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A STRATEGY FOR THE PRACTICAL APPLICATION OF MICROEROSION DATING

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Abstract. *A brief review of practical requirements in our discipline, in the context of recent developments in petroglyph dating, indicates an urgent need for a low-cost dating methodology that is accessible to most researchers, that is susceptible to realistic statistical treatment, that is reliable and that dates the petroglyphs themselves rather than some feature related to them physically. Microerosion dating can meet these requirements, but its utility depends much on large-scale testing in different geological and climatic environments which provide ample opportunities for calibration. A strategy is developed for such a program, which would involve global co-operation within the discipline. If successful it is likely to result in a viable and widely applicable method of petroglyph dating, and thus solve one of the most intractable problems in rock art studies.*

In the familiar argument that technologically advanced countries must pursue sophistication and excellence for the common good it is assumed that progress for its own sake is intrinsically good, even if it has a negative effect on the global discipline as a whole. I have examined some aspects of this belief recently (Bednarik 1992a) and reiterate that the overall effect is likely to be a widening in the gap between the scientific 'haves' and the 'have-nots'. Even where this can be avoided, it is difficult to escape the neocolonialist effect of scientific progress, unless conscious steps are taken to counteract this trend. One such measure is the development and promotion of research methods that are readily available to most researchers in developing or former socialist countries.

The discipline of rock art studies is crucially dependent upon the reliable dating of rock art, and very considerable progress has been made here in the last decade (Bednarik 1992b, 1993a). To appreciate the significance of rock art dating one needs to realise that we are witnessing a process of complete restructuring of the discipline. The old order was entirely dominated by European values and preoccupations, perceiving every single question and issue in terms of Eurocentricity. Art origins, the beginnings of language, symbolism and culture were all essentially European issues (Bednarik 1991, 1992c, 1993b, 1993c). It is the progress in rock art dating that will make a general reassessment of traditional beliefs in all of these areas possible. The results of just the last few years have already led to some significant changes. For instance, we now recognise that rock art of a conceptual complexity that might have been in excess of the figurative Pleistocene art of western Europe was produced in Australia perhaps 40-50 000 years ago, being at least three times as old as the simple paintings and engravings of Lascaux or Altamira (Dorn et al. 1992; Bednarik 1992d). It is reasonable to expect even older finds, perhaps from Asia. Another major effect of the current dating work is the significant re-assessment of the traditional chronology of European Upper Palaeolithic rock art, which had been based largely on stylistic and contextual reasoning rather than refutable scientific evidence (Bednarik 1992e). The unravelling of the story of early cultural and cognitive development has only just begun, and it would not have been possible without the introduction of credible, non-archaeological dating procedures.

It is evident from recent developments in rock art dating that the methods employed seem to have become increasingly sophisticated with time, and while some of the early methods are accessible to researchers in non-Western countries, and some have indeed been used there successfully (Bednarik and Li Fushun 1991), it does not seem likely that the more recent methods will be widely used in these countries in the near future. My work with many colleagues in developing countries and my acute awareness of their situation led me to search for a method of dating rock art that would be widely accessible, and would reduce dependence on Western technology. It had also become evident, particularly from the work of Lanteigne (1989, 1991), that all of the existing dating methods involve significant limitations in their susceptibility to statistical assessment. Moreover, every direct method of dating rock art has serious limitations of accuracy. In most cases the procedure does not attempt to determine the age of the art itself, but rather the age of some physically related feature. So, while the methods of direct dating of rock art have already been a boon for palaeoart studies, there are still severe limitations in their application and in their precision.

In my endeavours to find a simple but reliable dating method I returned to the geomorphological ideas I had developed during the 1960s and 1970s (e.g. Bednarik 1979). I had long noticed that wane formation is not limited to rock edges (Černohouz and Solč 1966; Ollier 1969). It also occurs at the microscopic level, on the edges of freshly broken crystals. My observations had led me to the view that, whatever the laws of wane formation might be, they would be the same at both the microscopic and macroscopic levels: erosion proceeds faster from an edge or from a convexity than from a flat surface, and this process leads to an increase in the radius of a wane. The laws governing it would probably be identical to those causing the edge rounding in a crystal that is being dissolved, or in a melting object. Essentially, it seemed that the formation of wanes is attributable to the propensity of a reducing mass to attain a physical state in which the reducing coefficients affect the surface uniformly, i.e. a spherical form.

I solved the problem geometrically, and when confronted with the need to estimate the age of petroglyphs in Karelia, Russia, I decided to try out the method in what was essentially a blind test (Bednarik 1992f). The sites were particularly well suited, being on granite, with several sources of calibration data. However, they offer no material for other currently used direct dating methods, no encrustations, accretionary deposits, no patinae. Savvateyev (1984) had provided the most convincing archaeological dating of the art. The results of my microerosion analysis of one motif, being a fairly crude attempt, centre on about E4000 years BP. This was obtained from the largest, and clearly dominant figure of the site Besov Nos (Demon's Cape). It had been considered by Savvateyev to be the oldest figure at the site (Figure 1). Besov Nos is one of about thirty petroglyph sites in Karelia, most of which I have examined microscopically.

The Russian Orthodox cross with halo and inscription, superimposed over the 'demon' figure by missionaries of a nearby monastery of the 15th and 16th centuries, and two nearby dated inscriptions of the early 20th century provided data for the upper end of the calibration curve, and a selection of the most recent of the millions of glacial striae provided the lower end. As the glaciers withdrew 9000 years BP it is reasonable to assume that the youngest striae are around 10 000 years old. The micro-wane widths of edges of about 90 degrees were estimated and their median values plotted on the calibration curve. Accordingly, an approximate age of marginally over 4000 years would apply to the demon figure (Bednarik 1992g). I discovered later that Savvateyev's archaeological estimate placed the motif in the very final Neolithic, which in this region is from about 4800 to 4000 years BP.

The method of microerosion dating is simple, and can be learned easily. A basic knowledge of geology is required, and some familiarity with microscopy is useful. The method is based on my theory of wane development, which is an intricate hypothesis involving geometry. Essentially, it had earlier been assumed that, in the case of macro-wanes on basalt and sandstone, one can estimate age by measuring the retreat and the angle of the two faces (Černohouz and Solč 1966). I had shown (Bednarik 1979) that this is a fallacy, but had not solved the problem at that stage. The theory, which I expect applies to all such phenomena, demonstrates that the micro-wane width has a linear relationship with age. The relationships of the various entities as well as the equations to explain and quantify them are rather complex (Bednarik 1992f). To double-check the results I compare the erosion of two different component minerals of the rock, such as quartz and feldspar in granite. Two different calibration curves are constructed and if the values derived for the sample of unknown age coincide in the two curves it supports the validity of the dating, by significantly reducing the danger that past environmental changes may have distorted the apparent age. Such past environmental oscillations are likely to have affected two (or more) component minerals differently.

It must be emphasised that with this method any rock surface may be dated, not just that of a petroglyph, provided that remnants of the original surface are still present. Obviously one would not consider a site whose petroglyphs may have been buried under sediments in the past, or covered by accretionary deposits such as rock varnish. There are, however, tens of thousands of petroglyph sites in the world where this method could probably be used successfully. Primary candidates are sites where historically or geologically datable surfaces of rock are common and coincide with materials suitable for microerosion analysis. The rock types most suitable are those containing discrete component minerals, particularly if quartz or another comparatively stable component is one of them. They include granite, rhyolite, quartz porphyry, granodiorite, rhyodacite, plagiophyre, quartz diorite, dacite, andesite, diorite, granophyre and the like. However, if remnants of the original surface remain in situ, even quartzitic sandstones may be suitable, especially once the influence of the crucial variables climate, geology and age are sufficiently understood.

The benefits of microerosion dating are so self-evident that they hardly need to be mentioned. This is the only available method that actually dates petroglyphs rather than some other, physically related feature. It is also the only one that involves no removal of samples or other interference, and it involves no major costs, no special equipment, very little training, and it requires no laboratory backing. In contrast to all other dating methods, it provides statistically meaningful data, and its system of expressing tolerances is superior to the traditional, arbitrary pronouncements (Bednarik 1992f). It changes the general impetus in rock art dating from a 'laboratory-orientated philosophy' to one favouring field work: the researcher needs to spend much more time examining the rock art thoroughly, and this is likely to lead to a better understanding of the many traces of past processes that can be observed on any old rock surface. There can be no doubt that the application of this method, and its conservation-conscious design, can have significant effects on research directions once the method has been widely introduced.

The principal shortcoming of the method is that a calibration curve is currently only useful under given climatic and geological conditions, as we possess no adequate knowledge of the effects of different chemical and physical environments. Development of the method involves testing in different geological and climatic environments which provide ample opportunities for calibration. As our knowledge of the variables increases, the precision of microerosion dating will correspondingly increase.

But first of all, the procedures need to be standardised. All I have done so far is postulated a hypothesis, developed a method and demonstrated that the former is valid and the latter is possible. There are several purely technical problems to overcome: how to determine the angle of large numbers of edges accurately and efficiently, and how to measure the wane width simply but precisely. I regard these technological, and quite solvable, issues as a far greater potential error source than the possibility that past climatic conditions could have affected the rate of chemical erosion. The method of using a dual calibration curve which considers two different minerals certainly affords some protection against distortions from environmental variables, because different minerals are unlikely to react to such variables in quite the same way, be they variations in pH, temperature or precipitation. Moreover, the susceptibility of, say, quartz erosion to pH variations is negligible up to pH 9, so this mineral provides a good reference standard in relation to pH changes. Mean temperature oscillations in the Holocene would certainly seem not to have been great enough to affect the accuracy of microerosion analysis. Much greater care may be required with deposits that may have concealed the rock surface in the past, be they liquid or solid: soil strata, accretions, algae or lichen, and inundation by water. The latter, however, is easily recognisable because it results in severe decay of a feldspar component.

In suggesting an appropriate strategy for developing the method, I perceive two basic expedients. One is to apply it in such regions that offer climatically and geomorphically diverse environments with suitable rock types and rich concentrations of historically datable surfaces, such as monuments, structures, quarries, inscriptions, grave stones and buildings, or where recent rock formations are well dated and bear petroglyphs. Examples are the granite regions of Egypt and India, the rhyolite sites in China (Bednarik and Li Fushun 1991), the richly striated petroglyph panels in Valcamonica, Italy, or the lava flows in Hawaii. There are also many other suitable test regions.

The second strategy is to use microerosion in tandem with other dating methods, just as Dorn et al. (1992) have sought to correlate the results of cation-ratio analysis with the AMS radiocarbon determination of microscopic organic inclusions in rock varnish. While microerosion dating ***can*** develop without such cross-checking, the main benefit to be derived from it is an ability to check accuracy efficiently so that the method can be introduced in those countries which cannot afford expensive Western technology, but whose researchers wish to develop their own, independent rock art dating programs. While the researchers in wealthy countries will no doubt experiment with ever more sophisticated methods for the common good of all, I believe that some of that commendable goodwill will need to be channelled into supporting the development of a cheap, reliable, non-interfering and readily available method. Since no direct rock art dating method is as cheap, reliable, non-interfering and readily available as the microerosion method, I urge that it be included in future co-operative projects designed to develop its accuracy, so that rock art dating technology does not become a monopoly of a few Western countries.

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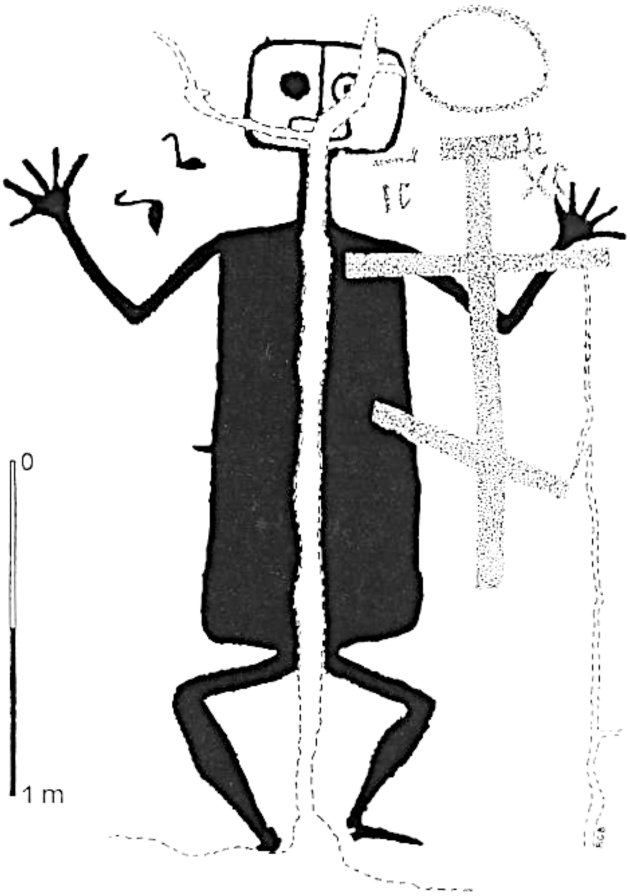

Figure 1. Anthropomorphous petroglyph from Besov Nos, east shore of Lake Onega, Karelia, called 'The demon'. A Russian Orthodox cross, inscription and 'halo' have been superimposed over the anthropomorph.