Bringing the Past to Life: Material Culture Production and Archaeological Practice

Hilditch, J.

DOI
10.2307/j.ctv1b0fvx7.6
10.1515/9789048543854-004

Publication date
2020

Document Version
Final published version

Published in
Reconstruction, Replication and Re-enactment in the Humanities and Social Sciences

License
Article 25fa Dutch Copyright Act

Link to publication

Citation for published version (APA):
Hilditch, J. (2020). Bringing the Past to Life: Material Culture Production and Archaeological Practice. In S. Dupré, A. Harris, J. Kursell, P. Lulof, & M. Stols-Witlox (Eds.), *Reconstruction, Replication and Re-enactment in the Humanities and Social Sciences* (pp. 63-90). Amsterdam University Press. https://doi.org/10.2307/j.ctv1b0fvx7.6, https://doi.org/10.1515/9789048543854-004

2. Bringing the Past to Life: Material Culture Production and Archaeological Practice

Jill Hilditch

Abstract
Performative methods in archaeology provide a valuable heuristic tool for investigating the many behaviours and interactions of both producers and consumers of material culture. Focusing on the potter's wheel at Bronze Age Akrotiri as a socially embedded performance of technical know-how, this chapter outlines an integrated approach to material engagement across three arenas of archaeological action – experiment, analysis, and visualisation – connected by an explicit engagement with the *chaîne opératoire* approach. An innovative tool-kit is presented for the investigation of this technology by the wider archaeological community. Given the large-scale regional and diachronic questions that the adoption and adaptation of ancient technologies can raise, a collective approach is proposed for the interpretation of the potter's wheel.

Keywords: material engagement, ceramic technology, experiment, analysis, visualisation

Introduction

Archaeologists seek to understand the past, that is the people, objects and environments that have shaped, and been shaped by, human experience. Yet, we can never fully recreate it. These complex, multi-scalar interactions between humans and the material record were *performed* both on a daily basis and throughout millennia. This task is further complicated by the study of an incomplete record of partial material remains, often the only

Dupré, S., A. Harris, J. Kursell, P. Lulof, M. Stols-Witlox (eds.), *Reconstruction, Replication and Re-enactment in the Humanities and Social Sciences*. Amsterdam: Amsterdam University Press
DOI 10.5117/9789463728003_CH02

surviving tangible link to a myriad web of intangible human behaviours or practices. In the face of such challenges, archaeologists have developed theoretically-informed methodologies for investigating material culture. These methodologies integrate reconstruction, reproduction and replication (RRR) practices with considerations of human agency, material engagement, and practice theory to seek greater understanding of processes of production, networks of learning, identity construction, and technological transmission in the past.

This chapter first presents a brief overview of how performative methods and material engagement practice have developed at the intersection of archaeology, sociocultural anthropology and the natural sciences. The second part focuses on how current archaeological practice uses reconstruction and replication to shed new light on ancient technology, in particular the process of ceramic manufacture and the transmission of the potter's wheel in prehistory. The adoption and adaptation of the potter's wheel at Bronze Age Akrotiri (prehistoric Greece) is discussed from an integrated *chaîne opératoire* approach across three loci of activity: experiment, analysis and visualization.

Performance and practice, now and then

Following the notion that all practices are, or were, performed within the broad arena of human activity, archaeology is a systematic attempt to characterize these performances in their original spatial and social contexts, as well as how they develop over time. The interaction between humans and material culture has been one of the defining relationships within modern archaeology; 'most archaeologists today see material culture as instrumental to how people create, experience, give meaning to, negotiate and transform their world'.[1] When face-to-face with material culture from the past, our curiosity invariably leads to the question; who made this and why did they make it? The performance, or act, of artefact production offers a unique opportunity to answer these questions, affording archaeologists a means by which to characterize the individuals who made, distributed and used these material artefacts. If we go on to consider the communities in which these individuals performed their craft, then we can also reach wider interpretations about the social practices and networks of interaction within which these communities operated. In short, tangible remains can

1 Dobres and Robb, 'Doing Agency', p. 161.

shed light on intangible aspects of past human societies. In the theoretical overview that follows, examples are given in relation to ceramic material culture.

Bodily performance and social space

The physical and technical knowledge needed to produce material culture, to make a pot, knap a flint tool or cast an axe head, is learnt or transferred by watching and copying 'techniques' until their constituent gestures become habit. These habitual, unconscious actions were first discussed by the French sociologist Marcel Mauss who 'radically separated the phenomenon of techniques from nature, and embedded it within social reason and social practices'.[2] Concepts of bodily gestures and actions, and subsequent sequences of rhythmic gestures, were, therefore, crucial to Mauss as he considered the body an aspect of the self that we live *through*, not in. One of Mauss' rare students, André Leroi-Gourhan, developed this idea by viewing artefacts as extensions of the body, meaningfully constituted through the results of sequences of gestures applied to material.[3] It was Leroi-Gourhan who coined the term *chaîne opératoire*, or operational sequence, which has led to an explicitly technological approach to studying material culture, 'reinsert[ing] technical activities into their gestural, spatial and temporal dimensions'.[4] In embracing this tradition, archaeological research into material culture acknowledges that all learning, past and present, takes place within a social context, hence making technical acts simultaneously social acts.[5] In effect, material engagement allows us to conceive past acts of production as 'meaningful and socially negotiated set[s] of material-based practices'.[6]

Technical or technological choice is a fundamental concept that allows archaeologists to uncover socially 'embedded' technological activities at both individual and group level.[7] Technological choices and social practice are closely related as 'techniques are first and foremost social productions, any technique is always the physical rendering of mental schemas learned

2 Mauss, *Sociologie* and Schlanger, 'Techniques', p. 23.

3 Leroi-Gourhan, *Gesture*.

4 Schlanger, 'Mindful Technology', p. 147.

5 Leroi-Gourhan, *Gesture*; Dobres and Hoffman, 'Social Agency'; Van der Leeuw et al., 'Technical Traditions'; Van der Leeuw, 'Giving the Potter'; Lemonnier, 'Introduction' and Dobres, 'Of Great and Small'.

6 Dobres and Hoffman, 'Social Agency', p. 213.

7 Lemonnier, 'Introduction'.

through tradition'.[8] Ethnographic observation within anthropology has been invaluable in leading us towards an understanding that technical actions for ancient people in pre-industrial societies could be quite 'elastic', given variable raw material properties in combination with other techniques.[9] As a result, technical strategies such as in pot-making have several solutions, or alternatives, and 'every pot is the unique result of a series of choices between alternative techniques'.[10] This applies not only to ceramic manufacture but to all prehistoric 'technicians', their products and their techniques. Even stone tool production, despite being a subtractive rather than additive process, is not entirely linear in character and the artisan could implement a number of different production strategies.[11] So, within material culture production, it is the choices that are crucial in determining the nature and shape of a product, its effectiveness and its life expectancy.[12]

Technical choices also relate to the wider issue of social agency and Bourdieu's *habitus*, i.e. to what degree individuals have the power, knowledge or freedom, to operate outside the socially constituted system of cognitive and motivating structures within their society.[13] Bourdieu defined practice as 'the product of processes, which are neither wholly conscious nor wholly unconscious, rooted in an ongoing process of learning which begins in childhood and through which actors know – without knowing – the right thing to do'.[14] Technical behaviours are not then solely determined by the social (or symbolic) context of production, nor entirely by material or environmental factors: rather it is the goal of technological studies to understand the micro-scale social processes behind the microscale prehistoric technical gestures.[15]

Reconstructing the archaeological framework of 'choice'

The initial step in inferring social context and meaning from material culture is to envisage technical choices as stages within Leroi-Gourhan's gestural sequence, or *chaîne opératoire*. The individual stages can be reconstructed

8 Lemonnier, 'Introduction', p. 3.

9 Van der Leeuw, 'Giving the Potter', p. 239; Mahias, 'Pottery Techniques' and Gosselain, 'Social and Technical Identity'.

10 Sillar and Tite, 'The Challenge', p. 3.

11 Edmonds, 'Description', p. 57.

12 Van der Leeuw, 'Giving the Potter', p. 241.

13 Bourdieu, *The Logic* and Dobres and Hoffman, 'Social Agency', p. 222.

14 Jenkins, *Key Sociologists*, p. 44.

15 Dobres and Hoffman, 'Social Agency', p. 226.

using detailed materials analyses to identify the technical behaviours involved in producing an artefact. Ceramic vessels are conducive to technological reconstruction because they have an observable structure that can be related to their operational sequences. By studying ceramic production technologically, it is possible to reconstruct the choices of potters by their behaviours within the gestural sequence, i.e. raw material procurement and processing, vessel forming, surface treatment and decoration, as well as firing conditions. The benefit of the *chaîne opératoire* as a 'middle range interpretative methodology' then lies in the ability to combine empirically-grounded analytic methods with a robust anthropological theory of social reproduction concerned with everyday practice, embodiment and identity, which embeds technicians into social collectives.[16]

Sander van der Leeuw has made a cross-cultural analysis of the *chaînes opératoires* of a number of pottery-making traditions to highlight the 'conceptual anchors' (shape, parts of a pot and the specific sequence of manufacture) and 'executive functions' (tools and techniques, rotating and support of vessel) that are both more difficult to manipulate than the raw materials.[17] It is these factors within ancient material culture production, examined within a social context, that have the greatest amount of information to give scholars. By studying material artefacts, scholars can recognize and then juxtapose these 'gestural traces of norms and variants' within the *chaîne opératoire* to reveal the degree of freedom technicians experienced within their social contexts.[18] We can also go further still by acknowledging that the cognitive correlates of tradition and innovation can be accessed by identifying how the *chaîne opératoire* is modified to introduce new products.[19] Even though the basic nature of the product can remain constant over a period of time, the *chaîne opératoire* does not necessarily follow the same patterns.[20] It is possible to reveal profound changes in the character of organization within production, either in structures or choreography, which can also be used to interpret the social context of artefact production, distribution and consumption. In other words, it is possible to 'pinpoint and define small coherent combinations of technical features that correspond directly to given social groups'.[21]

16 Dobres and Robb, 'Doing Agency'.

17 Van der Leeuw, 'Giving the Potter'.

18 Dobres, *Technology and Social Agency*, p. 155.

19 van der Leeuw, 'Giving the Potter', p. 141.

20 Edmonds, 'Description'.

21 Mahias, 'Pottery Techniques', p. 170; also Gosselain, 'Social and Technical Identity', and Lemonnier, 'Introduction', who goes on to associate technical choices with social identity and difference.

The *chaîne opératoire* is consequently a rigorous framework for structuring the approach to the social aspect of the overall context of production, i.e. environmental and technological constraints, economic and subsistence base, social and political organization and the ideology or belief systems of the people making the choices. The intentionality and decision-making involved within a particular *chaîne opératoire* can, however, be elucidated without tying those gestural sequences to a particular embodied individual.[22] This framework can also allow scholars to glimpse the social meanings behind material culture production, by highlighting various states of 'belonging' and 'not-belonging' within small coherent social groups.

Social scale and communities of practice

Determining socially meaningful groups as a scale of analysis is a primary concern for anthropologists, sociologists, ethnographers and archaeologists alike.[23] There are problems of establishing which attributes should be used to define groups, how visible such group boundaries may be and also to what extent these boundaries may overlap spatially and temporally.[24] With respect to material culture production, perhaps the most valuable of social collectives is that of Etienne Wenger's 'community of practice', 'the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence'.[25] Using earlier work with Jean Lave on 'situated learning',[26] a theory of learning as a form of participation, Wenger goes on to state that 'social participation is not just in local events of engagement in certain activities with certain people but a process of being active participants in the practices of social communities and constructing identities in relation to these communities'.[27] By participating or engaging in local activities and interactions, learning 'reproduces and transforms the social structure in which it takes place'.[28] In turn, collective learning reflects the social context in which we wish to participate and, therefore, the practices of a community (joint enterprise, mutual engagement, shared repertoire etc.) are always socially meaningful.

22 Hodder, 'Agency and Individuals', pp. 25-26.
23 Lock and Molyneaux, *Confronting Scale*.
24 See Stark, *The Archaeology*.
25 Wenger, *Communities of Practice*.
26 Lave and Wenger, *Situated Learning*.
27 Wenger, *Communities of Practice*, p. 4.
28 Wenger, *Communities of Practice*, p. 13.

As Wenger succinctly stated, 'in practice, manual activity is not thoughtless and mental activity is not disembodied'.[29]

The concept of a community of practice is extremely valuable to archaeological theory because the material and symbolic negotiation of membership within such a community *can* be traced in the archaeological record: the 'technical profile of [an individual's] products will resemble other members of those social groups'.[30] With respect to the production of pottery, this negotiation could manifest itself in clay paste recipe, formation or shaping technique, the tools used to decorate a vessel, the method or motif of painted decoration or even the firing conditions. This constant negotiation of meaning and identity (both as individual members and as a group) can occur over long or short periods of time, but all communities of practice are sustained by the introduction of new members who gain competency through situated learning. Identifying the performance of particular *chaînes opératoires* allows archaeologists to situate individuals within communities of practice, therefore allowing the social context of production, the gestures involved, and the learning of those gestures, to be enmeshed within a network of dynamic relations that can inform the long-term study of material culture.

An important point to emphasize is that the concept of a community of practice operating in the past should not be synonymous with previous definitions of archaeological 'cultures'. Many communities of practice may be operating within a large social group, either as specific differences in the performance and learning of a single technical task or with respect to the production and exchange of different materials. These different communities of practice may also operate at different scales of analysis, often linked to the physical or ideological properties of the material involved. From a ceramic perspective, forming techniques appear to be the most resistant to change as they are learnt through motor skill acquisition within social contexts, in contrast to decorative expression, or cooking methods, that may crosscut residential units as a result of marriage relations or other social processes.[31] This crosscutting of social groups by communities of practice creates contradictions and overlaps within material culture patterning, as different types and changing forms of community membership have the potential to influence or create formal variation within the operational sequence, even

29 Wenger, *Communities of Practice*, p. 45.

30 Jeffra, 'Experimental Approaches', p. 142.

31 Sassaman and Rudolphi, 'Communities of Practice', p. 407. See also Gosselain, 'Materializing Identities; Gosselain, 'Social and Technical Identity' and Van der Leeuw, 'Giving the Potter'.

after long periods of perceived stability that exhibit very little variation. In other words, a meso-scale perspective can provide evidence for similarities between intensive skill transmissions, as well as unconscious practices that can help us understand in greater depth 'the learning structures and mobility of the makers of the objects we analyse'.[32]

Archaeology and RRR practices

The terms 'reconstruction', 're-enactment', and 'replication' are most strongly associated with archaeological practice through the subfield of experimental archaeology, where practitioners are still often (incorrectly) characterized as 're-creating activities, artefacts, structures and processes that happened in the past'.[33] This chapter seeks to expand this familiar arena of performative archaeological practice and instead emphasize a *chaîne opératoire* approach combining material analysis with experimental and digital archaeologies.[34] Such an approach starts during post-recovery artefact analysis, allowing archaeologists to reconstruct past production processes, moves through systematic experimental replication, and finishes in the public domain, by communicating the results in a way that visualizes ancient objects and technologies. These three components, analysis, experiment, and visualization, can be integrated using the *chaîne opératoire* approach to structure their investigative process (Figure 2.1). The rest of this chapter uses ceramic manufacture and technology to illustrate how archaeologists use material culture to reconstruct the crafts, technologies and social practices of the past.

Ceramics are ubiquitous in the global archaeological record. This is for many reasons, not least the availability of their raw materials, as clays can form almost anywhere in the natural landscape. Fired clay was used for a vast range of objects, decorations, and structures, and its durability and compositional stability during deposition has ensured the survival of these objects for generations of archaeologists to discover. As it turns out, this is wonderfully convenient because ceramics are ideally suited for investigating technological innovation. Few other material categories offer such potential

32 Broodbank, 'Minoanisation', p. 60.

33 Outram, 'Introduction', p. 2.

34 The Tracing the Potter's Wheel Project is funded by an NWO Vidi Grant (2016-2021). The project is directed by Dr. Jill Hilditch (PI), in collaboration with Dr. Caroline Jeffra (postdoctoral research fellow) and Loes Opgenhaffen (PhD researcher) at the University of Amsterdam (UvA). More information on project activities and results can be found at https://tracingthewheel.eu (checked on February 28th, 2019).

CHAÎNE OPÉRATOIRE	ANALYSIS	EXPERIMENT	VISUALISATION
raw material acquisition	geological prospection/compositional analysis	clay pits/fills	photomicrographs of ceramic fabric and geological samples
paste processing	textural analysis (petrography/SEM); macroscopic analysis	temper/sediments within site	high resolution photography; ceramic fabric photomicrographs
forming	macrotrace analysis; textural analysis (petrography/SEM)	device/tools/specialised architecture	high resolution photography; video capture; 3D scanning
surface treatment	compositional analysis (petrography/SEM/XRF); macrotrace analysis	pigments/tools	high resolution photography; 3D scanning
firing	structural analysis (FTIR/petrography/SEM)	kiln architecture	ceramic fabric photomicrographs
FINISHED VESSEL	**Laboratory-based testing and replication for reconstructing the *chaîne opératoire***	**Investigation of forming techniques and tools through hypothesis testing and replication**	**Innovative methods for experiencing the material and physical aspects of objects and technologies**

Figure 2.1: Investigating the ceramic *chaîne opératoire* (summary of the methodology of the Tracing the Potter's Wheel project). Table: author.

for materializing the full range of social complexity within ancient societies. Ceramic objects provide evidence for eating, drinking, cooking, processing, storing, lighting, transporting and worshipping activities, to name a few, across multiple social and economic contexts. Developments in past activities and interactions are attested through changes in the ceramic objects, either in their shape or form, size, decoration, colour, skill of execution (finish quality) and even their production method. Yet, we do not just glean information on the potter or producer from such changes. Material culture production does not take place in a vacuum; the affordances and constraints of exchange mechanisms and the socially motivated desires of consumers also play a powerful role in how material culture changes through time. In this way, production/transformation and consumption acts are a window onto the social practices of both the potter and consumer and how both construct their identity in relation to their wider social worlds.

Analysis

Once a ceramic object has been recovered from its depositional context, the analysis phase begins. There are many stages of analysis that take place, frequently in more than one location. Analysis often starts in the dusty, temporary storerooms of an excavation before leading to the decidedly dust-free environment of a scientific laboratory and finishing in a permanently dusty collection of a museum. Although typological and stylistic analyses are undertaken to provide archaeologists with relative dating sequences, this section discusses scientific or ceramic fabric analysis, more specifically the compositional and textural investigation of fired and unfired clay bodies. The central questions of scientific analysis concern composition and technology, both of which are crucial for identifying which technical choices were made at each stage of the *chaîne opératoire* for the object being investigated.

Usually carried out on fragmentary pieces of the original vessel, ceramic fabric analysis can identify the types of raw materials used in the production of a particular vessel or ware, or indeed an entire ceramic assemblage.[35] This in turn facilitates the characterization of the technological choices employed by the potter in the raw material acquisition, paste processing and even forming technique stages of the production sequence. It is important to establish whether vessels were locally produced or imported when found within an assemblage deposit at a site. Macroscopic analysis of the ceramic fabric using the naked eye or a small hand lens (up to x60) is the most cost-effective means of establishing compositional and technological groups within an assemblage. Visual differences in the colour and texture of the clay, as well as any inclusions present in the clay matrix, are used to build broadly compatible fabric groups. These groups are then sampled to carry out more detailed, but ultimately destructive, methods of microscopic and chemical (mineralogical or elemental) analysis.[36] The integration of compositional and textural information at macroscopic, microscopic and chemical level provides the most effective means of characterizing ceramic fabrics, and comparing them with available raw materials in the landscape.[37] Determining whether a ceramic assemblage was locally produced requires geological comparatives, either in the form of detailed geological maps of the area or replication experiments using geological sediments (sands, clays, etc.) collected from the vicinity of a site. Replication involves the processing of collected sediments into experimental briquettes to transform the raw materials into a replica ceramic paste. Analysing the geological sediments, experimental briquettes and the archaeological ceramics side-by-side can

35 After Shepard, *Ceramics for the Archaeologist*. See Hilditch, 'Ceramic Analysis', for an overview of current ceramic fabric research carried out within the Aegean.

36 X-ray fluorescence (XRF) and scanning electron microscopy with energy dispersive spectrometers (SEM-EDS) are now the most widely available techniques for compositional and structural analysis of the ceramic body and its various layers.

37 The importance of moving coherently between scales of analysis was first highlighted by Peacock, 'The Scientific Analysis'. For a case study highlighting how integration is achieved today, see Hilditch et al., 'Taking the Rough'.

indicate the specific technical choices made by ancient potters in the *chaîne opératoire* (Figure 2.1). Reconstruction of the ceramic *chaînes opératoires* used within a ceramic assemblage at a particular site forms the empirical foundation for investigating the variation within local pottery producing communities, allowing subsequently broader regional and temporal differences to be identified.

Experiment

Expertise in the practical and material knowledge of a craftsperson emerges from material engagement, not just from a lifetime's experience of working with the material: It is 'a knowledge born of sensory perception and practical engagement, not of the mind with the material world but of the skilled practitioner participating in a world of materials'.[38] Material engagement is a central theme of experimental archaeology, a subdiscipline of archaeology that has been perceived as focusing its attention on 'reproducing former conditions and circumstances' or 'replicating past phenomena'.[39] The heart of experimental archaeology in fact lies in hypothesis-testing through experiment.[40] Academic context, and appropriate reference to the specialist literature, is also fundamental to the performance of successful experimental archaeology, and helps to differentiate the *experimental* from the *experiential*. This is an important distinction because re-enactment, as defined elsewhere in this volume, falls into this latter category, primarily in the form of 're-enactment groups, outdoor education and public presentation centres, and other demonstrations of past life and technology'.[41] Experiential activities are still important, however, as they provide a means for experimenters (archaeological specialists) to gain competence in the performance of particular activities, that is, the requisite skills or techniques of the experiment. They can also clearly and meaningfully convey the results of archaeological research to non-specialists. Experiential practices are necessary precursors then to successful experiments and effective ways of communicating them.

Experimental archaeology has historically focused on the technological questions, the 'how' and 'what' of material culture, yet has rarely engaged with the social questions, such as 'who' and 'why'.[42] To elucidate these social

38 Ingold, 'Materials against Materiality', p. 15.

39 A summary of the debate of the nature of experimental archaeology is given by Outram, 'Introduction', p. 2.

40 This point is emphasized by Outram, 'Introduction', and Marsh and Ferguson, 'Introduction'.

41 Outram, 'Introduction', p. 3, echoing the earlier work of Reynolds, 'The Nature of Experiment'.

42 Jeffra, 'Experimental Approaches', p. 141.

phenomena we need to turn our attention to the social contexts in which craftspeople learn and reproduce their crafts, or, in other words, we must return to the archaeological framework of 'choice', the *chaîne opératoire* approach. The choice of forming technique for ceramic vessels is one stage of the *chaîne opératoire* in which social phenomena play a significant role. This is due to the concept of salience within pottery-making techniques.[43] The choice of a potter to hand-build a vessel, or to use a wheel to finish a hand-built rough-out, or a wheel to shape a raw lump of clay into a vessel, is not known to the distributer or user of that finished vessel. Further still, the tools and gestures required to perform each forming technique also remain a mystery, if only looking at the finished vessel. Forming techniques represent knowledge that is not transmittable in the finished object but must be transmitted person-to-person.[44] Experimental archaeology is able to engage with the identification of forming techniques by reconstructing the sequence of actions that leave diagnostic macrotraces on the surfaces of ceramic vessels. The use of rotative kinetic energy (RKE) in the form of a tournette or a weighted wheel device leaves distinctive traces on the surface of a pot (rilling). If a hand-built coiled rough-out of a vessel is finished on a wheel, then other diagnostic traces can form that reveal the initial coiled structure in combination with the RKE (s-cracks and tension seams). Replication is embedded in the experimental process, because it is wrong to assume that the full range of potential diagnostic features will be present on each experimentally-produced vessel.

In practice, the strength of the experimental approach for identifying and tracing the transmission of the potter's wheel is the greater detail accessible in discussing *chaînes opératoires* diachronically. Moreover, the power of experimental archaeology lies in its ability to act as a bridge between data on the ground and higher level theories of social interaction. Experimental archaeology cannot be defined as solely replication or reproduction practice, but rather it is the interplay of these practices that provides a robust platform for considering socially meaningful questions through material engagement.

Visualization

Communicating technological change has always been a difficult task. Archaeologists are trained to identify and interpret material culture changes to create the material profiles or signatures of specific cultural groups. As archaeology

43 Gosselain, 'Materializing Identities' and Gosselain, 'Social and Technical Identity'.

44 Gosselain, 'Materializing Identities.'

has developed from its nineteenth-century roots in antiquarianism, so have its methods of visualization: 2D drawings, technical illustrations, and photographs have slowly been supplemented and, perhaps in some cases, even supplanted by digital and 3D techniques.[45] New visual technologies such as 3D scanning and modelling offer huge potential for enhancing research strategies within archaeology.[46] Yet, currently, the acceptance of these technologies has mostly served to automate existing archaeological practice.[47] So although many archaeological objects now exist as 3D scans and can be viewed on a computer screen, their conventional classification systems remain the dominant means to describe and present these artefacts to specialists and non-specialists alike. Fortunately, there is a growing number of projects designed to address this disconnect between academic research and public awareness, and to promote ancient technological studies to contemporary society.[48]

As with the experiment and analysis components, visualization draws upon the *chaîne opératoire* approach to structure the process of acquiring data and interpreting the results. Experimentation with equipment is a crucial first step in establishing a workflow that other specialists can replicate. Issues of cost, portability, resolution and suitability to the task must also be considered when choosing hardware and software for the scanning and subsequent processing of the models. In many ways, the digital archaeologist develops a workflow that mirrors an ancient craftsperson's *chaîne opératoire* of technical tasks, although the end product is somewhat different. Whereas a potter produces a tangible, fired clay vessel, the digital archaeologist produces a virtual, high-resolution model of a fired clay vessel that can be rotated and manipulated by the viewer.[49] Close collaboration is required between the analyst, the experimenter and the visualizer, because a clear understanding of what is technologically important is required, i.e. what needs to be visualized and to what resolution. In the case of wheel-made pottery, the distinctive surface traces made by RKE must be visible to the viewer, alongside more traditional views of the shape profile and location on the vessel. Replication of the 3D scanning process is also essential if

45 See Molloy, 'Recent Advances', for a current overview of the use of 3D techniques for studying archaeological objects.

46 See also Lulof, this volume.

47 Opgenhaffen, *Visualising the Potter's Wheel*.

48 The Pottery Goes Public Project (2015-2018) is presented in Opgenhaffen, Revello Lami and Kisjes, 'Pottery Goes Public'. See also The Bridges Collection: https://thebridgescollection.wordpress.com (checked on February 28th, 2019) and the Digital Epigraphy and Archaeology Project: www.digitalepigraphy.org (checked on February 28th, 2019).

49 Molloy and Milić, 'Wonderful Things?', p. 111.

other specialists are to add their compatible models to an open access database of diagnostic wheel traces. The creation (or following) of technical manuals is an important step in the digital archaeologist's workflow that allows archaeological specialists to build a detailed, annotated online reference collection for the identification of wheel traces in their own ceramic assemblages. On the other hand, an open access data repository also allows non-specialists to follow the questions, methods and practices of archaeologists by accessing the dataset virtually, manipulating the scale and angle of models and asking their own questions of the material 'in hand'. This is a significant step forward towards challenging the traditional perception of ancient artefact and technology research within archaeology as being rather static in its presentation to the public.

Tracing the potter's wheel in the Bronze Age Aegean

In the case of the Bronze Age Aegean (3100-1200 BC), terms such as Anatolianization, Minoanization or Mycenaeanization carry tacit indications of cultural contact, tentatively balancing between a *description of how* and an *explanation of why* changes in the material record are driven by hierarchical interactions between different socio-cultural groups (Figure 2.2). The technological dimension of such interactions is a field ripe for further study, and the potter's wheel in particular provides common ground for investigating millennia of prehistoric interactions in the Aegean.[50]

The traditional narrative for the innovation of the potter's wheel is a simple, linear explanation that correlates the emergence of the wheel-throwing forming technique to growing populations and social complexity that demanded routinized, increased production of ceramic products. However, recent work supports the first use of the potter's wheel in the Near East and Aegean regions as a finishing stage for hand-built, pre-formed roughouts, rather than the emergence of wheel-throwing a vessel from a lump of clay.[51] These roughouts are made by stacking hand-rolled coils of clay. Hand-built coiled pots are then finished without the use of rotative kinetic energy (RKE), in contrast to wheel-coiling, where the potter's wheel is used to thin,

50 Berg, 'Meaning in the Making'; Choleva, 'The First Wheelmade Pottery'; Lis et al., 'Mobility'; Jeffra, *The Archaeological Study*; Jeffra, 'A Re-Examination'; Kiriatzi, '"Minoanising"; Gauss and Kiriatzi, *Pottery Production*; Hilditch, *Reconstructing Technical Choice* and Hilditch, 'Analyzing Technological Standardization'.

51 Roux, 'Wheel Fashioned Ceramic Production'; Jeffra, 'A Re-Examination' and Choleva, 'The First Wheelmade Pottery'.

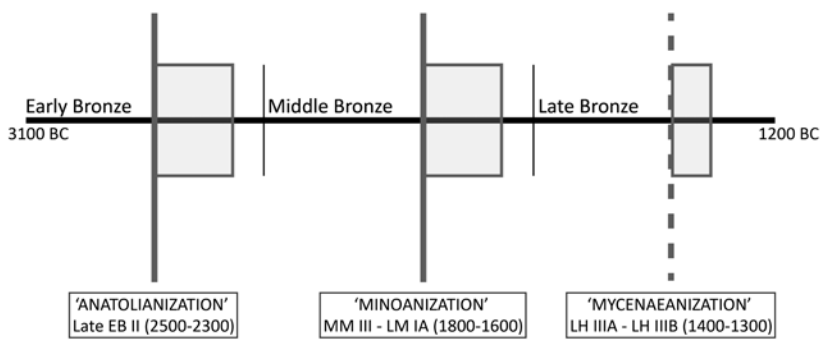

Figure 2.2: Overview of the Bronze Age Aegean'-ization' phenomena. Image prepared by Jill Hilditch and Loes Opgenhaffen, used with permission.

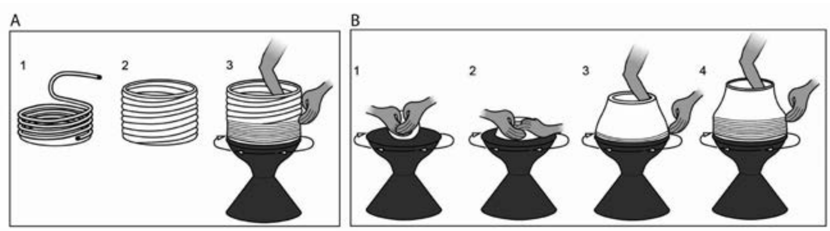

Figure 2.3: Comparison of the wheel-coiling and wheel-throwing methods of vessel construction. Image prepared by Caroline Jeffra, used with permission.

shape and finish the coiled walls, actions that require increasing amounts of RKE (Figure 2.3 for a comparison of the methods).[52] This means that we should see wheel-coiling as an intermediate or combination potting strategy, effectively bridging hand-building and the use of RKE techniques.[53] This distinction is important when considering how the potter's wheel spread throughout the potting communities of the Bronze Age Aegean.

In the Bronze Age Aegean, the appearance of the wheel was considered as two potentially independent events, connected to two different horizons of intensifying cultural contact.[54] The earliest identified horizon of wheel use appears during the later Early Bronze (EB) II period (*c.* 2500-2100BC), known as the Lefkandi I/Kastri phase, and is widely interpreted as the material result of increased trade in metals between social groups in the Aegean and

52 Roux and Courty, 'Identification'.

53 Jeffra, 'A Re-Examination', p. 31.

54 Knappett, 'Tradition and Innovation'; Choleva, 'The First Wheelmade Pottery' and Rutter, '"Minding the Gap"'.

(predominantly) western Anatolia, where the potter's wheel is known to have already been in use.[55] The vessels of this phase are accordingly known as 'Anatolianizing' shapes, reflecting close parallels to existing EB vessels from western Anatolian sites such as Liman Tepe, Çesme, and Troy.[56] In the later transition from the Middle Bronze (MB) to the Late Bronze (LB) period (1800-1600BC), the potter's wheel is considered as a technology of the Minoan culture of Crete. The potter's wheel then spread beyond the shores of Crete as part of a package of technologies that attest to growing Minoan power and influence, traditionally termed 'Minoanization', within the southern and central Aegean region.[57]

Diagnostic traces of wheel use within Cretan and non-Cretan but 'Minoanized' ceramic assemblages of the MB III to LB I have recently been reassessed and show that wheel-coiling techniques continue to dominate the ceramic record.[58] This would indicate that wheel-throwing was not an innovation linked to this transitional phase.[59] Instead, wheel-thrown pottery is necessarily a later technological development within the Aegean. This transition from wheel-coiling to wheel-throwing is poorly understood in Aegean archaeology and beyond. This is exacerbated by the fact that few ceramic assemblages offer the stratigraphic continuity to trace the trajectory of the potter's wheel as technological development. Stratigraphic continuity is essential for identifying and mapping modification of the *chaîne opératoire* from hand-building techniques to the incorporation of RKE. One Bronze Age Aegean site in particular, Akrotiri, known as 'the Pompeii of the Aegean', has afforded a closer look at the dynamics of technological change within ceramic manufacture.

The case of Akrotiri on Thera

Akrotiri is an exceptional Bronze Age site situated on the island of Thera (modern day Santorini) among the Cyclades of the southern Aegean Sea. The site was buried under thick layers of pumice during a catastrophic volcanic

55 Renfrew, *The Emergence* and Alram-Stern and Horeijs, *Pottery Technologies*.

56 Şahoğlu, 'Interregional Contacts'.

57 Along with distinctive architectural features (lustral basins, switchback staircases), Linear A script and the vertical warp-weighted loom. See Hägg and Marinatos, *The Minoan Thalassocracy* and Macdonald et al., *The Minoans*. See Evely, 'The Potter's Wheel' and Evely, *Minoan Crafts* for an overview of the evidence for the potter's wheel on Crete.

58 Jeffra, 'A Re-Examination'; Jeffra, 'Forming Technology'; Gorogianni, Abell and Hilditch, 'Reconsidering Technological Transmission'.

59 Jeffra, 'A Re-Examination'.

Plate 2.1: *Left*: Macrotrace identification with controlled light; R*ight*: ceramic fabric analysis using petrographic analysis of thin sections. Photo: author.

eruption towards the end of the seventeenth century BC. Ceramic material recovered from excavations at Akrotiri has revealed a complex local ceramic tradition in the millennia preceding the eruption. The diachronic nature of the Akrotiri ceramic dataset provides an excellent platform from which to investigate processes of Minoanization. By focusing on the mid- to later phases of the Middle Bronze Age sequence (approx. 1950-1700BC), distinguished by the arrival of Minoan stylistic and technological features (wheel-coiled vessels) within the local ceramic assemblage, we can reconstruct a detailed understanding of what is inherently 'local' versus 'Minoanized' at Akrotiri. Compositional and textural analyses of archaeological vessels and geological sediments were carried out in tandem with surface macrotrace analysis to characterize the fabrics of the assemblage (Plate 2.1). Using this information, the *chaîne opératoire* for each of the wares was identified and then compared across a range of local Theran and non-local or Minoanized shapes to reconstruct the practices of locally based potters. Through this integrated analysis programme, we were able to assess whether shared practices as a community at Akrotiri differed over time in response to changing interactions with the Minoan world.

For the wheel-finished 'Minoanized' vessels analysed at Akrotiri, such as the ledge-rim bowl, there seems to have been little attempt to refine the clay paste in imitation of the fine-grained fabrics of contemporary Minoan imports. Instead, these bowls were manufactured using locally compatible raw materials that showed little to no paste processing, effectively presenting the same production sequence as the local handmade pots, indicating the same technical decisions of the local clay recipe. It would seem, therefore, that the first use of wheel technology at Akrotiri was firmly integrated within the local tradition, rooted from the earliest stages of the production sequence. From this knowledge we can interpret that local potters at Akrotiri had sustained contact with Minoan potters, allowing them to learn the wheel technique, which they then incorporated into their own local potting traditions. This does not suggest political dominance by Crete, nor a strong itinerant or semi-permanent Minoan potting presence at Akrotiri. Instead, potters at Akrotiri, and therefore the people they were making pots for, actively chose to participate in certain Minoan ritual practices that required specific shapes, such as the ledge-rim bowl, for which deliberate formation techniques were used to enhance the intrinsic value of these novel artefacts.[60] A strong, local Cycladic tradition of pottery production was maintained, and with it, a well-defined 'non-Cretan' community identity within the settlement of Akrotiri.

In tandem with the scientific analysis of ceramics, a systematic programme of experiments was carried out to explore the wider material evidence, both products and tools, for wheel-coiling and wheel-throwing in the Bronze Age Aegean. A ceramic type set, designed to act as an analogue for the wide range of vessels corresponding to the Aegean Bronze Age, was created in order to improve our ability to differentiate between specific wheel use strategies through their macrotraces, facilitating deeper investigation of the relationship between these techniques.[61] Three primary variables were considered: vessel shape, forming technique, and clay type (degree of coarseness). The macrotrace results of the experimental type set were then applied to the study of archaeological material, consisting of key diachronic assemblages recovered from across the Aegean, including the later MB Akrotiri assemblage. The sequence of study described here is crucial; the experimental type set allows us to first establish the range of diagnostic traces associated with specific wheel-forming techniques. Following this, the traces on the Aegean material can be recognized as relating to one kind of wheel-forming or another.

The investigation at MB Akrotiri illustrates how we can assemble increasingly precise information about the practices and interconnections between communities of craftspeople. For example, small vessels were found to correspond with one of two different forming techniques: hand-building or wheel-coiling.[62] Conical cups, straight-sided cups, and hemispherical cups – shapes associated with Crete – were all wheel-coiled. Ledge-rim

60 See also Knappett and Hilditch, 'Colonial Cups?'.

61 The type set was based upon an expansion of earlier experimental work by Jeffra, *The Archaeological Study*, Jeffra, 'Experimenting Wheel-Coiling Methods' and Jeffra, 'Crafter'.

62 Jeffra, 'Forming Technology'.

bowls, also associated with Crete, were mostly wheel-coiled but also made by hand atop a woven mat. Lastly, locally-derived Cycladic cups were almost exclusively hand-made, with just two examples which were wheel-coiled. Emerging from this is a picture of technical negotiation, where shapes typical of Crete as well as shapes typical of Akrotiri and her neighbours were formed using wheel-coiling, alongside some cases of hand-building as well. In this way, the experimentally-derived data supports the presence of a network of communication between craftspeople on Akrotiri (forming Cycladic cups) and Crete (forming the other shapes) through which the transmission of potter's wheel technique took place.

So far, the technical details that suggest shared craft networks between Crete and the Cycladic community of Akrotiri are only visible, and therefore accessible, to archaeological specialists with the privilege of working at the site. Even communicating this dataset to other regional archaeological specialists is a challenge, but one which the visualization workflow is explicitly tackling. The visualization component starts with 3D scanning of the experimental type set to record, annotate and create 3D models of sherds or fragmentary vessels that display diagnostic macrotraces of specific wheel use techniques (Plate 2.2). This requires close collaboration with the experiment component, as recognizing which traces should be recorded and to what resolution is crucial. The next phase then involves 3D scanning of archaeological vessels to support the identification of wheel use techniques using traditional high resolution photography, and importantly to record these traces in a more accessible and easily manipulatable 3D format.[63] The 3D models of the experimental type set are digitally archived and made accessible through open access, online forums such as SketchFab and the Tracing the Potter's Wheel project website. Allowing specialists and non-specialist users to interact with the 3D models, to zoom in, out, or rotate as needed, aids future identification of forming traces on other archaeological assemblages. A technical manual has been devized to record the workflow of the visualization process and explicitly allow other scholars to replicate the 3D scanning process. In effect, through the production of annotated high resolution 3D models that highlight diagnostic macrotrace features,

63 Publication of Greek archaeological material in any format is subject to permission by the Greek Ministry of Culture and application for study and publication permits is carried out in collaboration with colleagues in the Greek Archaeological Service. The members of the TPW project are deeply indebted to Dr. Irene Nikolakopoulou for her generosity in inviting us to participate in the study of the MB Akrotiri ceramic assemblage, and to the site director, Prof. Christos Doumas, for allowing us to access the material at this incredible site. We hope there will be a future opportunity to 3D scan the ceramics from Akrotiri, once the relevant permissions are secured.

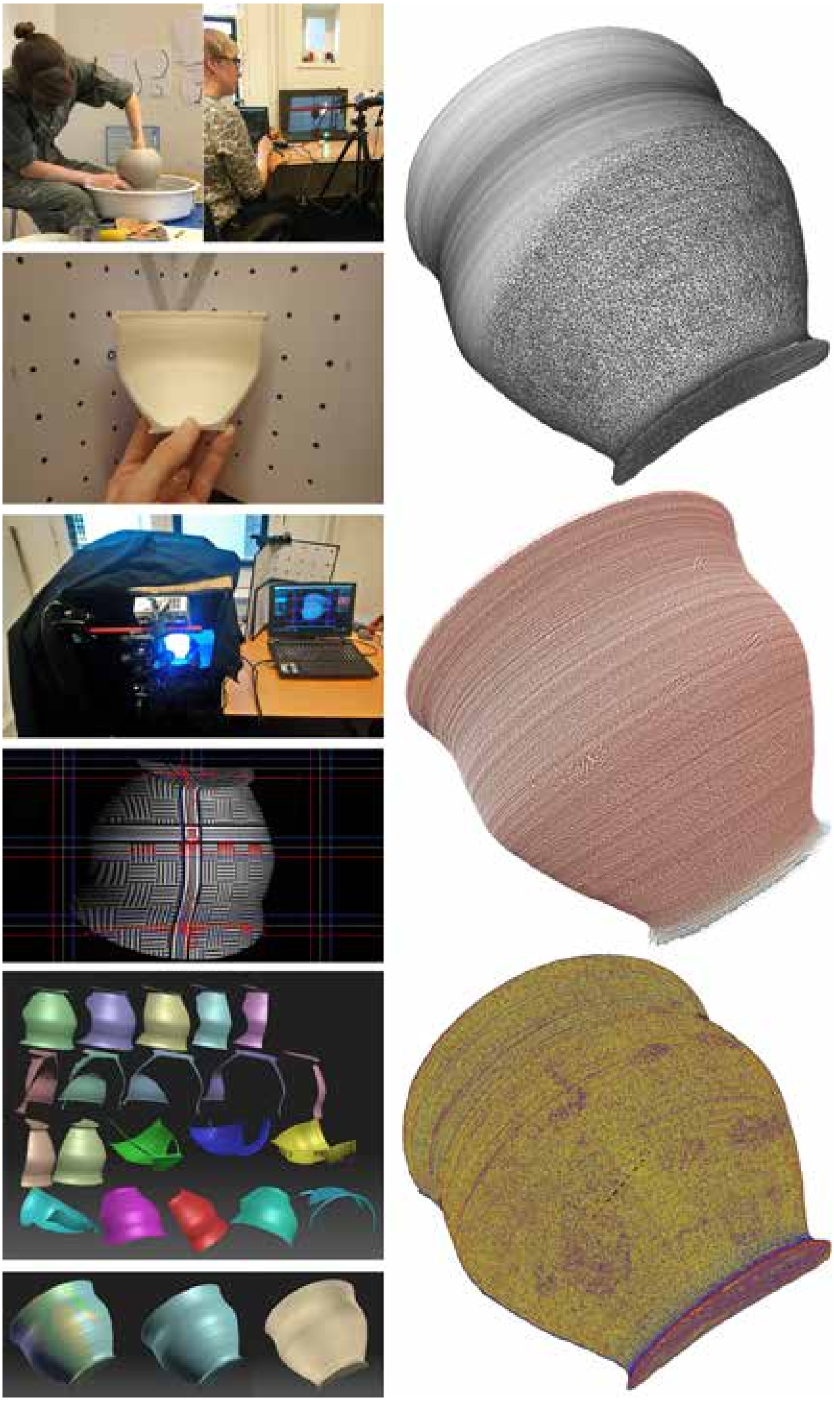

Plate 2.2: The visualisation workflow. Composite image: Loes Opgenhaffen, used with permission.

the analysis, experiment and visualization components combine to actively promote the reconstruction of technological practices among the sherd tables and within the minds of specialists and non-specialists alike. In this way, performative methods and material engagement in archaeological approaches can show us how understanding the past can inform and shape the future.

Conclusion

Performative methods in archaeology provide a valuable heuristic tool for investigating the many behaviours and interactions of both producers and consumers of material culture. This chapter has outlined an integrated approach to material engagement across three arenas of archaeological action – experiment, analysis, and visualization – connected by an explicit engagement with the *chaîne opératoire* approach.

Technological choices were made by ancient potters, from raw material exploitation and preparation, to forming technique and firing strategy. These choices can be investigated through the study of physical traces on the vessel and composition, allowing archaeologists to reconstruct *chaînes opératoires* for specific vessel types. By identifying these sequences within archaeological assemblages, and tracing their use spatially and chronologically, archaeologists are able to consider the communities of practice in which potters were learning and performing their craft. Recognition of these craft communities is crucial for investigating new technologies such as the potter's wheel, where the adoption and transmission of such technologies are materialized through the social dynamics of craft community membership and interaction. The strength of archaeological approaches to material culture resides precisely in this ability to move from tangible objects to intangible behaviours and interactions of people in the past, as has been demonstrated for the ceramic assemblage from Akrotiri on Thera.

The case of Akrotiri encapsulates the depth and scope of research that is necessary at every site in order to use the *chaîne opératoire* approach to its full potential. This realization has led to the development of an innovative toolkit for the wider archaeological community so that they may replicate integrated methods and practices and generate larger numbers of compatible datasets that can be brought into a collective interpretation of this technological phenomenon. By building up from the foundational strengths of the *chaîne opératoire*, and explicitly sharing workflow practices, a common lexicon of terms for wheel use within ceramic production, and its study, is established. The benefits are twofold: interested non-specialists are able to acquire expertise and directly access the tools to gain competence, and active specialists are able to contribute their data and findings seamlessly. Given that ancient technologies pose large-scale regional and diachronic questions, fostering participation with peers and the integration of data from different scholars and research teams is critical. Just as the wheel was introduced into the existing *chaîne opératoire* of ceramic production, primarily as a bridging technique between hand-building and wheel-throwing techniques, the 3D scanner has been introduced to the archaeologist's toolkit, effectively bridging the representations of hand-drawn images and the realism of photographic techniques. This idea of a *tradition in transition* forms a common thread for the analysis of technological innovation in past and present practice.[64]

Bibliography

Alram-Stern, Eva and Barbara Horejs, *Pottery Technologies and Sociocultural Connections between the Aegean and Anatolia During the 3rd Millennium BC*, OREA 10 (Wien: Austrian Academy of Sciences, 2018).

Berg, Ina, 'Meaning in the Making: The Potter's Wheel at Phylakopi, Melos (Greece)', *Journal of Anthropological Archaeology*, 26 (2007), pp. 234-252.

Bourdieu, Pierre, *The Logic of Practice* (Cambridge: Polity Press, 1990).

Broodbank, Cyprian, 'Minoanisation', *Proceedings of the Cambridge Philological Society*, 50 (2004), pp. 46-91.

Choleva, Maria, 'The First Wheelmade Pottery at Lerna: Wheel-Thrown or Wheel-Fashioned?', *Hesperia: The Journal of the American School of Classical Studies at Athens*, 81 (2012), pp. 343-381.

Dobres, Marcia-Ann, 'Of Great and Small Chaînes of Being: Toward Understanding the Sensual and Social Embodiment of Prehistoric Technology', in *Embedded Technologies: Reworking Technological Studies in Archaeology*, ed. by Brian Boyd and Bill Sillar (London: Routledge, 1999), pp. 1-19.

Dobres, Marcia-Ann, *Technology and Social Agency: Outlining a Practice Framework for Archaeology* (Oxford: Blackwell Press, 2000).

Dobres, Marcia-Ann, and Christopher R. Hoffman, 'Social Agency and the Dynamics of Prehistoric Technology', *Journal of Archaeological Method and Theory*, 1 (1994), pp. 211-258.

64 Opgenhaffen, *Visualising the Potter's Wheel.*

Dobres, Marcia-Ann, and John E. Robb, 'Doing Agency: Introductory Remarks on Methodology', *Journal of Archaeological Method and Theory*, 12 (2005), pp. 159-166.

Edmonds, Mark, 'Description, Understanding, and the Chaîne Opératoire', *Archaeological Review from Cambridge*, 9 (1990), pp. 55-70.

Evely, Doniert R. G., 'The Potter's Wheel in Minoan Crete', *Annual of the British School at Athens*, 83 (1988), pp. 83-126.

Evely, Doniert R. G., *Minoan Crafts: Tools and Techniques*, *Studies in Mediterranean Archaeology*, 92 (Göteborg: Paul Åström, 1993).

Gauss, Walter, and Evangelia Kiriatzi, *Pottery Production and Supply at Bronze Age Kolonna, Aegina. An Integrated Archaeological and Scientific Study of a Ceramic Landscape, Ägina-Kolonna*, *Forschungen and Ergebnisse* (Wien: Österreichische Akademie der Wissenschaften, 2011).

Gorogianni, Evi, Natalie Abell and Jill Hilditch, 'Reconsidering Technological Transmission: The Introduction of the Potter's Wheel at Ayia Irini, Kea, Greece', *American Journal of Archaeology*, 120 (2016), pp. 195-220.

Gosselain, Olivier, 'Materializing Identities: An African Perspective', *Journal of Archaeological Method and Theory*, 7 (2000), pp. 187-217.

Gosselain, Olivier, 'Social and Technical Identity in a Clay Crystal Ball', in *The Archaeology of Social Boundaries*, ed. by Miriam T. Stark (Washington D.C.: Smithsonian Institution Press, 1998), pp. 78-106.

Hägg, Robin, and Nanno Marinatos, *The Minoan Thalassocracy: Myth and Reality; Proceedings of the Third International Symposium at the Swedish Institute in Athens, 31 May-5 June 1982*, Vol. Skrifter Utgivna av Svenska Institutet i Athen 4 (Göteborg: Paul Åström's Förlag, 1984).

Hilditch, Jill, 'Analyzing Technological Standardization: Revisiting the Minoan Conical Cup', in *Understanding Standardization and Variation in Mediterranean Ceramics: Mid 2nd to Late 1st Millennium BC*, ed. by A. Kotsonas (Leuven: Peeters, 2014), pp. 21-33.

Hilditch, Jill, 'Ceramic Analysis in Greece', *Archaeological Reports*, 62 (2016), pp. 89-102.

Hilditch, Jill, 'Fabrics and Technology: Phases B and C', in *Akrotiri, Thera. Middle Bronze Age Pottery and Stratigraphy*, ed. by Irene Nikolakopoulou (Athens: Archaeological Society, 2019), pp. 377-470.

Hilditch, Jill, Duncan Pirrie, Carl J. Knappett, Nicoletta Momigliano, and Gavyn K. Rollinson, 'Taking the Rough with the Smooth: Using Automated SEM-EDS to Integrate Coarse and Fine Ceramic Assemblages in the Bronze Age Aegean', in *Insights from Innovation – New Light on Archaeological Ceramics: A Conference in Honour of David Peacock*, ed. by Emilie Sibbesson, Ben Jervis and Sarah Coxon (Southampton: The Highfield Press, 2016), pp. 74-96.

Hilditch, Jill, *Reconstructing Technical Choice, Social Practice and Networks of Exchange in the Middle Bronze Age of the Cyclades: The Ceramic Perspective*, Unpublished PhD thesis (Exeter: University of Exeter, 2008).

Hodder, Ian, 'Agency and Individuals in Long-Term Processes', in *Agency in Archaeology*, ed. by Marcia-Ann Dobres and John. E. Robb (London: Routledge, 2000), pp. 21-33.

Ingold, Tim, 'Materials against Materiality', *Archaeological Dialogues*, 14 (2007), pp. 1-16.

Jeffra, Caroline D., 'A Re-Examination of Early Wheel Potting in Crete', *Annual of the British School at Athens*, 108 (2013), pp. 31-49.

Jeffra, Caroline D., 'Experimental Approaches to Archaeological Ceramics: Unifying Disparate Methodologies with the Chaîne Opératoire', *Archaeological and Anthropological Sciences*, 7 (2015a), pp. 141-149.

Jeffra, Caroline D., 'Experimenting Wheel-Coiling Methods', *Arkeotek Journal* (2015b).

Jeffra, Caroline D., 'Forming Technology', in *Akrotiri, Thera. Middle Bronze Age Pottery and Stratigraphy*, ed. by Irene Nikolakopoulou (Athens: Archaeological Society, 2019a), pp. 471-477.

Jeffra, Caroline D., 'CRAFTER: Potting Techniques of the Bronze Age', *EXARC Journal* (2019b).

Jeffra, Caroline D., *The Archaeological Study of Innovation: An Experimental Approach to the Pottery Wheel in Bronze Age Crete and Cyprus*, Unpublished PhD thesis (Exeter: University of Exeter, 2011).

Jenkins, Richard, *Key Sociologists: Pierre Bourdieu* (London: Routledge, 1992).

Kiriatzi, Evangelia, '"Minoanising" Pottery Traditions in the South West Aegean during the Middle Bronze Age: Understanding the Social Context of Technological and Consumption Practices', in *Mesohelladika: The Greek Mainland in the Middle Bronze Age*, ed. by Anna Philippa-Touchais, Gilles Touchais, Sofia Voutsaki and James Wright, BCH Supplement 52 (Athens: École française d' Athènes, 2010), pp. 683-699.

Knappett, Carl J., 'Tradition and Innovation in Pottery Forming Technology: Wheel-Throwing at Middle Minoan Knossos', *The Annual of the British School at Athens*, 94 (1999), pp. 101-129.

Knappett, Carl J., and Jill Hilditch, 'Colonial Cups? The Minoan Plain Handleless Cup as Icon and Index', in *Plain and Simple. The Evolution and Significance of Plain Pottery Traditions in the Second Millennium BC Near East and East Mediterranean*, ed. by Claudia Glatz (Walnut Creek, CA: Left Coast Press, 2015), pp. 91-113.

Lave, Jean, and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge: Cambridge University Press, 1991).

Leeuw, Sander E. van der, 'Giving the Potter a Choice: Conceptual Aspects of Pottery Techniques', in *Technological Choices: Transformation in Material Cultures since the Neolithic*, ed. by Pierre Lemonnier (London: Routledge, 1993), pp. 238-288.

Leeuw, Sander E. van der, Dick A. Papousek and Anick Coudart. 'Technical Traditions and Unquestioned Assumptions', *Techniques et Culture*, 18 (1992), pp. 145-173.

Lemonnier, Pierre, 'Introduction', in *Technological Choices: Transformation in Material Cultures since the Neolithic*, ed. by P. Lemonnier (London: Routledge, 1993), pp. 1-35.

Leroi-Gourhan, André, *Gesture and speech* (Cambridge: MIT Press, 1993).

Lis, Bartek, Maria Choleva and Štěpán Rückl, 'Mobility in the Bronze Age Aegean: The Case of Aeginetan Potters', in *The Transmission of Technical Knowledge in the Production of Ancient Mediterranean Pottery*, ed. by Walter Gauss, Gudrun Klebinder-Gauss and Constance von Rüden (Wien: Österreichisches Archaeologisches Institut, 2015), pp. 63-75.

Lock, Gary, and Brian L. Molyneaux, *Confronting Scale in Archaeology* (New York: Springer, 2006).

Macdonald, Colin F., Erik Hallager, and Wolf-Dietrich Niemeier, *The Minoans in the Central, Eastern and Northern Aegean: New Evidence*, *Monographs of the Danish Institute at Athens* (Athens: Danish Institute at Athens, 2009).

Mahias, Marie-Claude, 'Pottery Techniques in India: Technical Variants and Social Choice', in *Technological Choices: Transformation in Material Cultures since the Neolithic*, ed. by Pierre Lemonnier (London: Routledge, 1993), pp. 157-180.

Marsh, Erik J., and Jeffrey R. Ferguson, 'Introduction', in *Designing Experimental Research in Archaeology, Examining Technology through Production and Use*, ed. by Jeffrey R. Ferguson (Boulder, Colorado: University Press of Colorado, 2010), pp. 1-12.

Mauss, Marcel, *Sociologie et anthropologie* (Paris: Presses Universitaires de France, 1936).

Molloy, Barry P.C., 'Recent Advances in the Use of 3D Modelling for the Study of Archaeological Objects', *Open Archaeology*, 4 (2018).

Molloy, Barry P.C., and Marina Milić, 'Wonderful Things? A Consideration of 3D Modelling of Objects in Material Culture Research', *Open Archaeology*, 4 (2018), pp. 97-113.

Opgenhaffen, Loes, 'Visualising the Potter's Wheel: Developing Integrated 'Digital Science' Approaches for Identifying Wheel Use in Pottery Production', (forthcoming).

Opgenhaffen, Loes, Martina Revello Lami and Ivan Kisjes, 'Pottery Goes Public. Performing Archaeological Research Amid the Audience', *Open Archaeology*, 4 (2018), pp. 62-80.

Outram, Alan K., 'Introduction to Experimental Archaeology', *World Archaeology*, 40 (2008), pp. 1-6.

Peacock, David P.S., 'The Scientific Analysis of Ancient Ceramics: A Review', *World Archaeology*, 1 (1970), pp. 375-389.

Renfrew, A. Colin, *The Emergence of Civilisation: the Cyclades and the Aegean in the Third Millennium BC* (London: Methuen, 1972).

Revello Lami, Martina, Loes Opgenhaffen, and Ivan Kisjes, 'Pottery Goes Digital. 3D Laser Scanning Technology and the Study of Archaeological Ceramics', in *Proceedings of the 43rd Computer Applications and Quantitative Methods in Archaeology Conference 'Keep the Revolution Going' (CAA, 30 March – 3 April 2015), University of Siena*, ed. by Stefano Campana et al. (Oxford: Archaeopress, 2016), pp. 421-432.

Reynolds, Peter J., 'The Nature of Experiment in Archaeology', in *Experiment and Design: Archaeological Studies in Honour of John Coles*, ed. by Antony F. Harding (Oxford: Oxbow, 1999), pp. 156-162.

Roux, Valentine, 'Wheel Fashioned Ceramic Production during the Third Millennium BCE in the Southern Levant: A Perspective from Tel Yarmuth', in *Techniques and People: Anthropological Perspectives on Technology in the Archaeology of the Proto-Historic and Early Historic Periods in the Southern Levant*, ed. by Steven A. Rosen and Valentine Roux (Paris: Editions De Boccard, 2009), pp. 195-212.

Roux, Valentine, and Caroline D. Jeffra, 'The Spreading of the Potter's Wheel in the Ancient Mediterranean: A Social Context-Dependent Phenomenon', in *The Transmission of Technical Knowledge in the Production of Ancient Mediterranean Pottery*, ed. by W. Gauss et al. (Wien: Österreichisches Archäologisches Institut, 2015), pp. 165-182.

Roux, Valentine, and Marie-Agnès Courty, 'Identification of Wheel-Fashioning Methods: Technological Analysis of 4th–3rd Millennium BC Oriental Ceramics', *Journal of Archaeological Science*, 25 (1998), pp. 747-763.

Rutter Jeremy B., '"Minding the Gap": From Filling Archaeological Gaps to Accounting for Cultural Breaks. A 2013 Perspective on a Continuing Story', *American Journal of Archaeology*, 117 (2013), pp. 593-597.

Şahoğlu, Vasif, 'Interregional Contacts around the Aegean During the Early Bronze Age', *Anatolia*, 27 (2007), pp. 97-120.

Sassaman, Kenneth E., and Wictoria Rudolphi, 'Communities of Practice in the Early Pottery Traditions of the American Southeast', *Journal of Anthropological Research*, 57 (2001), pp. 407-425.

Schlanger, Nathan, 'Mindful Technology: Unleashing the Chaîne Opératoire for an Archaeology of Mind', in *The Ancient Mind: Elements of Cognitive Archaeology*, ed. by Colin Renfrew and Ezra B.W. Zubrow (Cambridge: Cambridge University Press, 1994), pp. 143-151.

Schlanger, Nathan, 'Techniques as Human Action: Two Perspectives', *Archaeological Review from Cambridge*, 9 (1990), pp. 18-26.
Shepard, Anna O., *Ceramics for the Archaeologist*, *Publication 609* (Washington DC: Carnegie Institute of Washington, 1968).
Sillar, Bill, and Michael S. Tite, 'The Challenge of 'Technological Choices' for Materials Science Approaches in Archaeology', *Archaeometry*, 42 (2000), pp. 2-20.
Stark, Miriam T., *The Archaeology of Social Boundaries* (Washington DC: Smithsonian Institution Press, 1998).
Wenger, Etienne, *Communities of Practice: Learning, Meaning and Identity* (Cambridge: Cambridge University Press, 1998).

About the Author

Jill Hilditch is Associate Professor at Amsterdam Centre for Ancient Studies and Archaeology, University of Amsterdam. She specializes in the Bronze Age Aegean, ceramic analysis, and the reconstruction of production processes. She is PI of the Vidi project 'Tracing the potter's wheel' (2016-2021). This project uses the potter's wheel as a prism through which to investigate the transmission of craft knowledge amongst potting communities in the Aegean Bronze Age.