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Characterization of Petroglyphs

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Abstract
Forms of rock art created by a reductive process such as abrasion or impact constitute the category petroglyphs. Several criteria can be applied in their characterization, including their purported meaning or iconic interpretation, the basic metrical variables of petroglyph motifs, their formal characteristics, the technology of their production, their taphonomy, age estimation, and their discrimination from similar natural rock markings. These various approaches are briefly considered and it is established that while most of them can meet the criteria of scientific investigation, some do not. The epistemological basis of the various methods in characterizing petroglyphs is explored.

Keywords
Petroglyph, rock art, dating, forensics, interpretation, taxonomy

Introduction

The world's rock art can be conveniently divided into two principal components of roughly equal quantities—pictograms and petroglyphs. The former were created by an additive process, i.e., material was added to a rock surface, while in the production of petroglyphs, material was removed from the rock. Consequently pictograms include rock paintings, stencils, prints, pigment drawings and beeswax figures. Petroglyphs, made by a reductive process, include engravings, percussion petroglyphs, abraded petroglyphs and finger flutings in caves. This division is useful because it corresponds not only to the two basic technological classes of rock art, but also to various methods of its study, for instance in age estimation or conservation science.

Another factor separating pictograms and petroglyphs is that the former rarely survive out of caves [saseas0074] from the Pleistocene, whereas petroglyphs are more resistant to natural deterioration processes, particularly on weathering-resistant rock types such as granites and quartzite. Most of the world's surviving Pleistocene rock art consists of petroglyphs, especially where they are deeply pounded and relatively sheltered. In rare cases these may date from Middle Pleistocene traditions (in central India and the Kalahari Desert) but it is only with the last third of the Late Pleistocene that surviving petroglyphs become more frequent. The longevity of petroglyphs is proportional to the time it takes to create them. Replication has shown that the 'composite hardness index' (the measure of a rock's resistance to compressive force) of a rock determines very decisively the production time of percussion petroglyphs. For instance an identical petroglyph takes about 400 times as long to create on unweathered quartzite as it takes on weathered sandstone (Bednarik 2016a). These differences are very pronounced, as are the potential survival rates of petroglyphs on different lithologies. [insert Fig. 1 here]

The two principal methods of removing rock mass in petroglyph production are by percussion or by an abrasive action. Impact can be direct, by a hammer-stone, or indirect, by a chisel-like tool combined with a hammer, but there is no ethnographic or replication evidence supporting the view that the second of these methods was applied. Abrasive-action petroglyphs were created by incision or by polishing a surface area. Most petroglyphs have been made with stone or metal tools, although on very soft rocks, bone tools have been used. Another technological separation is between petroglyphs rendered prominent through color contrast, by breaking through a thin surface veneer (patina or weathering zone), and those relying on relief for visibility (where the rock's surface and interior are of similar color). Technologically, the former group is defined as sgraffiti: made by the removal of a veneer to reveal the differently colored rock beneath.

The scientific study of petroglyphs delves primarily into their forensic analysis, i.e., the recruitment of empirical evidence for determining the circumstances of their production and use. This includes information about the tools used in their creation, the recovery and study of such implements from sites of occurrence, the direction of tool application, the biomechanics and biokinetics of petroglyph production, identification of multiple applications of individual tools in abrasion petroglyphs, and the replicative studies required to translate such data into testable hypotheses. Another area of scientific concern is the taphonomy [saseas0568] of petroglyphs, which is intricately interwoven with their lithology, technology and environmental variables (Bednarik 1994). Various phenomena connected with the characterization of petroglyphs derive from a range of disciplines, such as geology (e.g., the presence of kinetic energy metamorphosis products) or acoustics (e.g., concerning rock gongs, or the acoustic properties of sites), as well as many other fields. In view of the frequent inability of archaeologists to effectively discriminate between petroglyphs and natural rock markings of many types, another important consideration concerns the factors distinguishing exogrammatic from other rock markings that may resemble them, and their effective determination. Numerous types of natural markings occurring on rock surfaces can resemble petroglyphs, among them xenoliths, other petrographic marks, weathering and solution marks, tribological marks (e.g. by clastic movement), and rock marks produced by plants and animals. They and even utilitarian anthropogenic rock markings (e.g. drag marks, tool marks) have all been frequently misidentified as petroglyphs.

Dating of Petroglyphs

One of the principal concerns in characterizing petroglyphs is the determination of their age. The strategies employed differ significantly from those applied to pictograms, because in contrast to them, there is no analyzable substance available that marks an image's antiquity. The rock mass removed in creating a petroglyph is not credibly recoverable, despite such efforts having been made. Therefore the range of methods engaged in estimating the antiquity of petroglyphs is unique. As in all dating work, the target date (time of execution; Dunnell and Readhead 1988) is the preferred variable sought, but in the case of petroglyphs, only two methods have so far been applied to secure such results: microerosion analysis and patina colorimetry. Archaeological excavation, for instance, can only provide minimum ages, as does the quantification of fluvial erosion wear and surface retreat; or lichenometry, OSL analysis [saseas0424] or radiocarbon sampling [saseas0424saseas0424] of insect nests. Similarly, the determination of uranium-series products of carbonates or ferromanganese substances, the ^{14}C analysis of carbonates and oxalates, or cosmogenic radiation products [saseas0135] only provides either minimum or maximum ages under favorable conditions. Cation ratio determination of accretionary mineral deposits has been rejected, and there are various problems with iconographic and stylistic claims about petroglyph age estimation (see below). In short, the dating of petroglyphs remains notoriously complex, and both microerosion and colorimetry deliver only results with substantial tolerance ranges.

Nevertheless, microerosion analysis (Bednarik 1992) has provided numerous credible results from much of the world, and is being applied very successfully in China, Europe, Saudi Arabia, and many other regions. In this method, the geometry of wane formation along the edges of crystals fractured during the production of a petroglyph is utilized. The widths of these micro-wanes, visible only under a binocular microscope [saseas0422], are a direct and linear function of age. The rate of their development needs to be calibrated to the environmental conditions of specific regions and for particular minerals. So far, only quartz and feldspar have been used in this method, and only comparatively erosion-resistant rock types are of relevance. The calibration curves now available from many climatic regions have suggested that the rate of solution is primarily a function of precipitation and therefore the need for calibration is expected to fade out progressively. The results obtained through microerosion analysis are reliable, as there is no potential contamination, and reversal of the underlying process is impossible. However, the precision of results is relatively coarse, with tolerances of about 20% to 25% being reported. An important factor in favor of the method is that it involves no physical intervention in the rock art, an attribute shared by very few other direct dating methods so far applied to petroglyphs. [insert Fig. 2 here]

Colorimetry of the ferromanganese accretions formed on petroglyphs is another method striving to establish 'target dates' without physical intervention (Bednarik 2009). However, this approach promises little in the way of precision and has so far only been applied experimentally.

Interpretation of Petroglyphs

Unless there is sound ethnographic information available, the determination of the meaning of petroglyphs or other rock art lies outside of proper science. Nevertheless, it is the approach favored by most archaeologists and therefore requires attention. All iconographic interpretation [saseas0332] of rock art involves pareidolia, the experiencing of meaningful patterns in random stimuli. Since modern beholders of such imagery lack the brain structure and composition, and therefore the perception, of its producers (Helvenston 2013), the modern observers cannot determine the emic meaning of supposedly figurative motifs. We can only function as human beings in the context of our societies here and now; we have no way of understanding the conceptual world of people thousands of years ago.

Neurologically, the process of etic interpretation of rock art is the imposition of imagery stored in the visual cortex over the signals the lateral geniculate nucleus (LGN) of the thalamus receives from the optic nerve (Bednarik 2016b). As much as 95% of excitatory, inhibitory or modulatory input in the LGN derives from the visual cortex, superior colliculus, pretectum, thalamic reticular nuclei, local LGN interneurons and other projections. The latter include feedback projections from the higher areas of the visual cortex of the inferotemporal cortex, where visual memory/imagery occurs, back to the visual cortex. Therefore what we see is determined mostly by our internalized model of reality, and the ontogenic experiences stored in the brains of earlier humans who created rock art can be assumed to have been dramatically different from ours. Unless archaeologists or other etic explainers of rock art can demonstrate why they should have some special cognitive endowment that enables them to divine the meaning of rock art better than, for example, tourists or children, their claims lack justification. Moreover, the "interpretations" of rock art decipherers cannot be tested; they are free-standing, capricious claims and are therefore not scientific.

In pareidolic interpretation of rock art the beholder divines the meaning of a motif by first deciding subliminally whether it is aniconic or iconic. If elements of the figure or its overall form convey the impression of being depictive it is perceived as iconic. The decoding of the motif is initially by disambiguation (Davis 1986) of marks and textures on a rock surface. The production of iconographic forms is simply the intentional creation of features prompting visual responses to a signifier; it induces visual ambiguity deliberately. The human visual system is prompted to perceive an object where only marks and textures exist, through exploiting their visual ambiguity. This is the basis of all iconographic art: its elements are arranged and rendered in such a way that visual disambiguation experiences them as resembling objects, via pareidolia. Once an arrangement of paint residues or grooves on rock is perceived as intended to depict an object, the arrangement is scanned for confirmation that one of the options presented by the visual cortex matches it in adequate detail to pursue the correspondence further. In this process any disconfirming visual aspects tend to be disregarded or explained away as not deliberate or as badly executed, as being attributable to awkward materials or deficient skills, or to stylization, conventionalization or schematization. At this stage of the process science, demanding the full consideration of disconfirming evidence, is discarded in favor of confirmation and autosuggestion. The beholder has latched onto a potential interpretation and now rationalizes accordingly.

The next crucial error in the process of pareidolic determination is to scan the detected image for diagnostic details: those elements that were "deliberately" rendered naturalistic. With this endeavor of determining *intention*, without credible reasoning, any pretension of a scientific process is abandoned. All of this takes place in a matter of a few seconds, and it determines how a motif is interpreted. Therefore the process of rock art interpretation is non-scientific.

Formal Characteristics

Another favored way of characterizing petroglyphs is to create taxonomies of them by defining formal categories. Although such an approach is essential for the quantification of assemblages, for their comparative assessment, for statistics and the definition of cultural entities, there are also considerable difficulties with such approaches. The range of motifs of a site does not present an inherently consistent system akin to the periodic table of elements; it can only be divided by arbitrary classification. Moreover, co-occurrence at a site does not imply that the components of a corpus belong to a single tradition. On the contrary, major rock art sites tend to be accumulations featuring the residue of multiple traditions, often prompted by pre-existing imagery. Unless these are recognized and separated, any taxonomy of motif forms serves little purpose and may be quite misleading. There is a tendency of believing to detect stylistic regularities, which are then proffered as evidence of culturally cohesive characteristics. This tends to lead to the circularity of the argument that such perceived formal consistencies have been demonstrated, and that they therefore reveal cultural diagnostics.

These are not the only adversities in creating etic taxonomies of rock art. The arbitrariness of the process is evident when the practicalities are considered in detail. For instance, one of the common petroglyph motif types is the circle, but there are in fact literally countless variations of the circle found in rock art. At what point should one discriminate between a circle and an oval? Without knowing the meaning of either, how can we know that they are not intended to be the same motif? Is a circle made by a male the same motif as one created by a woman? If not, how will the archaeologist distinguish between the two? Is a large circle the same motif as a small, a horizontal the same as a vertical? Are two circles two motifs or one? What if one is placed inside another one? The possible variations and combinations are endless, and wherever the analyst draws boundaries, these will always be arbitrary. Such etic taxonomies can be expected to differ from emic classifications and interpretations. Therefore they only serve as loosely descriptive tools, they cannot be analytically valid and their scientific utility is very limited.

Any taxonomizing process is based on searching for common denominators, and on seeking to find among them the one that is crucial in defining the phenomenon category in question. The number of variables available for this is practically unlimited, and could include variables of morphology, technology, style, form, size, geology, geomorphology, petrology, hydrology, acoustics, relative orientation, orientation to other motifs at the site, to other features at the site, or to other sites, and so forth. Most archaeologists select arbitrarily some subjective characteristics, most commonly purported style and motif morphology as perceived by the subjective alien observer, and then proceed to create taxa.

Not only must such taxonomy be considered arbitrary, we have no way of knowing how the *surviving* evidence relates to the *originally* created rock art. How much rock art has fallen victim to patination, exfoliation, rain water, frost shattering, insolation, sediment cover, erosion, dam builders or whatever other taphonomic factors? In short, formal characterization of a corpus of petroglyphs is of limited utility; its principal expediency is in the field of rock art conservation [saseas0112].

Other Scientific Approaches

An important part of characterizing petroglyphs is the study of their technology, i.e. how they were created. This is based on the methodology of forensic science, as is most of scientific work with rock art. The tribology of petroglyphs has only been considered most recently (Bednarik 2015) and this work has led to the discovery of kinetic energy metamorphosis (KEM) products in several continents. Replication studies of petroglyphs are inevitably involved in the investigation of their production methods, and they raise issues of biokinetics, energy investment, and the quantifiable empirical effects of petroglyph creation. Combined with inquiries into the taphonomy of petroglyphs and the application of forensic methods, this area of research has emerged as the most productive in generating credible scientific characterization of petroglyphs.

Another important aspect of the science of rock art is conservation science, a field that has been developed especially in the past forty years or so. In the case of petroglyphs, it involves a good understanding of the lithology and the weathering processes they are subjected to. These include the effects of natural moisture (meteoric, capillary, through condensation etc.), and physical and biological weathering. Alleviating these threats is the ultimate purpose of conservation work, and a variety of techniques have been developed. However, it needs to be clearly stated that the greatest threat to any rock art by far is from human intervention, be it by site visitation, professional vandalism of archaeologists, or the incidental introduction of environmental change. Concerning the latter variable, the most obvious factors are anthropogenic climate change and the universal global reduction of precipitation pH (acid rain).

Recording of Petroglyphs

Traditionally, the recording of petroglyphs has been accomplished by a variety of methods, such as freehand drawing, photography, rubbing or stamping, tracing on transparent sheets, and by casting with such substances as latex and wax. There are shortcomings or significant conservation issues with all of these approaches, and more satisfactory in terms of results are night photography, using low-angle ('strafing') lighting to provide better depth to photographs, and photogrammetry [saseas0191]. In the latter method, precise measurements can be taken and 2D or 3D models can be created from orthophotographs. Recent developments in the area of computer vision-based photogrammetry [saseas0108] have resulted in a simplified methodology of generating such models from standard photographs, processing these with dedicated software (Sanz et al. 2010; Plets et al. 2012). The results permit 3D manipulation of digitized products, rendering the documentation not only more dynamic and precise, but offering a tool for scientific dissemination of results and also for the management of petroglyph sites (López Fraile et al. 2016). These developments have already begun to revolutionize the recording of petroglyphs and introduced hitherto unimaginable precision.

Conclusion

The characterization of petroglyphs based on purported meanings has no scientific status because of the inability to test such determinations, and because their pareidolic basis lacks emic credibility. The formal classification of petroglyph motifs is subject to certain epistemological limitations, serving therefore primarily in the preliminary description of surviving corpora. By contrast the technology, taphonomy, and age estimation of petroglyphs are well suited for scientific investigation and review, as are the forensic analysis, replication studies, and conservation of petroglyphs.

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Further Readings

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Figure 1. Petroglyphs of various techniques, including one motif in the very rare negative petroglyph treatment, at Three Kings Site, Utah, U.S.A.
Figure 2. Relief percussion petroglyphs, dated to the Neolithic period, at Jabal al-Raat, Shuwaymis, northern Saudi Arabia.

Fig 1

140x115mm (300 x 300 DPI)

Fig 2

170x120mm (300 x 300 DPI)