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NATURAL LINE MARKINGS ON PALAEOLITHIC OBJECTS

ABSTRACT: A type of surface marking found on certain classes of archaeological objects is discussed, and described from two kinds of material evidence: ostrich eggshell fragments from central India, and ivory objects from central Siberia. The phenomenon is explained as the result of plant root activity, facilitated by symbiotic micro-organisms present in the root systems. The recognition of this effect renders it possible to confidently distinguish these natural line markings from engraved patterns. The possible consequences on the identification of marks on other types of materials are briefly considered.

KEY WORDS: Ostrich eggshell – Ivory objects – Decoration – Root marks – Chemical processes – Upper Palaeolithic.

INTRODUCTION

The question of distinguishing humanly made (anthropic) from natural markings is of fundamental importance to prehistoric art studies, and most particularly to the study of the most archaic arts, where it can be quite difficult to discriminate between the two. The literature offers numerous examples of erroneous identifications of rock markings, as well as misidentifications of marks on portable archaeological objects. They include the description of animal scratches in caves as petroglyphs (e.g. Glory 1955: Pl. 2; Hamilton-Smith et al. 1980, Pretty et al. 1983, Sharpe 1982, Sharpe and Sharpe 1976, Vértes 1965, but cf. Walsh 1964, who is more careful in his conclusions), the description of other natural markings as engraved or painted rock art (e.g. Bolger 1979, Hill and Hill 1974: 63, Loendorf 1986, Reid 1962, Rogers 1981, Sharland 1957, for some corrections see Bednarik 1987, 1989a, 1989b, 1991, Both 1963, Sieveking 1982, Sims 1977), and the description of natural markings on portable objects as intentional anthropic patterns (e.g. Dortch 1976, Freeman 1978, Frolov 1981, Leonardi 1988). Conversely, in many cases archaeologists have prematurely rejected the authenticity of human handiwork (some examples are the finger flutings in Koonalda Cave, Australia, which were considered to be natural or accidental, while those of Orchestra Shell Cave were described as animal claw marks by Hallam 1971; the artificial perforation of a wolf metapodial from the Bocksteinschmiede as well as the Bilzingsleben engravings were recently rejected by Davidson 1990).

The identification of doubtful marks on the surface of portable objects and rock is a specialist task which can be formidable even for a researcher with many years of experience in dealing with the many relevant phenomena. Numerous natural processes can result in changes to the surfaces of rock or archaeological objects which deceive even the trained eye and foster a belief that one is looking at non-utilitarian anthropic markings. They include dozens of types of animal marks, several classes of what I have summarized as 'geological' marks (Bednarik 1991), the results of various chemical processes, marks produced by plants and micro-organisms, and even incidental humanly made marks (for instance when a hard surface is marked in the course of serving as support in some production process).

On the other hand, geomorphological processes may alter rock art or other anthropic markings so much that they have been identified as the results of natural phenomena in some cases. This applies for instance to cave petroglyphs which have been significantly altered by speleothems (Bednarik 1984).

THE CASE OF THE MARKED OSTRICH EGGSHELL FRAGMENTS

In the present paper I shall describe and interpret one particular phenomenon which has caused such archaeological misinterpretation, and which may have affected a large number of specimens of ivory, eggshell, gastropod shell, and possibly bones and teeth. In this case the natural phenomenon can be easily identified, and misinterpretation can be readily guarded against by simple understanding of the process involved.

Decorated fragments of prehistoric ostrich eggshell have been reported from four world regions: from India, from the Sahara and Gobi deserts, and from southern Africa. Centrally perforated circular discs of this material have been found in all four areas, and G. Kumar (pers. comm.) has shown that matching replicas of them can be easily manufactured with stone tools. These discs were probably used as decorative beads. In the Saharan Capsian, an epi-Palaeolithic industry, they occur together with engraved containers made of ostrich eggs, and the engravings found on many fragments of this material include animal figures as well as various types of geometric patterns (Camps-Fabrer 1966). Depictions of Saharan ostrich are still common in the region's Neolithic rock art (e.g. Jelínek 1985). In southern Africa, ostrich eggshell beads were made to the ethnographic present by the Kalahari San (e.g. Starker et al. 1963: 153), but the practice of utilizing the shell extends into the Pleistocene (Wendt 1976), and the earliest engraved ostrich eggshell may even date from the Middle Stone Age.

In India, where the ostrich has long been extinct, 44 sites with fragments of ostrich eggshell have been recorded so far (Kumar et al. 1988, Kumar et al. 1990). At some of these sites the shells are stratigraphically associated with Palaeolithic stone implements. A small proportion of the many fragments found has been reported to bear engravings, while a total of four certainly authentic (Bednarik 1990a) perforated disc beads have been recovered from two sites. Two beads were found at the neck of an Upper Palaeolithic human burial at Bhimbetka IIIa-28 (Wakankar 1976). They bring to mind the large number of Upper Palaeolithic beads of other materials from Russia, including those from Mal'ta, Siberia (Abramova 1962: Pls 55, 56), and thousands from three Sungir burials (Bader 1978).

Sahni has conducted a SEM study of Indian eggshell fragments, concluding that they are certainly of ostrich, and similar to those of *Struthio camelus molybdophanes* on the basis of morphology, but that cf. *Struthio asiaticus* may have had a similar pore structure (Sahni et al. 1990).

The suggestion of Kumar et al. (1988) that ostrich eggshell fragments from seven Indian sites (Patne, Bhopal, Bhimbetka, Nagda, Chandresal, Ramnagar, Kekadi) bear traces of human modification has been debated by Nandadeva (1988), Tyagi (1988) and Wakankar (1988). In the course of this debate, several aspects of Kumar et al.'s proposals were rejected, including the suggested iconographic identification of one engraving as depicting part of an animal. The small scale of the engravings was queried, and Nandadeva considered that most are 'obscure' and doubtful.

A number of the Indian eggshell objects have been dated, in some cases via their own radiocarbon content, and the dates so far secured range from 25,000 to about 39,000 years B. P. (Kumar et al. 1988). They are therefore clearly among the oldest art evidence in the world, and most particularly in Asia (Bednarik 1990a). They are crucial in understanding very early art evolution and it is important to resolve any questions concerning their authenticity.

When Kumar and colleagues presented their 1988 paper they had not actually examined all the specimens themselves, relying instead on the description of others in some cases. A comprehensive critical study using microscopy was conducted by G. Kumar and myself in early 1990, as part of a major study tour of India during which all known or alleged Palaeolithic art of that country was examined on a common basis. This project even led to the unexpected discovery of significant new evidence of various types, such as the discovery of the first prehistoric petroglyphs in the central Indian rock painting region (Bednarik et al. 1991) and a striated haematite pebble from the Acheulian (Bednarik 1990b). Among other material I examined 45 'decorated' ostrich eggshell fragments in various collections, and visited three major find sites of such shell (Chandresal, Ramnagar, Bhimbetka) to analyze their sediments. Even new specimens were located at two of the sites during this field work.

I regard only one specimen, from Patne (*Figure 1*), as being actually engraved. Its markings are morphologically very different from those on all other fragments.

The Patne specimen measures 28.9 × 20.5 mm and is around 1.9 mm thick. Its well preserved surface remains partly concealed under a quite crystalline deposit of reprecipitated calcium carbonate, after more of this encrustation has been removed at the time the object was found. The band formed by cross-hatching is about 4.8 mm wide, the two bordering lines are almost parallel. The hatching is arranged at 30 – 32 ° to the 'outer' border in one direction, at 27 – 47 ° in the other, and the spacing between individual

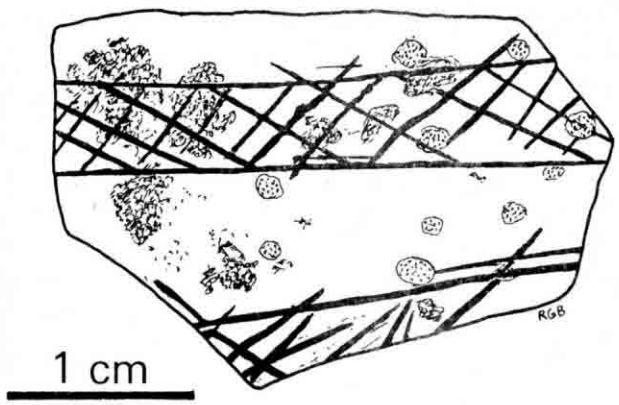

FIGURE 1. *The engraved ostrich eggshell fragment from Patne, Maharashtra, India. Upper Palaeolithic, approximately 25 000 years old.*

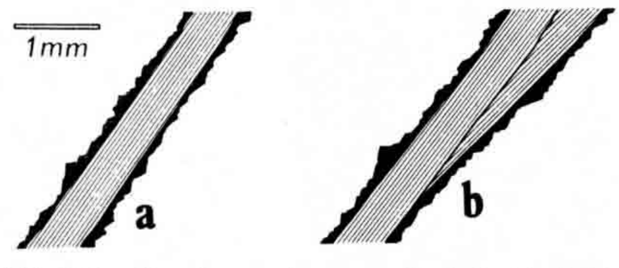

FIGURE 2. *Typical engraved groove on the Patne ostrich eggshell object, with the splintering scars shown in black on either side of the groove (a); (b) depicts duplication of a groove.*

hatching lines ranges from 0.8 – 2.7 mm. The second, truncated design is less regular. There is considerable variation in the depth and cross-section of individual grooves (which are up to 1 mm wide), and it is quite clear from microscopic examination that the abrasive action that formed them resulted in distinctively jagged edges along the grooves. This flaking effect is probably related to the three-layered structure of the eggshell Sahni has identified in his SEM work: the scoring of the shell's outer surface with a stone burin has removed minute angular scales of Sahni's thin 'external layer' (Sahni et al. 1990: Figure 2) on either side of the actual groove, as shown in *Figure 2a*. The pattern is so distinct that the direction in which the engraving implement was moved could probably be determined from it, had the tool been moved in only one direction. I believe that grooves on the Patne specimen were made by repeated application of the tool in both directions; repeated tool application is confirmed by the presence of some 'duplicated' grooves, where remnants of an earlier groove can be discerned along a subparallel later groove (*Figure 2b*).

Sahni et al. (1990) identified three layers in Indian ostrich eggshell: a thin (< 0.1 mm) outer veneer they call 'external layer'; the main body accounting for about three-quarters of the shell's thickness, called 'prismatic layer' due to its vertical columnar structure; and the inner, 'mammillary layer', in which the prisms terminate. The engraved lines on the Patne specimen are up to about 0.15 – 0.20 mm deep, while the pressure scale scars alongside them are only between one-tenth and one-quarter of the groove depth, which may coincide with the depth of the external layer (*Figure 3a*). The bottom of individual grooves is too corroded to permit the detection of engraving striations.

The grooves on the remaining 45 marked Indian ostrich eggshell fragments differ significantly from those on the described Patne specimen. In section they are distinctively rounded (*Figure 3b*) and clearly attributable to a solution process rather than a mechanical (e.g. abrasive) process. They are in the order of twice the width of the engraved lines, they lack straight lines, meandering over the surface in a random fashion, frequently fading out, or varying in depth. Unfortunately nearly all of these objects are small, providing inadequate information about the patterning of the marks on a larger scale. Only one specimen, from Ramnagar, is of a size permitting individual lines to be traced over several centimetres. It measures 52 × 49 mm and was assembled from four fragments. It is also the only one that bears clear markings on the inside (the concave surface), although these are considerably fainter than those on the outer surface. On other specimens, well-defined markings are restricted to the convex surfaces, although some vague patterns seem to occur on some concave sides. This suggests that the solution process causing the channels is significantly more effective on the smooth outer surface of the eggshell, than on the 'mammillary layer'.

The involvement of a solution process certainly does not automatically exclude the possibility that pre-existing artificial engravings have been emphasized by such a process, perhaps because the removal of a protective surface lamina had exposed a slightly more soluble structure beneath. However, I could not detect any apparent patterning in the arrangements of the grooves, or any form of 'strategy' or detectable intent.

To better appreciate the circumstances affecting these marks it is clearly essential to consider the geochemical environments from which the objects come. The survival of Pleistocene ostrich eggshell at unprotected sites is itself remarkable, and would re-

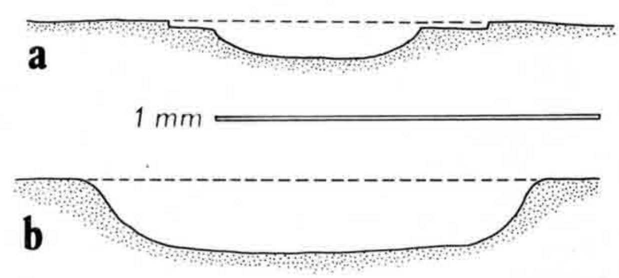

FIGURE 3. *Typical cross-sections of (a) an engraved groove on the Patne ostrich eggshell object, depicting the splintering of the surface layer; and (b) a groove produced by root action, as it appears on both Indian ostrich eggshell and Siberian mammoth ivory.*

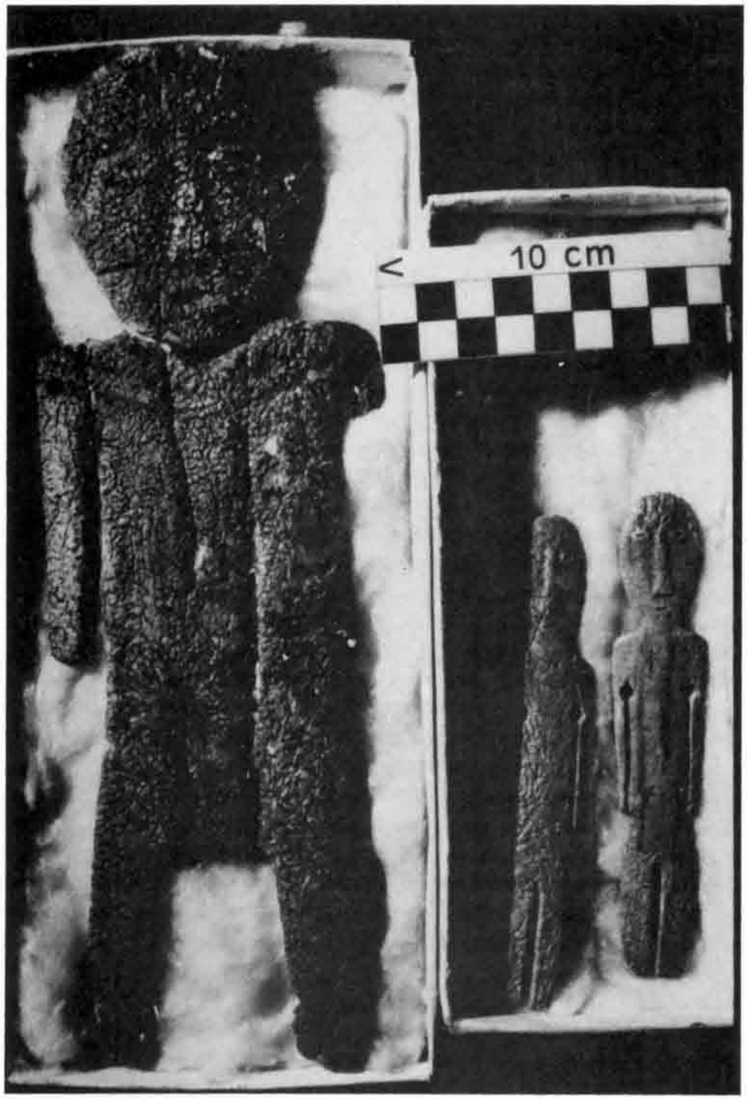

FIGURE 4. *The three ivory anthropomorphs from Ust'-Uda, central Siberia, showing very extensive linear marking by roots on much of their surfaces. Angara River, Bronze Age.*

quire an alkaline sedimentary matrix. At the find sites I examined it is quite evident that the soil profiles are most conducive to the survival of these remains. I obtained readings of pH 8 – 8.5 adjacent to egg-shell fragments weathered out of the deposit's surface at both Ramnagar and Chandresal, and without doubt higher values (probably close to the abrasion pH of limestone, almost pH 10; Bednarik 1980) apply within the unweathered layers beneath. The uppermost horizons at both sites are partially decalcified, and both sites have layers of well-developed calcite concretions below this. At both sites, a 2.5 m fluvial sediment sequence overlies bedrock, lacking a true stratigraphy; the strata of reprecipitated calcium carbonate merely mimic a stratigraphy, they are in fact post-depositional phenomena.

These deposits are dissected by extensive dendritic networks of *nalas* (drainage gullies) which provide ample opportunity to examine the sediments and their contents. At the surface, Mesolithic debris such as fluted cores and microliths abound, the uppermost metre or so of the deposit contains Upper Palaeolithic stone implements. There are tools of Middle Palaeolithic typology below this, while Acheulian handaxes and cleavers of brown quartzite occur just above the basalt rock. The ostrich eggshell seems restricted to the upper half of this sequence, and the six specimens I have seen in situ were in the zone characterized principally by an Upper Palaeolithic industry.

It seems very unlikely that a solution process could be active on these objects at the present time in this sedimentological environment, so the agents responsible for this phenomenon are to be found in the distant past. This is supported by the matching surface condition in the few instances where individual fragments could be fitted together. The smallness of most of the available sample of markings prevents a proper morphological assessment of the patterns, however. More conclusive evidence was required to determine the process that had caused them.

THE CASE OF THE MARKED IVORY OBJECTS

Ivory objects occur throughout much of the Eurasian Upper Palaeolithic, from the early aurignacoid industries of central Europe (Bednarik 1989c) to the final Magdalenian (Bednarik 1970). They were generally manufactured from mammoth tusks. In Siberia, this material was salvaged even in the Bronze Age and the Historical period, long after the extinction of the mammoth, and utilized for the production of art objects. In Europe the mammoth became extinct at the close of the Würm, it survived into the Allerød in Siberia, and to about 3,730 years ago on the remote Wrangel Island (Vartanyan et al. 1993), while the time of its extinction in North America (it ranged to Mexico; Bednarik 1990c) remains uncertain, but it was probably survived there by the mastodon. The remains of an estimated 25 000 mammoths have been unearthed in Siberia, the region considered here (Kurtén 1968: 138).

The state of preservation of archaeological ivory objects differs considerably among different localities, and obviously provides a number of clues to the geochemical conditions they were subjected to. The four most commonly observed surface types are: shiny, polished and well preserved surfaces; corroded, altered or discoloured surfaces; the various stages of exfoliation along natural laminations of the ivory, which results in a specimen's slow disintegration into subparallel lamellae predetermined by growth planes (as seen, for instance, in the female figurine Kostenki No. 2, and in several of the Avdeevo specimens); and finally the one being discussed here: a filigran-like network of surface solution grooves which usually covers part of an object, and in most cases only one side of it. This is particularly evident at the Siberian sites on the Angara River, near Irkutsk, and published examples are the anthropomorphs from Mal'ta No. 5 (its markings are not extensive), No. 6 (particularly on back of legs), No. 7, No. 9 (on back of figurine only, and quite extensive), No. 10 (front of figure) and Mal'ta 'flying bird' No. 5, among other objects from that site (Abramova 1962). At nearby Buret' (115 km from Mal'ta, but on the right bank of the Angara), the effect is even more pronounced on some specimens, particularly on the solitary 'flying bird' pendant from the site, anthropomorph No. 4 (most of the surface), and to a lesser extent on No. 3 (mostly on the front of the torso).

However, this solution phenomenon is not restricted to Palaeolithic finds, it can be seen also on several more recent specimens from the Irkutsk region. By far the best examples I have examined are three flat anthropomorphous figures made from ivory plate of only a few millimetres thickness (manufactured like the much older Kniegrotte amulet and similarly perforated for suspension; cf. Jelínek 1988: Figure 33). They were found by Abramova and Okladnikov in 1926 in a Bronze Age grave at Ust'-Uda on the Angara River. Two of the figures are each about 13 cm long, the third measures 27.8 cm. Although the two smaller objects also bear the lattice patterns, I shall most closely examine the larger of the three here, because it offers an unequalled opportunity to study the morphology of the marks on a large surface (*Figure 4*).

Individual lines are generally 1 – 1.5 mm wide, of uniform width and cross-section, with a rounded bottom and well defined. They meander over the surface seemingly aimlessly, often until they reach the edge. They then wrap partly around the edge only to disappear abruptly. In several cases lines branch off others. These disjunctive elements and the general arrangement of the patterns clearly favour the explanation that the marks were caused by vegetation, most likely by rootlets. These probably found their growth impeded by the buried object, they followed the surface until they reached its edge, wrapped around it and then continued their progress unobstructed. Morphologically the marking arrangements resemble the webs formed by rootlets on the surface of objects such as rocks.

Numerous plant species have symbiotic associations of the mycelium of a fungus with their roots (conifers, for instance). In endotrophic mycorrhiza the fungi penetrate deep into the internal cells of the root, while in ectotrophic mycorrhiza they only enter the epidermis. They can form a fine web over the surface of the rootlets, and I have often observed most luxuriant growths of this type on rootlets penetrating limestone via fine fissures. Mycorrhizal associations are complex and remain inadequately understood. In many species of plants they extend to bacteria within the root systems whose presence remains largely unexplained. Presumably they relate to the plant's metabolism, assisting in dissolving salts (the function of roots, besides providing support, is to supply the plant with water and nutrients, i.e. salts). The respiratory carbon dioxide of these micro-organisms reacts with moisture in the soil to form carbonic acid, which dissolves calcium carbonate (ivory is a dense form of dentine, which consists largely of $CaCO_3$) locally. The mycorrhizal relationship thus supports the nutrient exchange system and at the same time provides certain plant species with the means of attacking limestone bedrock and utilizing it for mechanical support (I have observed eucalyptus roots which had penetrated more than 20 m of solid limestone in this fashion, in southwestern Australian caves). It is relevant to consider that the CO_2 content of air is in the order of 0.03%, while the CO_2 content of a soil atmosphere (the gaseous component of a soil) can be 300 times as high (Ollier 1969: 40). This carbon dioxide is of biological origin (it is the result of oxidation of dead plant matter and respiration of soil microbiota; for a detailed discussion of the relevant chemical processes, see Hendy 1971), which is the reason why carbonates reprecipitated as speleothems are datable via the radiocarbon method: at the time the organism died, or the CO_2 was exhaled, it comprised ^{14}C in a known ratio, which was reflected in about one half of the speleothem's carbon at the time of precipitation (for the first application of this method in rock art dating, see Bednarik 1984).

I have observed grooves on limestone blocks which plant-induced solution had caused (Bednarik 1991). The channel patterns on mammoth ivory and ostrich eggshell may have been produced by the same process, although alternatives remain to be considered. As I mentioned, mycorrhizal relationships are poorly understood, and may well involve more complex microchemical processes. It seems possible, for instance, that organic compounds (such as acetic, formic, oxalic or propionic acid, to name a few) or even organically derived inorganic corrosives play specific roles in such associations.

Whatever the precise processes are, in the case of the archaeological objects considered here they result in a network of channels which essentially replicate the course of rootlets following the surface of the objects. This explains why the majority of these specimens bear the markings only on one side (presumably the upper side as they lay in the ground), and it also explains the arrangement of the channels, including the branching elements.

If one were to break the Ust'-Uda specimens into numerous small fragments of the size of most of the ostrich eggshell finds, the marks on individual pieces would appear much more artificial than if they are seen within their overall pattern. One would then see only a small number of lines on each fragment, seemingly forming a non-iconic 'motif'. It is only by seeing the parts in their context that the absence of any marking strategy becomes apparent. The misidentification of the Indian ostrich eggshell markings is attributable to this factor, primarily. The markings are in effect identical to those on Siberian ivory objects in every conceivable detail: in groove section, groove width and groove depth, and in their arrangement generally. The eggshell is chemically similar to ivory, consisting also essentially of calcium carbonate. If there were any clear morphological differences in the markings of the two corpora of evidence I have failed to detect them, and they could no doubt be accounted for by differences such as those one would expect to find between root structures of plant species in the respective regions, central India and central Siberia.

DISCUSSION

There are other similarities and they raise further questions. They concern the relevance of the sedimentary matrix and its influence on survival and preservation of objects consisting of calcium carbonate and similar materials. While it is true that the majority of the Indian ostrich eggshell fragments come from fluvial sediments, whereas the Siberian ivory objects are found in loess, i.e. aeolian deposits, the relevant chemical and pH environments are similar. Like the Indian sediments, the loess deposits of central Siberia (which I have studied at six Palaeolithic sites) are alkaline and often contain zones of carbonate reprecipitation in the lower strata, although these do not usually result in the pronounced horizons of concretions found at the Indian sites. Moreover, the ivory objects of Russia as well as those of the central European Upper Palaeolithic come either from calcite and dolomite-rich loesses (for important discussion of this subject, see Hädrich 1975), or from limestone caves where they were not only protected from the elements, but also preserved in carbonate-rich sediments of wind-blown or washed-in clays and loesses.

Neither the ostrich, nor the mammoth, nor the Upper Palaeolithic people utilizing the eggshell or the ivory can reasonably be presumed to have limited their range of distribution to regions with sediments favouring the preservation of calcium carbonate objects. It would therefore be judicious to question the distributional inferences based on the occurrence of such objects. Similar limitations should be observed in the distribution-related interpretation of various other archaeological materials. As a general rule it is to be considered that there are pronounced sedimentary, and various other, biases in the preservation of Palaeolithic material, which are likely to be reflected in perceived distributional, and other (e.g. statistical), patterns. These biases need to be taken into account in interpretations of Palaeolithic 'data' and it is necessary to reject simplistic notions about how trends in the empirical evidence can be translated into archaeological interpretation. (To give one example: the perceived sharp transition between the Middle and Upper Palaeolithic in Europe, coinciding with the appearance of art, is very probably part of archaeological mythology, as it can be more convincingly explained as a shift in technology, substituting non-perishable for perishable non-lithic materials.)

There remain several unresolved questions regarding the solution grooves on archaeological objects. For instance, why are the ostrich eggshell fragments almost always marked on the convex side? A mechanically selective process (such as the kinetics of water motion) could of course have favoured deposition with one or the other side uppermost, but I find it more likely that this can be explained in terms of differences in solubility, between the external and internal surfaces of the eggshell. Sahni's SEM identification of three discrete structural layers tends to support this explanation, as does the occurrence of very faint lines on the concave surface of the largest specimen: it may indicate that the internal surface is more resistant to solution. The considerable effects of very marginal differences in the solubility of carbonates are of course a well-known geochemical phenomenon (consider aragonite vs calcite, or the selectivity of replacement processes). Thus the paucity of fragments with the much fainter markings on the concave side may even reflect a bias in sampling: they would not be easily detected.

Would it be possible for a specialist botanist to identify the plant species involved in the mark production, from the arrangement of the root traces? I doubt it, because we cannot know for sure whether only one or more species were involved; whether the marks were produced by one individual plant, or in successive episodes caused by different plants. Not only is the available sample too small for such a broad quantitative comparison, we could never be sure that we compared the markings of a single species. The root system of grasses, sedges and most ferns is a fibrous lattice of numerous roots of about the same diameter, it therefore resembles the patterns on the specimens, but this certainly does not provide valid evidence.

The objects considered in this paper were all located well below the reach of dense root systems, and it is almost certain that their exposure to root action relates to a distant past, presumably to a period when they were located closer to the surface. This view finds some support in the fact that some of the youngest finds are among the most extensively marked. Thus the amount of marking is not a function of age, which suggests that solution occurred during a discrete phase of the object's history, and the varying densities of marking on items from a single assemblage, even on different parts of a single object, indicate considerable variations in the local effectiveness or influence of the process responsible.

The implications for other archaeological materials are also of interest. The shells of freshwater or marine gastropods consist of calcium carbonate and would certainly be expected to be suspect to the described processes, but I have not observed any specimens so affected. Teeth could be marked in the same way, as of course could objects of limestone, travertine, stalactite or marble. Calcareous materials occur often at archaeological sites, as artefacts or as non-artefactual debris; for instance many of the female figurines of the European Upper Palaeolithic have been fashioned from limestone (e.g. Bednarik 1990d: Figure 1). Bone and antler consist largely of calcium phosphate, which may not be as susceptible to the process considered here as ivory and eggshell are. Nevertheless, natural markings found on bone do bear some resemblance to the solution grooves I have described, although they also differ from them in other respects. A comparative study is required to examine whether the same factors might be involved. There are instances where such natural linear marks on bone have been mistaken for humanly made marks.

SUMMARY

I have shown that archaeological objects which consist either largely or entirely of calcium carbonate are susceptible to a highly selective solution process which forms surface channels tracing the rootlets of vegetation. This process is apparently attributable to a mycorrhizal symbiosis with micro-organisms and its results can be readily recognized by its quite distinctive traces. They consist of shallow channels of uniform width which follow a meandrous course over the surface for some centimetres. The grooves are distinctively rounded, and they lack any traces of impact, abrasion or force, such as striations, spalling or flaking. They are frequently restricted to one side of an object, and their density or distribution varies usually over the area they occupy. Superficially they resemble the filigree networks certain borers produce under the bark of many tree species.

This finding results in the rejection of nearly all the Upper Palaeolithic marked ostrich eggshell objects found in India, which have so far been regarded as having been engraved: apart from the few exceptions that are authentic (and are so beyond a trace of doubt) they are clearly not artefacts, but the results of a natural process that can easily mislead even the most conscientious researcher. My findings may also be relevant to the question of identifying similar patterns on other materials, such as limestone, ivory, gastropod shells, teeth, and possibly also on bone.

Finally, I have related some general considerations on the sedimentary bias in the preservation of Palaeolithic material, and on how they distort statistical or distributional data, leading to archaeological misinterpretation of evidence.

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