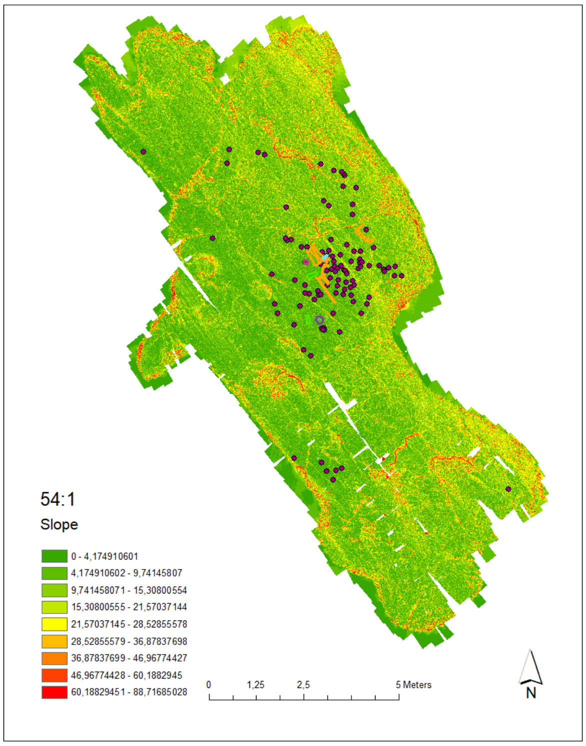


Fig. 59. The relation between elevation and motifs on panel 54:1.

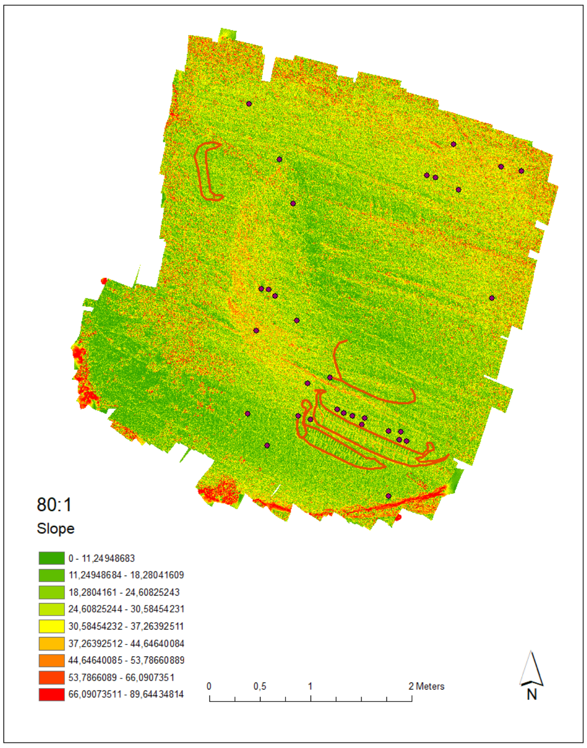


Fig. 60. The relation between elevation and motifs on panel 80:1.

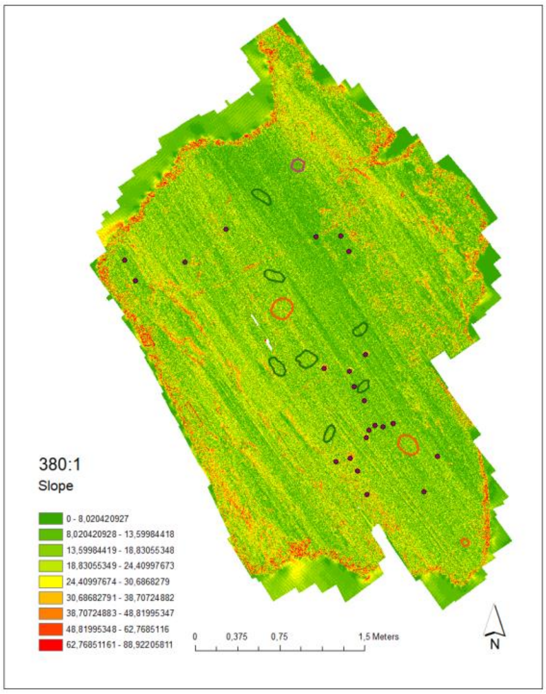


Fig. 61. The relation between elevation and motifs on panel 380:1.

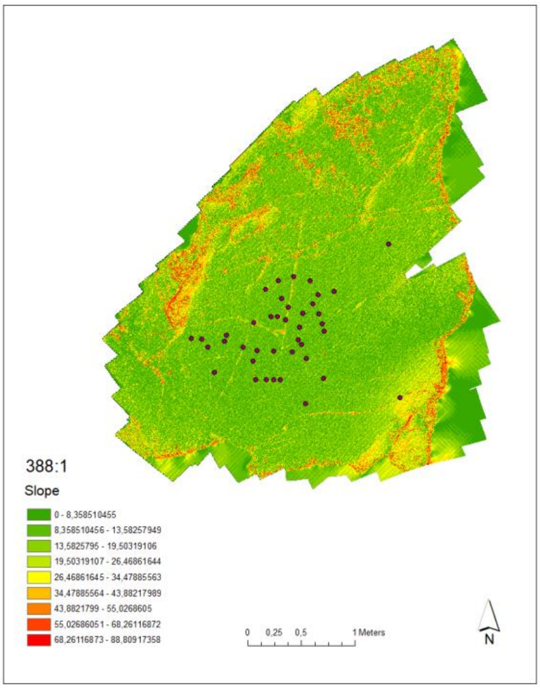


Fig. 62. The relation between elevation and motifs on panel 388:1.

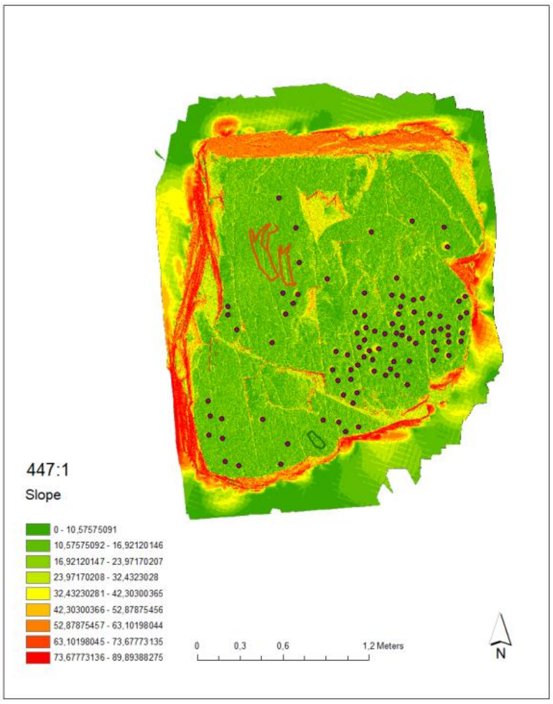


Fig. 63. The relation between elevation and motifs on panel 447:1.

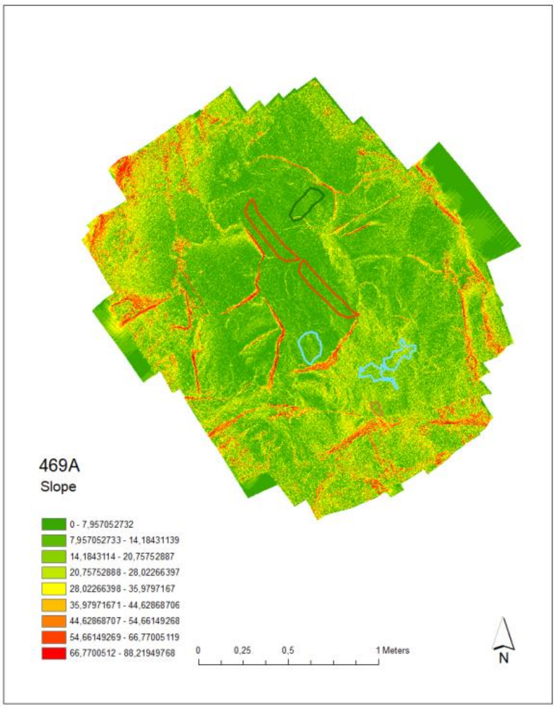


Fig. 64. The relation between elevation and motifs o on panel 469A.

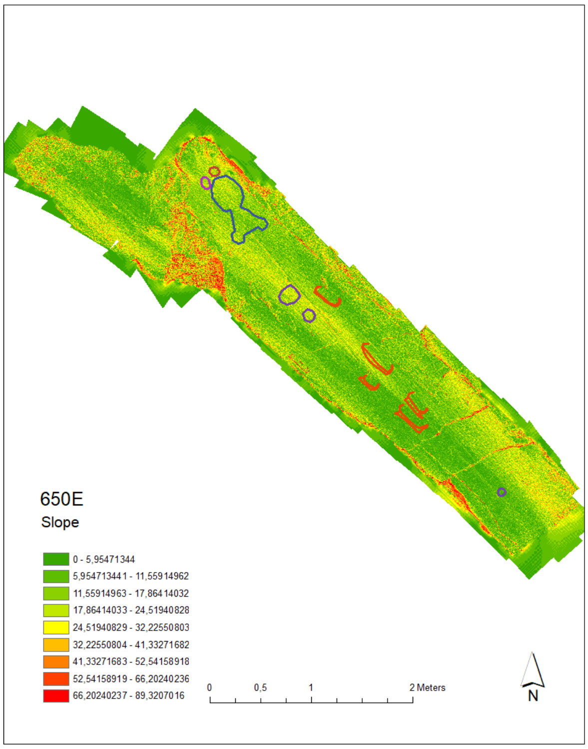


Fig. 65. The relation between elevation and motifs on panel 650E.

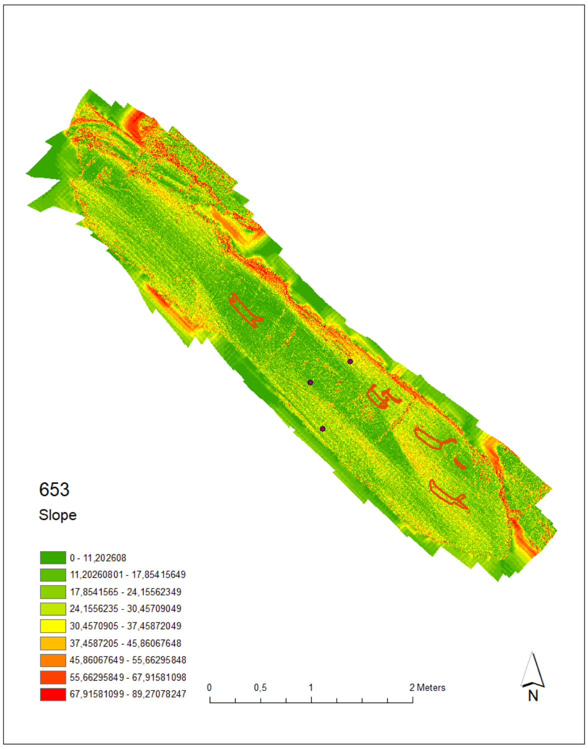


Fig. 66. The relation between elevation and motifs on panel 653.

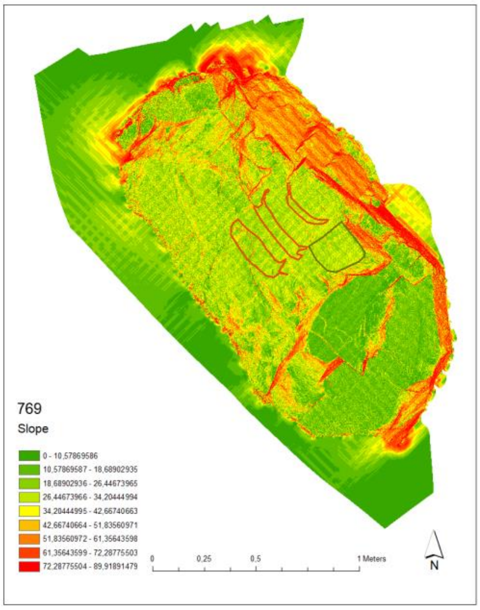


Fig. 67. The relation between elevation and motifs on panel 769.

## 5.5 Aspect

The following maps show how the motifs were placed on the panel depending on the panels' downslope direction.

The ships are placed on the part of the panel which is sloping down from north-east to south east except on panel 769 (Fig. 76) where the two ships are placed on the west sloping part.

The footprints on 54:1 (Fig. 68) are facing north to east and the footprint on 447:1 (Fig. 72) is facing east to south east. The footprints on panel 380:1 (Fig. 70) and the footprint on 469A (Fig. 73) are viewing the opposite direction. They are viewing south to west.

The ring figures on panel 54:1 (Fig 68) and the ring figures and ring / wheel crosses on 650E (Fig. 74) are viewing north east. The ring figures and ring /wheel crosses on panel 380:1 are viewing south west to west. The human figures and the animal on panel 469A are viewing south west to west. The frame figure on panel 769 is also viewing west. The cupmarks are viewing all directions on the panels.

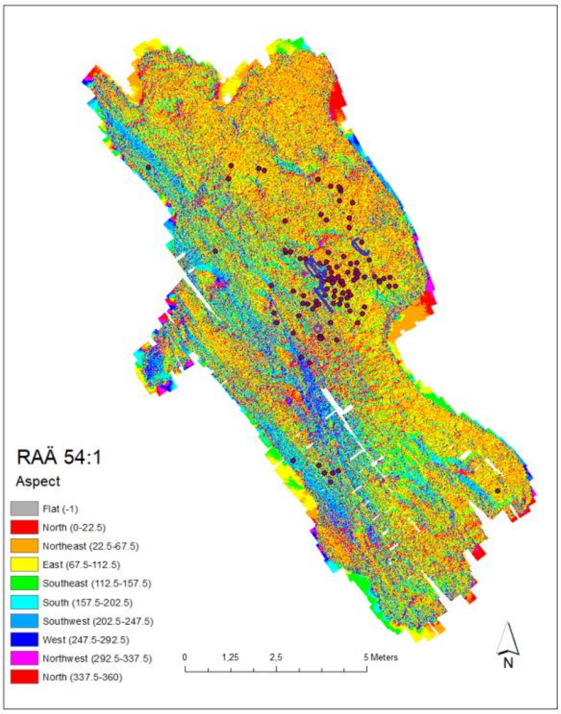


Fig. 68. The relation between downslope direction and motifs on panel 54:1.

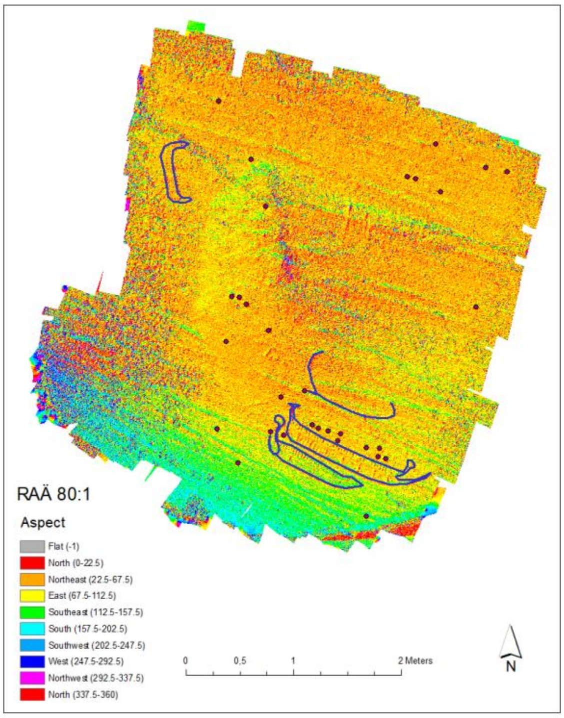


Fig. 69. The relation between downslope direction and motifs on panel 80:1.

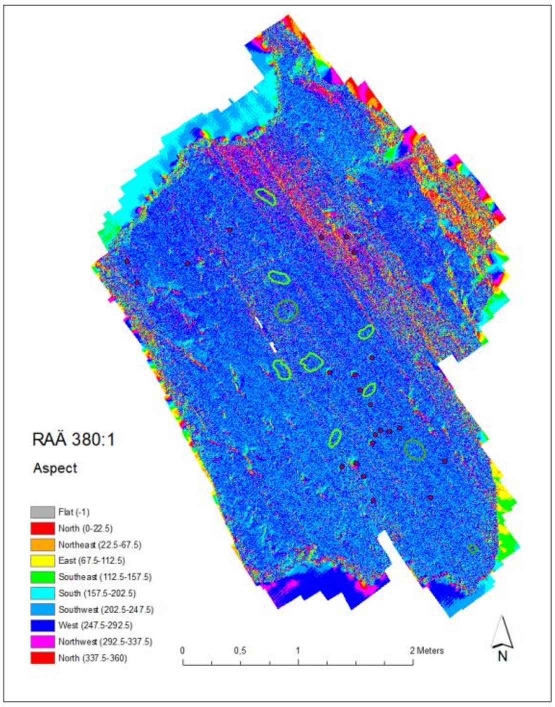


Fig. 70. The relation between downslope direction and motifs on panel 380:1.

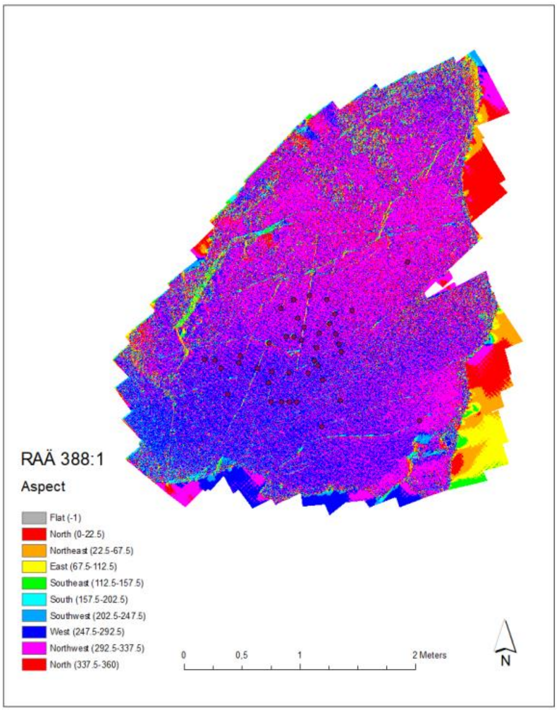


Fig. 71. The relation between downslope direction and motifs on panel 388:1.

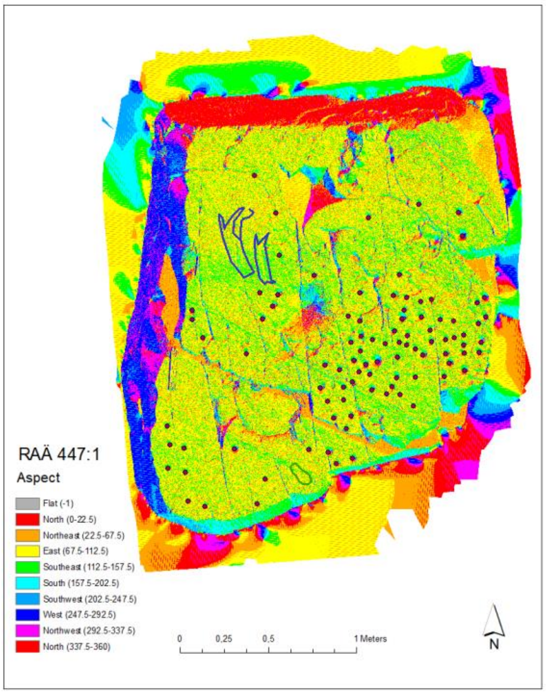


Fig. 72. The relation between downslope direction and motifs on panel 447:1.

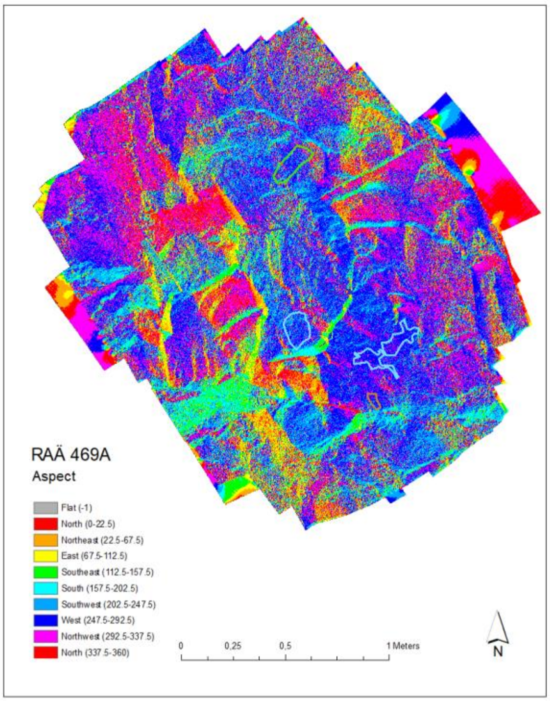


Fig. 73. The relation between downslope direction and motifs on panel 469A.

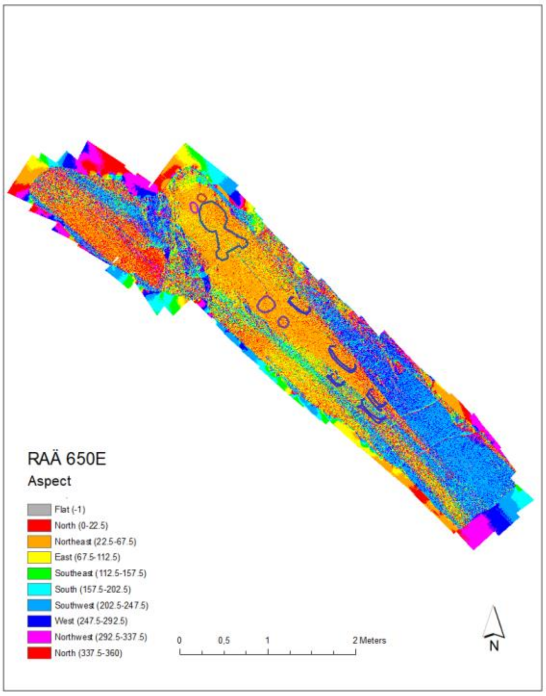


Fig. 74. The relation between downslope direction and motifs on panel 650E.

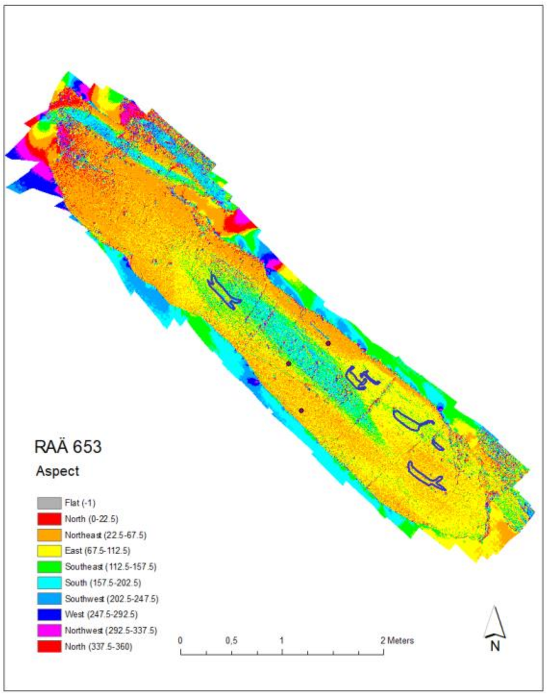


Fig. 75. The relation between downslope direction and motifs on panel 653.

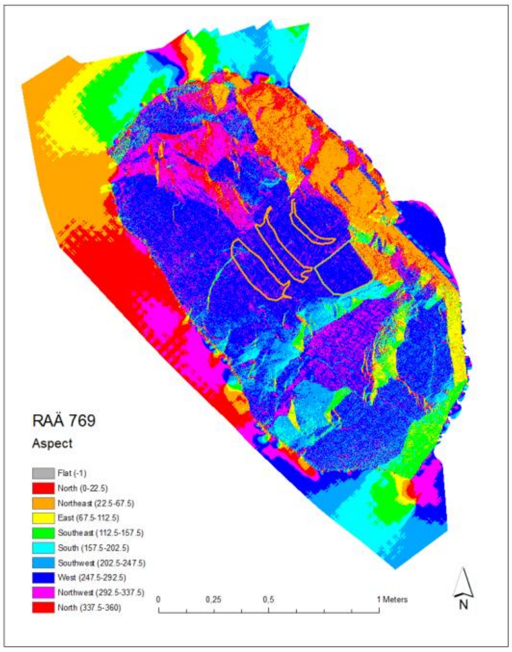


Fig. 76. The relation between downslope direction and motifs on panel 769.

# 6. Results

During the analysis, different surface analysis tools have been used to examine how the different rock art motifs, on the ten different panels in Gamleby parish in Tjust, have been placed on the panels. This has been studied to see if it there is a correlation between the motifs' placement and the topography of the panel, the panels' textures with cracks and striations, the panels' downslope direction and the relation between other motifs placed closest to specific motifs.

Apart from cupmarks, which constituted the majority of all rock art motifs, ships, footprints and rings/ ring figures were the most common motifs on the nine rock art panels. The four humans, the animal, sun carriage and mantle figure were also found, as well as four ring crosses. Many of the motifs were difficult to find, since many of them were almost invisible, even on the hillshade maps. The motifs that became the main focus of the analysis were ships, footprints, cupmarks and ring motifs of all kinds. Cracks are included in some parts of the analysis, and they show a close relationship to many of the motifs on the panels for this study, although this relationship might be something that should be further studied to see if the relation between these two variables can be statistically proven. The motifs on the nine panels analysed in this study are placed in between the cracks, which make it looks like the cracks are framing or dividing the motifs in groups. The only motifs that are carved on top of cracks are cupmarks.

The density of motifs was slightly different between the panels. When looking at the density of all motifs together, many of the panels show a higher density of motifs in the south eastern part of the panel. These panels are 80:1, 380:1, 447:1, 469A and 653. The panel with the highest density in the southern part of the panel was 388:1. The two panels, 54:1 and 650E had their concentration of motifs in the north eastern part of the panel. Some panels' motifs were also distributed across the middle part of the panel, and on panel 769, all the motifs were concentrated in the middle of the panel. The pattern seems to be that the motifs are mostly concentrated in the north east, south east and south.

## Ships

Ships were mostly placed in the north eastern, south eastern and southern part of the panel with a spread towards the middle of the panel. Only on one panel did ships occur in the western part of the panel, which is on panel 447:1 were the two ships occur on the north western part of the panel. The motifs which were carved closest to ship carvings were cupmarks. Ships also had a close relation to the rock's natural cracks, which is a phenomenon that has been studied in other places where the rock art motifs are placed in between cracks (Jones 2006) or has the cracks connected as a part of the rock art motif's design (Nash 2011). On panel 447:1, the ships even seem to follow the direction of the cracks from north to south. The panels natural texture like striations also seem to have influenced the direction of the ships. On the panels 80:1, 650E and 653, the ships are placed as they were "sailing" in the same direction as the striations from east to west and south east to north west. Their placement on the panel in relation to the panel's elevation seem to be that they were placed on the higher parts of the panels. According to the downslope direction of the panel, it seems like most of the ships were placed on parts of the panel which is sloping from the north east to south east. Only the ships on panel 769 are placed in a west slope.

### Footprints

Footprints show the highest concentration in the middle part of the panels, but on panel 447:1 the footprint is located in the south, while the footprint on 469A is placed in the north. The most common motifs closest to the footprints were cupmarks and ships. It also had a close relation to natural cracks, which is also something that has been studied before (Skoglund, Nimura & Bradley 2017). Striations on the panel 380:1, were most of the footprints are found, are extending from south east to north west in the middle part of the panel, were most of the footprints and rings are concentrated. As with ships, they are placed on the higher elevation of the panels. Two of the panels with footprints, 54:1 and 447:1, are placed on east sloping part of the panel and 380:1 and 469A a placed in a west slope.

### Cupmarks

Cupmarks had the widest spread across the panels. Panel 54:1 and 653 have the highest concentration of cupmarks in the middle of the panel. The three panels 80:1, 380:1 and 388:1 have the highest concentration in the southern part and panel 447:1 contain most cupmarks in the eastern part of the panel. The closest motifs were ships and footprints. Cupmarks also had a close relation to natural cracks, and some cupmarks are carved in cracks. Some of them were also placed in the cavity on panel 80:1. Since they are so scattered across the entire panel, it's difficult to find a pattern when it comes to slope and aspect.

### Ring figures and ring crosses

Ring motifs had their highest concentration in the middle, southern and northern part of the panels. The motifs that were placed closest to them were cupmarks, but also two ships, two footprints and two cracks. As with the rest of the motifs discussed above, the were placed on a higher elevation of the panel, except on panel 650E where two rings are placed a bit lower than the rest of the motifs. When it comes to the aspect of the panel, the ring motifs on panels 54:1 and 650E were placed in north eastern downslope. On panel 380:1 they are placed in a south west to west downslope.

Many motifs' placement on the panel shows a high concentration in the middle, southern, north western and south western part of the panels. Ships, cupmarks, footprints and ring motifs all show a close connection to each other and are also the most common motifs identified on the panels. The relation between the motifs and the panels' texture seems to be that the motifs are concentrated where the panel shows most of the striations and cracks. The direction of the striations also seems to correspond with the direction of some of the motifs, like ships for example. The motifs are placed on the higher terrain of the panels, and most of the motifs are placed in a down slope directed towards north east and south east except from some of the footprints on panels 380:1 and 469A, and some of the ring motifs on panel 380:1, which are placed in a downslope directed to the west.

# 7. Discussion

When comparing a certain amount of data and trying to find a definite answer that explain the relation between two or more variables, it demands a significant amount of data to be sure that a certain relationship is not just coincident. Therefore, this study, with only ten panels and many of the motifs non-identified, might not consist of enough amount of data to draw any conclusions saying that these relationships and these answers are fact and can be applied to all panels in Gamleby or Tjust. Although, what this study has shown is that these types of analysis can be done, and the observations regarding the panels for this study will still be discussed in this chapter.

All nine panels show a similar pattern when it comes to placement of motifs and the density of certain types of motifs. They all tend to be placed in the middle, and from the north eastern to south eastern part of the panels, but a couple of the panels stands out by having their density of motifs in northern and north western part of the panel. The lack of motifs on the western part of the panels, overall, is very interesting. Due to my lack of knowledge and experience with rock art, it's a little bit difficult for me to distinguish whether the ships are sailing towards northwest or southeast. But what I can see and what the different maps and images are showing is that most of the ships seem to be oriented towards northwest. If thinking about Kaul's sun cosmology (1998), which is based on the trinity between the sun, the horse and the ship, it could be that the ships on the panels are sailing towards west, which corresponds to Kaul's theory about the ships sailing through the underworld during night from east to west while transporting the sun.

Cupmarks, ships and footprints are the three most common rock art motifs in Tjust (Goldhahn et al. 2012) and the same trend can be found in Gamleby parish (Swedish National Heritage Board 2021). The majority of the figurative rock art motifs that I've been studying are ships, and it's not a coincidence considering the close connection to the sea. Tjust was, during the Bronze age a coastal landscape with bays and inlets (Goldhahn et al. 2012) and even today, even though the sea level has fallen 8 – 12 metre since then, the sea is still close enough for us to view it from the location of many of the rock art sites. This was something I discovered during the fieldwork, that many of the panels I documented are both facing and sloping down towards today's shoreline.

One interesting thing about the ships is their direction which seem to be in parallel with the old shoreline. The ships on panel 447:1, for example, is directed north to south and when looking at the old shoreline, it also stretches from north to south. On panel 650E and 653 the ships are carved horizontally and the ships' southeast-northwest direction is also corresponding to the shoreline which stretches in the same direction. The ships on panel 769 is placed horizontally on a vertical rock, which is faced towards the south west, and the motifs are placed in a west slope, also close to water west-northwest of the panel. These examples make me believe that this way to place ships on the rock is done consciously, maybe to make people see them and recognize them easily when they are approaching the panel from the sea. When you make your way from the shore to the inland areas, you will easily see the ships sailing in a horizontal line across the panels and when approaching the panel, you would only have to turn your head from side to side to see that all the ship are sailing together in the same direction.

Apart from cupmarks and ships, the third and fourth most common motifs on the panels are footprints and ring motifs (rings/ringfigures/ringcrosses). Ring motifs are interpreted to be depictions of the sun (Kaul 1998; Jensen 2002, pp. 273 – 288) and therefore it's interesting to see that rings occur on panels with ships, with the exception of panel 380:1 which didn't contained any ships but the biggest number of footprints of all panels. Despite the rings' close connection to ships in the Bronze age cosmology, only three out of ten rings were placed twenty centimetres from a ship. Panel 380:1 is the only panel without ships but with the biggest number of footprints. The lack of ships but presence of footprints could be explained by the fact that it is located more inland, compared to all the other panels which are located closer to the old shoreline, and footprints are usually placed in the inland areas (Jensen 2002, pp. 489 – 491). The fact that rings and footprints occur together on the panel, might have something to do with the cosmology as well since Skoglund (2006) means that the cosmology may change character depending on different regions and the different motif combinations (Skoglund 2006). Even though this is the only panel which lacked ship carvings, all other panels were supposed to contain ships even though I couldn't find all of them, I find it uncertain that the footprints are replacing the ships on this panel to fit in with the cosmological beliefs. In a region were many sites lack ship carvings, this theory could probably be more accurate for my case, but in this area, and Tjust overall, the ship is the most prominent figurative motif (Goldhahn et al. 2012). And if we look at the panel 612, which lacks footprints and should contain 15 ships, it is placed even more inland than panel 380:1. Interesting though is that the footprints on 380:1 is not placed in the same direction. They are directed towards northeast, south east and north west, even though they are placed in a west slope. Maybe these footprints symbolise actual people, and the fact that most of the footprints are facing the east, maybe this was a part of some sort of ritual where people had certain places to stand in relation to the sun (Skoglund, Nimura & Bradley 2017).

It becomes clear that the panels' topography and texture have played an important part when making the rock art. Just like rock art was impacted by the rock's natural texture and features like cracks and fissures in different places like Kilmartin (Jones 2006), Slagsta (Goldhahn 2005b) and Val Camonica (Nash 2011), rock art motifs on my ten panels were probably also affected by cracks and striations. Even though I haven't found motifs which includes cracks or certain rock elements in their design, the motifs are still placed close to cracks. Where several cracks are presence, the motifs are placed in between them, except from cupmarks which are carved on top of cracks. The most interesting panel is 54:1, where all figurative motifs have been carved inside two of the biggest cracks on the panel. Only cupmarks are scattered across the rest of the panel's surface. The cavities on panels 80:1 and 447:1 is also interesting when thinking about how the panel's topography may have affected the placement of the motifs. I can imagine that when it's raining and the cavities are filled with water, it will look like the ships on the panels are sailing towards these miniature lakes, which might also have been the purpose from the person or persons carving the ships. According to Gillings (2012) the landscape and specific landscape features possessed meaning to people more than being a physical resource, and these relationships can be studied if we only become aware of them

(Gillings 2012). It's possible that these cavities in the rock panel might have been symbolising lakes and also made the carving of ship motifs close to them as a way to visualise the close relationship between ships and water. Another observation I did in the field was that below panel 653, there was a puddle of water which stretched parallel to the panel. I think these natural elements of water collecting in cavities both on the panel but also beside or below them, could have affected the way people carved the motifs, since the ships on this panel are sailing in parallel with the water puddle. After a heavy rainfall, the puddle might have stretched up so high on the panel that some ship carvings were even connected with the water surface. Like they were sailing across the water surafce.

If I'm going to look at the panels and the placement of motifs from a phenomenological point of view, I would say that for the most part in the field, I experienced that I needed to move around the panel to see if I would recognize some motifs on the panels. This could off course be due to the quality of the panels and the facts that these carvings are old, worn off and have not been painted recently that I didn't see them at first and needed to investigate each panel carefully. To be able to see the motifs, I had to climb up on top of the panels 80:1 and 447:1 because the rocks were not in level with the ground. When making these maps with all the different motifs outlined, they are placed in the same direction, meaning that people during the Bronze age, probably didn't have to move around the panels to see them from their correct angle. With the smaller panels, you could probably have a good overview of all motifs from only one starting point, but on the bigger ones, especially panels 54:1 and 612 which are more than 10 metre long, you probably had to move across the panel to be able to come closer to the motifs. I experienced, when I was studying panel 54:1, that I had to walk across the panel and kneel in front of the ships to be able to see them clearly.

This study shows that using digital techniques really makes it possible to study the relationship between different aspects, like for example the relationship between the panel and the motifs, the panel and the landscape, and the motifs and the landscape. It's also possible to make the motifs more visible than they are in real life, which is also a common result with other similar studies of rock art were a digital techniques, like GIS, has been used to study the rock art panel (Jalandoni & Kottermair 2018). On many panels I wasn't able to see the motifs at all in reality, but by using the GIS and creating hillshade maps, many motifs suddenly appeared. Apart from walking across the panel while photographing, I didn't need to make physical contact with the panel which also minimises the amount of damage to the surface. As mentioned in chapter 3, projects in Tjust like the RANE project (Petersson 2009; Ring 2010; Schulze & Källström Alexandersson 2005) and the project regarding rock art in Casimirsborg in Gamleby parish (Goldhahn & Ernfridsson 2015) are important because environmental and human interaction with the panels causes damage and wear of the panel and its motifs. Off course, my lack of experience with identifying motifs plays a big part of when it comes to find the motifs in the field and on a computer screen. But I also experienced that even when using the Hillshade tool in the GIS, many motifs that I managed to find were still very blurry and hard to see, which may be because of wear and tear of the panel.

Even though the use of digital techniques were easy and created an accurate picture of the panel, this study still has problems when it comes to choices made by me as a person while working in the field and interpreting the models in a GIS, which in the end also affected the result. First of all, the panels I found in the field, doesn't have to be the entire panel, meaning that the majority of the original panel might have been hidden underneath the moss, lichen and soil. This creates a problem when trying to interpret and make some sort of assumption about where on the panel the motifs are more densely placed. Since part of the panel may be invisible it means that I don't have the complete context to make an estimation of which part of the panel that is the northern part and which part is the southern. I can only judge by what is visible on the photos and not what is hidden under the soil, which can be problematic. The other problem regarding this study is the fact that I couldn't find all the motifs registered on each panel. Since I lack the entire spatial distribution of motifs, the result will also have a different outcome, especially on the panels where many motifs are missing in my analysis. Also, the choices I made during the analysis while working in the GIS is also affecting the final result. The creation of fish nets is a really good way to study the density of, for example, motifs in each square across the panel, but the choice of size and number of columns and rows also affects the result in the end. It may also be problematic to analyse an irregular-shaped panel using a tool which creates a square-shaped net of rectangles.To summon it up, I agree with Goldhahn (2006b) who mean that no documentation technique is absolute and completely objective but always affected by personal decisions and interpretations.

# 8. Conclusion and Future research

Since studies about rock art motifs and their placement and relation to other motifs on the rock art panel is not a common theme when it comes to rock art studies, I wanted to focus on this subject for this thesis. The aim was to assess the limits and potentials of digital techniques, like photogrammetry and GIS, to study and analyse the spatial relations and placement of different rock art motifs with the purpose to see if there is a common pattern between different panels. Cosmological, spatial and phenomenological approaches were used to discuss the spatial relations between different motifs. The geographical area I was studying was Gamleby parish in Tjust in eastern Småland and for my analysis I chose ten panels from this area. My questions were:

1. How can digital techniques be used to study the placement of rock art motifs?
   - Where are the different motifs placed on the panel?
   - What relation do they have to other motifs and the panel itself?
   - What similarities and dissimilarities can be found between the panels?

2. In what way might symbology, an observer and the panel itself have influenced the placement of the motifs?

1. Using digital techniques like photogrammetry and GIS to study rock art have, during this thesis, been demonstrated to be a succeeding way to study the spatial relation between the panel and rock art motifs and between different rock art motifs. Photogrammetry is easy, time- and cost effective and makes it easy to document the panels without causing any wear or damage to the panel's surface. Different surface analysis tools in the GIS doesn't only make it possible to identify motifs that are almost invisible on the panel in real life, but it also makes it possible to study the texture and topography of the panel and the relation between the panel and the motifs.

The placement of motifs in total are mostly focused on the eastern part of the panel, from north east, south east to south. When looking at the topography of the panel, all motifs are placed on the highest part of the panels. Ships are mostly placed in the north-eastern, south-eastern, south and middle of the panels and are mostly placed in a north eastern to south eastern slope. Footprints, ring figures and ring crosses have the highest concentration in the middle, northern and southern part of the panel. Footprints are placed in east and west slope, ring figures and ring crosses are placed in a north east and southwest slope. Cupmarks were mostly placed in the middle, southern and eastern part of the panels and is the only motifs that are placed across the entire panel surface.

Ships, cupmarks, footprints and ring figures were all placed close to each other. The only motif closest to ring crosses were footprints. The biggest number of motifs close to every motif category were cupmarks, ships and footprints, where cupmarks dominates.

2. Ships and ring motifs all play an important part in the Bronze age cosmology and they are found together on the panels, even though they are not placed as close to each other as with other motifs. The direction of the ships may also be due to the beliefs that ships are transporting the sun or the dead souls through the underworld during the night, which can be depicted as ships sailing from east to west which occur on most of the nine panels in Gamleby. The footprints may symbolise living people standing in certain positions on the rock panel. Since many of the footprints found on the panels are oriented towards east, these may be due to some kind of ritual that took place and where people were positioned in relation to the sun.

The placement of the motifs may have been affected by their placement in relation to the old shoreline, which stretched far further inland then than it does today. Many of the ships have been carved as they are sailing in a direction in parallel to the shoreline and if people were moving from the shore to the inland areas, this is what they would have seen first. To see all motifs, they only would have had to move their heads from side to side to follow the ships sailing across the panels. On some panels, you probably would have had to walk closer, maybe even step inside the rock panel and kneel or climb up on top of them to see the motifs better.

Many of the panels show that the texture of the panel has had an impact on where the motifs were placed. Cracks and fissures are presence on almost every panel and motifs are explicitly placed in between them. The only motif that is placed in top of cracks are cupmarks. The striations on the panels are concentrated where the motifs are placed, meaning that they played an important part of the creation of the motifs. This is especially evident with many of the ship carvings which are oriented in the same direction as the striations and cracks. Cavities were water was collected during rainfall could have been seen as miniature lakes and was therefore affecting the placement of certain motifs, like ships.

Last but not least, what potential does this type of study has for the future? I believe that studying rock art through and with the help of digital techniques will be an important part of collecting information that can be used in the future for research of all kinds. The destruction of rock art due to human or environmental factors proves that we need to save what can be saved right now, otherwise it might be gone in a few years. There could also be of interest to document and work with rock art in this way to show it publicly, without having people going to the site but instead visiting a museum or look it up and have all the information online. This would create less pressure on the actual rock art site, if the rock art were to be experienced in other non-invasive ways.

This study has not been focusing on the surrounding landscape, although the proposed analytic approach suggests that there is a correlation between orientation of motifs and certain landscape features. This is something that could be addressed with more detailed analysis in the future. There is also the chronological factor that would be interesting to look more into, that I unfortunately didn’t have the time and possibility to do myself. But to study the placement of rock art motifs with help of GIS, and also study and compare motifs dated to different time periods during the Bronze age and see what correlations there is between different chronological groups, would also be very interesting to dig into. Studying the rock art panel from a spatial perspective and with the use of different theories and digital tools open up the possibilities to find out more about the rock art and I believe there’s so much more to discover.

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