SCOTLAND'S
ROCK ART
PROJECT

Research Workshops outcomes

The Scotland's Rock Art Project (ScRAP) ran two research workshops in November 2019 focusing on specific themes relevant to the project's objectives, methods and outcomes. The workshop themes were as follows:

Workshop 1. Research approaches to rock art

- Session 1: Theoretical approaches to rock art research
- Session 2: Digital approaches to rock art research

Workshop 2. Social value and community engagement

- Session 1: Social value
- Session 2: Community engagement

The aim of the workshops was to provoke wide-ranging and stimulating discourse around each of the specified themes. Each workshop involved around 35 invited academics, practioners and community team participants whose research interests intersect with and augment those of the project.

The workshops were informal and discussion based. Both comprised two sessions, each structured around a keynote talk, followed by provocative questions posed by three or four early career researchers or more established academics, and discussions around the issues presented by each provocateur.

The discussions were audio-recorded and synthesised into a readable format that captures the texture of the dialogue, organised under headings that reflect the key issues discussed.

This document focuses on Research Workshop 1.

The Scotland's Rock Art Project (2017-2021) is funded by the Arts and Humanities Research Council, and hosted by Historic Environment Scotland in collaboration with Edinburgh University and Glasgow School of Art. For more information about the project please see our website: www.rockart.scot.

Research Workshop 1: Research Approaches to Rock Art

Friday 22 November 2019, Edinburgh University

Session 1. Theoretical approaches to rock art research

The first session of this research workshop dealt with theoretical approaches to rock art research, introduced by a keynote address by **Antonia Thomas** (University of the Highlands and Islands). This talk considered the current pre-eminence of visual engagements in rock art and, using examples drawn from sites in Orkney, examined non-visual aspects of architecturally-situated Neolithic art. It went on to explore how creative engagement with this material can aid understanding of the process as well as the form of prehistoric carvings, reflecting not only on architecturally-situated carvings but also landscape-based rock art in prehistoric Scotland.

The session was attended by approximately 35 participants.

First discussion

The first discussion took place in reaction to the following provocations:

- **Andrew Cochrane** (Royal Horticultural Society): 'Creativity in rock art: from matters of fact to matters of concern', which examined the intersection of rock art theory, interpretation and engagement, in a post-truth world.
- **Aaron Watson** (Durham University): 'Structure from (e)motion', which considered the relationship between archaeological methods and interpretation, and in particular the implications of the use of photogrammetry, and more creative and subjective approaches to capturing an embodied experience.

Discussion overview

The discussion took the form of a wide-ranging consideration of the significance of truth and fact in archaeology, the role of artistic interpretations, the creative use of the uncertainty inevitable in archaeological research, and the ways in which these issues can be conveyed to the public. The session debated the nature of truth, its inherent subjectivity, and the different ways in which it can be approached. A strong narrative strand in the debate was that archaeology can only produce facts, and interpretations based on those facts, which must be differentiated from any philosophical search for 'truth'.

Uncertainty in rock art was seen to offer the possibility for discourse and wider engagement strategies, an opportunity to focus on the behaviours that created the art rather than the meaning of the marks themselves, a force for destabilising established 'sticky' hypotheses, and enabling, when presenting archaeology to the public, a more profound conceptualisation of the strangeness of the past, and the difficulties surrounding its understanding. The importance of integrity in the interpretation of archaeological evidence, in whatever form, was acknowledged, whilst still allowing creative discussions to take place, and the necessity of examining bias was emphasised, whilst acknowledging the importance of the expert view in public discourse.

The following specific points were made:

Does truth matter, and if so how do we get to it?

- What is the 'truth' in the context being discussed? This could be seen in many different ways and the nature of the approach – for example, through archaeology, mathematics, science – will influence the answer.
- Truth is situated, constructed in the moment, personal, and depends on a social group and its belief systems. People do not generally go against the established norm. In archaeology, it is important that people can have confidence in interpretations, and in the narratives professionals create and share which can be used as points of provocation to encourage people to think in different ways.
- There is truth in an individual's experience of the world at a given time, but there is a separation between this and the existentialist question of 'is this rock art in front of us'? There is also the 'truth' of interpretation, and what are we trying to do as archaeologists. Art has the freedom and the luxury to express feelings, but does that create an archaeological interpretation? Artists do not need to use facts in their work or to create rational interpretations, and archaeologists do not need to use art – but there is a useful dialogue and debate between them.
- There is a danger that the cultural relativism debate is a distraction and brings us no closer to understanding basic questions, such as when and why was this made and how did it relate to the broader society at the time?
- Fact and dialogue are tangled together. Multi-vocality means we are actually in different contexts talking about different things and in different ways, and do not have to agree on a single truth of narrative. Entangled conversations are useful, but we need to be sensitive to integrity. Must be aware of the lies we tell – if we are, then that will potentially resolve the 'truth' issue.
- How do we get to the truth? There is only an indirect link between the present and the past. Taking a structuralist approach we can reason about underlying truths, and that is essentially what we do in archaeology. In the 1970s, a school of people, such as Bradley, used a structuralist approach to look patterns, etc. to examine meaning. From analysis of structure, it is not necessarily possible to reach an absolute answer, but the range of possibilities can be narrowed down. If we think of truth and facts as equivalent, and which we are trying to examine via fragments of incomplete biased samples, excluding what is not the case, will bring us closer to those meanings. The structure will exclude some possibilities, and a series of possible outcomes will remain.
- As technology advances, this may give access to information which allows the truth to be established. The truth is attainable, but that is a structuralist approach, and is only one method. Art is another approach. However, context and chronology are still essential.
- Without going back in a time machine, it is not possible to know the past truth, but it is not futile to search. As archaeologists, we are not trying to find absolute truths, and that would be neither possible nor desirable. Facts can be obtained through the process of excavation and recording but, in archaeology, is there such as thing as truth or truths? Perhaps there is only context.
- Archaeology is concerned with facts. Truth is a philosophical and not a scientific concept and no scientific fieldwork attempts to reach the 'truth': rather the aim is to find evidence around which questions can be posed, and a model arrived at which best explains what has been found. In archaeology, there is a higher level of uncertainty, which means that our

models will not be as close to the 'truth' as we would want. The focus should be on the evidence, and improvement in models over time.

- It is important to engage with what is valid, on the basis of evidence, and to provide tools to consider different types of ideas. However, the audience is very important: in communicating with students the focus is on thinking about evidence and arguments, but working with indigenous peoples the interest is in the past as the ancestral force in their lives. These traditional stories are not establish through evidence but are meaningful to those people. There are many ambiguities, but in terms of a political and academic perspective, paying attention to evidence and argument is the important thing – but not the word 'truth'.
- Truth does matter, but it is inherently personal. What is more interesting is consensus, and the 'stickiness' of ideas. In rock art and other Neolithic and Bronze Age archaeology themes are re-presented over time regardless of new developments in data, such as invasion scenarios reappearing in different periods, indicating that change is only considered through mass migration. The challenge in rock art is to destabilise interpretations and think more creatively, but that might include unpalatable truths about the 'truths' that are sticky for archaeologists.
- Does our work resonate, empower or revitalise, or capture the imagination of others who want to have that conversation about truths with us? There is a 'truth' that different forms of cultural expression took place through mark-making on rock across the Atlantic seaboard over a time-span, with different forms of practice, and potentially different reasons for it. Is the mark-marking we currently carry out ourselves – what we permit and what we don't, on walls and other surfaces, digitally and in analogue terms – the dialogue about our own modes of practice which reveals truths that may transcend the times we are moving between.

Can we make a virtue out of uncertainty?

- One theme which has emerged from ScRAP examination of social value is the attraction of the ambiguity and unknowability of the rock art. There is the truth of materiality, and the practice of engaging in recording – which as professionals we can analyse – but the meaning remains essentially unknowable. In this space the authorised heritage discourse is not to the fore, and thus anyone can be involved with their own ideas and creativity.
- Is it a counsel of despair to say rock art is unknowable, and would that negate the important work of Bradley on patterning, orientation, and so on?
- Insofar as there are facts, one of them is that the past is unknowable. This is not to negate the deep learning and scholarship of those examining it, but it is the process we are engaged in that is enriching. Rock art, in particular, offers an avenue for everyone to engage in it.
- The only truth is that we will never really know what rock art means. This ambiguity gives us the liberty to consider it in all the different ways we are today. We need not so much to tackle the meaning, but to examine the behaviours behind it and what that tells us about its role in the societies that made it; we will never understand the symbols.
- Most rock art, such as that being dealt with by ScRAP, is without context other than in limited cases involving excavation. We normally do not have any other material to examine alongside the rock art.
- Just as designs on Orkney rock art were augmented and added to, what is happening today is just the latest iteration in biography of particularly piece of rock art, and that can tell us something about ourselves today, rather than the creators of the rock art. Looking at the

uncertainty issue, the focus on 'a' truth closes down the space for discussing diversity and we should reflect on that in our own archaeological practice.

- We can make a virtue out of uncertainty, out of the unexpected, working with the general public, to creates 'stickiness', by leaving gaps in the narrative, people's imaginations can be capture.
- Museum interpretation can include in its interpretation strategy approaches to rock art which can make useful points about the world. There is no opposition between creativity and destabilising objectivity, and what is objective. They are not alternatives, but layered on top of each other. Rock art can be used to help visitors to see that not everyone in the world is like them, that the past can be different and strange, that the interpretation of rock art is not immutable and that it might be worth questioning the elitism of top-down authorities, archaeological and others. It is important not to destabilise views to the extent that the past becomes unknowable, but there is a middle ground, and we can give visitors a sense that it is permissible for people to have different views and different perspectives.
- Probably the only truth is that we are in a constant state of flux. This should be embraced, as it does not contradict the role of archaeologists, and telling evidence-based, informative, useful stories about the past, and engaging people in the present. Carvings changed through time, but diversity of opinion would also have existed in the past just as now. So, by embracing these different perspectives, it can be highlighted that even within one day in one community in the Neolithic, those carvings would have had multiple meanings and contexts as well.
- Perhaps the role of archaeologist should be about producing facts, and allow others to look at interpretation. To get a more complete picture, many different perspectives are needed.
- One of the values of archaeology is to continue to tell us that we are not the peak of achievement and that people in the past were also at the cutting-edge of technology. Archaeology gives us an idea of how people lived in the past, and how they lived, making us question ourselves. Archaeologists gather facts, so that they can be examined now, and when more facts are available, examined again.

Can we help people understand the differences between fake, fact, alt-fact, post-fact, factish myths, and so on?

- There seems to be a suggested contrast between facts and truth in this debate. If we are trying to resist post-truth ideology, then coming back to this distinction seems to be bringing us back to post-truth. Is there a difference between fact and truth?
- We are not necessarily living in a post-truth (or post-fact, as these seem to be used interchangeably in popular cultural) era, but it is portrayed as such. Should the focus be on the truth – or rather from working from facts to put together a narrative, which may not necessarily be the truth – and what does any move into anti-realism do to the terms of the debate?
- If there is any integrity in artistic representations of archaeology, it is because they are constrained by evidence, so nothing is portrayed which the evidence is in denial of (although they do not have to be fully confirmed by the evidence). This creates space to manoeuvre within the framework created by archaeological research and knowledge.
- Consensus is important and as a community we need hypotheses that there can be some consensus about.
- Considering the issue of fact, alt-fact, etc. seems to be about challenging things. People providing information should give the full context and their reasons for it. And also ask, what are alternative ways of creating this? Could it be fake? Recording rock art, we need to

be asking more questions. For example, would sound carry from here? Can you see these other panels from here?

- We study archaeology to find out what happened in the past. We should also be able to discuss important questions about how we sift through information. We owe it to those we are addressing, and who fund us, to be explicit, including about the biases in our background. This is for the benefit for those who come after us.
- There is always a bias, and the pretence of scientism is highly problematic to these debates. Some of the points raised about being able to interrogate evidence, in contrast to 'fake news', also show the difficulties of the times we live in. What are our roles? Maybe it is just as we are doing here, to take time out to have this dialogue, and learn, and connect, and mobilise around issues of concern which affect all of us.
- Even with the best understanding of evidence, there are always multiple interpretations. It is problematic if single interpretations are presented as the dominant consensus. We are denying our own engagement with that evidence, which is in a constant state of flux because of new evidence, and new interpretations. Some ideas become 'sticky' – sometimes simply because they are fashionable – and then they disappear again.
- In my research experience with the public in landscape archaeology, people wanted the expert voice which can convey a situational, nuanced and biased interpretation of the landscape. This is more important than the opportunity to participate in excavation, recording or survey.

Second discussion

The second discussion took place in reaction to the following provocations:

- **Gregory Currie** (York University): 'Symbols, artefacts and the idea of an aesthetic explanation', on the marginalisation of aesthetic approaches to culture, and views about what constitutes an aesthetic explanation.
- **Seren Griffiths** (University of Central Lancashire): 'Moving beyond visual aesthetics', which examined approaches to integrating rock art in wider impressions of British and Irish prehistoric societies

Discussion overview

The discussion focussed largely on the developing role of artificial intelligence (AI) in rock art and archaeology: the current use of machine learning, its potential, and its possible drawbacks. The question was raised of whether the use of Big Data, even where possible in an archaeological context, is always the most appropriate approach. It was also noted that Big Data does not operate independently of archaeological theory, which therefore needs to be examined in the context of the development of digital-led research, along with other archaeological practices that emerged in the 20th century which may not be appropriate to newer and developing methodologies.

The potential contribution of notions of the aesthetic to archaeological research was considered, encompassing the difference between art and aesthetic, how the concept of the aesthetic can be used to examine behaviour in the past, and the ways in which modern ideas of the aesthetic affect archaeology.

The following specific points were made:

Big Data, artificial intelligence and interpretation

- With modern technology, it is possible to see things that would not have been visible in the past, and construct patterns over huge spatial areas. Is that 'real' in terms of our understanding of the past, does it matter, and does it link to the past?
- In computer programming, output depends on input: your data and your questions will lead your interpretation. Big Data is not, and should not be, theory neutral. It shifts our perspective, and by doing so should destabilise our narrative expectations. However, this is not a given, for example in the aDNA debate, which is the most problematic thing going on in archaeology at the moment. The practice of this is political, and it is not neutral.
- Considering what is normally understood by the term, most archaeology is not Big Data, although in some projects being suggested it may be. Machine learning is good for looking for patterns, but those developing those methods do not care why these patterns emerged. Embarking on research, does it matter if we will not know why carvings were made, or that there will be so many potential interpretations? Would it be better to use humbler statistical methods?
- The Kitchin classification of Big Data is based on the politics behind the data, rather than the scale of the dataset. Although archaeological datasets would not be classified as Big Data in those terms, they are because of the ambition of the scholarship. In the history of ideas in archaeology, changes in theory have resulting from decentring and destabilising the narrative. The identification of new patterns, and new ideas in connection with them, would be a way of decentring and destabilising the narrative without (necessarily) recourse to pre-existing 'sticky' ideas. There is, however, an epistemological problem with our classificatory

schemes which could potentially be resolved using Big Data to provide a random word generator of archaeological theory and apply that to see what comes out of that!

- It has been established that there is no such thing as a random sequence which can be generated by a purely deterministic machine – if you try to make something random based on a particular text, this is already a biased and incomplete sample. It is in fact pseudo-random, as set out in Doran and Hodson [*Mathematics and Computers in Archaeology*, 1975]. We need to consider structure, but what is particularly needed is to look at the implementation, the process, and, for instance, the concept of 'randomness'.
- Although it is commonly asserted that there is not enough data in archaeology for machine learning, work using LiDAR data on the very small set of Viking ring fortresses demonstrates that fewer data points can be used.
- We have too little Big Data in rock art research. Research on Swedish rock art is using artificial intelligence to look at motifs, carving techniques, and rock geology. Scandinavian rock art is complex with a huge range of motifs and one aim is to classify these, which would be difficult to do without artificial intelligence. 3D material is being used with the aim of combining data on geological texture with depth, style and form, and using those four features to address new questions such as whether individual carvers can be identified.
- The possibility of using 3D data for vector processing is being discussed. This would require enormous computational complexity, and Nordic countries are now considering building an exascale computer for use by research institutions, putting within our grasp enormous computational power.
- We need to be careful in bringing back the concept of categories and typologies, so we do not end up with tables and images which will tell us very little. How would machine learning work with rock surfaces with networks of motifs which are so intricately carved together that even with manual examination would be difficult to analyse, or motifs which are overlaid on each other? How can time and the biographies of individual stones be incorporated in considerations of their appearance?
- Depth, texture, style and form are used in artificial examinations of rock carving. Artificial intelligence is very powerful, and in many ways the analysis of rock art is simpler than other uses it is put to. There is not an infrastructure at the moment to support the resolution needed for this sort of research, and pre-knowledge is needed to choose the data to give to the artificial intelligence system. Classification for consideration of chronology and research questions and the intersection of traditional typology, citizen science and artificial intelligence is a way to further classification efforts.
- Research has shown that a neural network will outperform a human being consistently in image classification, which is a major part of archaeological work. Exploring the interface between traditional experience and knowledge-based approaches and new technologies takes away in part our primacy as the arbiters of what counts and how we classify it. It is a mistake to start thinking about things like machine learning and a neural network as like a black box. It is possible to examine the workings of neural networks, and as humans we have in any case unaccountable and unsystematic work processes. As neural networks become more sophisticated there is a process of inference going on where it uses its processes to examine a wider context.
- Interpretation takes place with the observation. It is not simply a technical recording and analysis process, but an interpretive process which is iterative and more nuanced than perhaps we represent.
- ScRAP will create datasets that might allow the kind of analysis via machine learning described here. However, there are fundamental issues around machine learning. In previous research in natural language processing, machine learning was used to tokenise

and extract information from large volumes of text. It did not work, as sentiment analysis was needed to carry out the examination, which is much more computationally intense, and much more arbitrary. The same problems will probably be encountered using machine learning to look at sets of symbols made in the past, particularly in relation to sentiment. These scientific ideas are very powerful and will be the way forward in analysis, but they are still partial and dependent on decisions archaeologists make in the field.

- As we start to explore technologies or approaches which are potentially transformational are we best served by taking our established, 20th century-developed, practice and continue to apply it to a digital environment and working iteratively with an artificial intelligence?
- The use of digital technology in rock art has to be critical, and constantly assessed. Archaeology looks at how people acted in the past and it is necessary to be aware of how we transpose cultural assumptions into interpretations to be used by digital technologies. Digital technologies are important avenues for research, but visibility analysis is not the only, or most important, aspect of archaeological science.
- It may be possible for a machine to identify a natural hollow, for example, although it is not yet clear if it will be as effective as a human. It is not possible to have a totally automated deterministic view, without considering aesthetics and other perspectives.

The aesthetic

- At a basic level, an artefact is expressive of the qualities of a person. That will be translatable in certain circumstances into propositions of a more general kind, so societies will be characterised by emphasis on different sorts of relationship. Going beyond the individual, why, for example, in the Acheulian, do we find highly developed artefacts which are time-consuming to make when, from a utilitarian point of view, this is not needed for function? The idea of presenting something as a specimen of your particular talents and abilities with respect to tool-making makes a lot of sense. So the basis of the idea is the relationship between the artefact and the individual, although there will be a lot still to be said at a societal level.
- Gell was reacting against the idea of art connoisseurship, and the way indigenous art was seen as 'primitive' art at the time of his writing. Since then, there have been changes in how we think about indigenous arts and now we have an idea of aesthetics which is more accommodating.
- Aesthetic is a useful category in archaeological thought, but art is more difficult, and an aesthetic object is the not the same as an art object: they are related but distinct categories and it is not helpful to confuse the two.
- In stone working in the 4th millennium BC, surfaces are being modified using different techniques. There has been a suggestion that awareness of what is below the surface is also part of the cosmology. In polished stone implements as well, there is something going on in the aesthetic with regards to how stone as a material is transformed.
- The idea that aesthetics is part of the analysis of the remains we encounter is important. What struck me in particular was a finely-produced form of carinated bowl pottery in the early 4th millennium BC, often deposited with Arran pitch stone which has a distinct appearance. I feel this is as much an aesthetic statement as ritual deposition or waste disposal.
- There is an assumption that rock art is encountered as completed works of art, which neglects the process. The understanding of the distinction between nature and culture has changed over time and perceptions of what was natural are likely to have been very different in the past. In discussions about both aesthetics and digital data, where does interpretation begin? For instance, what about the relationship between carvings and

natural features of the rock, which may not be considered in a purely visual study; carving technique and rock physics, where some rocks are easier to work than others; acoustic quality of the rock, and the sound environment within which it is located; the possibility of missing pigment; the possibility that the process included the release of pigment, or the production of luminescent dust? All these questions occur alongside the natural/culture issue. How are these, and other, questions, addressed by aesthetics, or by the use of machine learning digital Big Data processes?

- Another, baleful, aspect of the modern aesthetic perspective is in the antiquities trade, where, for example, jadeite axes are bought, sold and valued as art objects. We must be aware that it is necessary to call out the values of another part of the world. There are examples of portable rock art that has gone missing, perhaps suggesting sale, and also of medieval carved tombs being cut up and sold.

Session 2. Digital approaches to rock art research

The second session of the first research workshop considered digital approaches to rock art research, led by a keynote address by **Andrew Bevan** (University College London), which examined the ways in which digital and computation methods have transformed the way we collect and understand archaeological evidence, and the key challenges which remain.

First discussion

The first discussion took place in reaction to the following provocations:

- **Mark Lake** (University College London): 'Modern spatial statistics move us beyond environmental determinism', which examined the prospect for recent developments in spatial statistics to support more nuanced and multi-layered quantitative analyses, moving away from older debates about environmental determinism.
- **Xavier Rubio-Campillo** (University of Edinburgh): 'How do I know if I am wrong? Data, plausibility and hypothesis testing', on the computational methods which will be required to assess hypotheses via increasing open large-scale datasets in archaeology, and the challenges and limitations in employing such an analytic tool.

Discussion overview

The discussion considered the use of spatial statistics and other quantitative analyses in archaeology, and their potential role in examining rock art. The power of spatial statistics in analysing past use of the landscape was discussed, as were its limits, particularly in relation to establishing contemporaneity in source material, and in the lack of a fine-grained understanding of the prehistoric landscape. However, developments in nuanced approaches to statistical methods in archaeological research were presented and the strengths of statistical approaches were described. Examples included the possibility of examining probability via statistical models, and the transparency of input into these models, allowing the possibility of critique and improvement. Other statistical approaches were also considered, such as the use of graph theory. The session also discussed the possible application of these methods to ScRAP research questions, particularly in relation to rock art chronology.

The following specific points were made:

Do spatial statistics really move us beyond the debate about environmental determinism? Does it hinge on a kind of 'residual' logic — the social is whatever is left after controlling for the environment? What do we mean by 'environmental determinism anyway' — is this really about cognitivism versus behaviourism?

- Has environmental determinism been misunderstood, just as the question of whether aesthetics have been misrepresented? And how often is that a distraction from what we are debating?
- It can be argued that, when considering human responses to the environment, the proper examination is cognitivism versus behaviourism rather than environmental determinism. It is possible to make inferences about why people are occupying particular sites in the landscape and conclude that there are reasons for that, for example because of convenience for hunting. However, cognitive choices will precede that selection (such as with regard to a choice of prey animal), so as well as being a matter of economy and symbolism, it is also a cognitive choice made in an environment that affords particular possibilities. We appear to have elided the distinction between the environment and the social on one hand, and

between cognitivism and behaviourism on the other meaning the debate was not constructive.

- A difficulty with spatial analysis is that most of the models we are building are not really based on reconstructed landscapes because we often lack information on what the landscape looked like, even in terms of vegetation, and this may have been affected the placing of rock art.

Can all hypotheses be transformed into formal models?

- An advantage of statistical program models, which does not exist with non-program models, is that they are transparent, in that the source code and dataset have to be exhibited so others can criticise and potentially propose alternative models. Can we accept that there are some things that we cannot know, but still continue to examine them to seek to answer these questions?
- The issue of contemporaneity in spatial analysis is very important and a well-known problem. There are different ways of approaching this: you can acknowledge the lack of necessary resolution and not continue the research; you can assume contemporaneity and establish an interesting and coherent narrative until you come up with data which refutes that it is a useful narrative with which to consider the past; or, from an analytical point of view, you can rerun the models and within the bound of available evidence, reassign the distributions randomly to certain chronological bins, and see if that makes a difference? Or is the pattern established still robust or, more likely, robust up to a certain (chronological) point? This has the advantage of letting us quantify the uncertainty which we have.
- GIS is good at is looking at how people move through the landscape, in particular entrenched population movements over generations. However, there are problems, such as changes in landform or, for example, where wild animals would previously have been a significant factor in how people navigated the landscape, but cannot be accounted for in GIS.
- Apart from intervisibility, another element of possible research is soundscapes, and the audible qualities of sites, which can perhaps be approached through GIS. The focus is generally on the visual, but there are other dimensions to consider, including the acoustic.
- The representation of duration and temporality is a significant issue in archaeology generally. There seems to be potential for digital technologies to incorporate this issue, because it is fundamental to understanding movement and experience in the past, whether in buildings or in the landscape.

What models are best suited to answering ScRAP research questions?

- Considering the example of the cup marks in the Dalladies long barrow, is it possible to make a hypothesis that earliest forms of expression are the cup marks, perhaps in the first part of the 4th millennium BC or thereabouts, and make a model on the hypothesis that increasing complexity occurred over time, with rings added later perhaps by succeeding generations. If this is cross-correlated with other evidence and chronologies in the vicinity, such as in relation to axe movement, ceramic types, tomb types, can we use these to test the models? If the chronology of people's interaction with the environment through time is a goal in Scottish rock art research that is one approach.
- In rock art, one of the key questions surrounds any relationship between Irish passage tomb art – complex cup-and-ring art – and what is found in Orkney. Scientific techniques can be used to pull out the motifs which might relate to each other, and plot their geographical distribution. It is possible to create a model to test the hypothesis that simple cup marks

came first and then motifs became more complex without necessarily needing to employ machines.

- In rock art the problem with visibility analyses is that it is not normally possible to see other carvings, or even the rocks they are on, but merely just the place where the rocks are. That is why we have to have more critical input into the analyses that we do, and remember that humans made and interacted with the rock art.
- At a basic level, intervisibility is just another characteristic of the landscape, in the same way as soil type, and is environmentally deterministic to that extent. In practice, it is a function of the topographic structure of the landscape whether or not, within GIS, a ray traced will collide with the surface of the earth. Beyond that basic assessment of line of sight, the issue becomes more nuanced, with considerations of distance and its effect on what it is actually possible to see. However very basic visibility analyses are still seen and indicate the importance of gaining a conceptual grasp of GIS embedded within an archaeological context.
- What can be discerned about the palimpsesting of the different rock art sites, and are the most palimpsested sites in particular landscape locations? The biases in rock art distribution constitute a challenge if the simple distribution is used for analyses, but perhaps using multi-image sites in comparison with the simple sites may produce patterning.
- There are regional distinctions in rock art, and it is possible to map distinctions which blur and blend. But it is important overall not to consider rock art as created through one moment in time, but as part of relationships which would have been extended over time through oral tradition, and through return and reuse of sites. It may be possible to show different relationships over time in rock art – creation, return, curation of places – through dynamic GIS. Dalladies, for example, shows a site that was not forgotten over a number of generations.
- A three-year research project on late 4th and 3rd millennium BC Britain spatio-temporal site-specific chronological modelling will look at deposited rock art with robust associated dates, and rock art in structures with robust associated dates – including Irish monuments – which will help a process of comparing and contrasting. The issue is the dating of rock art without associated dates, where a palimpsest approach, or old-school seriation, will be necessary.
- In terms of unpicking chronological issues it is necessary to extract all possible information on when specific pieces of rock art were made. For instance, mobiliary art, often small stones with a single cup mark, probably dates to the Early Bronze Age because it is found in North-east England, and associated with monuments of that period (or additions to earlier monuments).
- At Clava Cairns, Bradley suggested existing cupmarks were being reused, although they look quite fresh. A working hypothesis that people were making rock art at a particular time, and reusing it at another time, to get that chronological texture, would be useful.
- In Knowth, as with Orkney, there is difficulty in unravelling the sequence of activity. In trying to classify it, although there is analysis of re-use, techniques, and of motifs, it is difficult to escape from the necessity of also including analysis of style.
- There is difficulty with dating rock art, even within datable contexts. In Orkney, there are carvings on stones in buildings where the carving may have been added a long time after the building was constructed. Micro-stratigraphies and micro-analyses of little contextual stories to unpick what happened is needed – we have to work at different scales at the same time, and have the human interacting with the computer analyses. Does the evidence, particularly from the Ness of Brodgar, that pecked marks often came later than incised marks assist with the dating of cup-and-ring marks across Scotland?
- It has to be remembered that at Ness of Brodgar we see the re-use of structures, and buildings are constructed on the top of other buildings, meaning it is difficult to pick apart

information on the micro-chronology. Context is also important: where buildings have been changed, or there is disruption in the biography of buildings, we tend to see cup marks, which is interesting as it hints that the making and placement of a cup mark (often inserted, almost 'aggressively' in building) indicates something more than a chronological relationship.

To what extent can we know if we are wrong without using quantitative approaches?

- How do we know if we are wrong? In comparison with other areas of science, where there may not be a solution to a posited problem, we know that things happened in the past, making the examination of them at least theoretically possible. When establishing if we are right or wrong, we start with a guess and, with relevant of evidence, it will be possible to examine its level of probability.
- When using statistical models it is essential that the criteria being used are examined to make sure they are correct ones, and that correct datasets (for example, chronologically correct) and appropriate proxies are employed
- In science, the guesses are informed and so the probability of a guess being correct is probably higher, because it is based on information and expert understanding. The advantage of computational methods is that there can be different hypotheses but still agreement, based on statistical analysis, that one is more correct than the other. This has not necessarily always been the core of the discipline of archaeology. Statistics are useful because with particular data and assumptions, the best model can be identified, but it can also be re-examined if a better approach/other evidence comes along.
- There is a wider intellectual outlook in terms of how much nuance [is necessary/desirable]. One of the best recent papers in social science was Kieran Healy's 'Fuck nuance' – and I think the issue of nuance is indicative of intellectual approaches to writing archaeological narratives and how you cope with noise and nuance. Understanding the technologies is important, but also understanding the tolerance and ambiguities of the technologies.
- We are looking simultaneously at a 'national' phenomenon that played out over millennia, regional traditions which are actually a different set of phenomena in social and culture terms in the past and then, in some areas, local landscape studies making for more qualitative examination. Complex nested models are needed that can work within these three scales.
- The divide between archaeology and digital technologies can be straddled, and technology used creatively, and to rethink standpoints. Both the ontological and the technical issues are important.
- We should be careful about the idea that the future of analysis is just about 'feeding' the machine. In all of those technologies of analysis – statistical, computational – there is a human researcher.
- To continue on scale and connections, one possible way forward beyond existing methods is to go towards graph theory, and visualising relationships in schematic, diagrammatic way where it is possible to represent scale. As well as representing them in space, it is also possible diagrammatically to understand how spatial and temporal variants occur. We have the beginning of these tools in the hardware, but can move beyond things like the Gower coefficient and the Jaccard coefficient which are standard in analysis. I think it would attractive to a funding body to work on new tools for archaeology, and for society more generally.

Second discussion

The second discussion took place in reaction to the following provocations:

- **David Cowley** (Historic Environment Scotland): ''Still' in the eye of the beholder? Beyond looking at digital data', which looked at the question of the primacy of our gaze and the challenges of exploring digital data in ways beyond the fixation on the visual.
- **Marta Díaz-Guardamino** (Durham University): 'Beyond 'pretty images': digital technologies, rock art, and posthumanism', which considered the challenge of discussing how digital technologies can best contribute to overcoming the framing of rock art research within western ontologies and representationalism and develop instead a posthuman research agenda on rock art.

Discussion overview

The discussion considered the role of new methodologies in rock art research and the ways in which digital research can go beyond what is allowed by the human gaze. Questions of what machine learning can be used for, whether what is produced is better or different than a purely human examination, and how effectively machines can learn to examine archaeological information, were considered. Discussions focussed additionally on the idea that digital technologies provide greater accessibility and engagement in a wide range of emerging platforms, and may permit new interpretations to emerge. Digital technologies also produce multi-sensorial material providing an enriched research evidence base, and have the potential to produce more robust examinations of visual material. A major issue that remains, however, is the lack of broadly understood conventions in the presentation of the output created by new technologies. The natural complementarity of new and traditional methods of encountering rock art was recognised, together with the importance of using our current knowledge base to iteratively inform digital technologies as they develop.

The following specific points were made:

Does thinking digital challenge established practice?

- Traditional recording methods are useful, but limited, and what is needed is a combination of both traditional and modern, high resolution approaches. It is a misunderstanding that once laser scanning is introduced, the human disappears. In Scandinavia, high resolution laser scanning shows us features which can also be seen if we go back to traditional paper-rubbing techniques. However, the laser scan is the only scientific method because of its accuracy and its consistency.
- In my experience of rock art, a combination of methods is necessary. Often when considering my 3D models I needed to revisit photographs I had taken in different lights in different situations.
- In Scandinavia, new techniques have expanded the recording of rock art from a small number of skilled teams to include the general public. It has also opened up scrutiny of traditional documentation and shown where it was wrong and incorrect interpretations occurred. There are as many truths as people looking at rock art.
- It is possible for machines to learn experiences. A machine welder was trained to work on the bridge between Sweden and Denmark, aiming for the same accuracy as an as experienced human welder using judgements based on smell, sight and heat. Those data were taught to the machine, which resulted in it achieving 95% accuracy. This compares to 100% with an experienced welder, but a machine can keep working on for long hours.

How do we move beyond 'just' looking?

- A bottom-up perspective is required when looking at the making of rock art and carving techniques, combining depth, geological texture, colour, form and style. This is what we are doing via machine learning in Scandinavia.
- In the field, often the best way to approach rock art and to ascertain whether a cupmark is artificial or natural is to use your hands. That process needs to be better documented, but it can be difficult to do so consistently and objectively.
- Some of the images produced both with traditional and modern methods are quite dry. However, there is a powerful sensuality produced with RTI images, which bring intimacy and a feeling of being there are the moment of carving, which we could make more use of, both in terms of interpretation and we engage with them.
- The surface texture of Neolithic figurines has been recorded in great detail using RTI. These figurines would not be touched directly once deposited, so this was a way of showing the texture which was also more robust and less subjective than touch.
- Digital techniques can be used to create multi-sensorial experiences. RTI permits, at a desk top, the exploration of the different facets of the rock art which would not be possible even at the site itself. 3D models can be transported into virtual reality, and from there it is possible re-inhabit that space physically and re-engage bodily. This creates a novel experience of rock art and, along with other techniques, gives us a different way of inhabiting those spaces, to re-think research questions, and experience natural taphonomic processes.
- At the moment we have limited platforms, such as Sketchfab, for presenting work and often people have problems opening models. Access via virtual machines and technologies is opening up possibilities for new and refreshing approaches to visualisation in rock art, and also working with terrain analysis and LiDAR.
- Bringing analytical data into virtual reality allows users to explore data independently of our narrative. Facebook, for example, has an app allowing virtual reality models to be occupied remotely. Potentially all ScRAP sites could exist on virtual reality sites, although there are issues surrounding resolution and accuracy.
- There is an opportunity for sites to reach greater audiences and allow engagement with data which goes beyond visiting the site itself. What would be possible in terms of combining different types of data, perhaps soundscapes and immersive virtual reality, and going beyond current digital outputs?
- As virtual reality is being used to record sites, many are actually being damaged or not conserved. What is the future of these sites: should they be turfed over and only accessible using virtual reality? Would a facsimile be the same as the real thing?
- Some of the intuitive processes we use can be incorporated into artificial intelligence, as part of a reflexive approach to iterating its design. For example, a commentary on capturing LiDAR data, can be fed back in to optimise the system. The real importance, whatever our work flows are, is that they are as explicit as possible. If that is built into image analysis, it makes it more powerful.

How clearly/explicitly do we understand what we see?

- This discussion is connected to the previous discussion about truth. Will the growth in the availability of data, and in the different types of data, help us resolve the debate about the role of truth and truthfulness in archaeology?

- In dealing with the issue of superimposition on multiple-image rock art sites, it would be interesting to take a citizen science approach and see what 1000 people took from each motif, and the order in which they had gone onto rock.

How do we develop experience/knowledge-based systems?

- Can artificial intelligence-generated identification be confirmed by excavation to assess how accurate it is?
- Excavation does not produce truth, but rather different types of information. The phrase 'ground truth' is unhelpful as, in the majority of cases, it is possible on the basis of experience to confirmation identification from visualisations. There are other processes of validation, but excavation does not produce truth, it produces different types of information.
- This is one of the reasons why we introduced levels of confidence into our desk-based mapping. It is important to be honest about uncertainty, but it can also be used in a creative way.

Beyond pretty pictures and visualisation anarchy – conventions?

- Is there an aspiration to produce conventions for presenting the digital output of ScRAP? Conventions are essential in conveying what we understand to a third party and that is lacking, for example, in LiDAR.
- It is difficult to create conventions which will cover all scenarios, but whatever is developed should be explicit, particularly about what may influence the result in terms of accuracy and repeatability.
- The use of digital techniques has been transformative and has challenged the series of conventions making output legible for users. That kind of visual language has not emerged yet for digital methods.
- It is necessary to consider ways of communicating sites, but we should not pursue the development of technologies that essentially reproduce the sites themselves. In technical illustration, it is necessary to find ways of extracting meaning, 'truth' and, unless the aim is merely to reproduce the site for those who are too far away to visit, it important not to deny the expertise of the interpreter. Illustrations fix a view which can be examined and critiqued. If all that is created is a model, there is no commitment to an interpretation. Older interpretive conventions, like the hachure, took a point of view and transferred that information from expert to expert. Otherwise it is an open-ended experience which requires a craft to enact.
- Opening sites up for engagement does not prevent the archaeologist from providing an authoritative view, and embedding aspects of my own perspective as an authority on the site. This ability to experience the sites could be part of the peer-review process, and enfolded into the conventions that allow archaeologists to discuss higher-order ideas. These technologies do not disempower archaeologists, but are a way of creating different experiences that allow the creation of different narratives.
- Many digital models of rock art are created, but when distinguishing between natural and cultural forms on those panels it is often necessary to go back to the actual panel, and look at it and touch it. And there needs to be an emerging craft to deal with the intersection of natural and culture, for example, superimposition, different stages of weathering, or a natural groove that meshes with a cultural groove. Going back to an older tradition of stipple drawing, would it be possible for that process to be semi-automated. At the moment, it requires a person with skill, a model that contains the information, or that has

been notated for saying ‘that is natural’, ‘that is cultural’, ‘that is weathered’, ‘that has been erased’, etc. Could a digital technique achieve that result, or does it always require the intervention of a human?

- In Iberia, Bronze Age stelae have been studied applying the *chaîne opératoire*, using 3D models, RTI, and traditional tracings, but there are no conventions to represent that interpretative synthesis. And when automatic techniques, from GIS for instance, are used, it also requires the intervention of an archaeologist to produce a final tracing. It is possible to continue in this way, but establishment of conventions would be useful.
- The value of the sketch is that it provides an interpretation, which other types of imaging do not. When artificial intelligence can interpret what it sees, it would be possible for it to go on to do the drawings too, as long as there was confidence that it understood what it was seeing.
- One question is what visualisations are going to be used for, and who is going to be interacting with them. Amazing and beautiful visualisations have been created based on rigorous interpretation of models. This use of datasets to create an art form can be used to engage people.