

A Logic of Archaeological Inference

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‘Hardly a pure science, history is closer to animal husbandry than it is to mathematics in that it involves selective breeding. The principal difference between the husbandryman and the historian is that the former breeds sheep or cows or such, and the latter breeds (assumed) facts. The husbandryman uses his skills to enrich the future, the historian uses his to enrich the past. Both are usually up to their ankles in bullshit.’

(Tom Robbins, *Another roadside attraction*, 1971)

The scope of archaeology

If twenty years ago archaeology was at a crossroads, then today it languishes in a traffic jam somewhere in a spaghetti-like motorway interchange, confronted by a vast array of choices, confounded by the inertia of self-consciousness and complacency. In a modern world where the smart money is on strange attractors, phase space and fractal geometry, archaeologists are just beginning to discover that their subject might relate to the real world, a world that is probably thirty years out of date. At a time when archaeologists should be looking to the past for sophisticated expressions of non-linear behaviour, there are those who say that the past is too dark a secret to unveil. I feel that there is an infrastructural problem: namely that there is no infrastructure; there is no mechanistic, Newtonian framework to fall back on, no quantum theory, no periodic table for the archaeologist. There is barely any philosophy, and that which exists assumes, to continue the metaphor, that everyone knows which side of the road to drive on.

There has been no comprehensive treatment of those problems of philosophy which particularly concern archaeologists. It is unlikely that such a survey could be written, for archaeologists rarely agree on the scope of archaeology (this is probably one of its enduring charms), let alone on the fundamental set of questions which it needs to address. This paper does not attempt such a survey; my intention is rather to look at some of the problems of logic and inference which a practising archaeologist is hound to encounter at those frequent times when the bullshit rises too far above the ankles, and to suggest that a modest infrastructure is an attainable destination, a stopping place on the road to the really interesting problems which are out there waiting for us.

Ironically, philosophical questions have played a prominent role in claims for the scope and status of archaeology. Many of these claims have been based on faith, rather than logic, but occasionally archaeologists, philosophers and other influential thinkers have suggested either that archaeology offers special methodological tools not shared by other disciplines, or that its unique concern with the past expresses social, political and moral solutions to human problems. Often these claims have been dismissed as trivial, or over-ambitious, and this must partly be because they lack consideration of the special problems of archaeological philosophy.

V. Gordon Childe, who read more philosophy than most archaeologists, held that culture was an information system which must exist to give evolutionary advantage to the human species. Knowledge, he argued, must be practical, passed from one generation to the next, bestowing a cumulative advantage on its recipients. He saw part of the role of archaeology as a useful means of making people think more, and ultimately behave in a more 'humanly' way (McNairn 1980, 134- 50). However, such functionalist arguments are now extremely unfashionable.

The French philosopher Michel Foucault believed that archaeology, as a tool, was a powerful aid to examining developments and change in the progress of thought, hence archaeology as 'text'. Although Foucault's language is often opaque, it is clear that he held a concept of the archaeological method, even though he seems not to have made an explicit statement of what exactly that method was (see, for example, Gutting 1989, 227f). In contrast to Childe, Foucault believed that this method was helpful in displacing man from his unique position, while inheritors of his philosophical tradition, notably Shanks and Tilley, have taken up an extreme 'anti-positivist' stance (Bell 1990).

Exponents of the New Archaeology, and in particular Lewis Binford and David L. Clarke, have claimed that archaeology has a unique conceptual apparatus which elevates it to the status of a social, perhaps even a natural science, a claim vigorously denied by the post-processual school, especially Ian Hodder. However, the archaeological philosopher Merilee Salmon has treated these claims with more than a token respect (Salmon 1982, 8-30), so it is possible that they may possess an as yet unproven merit.

Other archaeologists, especially those of the behavioural school, have stressed that a firm understanding of the processes of formation of archaeological entities and data is desirable before more high range theoretical propositions are attempted, but that the search for such 'covering laws' should not be hindered by our present ignorance. It seems that without an adequate treatment of the problems of archaeological philosophy these claims will (indeed, they very often do) fall on deaf ears. Why, it might be asked, should a discipline so young, and apparently quite derivative, have come up with a unique apparatus for looking at patterns in data whose nature cannot even be agreed upon? This is a highly significant question, which I shall return to.

Most philosophical concerns of archaeologists have concentrated on problems of Law-making, confirmation and causality, and yet have failed to deal with some really big questions, such as the very existence of archaeological entities. The answers to some of these questions may be taken for granted (in the manner of archaeology as archaeology as tautology) but with slender justification, for philosophers themselves are still very much concerned with questions of existence. There is also a tendency for high level theoretical statements to be dismissed as trivial (for example, the much derided 'Mickey Mouse' laws), and this must be a sign of immaturity in the discipline, for often apparently facile problems reveal a great degree of complexity when they are considered explicitly rather than tacitly. The world would have been poorer (intellectually, at least) if Einstein, when at the age of fourteen he began to wonder what it would be like to ride on a beam of light, had been discouraged from pursuing such an apparently puerile line of enquiry.

Nevertheless, if archaeology is to claim a genuinely unique apparatus for dealing with classes of data which may or may not exist, it must address unique questions not dealt with by other natural or social sciences, even though it may share many other concerns with these disciplines. That is not to

say that it really matters whether we call archaeology a science or not.

The philosopher Frege (1848-1925) demonstrated the value of what he termed *begriffsschrift*, which in English means something like 'the putting of concepts into notation'. Archaeology has singularly failed to put its concepts into notation, with the exception of stratigraphy and some middle range correlates generated by the behaviourist school. There is, however, no logical reason why ideas about the past should not be dealt with in this way. In particular, if there are unique relations which exist between the archaeologist and the matter of the past, there should be a means of denoting these. Taking the point of view of a practising archaeologist who feels the need to increase the reliability of statements made concerning the past, I have attempted a notation of those relations which concern me below. Initially, however, I want to outline some of the problems which we may need to consider on a 'first principles' basis.

The existence of archaeological entities

If the first of these problems is the very existence of archaeological entities, and we can broadly establish their existence, then the next problem is to account for their nature. What are they like? What do they consist of? How big or small are they? We then have to address the questions posed by the two fundamental archaeological relations: that between the human being in the past and the artefact (in the broadest sense of that word) which she, or he, produces; and that between the artefact and the archaeologist. Will a consideration of these relations lead us towards a logic of archaeological inference?

Let it first be said that the existence of anything external to ourselves cannot be demonstrated with any certainty. The only thing of which we can really be sure is the existence of the sense data (to use Bertrand Russell's phrase) from which we construct the external world around us. The systematic doubt expressed by the French idealist philosopher Descartes demonstrated that subjective things are the most certain - indeed, many philosophers accept that higher levels of reasoning are all, ultimately, tautological (Magee 1986, 8). The existence of public, neutral things which are even when we do not sense them, is a matter of probability rather than certainty. We are able to accept the existence of external things because of their effects; that is, that their apparent existence corresponds in a meaningful way with our experience of them. On the whole, we are probably justified in believing that things exist, as opposed to believing that life is merely a dream composed of internally-generated sense data. Indeed, the probability is strengthened by experiences which seem to confirm independent existence. The similarity of the sense data perceived by different people, and the apparent continuation of processes when we are absent, might be the result of subtle and devious dream constructs, but to believe this is to accept the highly improbable before the probable. For example, although two visitors to a great cathedral might differ in their views of its architectural, historical or aesthetic merits, both are likely to accept that it is a substantial building: the fact that they can touch it and enter it, and be affected by its atmosphere should suffice to prove that it is real to them, and would be real to anyone with the sense of touch. If they could travel into a time when that cathedral had fallen down, they would both agree that something had changed, even if the nature of that change remained obscure. So, we are affected by something, and the fact of the effect should be enough to prove the existence of an external entity.

If it is the case that we may accept the existence of an entity on the basis of its propensity to affect, have we any reason to suppose that archaeological entities exist as a different class of phenomena,

that the stuff of the past exists in other ways from the matter of the present? Russell, describing some of the ways in which we may know things, stressed that after the superior and immediate knowledge of sense, the first extension is acquaintance by memory:

‘This immediate knowledge by memory is the source of all our knowledge concerning the past: without it, there could be no knowledge by inference, since we should never know that there was anything past to be inferred.

(1912, 26)

This seems to suggest that knowledge of the past is of an inherently high quality, and indeed this may be so, but we have to be careful about what exactly memory is telling us. Memory does not furnish us with immediate knowledge of anything which has not existed during the time that we ourselves have existed. Memory cannot provide us with knowledge of, for example, the person Horatio Nelson, of his deeds or his personal habits, for there is no-one alive in the world today who could ever have known Nelson, who died in 1805. Our memory, or idea of him, is a memory of a history book, or a movie, or an anecdote borrowed from equally remote witnesses. Even then what we may remember is not the book or the film or the storyteller, but the sense data associated with the medium, which include the boredom of the lesson, the performance of the actors, or the quality of the port.

And yet, because we place a very high value, for the most part, on our own memories of sense data, there is a natural belief that there must be processes through which the past is transmitted into the present - processes which may not be infallible, but which consistently provide us with credible results. The past is therefore a powerful force in our thoughts, and the entities of which it consists, memories of one sort or another, are different from those which generate current, immediate effects upon us: the *now* things.

There are, indeed, strong arguments for such processes. These rely on concepts of substance and change, and on the generation of analogical reasoning. The Greek philosopher Aristotle was concerned with metaphysics (literally, after *Physics*). A central question which he addressed was, what makes a thing substantial which could not be removed (or changed) without losing the essential identity, or character, of the thing? We might say, for example, ‘that pub is not the same as it used to be, it has lost its character.’ This statement implies that although we recognise the pub as something which continues to exist, as a space and as an amenity, it now fails to fulfil an aesthetic role with which we associate it. We might, on the other hand, say ‘that used to be a pub before it was turned into a luxury home’, in which case we are saying that its very ‘pubness’ has been removed, it has lost the function by which we identify it. Sometimes, the line between changing the character of a thing, and changing it is very subtle, and this has occupied the minds of archaeologists for as long as they have been around. Take, for example, a classic archaeological problem. A 2nd-century Romano-British wing-corridor villa falls into partial disrepair, but at some time in the fourth century an apse is added to one of the rooms, and from the floor surface of the room tiles inscribed with the early christian chi-rho monogram are retrieved during excavation. Are we to infer that the function of the structure has changed from a domestic to a religious one? Has the occupancy remained in the same hands and a religious conversion taken place? What is the nature of the change, supposing that change, in some sense, can be detected?

This dilemma has spawned the modern science of topology, at a very high level of physics and mathematics, and its resolution lies at the heart of archaeological inference. We may sum up the metaphysical dilemma as the difference between to have and to be, or between those aspects of an entity which are *possessed* by, and those which are the entity. The resolution of this problem is essential for archaeologists, for we instinctively attempt to determine the difference in order to identify, describe, and account for the entities which constitute the past; while we need to be able to identify traits which reflect the character and history of an archaeological entity, we also have to differentiate between these and the identity, or name, which we have given to that entity.

As a significant historical example of this problem we might consider the work of the great 19th century French archaeologist Jaques Boucher de Perthes, who attempted to demonstrate the antiquity of man within a cultural atmosphere which still largely accepted Archbishop Ussher's assertion that the Earth, and everything in it, had been created in 4004 B.C. In order to overcome the prevailing canon, de Perthes had to demonstrate two truths: that he had identified stratified deposits belonging to remote geological periods of history, and that the stones which he found therein bore the marks of human action. That the objects he found existed there was no doubt: they had form and mass, they were stone, a geological product. That they were archaeological entities depended on the identification of differences between them and other, unworked specimens. They had certainly undergone change, enough for him to call them artefacts, but that the changes which they had undergone could be ascribed to human actions in the remote past relied upon an inductive argument which was vehemently rejected by many of de Perthes' contemporaries, such as M. A. Brongniart:

'.. I swear to you that he (Brongniart) could not, sirs, see the hand of man in these rude efforts. I saw axes, and I saw correctly, but the working was vague and the angles blunt: their flattened forms differed from those of the polished axes, the only axes which were then known.' (quoted by Daniel 1967, 55)

The final triumph in the 1860s of de Perthes' thesis was possible because of the generation of two closely related analogues, analogues which, eighty years earlier, would hardly have been acceptable because they relied on inductive proof. In essence, the inductive principle relies on repetition of experience to generate probabilistic statements about the future. In Russell's example, our unshakeable belief that the sun will rise tomorrow is based on the experience of the sun always rising, and on the total lack of examples of it not rising. The more times that it happens, the stronger the probability, as far as humans are concerned, that it will happen again. But in these terms the principle is not only facile, but fraught with danger: what if the sun had been programmed to rise fifty billion times only, and it turned out that tomorrow was the fifty billion and first day? That case would demonstrate that our model of the sun's behaviour had been inadequate; so it is necessary for us to establish causal links between the phenomena which we observe and other, co-incident, phenomena. For example, violence and pain are co-incident phenomena. We strongly associate the two, and would be very surprised, as well as relieved, if violent action directed towards us did not result in pain. There is a reliable causal link, which we understand in detail because of our knowledge of the human nervous system, and because repetition of such co-incident is so memorable: it is a consistent co-incident.

Statements about incidence with a high probability of being true in the future make good analogues. To demonstrate that a flint has been worked relies on identifying a number of flints which have been

worked within the experience of the observer, and predicting that new traits recognised on the worked flint are, and will be, diagnostic of such an action. The great value of the analogue is that it allows argument to progress without the need to repeat experiences every time that the analogue is employed. In describing an experiment a chemist hardly needs to explain the composition of a molecule of water every time it is used in the experiment; nor is it necessary to describe the properties or atomic values of elements every time that they are used. The chemist has a periodic table which has evolved over more than a century into an analogue set of extremely high reliability. The archaeologist has to be content at the present with a set of analogues of at best questionable reliability, even though there is no reason why we should not generate a periodic table of our own.

The analogical principle has become a general scientific law, established by the Scottish geologist James Hutton (1726-1797) in his *Theory of the Earth* (1785): he called it Uniformitarianism. It showed that all the processes of geology which were observable from ancient deposits were the same processes still operating, that in fact the phenomena of the present day are reliable analogues for the phenomena of the past. Jaques Boucher de Perthes was perhaps the first archaeologist to fully recognise the implications of this principle for establishing the true antiquity of man. In attempting to prove the age of the deposits which contained his worked stone, he noted:

the diluvial torrent, while sweeping the terrestrial surface, had done that which, daily, on a lesser scale, our rainstorms do when, collecting objects in the ground which are not solidly enough fixed by their weight or their appendages, they carry articles along and throw them in some sewer; or, when the rains do not find anything but flatlands, spread them in more or less thick layers, their analysis will indicate with certainty the areas which the flood had crossed: you will know if it had crossed a populated or a desert country, a town or fields, a prairie or forest, a cultivated field or stony or arid ground .. in brief, in this residue of a storm you cannot only follow its course, but can describe occurrences along the way. (op cit, 53)

The existence of archaeological entities, then, relies upon an inductive argument of considerable strength - strong, because it derives from personal experience of things which we sense are like other things, and because it obviates the need for constant repetition of observation. There are, of course, other philosophical questions raised by concepts of substance and change, of which probably the most important for the archaeologist are the ways in which change is conferred on entities, how we can identify change, and the nature of entities both before and after change. These are profound philosophical problems, which are dealt with here specifically in the context of a positive approach to the nature of archaeological entities: that is, what can we know about them which is useful to us in the generation of archaeological inferences?

The nature of archaeological entities

Archaeologists call their entities artefacts. In its loosest sense this term can be applied to anything that is of interest to archaeologists, but this again raises the tautological dilemma. Broadly speaking, archaeologists are in agreement about what exactly constitutes an artefact for the purposes of an enquiry: it is the physical product of an interaction between a human being and an entity of the physical environment, or ecofact. This is by no means the only plausible or valid definition, but it will serve a useful purpose here. In other contexts it is entirely appropriate to call ideas or concepts artefacts - it is the definition of the key terms of any one enquiry which is of the greatest importance.

In fact, it does not really matter where we draw the line between artefact and ecofact, because the boundary is largely defined by our personal interests and concerns which are liable, rightly, to change. So, for example, we may all agree that a prehistoric loaf of bread constitutes an artefact, both because it is the product of a relationship between a human being and his or her environment, and because it is recognised that the loaf takes us very close to a real event in the past. But what of the wheat from which the bread was made? A grain of wheat is an ecofact, in the sense that its growth does not necessarily rely upon human action, and yet it has been cultivated, probably from a strain which has been engineered by humans over many generations. Such concerns are, I think, of interest, but do not really pose questions which we need to answer immediately. While the role of the human in shaping the natural world raises many points, within the scope of an archaeological enquiry the definition of the key terms can proceed alongside such debate; it simply requires that the archaeologist establishes explicit parameters.

I do not think that archaeologists should find this disturbing. If we look for a moment at the relationship between the artefact and the archaeologist, it is clear that the conceptual apparatus of the archaeologist is highly influential in determining the scope and nature of the enquiry. This is strongly reflected in the relativist, post-structuralist school which has dominated much of recent archaeological theory. That there is fierce debate between this school and the inheritors of the positivist, empiricist tradition is entirely natural.

The archaeological entity may exist in a physical sense independent of the archaeologist (even if we cannot truly know this), but since archaeology is primarily concerned with understanding rather than merely describing, and since we rely so heavily on inductive knowledge, it seems inadequate just to have regard for the public, neutral properties of the artefact. The conflict is not only likely to continue, but also likely to prove quite productive, as the protagonists realise that their opposites are not as incompatible as they had thought (and perhaps hoped). As an example of how this conflict affects the archaeologist working in the field, one might consider the problems of measuring data, whether in terms of linear distance, mass, volume or shape. The development of fractal geometry has demonstrated that there is no such thing as objective, factual measurement, and yet we need methods by which we can compare distance, mass, volume and shape.

The answer is either to attempt to control variation by keeping it to within acceptable limits of error by rigorous procedure, which limits but does not confront the problem, or to acknowledge the problem by assessing the effects of variation due to human behaviour on the data, and the meaning subsequently conferred on those data. This has hardly been attempted in archaeology, but is a well-known and widely-adopted technique in other fields. At any rate, both schools have failed to denote their concepts in strict terms. This is genuinely surprising, because the task is not actually difficult, and can be accomplished without recourse to the invention of new terms.

Archaeological entities are generated by human impacting on ecofact. For the purposes of the archaeologist this act enhances the ecofact, because it now possesses new attributes (the *changes* referred to above) which have been conferred upon it by that impact or series of impacts. The interactive element of the action has created something new which did not exist before: it is unique and it is archaeological, the very stuff of the past. This new entity, the artefact, possesses attributes of the environment of which it has been, and attitudes of the human, his, or her, mental outlook and cultural environment.

Consider the creation of a pot. This is an activity which involves the selection of clays and tempers and of techniques, the manipulation of the raw materials, the choice and procurement of fuels, the acts of firing and finishing, and so on. The environment confers many physical properties upon this new entity, properties reflective of its own nature, from clay colour to moisture, to grass marks, to a new magnetic alignment. The same goes for the human (from style and technique to thumbprint), even if some of the attributes of the human, such as their state of mind at the time, are very difficult, if not impossible, to infer. We may, therefore, characterise the new entity as possessing two sets of attributes: those of cultural enhancement, and those of environmental enhancement.

Is this a useful characterisation? After all, it is already clear that we should find it very difficult to generate a set of rules which would consistently differentiate between environmental and cultural attributes. Well, this does not matter too greatly at this stage. If we can agree that a pot, or flint, or loaf of bread is a new entity, is archaeological, and is unique, it must be useful to denote the elements which go into making it so. My view is that for the archaeological enquiry those elements are analogues. Analogues allow the archaeologist to describe discrete sets of transformations *as if* they were facts, to treat them as bits of information. These could simply end up as vast arrays of data with little collective potential for being understood. So we have to classify these data and predict by reliable means whether they are likely to be useful, and for what purposes they may be used.

If we call these bits of information attributes, divide them into sets which reflect their potential for generating inferences - such as, but not necessarily, cultural and environmental, enhancing or reducing - and give them positive identity, we might possibly be able to provide the basis for an inferential structure. To do this we need to consider three further sets of attributes; after all, there is a difference between a pot which one has just made, and a pot which was made several centuries, or even fifty years ago. A ceramic expert might construct a pot for the purpose of testing analogues: coiling techniques, possible use of moulds, use-wear, and so on. This is a useful exercise, and quite reliable as a means of testing or establishing analogues. The ceramicist does not have to worry about too many variables, because these can largely be controlled; the background hiss of centuries of re-use, breakage and degradation can effectively be muted.

Suppose, though, an unscrupulous but talented potter wanted to create a fake, and was able to pass off a pot he made the previous day as a hitherto unnoticed example of Late Minoan Ib? If the fake was so stupendously good that every detail, down to subtle traces of use-wear, and a plausible but bogus provenance and context was enough to fool the best experts, would that pot still be a fake? The answer is no, until such time as new techniques of dating or analysis revealed traits which did not conform with established analogues: a Piltdown scenario. Theoretically, though, a perfect fake is no fake at all. So how is an archaeological pot different, in purely theoretical terms? When an entity is created by design or by accident, it may well acquire further enhancing attributes, and in this sense I mean impacts which confer information about culture and environment on the entity. Archaeologists intuitively recognise artefacts which have been further enhanced.

For example, a ceramic vessel which has been used to store grain, then wine, is then re-fired, filled with food and buried alongside a person in a grave, acquires enhancing attributes along the way, offering potential information about each impact. We commonly refer to processes which confer retrievable information on artefacts: use-wear, recycling, secondary use. However, unless an artefact remains in the precise cultural and environmental state in which it was created, it will also lose

information, and it will do so in two ways. Firstly, from the moment of creation, that creation becomes memory. It is unrepeatable, it is past. No matter what additional enhancing attributes it acquires, it loses information about the cultural world in which it was created. This loss encompasses a wide range of phenomena, from the drastic - a pot is crushed to make temper, a building is razed - to the subtle: a pot is curated for hundreds of years in fine condition as a souvenir or heirloom. Another set of processes ensures that the artefact loses environmental information along the way: weathering processes are often the most dramatic and destructive of information, but there are many others, and some of them can themselves be harnessed to provide data about the history of the entity (obsidian hydration dating being an example).

We may therefore characterise these two further sets of attributes as those of cultural and environmental reduction. Of course, what exactly constitutes an enhancing or reducing impact depends very much on the point of view of the archaeologist, but this has the advantage of enabling the archaeologist to define the key terms and operations for any specific enquiry; it enables rather than limits. At the same time an explicit denotation of concepts is being applied.

Take, as an example, two archaeologists who wish to exploit the potential of a group of data from an archaeological excavation. One of them is interested in understanding developments in ceramic technology during the period of occupation of the site; the other wishes to learn about patterns of ceramic discard in order to test whether behavioural patterns are reflected in such data. The first archaeologist might prefer to recover whole pots in well-stratified primary contexts, preferably from the kilns or bonfires where they were fired. For the purposes of that enquiry the act of creating the pot is the single most important impact.

The second archaeologist, on the other hand, is interested in processes which reflect primary and *de facto* deposition and, to a lesser extent, secondary discard locations. This archaeologist is 'turned on' by the realisation that sherds from a single pot appear to have been placed deliberately in discrete, separate locations: from this point of view the breakage and distribution of the sherds constitute an enhancing effect, even though to the first archaeologist these impacts reduce the chances of reconstructing manufacturing methods.

I am suggesting, then, that all the attributes which constitute an archaeological entity can be viewed as if they belonged to one of four sets: attributes of environmental and cultural enhancement, and attributes of environmental and cultural reduction. These attributes are conferred upon the entity by impacts of one kind or another, which are neither enhancing or reducing exclusively, but which can be labelled as such according to the concerns of the archaeologist. Likewise, the application of labels such as cultural and environmental are determined by the nature of the enquiry. It is the archaeologist who must ultimately confer meaning on these entities and their attributes, and in doing so confer on the entity a further set of attributes, a set which results from the process of the archaeological enquiry and from the behaviour of archaeologists themselves.

The instance of accidentally effecting entry into a human skull by means of the sharp end of a pick-axe is a reasonable enough cliché for characterising the gross effects which archaeologists themselves have on the objects of enquiry, but it is entirely inadequate for describing the whole range of impacts which entities undergo at their hands. This range of impacts is best termed *operational*, and is solely concerned with the archaeological process. Clumsy technique may offer the most visible

evidence of such impacts, but it is in no way the most influential. In order to explore the role of the operational impact we must address ourselves to the nature of the archaeological enquiry.

The nature of the archaeological enquiry

I have tried to show that archaeological entities exist as an identifiable and unique class of phenomena. They may be known to us through a process of inductive reasoning which is powerful, and in the right circumstances highly reliable. However, the nature of the archaeological enquiry is also characterised by more subtle aspects of the relationship between the artefact and the archaeologist. We have characterised archaeological entities, but does that mean that we have characterised archaeological data? The answer, simply, is no, and the reason is that while entities can be defined in terms of sets of attributes - the *have* part of the metaphysical dilemma - data, the things which actually affect us by our perception of them, are different. Data consist of identified traits which are visible, recordable characteristics, and while traits and attributes might initially appear to be the same thing, they are not, and the distinction is crucial to archaeological philosophy.

Attributes exist independent of us, whether we like it or not. Traits, however, are reflective, and their existence is based purely on analogues which derive from our immediate senses. We can say that an artefact has properties on the basis of logic, but its traits are the things which it does to us, the effects of those properties. Let me provide an example. An archaeological deposit of wind-blown sand does not *have* the property IOYR 3/4. The denotation IOYR 3/4 is simply a crude, variable means of describing an effect on our senses of the colours offered by the artefact (or ecofact, depending on your point of view) wind-blown sand. By an inductive argument we may establish to the satisfaction of our peers that the traits: fine-grained; IOYR 3/4; blows away when you try to clean it; wrecks the EDM', are so diagnostic of the entity wind-blown sand, that we can establish the proposition as an archaeological truth.

Similarly, we may establish that certain traits, when co-incident, reflect the operation of processes in the past: for example, small, abraded and fragmented sherds of pottery are indicative of processes of secondary deposition, while large, unworn sherds which fit together to make a more or less complete vessel indicate primary or *defacto* deposition. We may categorise traits into two useful groups: those which are diagnostic of processes or actions which occurred in the past, and those which are not diagnostic of such processes or actions. The determination of diagnosticity is the essential building block by which we may establish analogues with which to construct inferences about the past. This is useful because it allows us to value some traits more than others on the basis of the quality of the information that they offer. Decisions about diagnosticity have to be made at the appropriate stage in any archaeological enquiry, and the more limited the resources or the scope of the enquiry, the earlier that those decisions generally have to be made. It is an entirely valid exercise in data control, so long as the decision is both explicit and based on a rigorous assessment of the method of determining diagnosticity.

All doctors use similar techniques, explicitly or otherwise. A neural tube defect in a foetus is a diagnostic 'marker' for Down's Syndrome. Half a dozen or more such markers and a provisional diagnosis might be made with confidence.

What determines whether a trait is diagnostic or not? In the simplest logical terms, a trait can be described as diagnostic when the effects of its enhancing attributes are greater, or more retrievable,

than the effects of its reducing attributes. Given the two archaeological relationships discussed above, it will become clear that this question of diagnosticity accounts for a great deal of archaeology's dynamic and non-linear nature. If, for example, use-wear abrasion on a ceramic vessel is seen as constituting an enhancing property, and it survives primary breakage and deposition, the remaining traits will be diagnostic of such wear. On the other hand, if sherds of that vessel end up in a stream and have all the use-wear traits removed by the action of running water, the resultant traits will be diagnostic of fluvio-turbation, but not of use-wear. Since the work of Werner Heisenberg (1901-1976) on the 'tolerance principle' all scientists must know that knowledge of some things precludes knowledge of others.

Modern archaeological recording systems usually operate on the basis of recording an agreed set of essential traits which can be compared with those from other sites or categories of archaeological entities, and additional traits are often recorded to answer specific questions about a particular resource. The inherent flaw in most systems is that they make no explicit link between traits as recorded, and the processes of formation which they aim to reconstruct; nor do they attempt to differentiate between diagnostic and undiagnostic traits, despite the strong possibility that this would obviate the need for much unnecessary recording of traits which are not diagnostic of the processes which we wish to understand, and therefore largely irrelevant to the enterprise.

We may begin, then, to characterise operational impacts, those attributes which are conferred on an entity during the process of the archaeological enquiry. Firstly, we operate on the archaeological entity by inducing the fact of its existence; if our analogues are inadequate, then so will be the basis of the enquiry. Secondly, we have to make a choice, which is rarely explicit, a choice about what we, as individual archaeologists, value. There is nothing wrong in this. There are as many traits offered by an archaeological entity as we want there to be, and it is inevitable that we value some more than others. It seems to me to be important that the estimation of the value of a trait or entity should be based on the quality of information available, but this does not, and should not, rule out the adoption of alternative value-choices based on aesthetics, poetics or politics. Indeed, it would be foolish to suppose that archaeologists, making explicit choices, do not impose such ideas on the archaeological entity, and this is a strong characteristic of the operational attribute.

Thirdly, we impose on the archaeological entity by our ignorance of all the traits which we do not perceive, or which we physically destroy during the process of retrieval. The destructive result of the process of excavation is obvious; less so the reductive effects on an archaeological entity of inducing a large number of its traits on the basis of observing a few. An example of this is the interpretation of air photographs. This is a highly skilled operation, contributing enormously to our knowledge of the archaeological resource; and yet ignorance of the whole entity, known primarily from topographic traits, must constitute a reducing attribute. Indeed, it is axiomatic that operational attributes are always reductive. The exception would be the instance in which the archaeological process was itself the object of study, in which case the actions and effects of the archaeologists would themselves constitute an enhancing attribute; however, I suspect that this is the exception which proves the rule, and in any case probably constitutes more of a sociological enquiry.

Archaeological functions and inference

We may, then, view all the attributes of an archaeological entity as belonging to one or more of five sets of attributes: culturally enhancing, culturally reducing, environmentally enhancing,

environmentally reducing, and operational (reducing). These are not exclusive, and yet I believe that they are useful in the construction of reliable, accountable inferences.

We may further say that when the effects of the enhancing attributes are greater than those of the reducing attributes, the resultant traits will be diagnostic of a process or series of processes which operated in the archaeological past. It must also be evident that the importance of the operational attribute is such that we, the archaeologists, must accept responsibility for the material result of any archaeological enquiry. We may express this relationship between the attributes of entities and the inferences which *may* be generated from them, as follows. A trait is diagnostic (Td) when the effects of enhancing processes (Ce and Ne, for cultural and environmental) are greater than those of reducing processes (Cr and Nr); and, conversely, a trait is undiagnostic (Tu) when reducing processes or impacts have greater effects than enhancing processes:

$$Td = \Sigma a(Ce+Ne) - b(Cr+ Ni) \text{ where } a>b$$

$$\text{and } Tu = \Sigma a(Ce + Ne) - b(Cr+ Ni) \text{ where } b>a$$

Certain conclusions may be drawn from this denotation of the fundamental archaeological relations. Firstly, we may characterise the potential of an archaeological resource, consisting of any number of archaeological entities, on the basis of the ratio between the number of diagnostic and undiagnostic traits which may be, or have been, retrieved. Since diagnostic traits offer a greater potential for inferring the nature of the past, we may say that the higher the ratio between diagnostic and undiagnostic traits the greater is the *inference potential* (P) offered by that archaeological resource. This may be expressed as follows:

$$P = Td/Tu$$

We may also say that the value of an archaeological resource might be characterised as the outlay of resources required to retrieve a given potential. This should be termed the *inference quality* or IQ of the resource, and may be expressed as a function of the attribute set as follows:

$$Iq = P/\mathcal{L}$$

How, then, can we define the resource itself? I think that the resource (R) must comprise all of the attributes which are possessed by all of the entities. Since logically the reducing attributes must be irretrievable, it follows that the retrievable data set of any archaeological resource can never be complete. This data set (A) can be described as the total resource (R) minus all the reducing impacts (It), producing the following functions:

$$R = Ce+Cr+Ne+Nr$$

$$It = Cr+Nr+Or$$

$$\text{and } A = R - It$$

We must realise that as our archaeological 'periodic table' of analogues is enhanced along with our techniques, some of those attributes currently regarded as reductive may become enhancing: we will increase the ratio between diagnostic and undiagnostic traits. However, the retrieval of the archaeological resource must remain, logically, an unattainable helicon.

So how can we use this infrastructure in practice, to increase the reliability of inferences generated from raw archaeological data, and how can we hope to control data in structures which allow us to exploit their full potential? Since we can generate reliable analogues, and since we are beginning to understand the relationship between the past and the present, this should not be an impossible task. However, it will rely on the rapid implementation of decisions in the field, directly controlling the identification and recording of traits. This in turn is going to have to rely on altering the emphasis of the archaeological investigation so that traits which are diagnostic of formation processes are recognised explicitly at a very early stage - that is, while entities still retain their archaeological context in as near a complete state as is possible. From personal experience I think that this is possible in both salvage and research contexts, once an adequate data structure has been designed. A structure which is based on the attribute sets outlined above will perform this role, and at the same time provide a means for testing inference reliability. It is hoped that such a system may be tested in the near future.

Archaeological dynamics and beyond

In my view archaeology is a science: a creative, dynamic science which concerns itself with a unique set of phenomena. These phenomena are the products of an interaction between human beings, other human beings, and their environment. In order for them to have significance, they have to have meaning conferred on them by the archaeologist. The dynamics of these relationships seem to me to be capable of expression, if not prediction. My uninformed guess is that the dynamics of phase space, strange attractors and fractal geometry, in other words the behaviour of non-linear dynamic systems, offer us a chance to glimpse some of the patterns which the past contains. We may not yet know how all the bits work, but there is a deep-rooted feeling amongst archaeologists that there are structures, patterns and form in the past, and that they must be worth looking at, if we can know how. Indeed, it may well be the case that the apparently futile search for scientific archaeological truth results precisely from archaeology's non-linear nature.

Now that physicists and mathematicians are more aware of the very restrictive applications of mechanistic systems, that the universe is dominated by non-linearity, the archaeologist can claim a head start in the understanding of non-linear behaviour and its vast attendant possibilities. Archaeology, as a synthetic discipline, may yet become the most progressive of the sciences, because it can encompass the dynamics not only of the physical universe, but also of the human beings who inhabit, and must interpret, that universe.

Physicists have a way of grading their problems: they are either Obvious, Not Obvious, or Deep. With a bit of luck, archaeologists might make a start on the second.

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