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A NEW METHOD TO DATE PETROGLYPHS*

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A new calibrated method based on erosion phenomena is presented for the dating of petroglyphs (rock carvings and engravings) and geomorphic surfaces. In contrast to previous methods of petroglyph dating, which sought to determine the age of various mineral and organic deposits coating the art, microerosion analysis attempts to ascertain the time of mark production itself, by creating a geomorphologically based time frame. The method involves the establishment of calibration curves for the crucial variables to be considered. These are the rock type and climate of a particular region, microerosional indices and age. The theory, practical application, and prerequisites of the method are considered, and the paper concludes by defining the disadvantages and advantages of the method.

KEYWORDS: KARELIA, LAKE ONEGA, NEOLITHIC, GEOMORPHOLOGY, MICROEROSION, ROCK WANES, PETROGLYPHS, DATING

INTRODUCTION

Prehistoric rock art is broadly (though inadequately) divided into two categories: rock paintings and petroglyphs. The former are the result of additive processes, in which paint or pigment has been added to the rock surface. Rock paints consist of one or more pigments (the substance providing the colour), sometimes binders (Loy *et al.* 1990; Prins 1990; Li Fushun 1991) or extenders (Clottes *et al.* 1990), and a liquid base. Since it is often not possible to readily differentiate between paintings and drawings (pigment applied dry) it is best to consider them as a single major class.

Most petroglyphs were produced by a deductive process, the exception being finger flutings in caves which are the result of re-shaping of a soft surface (Bednarik 1986). Rock may have been removed by percussion, abrasion, or, in rare cases, etching with corrosive agents (Dubelaar 1986). It follows, then, that two entirely different approaches are necessary in the absolute, 'direct' dating of rock paintings and petroglyphs: while paintings always present a substance, the preparation of which coincides chronologically with the execution of the art, in petroglyphs a substance has been removed, and is not recoverable.

During the 1970s I developed a concept of '*direct dating of rock art*', contrasting it with the traditional 'archaeological dating methods' (Bednarik 1979, 1981a, and 1984), and defining it thus (Bednarik 1981a): '. . . the most reliable means for determining the antiquity of rock art remains the investigation of features related to the art itself, which either date it (e.g. pigment), predate it (e.g. the rock art's medium, or the particular surface it was executed on), or postdate it (e.g. later cracks dissecting a motif, or precipitates deposited over the art).' After first examining the potential of various patinae, rock varnish and weathering wanes to provide 'direct dating' information relating to the age of petroglyphs, I focused on the rock

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art stratigraphies in several newly discovered caves near Mount Gambier, South Australia. Finding petroglyphs sandwiched within series of cutaneous reprecipitated layers of calcium carbonate, and utilizing the speleothems' susceptibility to various radiometric dating methods, I secured 'direct' rock art dating information from these caves (Bednarik 1981a, 1981b, 1984 and 1985).

At about the same time as I experimented with secondary carbonate dating in Australia, R. I. Dorn began developing his cation-ratio dating method in the south-west U.S.A. (Dorn 1983 and 1986). It utilizes the phenomenon of selective leaching of cations from rock varnish (Engel and Sharp 1958), a ferromanganese accretionary deposit of biological origin. The readily soluble cations K and Ca are compared with the relatively stable Ti. In recent years, Dorn refined the method of calibration with AMS radiocarbon dating of the organic matter contained in rock varnish. Following his striking results in Australia (Nobbs and Dorn 1988), the cation-ratio method was subjected to stringent review (cf. Bednarik 1992 for summary), and Dorn (1990) concedes that it remains an experimental method, that he has to revise calibration curves and that the method 'will always be a weaker sister' of other approaches.

Recently Watchman identified oxalates at a series of rock art sites in Kakadu National Park, northern Australia, and recognized their potential of providing minimum dating where they are in physical contact with rock art. Whewellite and weddellite are salts of oxalic acid and thus susceptible to radiocarbon dating (Watchman 1990).

While it can only be a matter of time before experimental work in the absolute dating of rock paints (Van der Merwe *et al.* 1987; Lorblanchet *et al.* 1990; Loy *et al.* 1990; McDonald *et al.* 1990) leads to a reasonably comprehensive methodology, petroglyph dating remains a largely opportunistic pursuit demanding considerable methodological creativity. Although there are likely to be improvements in the methods of dating surface encrustations, accretions or patinae that cover and postdate petroglyphs, these can only provide minimum ages for the art, which itself may be just marginally older than the mineral skin, or may be many times as old. All 'direct' dating methods so far applied to petroglyphs relate to features concealing or supporting them, such as carbonate precipitates, rock varnish and oxalate skins. This illustrates a preference for techniques that lend themselves to standardization, which are seen as maintaining a semblance of the replicability science demands, whereas exploratory or tentative methods are more likely to be spurned. Complex and perhaps over-sophisticated methods involving 'high technology' are favoured, which only contributes further to diminishing scientific participation of developing countries in these endeavours.

The many potential rock art dating methods that are comparatively simple, cheap and non-destructive (Bednarik 1979) continue to attract no interest. Bearing in mind that all above-mentioned methods involve removal of samples, however minute they may be; that the discipline still lacks a uniform code of ethics regulating the removal of such samples (Bednarik 1990a, 1991a); and that they can in any case only provide minimum or maximum ages, our obsession with 'technological solutions' is very much more susceptible to various criticisms than many researchers may realize.

Only one physical phenomenon has remained of the actual manufacture of a petroglyph: the surface exposed by the impact, abrasion or etching process which produced the mark forming the petroglyph. This process exposes a new lithospheric surface to the effects of atmosphere, hydrosphere and biosphere, an event which indisputably dates the time of execution. If it could be dated, the result would be irrefutable within the limitations inherent to the method itself. Such an approach would be applicable to any rock surface, not just petroglyphs. It would in effect reverse the strategy of previous petroglyph dating attempts which used non-archaeological data in the dating of rock art: it would use rock surfaces or marks of known ages (historically, archaeologically, geomorphologically or palaeogeographically known ages) to calibrate the rate of erosion processes, in order to determine the antiquity of rock surfaces of unknown ages.

The traditional methods of rock art dating will continue to play subsidiary roles, but I find it important to be conscious of their significant shortcomings. Archaeological dating relies on claimed correlative relationships between the rock art and archaeological finds or deposits (either because the art was covered by datable strata; because art-bearing clasts had been found in sediment strata; or because dated portable art is seen as stylistically similar to rock art), which are no doubt valid in many cases, but which are based on unfalsifiable assumptions about stratigraphic integrity, stylistic or iconographically-based propositions, and other unscientific arguments (Bednarik 1991b and 1991c; Tangri 1989).

THE THEORY OF THE MICROEROSION DATING METHOD

Microerosion dating distinguishes between two types of rocks: (1) those on which individual grains or crystals which were fractured, exposed or truncated during the manufacture of a petroglyph are capable of remaining *in situ* for periods exceeding the age of the petroglyph; and (2) those sedimentary rocks that are subjected to relatively swift granular exfoliation or chemical corrosion, such as carbonate-cemented sandstones, calcite and dolomite. Only the former are of interest here, because microerosion analysis is totally contingent upon the presence of crystals or grains exposed by the prehistoric rock artists. Certain rock types are inherently better suited than others, and at least initially composite rocks which include quartz (or another comparatively stable component), such as granite, rhyolite, quartz porphyry, granodiorite, rhyodacite, plagiophyre, quartz diorite, dacite, andesite, diorite, granophyre and the like, are more likely to produce valid results. As reliable quantitative information becomes available, certain other minerals may become susceptible to the method.

Since the method uses optical observation, and relies on the assumption that no chemicals have accelerated or retarded the development of erosion phenomena, petroglyphs to be analysed must be free of mineral accretions or other natural deposits concealing them (including coats of rock varnish, carbonate, oxalate, silica or lichen), paint or other physical enhancement substances, and previous application of a range of chemicals, particularly those influencing the pH environment (cf. Bednarik 1990b concerning professional vandalism).

The microerosion method is based on the principle that for relatively stable rock surfaces, microscopic erosion phenomena provide a measure of their relative antiquity. Of these phenomena, micro-wanes seem to be the most readily definable. To understand the processes of their development, it is instructive to consider the formation and age-relatedness of macroscopic wanes (in geomorphological usage, 'wane' refers to the phenomenon of progressive rounding of a rock edge through weathering processes). Černohouz and Solč (1966) have described a method for determining the ages of blunted edges on sandstone by using two constants a and b, the angle of the edge ϕ, and the distance of retreat at the edge h (Figure 1), in cm:

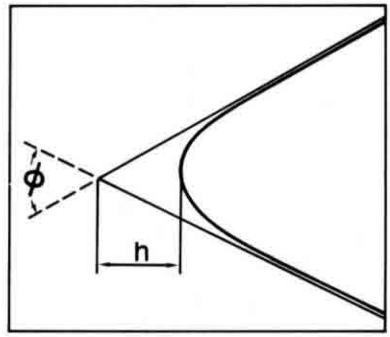

Figure 1 *The development of sandstone wanes, after Černohouz and Solč (1966).*

$$h = \frac{at\sqrt{(2)}}{1+b\sqrt{(t)}} \cot\frac{\phi}{2} \quad (1)$$

Time t in millennia can be obtained, reportedly with an accuracy of ± 10–20%. Černohouz and Solč provide 'experimentally found' constants of $a = 1.01 \pm 0.1$ and $b = 0.20 \pm 0.02$ for a Czechoslovakian sandstone.

This theoretical model is not correct (Bednarik 1979). Dimension h is intended as a measure of retreat from the original sharp edge (Figure 1); however, the rock surface recedes not only at the edge, but also on the two surfaces forming the edge. The reason for the wane formation is that the retreat proceeds markedly faster from the edge than from the flat surfaces. Therefore, the original position of the edge and of the two surfaces at the time it was produced are unknown, and the retreat cannot be measured. It should also be noted that the retreat at the edge 'does not occur as the simple curvature shown by Ollier (1969, figure 149), it consists of a hyperbola in section' (Bednarik 1979, 28).

The various factors one must consider to understand the development of rock wanes are depicted in Figure 2, in which the wane is shown of circular section rather than hyperbolic, in order to simplify the principles of interdependence. In practice, dimensions h, y and A, and angle α are measurable, and 'radius' r can be either determined physically (but only approximately, because it is a hypothetical value, and often not accessible for measurement), or from α and y:

$$r = y \tan\frac{\alpha}{2} \quad (2)$$

The ratio $h:r$ is constant for any angle α, irrespective of distance of retreat of the faces and the edge. Ratio $x:z$ is a function of α, and at $\alpha = 60^\circ$, $x = 2z$. Dimension x can be expressed in algebraic fashion:

$$x = \sqrt{\left[\left(\frac{z}{\tan 0.5\alpha}\right)^2 + z^2\right]} \quad (3)$$

This leads to the prediction of β, the angle expressing the rate of wane development relative to surface retreat:

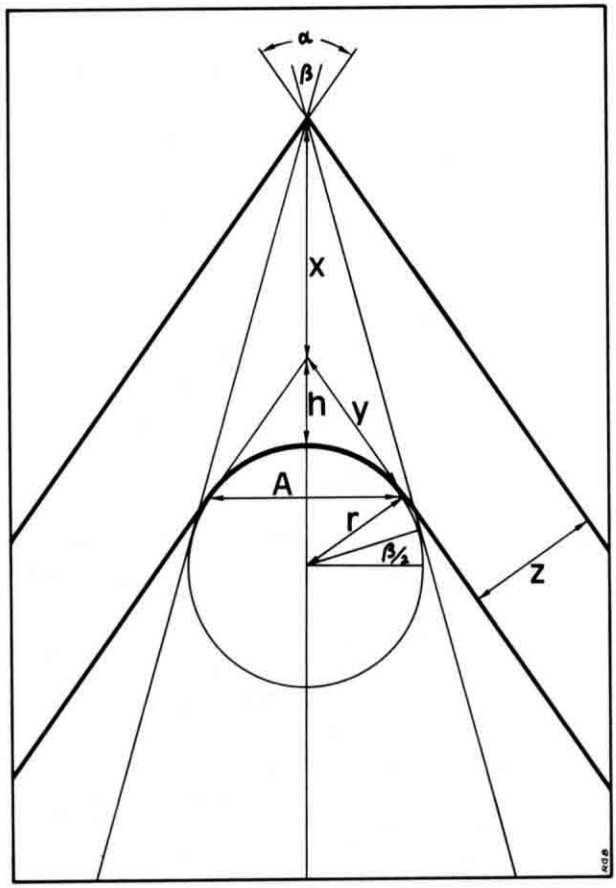

Figure 2 *Diagram depicting the laws of wane formation in a simplified fashion.*

$$\beta = 2 \sin^{-1}\left(\frac{r}{x + h + r}\right) \tag{4}$$

The relationship wane width A with age, irrespective of actual retreat, is ultimately determined by the ratio $\alpha:\beta$, which must be established empirically: A, r, z, α and β are all related in a complex fashion which I shall not attempt to explain here and which it is not necessary to consider for practical applications. These relationships can be expressed in tabular form, as exemplified in Table 1. For present purposes it suffices to know that the incremental increases in time of the variables A, r, x, z and h are all proportionally equivalent.

I postulate that these laws of wane formation are universal, they apply macroscopically (on basalt, for instance) as well as microscopically (on crystals, truncated or fractured grains, cleavage facets or conchoidal faces). Micro-wanes are particularly distinct where component minerals were exposed as crystals upon fracture of a rock, or offer numerous

Table 1 *Typical relationships between* A, r, x, z *and age, for two angles* α *(60° and 160°), and assuming* β *is constant at 60% of* α

	$\alpha=60°$			$\alpha=160°$			
z	*A*	*r*	*x*	*A*	*r*	*x*	*Time units*
15	38	22.5	30	18	45	15.23	1
30	76	45	60	36	90	30.46	2
45	114	67.5	90	54	135	45.69	3
60	152	90	120	72	180	60.92	4

sharp angles and clear cleavage faces for examination. Where such freshly formed surfaces are exposed to erosion, weathering attacks component minerals at different rates. The rates of micro-wane development may vary somewhat through time—they are likely to be susceptible to environmental factors—but such fluctuations are probably minor (for instance, the solubility of most of the minerals being considered here remains fairly stable over the pH range of most natural environments). This is the method's only potential major error source, which can affect its accuracy but not its validity. Certainly, wane formation would be far less susceptible to environmental variations than, say, the cation ratio of rock varnish: while a varnish could conceivably disintegrate in a relatively short time due to chemical changes of a magnitude occurring in nature, no *common* natural agent could appreciably affect the micro-wane formation of quartz (cf. Bednarik 1980, on silica solubility).

Microerosion analysis is of course not restricted to petroglyphs; it can be applied to any geomorphic surface of appropriate characteristics. This may assist rock art dating indirectly, namely when a motif (painting or petroglyph) has been truncated or dissected by a later crack, and the surface exposed by the fracture provides a means of minimum-dating the art.

In introducing a new analytical method it is appropriate to offer some comments on the technical aspects involved. For the assessment of microerosion it is essential to select for

Figure 3 *Examining petroglyph pavement at Zalavruga, Karelia.*

examination cleavage surfaces of homogeneous minerals, preferably with features such as corners, edges, scalloping, impact crushing and fracture margins that lend themselves to ready comparison. Similar features must be examined on all specimens, and compared. Lighting conditions should be uniform, being crucial for accuracy. An almost direct reflection of light provides the best visual conditions for the method. Pavements are easiest to work on, as one can position the microscope (with padded support surface) over the engraved area and work without effort (Figure 3). Scanning of vertical cliffs involves considerably more preparation and effort. For wane assessment, magnifications of up to 100× may suffice, but further development of this methodology may well require the examination of 'frosting' on quartz and other visual phenomena at higher magnifications.

It is of crucial importance that the rock surface being assessed does actually date the manufacture of the petroglyph in question, or the event of its most recent modification. I have found that this is particularly easy to establish in petroglyphs which involved some kind of abrasive process in their manufacture. They may bear microscopic longitudinal striations. While microerosion dating is generally more suitable for percussion petroglyphs than for abraded ones, there are clear exceptions. The basic disadvantage of abrasion petroglyphs seems to be their frequent lack of crystal surfaces and edges that would permit the development of wanes. But grains or crystals truncated by abrasion may remain in situ during erosion, while the intervening cement exfoliates. At Sproat Lake on Vancouver Island, Canada, the petroglyphs on a cliff of dense quartzite rising from the lake are deeply abraded. While much cement has weathered away and even granular massexfoliation has commenced, grains truncated by the abrasion that produced the petroglyph grooves are still plentiful. I found them easy to recognize by the distinct striations they still bear. The more rapid erosion of the cement ensures that micro-wane development at the edge formed by the truncation is not retarded. Thus the Sproat Lake petroglyphs fulfil the crucial requirement for microerosion analysis: remnants of the surface exposed by the rock artist can still be detected.

THE PRACTICAL APPLICATION OF MICROEROSION ANALYSIS

In a practical application of dating a geomorphic or petroglyph surface through assessing microerosion phenomena it is requisite to determine the rate of wane development, initially by establishing a calibration curve for surfaces of known, or approximately known, ages. These rates may vary in different climates, rock types, and even mineral compositions, and since the influence of all such variables is an unknown in the case of a new dating method, one must begin by establishing the necessary knowledge by determining known erosion rates.

After investigating macro-wanes for many years I selected a series of petroglyph sites on the eastern shore of Lake Onega, (former) U.S.S.R., for testing the viability of microerosion dating. Of the various past attempts to date this corpus of petroglyphs 'archaeologically', that of Savvateyev (1982, 1984 and 1988) is the most carefully argued. Based on the hypothesis of Pankrušev (1978), which attributes Holocene water level changes of the lake to buckling of the continental plate, Savvateyev correlates archaeological models with geophysical theory. He relies on the assumption that the petroglyphs were inundated by a transgression 3800 years ago, from which they emerged more than a millennium later. However, my microscopic study of the presumed oldest petroglyphs (at Besov Nos, one of the 22 sites in question) provides no evidence that they could have been inundated for any great length of time, and the water level hypothesis is also refuted by some of the

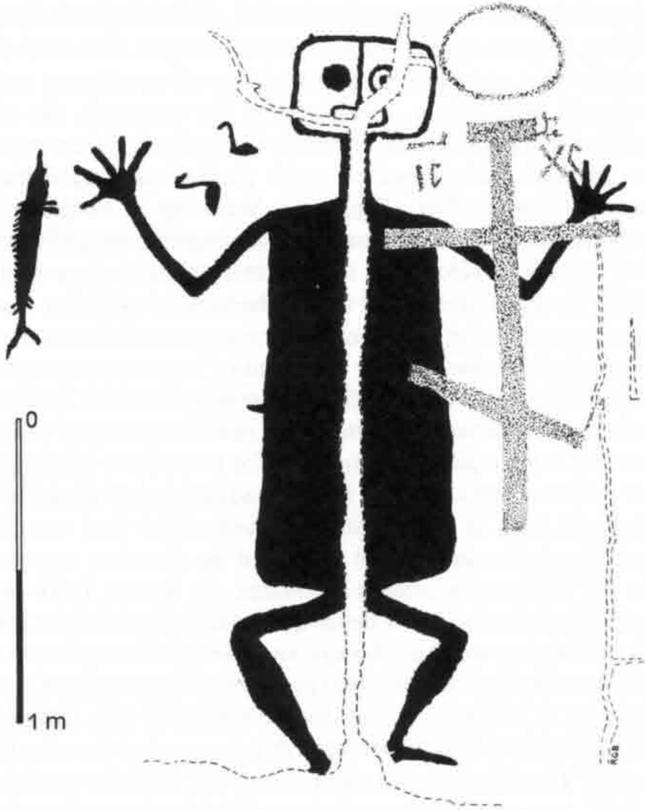

Figure 4 *The Besov Nos 'demon', Lake Onega (former) U.S.S.R. A Russian Orthodox cross, inscription and 'halo' have been superimposed over this large petroglyph, which is thought to be among the oldest in the region.*

archaeological data (e.g. Savvateyev 1988, 63). My survey of motifs which have been below water, or are occasionally awash now (at the nearby sites Besov Nos North 2, Peri Nos 4, 6 and 7), has shown that they have experienced significant removal of feldspar. The rock is a gneissic granite, of 60–70% feldspar (plagioclase), 25–30% quartz and about 5% biotite (thin-sections were taken at Lake Onega and Zalavruga sites). Prolonged exposure to water does not affect the quartz component markedly, but the feldspar becomes deeply pitted and alveolate. No trace of the alveolation process has been observed on the motifs I have examined at more than 1 m above the present water level. Obviously microerosion analysis has applications other than in actual dating (see below).

At Besov Nos I utilized surfaces of known, or approximately known, ages to derive a tentative calibration curve: freshly broken rock; two inscribed dates, '1933' and '1937', about 50 years old; a Russian Orthodox cross with 'halo' and inscription, about 500 years old (superimposed by monks from Murom, fifteenth or sixteenth century AD), engraved partly over the motif that is considered to be the oldest at the site (the Besov Nos 'demon', Figure 4; similar superimposition of religious symbols over rock art has been practised elsewhere to 'neutralize', 'exorcise' or 'convert' the indigenous figures, for instance in Bolivia, Bednarik 1988); and a sample of six of the most recent of the vast number of glacial striae found throughout the area, probably *c.* 10000 years old (the last glaciation withdrew about 9000

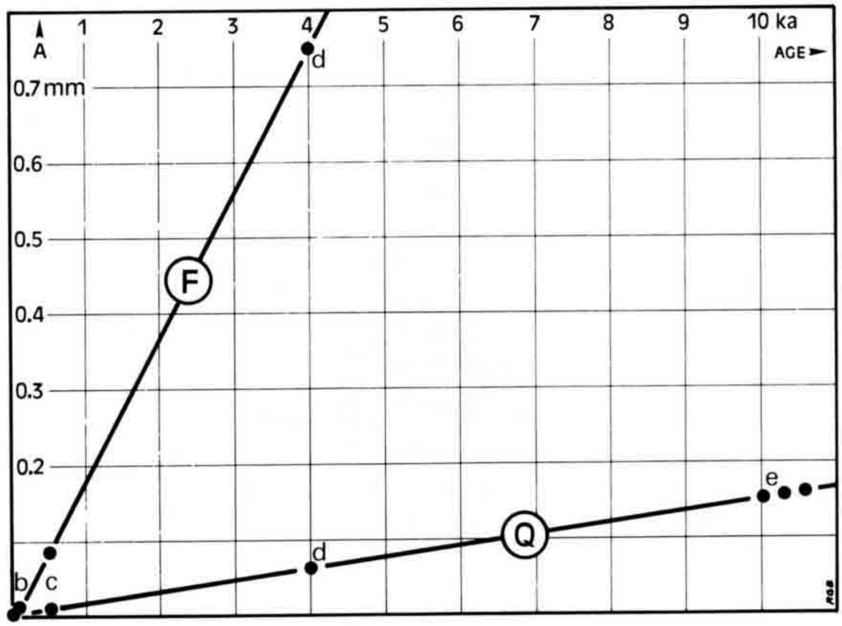

Figure 5 *Model of microerosion calibration curves, using the experimental Besov Nos data. The surface ages* (b), (c) *and* (e) *are known, or approximately known. The age of* (d), *the surface of the Besov Nos 'demon' motif, is to be determined. Curve* (F) *represents the feldspar component, curve* (Q) *the quartz component,* (A) *is the wane width at* $\alpha \approx 90°$, *and the age of the samples is shown in ka (thousand years).*

years BP). My attempts to locate the youngest striae led to the observation that the relative degree of microerosion among superimposed glacial marks corresponds to their relative ages.

The results of detailed scanning of these marks were correlated with microscopic surveys of several areas of the 'demon' motif, particularly of areas of his head and legs. In each area examined, between 15 and 30 edge angles α or about 90° were selected and their estimated wane widths A recorded (Figure 6 depicts these data graphically). The observations are summarized here.

(a) Surface of freshly fractured rock. No weathering of any morphological characteristics.

(b) Two inscribed dates, *c.* 50 years old. Under low magnification (10–20 ×), the cleavage faces of the feldspar appear entirely fresh, edges are sharp, and typical spathic fractures or 'scalloping' remain clear; flat crystal faces are highly reflective. Only at around 100 × does erosion become apparent.

(c) Orthodox cross, *c.* 500 years old. Even at 10 × magnification, feldspar edges are blunt, wane widths of right angle edges are about 0.1 mm, crystal facets are barely discernible, and scalloping is not preserved; reflection is diffuse and surfaces are 'frosted'. At higher magnification the erosion becomes very apparent, micro-wanes are narrow and well defined, wane widths are clearly related to edge angles (as predicted by the theoretical model above). Micro-wanes of quartz become discernible at 100 × ($A < 10\ \mu$).

(d) The 'demon', age unknown. The feldspar micro-wanes suggest a retreat ranging from 6

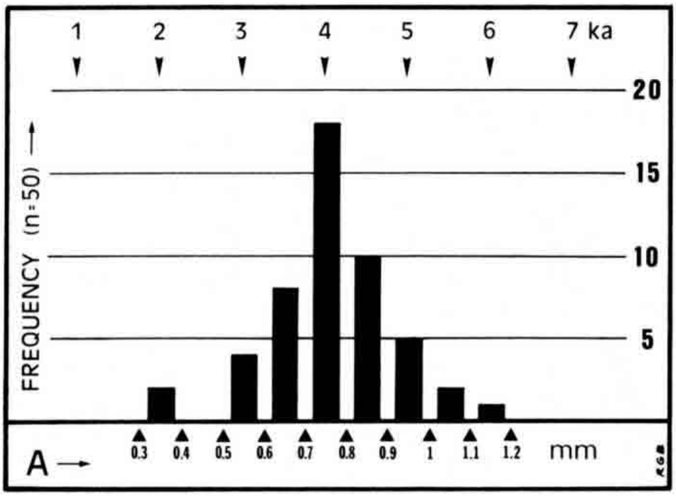

Figure 6 *The relative probability of the sample* (d) *age determination of E4000 years BP being valid, based on Figure 5. Fifty values of* (A), *taken from feldspar on the Besov Nos 'demon', are presented in a histogram.*

to 10 times as much as on (c), flat surfaces have retreated so much that they present a 'sculpted' appearance. Quartz appears 'frosted' even to the unaided eye, and its micro-wanes are quite clear at 20 × ($A \approx 60\ \mu$ at $\alpha = 90°$).

(e) The most recent glacial striae, *c.* 10000 years old. The feldspar has become quite unsuitable for analysis, while the quartz micro-wanes range from 0.1–0.2 mm at median angles (i.e. at 80–100°).

Figure 5 provides a tentative model of microerosion calibration curves, exemplified by the Besov Nos data. It must be emphasized that, at this initial stage in the development of the new methodology, calibration can only be considered valid for the geology and climate of the region where it was obtained. Also, the accuracy of results would be greatly enhanced if we could be certain that the site's exposure to weathering processes has not changed significantly since the production of the marks. One needs to consider several possibilities here, such as vegetational changes, oscillations of climate and environmental pH, or whether a site may have been covered by sediment in the past. In short, this experimental method should be used only with the appropriate restraint and care.

Rather than stating the proposed age for a 'sample' with a reasonable error margin, I prefer to express it in the form of a 'probability histogram', as shown in Figure 6, based on the observed 'spread' of the microerosion data. In this example the probability that the true age is 4000 years is about twice as high as the probability that it is either 3500 or 4500 years, and, while an age of below 3000 or above 5000 years remains possible, it is in practical terms outside the range of realistic probability.

The microerosion dating result of E4000 (the 'E' is to indicate that it is erosion derived) years BP thus seems to confirm Savvateyev's dating to between 4800 and 4000 years BP, or the Eneolithic period—at least approximately. I also agree with Savvateyev's key postulate that the 'demon' is among the oldest motifs of the site.

SUMMARY

Having myself many years ago proposed the first of the currently used quantitative methods of 'direct' rock art dating, I can afford to be critical of these methods. While they have been a great improvement over the traditional approaches (the archaeological, iconographic and stylistic approaches in rock art dating) in that they introduced scientific methods, and while they will no doubt soon lead to routine absolute dating of rock paintings, they are still subject to severe limitations when applied to petroglyphs. Here I have presented an alternative calibrated approach, which is intended to date the event of the art production rather than the age of some subsequent or earlier mineral deposit.

My first results as presented here demonstrate the viability of microerosion dating as a research tool in rock art studies. They also suggest that it may be profitably utilized in various other areas of research. For instance, rock surfaces are likely to bear traces of past environmental events, such as prolonged inundation, exposure to fire, wind blasting, and glacial scouring, and such traces are likely to become apparent during microscopic scanning. Where rock has been subjected to successive fractures, each ensuing surface bears some but not all of these traces, and thus has a relative chronological place within this geomorphological record (Bednarik 1979). The dating potential extends of course to any geomorphic surface, to any man-made or natural rock surface of the right attributes. Moreover, there are various potential applications in comparative studies, for instance to determine relative chronological order fast and reliably, or to discriminate art phases in a specific region and within a single petrological zone. The methodology outlined here defines at best a first stage, and I find it very likely that other techniques will be developed from it in due course. For instance, my recent microerosional study of varnished petroglyphs in the Helan Shan (Ningxia Province, China) has led to the refutation of the key postulate in the dating of petroglyphs via the cation-ratio method (i.e. the postulate that rock varnish formation commences soon after a fresh surface is exposed, usually within a century).

I propose that microerosion studies will deal with the traces of all those erosional processes that occur at the interface between lithosphere and atmosphere, and which reflect specific events, periods or phases in the life of a natural or anthropic rock surface.

The new method introduced here has a few disadvantages, notably in its early stages of development. Its initial dependence on calibration dates will obviously diminish with time, as microerosion rates in different climates and lithologies become better understood. I have investigated the method's potential not only in various parts of Europe, but also in India and Siberia, in North America from Canada to Mexico, in the Caribbean, and in many regions of South America and Australia. This work has led to the view that one will need to focus initially on rock art regions where suitable rock types coincide with rich concentrations of historically datable rock surfaces (like monuments, structures, quarries, inscriptions, and buildings), such as the granite zones of India and on the Nile, or where recent facies are well dated (such as lava flows) and coincide with petroglyphs (as in Hawaii). As reliable calibration becomes available for the three main variables (climate, rock type and age), many regions throughout the world will become eligible for applications of this method.

While the disadvantages of microerosion dating are little more than teething problems of the method, its immediate and tangible *advantages* are most impressive indeed.

(1) It offers very considerable scope for development (which I intend to explore fully), and

this is by no means limited to utilizing micro-wanes; for instance, measurement techniques, statistical controls and calibration procedures can all be greatly improved in future work.

(2) It is the only petroglyph dating method that seeks to date the event of petroglyph manufacture, rather than the age of some related phenomenon which is inevitably either older or younger than the art.

(3) It is the only viable rock art dating technique currently available that involves no damage of the art or of a related feature; in fact it requires no contact with the art at all, being a purely optical method.

(4) It involves no expensive or sophisticated equipment, handling of samples, possibility of contamination, laboratory costs or waiting for results (the results can be determined in the field).

(5) It does not require a great deal of specialist knowledge or training, and can be conducted by a single field researcher, without laboratory backing.

(6) It has applications beyond actual dating projects, for example, it can be adapted for identifying retouch and alteration of poorly patinated motifs, or for simple sequencing and relative chronological cross-referencing.

(7) It is likely to lead to a variety of observations concerning the history of the rock art and its support surface, or concerning the manufacture of the art, because it involves intensive field examination of minute details; it has the very heuristic effect of promoting *scientific* work and inducing researchers to neglect the traditional subjective approaches to rock art.

(8) In contrast to other rock art dating methods, it provides adequate data to satisfy statistical sampling requirements, because it does not provide one single, expensive 'date', but a large number of age-related values. These can be used to generate variance analyses or other meaningful statistical solutions (cf. Lanteigne 1989 and 1991).

(9) While initially its accuracy may only correspond to that of other petroglyph dating methods, such as cation-ratio dating, it cannot be matched by them in terms of simplicity or—perhaps most importantly—reliability. Given the choice between an accurate but not very reliable method, and a reliable but not very accurate method, the judicious rock art researcher will choose the latter.

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