James Dodd
With a contribution by Manuel Dueñas

New discoveries, new directions

Rock art research on Bornholm 2013 – 2014

This article presents and discusses new discoveries and insights offered by recent rock art research carried out by staff and volunteers from Bornholms Museum during 2013 and 2014. Investigations have been carried out at numerous locations across the island using a variety of strategies and techniques. Searches for new rock art panels have been undertaken at a variety of locations. Soil has been removed from the area around certain known panels in order to find new carvings and investigate the archaeological context surrounding the rocks. New figures have been discovered on surfaces already registered with carvings, through the combination of evidence from night photography and the creation of 3D models, using the Structure from Motion technique. The searches for new carvings and, where appropriate, their surrounding archaeological context will be discussed by James Dodd, whilst technical questions concerning the application and results of the Structure from Motion models will be addressed within Manuel Dueñas's contribution.

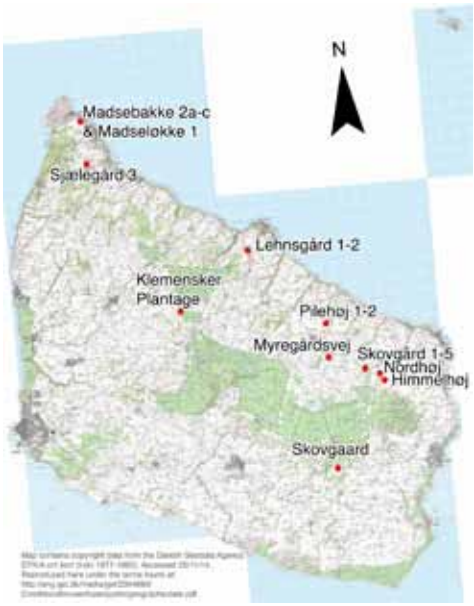


Figure 1: Map of sites mentioned in this article (all photos and illustrations J.Dodd, unless otherwise stated)

New discoveries and insights at Madsebakke and Madseløkke

One major focus of activity has been the two rock art localities of Madsebakke and Madseløkke, Allinge, North West Bornholm (Figure 1). In 2013, a protection zone was created by The Danish Agency for Culture to protect several of the known sites within these localities, as well as their surrounding archaeological context. Between Summer 2013 and Autumn 2014, a programme of fieldwork was undertaken to ascertain if any unknown rock carvings could be found upon surfaces buried beneath the ground surface or covered by vegetation. The entire protection area was surveyed and a large number of surfaces were identified and uncovered. Further uncovering also took place on rock outcrops already known to evidence carvings.

The principal focus of efforts has been upon the largest outcrop, forming the Madseløkke 1, rock art panel. Turf removal has resulted in the discovery of three ships and fifty-one cup marks (Figure 2). The style of the vessels, following the chronology proposed by Flemming Kaul (1998; Kaul 2005c), proposes Late Bronze Age dating (1100-500BC). This is informed by the out turned prows and low keel extensions of each of

Figure 2: New ships discovered in 2013 on Madseløkke 1. Additional photos can be seen in Kaul et al. 2015.

the three vessels. One of the vessels appears to be sailing down the slope of the outcrop, interestingly, in the direction of Gudhjem, one of the most important natural harbours on the North Coast of Bornholm. This orientation is different from all the other vessels, which follow the main direction of the outcrop. Another vessel exhibits out turned spiral prows, as well as a stylized animal head with two ears atop the keel extension. These two details have been hitherto unknown on Bornholm, although such details are present within several other areas of Scandinavia. Elsewhere on the panel, night photography (J. Dodd) and Structure from Motion (M. Dueñas) have been successful in defining new details of figures, documented during earlier programmes of fieldwork, that are more difficult to observe in natural light conditions.

Archaeological layers from a range of prehistoric periods have also been found adjacent to these freshly exposed carved surfaces. Deposits overlying the Western portion of Madseløkke 1 were excavated in October 2013. The uppermost layer consisted of stones and earth, principally containing evidence of field clearance in historic time, alongside a small number of out of context Prehistoric finds, including a possible hammerstone. Beneath the upper layer, a layer of stones and soil was found, containing flint and pottery. The finds came from a range of periods, including: the transition between the Stone and Bronze Age, around 2000 BC, the Late Bronze Age (albeit, one sherd), as well as the Iron Age (Figure 4; Nielsen 2014). Also, traces were found of what is believed to be a stone layer (also referred to as a stone platform or pavement) bearing a resemblance to that revealed during excavations of Madsebakke (Kaul 2005d: 136). However, this conclusion remains tentative at present, as final results from Madseløkke are still subject to more extensive analysis. Further excavation also remains to be undertaken, namely the deposits on the top of Mad-

Figure 3:
Night photography suggests new details, Madseløkke 1

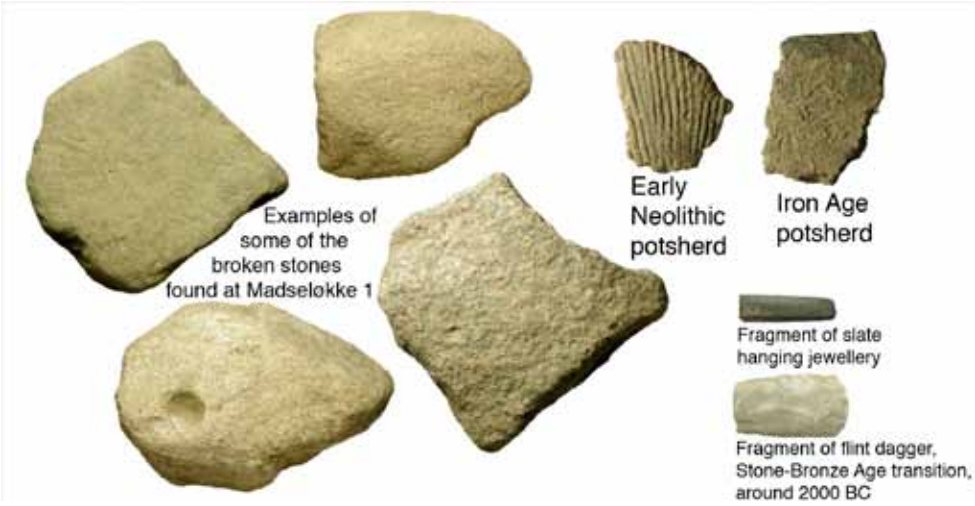


Figure 4: Finds from excavation, October 2013, Madseløkke 1 (illustrations courtesy Bornholms Musuem)

seløkke 1, which has already yielded promising signs during de-turfing in the form of pottery and flint.

In addition, two new panels were found in the Madsebakke locality, both within the area of outcropping rock around Madsebakke 2a (Figure 5). Discussions are ongoing as to whether a ship carving is evidenced upon Madsebakke 2b, in addition to the cup marks. On the Madsebakke 2a panel, night photography has been particularly effective in imaging details of a vessel, whose existence was first highlighted by Martin Stoltze.

Full circle at Sjælegård

In 1981, whilst still at school, Martin Stoltze found his first rock art site on the Sjælegård farm, located near Olsker, North Bornholm, not very far from his own home. Martin's

Figure 5: New panels, Madsebakke 2b and 2c, in the vicinity of Madsebakke 2a

Figure 6: Night photograph and frottage of the ship on the Madsebakke 2a panel

finds since that date have been considerable, but Sjælegård 1 is noteable as, at the time, it constituted the first major discovery of figurative rock art on Bornholm for decades (Nielsen 2005: 19). In light of this, it is perhaps most poignant that, in 2013, a remarkable new find of figurative rock art was made at Sjælegård. The Sjælegård 3 panel is located on a large rock outcrop. Limited areas of rock surface were already exposed, evidencing one cup mark, prior to commencement of de-turfing in 2013. Turf removal has resulted in the exposure of several areas of bedrock, many of which evidence carvings. The majority of representations are cup marks, but on the North facing slope of the outcrop, at least two certain ship carvings are found (Figure 7). Due to the weathered surface on this elevation of Sjælegård 3, it remains possible that further representations are present. However, all investigative methods applied to date propose that frottage over a large area of this surface will be necessary to confirm beyond doubt the presence and form of any additional ship carvings. Paradoxically, although the area evidencing the ship carvings is very weathered, making identification difficult, on another area of Sjælegård 3, the pecking marks made to initially outline the carving, in this case a cup mark, can be clearly seen alongside two additional cup marks that have been subject to lesser degrees of protection from the weathering process (Figure 8).

Figure 7: Two of the ships evidenced on the Sjælegård 3 panel

Application of Structure from Motion

Contributed by Manuel Dueñas

Investigative methods in the field have been strengthened through the application of 3D modelling, in the form of the Structure from Motion (SfM) technique.

Figure 8: Differing states of preservation of cup marks on Sjælegård 3

Although other contributions in this edition of Adoranten address SfM in greater depth, the application of SfM has proved a useful tool in augmenting and supporting the established field methods of: day and night photography, frottage, and finger tip examination. SfM has been selectively applied to some of the rock art on Bornholm, mainly at Madsebakke, Madseløkke, Sjælegård and Lehnsgård. Dueñas, within the contribution contained in this section, addresses this and presents some of his results:

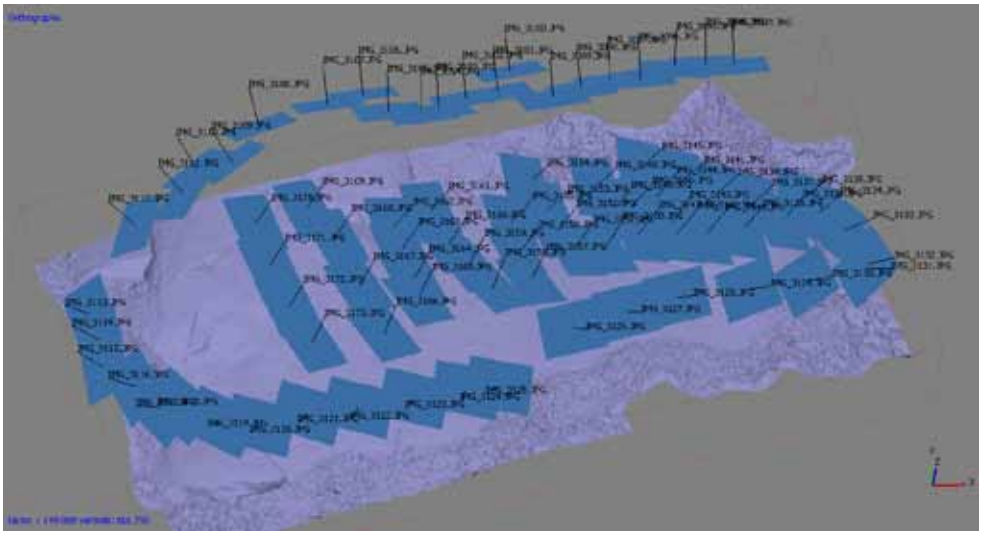
The technique for acquisition of 3D models using 2D images collected from different viewing angles operates under the same principle as the human vision system. When a person looks at a certain point, the distance to the point is perceived by comparing its apparent shape according to the image captured by both eyes and interpreted by the brain. In simple terms: a small shape means the object is far away, and a big shape means the object is nearby. Using this approach, together with the principles of perspective, lighting, and an automatic algorithm for pattern recognition, there is software capable of delivering point clouds, each of these points with X, Y and Z coordinates.

In this technique, the process and phenomenon that describes how to estimate three-dimensional structures from two-dimensional images is known as Structure from Motion (Lowe 1999). Until a few years ago, practical application was unthinkable in the amount of technical precautions that had to be taken whilst performing photogrammetric survey, such as: camera calibration, knowing the distance between the lens and the subject, checking the homogeneity of light, and the exact percentage of overlapping images that could only be viewed with stereoscopes.

These limitations began to decrease in 1999, when Dr. David Lowe patented the algorithm SIFT (Scale- Invariant feature transform), at the University of British Columbia, that has consequently made photogrammetry accessible to the wider community (ibid). This algorithm makes it possible to detect the outline of any object in a digital image and draw a number of points to provide a description of its shape. This theorem also includes a solution to detect the object within a different image.

Numerous articles from recent years show how 3D models made of photographs

Figure 9: Screenshot showing the aligned photos over the surface of Lehnsgård 1. (M. Dueñas)



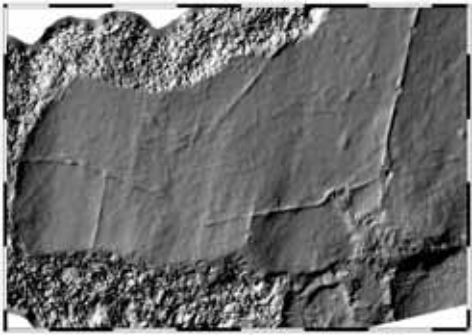


Figure 10: Image from Quantum GIS, showing the Eastern section of Lehnsgård 1 (M. Dueñas)

Figure 11a: Lehnsgård 1 (photo and painting by Kaul & Milstreu, 1999).

allow archaeologists to record all kinds of objects, buildings and contexts of interest within the discipline (Dueñas, 2014; Alkheder, 2009; De Reu, 2013). In the specific case of the recording of petroglyphs, photogrammetry focuses on the geometric detail. Therefore, the number of pictures needs to be greater to increase number of angles, thereby ensuring geometric accuracy. In this study, the goal was to obtain a 3D model that could be used to identify and record the petroglyph clearly enough to observe details of the carvings contained in the 3D model, in order to be able to classify them. During recording, 80 photos were taken, over an area of 20.46 m^2 (Figure 9). For the process of scaling, a foldable ruler divided into segments of 25 cm each was used. The high quality alignment generated a disperse cloud with 165 713 points. The interpolated concentrated dense cloud of 5 970 065 points generated a polygon mesh with 1 199 888 vertices and 601 750 faces.

With the model shown in Figure 9, we can analyse the data in two ways. As a digital elevation model, we can export a TIIFF format image, that can be imported into any GIS to generate digital terrain models, also called hillshades, that allow us to project a simulated light source from any direction (Figure 10). In addition, we can generate graphical information using MeshLab software, by importing a 3D model in OBJ or PLY format and changing the direction of light projected onto the model (Figure 11b).

Figure 11b: Screenshot from MeshLab, showing the complete panel, Lehnsgård 1 (M. Dueñas)

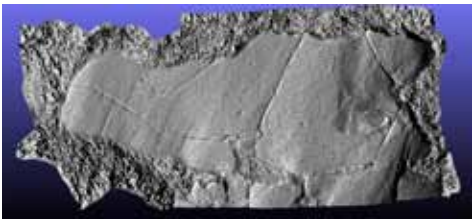
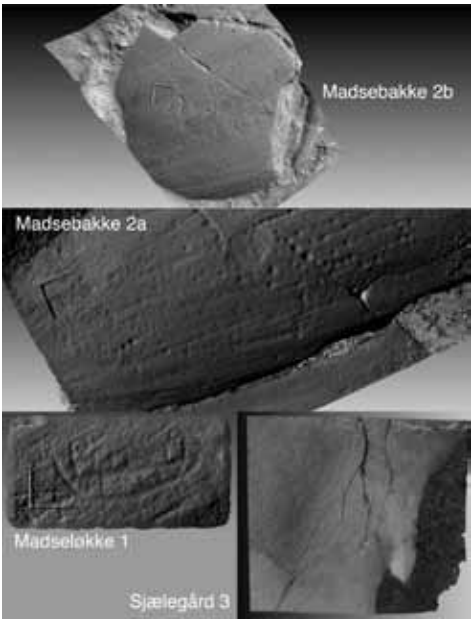


Figure 12: Four screenshots from MeshLab of various panels, where the light source has been optimized in order to highlight the motifs (M. Dueñas)



In addition to Madseløkke 1, we analysed 13 additional panels with rock carvings, however for publication purposes, only 4 screenshots are presented (Figure 12). These assisted in the task of finding and recording this type of archaeological monument.

Cup marks in Eastern Bornholm

Another major focus of rock art research on Bornholm in 2013 and 2014 has been in North East Bornholm. During 2013, a group of volunteers documented four recently discovered cup mark localities at Skovgård, Østermarie. An additional site, reported by antiquarian J. A. Jørgensen during the 19th Century, but never seen since, was relocated and also documented. In 2014, a large-scale systematic search for unknown rock carving sites, covering a large swathe of Eastern Bornholm, was initiated. These ongoing searches have been instigated by the museum, on its own initiative, in response to undecided proposals for an atomic waste storage facility within a defined area. The politics of this is not the subject of this article and the museum only possesses information in the public domain. The key objective of the Museum's project is to inspect, if possible, every rock surface within the proposed area. Opportunities to search and document rock art in the vicinity outside of the main area are also being undertaken, as they present themselves.

Figure 13: Cup marks on Myregårdsvej (photo and painting: J. Dodd and D. Kofod)

Documentation following the ten new discoveries made during 2014 has provided some interesting insights concerning the placement of carvings - on two scales: the landscape, and the rock surface itself. On Myregårdsvej, Østermarie, a cup mark site was investigated and documented, following a report made by the owners to Bornholms Museum. Artificial lighting resulted in the identification of additional cup marks (Figure 13). Two groups appear to have been placed in areas of the rock surface where water flows from small water basins that fill following significant rainfall. In another area of the panel (Figure 14), within a prominent vein of feldspar running through the rock, an uneven natural depression on the surface appears to have been enhanced by carving, in the form of pecking and smoothing, to produce a large cup mark. A few centimetres away, it appears that work has been begun, using the same process, to create a half cup mark. Further discussion of relationships between carvings and features

Figure 14: Alteration of natural features of the rock surface to produce carvings (photo: J. Dodd and D. Kofod)

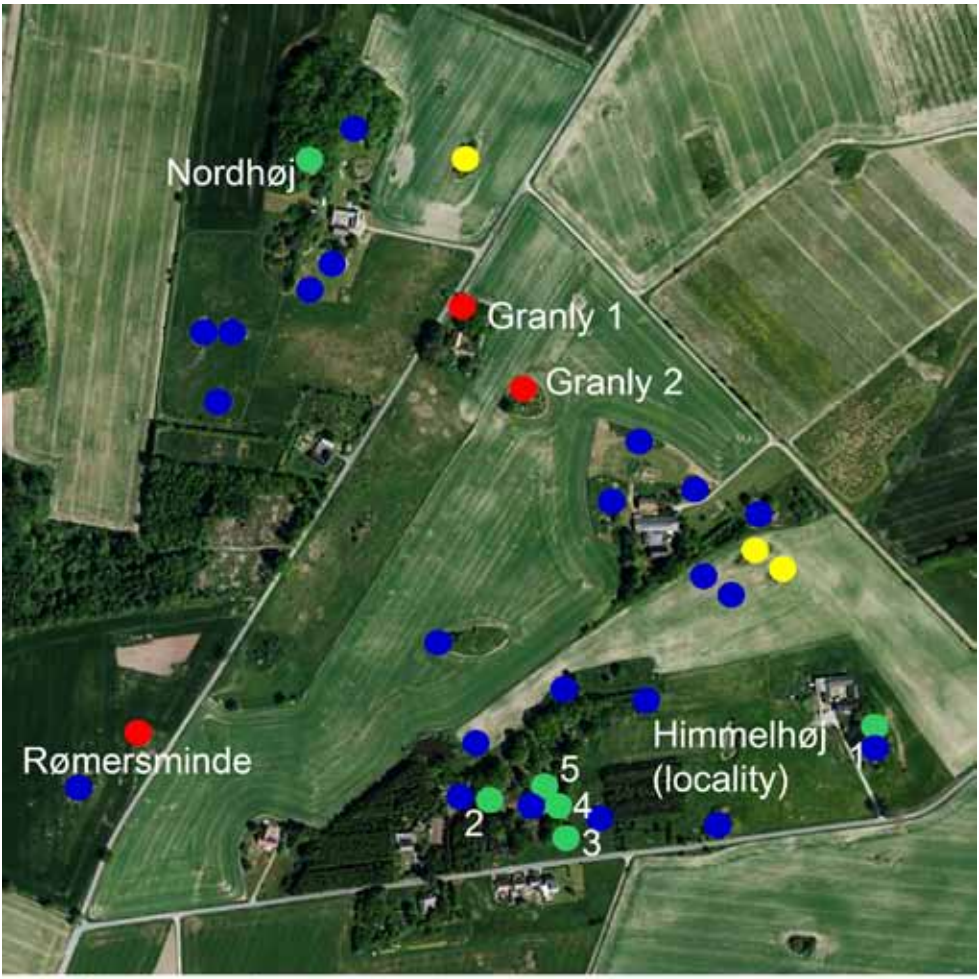


Figure 15: Rock art around Himmelhøj and Nordhøj

of the rock surface lie beyond the scope of this article, but the relationships identified at this site appear less frequent within the context of cup marks on Bornholm.

The large-scale systematic strategy of the investigations upon every rock and outcrop within the search area offers a rare opportunity to examine the placement of carvings in the landscape. Within this context, the new findings within the area bordered by the farms of Hoppegård, Nordhøj and Himmelhøj, near Ibsker, contribute significantly to our understanding of the relationships

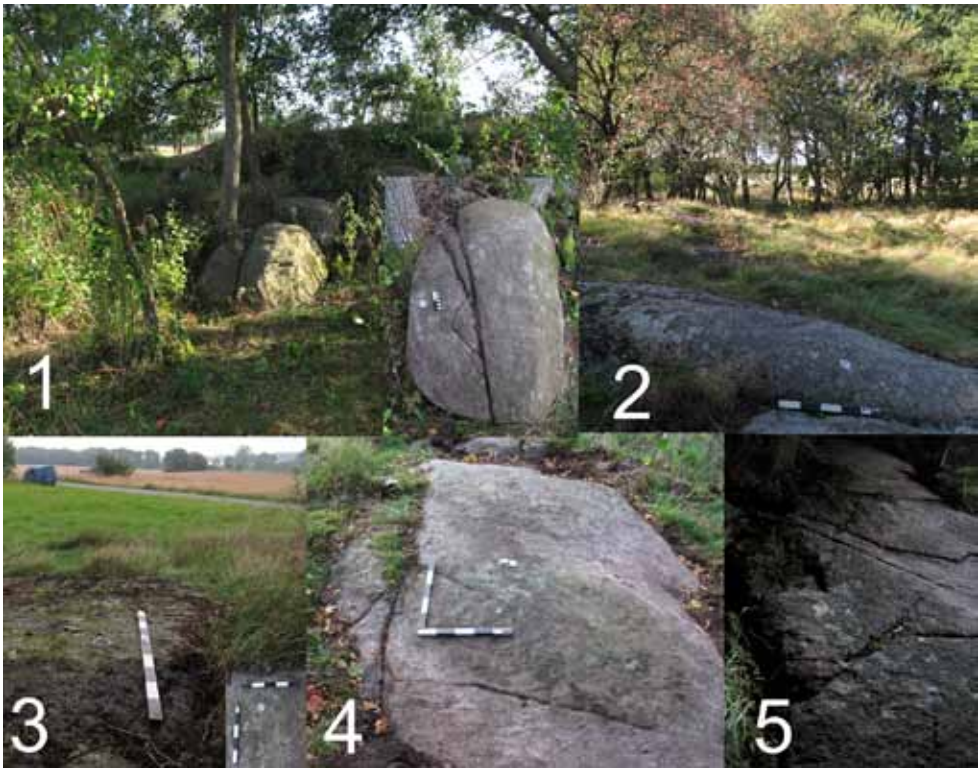


Figure 16: Himmelhøj, panels 1-5

between cup marks and landscape on Bornholm. The map, Figure 15, shows results of the investigations to date.

Although the discoveries have been mainly single or small groups of cup marks, the overall view of their location in the landscape presents an interesting picture. Not all outcrops suitable for carving have been subject to attention. It is clear from the landscape location, as well as the placement of the figures on the panels, that there has been a selection of surfaces. The highest points within the landscape have not been chosen in all instances, particularly at Himmelhøj. Moreover, the slopes a little way down from the summit appear to be, to an extent, favoured. It can be noted that the cup marks at Himmelhøj and Nordhøj are particularly visible in mid-afternoon sunlight during Summer and Autumn.

Elsewhere at Himmelhøj, other carvings appear to have been placed singly along the boundary of an area of outcropping rock and, what is today, lush grass that could have been a cultivated area during Prehistory. Consequently, it would appear that the panels at Himmelhøj are marking or delineating an area, perhaps indicating ownership, boundaries or distinctions, such as between the infield and outfield. Evidence from the records of the Danish Agency for Culture show that at the top of Himmelhøj, upslope of the Himmelhøj 2-5 panels, evidence of cremation burials and fire pits from the Pre-Roman Iron Age were found between 1870 and 1881. It is unclear whether the rock art is contemporary or pre-dates the PRIA activity.

In other areas of East Bornholm, further discoveries have come to light. At

Figure 17: Cup marks on the vertical face of an outcrop at Skovgaard

Skovgaard, near Bodilsker, an interesting instance, believed to be very rare, or even unique within the context of Bornholm, has been found in the form of two cup marks placed on a vertical, as opposed the more usual flat or gently sloping skyward face of an outcrop (Figure 17). These came to light following forest clearance. Elsewhere, two new cup mark sites have been recorded on an area of outcropping rock, North of Østermarie (Figure 18). Systematic investigations of the outcrops, which form a local high point in the landscape, are likely to produce further results in future.

Closing remarks

Discoveries on Bornholm from the last two years have made significant contributions to our understanding of the content and extent of rock art on the island. The results of investigations offer significant insights into form, chronology, landscape location as well as the archaeological context surrounding panels. Future investigations across the island will add to this picture over the coming years.

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Acknowledgements

The investigations discussed in this article would not have been possible without the generosity of others. Although there is not space to list everybody, I wish to extend thanks to Bornholms Musuem, all the volunteers, and all the landowners who kindly permitted access for the investigations. I also thank Gerhard Milstreu for introducing me to the island, and his unfaltering generosity.

Figure 18: New cup mark sites discovered North of Østermarie

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