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Original article

Condition assessment and preservation of open-air rock art panels during environmental change

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ABSTRACT

Thousands of Neolithic and Bronze Age open-air rock art panels exist across the countryside in northern England. However, desecration, pollution, and other factors are threatening the survival of these iconic stone monuments. Evidence suggest that rates of panel deterioration may be increasing, although it is not clear whether this is due to local factors or wider environmental influences accelerated by environmental change. To examine this question, 18 rock art panels with varied art motifs were studied at two major panel locations at Lordenshaw and Weetwood Moor in Northumberland. A condition assessment tool was used to first quantify the level of deterioration of each panel (called "staging"). Stage estimates then were compared statistically with 27 geochemical and physical descriptors of local environments, such as soil moisture, salinity, pH, lichen coverage, soil anions and cation levels, and panel orientation, slope, and standing height. In parallel, climate modelling was performed using UKCP09 to assess how projected climatic conditions (to 2099) might affect the environmental descriptors most correlated with elevated stone deterioration. Only two descriptors significantly correlated ($P < 0.05$) with increased stage: the standing height of the panel and the exchangeable cation content of the local soils, although moisture conditions also were potentially influential at some panels. Climate modelling predicts warming temperatures, more seasonally variable precipitation, and increased wind speeds, which hint stone deterioration could accelerate in the future due to increased physiochemical weathering. We recommend key panels be targeted for immediate management intervention, focusing on reducing wind exposures, improving site drainage, and potentially immobilizing soil salts.

1. Research aims

Open-air rock art stone panels exist around the world; however, growing evidence indicates such panels are rapidly deteriorating due to natural and anthropogenic causes [1] and we now see only a small fraction of what once existed [2]. As such, remaining panels are of special importance for preserving tangible links to our distant past. Unfortunately, processes that influence deterioration of exposed panels are not well understood, especially relative to preservation and management [3]. Stone is not immutable, but because of perceptions otherwise, rock art has received less direct conservation attention than other archaeological materials [4]. Change and decay are innate to all stone [5]. Therefore, delineating factors that influence stone deterioration is critical, especially with prospective environmental change [6–9]. In reality, rock art management largely has focused on controlling public access with less attention has been placed on protection against stone weathering from an eco-environmental perspective [10,11]. As such, we assessed 27 geochemical and physical descriptors around 18 open-air rock art panels across Northumberland in Northern England to compare current panel conditions with present (and past) local environments to develop more science-informed approaches for managing these monuments into the future.

2. Introduction

Rock art is one of the earliest forms of artistic expression, with some sites being more than 50,000 years old [12]. This art is either found as pictographs (paintings) or petroglyphs (engravings and carvings) on natural rock surfaces (boulders, cliffs, cave walls, etc.) with motifs ranging from animal forms to geometric shapes like circles, spirals, hollows, and lines. Although such art often has been ignored [13], studies are now increasing due to a growing awareness of their social and historic significance [14–18].

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Fig. 1. Example rock art panels located in northern England at Lordenshaw and Weetwood Moor, Northumberland.

Neolithic and Bronze Age rock art across Northumberland in northern England is a good example [1], where over 1200 carvings have been inventoried [17,19]. Northumberland motifs usually are found in the open-air on isolated rock outcrops or boulders in the countryside, and range from simple cup-like features to more complex patterns with rings and grooves (Fig. 1). However, micro-environmental exposures around individual panels differ across the region, which we hypothesise differentially influence their physical condition. Such speculation makes sense because present and past environmental factors have been shown to influence the condition of other heritage monuments elsewhere the world [20–22].

In the case of Northumberland, mid-Holocene woodland landscapes gave way to exposed heathlands over 2000 years ago due to changes in land-use [23]. This shift in vegetative cover appears to have led to altered soil moisture patterns (fluctuating watertables were replaced by more consistently waterlogged conditions and less vegetative water demand) and increased wind exposures. In contrast, rock art panels are present as fixed points in a dynamic landscape, but their present condition still is the product of past climates and their future condition depends on environmental change [24,25]. However, despite broad climate variations, often it is the very local environment (e.g., soil chemistry, panel orientation, animal impacts) that has a greater influence on the physical condition of individual stones and panels [20,22]. Clearly, factors that affect the relative deterioration of rock art panels are complex across spatial scales as well as over time; therefore, past, present, and future environmental conditions must be considered to develop appropriate strategies for site management.

In order to understand rock art condition, one must first recognise the array of environmental stresses that influence stone deterioration and weathering [26–29], and also acknowledge that different rock types respond to stresses differently [5]. Stone weathering is not a simple process and stresses vary. For example [30], diurnal heating and cooling events cause low magnitude, high frequency stresses. Whereas, freeze/thaw cycling can cause high magnitude, low frequency stresses due to expansion and contraction of water and ice in rock micropores. Further, air pollution can accelerate rates of stone deterioration in urban settings [31]. Although the scale of stress differs, diurnal and freeze/thaw events, and air pollution can weaken the stone, making it more susceptible to other stresses, such as physical weathering due to wind or saltwater intrusion that disturbs the fabric of the stone.

An appreciation of such issues is key to developing informed rock art management strategies. However, we can only measure contemporary conditions at existing sites, and we must determine the usefulness of this information to relative to long-term preservation. As such, our approach was to measure 27 ambient geochemical and physical descriptors around 18 individual open-air rock art panels with different levels of deterioration to identify specific environment descriptors that correlate with higher levels of rock art deterioration. We then contrasted past and present climatic conditions in the region and assessed how descriptors that correlate with stone deterioration might be effected by environmental change (using UKCP09 [32]). Ultimately, our aim was to develop science-informed strategies for preserving open-air rock art into the near and distant future.

3. Materials and methods

3.1. Rock art panels locations

Two field locations with different types and arrays of open-air rock art panels were chosen for comparison in the study (Fig. 1). Both locations are in areas dominated by Fell Sandstone, with stone type being very consistent among all panels assessed. Fell Sandstone is from Lower Carboniferous age (350–320 Ma) and is composed of fine to medium-grained quarzitic sandstone with some cross-bedding and occasional conglomerate bands [33].

The first location, Lordenshaw, is situated south of Rothbury in north central Northumberland. The panel area crosses a series of hills near an Iron Age 'hill fort', which was reused as a Romano-British settlement [16]. Lordenshaw lies within Northumberland National Park and is visited frequently by walkers and tourists. Lordenshaw has over 100 panels with eight panels chosen for study here based on the novelty of motif, their physical location, and the relative prominence of each site. The second field location is known as Weetwood Moor and is ~30 km north of Lordenshaw near the town of Wooler. This location is less visible from local roads and has had less human contact. Ten panels were selected at Weetwood, using similar criteria for panel selection at Lordenshaw.

The names and exact locations of the 18 panels are summarised in Table S1 (see Supplemental Information; SI). With the exception of one panel at Weetwood Moor (Weetwood Moor 6), all 18 panels are in open heathland, and recently have been exposed to grazing animals, including sheep and occasionally cattle. Pollen evidence indicates that both sites were forested prior to about two thousand years ago [34], but forests were cleared as more intensive agriculture developed. Therefore, both panel locations have been in heathlands for over 2000 years.

3.2. Panel Condition Assessment: application of a revised staging system

Various stone condition assessment methods are available for characterising the level of deterioration of rock art panels. Dorn et al. [3] developed a rock art stability index for assessing stone condition, which is complex and useful. In contrast, a simpler approach was developed for building preservation (UAS method; [35]) that is rooted in triage decisions for identifying the stage (condition) of disease in cancer patients [36]. The UAS method is intentionally simple because it is designed for non-experts and volunteers. Given