

THE CURRENT STATUS OF RESEARCH INTO DANISH ROCK ART

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SUMMARY

Previous national and European projects have raised awareness, generated increased interest in Danish rock art and, not least, improved the volume and quality of documentation and recording. Since projects such as RANE (Rock Art in Northern Europe) and 'Ships on Stone', activities have continued, but on a smaller scale. However, the past few years mark an upturn in the fortunes of Danish rock art in terms of funding and the level of interest. The current and future potential to apply technology within the discipline is a key driving force behind this change. However, access and ownership of data are serious challenges if the opportunities on offer are to be realized and we are to live up to national and EU requirements concerning open access and FAIR data. This presentation will present an overview of the current situation with reference to examples drawn from the author's current work, as well as look ahead to some developments on the horizon.

RIASSUNTO

Alcuni recenti progetti nazionali ed europei hanno non solo migliorato la conoscenza e generato un maggiore interesse per l'arte rupestre danese ma hanno anche spinto verso un significativo aumento sia quantitativo che qualitativo della documentazione e della catalogazione dei dati raccolti. Dopo progetti come RANE (Rock Art in Northern Europe) e "Ships on Stone" le attività sono continuate, anche se su scala minore. Tuttavia gli ultimi anni hanno segnato una svolta per l'arte rupestre danese, che ha visto crescere i finanziamenti e l'interesse generale del pubblico. Le potenzialità presenti e future legate all'applicazione delle nuove tecnologie nell'ambito delle ricerche sull'arte rupestre rappresentano uno degli elementi chiave alla base di questo cambiamento. Ma tutto questo ha reso evidente che l'accesso e la proprietà dei dati rappresentano una fra le maggiori sfide per portare effettivamente a realizzazione queste potenzialità e allo stesso tempo mantenere il rispetto dei requisiti richiesti dai singoli stati e dall'Unione Europea nei confronti dell'open access e dei FAIR data. Il presente articolo intende esporre una panoramica sulla situazione attuale prendendo spunto dall'attuale ricerca dell'autore, per poi analizzare brevemente alcune delle prospettive che si pongono per l'immediato futuro

A LONG TRADITION

Interest and involvement from Denmark in the Valcamonica Symposiums go back a long way. At the very first symposium, in 1968, Danish born artist, Fred Gudnitz, director of the Tanum Museum of Rock Art, Underslöss, Sweden, attended as a delegate, alongside a number of Swedish and Norwegian colleagues. The connections between the Scandinavian nations continue to shape the agenda of international collaboration in the present. Perhaps one of the most well-known figures, P.V. Glob, author of what remains the most comprehensive survey of Danish rock art produced in print to date (GLOB 1969), was also a regular participant in the symposia. More recently, major EU projects between various regions of Scandinavia and Valcamonica have worked together on shared problems, such as documentation, access to archives, management and public dis-

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Rock carvings by context

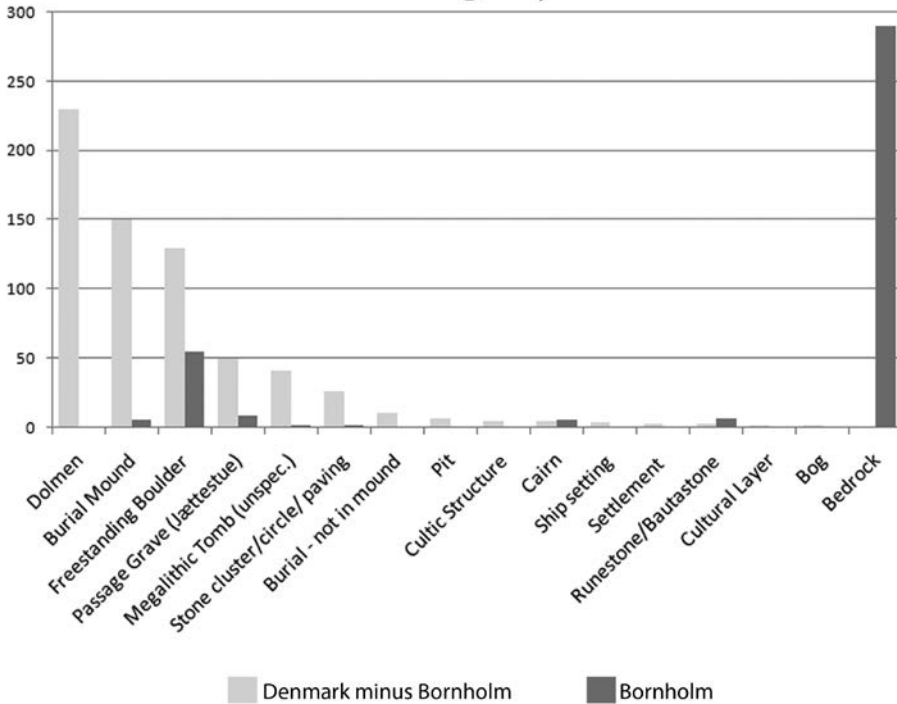


Fig. 1 - Danish rock carving contexts for localities registered in 2009 within the national sites and monuments register published in 2010. Totals for Bornholm and other parts of Denmark are given separately. From Felding 2018, Figure 2.

semination. The outcomes of this work have been reported in the proceedings of previous symposia, as well as a host of other publications.

The aim of this article is to bring the story up of rock art in Denmark to speed, for the period since the last overview was presented to an audience in Valcamonica (MILSTREU 2009; MILSTREU 2004b) between 2006 and 2020. After a few introductory words about the rock art found in Denmark, and its chronology, we begin by taking a recap of the story so far, then look at the present situation, and finish by briefly looking ahead to give an impression of the possible future directions the discipline may take. This overview is exactly that, for the detail the reader is referred to the references, but it should be noted that these are limited to those which are in the public domain. The few exceptions made to this rule are to works by the author.

ROCK ART IN DENMARK – A VERY BRIEF INTRODUCTION

Rock art in Denmark consists of rock carvings made on stones, boulders, glacial erratics, and on the island of Bornholm in the Western Baltic, on bedrock. In Denmark, bedrock is only present at the surface on the islands of Bornholm and Møn, although the latter consists of chalk, upon which no carvings have been



Fig. 2 - Stone with rock carvings prominently incorporated in the fabric of a church wall, Kirke Sâby, Lejre, Zealand (ID 020607-45). Photo and 3D model (processed on Amazon AWS/Agisoft Cloud unless otherwise stated) J. Dodd, Aarhus University, 2020.

found to date. Rock art is unevenly distributed throughout the landscape (Figure 1), which can be partly, but not entirely explained by the geology. With the exception of Bornholm and Møn, mentioned previously, the country is, broadly speaking, divided into two geological zones, consisting of Eastern Jutland and the Danish islands (Jutland is the peninsular of land extending North of the land border with Germany), and Western and Southern Jutland. In Eastern Jutland and the Danish islands, clay soils of glacial till and moraine, deposited by ice sheets during the Ice Ages, are dominant. In Western and Southern Jutland, glacial outwash, consisting of sands of gravels, laid down by meltwaters from the ice sheets predominate. The consequence of this situation is that there are fewer stones and boulders of a suitable size for the making of rock carvings in Western and Southern Denmark. As one moves further East, the situation is quite the opposite.

Differences in the distribution are also, like any archaeological remains, subject to various biases in preservation. Agricultural practices from more recent times, are another major factor when considering the location of Danish rock art. Efforts to progressively improve the land, particularly during the 19th and 20th Centuries have destroyed many archaeological monuments in Denmark, with it being estimated that around three quarters thirds of the burial mounds, dating to all



Fig. 3 - A small stone with cup-marks poking out from the foundations of Langå Church, Eastern Jutland (ID 130707-69). Photo J. Dodd, Aarhus University, 2019.

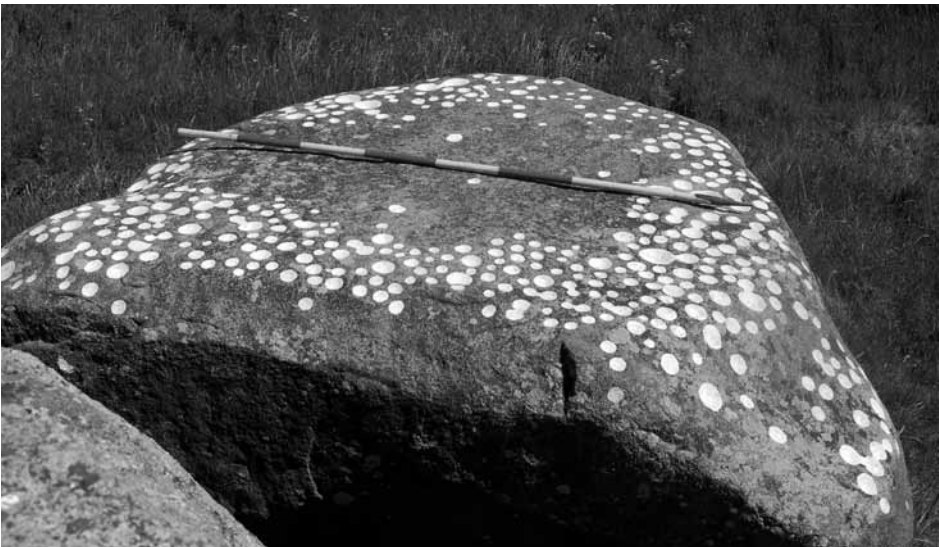


Fig. 4 - Cup-marks on the cap stone of an Early Neolithic dolmen, Sømarke, Møn. Denmark, ca. 3500-3200 BC. Photo of painted illustration: Milstreu & Prøhl.

prehistoric periods, recorded during surveys made by antiquarians during the late 1800s have been destroyed (BAUDOU 1985; JENSEN 2002, pp. 144-146). However, the removal and destruction of stones with rock art began long before the start of the 19th Century (NIELSEN 2005), not only for the purposes of field clearance, but also other reasons, some of which are still unclear. A number of stones, were removed and incorporated into the fabric of churches, sometimes in a very prominent (Figure 2), or symbolically significant positions, for example: female entrances to Churches (MILSTREU, DODD 2018, pp. 23-24) suggesting this was with intent. At other times, stones with rock art incorporated within the fabric of churches are of a more concealed nature (Figure 3). The consequence of all these factors is that many of the stones and boulders with rock carvings which have been found in Jutland, and on the islands of Fyn and Zealand, are from a secondary context.

Rock carvings can also be found in their original context within preserved parts of the prehistoric landscape (Figure 1). These range from obvious contexts, such as burial monuments, like the cap-stones of Neolithic dolmens (Figure 4) or the kerb stones of Bronze Age burial mounds (Figure 5), to erratic boulders nested amongst prehistoric field systems (Figure 6). To what extent there is, or is not, a connection between the rock art and the surrounding archaeological remains is not clear cut, as in many cases, it would seem the glacier, rather than human agency, have determined the locations of the sites (Figure 6). However, discussion of this subject must be postponed for another time.

The rock art of Denmark belongs to what is categorized as Southern Tradition rock art. This label is the name given by SOGNNES (2001, p. 19) to the tradition of visual representation found across rock art and other media amongst the agrarian societies of Scandinavia. It is understood to have a long chronology, believed to discontinuously extend from some point during the Middle Neolithic, to become a firm part of the archaeological landscape of the Nordic Bronze Age (1700-500 BC) and the Pre-Roman Iron Age (500 BC- 0AD). As is the case with Southern Tradition rock art in general, most of the known rock carvings in Denmark are comprised of cup-marks. Figurative art, is considerably rarer within Southern Tradition rock art, with the most recent survey across Denmark, Norway and Sweden suggesting, approximately, only 20% of Southern Tradition rock art consists of figurative motifs, whilst around 80% consist of cup-marks (NIMURA 2015).

The dating of the carvings was, until recently, believed to be primarily confined to the Bronze and Pre-Roman Iron Age. However, an increasing number of finds from across Denmark have confirmed what was postulated by earlier scholars, such as Glob (1969, pp. 109-129, p. 298), that the creation of rock carvings in Denmark began at some time during the Neolithic.

The earliest currently confirmed dates come from two cup-marked stones which have been found at Vasagård, on the island of Bornholm, which suggest a terminus post quem toward the end of the Funnel Beaker Culture, of the Middle Neolithic period, at the end of the 3rd Millennium BC (*Bornholms Museum: Beretning for 2016*, p. 21-23; *Bornholms Museum: Beretning for 2017*, p. 21-22; IVERSEN 2018; IVERSEN et al. in prep.) These remarkable discoveries, from secure contexts are found in association with the fills of the ditches of a causewayed enclosure, and a palisade enclosure, respectively (IVERSEN 2018; IVERSEN et al. in prep.). It is

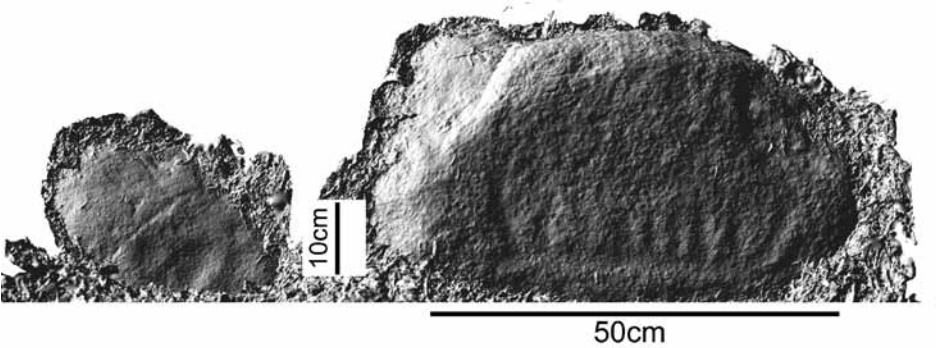


Fig. 5 - Ship and cup-marks on kerb stones of a Late Bronze Age burial mound at Vindblæs, Jutland (ID 140410-110), ca. 1400-1300 BC. Photo of painted illustration Kaul & Milstreu 2001, source: SHFA. Inset: 3D model, J. Dodd, Aarhus University, 2017, processed on the DelC HPC, Abacus 2.0.

also important to remark, albeit all too briefly, that the cup-marked stones are also somehow part of a wider tradition of prehistoric visual expression found on small stones (NIELSEN et al. 2014), ceramics and rock art from the late 3rd Millennium stretching across Denmark, Sweden, Northern Germany, Southern England and Northern Italy (KAUL et al. 2016). The findings on the island of Bornholm are the result of a number of collaborations between, in alphabetical order, Aarhus University, Bornholms Museum, University of Copenhagen, The National Museum of Denmark, University of Warsaw, with the support of a range of State and independent grant giving bodies. These important findings are still in the process of full publication. Therefore, readers must content themselves with the references provided and wait patiently.

In any case, it would seem that the still emerging evidence from Bornholm is part of a much larger and complex picture. A recent survey of findings amongst existing publications concerning the findings of cup-marks in Neolithic contexts

by Iversen (2019), makes for interesting reading, highlighting examples associated with funerary monuments, dolmens from the Later Early Neolithic, and stone cist graves from the Early Late Neolithic, whilst also discussing why the creation of rock carvings appears to have ceased at certain periods of time. The dolmens, upon which a large number of the cup-marks are found, predate the terminus post quem dates obtained from Vasagård by around 500 years. Another study by SØRENSEN (2018), into the so-called ‘pocket-sized’ cup-marked stones suggest that cup-marks may also be attested in the Late Neolithic, although whether these occurrences have more of a functional purpose could be discussed. In any case, the nett contribution of all these studies into round, bowl shaped depressions in Neolithic contexts has extended to the chronology of Southern Tradition rock art into earlier periods. This conclusion that cup-marks have a long chronology is perhaps not so remarkable to our European colleagues (HORN 2015, pp. 29-31; IVERSEN 2019), but marks a change in the prevailing paradigm within Scandinavia, although efforts have already been made to change this at the latter end of the chronology (LØDØEN 2015; GOLDBAHN 2018; 2019).



Fig. 6 - Randkløveskov Vest 2 (ID 060406-222). Erratic located in fossilized field system. Terraces of lynchets extend upslope in the distance. Photo of painted illustration J. Dodd, Aarhus University, in co-operation with Bornholm Museum, 2017.



Fig. 7 - The author (right) working with volunteers from Allinge-Sandvig Civic Society at Madseløkke, 2014. In 2013, the outcrop was the subject of an excavation by Bornholms Museum, a brief account of which is given in Dodd and Dueñas García 2014. Photo: Finn Ole Nielsen, Bornholms Museum.

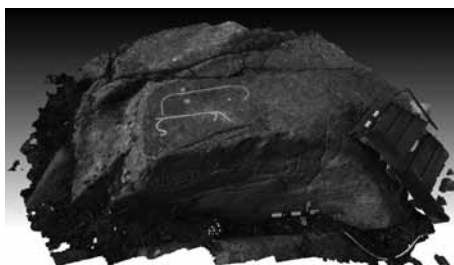


Fig. 8 - Screenshot of 3D Model, Storløkkebakken 7, Olsker, North Bornholm (ID 060105-309). Illustration from Dodd & Milstreu 2019.

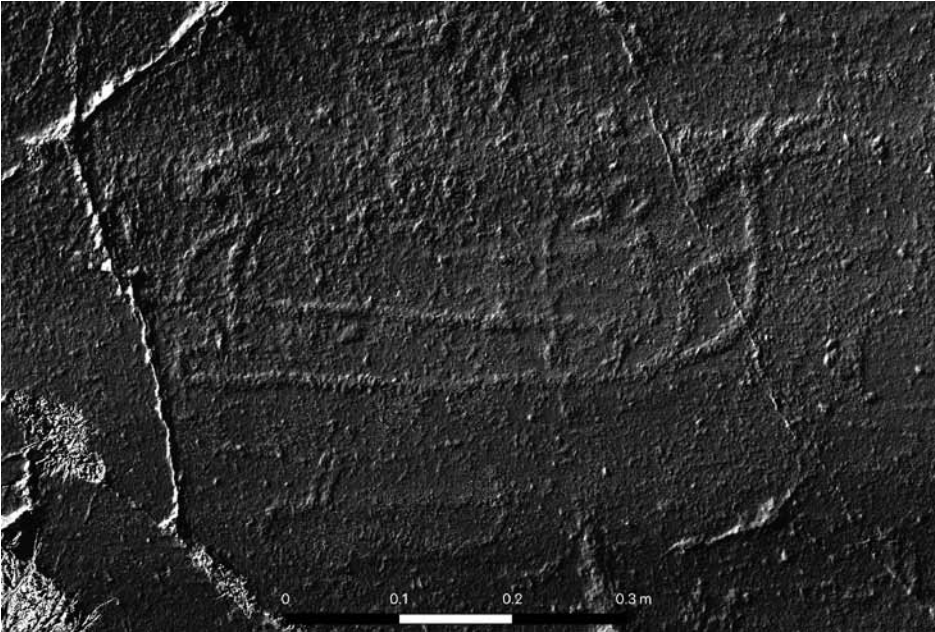


Fig. 9 - *Knægten 2, Olsker, North Bornholm (ID 060105-189)*. Hillshade of DEM of model processed on Amazon AWS/Agisoft Cloud. 3D model J. Dodd, Aarhus University in co-operation with Bornholms Museum, 2018.

THE STORY SO FAR

Rock art research has a long tradition in Denmark. An overview of the early research history, at least as is understood on the basis of current evidence, is presented in Glob 1969. However, in general terms, rock art research, within what is the present-day Denmark, began in the early 19th Century (GLOB 1969, p. 9). As alluded to in the previous section, much of the rock art in Denmark known to date is found on the island of Bornholm. Whether this reflects the situation within Prehistory is unclear and should probably be discussed and interrogated more thoroughly, although the lack of a time machine to go back and verify any theoretical model means that it will never be possible to provide a definitive answer. Besides the geological differences, which have imposed at least some practical constraints on the distribution, one could argue that the longer history of rock art research on Bornholm, detailed thoroughly and concisely in two publications by Nielsen (2005; 2018), might mean that Bornholm has been searched more intensively than other areas of Denmark might have been. In this regard it is interesting that GLOB (1969, p. 11) remarks that some of the clusters evident in the distribution map, for example of the island of Als, Southern Denmark, are the direct result of systematic searches made in the area. Glob's (1911-1985) study marked a high point in Danish rock art studies, both in terms of the amount of interest it generated, as well as the volume of research conducted. The scale of the importance of the work can be judged by the fact it still remains one of the key sources on Danish rock art. Following the publication of Glob's magnum opus, Danish

rock art research seems to have quietened down, although this does not mean to say nothing happened.

Carvings continued to be discovered and registered variously by the local museums, who act on behalf of the State as appointed competent authorities, as well as within the national sites and monuments registry. Discoveries, of course, continued, of which one of the most notable was the discovery of a number of stone slabs with carvings of arms and hands at Sandagergård, on the island of Zealand. The slabs were found in association with what is believed to be a cult building from the Late Bronze Age (KAUL 1987; KAUL 1998, pp. 42-43).

Whilst the author is uncertain of to what extent the following statement holds true for Denmark generally, on Bornholm, the flag of rock art research was also kept flying by interested members of the public without a formal training in archaeology, in particular Martin Stoltze and Mogens Jensen (NIELSEN 2005, pp. 19-23). These two figures have contributed much to the sum of knowledge about the sites and figures on Bornholm through their searches for and the discovery of new sites. Systematic field surveys for rock art are seldom undertaken, if at all, as the necessary time and finance have never been made available. Therefore, a very large proportion of the current knowledge about the distribution of rock art on Bornholm, comes from the discoveries made by Stoltze and Jensen. The information which has come into the museum archives as a result is, of course, vital. In return, for archiving information and material in the archives, Bornholms Museum, have given help and assistance from employed archaeologists as well as facilitated access to archives, including information held nationally in the national sites and monuments registers, which were not made public until 2002, and were not available online until July 2010¹.

The period 1994-2006 marked an upturn for the fortunes of rock art research in Denmark, in so far as Denmark became more integrated within major projects investigating rock art recording, management and conservation. The projects and initiatives implemented on a national and international scale contributed to a wider recognition of the information value of the pictures, placing the images, as source material, on an equal footing with objects and texts in order to gain a deeper insight into pre-historic times, particularly the Bronze Age (MILSTREU 2004a). This said, one could argue in hindsight that the beginnings of this position have much earlier roots, in the early 1970's (MILSTREU 2013), amongst Scandinavian scholars who saw that if the use, function and interpretation of rock carvings was to be fully understood, full account had to be taken of the relations between the rock art and the surrounding archaeological context. One of these voices was the prominent Swedish archaeologist, Carl-Axel Moberg, who once remarked that "the less rock art research is solely concerned with rock carvings, the better"² (author's free translation, MOBERG 1970, p. 230).

Important steps were made in this direction onward from 2001, with the commencement of the project at The National Museum of Denmark 'Ships on Stone', led by Flemming Kaul, of The National Museum, and Gerhard Milstreu, Tanum Museum of Rock Art and Research Centre, Underslös. On Bornholm, the project

1 <https://www.kulturarv.dk/fundogfortidsminder/Information/Databasen>

2 Original text: "Hallristningsforskning blir battre ju mindre den ar enbart hallristnings- forskning ..."

was carried in close collaboration with Bornholms Museum, within whose jurisdiction falls the greatest known concentration of rock art in Denmark. 'Ships on Stone' followed up on the 'Ships on Bronzes' project, which catalogued and analysed the images on metalwork found in Denmark from the Nordic Bronze Age, (KAUL 1998), As is well known from Kaul's influential study, similar motifs are represented across a variety of media during the Nordic Bronze Age, including metalwork, perishable materials, and rock art. As MILSTREU (2013, p. 1) writes, "it rapidly became clear that the broader picture of Danish ship motifs would only be complete if the ships on stone were included in the material."

'Ships on Stone' continues to the present day, and aims to document all representations of ships, and other figurative rock carvings found in Denmark. Due to the inherent nature of archaeology, new discoveries continue to be made, so the work can never be truly said to be finished. However, the results stand alone as of themselves, as a living and evolving dataset, in the form of documentation, reports and publications disseminated on an ongoing basis. The documentation itself, consisting of scanned and mounted sheets frottage, images and many reports, are made available to researchers via a specially dedicated Danish section of the digital archive solution Swedish Rock Art Research Archives (SHFA), www.shfa.se, which was itself first established 2008. Further images and all reports are held in the open archives of The National Museum of Denmark, and can be consulted in person by arrangement. The National Museum also has an online digital collection (<https://natmus.dk/digitale-samlinger/>) and the author understands that museum's policy is to make all possible parts of its archives, including the material from 'Ships on Stone' available online. We will return to the issue of digital collections and access in the final section.

For now, let us backtrack slightly: between 2001 and 2005, 'Ships on Stone' formed part of the Danish involvement within the international 'Rock Art in Northern Europe' (RANE) project, the Danish section being led by Gerhard Milstreu. The budget (> €3 million) and scope of the project (5 countries: Denmark, Finland, Norway, Sweden and Russia) marks RANE out as one of the largest investments made in Danish rock art research to date. RANE was part financed by the European Union Inter Regional Programme (Interreg) 2000-2006 for the Baltic Sea Region (MILSTREU, KAUL 2013; KEEP.EU 2021).

Within Denmark, RANE carried out a large programme of rock art documentation, as part of the 'Ships on Stone' project, described previously. On Bornholm, RANE has left an important legacy in the form of much of the visitor infrastructure, both physically, at the sites themselves, as well as the information produced for public dissemination, including: a guidebook with maps and directions to those sites opened to the public (MILSTREU, STRØBY 2006); and what has become the most comprehensive book produced to date on the rock art of Bornholm 'Helleristninger: Billeder fra Bornholms Bronzealder' (KAUL et al. 2005). A revised, updated English edition is at an advanced stage of preparation (DODD et al. in prep), which will hopefully introduce the rock art of the area to new audiences outside of Scandinavia. RANE also led to the employment of Mogens Jensen, one of the independent researchers responsible for finding much of the known rock art on Bornholm, as an assistant at Bornholms Museum between 2001 and 2011. Part

of Jensen's position was allocated to the documentation and registration of the large numbers of cup-mark sites. During this work to follow up on the information already held in the archives, it became rapidly clear to Bornholms Museum that a complete documentation of all known cup-mark sites within the timescale of the RANE project period was impossible with the time and resources at hand. This was largely due to the large number of new discoveries also being made, which raised the total number of reported sites on Bornholm to 600 (the author's own research suggests the total number has been subject to over reporting and the actual figure may be around 400). Even at the time of writing, the new discoveries continue, clearly indicating that a large number of rock carvings remain undiscovered on Bornholm.

However, perhaps the most important legacy of RANE was the emphasis on the archaeological contexts surrounding rock art sites, whose environs have, for the most part, never been investigated. RANE proved to be the kick start for a number of investigations of the archaeological context of rock art sites, all on the island of Bornholm (KAUL 2005; 2006a; 2006b), which is renowned for the richness and high density of its archaeological heritage, in relation to the rest of Denmark. Thanks to a major grant from the Danish National Humanities Research Council³, which the author understands Søren H. Andersen played a prominent role in securing (pers. comm., NIELSEN 2021), it was possible to continue and expand the initial investigations funded by RANE. The results of investigations at one of Denmark's largest, and perhaps most well-known rock art site, Madsebakke, in North Bornholm, were particularly informative, revealing a long period of activity, beginning in the Early Neolithic, resuming in the Late Bronze Age, and continuing into the Early Iron Age (KAUL 2005p. 137). The evidence from the Late Bronze Age is believed to be contemporary with the rock art, and consisted of a series of posts, separating the rock from the surrounding landscape. A large number of cooking pits scattered over the site are also believed to be contemporary with the carvings, and are thought to indicate ritual activity, which will be reported on in within a chapter by Kaul and Østergård Sørensen in Dodd et al. (in prep).

THE STORY NOW

We will begin by looking at the years immediately after RANE, before considering the developments over more recent years, before wrapping up with a discussion about the possible future directions rock art research in Denmark may take.

In the years immediately following the end of RANE, rock art research in Denmark has continued, albeit at a reduced scale perhaps in comparison with pre-2006 levels. However, this is not to imply that activity fell into the doldrums. As can perhaps already be judged, rock art research in Denmark is driven by a relatively small, but very dedicated and highly motivated band of individuals, made up of both independent researchers/archaeology enthusiasts and professionals. Until the last few years, many initiatives have consisted of small scale, local projects, such as 'Give Your Past A Future', on Møn and South Sjælland, as well as a host of projects on Bornholm documenting and presenting rock art to the public, which are summarized in the annual reports released by the museum and avail-

3 Now known as Independent Research Fund Denmark

able online. Such projects are often run in conjunction by groups of volunteers (Figure 7), often working alongside local museums, and supported by grant giving bodies, including The Queen Margrete II Archaeological Fund (no less than three awards!) and A.P.Møller & Hustru Chastine Mc-Kinney Møllers Fund.

One of the significant achievements of the various initiatives during this period was the successful attainment of a protection order covering a large area around Denmark's most well-known rock art panel, Madsebakke, thereby hopefully securing the area in perpetuity. The order, which came into force in 2011, was the culmination of many years of work by Bornholms Museum, The Danish Society for Nature Conservation and Allinge-Sandvig Civic Society (*Bornholms Museum – beretning for 2009*), involving protracted appeals from both the authorities and the owners subject to compulsory purchase orders⁴. The order protects the area and immediate surroundings of the many known rocks at Madsebakke and Madseløkke, including any remaining archaeological evidence lying undiscovered in the ground. The protection order obtained in 2011 was the first of several attempts to preserve the rock and their surroundings, the first having been made by antiquarian J.A. Jørgensen in 1894 (NIELSEN 2005, p. 14) shortly after the discovery of Madsebakke by quarrymen.

The 'Ships on Stone' project has continued, throughout Denmark, and the results of fieldwork, are integrated within a Danish section of Swedish Rock Art Research Archives, which went live in January 2013. The collection visible online includes all photos and frottage up to and including 2012, and researchers can expect that further additions will be made to this material covering more recent years.

Discoveries, have continued, as before, with carved rocks of varying sizes and descriptions appearing regularly every few years: sometimes in ones and two, others time in clutches, depending on the nature of the find circumstances. On Bornholm, the finds included several outcrops in North Bornholm with concentrations of figurative art of various sizes (KAUL 2013). The author will not report on each and every discovery here, but wishes to draw attention to two findings which are, arguably, particularly significant.

In 2017 and 2020, on an outcrop where cup-marks had been reported at several locations, two rock surfaces were discovered with large numbers of carvings (mainly ships) on separate faces of a large rock outcrop, on the hill of Hammersholm, North Bornholm, now understood to be the richest outcrop in Denmark, in terms of the total number of figurative representations (THORSEN 2020a; KULTURSTYRELSEN 2020; JENSEN 2020, pp. 167-174). The 2017 and 2020 discoveries were made by Michael Thorsen, an archaeologist from Bornholms Museum. Apart from the initial stages of the clearance the area around one surface in 2017 by volunteers, investigations were conducted by Thorsen and aided by his family, in their own time, as finance from Bornholms Museum was not available (THORSEN 2020a, p. 3). Fortunately, a grant from the 15 June Foundation has funded the completion of the investigations which were in progress on Hammersholm, as well as fostered the beginnings of new ones (THORSEN 2020a; ØSTERGAARD MØLLER, THORSEN 2020). The investigations of other outcrops and stones in the area have already resulted

4 *Natur og Miljøklagenævnets afgørelse af 8. september 2011 i sagen om fredning af bronzealderlandskabet ved Madsebakke i Bornholms Regionskommune (sag nr. NMK-520-00008) (Afgørelser - Reg. nr.: 08090.00)..*

in more finds (ØSTERGAARD MØLLER , THORSEN 2020). Given the potential already indicated, we should expect these discoveries to continue in the immediate area.

The second remarkable discovery in recent years occurred in autumn 2019, in the grounds of a private garden, when Gerhard Milstreu, whilst working in collaboration with this author at a site the latter had discovered in 2018, observed three ships on the vertical faces of two separate outcrops. Whilst carvings of cup-marks are rare but not unknown on vertical surfaces on Bornholm (DODD , DUEÑAS GARCÍA 2014, p. 10; JENSEN 2020, p. 190), and figurative Southern Tradition art can be found on vertical surfaces many places elsewhere in Scandinavia (MILSTREU , PRØHL 2020, pp. 191-195, 200-202), this discovery was the first example presented to the scientific community of figurative art on a vertical surface from Bornholm (DODD , MILSTREU 2019). As stated in the referenced publication, this finding is significant for two reasons: it indicates the existence of a possible bias in the search and recovery strategy on Bornholm, 130 years after figurative rock art was first recognized on Bornholm, and clearly attests the existence of complex relationships between the topography and the figures (Figure 8).

Elsewhere in Denmark, finds of cup-marks and figurative art have also continued (SVENSTRUP , DAHL 2012), with one stone with complex cross-in-circle designs found on the Mols Peninsula, Eastern Jutland, being declared treasure trove (KAUL 2017). In 2019, a carving of a hand with five fingers was recognized by an archaeology enthusiast on a stone block already known to evidence a large number of cup-marks, located in the town of Ejby, Zealand, by an independent researcher (JUUL BRUUN 2019). Previously, carvings of an extended arm with hand and fingers appear to have been associated with specific contexts from the Late Bronze Age, including graves (GLOB 1969, pp. 85-90) and on portable stone slabs included within special buildings with a ritual or religious significance (KAUL 1998, pp. 42-43).

Finding new localities and documenting them is not the sole focus rock art research in Denmark. One of the most encouraging trends is the increase in academic interest. Perhaps as a consequence of the outreach activities by the aforementioned motivated and engaged individuals, more and more students are studying prehistoric art, including Danish rock carvings. The Scandinavian Society for Prehistoric Art's annual seminar on rock art research and documentation, held in Tanum, Sweden, has for many years been the training ground for several generations of Danish rock art researchers. Recently, many of these students have gone on to make detailed studies of rock art as part of their education (FELDING 2009; RABITZ 2012; KOFOD 2018; VAN DE MERWE 2019), and continue to be involved as professional archaeologists at the local museums and universities. This can only bode well for the future, especially from the perspective of the management of rock art.

Of the recent studies, two works warrant further discussion. In 2009, Louise Felding conducted the first survey of Danish rock art since Glob (FELDING 2009), albeit limited to the material registered in the national sites and monuments record, and therefore not able to take into account the localities which do not yet appear in the register, the number of which are considerable on Bornholm. However, as we have discussed previously with respect to RANE, this would have been impractical to undertake. Felding's study, conducted as part of a Masters

dissertation, focused on describing and analysing various aspects of the context of Danish rock carvings (Figure 1). Felding also highlights differences in the visibility of rock art on stones, boulders and blocks with those found in burial contexts, including both megalithic graves and burial mounds, the latter occupying more prominent positions (*ibid*, p. 7). Following the delivery of her Master dissertation, Felding has produced a host of publications on the subject of Danish rock art, both on the subjects of the dissertation, as well as material which was not included in the Master thesis (FELDING 2010; 2015; 2015b; 2018).

Another important work is the Master's dissertation of Mette Rabitz (2012), which was the first rock art dissertation to focus on the subject of 3D recording of rock art. Rabitz gave an overview of the status of 3D recording within rock art research as understood at the time, with reference to experiments outside of Denmark, within Sweden, Norway and the UK. Rabitz also conducting her own investigations in Western Sweden using stereophotogrammetry using PhotoModeller software. In this author's opinion, the main contribution of Rabitz's study was its influence on colleagues, with the author aware that the work reached the desks of several colleagues in Denmark, as well as across Scandinavia. The work remains frequently cited at the time of writing within Scandinavian circles, but those who do so should also read Rabitz's work in conjunction with more recent descriptions of the research history and evaluations of recording methods and techniques, which, at the time of writing include: BERTILSSON (2018), two publications co-authored by this author with Meijer (MEIJER, DODD 2018; 2020) as well as the contents of MILSTREU, PRØHL (2020) generally.

Rock art recording is a process subject to continual evaluation, refinement and development (MILSTREU 2008, p. 21), especially with the pace of development of modern technology. The development and more widespread availability of dedicated graphic processing units and optimized application programming interfaces within computing over the last twenty or so years has meant that image-based 3D modelling has become both an accessible and practical proposition for disciplines such as archaeology. Following the lead of a pilot study published by GOLDBAHN, SEVARA (2011), multiple view structure from motion (SfM) has risen to become the dominant 3D recording method currently in use at the time of writing. The exact workings of the technique will not be described here: a full description with technical details and references can be found in MEIJER, DODD (2020).

In 2012, the first steps were taken that would lead to a pilot study concerning the application of image based modelling and triangulation laser scanning in Tanum, Sweden (BERTILSSON et al. 2015, p. 1; BERTILSSON 2018, p. 278). In 2013, Bornholms Museum instigated their own evaluations of the use of employing SfM as a recording method for excavations and the recording of rock art, through their collaboration with Nicolas Caretta: an archaeologist from the Autonomous University of San Luis Potosí, Mexico, with connections to the island and experience of 3D recording in Mesoamerica (*Bornholms Museum: Beretning for 2014*, p. 17; DODD, DUEÑAS GARCÍA 2014, pp. 117-120). As a consequence of their positive experiences during this exercise, Bornholms Museum, like many other museums in Denmark at that time, began to use the method as part of museum recording protocols. This, of course, included rock art (MILSTREU, DODD 2018, Figure 18),

where it was also possible to learn from and improve field methodologies with reference to knowledge of the ongoing investigations in Tanum going on at the same time. A major turning point in Bornholms Museum strategy, which has led to the commencement of a programme of surface-based documentation on the island, occurred in 2015, when Michael Thorsen (an archaeologist at Bornholms Museum) spotted during evening sunlight a ship carving on part of the well-known Madsebakke panel in 2015, which had been hiding in plain sight for decades (GLOB 1969, p. 39). The 3D model confirmed this observation, led to the discovery of another ship carving on a nearby surface and indicated a number of other anomalies which Thorsen contends are ship carvings (*Bornholms Museum: Beretning for 2016*; THORSEN 2020a; 2020b).

The value and potential of 3D recording of rock art has been known for a long time, within Scandinavia at least since the 1970's (MEIJER, DODD 2020, p. 64). Beyond the fact that rock carvings are by definition three dimensional, this underlying desire can be seen as the culmination of the general preference of the scientific community for surface-based documentation, where the stages of recording and interpretation are demarcated from one another (MEIJER, DODD 2018).

Image based 3D modelling facilitates the creation of detailed, quantifiable, records of depth variations present on the surface. Whilst other surface-based methods: paper rubbing and photography under oblique lighting continue to remain relevant and useful, the digital technologies offer the possibility to extend the deployment of surface-based methods to more rock art panels than has previously been the case: in theory, to all known rock art sites. The recording of quantifiable data on depth variations opens up a currently expanding range of possibilities for visualization, registration, analysis, management and preservation.

As already apparent during the RANE project, documenting the hundreds of sites on Bornholm was a desirable, but challenging task. A significant advancement has been made towards improving the situation through the completion of a large scale programme of 3D surface based documentation undertaken as part of the author's PhD project at, and entirely financed by, Aarhus University. The project is largest investment in Danish rock art since RANE. As part of the project, over 247 rock surfaces have been recorded on the island of Bornholm alone, out of the believed, but uncertain, total of between 400 and 600 known sites. The discrepancy in the number of known sites is due to overreporting, which has been the consequence of researchers mistaking natural features of the rock surface for carvings (DODD 2016; 2017; 2019b; 2020). The issue is by no means confined to Bornholm, but would appear to be expected, judging by the findings of ongoing investigations further afield (Rock Art Database - Scotland's Rock Art 2017-2022). Processing of the models gathered during fieldwork on Bornholm, as well as other locations in Denmark, Sweden and Norway, in levels of hitherto unmatched levels of detail and speed from the field itself, has been possible thanks to access to high performance computing resources (Figures 5, 8 and 9), including The Danish e-Infrastructure Collaboration's (DeIC) supercomputer Abacus 2.0, using software licences for Agisoft Metashape, provided by funding from the Dean of the Faculty of Arts, Aarhus University. How this operates in practice has been described elsewhere and will not be repeated in detail here (STOTT et al. 2018; DODD 2019a).

With access to remote processing on high performance computing (HPC) clusters now available to all licenced holders of Agisoft Metashape Professional, (50 machine hours on the Amazon HPC cluster per month, with additional hours available for purchase), it is worth reflecting on why this development offers such a range of possibilities. Considerable computing power is necessary to process models derived from the structure from motion method with the necessary levels of detail >1mm (0.2-0.5mm can be considered preferable within rock art). Most of the personal computers used by researchers that can be taken into the field today lack the necessary hardware requirements. HPC clusters offer economies of scale, with the investment of hardware only necessary at some central point, and need not be assembled and maintained solely for the benefit of one particular group. Advancements in mobile internet, such as 5G and internet via satellite will be able to provide a much higher standard of internet access worldwide, making it even more sensible to conduct processing on external rather than local hardware. The reduction of processing from days or hours to a matter of minutes, or some fraction of the time the task would otherwise take, as well as the possibility to use the same, or other, hardware to visualize the large file created, via a web-based solution removes these, as well as other, limitations which have previously constrained the application and use of 3D modelling. It is now possible to: make full use of all the information contained within the images, by processing at original resolution, display the large models created without the system crashing, and to have the results available to hand in the field, rather than having to wait until the post-processing stage. All these factors transform the use of image based 3D modelling from that of an end product to a tool actively used to aid investigations in the field. In this way, 3D modelling has become more fully integrated in the process of what has been termed the 'dialogue with the surface' (KOFOD 2018; MILSTREU 2020). The technology also opens up other possibilities, including the ability to follow up on any anomalies identified, or add more photos to the model.

FUTURE DIRECTIONS

The creation of all this digital data from all these projects: past, present and future, will all the new opportunities it brings, has raised new dilemmas - and not just those associated with archiving generally, in so far as ensuring that the material can continue to be read as computer systems change and evolve. Whilst the problems are not solely confined to rock art research, it is nonetheless essential that the discipline addresses these challenges.

As Kristian Kristiansen recently remarked: the past 10-15 years have led to a wide range of initiatives establishment of an enormous body digital infrastructure in the form of a number of large, specialized archives, which have safeguarded information for future generations - which was indeed the aim of projects such as SHFA. These databases have created a shared methodological platform forming the basis of a new starting point for working together in teaching and research across disciplines (KRISTIANSEN 2019, paraphrased based on author's notes).

One way to further this aim in practice, is through the integration of existing datasets, and to make them freely accessible for researchers according to the FAIR data principles (Findable, Accessible, Interoperable, and Re-usable). Information

about cultural heritage in Denmark belongs to the State and should be freely and publicly available, subject to the limitations of data protection. This is stated in the Danish Museums Act 2014 (*LBK nr 358 af 08/04/2014*, Kap. 1, §2), which broadly supports relevant articles of the 1992 Valetta Treaty of the Council of Europe, as well as the State supported current policy for Open Access and Open Science within research.

Within Danish archaeology, generally, positive steps are being taken in this direction, through involvement with initiatives such as the Nordic European Open Science Cloud (EOSC), which is part of the EU Horizon 2020 programme (ANDRESEN , WINTHER 2019). At present the focus is on integrating the major national databases on a national and international level within the Nordic countries, through data harvesting.

Project leader of the archaeological component of Nordic EOSC, Jens Andersen, Aarhus University, in a press release on the Danish e-Infrastructure Collaboration's website, summarizes the present situation: "If I as a researcher wish to find, for example, settlements with preserved structure from the Bronze Age, I have to go around and ask each and every museum whether they have material on the subject. I have to go into the archives at each and every place and rummage through the drawers. The challenge is even greater if I wish to search in other countries" (ANDRESEN , SØRENSEN 2019: author's translation). Such a situation can hardly be described as optimal.

A small sample of the future to come can already be browsed on two platforms at the time of writing. The first is B2FIND⁵ (WINTHER 2020) a collaboration between University of Oslo, Aarhus University and Deutsche Klimarechenzentrum (DKZ), Hamburg, which allows the user to search content from the elements of the sites and monuments register in the public domain. The second is MeLOAR⁶ (Mediastream Library Open Access Repository), a collaboration between the Royal Danish Library, Moesgaard Museum and Aarhus University, which provides access to a large collection of reports and documentation, available in the public domain, from the report archives for archaeological excavations, deposited by the local museums at The Danish Agency for Culture and Palaces.

The sharing of data is dependent on all parties being in agreement as to the conditions and extent of access. The various interest groups each have their own arguments and valid points which need to be addressed. Space constraints prevent full discussion of the issues, but this challenge must be resolved if Danish archaeology is to move forward in the long term. Rock art research is no exception, and has an added curved ball, as much data lies in private archives, which are not obligated to give any information, besides those to allow the local museums to meet the minimum registration requirements as stated in the law. Of course, one hopes that this, in some cases very important, information is also integrated. This topic also has its own unique legal, logistical and ethical challenges, particularly for those who want to remain the hosts of their data.

Even if the above obstacles can be overcome, some specific challenges have to be overcome in terms of working with the 3D data, the volumes of which are

5 <http://b2find.eudat.eu/dataset?groups=slks>

6 <https://labs.statsbiblioteket.dk/meloar/fof/#/>

particularly prodigious for the recording of rock carvings, due to the need for precision on a large scale. Not only does the model have to be hosted and accessible over the web, and/or available for download: researchers also require more tools to visualize the 3D models and record their observations.

With regard to visualisation, the author is currently working with Peter Trier, a world leader in the field of ray tracing within graphics processing, at the Alexandra Institute, Aarhus, concerning the application of this new and developing graphics processing technology to the study of rock art. An article, presenting the first results of this work, is at an advanced stage of preparation, so will not be discussed here.

In terms of recording our observations, software frameworks are being developed to record observations in 3D space, including spot locations, cross sections, viewpoints and other settings which can be saved, exported and imported to an online interface (EKENGREN *et al.* 2020). Another study, has developed an automatic classifier employing deep learning using convolutional neural networks, to identify possible carvings and categorize them according to the major image types (HORN *et al.* 2021).

This way of recording observations and analysing data is becoming a more pervasive trend within current research, which will probably increase and intensify as the digital world around us changes the way we organize information: away from an alphabetical based system, towards one structured according to content and context (STREET 2020). This process may change the kinds of documents we create and how we use them. One could see the author's forthcoming PhD dissertation (DODD *in prep.* 2021) as something not unconnected to this trend. Theoretically and methodologically speaking, it is firmly rooted in the research history of semiology and linguistics, but, at the same time, it also explores some of the new territory lying before us. The reader will note that its contents are not previewed here in this overview of recent rock art research in Denmark. It is another story, for another time, which time itself will be the judge of.

To be continued...

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