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Geology/archaeology in action: a personal perspective

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Abstract This article uses Bruno Latour's concept of Science in Action to consider the relationship between archaeology and geology. It is argued that neither the New Archaeology nor Postprocessual Archaeology provides a strong foundation for dialogue between archaeology and geology. Significant differences in temporal scale and structure pose a significant hurdle to integration of geology and archaeology. However, the practice of both disciplines is characterized by an internal tension between the use of imagination and intuition versus a reliance on data. This dynamic provides the basis for cooperation between geology and archaeology, but it must be realized that collaboration requires that geologists be seen as equal partners in inquiry rather than as specialists in service of an archaeological research agenda.

Keywords Geology · Archaeology · Geoarchaeology · Imagination · Abductive reasoning

> *Scientific reasoning is an exploratory dialogue that can always be resolved into two voices or two episodes of thought, imaginative and critical, which alternate and interact* (Medawar 1968: 46).
> *Here every work is an experiment…in the sense of prising an opening and following where it leads. You try things out and see what happens* (Ingold 2013*:* 7).

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In his influential book *Science in Action*, Bruno Latour (1987) illustrated his view of the two sides of science through a series of simple cartoons of a Janus-faced image. In Latour's view, science is at once a process where all is in play—science in the making—and at the same time a set of established facts. Latour's Janus figure is an effective visual metaphor and one that is used in this paper to develop a perspective on the common ground shared by geology and archaeology (Fig. 1).

It is first worthwhile to consider the internal dynamics of archaeology, which are often represented as a dichotomy between New Archaeology and Postprocessual Archaeology (see for example Chazan 2013). These are not the Janus faces of archaeology, two voices that speak from one body, but rather something of a two-headed monster where each face projects forward simultaneously, in seeming combat for our attention. Although the New Archaeology/Post-Postprocessual dichotomy remains of pedagogical value, the reality of archaeological practice has long left this dynamic behind. In particular, neither Postprocessual nor the New Archaeology provides a strong basis for geoarchaeology. Postprocessual archaeology, at least in its rhetoric, often opposes scientific method, although the call for a contextual understanding of archaeological deposits provides an excellent basis for attention to site formation processes. Unfortunately, in the postprocessual literature, 'contextual' is often exclusively linked to aspects of human subjectivity relegating other aspects of context to secondary status. The result is to undervalue methods that do not inform us about subjective experience and in some cases to shoehorn geoarchaeology into filling this role.

It might be assumed that New Archaeology, which drew on a rhetoric valorizing science, would offer a strong prospect for a unified geoarchaeology. However, I find that a number of aspects of the New Archaeology have actually had a negative effect on the development of a serious working relationship

Fig. 1 Latour's Janus figure

between geology and archaeology. The New Archaeology emphasized archaeology as a social science (Binford 1962). Rather than valuing scientific practice, the New Archaeology placed an emphasis on the rhetoric of positivism, a rhetoric that today feels dated in almost all aspects of natural science research and never really applied to geology. The goal set by the New Archaeology for the geologist is to provide data needed to further the archaeological agenda. Ironically, the New Archaeologists who rebelled against being dismissed, in a tellingly sexist phrase, as the 'handmaidens of history', did not hesitate to relegate geologists to the scullery.

At a deeper level, the New Archaeology developed in part as a reaction against what Walter Taylor described as 'the archaeologist as technician' (Taylor 1967). To a degree, the New Archaeology deemphasized the development of analytical skills in favour of couching research programs within the framework of hypothesis testing. There were areas such as faunal analysis and palaeoethnobotany where the New Archaeology encouraged the development of analytical skill, but there are strong reasons to largely attribute these developments to the effects of Economic Archaeology as developed by Grahame Clark rather than the American New Archaeology (see discussion in Trigger 1989: 244–286).

Differences Between Geology and Archaeology

Both archaeologists and geologists are interested in processes that took place in the past. However, there are significant differences in the temporal dimension of these disciplines. The most essential is that archaeologists are interested in the human past with a time depth of 2.5 million years while geologists look at a timescale that reaches back over 2 billion years. Even when geologists are looking at Quaternary processes, which overlap chronologically with archaeology, or events taking place over very short time intervals, they are conscious of longer-term processes of landscape formation. Beyond this essential difference in time scale, the fact that archaeologists' subject matter is the human past introduces a narrative structure that is largely absent from geology. Archaeologists are, after all, talking about people much like themselves whereas geologists are engaged with physical processes, which are governed by natural laws that are predictable to a certain degree. The contrast in narrative strategies is evident in the differences between the disciplines in practices related to periodization. The recent decision of the International Union of Geological Sciences (IUGS) to move the boundary between the Pliocene and Pleistocene provides an archaeologically relevant illustration of how geologists approach periodization (Gibbard et al. 2010). One issue was the determination of the position of the Quaternary within a hierarchical chronological system. But the key question was where to situate the Pliocene-Pleistocene (epochs) Boundary which in accepted systematics is also the boundary between the Quaternary and Neogene periods. The accepted boundary had been the base of the claystone conformably overlying the sapropelic marker bed 'e' in the Vrica section in Calabria, southern Italy, dated to 1.8 mya. The problem with this marker was the widespread consensus that 1.8 mya does not mark the inception of global cooling. The IUGS decided, following by a vote of members, to set the Pliocene-Pleistocene boundary to the top of the sapropelic Nicola bed in the Monte San Nicola section dated to 2.58 mya. This age is a fixed point in time that correlates to a long-term planetary process of global cooling linked to the closure of the Panama isthmus. It is important to emphasize that the goal in fixing the chronological marker was not based on a determination of a 'moment' when the earth's climate changed. Rather, it is a fixed and identifiable point within a gradual process. There is no moment when the earth's climate changed so that the boundary point is to some extent arbitrary within a range.

It is worth noting that geological systematics does generally recognize human activity as a relevant factor. However, the IUGS committee grudgingly allows for the recognition of the Holocene as an epoch 'distinct from the Pleistocene, in recognition of the fundamental impact of humans on an otherwise unremarkable interglacial' (Gibbard et al. 2010: 101). More recently, geologists have taken up the proposal of the Anthropocene as an epoch in which humanity has become a planetary force (Steffen et al. 2011).

In contrast, the conceptual basis of archaeological chronologies is rarely the subject of explicit debate. For the Palaeolithic, chronologies combine an absolute age range with characterization of lithic industries. The characterization of lithic industries can combine notions of progress in the degree of sophistication alongside stylistic markers used as signifiers of a continuous population (Chazan 1995). The process involved in defining the chronology is rarely made explicit (although see Dusseldorf et al. 2013 for a recent exception). To my knowledge, there has never been an effort to base archaeological chronologies on fixed arbitrary points in time that are linked to global processes, although archaeologists increasingly use oxygen isotope stages as a temporal scaffolding. The distinctiveness of archaeological chronology is the insistence on creating entities—whether industries or

cultures—that are then situated in time. These entities are not considered as simply convenient or recognized as arbitrary markers as is the case with geological time divisions. These archaeological entities are essential tools for incorporating prehistory into the kinds of narrative structures found in the writing of later stages of history—creating a unified narrative of human life on earth. For geologists, there is no such imperative as their history is not of humanity but rather of physical processes in the history of planetary systems.

Imagination and the Practice of Archaeology and Geology

I would like to suggest that the most significant commonality between the disciplines is that both geologists and archaeologists tend to share a similar internal split. This is not Latour's Janus face speaking of science in the making out of one side and science as established fact out the other. Rather, it is an internal tension between the use of imagination versus a reliance on data (Fig. 2). The balance, and degree of self-awareness, will vary among practitioners, but it is this internal tension that might provide the most authentic meeting ground for archaeology and geology.

The term *imagination* has multiple meanings and is used here in the restricted sense of the active development of internal images or ideas that go beyond the objects or landscapes actually present to the senses (adapted from Oxford English Dictionary). Imagination is not used here in the sense of predicting the future or developing ideas that do not correspond to reality. Imagination as used here overlaps with the concept of abductive reasoning as developed by Pierce (for a very relevant discussion of abductive reasoning in archaeology, see Shelley 1996). Abductive reasoning involves the development of plausible explanations on the basis of limited evidence and, as discussed by Shelley (1996), often is based on visual mental imagery rather than linguistically formulated statements, and for archaeology and geology, this can be expanded to a wide range of responses to tactile experience, whether walking through the landscape or handling an artefact. Imagination in this sense is not 'child's play' (although it might well develop out of the capacity for play that is so critical in human ontogeny) but rather is a critical component of scientific practice. In discussing scientific observation, Hacking writes of Caroline Herschel, the sister of the eighteenth and early nineteenth century astronomer William Herschel, who had a particularly acute ability to identify comets. Hacking writes that this ability was not because she was a 'mindless automaton' but rather that 'she had one of the deepest understandings of cosmology and one of the most profound speculative minds of her time' (Hacking 1983: 180). I would place an emphasis on Hacking's use of the term *speculative*, which is another way of expressing what is included here under 'imagination'. In other contexts, the term *intuition* is used to express this grasp of non-verbal and incomplete evidence to make a leap of inference (see for example Fischbein 1987).

It may well be the case that the use of imagination as defined here is characteristic of all scientific pursuit (Caroline Herschel provides an example from astronomy) and that it is wrong to associate this aspect of practice specifically with archaeology and geology. This may well be the case, but I think there is a strong argument that the use of imagination, or abductive reasoning, in these disciplines is distinctive and rests on a shared foundation. Archaeologists and geologists are both involved in the study of dynamic processes on the basis of a radically incomplete physical record. The need to move from static objects or landscapes to a dynamic process combined with the fragmentary nature of the record combines to place a premium on making imaginative leaps. Bergson (1907) argued that this need for leaps of what he labelled as intuition was essential to the basic human capacity 'to grasp the very essence of living and changing phenomena' (Fischbein 1987: 3). Bergson compares human observation to still images and the role of intuition to cinematography. This is an interesting perspective on human cognition, but the point here is more limited. Within the fields of archaeology and geology, the role of imagination is particularly critical as not only is there a need to build a moving image from a series of stills but the still images that exist are fragments of the original totality.

The data side of the equation is fairly apparent. Open any publication in either discipline and the data spills out. In fact, I have been struck when speaking to geologists to hear the refrain that they have to use instrumentation and quantitative measure in order to get anything published—even if they reached the same results using field observations. I want to emphasize that I do not mean to devalue the data aspect of archaeological and geological research; it is fundamental. Remove this face from the figure and one can no longer maintain a claim to be engaged in scientific enquiry. Quantification is not a 'rhetorical stance'; it is a fundamental way of knowing about the world.

However, I have noticed in recent years that among archaeologists who study stone tools, there seems to be a growing

Fig. 2 The Janus face of intuition and data

sense that data alone should be able to generate understanding. Particularly with the development of advanced methods of high-precision data acquisition and shape analysis, some seem to see a future where lithic analysis will become a real science by being wholly dependent on quantification. As an advocate of the '*chaîne opératoire*' approach to studying stone tools, I tend to be wary of this reliance on quantification (see discussion and references in Chazan 1997, 2009). The *chaîne opératoire* school of thought has a strong theoretical foundation rooted in French writing on technology. Since the 1980s, lip service to the *chaîne opératoire* has become ubiquitous in the archaeological literature, prompting a degree of outrage from North American archaeologists who see little novel in the approach. North American archaeologists point to the similarities between the *chaîne opératoire* and the 'reduction sequence', which has been central to North American lithic analysis since the late nineteenth century (Tostevin 2011 and other contribution to the 2011 special issue of *Paleoanthropology*). There is certainly truth in this critique as both the *chaîne opératoire* and reduction sequence look at artefacts as elements in a dynamic process rather than as static objects. However, there are critical aspects of the *chaîne opératoire* that are missed by reduction sequence, which brings back the question of the role of imagination in research.

When I carry out an analysis on an assemblage, I think it is critical to understand how the person who created these tools organized the task. For making stone tools, a spatial model of the block of material guides the process of knapping. The most famous of these spatial models is the 'Levallois method'. In the Levallois method, the block is conceived as two hierarchically related surfaces. This spatial relationship is imposed by the knapper; it is not inherent in the material itself. The Levallois is only one of the methods (meaning in this context spatial models) identified by archaeologists working in the *chaîne opératoire* school of thought. In my own experience, I have worked on an assemblage that was produced using the trifacial method and worked on the method used to make Dufour bladelets from busqued burins during the Aurignacian (Chazan 2000, 2001a, 2001b). Reaching the identification of a method is not the endpoint of analysis; rather, it orients the analysis, providing a framework for subsequent research. The actual process of identifying the method used to produce a particular assemblage is an act of imagination. It does not involve a single criterion; it is not based on simply identifying a typologically diagnostic object or series of measurements. Indeed, there are cases of Levallois industries with very few typologically diagnostic Levallois cores (i.e. Meignen 1993). Rather, this identification is an act of imagination by the researcher who combines their own experience (both in making stone tools and working with collections) with observations made on the entirety of the assemblage. This is a powerful approach; however, it is fair to criticize the *chaîne opératoire* school of thought for often neglecting to rigorously test the ideas developed using abductive reasoning.

The North American lithic community has not dwelled on considering the role of abductive reasoning, imagination and intuition in analysis, although I suspect that most practitioners would accept the role of these processes as perhaps being self-evident. One reasonable question is whether the *chaîne opératoire* assumes a spatial model where none may be present and to point out that identifications might be incorrect. The first point is belied by any experience making stone tools. Without some kind of spatial model, producing regular results such as are found in archaeological assemblages is impossible. I like to think of methods as analogues to recipes and the idea of knapping without a method to be analogous to making a cake without a recipe (Schlanger 1990). Of course, the nature of the recipe—the degree of rigidity vs. flexibility, the modes of transmission—is highly variable, but at some level, there has to be a plan. The second objection is more interesting as it offers as a counter-model an infallible observer. I will return to the 'infallible archaeologist' below, but at this point it is simply adequate to admit that the analyst might be wrong and that this does not in any way lessen the scientific validity of their work. Indeed, the possibility of error is essential to scientific research. One of the real challenges in lithic analysis is to develop quantified methods that allow us to test the identification of method, essentially strengthening the dialectic between imagination and data.

As a lithic analyst, I feel that employing my imagination is fundamental to my work. I have also felt this in the field (see Hodder 1999 for a full discussion). I can remember visiting the Biblical site of Gezer as a child and hearing the archaeologists tracing out buildings where I could see nothing but stones. This memory stands for me as an example of the powerful need for imagination in archaeological fieldwork, to fill out all that is absent. All field archaeologists operate to a greater or lesser extent on hunches based. These hunches are essentially an act of imagination based on prior experience. When excavating on the Giza Plateau, I had the hunch that two short wall segments might continue to form a room that would parallel a bakery room that we were in the process of exposing. This hunch was based on the observable features of the wall but also on prior knowledge that Old Kingdom Egyptians often organized labour groups in pairs so that it would not be unreasonable to expect a parallel bakery. In this case, the hunch paid off and the second bakery emerged precisely as I had imagined.

In the field, the dialectic between imagination and data is unavoidable. In the case of the Giza excavation, this process came out in my favour, but this is only occasionally the case. While excavating at the Epipalaeolithic site of Wadi Mataha, Jordan, my colleague Joel Janetski and I were surprised to come across a burial in a Geometric Kebaran context (Stock et al. 2005). Burials from this time period are rare (although

becoming more common; see Maher et al. 2011), and we had not come to the site with a strategy for excavating a burial. When I looked at the remains that had been exposed, I suggested that we proceed on the assumption that this would be a flexed burial based on my familiarity with this practice with burials from the later Natufian period. We dug around the slightly exposed vertebral column and cranium, searching in vain to delineate the limits of the skeleton. Only gradually did we realize that I had been completely wrong—the skeleton was buried face down and hog tied, a burial pattern that was previously unknown for the Epipalaeolithic. Once we realized my error, the excavation was reoriented towards unpacking this folded skeleton.

I was surprised to find when I began to work with geologists how much their work relies on a similar mode of thinking that draws on visual mental imagery and imagination. Walking in the field with a gifted geomorphologist is for me an incredible experience; they are able to conjure past landscapes that I can only slowly begin to comprehend. Having landslides emerge where I had only seen hills, or past lakes spring out of sections exposed in a desert, are among my highpoints in working with geologists. When I was invited by Hanan Ginat to see the Pleistocene Lake Zikhor in the Negev, I had not expected to see only relics preserved in sections that required a practiced eye to conjure the outlines of a now absent body of water (Ginat et al. 2003). Similarly, after a number of years working at Wonderwerk Cave, I was oblivious to the evidence of a massive landslide and the resulting reorientation of stream channels which only became apparent when pointed out by geologists on the research team (Goldberg et al. 2015). The Zikhor Lake and the Wonderwerk landslide (or in geological terminology, mass wasting event) are not observations based on the collection of data; they are acts of imagination that then orient the collection of data. Without this orientation, geologists would be left to sample the entire surface of the globe, never ceasing in an endless process of running samples through automated grain size analysis. The same holds true for my observations from working with micromorphologists. One is constantly jumping back and forth between observations made under the microscope, to the configuration of layers on the site, to questions of landscape evolution and human activity. It is an act of imagination to synthesize all of these disparate lines of information.

What joins archaeologists and geologists is not simply that both disciplines employ imagination and intuition; it is that they simultaneously insist on data and quantification. This is the shared Janus face of geology and archaeology. The Janus face image captures some of the dynamic, but it might be misleading as it suggests that imagination and data are not in dialogue. Perhaps, it would be better to turn these two faces towards each other to better represent the reality of a constant dialogue between imagination and data as an ideal for researchers in geology and archaeology (Fig. 3). I would

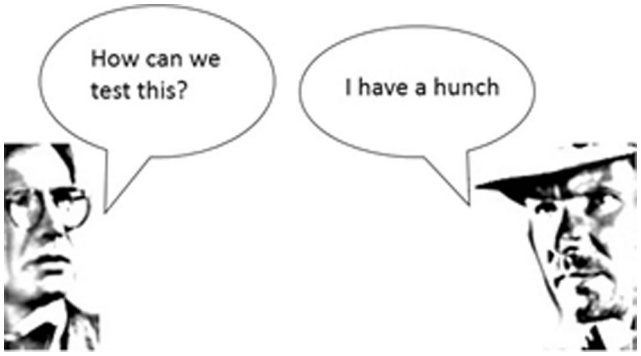

Fig. 3 Data and intuition in dialogue

suggest that recognizing this shared internal dynamic opens up a basis for collaboration between geologists and archaeologists. In an ideal scenario, the dialogue grows as archaeological imagination plays off not only archaeological data but also geological imagination and data. In the large interdisciplinary teams that now are developing around key archaeological sites, what can develop is a complex and multifaceted conversation.

From the perspective outlined here, there is real benefit to collaboration between geologists and archaeologists. But where does this leave the geoarchaeologist, the hybrid individual? I see no reason that the multiple voices presented here cannot be contained within a single individual. Indeed, this would seem to be an intellectually stimulating perspective. However, for geoarchaeology to flourish, it must view geology as a full partner, and not see geoarchaeology as a tool to serve archaeological goals. The future of geoarchaeology relies on finding a home in Earth Science and Geology Departments and publication in major scientific journals. Geoarchaeology must emerge as a full-fledged aspect of studying earth history and planetary dynamics, not a tool for archaeology. Taking part in a large research team in South Africa, I have found in working with geologists that when we allow for a full dynamic where the geology is an equal participant, as much served by the interaction with archaeology as it is serving the archaeology, the results are significant geological breakthroughs. For example, when we first invited Ari Matmon to help with the dating of the Earlier Stone Age sequence at Wonderwerk Cave, our interests were wholly archaeological. However, the use of cosmogenic dating requires understanding the source material and led to a wide-ranging inquiry into the Kalahari sands. As a result, it was possible to establish that the Wonderwerk sequence is the earliest geological evidence for transport of sands in the Kalahari (Matmon et al. 2012). With the emerging debates about the Anthropocene, and subjects such as the Amazonian Black Earth, it is possible for geoarchaeologists to claim a unique position to contribute a vital piece to understanding earth systems (Steffen et al. 2011; McMichael et al. 2014). As

individuals who combine an archaeological and geological imagination, with a knowledge of the data and methodology of both fields, the key goal of geoarchaeology should turn towards making fundamental contributions to geology rather than simply serving to help archaeologists do their job.

The infallible archaeologist

In concluding, I would like to offer a critique of one aspect of archaeology that is a real impediment to cooperation with geologists. For reasons that are difficult to identify, archaeologists are very concerned about being 'right'. I have been surprised that geologists often do not share this need to be right; rather, they want their research to make a contribution, to be methodologically sound and to have an impact. 'Archaeological infallibility' can lead to the suppressing of data that is inconvenient to the archaeologist published position and to a dismissal of analytical methods that yield contradictory data. As archaeologists, we are trying to understand past societies based on very limited material remains. As scientists, we present data and create scenarios that express our best understanding. There is no way to assure that in the arguments we advance, we are ultimately correct. My sense from working with geologists is that they do not share this idea of being 'ultimately correct'. Rather, they often seem comfortable with Latour's idea of science in the making, which allows for the possibility of error. Perhaps, it is time for archaeologists to take Latour's Janus-faced figure seriously and to understand that our current ideas of the human past are constantly open to questioning and in flux. The fallible archaeologist might be in a better position to open a dialogue with geologists to mutual benefit.

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