An Archaeology of Traces

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Archaeology is centrally concerned with the tension between material remains in the present and a reconstructed past. This tension is captured by the concept of a trace, namely a contemporary phenomenon that references the past through some sort of epistemic intervention. Traces are deceptively complex in terms of both their epistemology and their ontology and hence worthy of detailed exploration. In particular, archaeological traces not only concern the past per se *but also possess a latent quality of as yet unrealized signification. This gives archaeological traces a future orientation that is rarely considered in discussions of archaeological epistemology.*

> The floods uncovered the ruins as if they were writings whose texts their pens renew;
> Or the repeating of the tattooer, her indigo sprinkled in circles above which the tattooing appears.
> I stopped, questioning them, but how do we question rocks deaf and dumb, forever in one place, their words indistinct?
>
> Abu Aqil Labīd ibn Rabī'ah (d. *c.* 34 AH/661 CE), *Mu'allaqa* 8–10
> (as translated in Serrano 1997, 73)

In the *aṭālal* (ruins) section of his 'Hanging Poem' (*Mu'allaqa*), Labīd, the last of the great pre-Islamic Arabic poets, conveys a quandary at the heart of archaeology as a knowledge-forming practice. Labīd recognizes that the receding flood waters were revealing the remains of a campsite, as if reinscribing the story of its inhabitants, but it is a story that he cannot decipher from the traces left in the stones. At the same time, Labīd knows more than he realizes, since he recognizes not just a configuration of stones, but the remains of a camp. This tension between knowing and not knowing, between encounters in the present and inferences about the past, captures something central to the practice of archaeology. Indeed, it is no coincidence that archaeology's best known interpretive frames of reference, from 'the ladder of inference' (Hawkes 1954) and 'middle range theory' (Binford 1983, 45–56) to 'the hermeneutic spiral' (Hodder 1999, 30–36), are positioned at precisely this point of tension between material remains in the present and a reconstructed past.

Over the past 15 years, a cluster of related approaches (e.g. symmetrical archaeology, new materialism, archaeology of the contemporary past, object-oriented ontologies, etc.) have sought to rebalance this equation, shifting attention from inferences about the human past to the ontology of material remains in the present. This change of perspective allows for new insights, not the least of which is the ability to talk about anthropogenic deposition and material remains in terms of the ongoing realities of the Anthropocene. However, this recasting of archaeology as the discipline of things in the present (Olsen 2010; 2012; Witmore 2014; 2021) sublimates, rather than escapes, the problem of an absent past. 'Ruin', 'waste', 'after-life', 'memory'; the key terms deployed in this literature all imply surveying the scene after the fact. Whether minutes or millennia have passed, 'afterness' is what makes these engagements with things recognizably archaeological. Even the most assiduous attempts to avoid signifying the past in producing formal and aesthetic descriptions of archaeological remains (e.g. Nativ 2022) still define these remains (e.g. pottery, bones), and implicitly distinguish them from the surrounding matter that is not described (e.g. earthworms, gravel), in terms of traditional categories aimed at capturing the potential of certain things to signify the past. To

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say this is not to embrace historicism or to deny that archaeologists have an interest in the ongoing, future-facing, realities of material remains. Rather it is to acknowledge that archaeology cannot meaningfully engage with 'everything, everywhere, all at once', as is entailed by a limitless definition of things that extends by implication to encompass all matter. For archaeology, the material past provides disciplinary parameters, acting as a kind of boundary object (Star & Griesemer 1989) that gathers together people with diverse interests and frames of reference and enfolds many human and non-human things, but also limits and focuses our disciplinary care.

In this paper I want to revisit the tension between material remains in the present and a reconstructed past, by exploring archaeology not as a discipline of the past, nor of things, but as a discipline of traces. Traces, I will argue, do not resolve the central tension of archaeology; rather they embody this tension both ontologically and epistemologically. Insofar as this tension is essential to archaeology as a knowledge-forming practice, reflecting on traces is an effective and insightful means of reflecting on what we do as archaeologists. Indeed, epistemic choices and traditions in the research process often turn on implicit understandings of the concept of a trace. The principle of 'preservation by documentation' that underpins commercial archaeology, drives the production of grey literature and justifies much heritage-oriented planning legislation and infrastructure, is fundamentally trace-based and yet the concept has barely been discussed in these contexts. Finally, as we shall see, the concept of the trace makes clear the future-oriented nature of issues such as curation, preservation and the place of the past in the present.

Defining traces

What is an archaeological trace? Both Rosemary Joyce (2006; 2015) and Anna Boozer (2015) have explicitly discussed archaeological remains in terms of traces, but in the restricted sense of unintended survivals with quotidian and subaltern referents, what Marc Bloch (1954, 51) referred to as 'witnesses in spite of themselves'. Both Joyce and Boozer contrast traces in this sense with 'monumental' remains that were intended to endure and bear witness through time. In practice, defining archaeological traces in terms of the absence of intent to preserve or represent is problematic as it hinges on identifying intentionality in deposition and begs the question of whether traces and monuments differ in kind or merely by degree when it comes to signifying the past.

The philosopher Hans-Jörg Rheinberger (2011, 342) notes with reference to the experimental sciences that while signal and trace are very similar in their referent, signal is deployed from the perspective of an entity emitting something (e.g. isotopes emitting beta particles in the course of their decay), whereas trace is deployed from the perspective of an effect left by an event or entity (e.g. beta particles detected in an ionization chamber as a trace of isotopic decay).

Both the 'afterness' and the substantive connection between traces and past phenomena that one finds in Rheinberger's discussion are important to understanding archaeological traces. More problematic is his assertion that the trace is an 'asemic kernel' that is anterior to its symbolic representation as data (Rheinberger 2011, 338). As we shall see below, there are good reasons to distinguish between traces and data. However, it is hard to understand traces as 'asemic' in the context of experiments designed *a priori* to detect specific traces as the by-products, remnants, or effects of a given phenomenon. Rheinberger's position seems to arise from his adoption of Jacques Derrida's deconstructive sense of the trace. For example, Rheinberger holds that experimental traces are 'the trace of something, but this something is always only a substituted or supplemented something' (Rheinberger 2011, 338) such that '[s]omething like an origin then only *arises* in the process of tracing as a second-order concept' (Rheinberger 2011, 339).

Elements of Derrida's deconstructive trace are relevant to the recognition and definition of archaeological traces. In particular, past phenomena only known to us by means of our recognition of their traces in material remains cannot be said to be the origin of those traces in any simple sense. This is because our reconstructed past is always changeable in relation to (i.e. supplemented by) our understanding of its traces in the present and hence is in some sense unstable ('the trace … thus becomes the origin of the origin': Derrida 1997, 61). Similarly, because our reconstructed past is always emerging and is never fully fixed, there is a sense in which the deferral of meaning, as captured in Derrida's neologism *différance*, is a necessary component of archaeological traces. However, this deconstructive trace is built on a critique of Saussure's linguistic semiotics that nonetheless incorporates key aspects of Saussure's system in problematic ways. In particular, Derrida builds his deconstructive sense of the trace on the arbitrary relationship between the signifier and signified. For Derrida, signs signify not an original referent or object but rather the trace of all of the absent signs that define the signifier through their difference

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(Derrida 1997, 46–50, 61–2, 66–7). Hence, the trace embodies an absent presence whose origin and meaning is perpetually deferred because it depends upon the free interplay of a chain of signifiers.

All of this is very problematic for archaeology since it is rather difficult to maintain that the relationship between traces and past phenomena is arbitrary. Both the ontological characteristics of archaeological traces (e.g. their materiality and their presence) and the epistemological characteristics of traces (e.g. the relationships linking traces and past phenomena) constrain specific archaeological traces in specific ways that are independent of their participation within a sign-system.

Rheinberger implicitly recognizes this problem by invoking the alternative semiotics of Charles Sanders Peirce in several places. He labels traces (such as molecules) that 'share in the very materiality of the epistemic thing under consideration' as indices in contrast to models, which he labels as icons in Peirce's sense (Rheinberger 2011, 343). Indices and icons in Peirce's triadic classification of signs are defined by non-arbitrary relations of indexicality and resemblance, respectively, whereas Peirce reserves the term symbol for signs defined by arbitrary relations of difference, as is the case for many linguistic signs (Peirce 1958, 220–45).

Zöe Crossland (2021) has referred to archaeology as a discipline of traces with reference to precisely this Peircean framework. In this sense, archaeological traces are equated directly with signs in Peirce's triadic taxonomy, which allows natural and conventional signs, as well as the product of their interpretation (i.e. the interpretant), to be incorporated into a single conceptual system. This is a fruitful approach for archaeological interpretation, as is evidenced by the burgeoning body of archaeological literature that engages with Peircean semiotics (e.g. Crossland & Bauer 2017; Preucel 2006; Swenson & Cipolla 2020). However, for present purposes, the focus in this literature on semiosis as a universal process, on Peirce's taxonomies and on the exegesis of his writings, takes us away from our specific concerns with archaeological practice. Hence, although the approach developed in this paper is compatible with Peircean semiotics, moving directly to the universal qualities of signs skips the important step of elucidating what is specifically archaeological about archaeological traces.

More useful in its precision and relevance is the definition of traces in the historical sciences given by the analytical philosopher Adrian Currie:

> Some contemporary phenomenon, x, is a trace of some past state of affairs, y, if and only if x is downstream of y, and x is evidence of y, and x is evidence for y according to some justified midrange theory. (Currie 2018, 70)

Currie's definition highlights three key components of traces—they are contemporary phenomena that reference the past through some sort of epistemic intervention (e.g. 'midrange theory'). Currie's focus is explicitly epistemological in that he defines traces in terms of their evidential role in making inferences about the past. In this sense, his definition can be productively compared to that of the continental philosopher Paul Ricoeur.

Paul Ricoeur (Changeux & Ricoeur 2000, 151–2; Ricoeur 2001, 13–15, 415), in exploring the relationship between living memory and historical time, extends the definition of traces to include neuronal imprints, and the conscious effects of experience in addition to 'a cultural trace conveyed by a cultural support external to the body' (Changeux & Ricoeur 2000, 152). However, like Joyce and Boozer, Ricoeur (2001, 171–5) also makes the distinction between intentional and unintentional traces by distinguishing within cultural traces (which he also refers to as documents) between testimony and clues. Clues, for Ricoeur, are unintentional historical sources that include vestiges in Bloch's (1953, 52–4) sense of archaeological remains, place names and linguistic or folkloric survivals.

Given the problems with defining intentionality that we have already noted, Ricoeur 's earlier, and more flexible, definition of a trace as a mark in the present that 'signifies something [from the past] without making it appear' (Ricoeur 1988, 125) is closer in its simplicity to Currie's definition and works better for archaeology. However, in contrast to Currie, Ricoeur's focus is ontological in that he is concerned with the paradoxical nature of traces as a presence that signifies an absence or a passage ('a passed past that nevertheless remains preserved in its vestiges': Ricoeur 1988, 120). In the remainder of this paper, I will develop an understanding of archaeological traces that holds these ontological and epistemological foci in tension.

Traces *versus* data

Our definition of traces becomes clearer if we distinguish between traces and data. Against the etymological meaning of data as 'something given', ethnographies of archaeological practice (e.g. Edgeworth 2003; Mickel 2015; Yarrow 2008) have discussed in some detail how data recording actively works to fix and recontextualize unstable phenomena

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encountered in the field to produce data that can circulate beyond the experience of the field and be deployed by others. Bruno Latour (1999, 72–3) has described this process as one of simultaneous reduction and amplification, such that some dimensions of reality recede and others are brought forward as stable entities that can circulate, be manipulated and compared (cf. Leonelli 2016; Leonelli & Tempini 2020). In other words, data are about collection, documentation and circulation. In contrast, traces involve the recognition of phenomena eligible to become, or already captured by, data. Traces and data are two conceptual moments in the process of archaeological knowledge formation, although they are not necessarily temporally or sequentially distinct.

Importantly, the distinction between traces and data is not a distinction between 'raw' perception and processed representations. Dietmar Offenhuber (2020) makes this clear in analysing the difference between the visual representation of symbolically encoded data sets (i.e. information visualization) and what he terms autographic visualization, namely techniques that enable material phenomenon to manifest themselves as visible traces. In contrast to information visualization, in which data sets are the starting point, in autographic visualization data sets are the outcome and hence are not being represented. Instead, autographic visualization involves techniques that allow a phenomenon to present itself through traces. This can be as simple as skilled observation, or it can involve a range of interventions 'that aim to reveal, isolate, amplify, conserve, and present material traces as records of past processes and events' (Offenhuber 2020, 99). Offenhuber (2020, 99) gives the example of a sundial as a device by means of which the movement of the sun makes itself visible in the trace of a shadow. The myriad of laboratory equipment, sample preparation methods and quantitative transformations used in the archaeological sciences to facilitate the detection and interpretation of phenomena as traces most immediately come to mind. However, simple field techniques aimed at increasing the visibility of archaeological traces, such as trowelling or sweeping to highlight changes in the soil matrix, are also autographic design operations in Offenhuber's terms (Offenhuber 2020, 101) and are distinct from the drawings, context sheets, Harris Matrices, photographs, etc., used to capture matrix changes as data. Giuseppe Fiorelli's use of plaster of Paris at Pompeii is a particularly striking example of this sort of intervention. By pouring plaster of Paris into voids in the volcanic ash, Fiorelli facilitated the visibility of the interface between decayed flesh and the ash. Fiorelli's intervention allowed past organic bodies to reveal themselves as traces in what was otherwise a void (Dwyer 2010; see Lazer *et al.* 2021 for an analysis of the composition of the surviving casts).

Importantly, understanding traces as self-revealing does not mean treating traces as 'raw' material givens or sensory stimuli, since

> autographic visualizations are not stable artifacts whose correct interpretation is just a matter of visual literacy, but phenomena that emerge from a recipients' extensive engagement with the world and with the knowledge of others, like a hunter who learns to spot latent animal tracks that are not just invisible but non-existent for an unskilled person. (Offenhuber 2020, 100)

Offenhuber's hunting metaphor itself contains a trace hidden in contemporary English usage, but one that is more obvious in French where the semantic field of 'trace' includes a track or trail (Serres 2002, 2–3). Indeed, it was in this sense that 'trace' entered Middle English from Old French (OED Online 2022). In German (see Krämer 2007, 13–14), 'die Spur' also retains this tracking connection, deriving from Old High German roots that designated a 'footprint' (reflected etymologically in the English words 'spur' and 'spoor': OED Online 2022). It is, therefore, not surprising that this hunting metaphor turns up in many discussions of traces in the human sciences. Ricoeur (1988, 119–20), for example, uses this metaphor in his discussion of traces and historical time, as does the historian Carlo Ginzburg (1989) in his discussion of the emergence of an 'evidential paradigm' in the late nineteenth century (see below). In archaeology, Matt Edgeworth has described the process of excavating by following the cut of a pit 'as a kind of active searching like the tracking of an animal along the trail or spoor it left behind' (Edgeworth 2012, 78). Similarly, Timothy Ingold (1993, 153) drew an analogy between archaeologists and hunters, both of whom learn to read a landscape by attentively dwelling in it. Ingold focuses on the moment of recognition in which

> Every feature, then, is a potential clue, a key to meaning rather than a vehicle for carrying it. This discovery procedure, wherein objects in the landscape become clues to meaning, is what distinguishes the perspective of dwelling. (Ingold 1993, 172)

Dan Hicks (2016a, 11) zooms in on this hunting metaphor in criticizing what he terms Ingold's landscape romanticism. Hicks quotes Joan Gero's (1985, 344) critique of the gendered division of labour and

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prestige in archaeology wherein masculinist tropes of 'Man the Hunter' run parallel to triumphant narratives of archaeological fieldwork. Gero's trophy-hunting metaphor, however, is distinct from Ingold's trace-following metaphor (Ingold 2016, 31). More salient, in light of my distinction between traces and data, is Hicks's central critique that 'archaeological knowledge is constituted not from "real" human experience in the field, but from retrospect upon what is created through practices of documentation' (Hicks 2016a, 14).

Hicks's emphasis on archaeological knowledge formation as revisitation via the archival products of archaeological labour, what I define as data, requires us to reemphasize that the distinction between traces and data is neither temporal nor sequential. For example, Offenhuber (2020, 99) notes that a simple analogue seismometer simultaneously reveals traces and documents them as data. Seismic movements make themselves visible as traces by mechanically exciting a stylus to produce a seismogram, which also serves to document information about those movements by means of the seismogram's temporal and magnitudinal scales. Many instrument-aided forms of archaeological science, such as ancient DNA (aDNA) analysis or radiocarbon dating, rely on outputs that simultaneously reveal traces and document them as data. In field contexts trace recognition often occurs in the process of recording, and indeed this is one of the disciplining purposes of routinized recording methods. Importantly, the indexical nature of traces prevents recognition from being trapped in a pre-documented moment of discovery, what Hicks refers to as 'an unending, traceless loop starting and ending in the trench' (Hicks 2016b, 35). Data in the form of the archaeological archive both inscribe traces and are latent with unrecognized traces. Hence the importance of redundancy and 'over description' in the documentation practices of archaeology. In this sense, the transformation of archaeological knowledge by the passage of time (Hicks 2016a, 18–19) may itself allow phenomena to reveal themselves as previously unseen traces through the revisitation of legacy data with new tools, orientations and understandings (Currie 2021; Wylie 2017a).

Recognizing traces

If data are about documentation and traces are about recognition, what does it mean to recognize a trace? At first glance this would seem a straightforward question since archaeologists regularly recognize traces in the course of conducting research. Yet, on examination, traces reveal complexities overlooked, perhaps necessarily, when focused on 'doing' archaeology (cf. Ricoeur 1988, 126). The complexities of recognizing archaeological traces revolve around the tension between the ontology of traces as a surviving material presence and the epistemology of traces as potential evidence regarding the past.

One common mode of recognition could be termed a 'disruptive encounter'. Emmanuel Lévinas (1972, 66) asserted that, much as animal tracks disturb tall grass, traces 'disturb the order of the world' [my translation] through an out-of-placeness that is always signifying something that has already passed. Think of how the poet Labīd's attention was caught by the unexpected camp remains exposed by receding flood waters, or how archaeologists are drawn to lithic scatters whose disconnection from the field in which they lie demands investigation. Certainly, the formation of archaeology as a discipline hinged in part upon such disruptive encounters, where the strangeness of artefacts and features in the landscape made them objects of enquiry via curiosity cabinets and antiquarian compendiums. Gavin Lucas (2015, 317) has argued that archaeological remains continue to draw our attention in their untimeliness: 'The archaeological is what does not belong, temporally speaking'. This captures a key aspect of archaeological traces, one that makes archaeology possible—namely that we recognize traces as vestiges of a 'passed past' that are nonetheless contemporary with us.

However, a strictly ontological definition is insufficient. There are many archaeological traces that we do not encounter as an untimely presence in the present. Some archaeological traces can only be encountered if they are first 'imagined forward' from the past as potential evidence according to a wide variety of theoretical and methodological scaffolding (on scaffolding, see Routledge 2021). Such archaeological traces are not only observed but are also sought out, often by means of specific instruments, or modes of observation, whose parameters are determined by anticipating the nature of the traces in advance of their recognition. Stable isotope signatures and aDNA, for example, exist in the present as chemical signals, but can only be detected with specialized instruments (e.g. mass spectrometer) and processing techniques (e.g. Next-Generation Sequencing) and are dependent on a wide variety of scaffolding in order to be identified as traces of past environments, diets or populations. Indeed, virtually all microscopic archaeological traces are first postulated as potential traces and then sought out by specific means before they are encountered in the archaeological record.

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Some archaeological traces are proxies, rather than vestiges. To the best of my knowledge, there is no direct physical evidence for the existence of lapidary engraving wheels in Bronze Age Mesopotamia. However, microscopic abrasions on cylinder seals suggest that after 1750 BCE such tools began to be used in their production. This inference is supported by both experimental replication and by analogy with pre-modern engraving tools (Sax *et al*. 1998). Finally, traces can even be absences or negative spaces made meaningful by intervening theory. For example, negative stratigraphic interfaces only become traces of ancient pits (or 'robber's trenches' or post-holes or plough-marks) by means of depositional models that explain why such interfaces are both necessary and indicative.

From an epistemological perspective, traces are not an 'untimely' material presence but rather anything with demonstrable evidential value regarding the past according to some justified theory linking past and present. Hence, what we define as a trace is inherently heterogenous, constantly changing and expanding in line with the scaffolding that we bring to bear on our study of the archaeological record. Adrian Currie (2018, 64–73) argues for this sort of epistemic understanding of traces as it avoids the metaphysical problem of defining the nature of traces *a priori* (Currie 2018, 72–3). Currie concedes that the theory-dependence of traces in his account may sit uneasily with a realist ontology and suggests that one could speak instead of 'accessible traces' (Currie 2018, 73). However, the ever-evolving nature of traces implied by an epistemological perspective creates difficulties for any approach focused only on accessible traces. This is because the latent qualities of traces, what one might call 'temporarily inaccessible traces', are conceptually significant in archaeology.

The conservationist ethic of archaeology, the belief that excavation is destruction and that archaeological sites are a non-renewable resource, means that archaeologists frequently collect and archive data they will never employ and employ data that they did not collect. Disciplinary traditions of data categories, such as pottery sherds animal bones, charred seeds, etc., are essentially 'good bets' as potential future evidence, useful to other archaeologists based on their past epistemic success. As such, the trace-value of material remains always contains a latent element of as yet unrealized signification. All curated or recorded data from archaeological field research do have the minimal trace-value of being presumed 'relevant to the past'. These data are collected and documented as if they were already traces, even though their trace-value is not yet fully realized (and in some cases may never be). As such, archaeological traces are not static in the sense of being only accessible/inaccessible—rather they evolve. The trace-value of archaeological data may gain specificity, credence, new referents or correction in the course of analysis. It follows that these new trace values must be latent in the documented material remains from an ontological perspective if we are to understand these traces as vestiges of the past rather than scholarly constructs.

These new trace-values emerge through new discoveries, theoretical and methodological innovations and the juxtapositioning of traces within new explanatory arguments. This last point is important but under-discussed. When archaeological data are made relevant as evidence to some aspect of the past via effective argumentation, the data not only provide evidential warrants for the argument, their trace-value is also transformed, becoming more specific, more believable or novel in terms of what they signify. Indeed, sometimes material remains can only be considered traces of some aspect of the past when situated in relation to other traces within an effective argument; on their own they would fail to signify that particular past. Let us consider these points in more detail using a concrete example.

The Late Bronze Age cremation cemetery of Herstal in Belgium's Meuse Valley was excavated in 1965–66 and the results of these excavations were recently re-examined (Sabaux *et al.* 2021). In this reanalysis the data from the original excavations were transformed as traces using a variety of methods. The written and graphic representations of the burials were used to reclassify each burial according to a recent typology developed for Belgium's better-known Scheldt Valley. Curated calcined human bone was re-examined using recently developed age, sex and pathology criteria specific to cremated remains. Bone samples were radiocarbon dated, with multiple samples taken from the burials containing two distinct bone deposits. Finally, at least two samples from each bone deposit were subject to strontium isotope analysis ($^{87}Sr/^{86}SR$).

As a result of this reanalysis, we see the trace-value of the originally excavated material gain increased specificity, increased credence and new or corrected referents. The burial typology highlighted more specific links to funerary practices in the Scheldt Valley as well as identifying practices distinct to the Meuse Valley and indeed to Herstal itself. Osteoarchaeological analysis generated new information on the cemetery's demography as well as adding credence or correction to observations such

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as the identification of juvenile remains. Radiocarbon dating offered a more precise chronological range for the use of the cemetery and the $^{87}Sr/^{86}Sr$ analysis provided new information on the mobility of the cemetery population. Combinations of these analyses also transformed the trace-values of the data. Statistical analysis showed that burial types were not correlated with either biological age or sex. Distinct radiocarbon dates and $^{87}Sr/^{86}Sr$ profiles from bones within the same grave added credence to the interpretation of the burials with dual bone deposits as containing the remains of two individuals. The $^{87}Sr/^{86}Sr$ analysis is also interesting as an example of data gaining a trace-value they would not otherwise possess when situated in relation to other data. All of the $^{87}Sr/^{86}Sr$ ratios derived from the curated bones were higher than those derived in a baseline strontium isotope study of plants from the local region, something that might normally suggest a non-local origin for the population buried in the cemetery. However, when viewed in light of the diverse but local burial practices and the heterogenous nature of the local geology, this difference was taken as evidence for high levels of mobility and diverse resource exploitation within the wider Meuse Valley rather than evidence for long-distance migration.

The cemetery at Herstal illustrates the emergent nature of trace recognition. None of the reanalysis would have succeeded if the recorded and curated data had not contained latent trace-values. At the same time, it was only through argumentation and the ongoing development of relevant scaffolding that such traces could be recognized. So both epistemology and ontology, mediated by argumentation and scaffolding, matter for the recognition of traces. If we remember Currie's definition, much of the complexity in trace recognition that I have identified falls into what he termed 'mid-range theory' and what I termed more broadly as 'epistemic interventions'. So let us now turn our attention to the question of these interventions.

Epistemic interventions: Ginzburg's clues and Binford's correlates

Within a year of one another, the Italian historian Carlo Ginzburg and the American archaeologist Lewis Binford published papers in which the inference of past states of affairs from contemporary traces was compared to medical diagnosis from symptoms. In tracing the development of what he terms an 'evidential paradigm', Ginzburg (1989, 96–102) shows both common methods and directly documented influence extending from the art historian Giovanni Morelli's use of apparently inconsequential features of unsigned paintings to identify individual artists, through Sherlock Holmes's use of clues to reconstruct crimes, to Sigmund Freud's use of symptoms to identify repressed trauma. Ginzburg (1989, 101) notes that 'In each case, infinitesimal traces permit the comprehension of a deeper, otherwise unattainable reality'. For Ginzburg, it is no coincidence that Morelli, Conan Doyle and Freud all trained as physicians. 'In each of these cases the model of medical semiotics is evident: that discipline which permits the diagnosis of diseases inaccessible to direct observation based on superficial symptoms, sometimes thought to be irrelevant in the eyes of the layman' (Ginzburg 1989, 102). Ginzburg speculates that this mode of trace-recognition has its origins in hunters tracking animals and diviners reading *omina* in nature. However, according to Ginzburg (1989, 102), it was during the 1870s that the medical model allowed the crystallization of an 'evidential paradigm'. This semiotic model is based on metonymy that proceeds by conjectural inference from effects to causes in relation to individual cases. For Ginzburg, the humanities' evidential paradigm stands in contrast to Galilean science because differences took on greater significance than regularities when they were located 'close to home' in the case of humans studying other humans. Hence, the specifics of individual cases mattered, and these could only be explained causally through a narrative-based interpretation of clues.

Ginzburg's essay is concerned with the history of ideas rather than methodology. His central example is the so-called 'oriental fable' that inspired Voltaire's *Zadig*, in which three brothers describe a missing camel or horse using inconsequential traces left by its passing. While Ginzburg uses this story to emphasize the narrative reconstruction of 'a complex reality that could not be experienced directly' (Ginzburg 1989, 103), he says little about the use of bridging theories and background knowledge to constitute phenomena as clues or traces. Instead, Ginzbug seems to revel in the conjectural leap from effects to causes, downplaying the role of general principles in interpreting individual cases and leaving us with limited guidance as to how one recognizes and justifies traces as effects that point to causes one cannot directly observe.

In light of Ginzburg's essay it is interesting that Lewis Binford independently chose medical diagnosis as an analogy for what was wrong with archaeological inferences that ran from effects to causes via material traces:

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> The situation is similar to conditions during the early years of the development of medical science. We wish to be able to cure and prevent disease. Do we obtain such knowledge through the comparative study of the symptoms of disease? The symptoms are the products of disease. Can they tell us about the causes of disease? In a like manner the archaeological record is the product or derivative of a cultural system such that it is symptomatic of the past. We cannot hope to understand the causes of these remains through a formal comparative study of the remains themselves. (Binford 1980, 4–5)

For Binford, the 'archaeological record is a static contemporary phenomenon' (Binford 1983, 416) that cannot serve directly as a trace of the dynamics of past cultural systems that are of interest to archaeologists. Past dynamics must be inferred from contemporary statics, but this cannot be done without uniformitarian principles allowing us to identify 'properties of the archaeological record that will *have unambiguous referents in the past and will be uniformly relevant to the past*' (Binford 1983, 50, emphasis in original). From this perspective the logical necessity of Binford's programme of developing Middle Range Theory (MRT) through actualistic studies emerges. Here Binford also makes use of the hunting metaphor, but reverses the direction of inference:

> The persons who develop the knowledge that permits the recognition of the track, and hence the identification of the animal responsible, *must* study the footprints of identified animals so that the relationship between animal and track is a controlled or known relationship. Given such a control in the contemporary world, and given that one is successful in recognizing and describing diagnostic criteria (constant and unique) between cause and effect, animal and footprint, then when one encounters the diagnostic footprint in the future the inference of the prior presence of the indicated animal may be considered an inference of high probability. (Binford 1983, 418)

The critique of Binford's MRT is well known (see Tschauner 1996) and focused primarily on his social theory, namely that culture was a holistic adaptive system realized in a limited number of evolutionarily significant forms that accounted in a generative sense for the variability of human behaviour (Hodder & Hutson 2003, 14–15). However, there were also epistemological problems. How does one identify living exemplars of a common generative system when identifying and understanding that system is the goal of one's archaeological research? How can the inductive identification of behavioural correlates in actualistic studies produce valid premises for interpreting archaeological remains via deductive syllogisms? How does MRT avoid the problems of equifinality and affirming the consequent?

Over time, Binford changed how he framed MRT, introducing tensions that he never fully resolved. He never abandoned the quest to make MRT an unambiguous observational language, a Rosetta Stone that would provide uniformitarian translations of the archaeological record. However, he seemed to accept that his inductive source-side work building MRTs was no less theory laden than were direct observations of the archaeological record. What he insisted was that a relative objectivity could be attained if the theory informing MRT was independent from the theory informing the evidential uses to which archaeological traces were put (Binford 1983, 45–55; Wylie 2002, 117–26).

It is at this point that the philosopher Peter Kosso picked up MRT from Binford, subtly changing it in the process (e.g. Kosso 2001). Kosso represented MRT as any background knowledge or theory that accounts for observational data independent of its evidential use. For example, at the Neolithic site of Çatalhöyük excavators have argued that, in the lower levels, houses were divided into 'clean' and 'dirty' areas, reflecting the embodied beliefs of their inhabitants regarding the spatial segregation of 'clean' activities such as burial and wall painting from 'dirty' activities such as food preparation (Hodder & Cessford 2004). The distribution of micro-artefacts embedded within the floors of the houses was used as evidence in support of these inferences. However, the background theories and knowledge connecting micro-artefacts with past activities such as sweeping or food preparation are independent of those connecting the spatial segregation of activities with embodied spatial order and hence act as MRTs in Kosso's sense. Importantly, and in contrast to Binford, Kosso (2001, 64) allows MRTs to be both general and particular in nature.

Adrian Currie adopted his concept of mid-range theories from Kosso's discussion of MRT (Currie 2018, 70). However, Currie (2018, 73–8) adds the constraint that mid-range theories hinge on dependency relationships between past phenomena and their traces. According to Currie:

> Some variable v_1, is *minimally dependent* on another variable, v_2 just when v_2 taking a particular value, or range of values, effects the probability of v_1 taking a particular value or range of values. (Currie 2018, 74)

In other words, if traces are dependent on past phenomena, then if the past were different, it is likely that its traces would be different, and similarly

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different traces imply different pasts. Currie's definition allows for MRTs based on correlative and well as causal relationships between pasts and their traces. He also recognizes that MRTs incorporate distinct modes and strengths of dependencies, describing these in terms of the number of dependent variables linking a trace and some aspect of the past (*embeddedness*), the specificity with which a trace signifies a particular past (*informativeness*) and the *strength* with which a trace signifies a particular past. For example, the colour of the clay body of a pottery sherd can provide information on both the firing environment and the firing temperature of the original vessel (Daszkiewicz & Maritan 2016), meaning colour as a trace of firing conditions is *embedded* across two variables. However, on its own colour cannot provide more specific information on firing conditions, such as the precise maximum temperature or the percentage of oxygen present, hence its *informativeness* is arguably low. Finally, within broad parameters, reducing and oxidizing environments can be inferred with reasonable certainty from colour, meaning that the *strength* of this dependence is high, whereas the relationship between colour and firing temperature is mediated by contextual factors that can be said to reduce the *strength* of dependence.

Currie (2018, 81, 137–65) shows quite effectively that in the historical sciences traces are not treated atomistically as individual 'facts', but are deployed using a range of evidential strategies (e.g. unified in common cause arguments; intersected through arguments of consilience; aligned through arguments of confluence, etc.). Currie argues that none of these strategies can be said to exhaust the options available to the historical sciences, but he also goes further. Currie argues that beyond these trace-based strategies the historical sciences also have non-trace-based options when it comes to generating evidence about the past.

Currie offers three examples of non-trace-based forms of evidence, dependencies in the past, analogies, and modelling. However, for each of these cases, I would argue that what Currie considers to be non-trace-based forms of evidence are better understood as different kinds of epistemic interventions linking traces and past phenomena. Let us look at each of Currie's non-trace-based forms of evidence from the perspective of what I am terming epistemic interventions.

Dependencies in the past are cases where a relationship of dependency exists between two phenomena in the past rather than between phenomena in the past and their traces in the present (Currie 2018, 153–7). The problem with dependencies in the past is that to have evidential value they need to be knowable in the present. This requires a chain of dependencies that ultimately lead to a trace. For example, plants belonging to the genus *Cucurbita* (e.g. squashes and gourds) require insect pollination to reproduce. Hence, in the past there was a dependency between the presence of *Cucurbita* and the existence of pollinating insects such as bees. This dependency is particularly strong and bi-directional in the case of squash bees (members of the genera *Peponapis* and *Xenogloss*) which pollinate exclusively on *Cucurbita* (Hurd *et al*. 1971). This dependency in the past is established by uniformitarian MRTs that allow the retrodiction of both *Cucurbita* reproductive cycles and the behaviour of bees. *Cucurbita* can be identified archaeologically from a wide variety of macrobotanical and microbotanical remains. While *Cucurbita* phytoliths, for example, are connected to *Cucurbita* rinds by dependencies captured through MRTs, the same cannot be said of phytoliths and ancient bees. However, there is a secondary dependency between phytoliths and ancient bees in the sense that if there were no ancient bees, there would have been no *Cucurbita* phytoliths in the archaeological record. Hence, the presence of *Cucurbita* phytoliths in the archaeological record can be said to constitute at least a secondary trace of ancient bees. Indeed, several studies have used archaeological evidence for the spread of *Cucurbita* in North America to reconstruct the spread of one species of squash bee (*Peponapis pruinosa*) beyond its ancestral distribution in Central and South America (Bischoff *et al*. 2009; López-Uribe *et al*. 2016).

Currie recognizes that knowing if past dependencies are active and relevant 'is going to depend to some degree on traces' (Currie 2018, 157). However, what matters for Currie is the locus of the epistemological work being done. As he later clarifies (Currie 2019, 5–6), Currie's principal concern is to counter the claim that the *only* evidence available to historical scientists is directly ancestral traces, in whose absence past phenomena are unknowable. For archaeologists, who have long deployed surrogative evidence such as analogies and experimental reconstructions, this is not the issue it might be for some philosophers. However, I would like to suggest that even surrogative evidence must 'run-through' traces in at least the secondary sense that we have already seen for dependencies in the past.

Surrogative evidence such as analogies or models do not have the directly ancestral relationship to past phenomena that is implied by the concept of a trace but can still play an evidential role in

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archaeological arguments (cf. Wylie 2002, 136–53; 2017b). Hence, for Currie surrogative evidence is non-trace-based because it is ampliative and goes beyond causal relationships of ancestry (Currie 2019, 6–7). In the case of analogies, however, it is important to remember Alison Wylie's (2002, 136–53) discussion of the source-side and the subject-side in any analogical argument. As Wylie shows, analogies differ in strength depending upon the relationship between source (the analogue) and subject (the trace), with strong analogies incorporating not only numerous similarities across a diverse range of sources, but also connections that are relevant to a focused and limited range of inferences and which are relational (e.g. causal) rather than only formal in nature. Furthermore, the inferential work needs to occur on both sides, with questions of context and relevance depending upon our understanding of the subject as well as the analogous sources (Wylie 2002, 151–2). Using Currie's own definition of dependencies, we can say that if the subject (or trace) side of the analogy were different, then different sources would be chosen and hence the inferred past phenomena would be different.

This dependency applies even to composite analogies (Currie 2018, 203–27; Wylie 2002, 152–3; 2017b, 990–91) built from multiple sources when no single analogue is available in the present. Currie (2018, 214–22) uses the example of the unique sabre-toothed marsupial *Thylacosmilus atrox*, whose bite mechanics and predatorial behaviour are reconstructed analogically using individual features of extinct sabre-toothed mammals and modern big cats. In archaeology, one regularly encounters more complex and less causally constrained composite analogies. For example, Scott Hutson (2010) has developed an interpretation of personhood and communal identity at the Mayan site of Chunchucmil, Mexico, by combining the concept of relational personhood drawn from Melanesian ethnography (Strathern 1988), with the concept of house-based corporate identities, drawn from 'house societies' of the Pacific Northwest and Southeast Asia (Lévi-Strauss 1982). While such composite analogies are very complex, it remains the case that the analogue sources, and the inferred past phenomena derived from such sources, would cease to be relevant if the archaeological remains at Chunchucmil were different than we currently know them to be. As such, within Currie's own definition, analogies fit better as a distinct form of intervention standing between traces and past phenomena, parallel to the role he already gives to MRTs, rather than being understood as a distinct form of evidence disconnected from traces.

For Currie (2018, 229–47) models can also provide non-trace-based forms of evidence in the historical sciences, in the sense that modelling can produce outcomes not inherent in a physical trace that allow one to distinguish between hypotheses. For example, Currie notes that the fossil record for echinoids is very patchy and cannot be used to reconstruct the evolutionary history of their body plan. At the same time, one can only derive the body plans of modern echinoids (e.g. sea urchins and sand dollars) from the body plans of fossil Palaeozoic echinoids through models that exempt the ancestral examples from the Ocular Plate Rule (OPR), which limits the loci of plate attachment in the development of modern echinoids. Hence, the inference that the OPR did not apply to ancestral examples of echinoids is an inference warranted by modelling rather than by fossil traces. However, it is notable that the body plan of Paleozoic echinoids provided a key set of parameters for building the model, and that the body plan of modern echinoids, which constitutes a trace of their evolutionary history, provided a target against which the model is measured for congruency. Therefore, in terms of relevance and plausibility, the model is secondarily dependent on traces at two distinct points.

As Wylie (2017b) notes, models in the sense of simplified representations of real or possible worlds are widely used in archaeology beyond the problematic whole-system models associated with early Processual Archaeology. Artefact typologies, *chaînes opératoires*, GIS viewsheds or Relational Ontologies can all act as models in archaeological discourse, as do formal causal and decision-making models. However, despite the diversity of structure and intent, archaeological models depend upon traces for their relevance and plausibility in ways that are very similar to Currie's example. Archaeological traces either provide parameters that constrain model construction or they provide a measure of congruency between the model and the known world. Hence, while models are ampliative in making visible and plausible phenomena that are not inherent in the archaeological trace on its own, these inferred phenomena remain secondarily dependent on archaeological traces in a manner very similar to dependencies in the past and analogies. If the archaeological traces were different, then the model parameters would be different and/or the modelled phenomena would be different.

Even when the primary epistemic work appears to be going on 'elsewhere', in analogies or models for example, the ontological characteristics of archaeological traces, their materiality and their presence,

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remain central to archaeology as a knowledge-forming practice.

Implications and conclusions

If we return to Currie's original definition of traces, we can reiterate that archaeological traces are contemporary phenomena that are recognized as referencing past phenomena through some kind of epistemic intervention. In this definition, 'epistemic intervention' is intentionally open-ended, as such interventions are highly variable and could include anything from narrowly causal MRTs to an experiential and empathetic hermeneutics. For the sake of exposition, I have assumed that such interventions are empirically and theoretically adequate. This glosses over the actual content of our epistemic interventions, which can be ideologically biased, poorly formed, or simply wrong. Certainly, the theoretical framing, requisite background knowledge and disciplinary scaffolding employed in epistemic interventions are often quite contentious and subject to debate.

What I have specified is that, even though epistemic interventions are necessary to the recognition of archaeological traces, empirically and theoretically adequate interventions must run through traces in the sense of establishing primary or secondary dependencies between archaeological traces and a reconstructed past. This means that our reconstructed pasts are not reconstructed exclusively within our epistemic interventions but hinge upon the ontological characteristics of the traces in question. The presence and the materiality of archaeological traces, broadly conceived, shape what we can know about the past in specific contexts. This extends far beyond Shanks and Tilley's (1987, 104) 'network of resistances' since archaeological traces are also creative enablers when it comes to our understanding of the past. The ontological reality of 'this is what we have' or 'this is what we are likely to find' is a great source of imaginative innovation within archaeology. Going further, we have seen that the latency of archaeological traces, their as-yet-to-be-realized significance, gives them a future-oriented potentiality that is extremely interesting.

To think about the potentiality of archaeological traces is to think about future pasts that will be different from current pasts in ways that we cannot know at present. This uncertainty raises questions not only regarding how one preserves the potentiality of archaeological traces, but also which future pasts will be realized according to which priorities and by what means. Ensuring the open-ended protection of archaeological sites and the curation of archaeological specimens and records does not address these issues, nor does virtual preservation via digital replication. The proliferation of heritage resources in a finite world raises issues of choice and priority that are not inherent in the ethic of preservation itself. Furthermore, data proliferation, as in the case of ambiguously structured Open Data or grey literature repositories, creates barriers to the reuse of data and hence the recognition of new trace values (see Huggett 2015; 2022, 284–7). As Sabine Leonelli (2016; Leonelli and Tempini 2020) has pointed out in her critique of Latour's term 'immutable mobiles', digitization and data mobility transform, rather than re-present, data because their materiality and ontology is significant. As archaeologists have come to realize, digital data have certain affordances and are structured in specific ways that allow the expression of some relationships and not others (Hacıgüzeller *et al.* 2021; Huggett 2020). Hence, our choices in curating, digitizing and mobilizing data will help to shape which latent traces are recognized and hence which future pasts are realized.

Issues of uncertainty, proliferation and transformation are already central to discussions of so-called 'Heritage Futures' (e.g. Harrison *et al.* 2020); however, little attention is paid in this literature to epistemological questions of future knowledge formation. Yet, as the example of feminist-inspired reinterpretations of archaeological remains in the 1980s and '90s makes clear, recognizing latent archaeological traces can be transformational and emancipatory rather than merely additive or corrective. In this age of perpetual crisis, the question of which future pasts we realize is vital and pressing, but it is not merely a question of shaping collective values or government policies; it is also fundamentally a question of knowledge formation. While we do not know how archaeological knowledge will be transformed in the future, we do know that such future pasts, insofar as they are archaeological, will 'run through' traces. Hence, exploring archaeological traces, as I have tried to do in this paper, entails not only the tension between material remains in the present and our reconstructed pasts, but also an orientation and responsibility towards the future.

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