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Critical Archaeology in the Digital Age: Proceedings of the 12th IEMA Visiting Scholar's Conference

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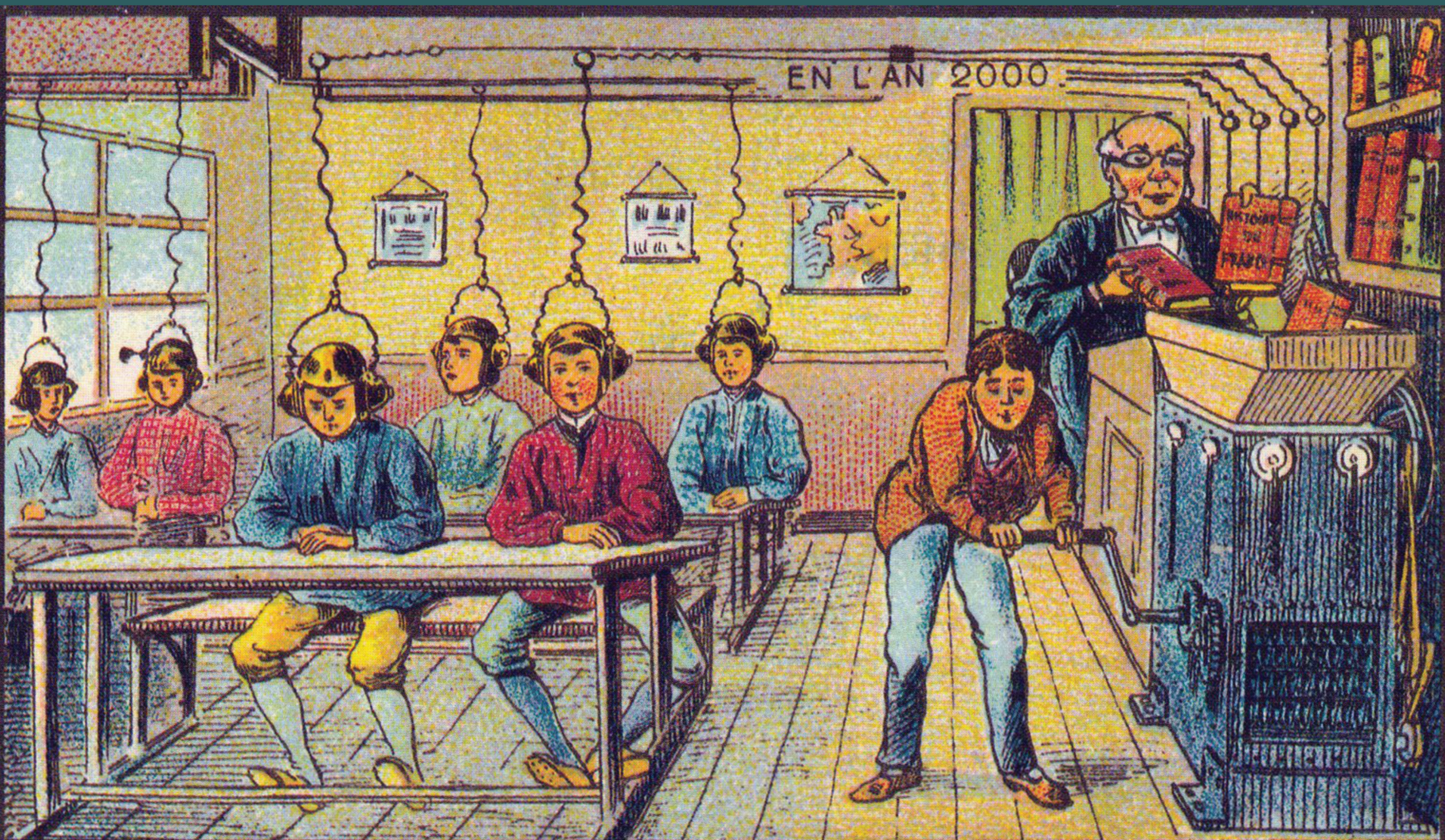

Edited by

Kevin Garstki

Critical Archaeology in the Digital Age

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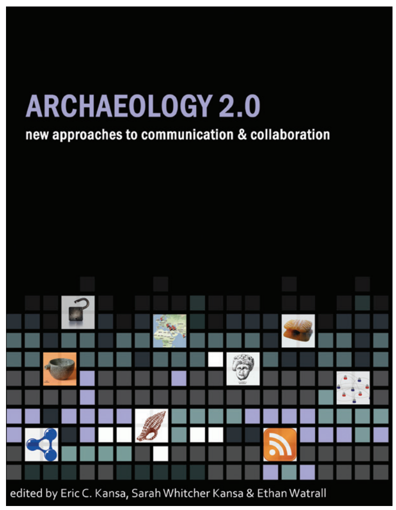

Archaeology 2.0:
New Tools for Communication and Collaboration

Edited by Eric C. Kansa, Sarah Whitcher Kansa,
and Ethan Watrall

Critical Archaeology in the Digital Age

Proceedings of the 12th IEMA Visiting Scholar Conference

Edited by
Kevin Garstki

Cotsen Digital Archaeology Series 2
UCLA COTSEN INSTITUTE OF ARCHAEOLOGY PRESS

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The IEMA conference only took place thanks to the students who volunteered an enormous amount of time to help plan, drive to Canada to pick up speakers, shuttle speakers around Buffalo, set up in the morning and take down each night, be bartenders and clean-up crews, and overall provide a wonderful environment for all the attendees and speakers. Not only did their help come in the form of time and labor, but they also contributed significantly to my own thinking about these topics in the class they took with me. I appreciated their support in my time there and their friendship.

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While planning the IEMA conference I decided to invite many of my favorite and the most brilliant thinkers working around the amorphous sub-field that may be called digital archaeology. Surprisingly, many of them said yes. Through the process of writing this volume, they have been supportive and kind in their collaboration. Despite significant personal demands and hurdles (Covid, to name just one), they answered emails, made corrections, and (mostly) stayed on schedule. I often pinch myself, thinking that I am attached to the brilliant work they have created for this volume.

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As in all things, my family has supported me to no end. Finally, the single biggest reason I have succeeded (if I have) in anything I have done, in archaeology, teaching, 'real life,' and so on, is Adrienne. This is dedicated to her.

Contributors

Rebecca E. Bria
University of Texas at San Antonio, Department of Anthropology

William Caraher
University of North Dakota, Department of History and Indian Studies

W. Christopher Carleton
Extreme Events Research Group, Max Planck Institutes for Chemical Ecology, the Science of Human History, and Biogeochemistry
Germany

Karin Dalziel
University of Nebraska–Lincoln, Center for Digital Research in the Humanities

Paola Di Giuseppantonio Di Franco
University of Essex, Interdisciplinary Studies Centre and School of Philosophy and Art History
United Kingdom

Jessica Dussault
18F

Bernard Frischer
Indiana University Bloomington, Luddy School of Informatics, Computing, and Engineering

Kevin Garstki
University of Wisconsin–Oshkosh, Department of Anthropology, Global Religions, and Cultures

Laura K. Harrison
University of South Florida

Jeremy Huggett
University of Glasgow, Archaeology, School of Humanities
Scotland

Eric C. Kansa
Open Context

David Massey
Indiana University Bloomington, Department of Geography

Rachel Opitz
University of Glasgow, Archaeology, School of Humanities
Scotland

Jeroen Poblome
University of Leuven, Department of Archaeology
Belgium

Adam Rabinowitz
The University of Texas at Austin, Department of Classics

Heather Richards-Rissetto
University of Nebraska–Lincoln, Department of Anthropology

Lorna-Jane Richardson
University of East Anglia, Interdisciplinary Institute for the Humanities
United Kingdom

Benjamin Štular
Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Archaeology
Slovenia

Ebru Torun
University of Leuven, Department of Archaeology
Belgium

Ruth Tringham
University of California, Berkeley, Graduate School (Anthropology)

Greg Tunink
University of Nebraska–Lincoln, Center for Digital Research in the Humanities

Ralf Vandam
University of Leuven, Department of Archaeology
Belgium
Free University Brussels, Department of Art Science and Archaeology
Belgium

Erick Casanova
Universidad Nacional Mayor de San Marcos
Peru

Patrick T. Willett
University at Buffalo, SUNY, Department of Anthropology
University of Leuven, Department of Archaeology
Belgium

Introduction

Challenges of a Critical Archaeology in the Modern World

Kevin Garstki

The final session of the 12th Institute for European and Mediterranean Archaeology (IEMA) Visiting Scholar's Conference at the University at Buffalo, the event that was the foundation for this volume, was scheduled to be a comprehensive discussion about common threads running through the speakers' presentations, touching on important take-aways from the conference. Instead, the discussion focused on whether institutions will ever recognize the value of digital projects or publications, and if it is possible to 'practice what we preach' regarding digital ethics. In particular, the discussion focused on how, or whether, we should try to publish this volume in an open-access format. This discussion included the acknowledgment of the potential irony if the volume were published only behind a paywall, considering that several papers discussed the need for a more open archaeology. Participants discussed the drawbacks of open-access publishing for early-career scholars, particularly for those attending the conference, worrying that open access is considered 'less than' in the eyes of hiring or tenure committees. We also discussed the impact of this model of publication on traditional norms in academia—an open-access publication strategy disrupts long-held views of legitimate publication, while also disrupting the publishing industry itself. Such a model challenges us to abide by our ethics of responsible archaeology and open science.

That conversation demonstrated precisely why our adoption and continued use of digital approaches to archaeological practice must be grounded in critical thought. The evaluation of new approaches demands that we rethink not only the technical standards and best practices for a tool or technology, but also requires a reevaluation of long-held frameworks for how, why, and for whom we practice archaeology. Critical archaeology does not suggest an aversion to emerging technologies in the field; rather, it is an opportunity to be intentional in our application of digital tools and consider the context in which we are using these tools. This book then acts as a call, and a demonstration how, to apply this intentionality and consideration to the ways in which we work, produce, and engage with digital things, as well as how we structure the professional institutions in which we are situated.

Challenges

Continuing our development in an all-digital discipline brings significant challenges not only for those working directly with the 'latest and greatest' technology but all archaeologists. Everyone participating in cultural heritage work is entrenched in the archaeological 'digital revolution' that has been ongoing since at least the development of micro-processors in the 1970s (Lock 2003:10). Echoing others (for example, Costopoulos 2016, Huvila 2018:1, Morgan and Eve 2012:523), archaeologists are so embedded in a digital society that no participant can avoid the challenges that digital archaeologies bring.

Data creation: The most obvious developments in archaeological practice brought about by the digital turn are in the realm of fieldwork; obvious because they stand out as distinct practices from field methods of the past. Yet past the superficial façade of 'new technology' are the ways these products and techniques force us to *think* differently, both in the field and out of the field. It is these cognitive shifts in our direct engagement with the archaeological record brought about through digital tools that are illuminated by a critical perspective on this transition. For example, mobile databases and structure from motion (photogrammetry) have become common tools for recording excavations in progress. However, Morgan and Wright (2018) have persuasively argued that traditional archaeological practices such as mapping or hand-drawing provide a deeper level of insight into the complexities of a site, insight that may be missed by using more regimented or standardized approaches to digital recording. A hand-drawn feature or profile map affords a level of creativity and embodiment that may not be possible when taking photographs for a photogrammetric model. Caraher (2013, 2016) has similarly suggested that born-digital recording practices, while not necessarily 'de-skilling' archaeologists, certainly resituate required knowledge.

These types of recording practices are not unlike the shift to scientific recording of the 1960s, with an eye toward recording as much as possible. And just like field recording in the sixties, digitally-based archaeological practices are situated in larger disciplinary paradigms and the data-creation techniques that influence the down-the-road role of these data. Digital recording techniques in the field have an impact not only on an excavation workflow but also on way archaeologists envision futures for the data they create. The role of data does not end in the field or with a write-up of the site. Archaeologists are now obliged to think like a database, not just to standardize recording practices but also to ensure that these data are eventually stored properly and maintained for future use. This is, of course, not necessarily how humans think. Faniel et al. (2018) demonstrated that both students and professionals require specific training to design recording strategies, as well as to use them. The idiosyncrasies of data recording on projects have given way to more standardized data structures, which has changed not only how these data can be reused but also the scale of our research focus, from small to large.

Data archiving and sharing: It is thus the development of our conceptual frameworks that have the wider effect of creating new modes of archaeological analysis and data futures. Instead of written field notes and forms languishing in dusty cabinets, archaeological information can be stored, collated, combined, reused, and shared. The first and last of that list are perhaps the most important evolution that digitality has brought to the way archaeologists think of the information they create. Long-term storage in a digital archive provides a level of sustainability for digitally-created data that is missing from analog recording (although see both Rabinowitz and Tringham, chapters 11 and 12 of this volume). The sustainability of our data remains a high priority, demonstrated by the increasing number of data repositories and archives (such as ADS, tDAR, DANS). It is clear that archaeological data, in all of their forms, do us no good if they are stuck on a hard drive after a computer breaks down or worse yet, stuck on a floppy disk made three decades ago that can no longer be read (see Jeffrey 2012). Data sustainability thus requires the challenging task of predicting the future—predicting what file types will be readable ten years down the road, or if the data is stored in such a way that it can even be accessed. The FAIR data principles (Findability, Accessibility, Interoperability, Reuse), for example, are one way that researchers can approach sustainable data futures (Wilkinson et al. 2016). These practices are a change to the way archaeological data are conceived, as future resources rather than just information about the past.

As a result of the push toward digital storage and data sharing, open data policies pervade the discipline. It is not good enough to just create data, data must also be accessible. The ethos of open science in archaeology did not emerge with the onset of digital archives and repositories, but these developments provided a means through which open principles could be enacted. Data accessibility has become even more necessary considering the global Covid-19 pandemic occurring at the time of writing. The ever-growing body of archaeological data that is available through open-access repositories has the enormous potential to support teaching practices in university archaeology courses, especially in the event that courses must be taught in online and distance-learning formats. The pedagogical benefits of using these open-access datasets include allowing students to engage, and even struggle, with real-life (imperfect) data, and providing an example of reproducibility in archaeological analysis (Agbe-Davies et al. 2014). Also, if we are moving to a truly more inclusive discipline, having open data allows more widespread access to research without the barriers of expense and accessibility of frequent travel, avoiding ableism and benefiting graduate students, early-career researchers, and many others struggling with underpaid jobs while trying to progress in the field.

Data analysis: The larger amounts of archived data are slowly becoming part of bigger datasets of interoperable information, a facet of data reuse that was not possible in the past to this scale. These more expansive datasets, connected through shared standards and schemata, have been approached in similar ways to ICT 'big data.' In particular, geospatial, zooarchaeological, and DNA data lend themselves to big-data approaches due to the standardization of the data structures (see, for example, Supplement of *Journal of Field Archaeology* volume 45). Expanding upon the mission of data-driven approaches, machine learning relies on Artificial Intelligence (AI) to identify new patterns of archaeological data. Whether in airborne LiDAR datasets (Davis 2019) or classification of pottery (Anichini et al. 2020), machine learning has the potential to reframe the position of the archaeological researcher—from conducting the analysis to instead developing the training datasets and interpreting the outcome. An argument can be made that this development is both positive, by illuminating new patterns unidentified at smaller scales, as well as negative; one danger is that the scale of data used in these types of data-driven approaches increases the risks of false positives, letting the data lead the way rather than a hypothesis.

Publishing: Returning to the discussion at the end of the IEMA conference, alterations to academic publishing that are facilitated by digital platforms, and the open-science spirit that has accompanied them, challenge the traditional gatekeepers of academic capital and force the discipline to adjust its expectations of research outcomes. Digital technologies have significantly expanded the available ways to disseminate research and data, specifically web-based platforms. Instead of only publishing in peer-reviewed printed journals or monographs, digital scholarship can now be published in an ever-increasing number of web-based and/or open-access journals, it can be disseminated through open-access repositories or archives, and narratives can be shared through non-traditional digital media such as blogs or social media. Importantly, the labor that is required to make these 'non-traditional' products, which had in the past been relegated to the 'technician,' is becoming identified as worthwhile scholarly work that deserves recognition and academic capital (although see Štular, chapter 7 of this volume, about the need for more of this). Recently, both the Archaeological Institute of America and the Society for American Archaeology have added significant sections about digital scholarship to their guidelines for promotion and tenure. These institutions lend credibility to digital products that have, in the past, been viewed as 'less than.'

Challenges: The openness of information and communication that has accompanied social media, crowdsourcing and funding platforms, and open-access repositories has also brought challenges as to who has a role in the creation of archaeological content and narratives. Micro-blogging platforms such as Twitter provide an invaluable way to communicate archaeological discoveries, share ideas and information, and connect to existing archaeological communities. At the same time, however, there is potential for this mode of research to have a significant, if understudied, impact on communities engaged with them (Perry and Beale 2015, Richardson 2013, 2018, Walker 2014). There remains a danger that the post-colonial ideals proposed to be at the heart of archaeological practice on the social web may actually become neocolonial appropriation (Perry and Beale 2015), and there are potential dangers in the use of personal data in research (Richardson 2018).

In addition to research through the social web, other digital archaeological projects aim to involve and collaborate with publics outside of the traditional academic bubble. Yet what is often missing in projects that aim to involve public participation is a direct role for non-specialists in research design. Addressing this challenge begins with harnessing the aspects of digital archaeologies that provide a platform for multivocality. We can work to account for Indigenous and other stakeholder rights in the design of our projects and data publication (Gupta et al. 2020, Mickel 2020), and more consciously incorporate community voices in project design. Most public-facing digital archaeological projects that incorporate a 'citizen science' model of labor still reinforce a hierarchy that places the archaeologist at the top (Fredheim 2020); the research goal is still designed by the archaeologist. However, alternative approaches to community-driven research have demonstrated the need for reevaluation of who participates in research design (for example, Jones et al. 2018). By centering the collaboration with stakeholders in the design of archaeological projects, digital tools can be used with the public and for the public, rather than reinforcing traditional relationships of power.

The challenge for archaeologists is that a move toward open data and open archaeology often ignores traditional power inequalities inherent in archaeological work with Indigenous pasts. The adoption of approaches like the FAIR data principles brings about new challenges that pit best practices against sociopolitical realities. During this period of increased access to data it behooves archaeologists to examine how these practices affect the control of Indigenous data and the role of stakeholders in data governance. The recent CARE Principles for Indigenous Data Governance (Collective benefit, Authority to control, Responsibility, Ethics) address some of these issues as they relate to stakeholders traditionally removed from the archaeological project by focusing on how stakeholders may use, understand, be affected by, or are invested in archaeological research and the data it produces.

The challenge of 'forgetting the people' who are represented and affected by the data is also entangled with data-driven approaches to archaeological research. Techniques that often fall under the big-data umbrella require data that are of a scale which makes it impossible to truly understand their creation and the behaviors they represent. Huggett (2020) has recently noted that data-driven research risks alienating the people from the data by relying on a data fetishism that overlooks the inherent disconnection between past behaviors and the data that are presumed to represent those behaviors. This realization forces an acceptance of archaeology as a social discipline, of both people it studies and those doing the studying.

Digital technologies are a lens, one of many, through which archaeologists can examine methodological, epistemological, and structural traditions in the discipline, allowing us to build upon developments that came before and challenge the status quo. The evolutions in archaeological thought and technology do not exist solely at the level of archaeological recording or archiving but extend to the ways the discipline itself is conceived: impacting day-to-day practice, reframing how we think of archaeological futures, and the relationships archaeologists and the public have with archaeology. Katherine Cook has outlined the ways that the *deliberate* use of digital technologies has the potential to:

> i. confront the archaeological past we have created
> ii. confront the present (particularly of the discipline)
> iii. confront authorship and authority
> iv. act as platforms to support the above.
> (Cook 2019:402)

This potential requires an intentional use of digital tools and a critical perspective on process. The challenges we face come down to whether archaeologists of the 21st century can 'practice what we preach' or if we merely pay lip-service to the transformative power of digital archaeologies.

Critical Archaeology

Self-reflection is a necessity if the discipline is to extract the potential of digital tools while also limiting the negative byproducts of their use. We do not have a choice but to critically engage with our digitalism when so much of our practice is impacted by, or has the potential to be impacted by, digital technologies. Dennis (2020) has recently outlined how such a critical and reflexive approach to digital archaeology (and archaeology as a whole) is necessary to address significant gaps in archaeological ethics. So, what does a future critical archaeology look like? A critical approach in 'the digital age' requires the reciprocal practice of creating knowledge, while at the same time acknowledging the circumstances in which that knowledge is created and enacted. A key here is thinking of technology as a process and not just a product. Processes occur within sets of intentions that are influenced directly by the paradigm(s) within which the practitioner is situated. It is therefore important to remember that paradigmatic change is not a product of technological change; they are intertwined and complement one another. A critical lens for archaeology in this case does not begin with how digital products are used but must focus on the reciprocal relationship between process and paradigm(s). Throughout the discipline, and especially in this volume, we see archaeologists thoughtfully engaging with broader disciplinary trends through the lens of digital technologies. The purposeful alignment of these lines of thought, digital and otherwise, have brought about some examples of necessary ways to practice archaeology. I see four major themes arising from a critical archaeology that should underlie our work moving forward and are also woven through the chapters of this volume.

Making

Archaeologists have always made *things*—data, reports, books; we just now make so much more, and most productive work is facilitated by digital tools. Significantly larger data came about through a wide range of developments, such as a larger number of excavations accompanying infrastructure projects, the appropriation of biochemical or DNA techniques in archaeology, and cameras capable of capturing large numbers of high-resolution images. With these conditions and adopted techniques we have increased our data production. These techniques are tending more and more toward the production of structured data, following strictly defined categories and observations that fit within a standard database structure. With these data we then make new things: predictive models, 3D reconstructions, or 'big data' analyses, in addition to the traditional products of archaeological work. However, structured data have the potential to mask archaeological variability. The context in which these data were originally created, combined with the production context of these secondary products, are demonstrably influential in the final outcomes. The important takeaway here is that how products are made affects their nature, how they are used, and how they shape future knowledge and discourse. From a technical perspective, recording this process is (theoretically) the role of meta- and paradata—tracking subjectivities and choices that may impact data or knowledge products. The desire to retain process in the data/product is not a new wish but one that is better facilitated by digital tools, where detailed process information can be connected directly to data without overshadowing or obscuring it. A renewed attention to the making of digital products provides a ground-up framework for purposefully designing and utilizing tools to meet the goals of the discipline or publics, and provides a space for intentionality in archaeological practice.

Engagement

The increasing attention archaeologists are paying to those outside of the discipline is hardly a digital development. This attention to various publics has spurred not only increased communication and collaboration, but also exposed alternative ways to think of our engagements with the archaeological record writ large. With terms like enchantment (Graham 2020, Perry 2019) or play (Di Giuseppantonio Di Franco, chapter 1 of this volume), there is an acknowledgement that we need not completely emphasize the 'serious' nature of archaeological research. The past sparks fascination and wonder for many. Digital tools have been harnessed to expand upon these types of engagements that tap into the sense of enchantment with the past or to facilitate play, from increasing gamification of archaeological interactions to providing platforms to touch (physically or digitally) reproductions of artifacts. We should continue to ask ourselves, why do we need to learn about the past only from a book,[1] a lecture, or artifacts behind a museum case? The platforms of the nineteenth and twentieth centuries afforded a particular engagement with the past, certainly, yet why should such platforms continue to dominate in the digital age?

Planning for the Future

A consideration of the future has been a part of archaeological practice through the last century, but it is becoming an increasingly important concern. We must now consider

1. I recognize the irony of writing this sentence in a book.

how the digital products of our archaeological making can (or should) last in perpetuity. This requires a more active consideration of the steps after the creative process: how to archive, to reuse, to access. Furthermore, the connection of data, documents, or other products takes a new form in the digital age. Connections have always been important in archaeological work, such as cross-referenced books and reports or card catalogs with linked keywords. But now, digital tools allow us to connect to more than could ever possibly be contained in a single lab or library.

Data futures also require a certain generosity on behalf of the researcher. Of course, we could always retain everything we produce on our hard drives, disseminate interpretation behind paywalls, and leave it to the next person to figure out what to do with our data after we retire or pass on. Yet, this does not seem to be the current trend in the discipline, even outside of a digital archaeology subfield. Open-data futures require a release of control over how one's digital products are used by others. It also requires a level of digital literacy to achieve the goals of sustainable futures; to ensure reuse and interoperability, data need to be in forms that allow reuse (legacy file types or standard ontologies), which requires forethought in the production process. However, this path is dependent on supportive platforms, institutions, and funding that are often beyond the control of the researcher. These desired futures thus require strategic investment of resources in the present.

Responsible Citizenship

Long gone are the days when we could view our work, process and product, as being somehow removed from all stakeholders in cultural heritage. As we confront the reality that archaeology is practice in the world, we are challenged with engaging in difficult discussions about the broader impact of our work. All stages of archaeological practice are embedded in sociopolitical institutions and formal and informal communities. As such, the design and use of digital tools in this practice cannot be conducted without the broader considerations of their impact; how does it help, and hurt, all stakeholders.

Furthermore, the concerns over the sustainability of data that support future archaeological research also challenge our everyday computational practice. Everything that we do as 'digital archaeologists' requires energy and other resources, for our tablets, cameras, computers, but especially the data centers that house servers maintaining our data. Data centers have to run all day, every day, requiring the constant use of cooling systems. The data centers in Europe will soon likely consume 104 TWh/year, or about 4 percent of the total EU energy consumption in the coming years (Bertoldi et al. 2017). Fossil fuels make up a large portion of the energy responsible for powering these centers. Archaeology is thus forced to confront the reality that with this larger shift to all-digital practices, our role in massive energy consumption, albeit still minor, will only continue to increase. That consumption does not even include the production of the components used to make the physical digital tools and their place in socially and environmentally exploitative systems. As citizens of the world, archaeologists are not passive but active players in global sociopolitics.

Volume Contents

What I hope to have expressed as the themes underlying a critical archaeology in the contemporary world is that we must practice archaeology with intention, particularly with the production and use of digital *things*. To be intentional in our use of techniques means we consider the full context in which the process is situated. This intention is exceptionally demonstrated in this volume, which also reveals the breadth and scale of digital work within archaeological practice and thought.

The volume begins with the section titled *Impactful Technologies*. While all the chapters in this volume in some way discuss how digital practice may impact our conceptions of the archaeological past, the chapters in this section outline case studies that demonstrate how certain tools are already having these repercussions. In the first chapter, Paola Di Giuseppantonio Di Franco examines how 3D digital and printed replicas of artifacts have the potential to alter visitor experience with cultural heritage through play and a tactile engagement with the object. Whereas artifacts in glass cases position visitors at a distance, 3D artifact prints contain a regenerative power that may make them more authentic than the real artifacts. In this case, the 3D scanning and printing of artifacts has the potential to shift how research is conducted on authenticity and object aura, and their critical and deliberate use in museum contexts could transform heritage engagement in the future. Bernard Frischer and David Massey (chapter 2) follow with their examination of how 3D visualizations can move beyond their use as teaching tools and act as evidence in empirical research. By utilizing a 3D reconstruction of the Roman forum, developed as part of the Rome Reborn Project, they were able to demonstrate the potential for making structured observations and conducting experiments within a faithful reconstruction of ancient conditions. This approach, only made possible with hardware and software developed in the last few decades, brings not only phenomenological but empirical evidence to reinterpreting the long history of scholarship in this context.

Moving from empirical research to collaborative archaeology, Rebecca Bria and Erick Casanova Vasquez (chapter 3), outline how computational photogrammetry can be used with communities to disrupt traditional interpretive hierarchies. While working in Hualcayán, Peru, they explored the use of photogrammetry for an active co-creation of knowledge, as well as for education and storytelling. They specifically highlight how open-ended storytelling that makes use of digital and analog media has the potential to reframe the ways that students engage with prehistory and local archaeology. Patrick Willet and colleagues (chapter 4) continue the discussion of how relatively new technological methods can reframe archaeological narratives, but also how they may be used to contribute to and challenge traditional heritage work. They explore how predictive modeling of site locations in the regions around Sagalassos, Turkey based on decades of survey data, can provide meaningful input to governmental infrastructure planning. The role archaeologists have in heritage sustainability can be active instead of reactive in site preservation. Finally, Laura Harrison (chapter 5) demonstrates the impactful nature of a digital approach to post-excavation analysis, curation, data reuse, and media creation. Presenting the salvage excavation project at Seyitömer Höyük, Turkey, Harrison discusses how these at-risk heritage sites that may be excavated in less-than-ideal scenarios have the potential to be integrated into a holistic digital archaeology through a purposeful approach to the data. At the same time, these data provide opportunities to re-envision the ways archaeologists engage with various publics that make use of digital media, comic art, or 3D prints.

The second section of this volume, *Rethinking Data*, contains contributions that each address significant aspects of how data can be reconceived, shared, accessed, and ethically reused. Jeremy Huggett (chapter 6) begins this section by framing a future for archaeological practice that resists some of the worst impulses of data-centrism and instead relies on a 'slow data' methodology. As a reaction against the velocity of big data approaches, slow data allows researchers to *understand* the data more fully so that it can be used appropriately. A slow-data future challenges the recent excitement of data-driven, big-data archaeology to focus as much on the process of data creation as on the data itself. It is precisely the need to understand the data-creation process that underlies Benjamin Štular's (chapter 7) work on the sharing of airborne LiDAR data, or rather, the lack of a robust mechanism to communicate these data to other scholars. LiDAR-derived data have demonstrated significant potential to impact archaeological prospection, but Štular examines the developments that will be necessary for these data to reach their disruptive potential. Specifically, the academic community will have to recognize data processing and curation as scholarly endeavors, and adequately reward the labor that is expended on these practices, as well as creating a repository capable to allowing easy access to data.

Rachel Opitz and colleagues (chapter 8) also address the current limitations that exist for the reuse of 3D data. They look specifically at procedural modeling in archaeology, due to its complex and varied nature, as a basis for developing best practices in open 3D data storage and usability. In many ways, procedural modeling is better suited to the vision of FAIR data than other types of 3D data used in archaeology, due to their inherent reusability and the ability to track (re)usage. Complimenting this discussion is Eric Kansa's chapter (9) on data infrastructure and the intersection of archaeological data management, privacy, and surveillance. A critical examination of the infrastructures archaeologists rely on for our data illuminate the underlying dependencies on commercial services, which often clash with our ethical responsibilities.

In the final section, *The Past of Digital Futures*, the authors share perspectives on how future digital archaeologies will impact publication, data preservation, and global sustainability. William Caraher (chapter 10) begins this section by addressing the institutional disruption that spurred the interesting conversation at the end of the IEMA conference discussed above: publication. Caraher highlights the reality that the publication process, despite being a key node in archaeological knowledge-making, is one of the few aspects of archaeological practice that is rarely critically assessed. He delves into the ways that digital workflows have shaped and continue to shape this archaeological work. Part of the shifting landscape of archaeological publishing is grounded in the needs and capabilities of data dissemination, storage, and archiving. Adam Rabinowitz (chapter 11) explores how the notion of an archive has changed over time and how the choices made about current archives will impact future work with archived data. Despite the robusticity of modern, born-digital archaeological data compared to previous analog records, Rabinowitz argues that the level of curatorial investment is significantly higher. The ways we structure our archives in the modern day will also structure the uses of data in the long term.

The question of data futures extends to Ruth Tringham's discussion (chapter 12), where she asks, what can we let go to the internet graveyard? As our archaeological projects are born and live in a digital world, the afterlives of these projects have also shifted into a digital world. This shift forces a decision about what needs to be preserved for the future. Lorna-Jane Richardson (chapter 13) concludes with a sobering discussion of the broader impacts of a digital archaeology on global sustainability. A critical look at digital archaeology and heritage should not simply focus on the use of certain tools or techniques, but also on the nature and by-products of the field itself. As we continue as a digital discipline, as part of a digital world, what can we do to mitigate the global harm of these digital practices?

As a whole, this volume outlines a way forward for archaeology in a digital age, incorporating the themes of a contemporary critical archaeology: *making, engagement, planning for the future, responsible citizenship.* Critical archaeology is a purposeful and deliberate archaeology. When applied to digital technologies, our focus is on the process as much as the product. In this way our disciplinary paradigms, our goals for the future, our activism, and our tools can align and develop alongside one another.

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CHAPTER 1

The Ontology of 3D Digital and Printed Replicas of Artifacts Inside Museums

Authenticity, Play, and the Sense of Touch

Paola Di Giuseppantonio Di Franco

Introduction

New technologies are giving museums an unprecedented opportunity to celebrate the multi-sensorial nature of the artifact experience, which enhances the materiality of our encounter with remnants of the past. While we preserve original artifacts safe inside a glass case, we can enable museum visitors to play with 3D digital and printed replicas and experience forms of past materialities, rather than just learning about them through curatorial intervention (Di Giuseppantonio Di Franco et al. 2015, 2016, Novak and Schwan 2020, Sheehy et al. 2019. Williams et al. 2019). The increasing ease of access to digital replicas makes performative engagement with our past much easier. Recent studies have suggested that performative engagement with different kinds of object replicas enhances curiosity through play and can contribute to redefining the relation between museum visitors and artifacts as an ecological encounter "where people, meanings, and things interrelate" (Kalshoven 2015:572; see also Bann 2003, Bateson 1972, Ingold 2012). In this paper I focus specifically on 3D digital and printed replicas of museum artifacts, which are accurate replicas of those objects, made using techniques such as laser scanning, photogrammetry, and rapid prototyping. Drawing on recent studies that offer a re-reading of The Work of Art in the Age of Mechanical Reproduction by Walter Benjamin (1935), in this chapter I will argue that the study of 3D digital replicas of artifacts should be less concerned with the preservation and migration of the aura and more focused on the regenerative power that such replicas have to emphasize the historicity of ancient artifacts. I also argue that the regenerative power of the replica stems from the possibility of playing with it. The performative encounter with replicas is what regenerates the aura of the original. My chapter will reinforce the idea that the perceived authenticity of artifacts is not intrinsic to the qualities of the object, but rather is defined by the level of engagement we have with it. In particular, the sense of touch, by playing a crucial role in our encounters with objects, is a key element for the definition of authenticity, to the point that replicas of artifacts that can be touched and physically or virtually manipulated can sometimes be perceived as more authentic than real objects exhibited in a glass case.

In this chapter I will first provide an overview of studies of authenticity and replicas that have been influenced by Walter Benjamin and his discussion of aura. I will then introduce a new study on Walter Benjamin that focuses on the centrality of play as allowed by the replica. This study emphasizes Benjamin's account regarding the mimetic power of the replica, which is separate from religion, magic, and cult and serves as a heritage object rather than simply an archaeological artifact. I will then present studies that show how play and sense of touch can contribute to the definition of authentic objects, where authenticity is defined by engagement and how this revitalizes the aura, rather than fixing it in time and space. I will conclude with a discussion on the glass case and how it limits our encounter with artifacts. I will show how museums tend to treat the replicas as artifacts in their own rights and maintain their aura by framing the replicas within the glass case; through this kind of curatorial practice replicas acquire the status of museum objects (that is, a 'sacred,' cultural status that is usually assigned to original objects). I suggest that museum curators should play with replicas of artifacts more, experimenting with new creative ways in which these objects could make the encounter with original artifacts user-centered, as well as more materially performative and emotional. My argument is complementary to that of Rebecca Bria and Erick Casanova Vasquez (chapter 3 of this volume), who present a case for how storytelling and photogrammetry can be combined to create more meaningful relationships with cultural heritage. These two contributions to the book align with recent work by Sara Perry (2019), aimed at defining a model of practice that facilitates people's intimate, enchanting encounter with the archaeological and heritage 'record,' suggesting how emotive storytelling and user-centered creative practices can enhance this kind of encounter.

Authenticity and the Replica

Walter Benjamin and the Migration of the Aura

Studies of 3D digital and printed replicas of artifacts are often influenced by the work of Walter Benjamin. The central question for all these studies is: can the aura of an original work of art migrate from the original to the replica? This question stems from Benjamin's renowned book The Work of Art in the Age of Mechanical Reproduction (1935). The traditional reading of Benjamin emphasizes some key passages that clearly demonstrate his skepticism, even rejection, of a replica, which is seen as a real threat to the original work of art: While original artifacts possess an 'aura'—arising from their uniqueness as an effect of a work of art being uniquely present in time and space, once the objects are reproduced, they become merchandise, and as a consequence they lose their aura. This passage relates directly to Benjamin's idea of authenticity: if there is no original, it is never fully present anywhere. Authenticity cannot be reproduced and disappears when everything is reproduced, while the original is devalued because it is no longer unique. Along with their authenticity, objects also lose their authority. The masses contribute to the loss of aura by constantly seeking to own things. They create reproducible realities and hence destroy uniqueness. While Benjamin claimed that it is impossible for replicas to maintain the aura of the original, more recently some notable scholars in the fields of anthropology and heritage have claimed that 'migration of aura' from the original to the copy is both possible and traceable. Notably, Bruno Latour and Alan Lowe underline how the aura migrates from an original to the replica, as the latter can increase people's obsession for the original:

> The real phenomenon to be accounted for is not the delineation of one version from all the others but the whole assemblage of one—or several—original(s) together with its continually rewritten biography. . . . [F]acsimiles, especially those relying on complex (digital) techniques, are the most fruitful way to explore the original and even to help re-define what originality actually is . . . . To say that a work of art grows in originality thanks to the quality and abundance of its copies, is nothing odd: this is true of the trajectory of any set of interpretations. (Latour and Lowe 2011:278–79)

From this perspective, the authenticity of an object is maintained thanks to its temporal and material fluidity: that is, by the biography of an object as defined by its historicity rather than by its original time, frozen and preserved as in a snow globe (Holtorf 2002, Knappett 2002, Kopytoff 1986, Pred 1984, Tringham 1994).

The claim that the aura can migrate is reiterated in different ways by most of the contributors to a recent volume edited by Di Giuseppantonio Di Franco et al. (2018). In particular, Jody Joy and Mark Elliot (2018), curators at the Museum of Archaeology and Anthropology, University of Cambridge (MAA), argue that the replica simply emphasizes the spatiality and temporality (that is, hic et nunc) of an object, which implies a transferability of the aura (or part of it) from the original to the copy. This suggests the aura of heritage is not necessarily intrinsic to the objects themselves, but must be constituted in performance (Joy 2002). Similarly, Stuart Jeffrey (2018) and Kevin Garstki (2018) both stress the performative power of replicas and demonstrate how when a community participates in the co-creation of the 3D digital replica, it is felt to be more authentic. Through analysis of three different case studies (an interdisciplinary scholarly collaboration, a community archaeology project, and a public art project), Gareth Beale also emphasizes how authenticity cannot be said to reside in the image (that is, digital replica) itself but in the interplay between image maker, image, and the audience (Beale 2018:92). Scholars studying engagement with different kinds of replicas arrive at similar conclusions. For instance, Petra Tjitske Kalshoven (2015) argues that the replica allows for a dialogic process centered on what has become a rather different kind of artifact. She studies re-enactors and living historians, who are keen to make artifacts perform outside their glass cases in an attempt to experience past material culture:

> Fascinated by the historicity and tangibility of the 'real thing' but frustrated by its inaccessibility in the museum environment, living historians and re-enactors create replicas and make them come alive through performances that, as I argue, both defy and celebrate the sanctity of the museum space. [We are] concerned with the tension between, on the one hand, the pleasure associated with the 'real thing' displayed in museums and, on the other, mimetic practices modelled on museal representation. (Kalshoven 2015: 555–56)

In her conversations with Indian hobbyists, Kalshoven found that they consistently define their own replicas as authentic even when they are not an exact copy of an existing 'original.' The author argues that such replicas become an embodiment of the knowledge that practitioners acquire in museum spaces: "This expert emulation takes place not only on the level of the artifact, but also on the level of performance. In other words, replicas must resemble originals both in the way they look or feel and in the way they are made and handled in action" (Kalshoven 2015:560). Work by Stuart Jeffrey (2018) and Kevin Garstki (2018) reinforces Kalshoven's views, as they have both demonstrated how when communities are involved in the process of digitally replicating their cultural heritage, the 3D digital replica is felt to be more authentic. Similar to re-enactment, the very process of digital replication is a performance that enhances affective bodily interaction with an object: "In fact, digital replication and reconstruction involves 'body-based image schemas' (Csordas 1994)—that is the descriptions, metaphors, and metonyms of the body that mediate between physicality and sociality, the material and the virtual, the real and the copy" (Di Giuseppantonio Di Franco et al. 2018:5).

These premises reinforce the idea that authenticity is defined by the engagement of people with artifacts and the aura can be continuously reconstituted and regenerated through the engagement of people with such replicas.

The Shifting Paradigm

From Migration to Regeneration of the Aura

As described in the previous section, most of the studies concerning authenticity and digital replicas have tried to demonstrate that the aura can migrate from the original to the replica. I will now suggest shifting the research focus to an analysis of how the aura can be regenerated through the replica. This is an ontological question because we must understand whether digital replicas can be considered elements in the life of the original, or rather as new artifacts with their own life; and especially what the whole point of replicating an object is. Is repetition only a symptom of our society, where capitalistic practices aim to commodify the past? Or is it not also the principle of the game—the way we can build intimacy with past material culture, through performance, engagement, and play? Recent studies by philosopher Marina Montanelli (2016, 2017) might help us to rethink the real ontology of digital replicas. Her studies shed new light on the work of Walter Benjamin and suggest a re-reading of his principle of repetition.

As we know, for Benjamin the aura is linked to the ritual dimension of the work of art:

> The uniqueness of a work of art is inseparable from its being imbedded in the fabric of tradition. This tradition itself is thoroughly alive and extremely changeable. An ancient statue of Venus, for example, stood in a different traditional context with the Greeks, who made it an object of veneration, than with the clerics of the Middle Ages, who viewed it as an ominous idol. Both, however, were equally confronted with its uniqueness, that is, its aura. Originally the contextual integration of art in tradition found its expression in the cult. We know that the earliest art works originated in the service of a ritual—first the magical, then the religious kind. It is significant that the existence of the work of art with reference to its aura is never entirely separated from its ritual function. (Benjamin 1969:2)

The aura is therefore sacred, ritualistic, magic, as well as unique, original and, especially, unrepeatable. Art becomes entangled with tradition through ritual, first magical then religious. The condition of the original work of art is its 'original' (that is, historical or archaeological) context and it is through our understanding, presentation, and preservation of this context that we can maintain the aura of an original object. On the other hand, the technical reproduction detaches the replica from tradition.

> By making many reproductions it substitutes a plurality of copies for a unique existence. And in permitting the reproduction to meet the beholder or listener in his own particular situation, it reactivates the object reproduced. These two processes lead to a tremendous shattering of tradition which is the obverse of the contemporary crisis and renewal of mankind. (Montanelli 2016:40)

The social function of art is at this point turned upside-down:

> An analysis of art in the age of mechanical reproduction must do justice to these relationships, for they lead us to an all-important insight: for the first time in world history, mechanical reproduction emancipates the work of art from its parasitical dependence on ritual. To an ever-greater degree the work of art reproduced becomes the work of art designed for reproducibility. From a photographic negative, for example, one can make any number of prints; to ask for the 'authentic' print makes no sense. But the instant the criterion of authenticity ceases to be applicable to artistic production, the total function of art is reversed. Instead of being based on ritual, it begins to be based on another practice—politics. (Benjamin 1969:6)

Montanelli's work emphasizes how for Benjamin the interruption of the ritual power of the aura is both a decline and a chance at the same time. Why? Because by permitting the copy to move beyond its original time and place, the replica "reactivates the object produced" (Benjamin 1969:4). Where the ritual comes to an end through the replica, the possibilities of play begin (Montanelli 2016). At this point Montanelli highlights a crucial passage that is contained only in a note to chapter XI in the third edition of the book: "What goes with the deterioration of appearance, with the decay of the aura in the work of art, is a huge gain in terms of space for play" [Translation from the original] (Benjamin 1939, note 1: 120–1; cited by Montanelli 2016:44).

The chance embedded in the replica comes from the fact that having lost the sacrality of the original, the replica can now be played with (like a child would do with their toys): it can now be altered, transformed, even destroyed (Agamben 2001:73–74). The cyclical time of cult and ritual associated with the original is transformed in the linear time of history. The replica becomes more permeable to mimesis, but also to the changing values we apply to the very notion of heritage. If, on the one hand, the risk of replication is commodifying the original, exploiting its meanings, and diminishing its importance, on the other hand there are many gains, which are linked to the malleability of the replicas: their susceptibility to change that can regenerate the meaning of the original; the democratizing and personalizing of the experience we can have with the object; the increase in access. All contribute to making our engagement with, and interpretation of, the object more creative and multi-vocal. The replica cannot be conceived as a way to fix the original in time and space, but rather to regenerate the meaning of the original object in the present. As well expressed by Brendan Comier (2017), a curator at the Victoria and Albert Museum, the purpose of the replica cannot be the preservation, but rather the perpetuation of the original. This is because while preservation means keeping things the same, the replica allows for the cultural perpetuation of the original, which encourages a layering of meanings and values and an ongoing dialogue about the original.

Playing with Digital Replicas

Authenticity and the Sense of Touch

Philosopher Hans-Georg Gadamer conceived of 'play' as the ontological basis for the notion of aesthetics (2004:102–57). When discussing replicas he suggested that imitations may be better than the real thing, because "imitation and representation are not merely a second version, a copy; but a recognition of the essence . . . . They contain the essential relation to everyone for whom the representation exists." ([1960] 2004:114). Copies can embody creativity and curiosity and offer convenient opportunities for handling, performance, and re-enactment, which is defined as a form of competition with the original that brings out the element of creative play through material interactions with past material culture (Kalshoven 2015:563). Museum replicas take, ipso facto, the artifacts out of their case, turning people's engagement with them into a tactile experience. I have described how Kalshoven, during her conversations with Indian hobbyists, found that they consistently define their own replicas as authentic even when not an exact, identical copy of an existing 'original.' I also mentioned how this can be linked to authorship and ownership of the replica (Garstki 2018, Jeffrey 2018), considering the fact that the hobbyists made the objects themselves. Another element to consider, to explain this finding, is the tactile interaction with the replicas. The tactile experience certainly plays an important role in the definition of aesthetic and authenticity, as well demonstrated recently by philosopher Carolyn Kosmeyer:

> [G]enuineness possesses an aesthetic aspect. As will become clear, this is not a standard use of 'aesthetic,' but I think it is the best available concept to understand the thrill of encounters with things that are prized for being original, authentic, rare, very old, or unusually special; that no substitute or replica can possess that dimension (though we can certainly be fooled in the individual case); that the sense of touch plays an especially central role in the encounter: with this piece that we hold in our hand the past is gathered into an aesthetically perceptibly present. (Kosmeyer 2019:22–23)

She then continues:

> [I]t is simply the realness of an artifact that is the target of admiration, and being real doesn't have any distinctive tactile qualities. Rather, touch seems to be invoked because it registers a singular thrill of contact with something old and rare. Such a thrill was reported by a treasure hunter diving off the Florida coast who plunged his hands into the sandy seabed and grasped a handful of Spanish doubloons. 'Being the first person to touch something in over 300 years, there's a euphoric feeling that you'll never forget . . . . I couldn't believe what I was holding in my hand.' (Kosmeyer 2019:25)

Some recent studies can provide an empirical base to Kosmeyer's argument, but also serve as a counterargument for her thesis that replicas do not possess the same aesthetic quality provided by the tactile encounter with the original.

In a study conducted by University of Cambridge MPhil student Adriana Fernandez (2016), which aimed at understanding which elements contribute to the definition of authentic artifacts, she suggested how the sense of touch is often used by museum visitors to define authenticity. For her study, based at the MAA, she asked a hundred volunteer participants to rate a selection of five objects from the most to the least authentic and then explain the reasons for their choice. This selection included the 3D print of the Star Carr headdress on display at the MAA, which I had made for my Marie Sklodowska Curie Project at the University of Cambridge and donated to the museum for their handling collection (Figure 1.1.). This print could therefore be held and manipulated. The study also included: a dagger-axe from Bronze Age China, located in a display case accompanied by ample textual information about both the object itself and the culture surrounding it; a Roman pot sherd taken from the handling collection, the provenance and archaeological context of which are unknown; the Inigo Jones Winchester Cathedral screen, relocated from the cathedral and displayed not behind glass (that is, people can touch it); a drawing of the Inigo Jones Winchester Cathedral screen that shows what the screen looked like before it was relocated.

A majority of the participants rated the Winchester screen as the most authentic object of the five presented. This was also the only object that participants never placed as the least authentic. The second most frequent object participants ranked as most authentic was the pot sherd (which they could touch), followed by the dagger-axe (original in a display case), and the 3D printed replica of the Star Carr headdress (which they could touch). The Winchester image was only chosen first once, and was placed last in more than half the responses, making it the object perceived as the least authentic. While the three objects most frequently identified as most authentic were the original ones (what Kosmeyer would call the genuine ones), what is interesting to note is that more than half of the study participants ranked the 3D print of Star Carr over one of the 'original' artifacts. Young participants (under the age of twenty-four) in particular rated the 3D print as the most authentic.

Figure 1.1. Cambridge MAA museum visitor playing with the 3D print of the Star Carr deer antler headdress on display on the third floor of the museum (World Archaeology Gallery) *Photograph by Paola Di Giuseppantonio Di Franco.*

To explain the reasons behind their overall ratings, participants mainly indicated that the originality of the object makes it authentic, but many also indicated the possibility to touch and feel as one of the characteristics defining the authenticity of the artifacts or the 3D printed replica. While the data reinforce Kosmeyer's assumptions about the sense of touch being an important aesthetic quality embedded in original artifacts, it also suggests how for some people a tactile encounter with a replica makes an object more authentic than its original counterpart, which they can only view in its glass case.

The research findings described above reinforce the findings from studies by Di Giuseppantonio Di Franco et al. (2015, 2016). Some of these findings come from a one-day exhibition entitled What Are You 'Looking' At: Experiencing Ancient Artifacts, which I co-organized in April 2014 at the University of California, Merced. Through hands-on 3D virtual and material interaction with ancient artifacts, the exhibition was aimed at problematizing the archaeological display and showing how our perception of the past is affected by the medium used to present it. For the exhibition, participants were first brought to a room (stage 1) where they could interact with 3D digital replicas of artifacts through an immersive system called the Powerwall. In a second stage (stage 2), all participants were brought to a second room where they could see the original artifacts displayed in glass cases (look condition) and also interact with photographs (2D digital condition), 3D prints (3D prints condition), and 3D digital replicas (3D digital condition) of the same artifacts displayed on a computer screen. In this room, they were free to interact with any of the given conditions and were then asked to participate in a questionnaire and rate their overall experience with both the Powerwall and the other conditions chosen. Sixty visitors agreed to participate in the questionnaire. During stage 2, just a few participants selected the 3D digital replicas on a computer screen (four out of sixty), while no one wanted to interact with the photographs. The questionnaire ended with a multiple-choice question in which we asked participants to compare the various experiences and an open-ended question in which we asked them to explain why they preferred a particular experience (Table 1.1.).

Table 1.1. Visitor questionnaire (N=60) from 2014 exhibition *What Are You 'Looking' At: Experiencing Ancient Artifacts*, using the Likert scale, with 1 being strongly disagree and 9 being strongly agree. Visitors graded their interactions with artifacts via the Powerwall, 3D prints, and artifacts behind glass cases (Look). Mean (average of the most common value; ANOVA); SD (Standard Deviation). (from Di Giuseppantonio Di Franco et al. 2015:258).

Powerwall		Mean	SD
Q1.	The possibility to select appropriate lights improved my understanding of the artifacts' characteristics	7.45	1.54
Q2.	The possibility to remove original colors of the artifacts improved my understanding of the artifacts' characteristics.	6.5	2.37
Q3.	The ability to use the Powerwall (full-scale 3D screen) was very helpful compared to a traditional museum display.	7.8	1.7
Q4.	The Powerwall system seems to be a good approach to interact with ancient artifacts.	8.2	1.11
Q5.	This experience with 3D digital artifacts was engaging.	8.9	0.31
3D prints			
Q6.	The possibility to touch 3D printed artifacts improved my understanding of the artifacts' characteristics.	8	1.08
Q7.	The ability to interact with 3D printed artifacts was very helpful compared to interacting with 3D digital artifacts in the Powerwall.	7.6	1.5
Q8.	3D prints seem to be a good approach to interact with ancient artifacts.	8.05	1.05
Q9.	This experience with 3D prints was engaging.	8.3	0.86
Look			
Q10.	The possibility to look at original artifacts through a display improved my understanding of the artifacts' characteristics.	7.47	1.74
Q11.	The ability to look at the artifacts was very helpful compared to interacting with 3D digital copies in the Powerwall.	6.64	1.98
Q12.	Traditional display seems to be a good approach to interact with ancient artifacts.	7.35	2.21
Q13.	This experience with original artifacts was engaging.	7.12	2.2

Comparisons between Powerwall and the remaining conditions (Look and 3D prints) revealed that participants interacting with original artifacts exhibited in glass cases preferred the experience with the Powerwall. Most of the participants who expressed their preference for 3D prints and Powerwall explained that these experiences were more engaging because they could touch (in the case of the 3D prints) or 'almost' touch (in the case of the Powerwall) the objects (Figure 1.2.). When analyzing these data I concluded that museum visitors were prepared to negotiate with what I defined as inauthentic artifacts for the sake of a tactile/semi-tactile experience with these objects. The data all lead to the conclusion that play, performance, and the sense of touch are crucial elements for the perception of authenticity of past material culture, at least in our current culture and time.

Figure 1.2. Study participant playing with the 3D digital replica of a ceramic pot displayed in the Powerwall immersive system. The image shows how the user is virtually holding the pot. *Photograph by Paola Di Giuseppantonio Di Franco.*

Playing versus Displaying
How the Glass Case Affects the Museum Visit

I have just suggested how the sense of touch plays an important role in fostering engagement, play, and the definition of authenticity, to the point that in some cases museum visitors might consider a replica more authentic than the original artifact framed by a glass case, since it provides a tactile, material experience that is usually denied in the museum context. While original artifacts cannot usually be handled for obvious reasons of preservation, some studies have shed light on how the glass case affects the knowledge experience with museum objects.

In a study aimed at understanding how people engage with ancient artifacts through different media (for example, visual examination of an artifact in a glass case; computer-mediated manipulation of a digital artifact; tactile experience of 3D printed replicas of artifacts) Di Giuseppantonio Di Franco et al. (2015, 2016) videotaped people while they interacted with ancient artifacts through these different media (only one medium per person) and then examined both how they described the objects and how they gestured while describing them, to investigate how people perceive and understand artifacts. Analyzing the gestures and speech of people talking about objects provided useful insights into how they experience and make sense of artifacts in varied forms, including 3D digital and printed replicas, and how curiosity is enhanced by tactile or semi-tactile engagement with such replicas. It is proven that gestures facilitate reasoning and learning (Goldin-Meadow 2003; Matlock et al. 2012). Iconic gestures demonstrate well how mimesis happens through the body when trying to make sense of ancient artifacts. These are movements that convey visual–spatial information (McNeill 2007). While describing the function of a hand axe, for instance, a person might say, "this might have been used for pecking" while making a gesture that mimics the action (Figure 1.3.).

This study showed how the body movements of people while looking at objects inside a case are very constrained: they tend not to move while describing the artifacts and to keep their hands away from the case or at their back, reinforcing the idea that the glass case represents not only a physical barrier but also a psychological barrier that inhibits the experience with the objects (Figure 1.4.). They have an internalized way of behaving, which constrains their body language as well as limiting the material encounter and nullifying the affective experience with the objects in the case.

Based on what has been described, 3D digital and especially printed manipulation of object replicas, if well integrated in a museum visit, have great potential to counterbalance the limitations described above. Unfortunately, one often finds when visiting a museum that 3D prints are also displayed in glass cases, as if they were original artifacts. One might question whether this practice should be understood as a way to frame digital and printed replicas within the modernist museum paradigm that obtains authority

Figure 1.3. Museum visitor at Cambridge MAA mimicking the pecking action of a hand axe on display on the first floor of the museum. *Photograph by Paola Di Giuseppantonio Di Franco.*

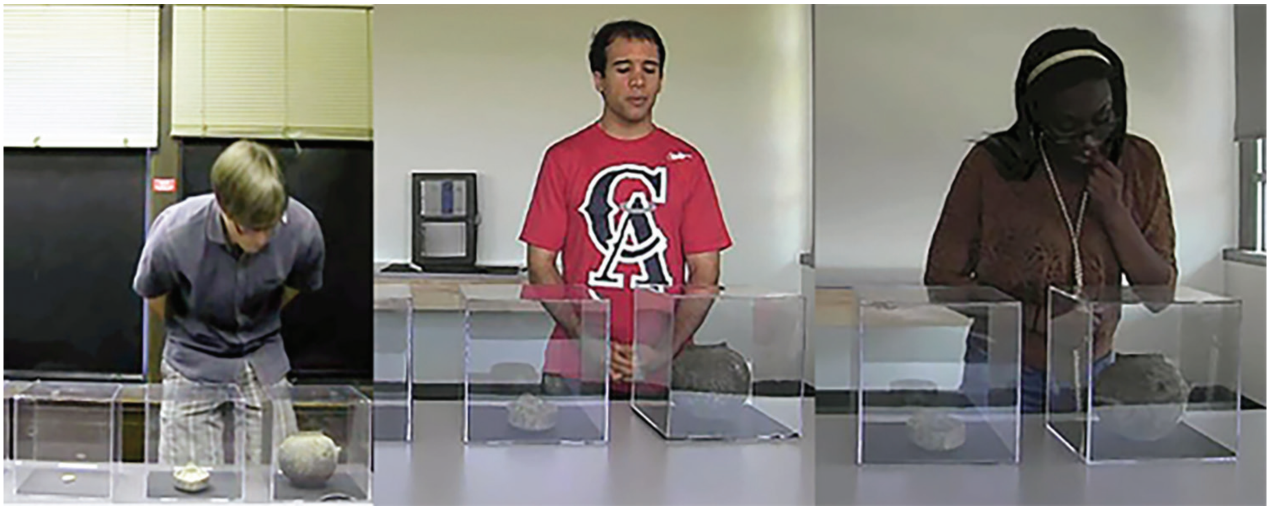

Figure 1.4. Study participants keeping their hands still or behind their backs while describing artifacts displayed in a glass case. *Photograph by Paola Di Giuseppantonio Di Franco.*

through the promise of authenticity as traditionally defined (Russo and Watkins 2007:157). This paradigm is still prominent in quite a few museums today, empowering curators and other museum specialists who become the authority entitled to handle the objects, reinforcing their status and their right to handle, touch, curate, and narrate. Such curators and museum specialists become the sole intermediaries between the relics and the public.

There are many documented examples of replicas framed in glass cases (see for instance Amico et al. 2018, Cooper 2019, Maxwell et al. 2015). Nicola Amico et al. (2018) suggest that curators might choose to display the 3D print inside a glass case as a guarantee of its 'authenticity'; in other words, in the absence of an original artifact, the replica is curated and treated as the original, thus 'guaranteeing' its authenticity. These authors also argue that even in the presence of textual information indicating that the object on display is a replica, visitors are sometimes confused and believe the object to be the original artifact. They provide the example of the display of a 3D print of the Cypriot Kazaphani boat, which was temporarily exhibited at the National Museum of Natural History, Smithsonian Institute, and note:

> [T]he 3D replica was placed, as any other ancient object, behind the glass and it was explained that the object was the replica of an original located somewhere else. Interestingly, a journalist, while interviewing museum curators regarding the exhibition, appeared surprised when he learned that the object was a replica, commenting that it was a 'wonderful depiction!' . . . The misunderstanding could have been caused by the peculiar exhibition of the object. The replica was exhibited under glass, exactly as an original masterpiece. The use was completely different from the role usually attributed to 3D prints, such as giving a sensorial experience usually denied to the museum visitors for obvious security reasons. (Amico et al. 2018:118)

A similar case is reported in a recent article by Catriona Cooper (2019), who reviewed the exhibition titled A Survival Story, curated by Jody Joy at the Museum of Archaeology and Anthropology in Cambridge in 2019. For this exhibition a series of Mesolithic headdresses from the Star Carr site in Yorkshire were 3D printed to reunite this collection of unique artifacts that are dispersed across five different institutions (Yorkshire Museum, Scarborough Collections, National History Museum and British Museum in London, and MAA in Cambridge). This collection of 3D prints had great value, as it had the potential to increase visitors' understanding of the artifacts and enhance their overall experience of the Mesolithic site of Star Carr. The 3D prints are presented in lieu of the original artifacts to show the range of headdresses found at the site and to foster people's engagement with the similarities and differences between the objects and their possible functions in the past. Unlike the Kazaphani boat, the 3D prints of the Star Carr headdresses are presented outside of a glass case, but still behind a rope barrier, which limits physical engagement and only allows the museum visitors to see and scrutinize the replicas from a distance. Cooper reports on a conversation she had with the assistant curator and senior curator of the exhibition, where she asked why they decided to deny a physical interaction with the replicas; the curators responded by claiming that the 3D prints were quite expensive and they wanted to preserve them from damage. Following Cooper (2019:446), while the latter claim is understandable, it is also quite problematic, as by 'preserving' another object from damage, "we are adding to an increasingly problematic issue in that the act of recording has become more urgent than experiencing that which is being recorded" (Hoskins 2017).

Conclusions

In this paper I have demonstrated how a replica can perpetuate an original artifact through its mimetic permeability and openness to play. I have also shown how replicas can sometimes feel more authentic than original artifacts because of the level of performative and material engagement we can have with them. The sense of touch (that is also activated through virtual manipulation of 3D digital replicas) plays an important role in fostering engagement and perceiving objects (even replicas of original artifacts) as authentic. While original artifacts cannot usually be handled for obvious reasons of preservation, some studies have shed light on how the glass case affects the knowledge experience with museum objects. On the opposite side, 3D digital and especially printed replicas give new possibilities of performance, multisensory interaction, and mimetic play. These replicas are seen as an innovative way to produce an accurate replica of the original object, that can be easily moved, lent, studied, and, especially, physically handled and manipulated. By extending the number of people that are entitled to touch replicas of ancient objects, these innovative technologies can, potentially, invite us to reconsider the traditional concept of authenticity. More importantly, these technologies can foster new museum practices, where the physical experience with original artifacts through their replicas becomes an intimate first encounter with our past materialities. Further, virtual and/or tactile manipulation of artifacts' replicas allows museum visitors to freely create their own narratives of the past. As a result, museum visitors become more intrigued with the stories of museum objects and more critically engaged with expert interpretations proposed a posteriori. We can only hope that once the 3D printing process becomes more accessible economically, the curatorial habitus of framing 3D prints behind a glass case will come to an end. In the meantime, creative ways to integrate other kind of replicas (digital or physical) in the museum visit should also be explored (Cooper 2019:447), to analyze the differing effects they have on people's engagement and understanding with the original museum objects inside the glass case.

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CHAPTER 2

3D Urban Models as Tools for Research and Discovery

Two Case Studies of the Rostra in the Roman Forum Utilizing Rome Reborn

Bernard Frischer and David Massey

Introduction

> "Undoubtedly, the modeling of large-scale urban areas of historical cityscapes is an ambitious and difficult task, but initiatives such as the Rome Reborn project . . . promise to produce a vast amount of 3D data that could be also used for the formal analysis of human experience in the reconstructed environments." (Paliou 2016:257)

The Rome Reborn project (www.romereborn.org) is an initiative, launched in 1996, to create a 3D reconstruction of ancient Rome in 320 CE, shortly before the capital of the empire was moved to Constantinople. This year was chosen because it represents the peak of the urban development of the ancient city, and, indeed, after the capital had moved, new civic building was generally forbidden in the Eternal City (Machado 2019:75–82, 107). The reconstruction took twenty-two years to complete and went through three versions. The first two versions were developed in the period 1996 to 2008 under the auspices and with the copyright of the Regents of the University of California. The later versions (3.0, 4.0) were created from 2009 until 2022 with completely new content produced by Flyover Zone, a company founded by the first author and owned by him and several employees. In 2022, virtual tours using the model are being made available on a free-to-play basis on the Yorescape platform for virtual tourism (www.yorescape.com). Yorescape offers expert commentary at each stop on a tour. It also supports free roaming through the model as well as multi-player.

Once outputted to a consumer-level device like a personal computer or Virtual Reality headset and enhanced with expert commentary explaining the features seen in the urban simulation, the Rome Reborn model has the potential to enrich K–16 curricula, making it possible even for newcomers to the subject of Roman topography and urban history to obtain a quick visualization of the monuments in their context in the city. The purpose of this paper is not to explore these instructional uses of the models but to draw out their scientific applications as tools of discovery.

Until now, Roman topographers have most often approached the imperial city by concentrating on a specific monument or region, or on an emperor's or dynasty's prestige building projects throughout the city. That is, they have concentrated on the specific part or parts. Even the two indispensable compendia for any study of the ancient city—Steinby's *Lexicon Topographicum Urbis Romae* and Carandini's *The Atlas of Ancient Rome*—treat the city part by part, not as a seamless whole. The *Lexicon* proceeds monographically, monument by monument; the *Atlas* topographically, region by region. Now, thanks to the availability of the interactive digital models (Frischer 2005), we can look at the city in a more holistic, experiential, diachronic, and dynamic way: no longer constrained by the print medium, we can have the experience of seeing the reconstructed ancient city at adult eye-level off the ground (ca. 1.6 m) or, if we like, from the air. We can move around at will, changing our perspective, and, after importing the model into the planetarium software Stellarium, we can even change the sky on a minute-by-minute basis with the position of the astronomical features like the sun, moon, five visible planets, and constellations keyed to our exact position on the ground (see Frischer et al. 2016, 2017). Like all new scientific instruments, Rome Reborn allows us to make observations and to run experiments that in the case of a historical discipline such as Roman archaeology would be impossible without true time travel (Frischer 2008). This paper will illustrate the validity of the claim with a case study of the temporal interaction of 3D viewshed and monument in the Roman Forum. Before presenting them, it will be useful to mention our theoretical grounding.

Arnheim (1969) undertook to "re-establish the unity of perception and thought" (Arnheim 1969:294). A building block of Arnheim's approach is the realization that "direct observation, far from being a mere ragpicker, is an exploration by the form-seeking and form-imposing mind" (Arnheim 1969:278). In other words, visual perception is not a random process but is actively involved at every step of the way with cognition that interprets the sensory input and gives it form and meaning. The present study is a case in point. As will be seen, had we not been able to see the Roman Forum as it appeared in the age of Constantine, move around virtually in it, and try to find the optimal point of view for seeing the various monuments, the ideas behind this paper would never have occurred to us. Indeed, the problem addressed here has never been raised by a previous scholar writing about this extremely well-published site.

In the fifty years since Arnheim wrote, the field of visualization has become a full-fledged science. A good entry point into that field is Ware (2013), which is a compendious textbook drawing on the hundreds of articles and monographs written about the many and varied ways that perception and thought are inextricably tied together. Ware begins by listing the several general ways that a visualization can be used, such as:

- To facilitate comprehension of huge amounts of data
- To enable the perception of emergent properties that were not anticipated in the data
- To facilitate hypothesis formation through pure observation, experimentation, or re-experiencing something that once existed but no longer does. (Ware 2013:3–4)

The pedagogical use of a visualization such as Rome Reborn relates nicely to Ware's first general use—making it easier for people to understand a huge amount of visual information, in our case, the entire urban landscape of ancient Rome. The case study presented here involves research uses of the visualization exemplifying, especially, the perception of emergent properties that were unexpected and the facilitation of hypothesis formation through observation, experimentation, and re-experiencing. Common to all these uses is the priority of observation.

Research based on observation and experimentation is, of course, called empiricism, and there is evidence that we are about to enter a phase that in certain pioneering fields, such as law (Schaffer and Ginsburg 2012) and the philosophy of technology (Franssen et al. 2016), has already been called the "empirical turn."

Visual observation has depended, in the first instance, on the eye unaided by an instrument such as a microscope, telescope, x-ray, or, in the case of archaeology, a GPR or ERT image. Humphreys (2004) called such instruments "epistemic enhancers," and the author, a philosopher of science, builds on the obvious point that no one doubts that what the trained eye of the expert sees in the output of such enhancers yields valid, empirical knowledge. Humphreys's book is relevant for this paper because it makes a strong case for viewing a computer simulation like Rome Reborn as a valid epistemic enhancer. We have elsewhere termed research based on such enhancers "simpiricism," a portmanteau word combining "simulation" and "empiricism" (see Frischer 2016–17:71–73).

A final piece of the background to this paper concerns Virtual Heritage (VH), a new field whose experts typically start by digitizing the 3D cultural heritage object of interest, digitally restoring it, and, finally, putting it back into its ancient context, which must also generally be reconstructed digitally. Next, the digitized replica of the object set in its original built context becomes the subject of experimentation and the site where experiences and behavior of the past can be observed (see https://informatics.indiana.edu/programs/phd-informatics/virtual-heritage.html). If we want to take a VH approach to the vanished city of ancient Rome in the spirit of the methodological program we have been sketching, before we can use digital means to visualize our object of study and try to see something new in it, we must first recreate it by means of one of Humphreys's epistemic enhancers. In our case, this means digital urban models. Like the city itself and its parts, the models will have to incorporate the three spatial dimensions and, of course, represent it in its ancient, not modern aspect.

This, then, brings us to the final preliminary matter that needs to be treated only briefly here: how did we make the models that are the subject of this paper? Humphreys rightly warns that "[with computer simulations,] there is a danger of a return to *a priori* science" (Humphreys 2004:133). It goes without saying that our simulations can only give valid results to the extent that they are built on a foundation of hard data and do not simply express our own preconceptions or idle fancy. The archaeological data used to create the Rome Reborn mode of the Roman Forum in the year 320 CE are set forth in a technical paper downloadable from the product website at: docs.google.com/document/d/1Se61jZCzeKZ7UpM6g2VyLt5huodzcw7WxaedkUTRxRY/edit. For the present research project, the synchronic model of one moment in time was diachronized by progressively removing major additions to create approximations of how the Forum looked in earlier periods, which are listed here in reverse chronological order starting from the base model of 320 CE:

- Model of ca. 320 CE: after the additions of the Diocletianic Rostra, the seven honorary columns and the so-called Column of Phocas (for the date, see Verduchi 1993:307), the five honorary columns on the Augustan Rostra, and abutting that rostra the Rostra Vandalica (on whose dating to the late third century CE, see Liverani 2007:182)
- Model of ca. 270 CE: after the death of Septimius Severus (211 CE) and before the construction of the Rostra Vandalica and Diocletianic Rostra
- Model of ca. 190 CE: after the death of Augustus (14 CE) and before the addition of the Arch of Septimius Severus (on which see Brilliant 1967) and the Severan phase of the Umbilicus Urbis (Coarelli 1999b; Verduchi 1982–84)
- Model of ca. 28 BCE: after the addition of the Temple of the Divine Julius Caesar and the completion of the Curia Iulia the previous year

Methodology

A viewshed, or isovist, is a calculation that estimates the area within an environment that is visible (or not) from a specific location in space. The appeal of viewsheds for archaeology lies in their ability to visualize a landscape from the point of view of those individuals who perceived, interacted with, and moved through it in the past (Turner et al. 2001, Wheatley and Gillings 2002). However, "if vision is a deliberate and perpetual act, rather than an environmental side effect," then a viewshed might be analyzed in a way that new archaeological information might be uncovered. In particular, one might ask not just what can be seen from a point in space (visibility or intervisibility), but why a particular viewpoint might be useful or why a landscape or structure may have been constructed (Opitz 2017). As discussed by Barrett (2006) and Llobera (2012), viewsheds become part of an *archaeology of potentials*, that is, a means of investigating past actions through the material conditions and models of a site.

Viewsheds are usually created in GIS software, primarily using digital elevation models (DEMs) or triangulated irregular networks (TINs). However, these models of the landscape are deficient because raster and vector data can only store a single z-value (elevation) for each x–y point location (Paliou 2018). Thus, these models are not ideal for displaying vertical features, such as walls, caves, and architectural details, which might contain thousands or even millions of z-points depending on the spatial resolution of the data. Critically, this single-point representation of elevation data in DEMs and TINs can result in a block-like or coarse representation of a feature that obscures important aesthetic details that occur on the same vertical plane. As such, these models are not true 3D representations of a landscape and can be more precisely described as 2.5D models (Richards-Rissetto 2017).

A remedy to this problem is to utilize true 3D imagery and software, which offers more detail and thus a better sense of data sources and human–environment interactions of the past. Environmental Systems Research Institute's (ESRI) CityEngine is a 3D modeling application specializing in the generation of 3D urban environments. Since 2017, the tools for visibility analysis typically found in GIS software such as ESRI's ArcGIS have been included in the CityEngine suite enabling viewsheds to be created in 3D space. To test the capabilities of CityEngine for viewshed generation and analysis, we used the models of the Roman Forum described above (Figure 2.1.). By leveraging the capabilities of CityEngine, we were able to simulate and analyze the visual experience of visiting the Roman Forum that would not otherwise be possible (*sensu* Llobera 2011).

The models of the Roman Forum were built in Autodesk 3D Studio Max (3ds Max) and exported as Object (OBJ) and texture (MTL) files. These were imported into ESRI CityEngine and were georeferenced (UTM Zone 33N) using satellite imagery. From there, viewsheds were created looking out from the Augustan Rostra and the Diocletianic Rostra toward buildings and monuments in the Forum. To replicate the average adult male point of view, we set the camera at a height of 1.6 meters from the ground. We have also experimented with ergonomic tilts of the eyes throughout the viewshed in order to find the optimal viewing position. For reasons to be explained below, the tilt ranged from 0 to 30 degrees.

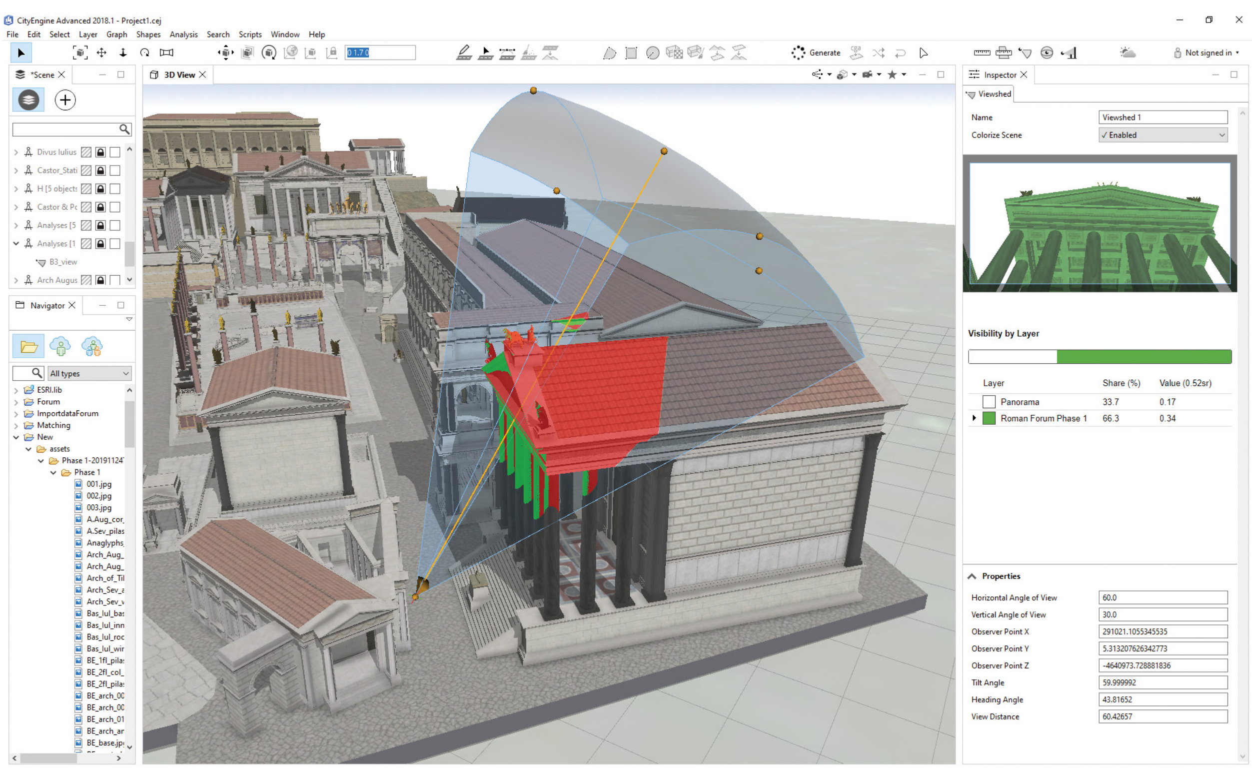

Figure 2.1. Screenshot of 3D viewshed analysis of the Temple of Antoninus and Faustina in CityEngine based on the Rome Reborn model of the Roman Forum. Note that the user can control the position of the camera, its height off the surface, its horizontal and vertical angles of view, and the camera's angle of tilt. The image illustrates that for the viewer of average height standing in an axial–frontal position with back against the wall of the Regia, the view of the façade of the temple was quite limited, and the eyes and head had to be uncomfortably tilted by 60°. In the upper right, the software shows the view as it would have appeared in antiquity.

The Case Studies

With this background in mind, we can now proceed to our case studies set in fourth-century Rome, both of which involve the structures known as rostra in the Roman Forum. The first study concerns the west rostra (the way we will refer to the Augustan Rostra [Verduchi 1999a] with its later annex, the so-called Rostra Vandalica [Liverani 2007]) in relation to the Arch of Septimius Severus (Brilliant 1967), the Basilica Aemilia, the Basilica Julia, the Curia Julia, the Temple of Concordia Augusta (Ferroni 1993), the Temple of Vespasian and Titus, and the Temple of Saturn. The second concerns the east rostra (also known as the Diocletianic Rostra; see Verduchi 1999b) in relation to the Temple of the Divine Julius Caesar, the Temple of Castor and Pollux, and the Arch of Augustus.

In general, the studies presented here can be seen as a continuation, using a new and richer model of the Roman Forum, of a research program that bore its first fruit in Frischer et al. 2006. In that article, the section authored by H. Ziemssen ("Gazing Across the Forum Romanum, Now and in Antiquity" at pp. 175–81) is the most relevant: it treated gazing at the Forum not from the rostra but from the Palatine. Also worth noting here as a precedent for the present study is Favro and Johanson (2010), which uses computer models of the Roman Forum at various periods as a resource for studying viewsheds in relation to Roman funerary processions.

Our focus is on the evolution of the rostra as a building type from its predominant political function during the Republic to its primarily aesthetic function in shaping and intensifying the visitor's experience of the Forum in late antiquity. The *Oxford Latin Dictionary* defines the word *rostra* (plural of *rostrum*) as "the platform from which speakers addressed the people at Rome." The primary occasions on which that happened during the Republic were at meetings of the tribal assembly and at *contiones*, meetings called by magistrates to consult the people but not to pass laws (Mouritsen 2004:18). Numerous testimonia survive from the Republic era of Roman history attesting the use of the rostra—whether the old one before the Curia Hostilia or the new 'west' rostra constructed by Julius Caesar and Augustus—as a speaker's platform. Indeed, for Tacitus (*Dialogus* 36), the rostra became synonymous with the old republican form of government in which the magistrates would "practically spend the entire night" addressing the people in *contiones* from the rostra. It was precisely the virtual disappearance of such speeches—and the form of popular government of which they were an essential part—that is invoked in the *Dialogus* to explain the decline of oratory during the course of the first century CE.

No laws passed by the people are recorded after Nerva (Williamson 2005:427). As the people became less and less involved in political decision-making, the need for the earlier, west rostra to serve its original purpose gradually diminished, even if it never wholly disappeared. During the Principate and Dominate, leaders still occasionally felt the need to address the people. As far as we can tell, this did not happen very often. Hence, the word in the context of a platform used by a leader to give a speech to the people occurs only once in the entire *Historia Augusta* (Maximus and Balbinus III.3), the main historical source for the nearly two-hundred-year period of Roman history on which we are concentrating. In the vast corpus of Roman visual art, we have illustrations of only four instances of emperors addressing the people from rostrated platforms. The first two occur on the so-called Trajanic Anaglyphs, of which one (the *Adlocutio* relief) shows an emperor addressing a crowd of thirteen men in a scene set on the rostrated platform of the Temple of the Divine Julius Caesar, while the other relief shows an emperor seated on the west rostra (Boatwright 1987:182–90). A third scene of imperial oratory from a rostrated platform is found on sestertii of Hadrian (*BMC* 1309–11) probably dating to 126 CE that show him addressing the people from the Temple of the Divine Julius Caesar. We should note that Boatwright (1987:102–104) thinks the occasion was funerary, not political. The fourth example appears on the *Adlocutio* relief on the Arch of Constantine: Constantine's address to the people from one of the rostra in the Roman Forum during his celebration of the victory over Maxentius in 312 CE.

So, while it would be incorrect to state that the rostra entirely lost their original political function during the imperial period, their use for that purpose was comparatively infrequent. This raises the question about why the west rostra was even preserved in the imperial period and, especially, why the east, 'Diocletianic' rostra was added at a relatively late date. As will become clear, we suggest that it was their aesthetic role that came to the fore and kept the rostra useful, even as their political function declined.

That the topic of the aestheticization of the rostra is something that would be useful to delineate is suggested by a trivial *lapsus calami* in the otherwise authoritative new study of Constantius II by Murile Moser. About the visit of that emperor to Rome in April of 357 CE, she writes, "in accordance with the strict protocol of Rome, Constantius' *adventus* led straight to the Forum Romanum . . . . Once in the heart of Rome, he addressed the people *from the rostra* [our emphasis] in the Forum Romanum and staged splendid games of horse-racing in the Circus Maximus" (Moser 2018:288–89). Moser cites our primary source for the visit of Constantius II, Ammianus Marcellinus 16.10.13, which we shall discuss presently. At the moment, suffice it to say that what drew our attention to this passage was precisely the fact that it tells us that the emperor did *not* address the people from the rostra. He went there for a different purpose, led by his guides, the senators of Rome. But Moser's mistake is interesting and certainly forgivable: it reveals the image of the rostra as speakers' platform implanted in the minds of even experts on late-antique Rome.

Our thesis is that by late antiquity, the two purposes the rostra always served—the political and aesthetic—had shifted markedly toward the aesthetic. Originally conceived primarily as a platform amplifying the visibility and audibility of a speaker addressing the people in the Forum plaza below, this political purpose diminished by the late imperial period when it was now mainly used to serve the aesthetic function of gazing by visitors to the Forum.

We note that there is no detailed treatment about who these visitors were and in what number they came to Rome (Mooney 1920 and Casson 1974 disappoint by not dealing specifically with this matter). Random evidence has been collected about provincials and foreign diplomats visiting Rome in various periods (Friedländer 1913:11–17), foreign writers visiting Rome (Baldson 1979:193–213), and Christians stopping in Rome during pilgrimages in the late-antique period (Elsner 2000). Pausanias is known to have visited Rome, where, like Constantius II years later, he was most impressed by the Roman Forum (10.5.11) and the Forum of Trajan (5.12.6)—though, perhaps damning Rome with faint praise, what he found most noteworthy about both places was the abundance of bronze roofs! Our working assumption is that Baldson (1969:242) was on the right track when he wrote that "apart from foreigners who settled in the city, Rome was probably visited by more tourists than any other city in the world." Of course, no ancient statistics on tourism survive, so it is risky to try, as Baldson does here, to quantify tourism to ancient Rome and other cities around the empire. For our purposes, it suffices to claim that the Roman Forum was one of the places that both Romans from Rome and tourists to the city would have been likely to visit in late antiquity.

Today, depending on how much time we have available, we visit the Roman Forum in one of three ways: (1) gazing at it from the Via del Campidoglio over the Porticus Deorum Consentium (called "a good *SURVEY OF THE FORUM" by Baedeker [1904:253], or what we below call the "best general view"); (2) walking around at plaza level from one monument to another; (3) a combination of (1) and (2).

As can be seen using the Rome Reborn model (Figure 2.2.), the view from the Via del Campidoglio did not exist in antiquity: from this vantage point, the superstructures of the Temple of the Divine Vespasian and Temple of Saturn blocked the vista. Similarly, today's spectacular view from the Gallery of the Tabularium in the Palazzo Senatorio was blocked in antiquity by the temples of Vespasian and Concordia. The ancient visitor could have best experienced the quick tour by gazing from the rostra. Then, if time permitted, the tour could have continued by walking from one monument to the next in a circuit around the Forum. For those who lacked the time, the gaze view could have sufficed, whether from one rostra (as may well have been the case with the Emperor Constantius II; see below) or from both.

In the Forum, rostra gazing worked in two directions: *toward* and *from*. By the early fourth century CE, the rostra attracted the gaze of visitors standing on or along the Forum plaza: their eyes were drawn toward the prestige monuments arrayed atop the rostra (Figures 2.3. and 2.4.). For those visitors standing on the rostra themselves, the structures facilitated scanning the structures and monuments along the margins of the Forum plaza. Liverani (2007:175) touched on the function of the rostra to support statues and columns that attracted visitors' gaze. In this case study, we will concentrate on the equally important

Figure 2.2. View toward the central plaza of the Roman Forum from the position of today's best general view on the Via del Campidoglio above the ancient Porticus Deorum Consentium. In antiquity, the view of the Forum plaza would have been largely blocked by the temples of Vespasian (left) and Saturn (right). *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.3. West rostra seen from the central plaza of the Roman Forum. Camera is set at 1.6 m off the pavement, angle of horizontal view is 120°, camera (=eye) tilt is 0°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.4. East rostra seen from the central plaza of the Roman Forum. Camera is set at 1.6 m off the pavement, angle of horizontal view is 120°, camera (=eye) tilt is 0°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.5. View of the façade of the Curia Julia (arrow) from the west rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 0°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Table 2.1. Optimal viewing positions on the west rostra. *N.B.* Positions were studied in front of each column. Reported on the table for each feature of interest is the best general view, which we define as the least distance with eye tilt <30o. The columns are numbered from south (column 1) to north (column 6).

Feature of interest	Eye tilt (degrees)	Distance (m)	Viewing position	See Figure
Basilica Aemilia	10	104.5	E side column 4	2.12
Basilica Julia	15	50	E side column 6	2.13
Curia Julia	10	59.67	E side column 2	2.5
Temple of Concordia	27	47.5	W side column 1	2.10
Temple of Saturn	28	38.25	W side column 4	2.11
Temple of Vespasian	18	57.3	W side column 5	2.6

and hitherto unremarked function of rostra to serve as observation platforms in the Forum. That function was present from the start: when Caesar rebuilt the Curia and the rostra, he sited the rostra such that it intersected an extension of the axis of the Curia. Hence, from the time it was built, the west rostra offered the best general view of an important building to which it was tightly related by date and patron: the Curia Julia (Table 2.1.; Figure 2.5.).

Ammianus Marcellinus provides the best surviving piece of ancient evidence attesting the idea that the rostra were used as vantage points from which to view the features of the Roman Forum. We know that Emperor Constantius II visited Rome for the first time in his life in 357 CE (on his career, see Moser 2018, Stevenson 2019). Symmachus informs us that the senators took him on the tour of the city (*Rel.* 3.8: ...*per omnes vias aeternae urbis laetum secutus senatum vidit placido ore delubra*....). In a well-known passage (for the secondary literature, see Moser 2018:312n40), the historian Ammianus Marcellinus recounts the stops on the tour. Here is the section that is relevant for our purposes:

> Proinde Romam ingressus imperii virtutumque omnium larem, cum venisset ad rostra, perspectissimum priscae potentiae forum, obstipuit perque omne latus quo se oculi contulissent miraculorum densitate praestrictus, adlocutus nobilitatem in curia populumque e tribunal in palatium receptus favore multiplici . . . .
>
> ["So then [the emperor] entered Rome . . . and when he had come to the rostra, the most renowned forum of ancient power, he was awestruck, and on every side on which his eyes rested he was dazzled by the crowding together of marvelous sights. Having spoken to the nobility in the Curia Julia and to the people from the Tribunal and after being welcomed to the palace with various kinds of enthusiastic support . . . ." (Ammianus Marcellinus 16.10.13)]

So, from Ammianus's account we learn that during his visit to the Forum, the first thing Constantius II did was to mount the rostra, which could be either the west or east rostra (for the hypothesis that the rostra mounted by Constantius was the Diocletianic Rostra, see Liverani 2007:177, 186; and see below for the alternative view). Whichever rostra was intended, Constantius was *not* there to give a speech. Ammianus tells us that Constantius II did give two orations while stopping in the Forum, but he did so elsewhere: in the Curia Julia to the Senate, and to the people at the Tribunal Praetoris on the Forum plaza (on the Tribunal, see Verducchi 1999c; Liverani 2007:176).

Constantius II stood on the rostra in order to get his first view of the many buildings and monuments in and around the Forum. He was awestruck "and on every side on which his eyes rested he was dazzled by the crowding together of marvelous sights." Ammianus continues his description of Constantius's visit for many more lines, telling us that the emperor was impressed by other sights in the city such as the Forum of Trajan. But he never again mentions where on his tour of the city Constantius had to stand to see the monument he was visiting. This happens only in the Roman Forum, and it is interesting to ponder why in the fourth century a visitor to the Forum would have immediately mounted one of the rostra to survey the scene. It is also interesting to ask what about the Forum the emperor found so impressive. These are questions that as far as we can tell from a review of the literature have not been raised in interpretations of the passage in Ammianus Marcellinus.

The passage in Ammianus Marcellinus came to mind only after the first author had taken many virtual visits to the Roman Forum using the Rome Reborn model and, especially, after he had worked with the technicians of Flyover Zone Productions to prepare the application presenting the Forum to the general public. What the production team discovered in trying to find the best general view of a certain monument to offer the user of the application is that this was sometimes unexpectedly blocked. 'Best general view' is a term of art in photography (for example, Raymond in Goin et al. 1992:33) and travel writing (for example, Baedeker 1897:277, 400). Impeding the best general view were two factors: the *densitas*, mentioned by Ammianus, which impacted the X and Y spatial coordinates, and the height of the structures, which relates to the Z dimension and affects the tilt of the viewer's eyes in trying to take in a scene. At least, this was the case if by 'best general view' we mean one that is axial and frontal with respect to the feature of interest. That this is the canonical viewpoint that Roman designers strove to provide visitors in creating public monuments and spaces has been long recognized by modern scholars (for literature, see Frischer et al. 2017:27n24). For examples close to hand, one need only recall the imperial fora, all of which provide unobstructed frontal–axial views of the main feature dominating their plazas (the Temple of Venus Genetrix in the Forum of Caesar, the Temple of Mars Ultor in the Forum of Augustus, and so on).

That the concept of a 'best general view' is not simply reflective of modern prejudice is suggested by the ancient evidence offered by coins of the Roman era illustrating the famous buildings and monuments of Rome and other cities around the empire. As the study by Brown (1940:20) of the representation of temples on Roman coins shows, the frontal and axial view is the only one found, frequently with the doors to the cella open to reveal the cult statue (for Rome, see Hill 1989:9–39; for cities around the empire, Price and Trell 1977:*passim*). Brown identifies four variants or "methods": Method 1, called the "full-front 'simple' type;" Method 2, called the "full-front 'ornate' type;" Method 3, called "the 'vista' type where perspective is used;" and Method 4, called "the 'background' type." In all four methods, the temple is seen frontally and axially. When it comes to the late-antique Roman Forum, however, if you try to see a building from such a spot and do so with your eyes tilted in the comfort zone of 0°–30° upward or downward (the lower the degree of tilt, the more comfortable), there are instances when you find that it is not possible to do so. The reason is that by the year shown in the model (320 CE), comfortable views had been entirely or largely blocked.

It should be noted that the cited 'comfort' range of 0°-30° reflects standard EG 18:1994 of the Society of Motion Picture and Television Engineers (SMPTE), which recommended that screens be positioned in a theater so as to require a 15° tilt of the viewer's eyes and not exceed an angle of 35°, which begins to cause discomfort.[1] The SMPTE recommendation is consistent with Cousin (1980), which defines comfortable viewing as 14 degrees above the horizontal. Meanwhile, Higuchi (1983:40: Figure 4.4) illustrates the maximum tilt of the eye as 25 degrees above the horizontal, meaning that taking in a view that exceeded 25 degrees off the horizontal requires movement of the head (see also Letesson and Vansteenhuyse 2006:93). We infer from these studies that, when, as in the present case, looking below the horizontal is not an issue, the best general view should require an eye tilt in the comfort zone of 0°–15° and in no case exceed 30°. In this regard, we note that Maertens (1890:5) already observed that "for the elementary, favorable overall impression of a structure, almost only the angle of the eyes is decisive" (our translation; for a sympathetic treatment of Maertens' theories, see Moravanszky (2012); for his enduring influence, see Colonnese 2017).

Hence, in making our application we sometimes had to resort to placing the user well off the ground, in a position impossible for a Roman to enjoy, in order to provide the best general view. The extreme example of this is provided by the Temple of Antoninus and Faustina. Despite the fact that its roof is decorated with acroterial sculpture that must have been intended to be seen and appreciated (Lugli 1947:129–30), its frontal–axial view (at least with the eyes tilted with an angle of 25° or less) is blocked by the Regia across the street; if you wanted to view it that way, you had to tilt your head 60°; otherwise, the only frontal and axial view of the acroterial sculpture was from a position in front

Figure 2.6. View of the façade of the Temple of Vespasian and Titus (arrow) from the west rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 18°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

of the shrine of Vesta, but even there the Regia blocked the view of the lower half of the temple's façade. To view the entire façade of the Temple of Antoninus and Faustina in the comfort zone, the visitor had to look from an oblique angle of 70°, whether to the east or to the west (see Figure 2.1.). For purposes of understanding Ammianus Marcellinus' account, this example is, to be sure, not relevant because the temple was not situated around the Forum plaza and hence was not one of the monuments that could be seen by Constantius II from a rostra.

An earlier, less extreme case is the Temple of the Divine Vespasian and Titus (De Angeli 1999), whose perfectly axial–frontal view was, from the start, blocked by the staircase and pronaos of the Temple of Saturn (Coarelli 1999a). An alternative 'second-best' view would have been that provided a visitor standing on the west rostra and looking at the temple from an oblique angle of 21° (see Table 2.1. for details, Figure 2.6.).

The two temples dedicated to deified emperors show that the Roman Forum represented the most desirable location in the city for such a cult sanctuary, even if the vacant ground available required that the view of the façade be less than ideal. With the passage of time, people must have become used to mounting the west rostra to gain an oblique view. This oblique viewing—perhaps at first felt to be a compromise—became a new principle of design for the Forum by late antiquity.

The Temple of Concordia *(Aedes Concordiae Augustae)* presents the first example in this period. After the construction of the Arch of Septimius Severus in 203 CE, it was no longer visible from its originally intended frontal–axial position but could have been seen by Constantius II or any other visitor to the Forum by going atop the west rostra (a point not made in Brilliant 1967:85–90 nor Lusnia 2014:82–83, both devoted to analyses of the topography of the arch).

The Temple of Concordia is located at the west end of the Forum. The building went through various phases (Ferroni 1993, and to the bibliography cited there add these later works: Bravi 1998, 2014:185–201, Celani 1998:125–32, 209–13, Stähli 2003), of which the most important for present purposes is the Tiberian, when it was rebuilt as what has been aptly called a "temple–museum" (Ferroni 1993:319; see, especially, Kellum 1990 and see, in general, Casson 1974:248–5, Rutledge 2012). Inside, the temple

Figure 2.7. Frontal–axial view in Sketchfab of the Temple of Concordia (arrow) prior to construction of the Arch of Septimius Severus. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

housed an impressive collection of Greek sculpture and painting. To judge from the numismatic evidence, the façade was adorned with at least eleven colossal ideal sculptures and also a sculpted pedimental group (Hill 1978, Gasparri 1979:19–22, Zanker 1988:111, Gorski and Packer 2015:178 and see 177, fig. 9.7 for a Tiberian sestertius illustrating the pedimental sculpture).

As is illustrated in Figure 2.7., an unobstructed frontal and axial view of the façade and its sculpture was possible for almost two centuries until the Arch of Septimius Severus was built. The best general view, with eyes tilted 15º, was 80 meters from the front columns of the pronaos. It is clear from Tiberius's coins illustrating the façade (Hill 1989:18–19) that, with the exception of Jupiter Capitolinus (Hill 1989:25), its display of sculpture on the façade was one of the features most distinguishing this temple from every other at Rome. Presumably, the façade was meant to be seen and appreciated, and for this an unobstructed view as axial and frontal as possible was required.

When the Arch of Septimius Severus was constructed, it stood athwart the previous axial–frontal sightline of the Temple of Concordia, thereby all but blocking the old view of the temple and its façade (Figure 2.8.). To be sure, the ancient visitor could still have an axial–frontal view by standing with their back against the arch on its west side, but the vantage point was so close to the temple that the angle of tilt of the head was an uncomfortable 45º, and the view of the sculpture on the building (especially the acroterial statues) would have been greatly foreshortened and hard to read (Figure 2.9.). Moreover, as Maertens (1890:6) notes, at this angle "the observer's eye has to refrain from overlooking the whole" (our translation).

A solution or at least mitigation for this problem of viewing the Temple of Concordia Augusta was to hand: using the Rostra Augusta as a viewing platform, providing a comfortable, if oblique, view (see Table 2.1., Figure 2.10.). In compensation, the new viewing position had one advantage over the old: because of the height of the floor of the rostra (3.75 m), the new position could be closer to the façade of the temple: the distance to the façade from the rostra now was 47 meters with eyes tilted 27º, as compared to the 80 meters previously noted. Hence, the visibility of the façade and its decorative sculpture was improved, even though the angle of view was now oblique.

Figure 2.8. Frontal–axial view of the Temple of Concordia after construction of the Arch of Septimius Severus. Seen from the same position as seen in Figure 2.7, the façade of the temple is almost completely blocked by the arch. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

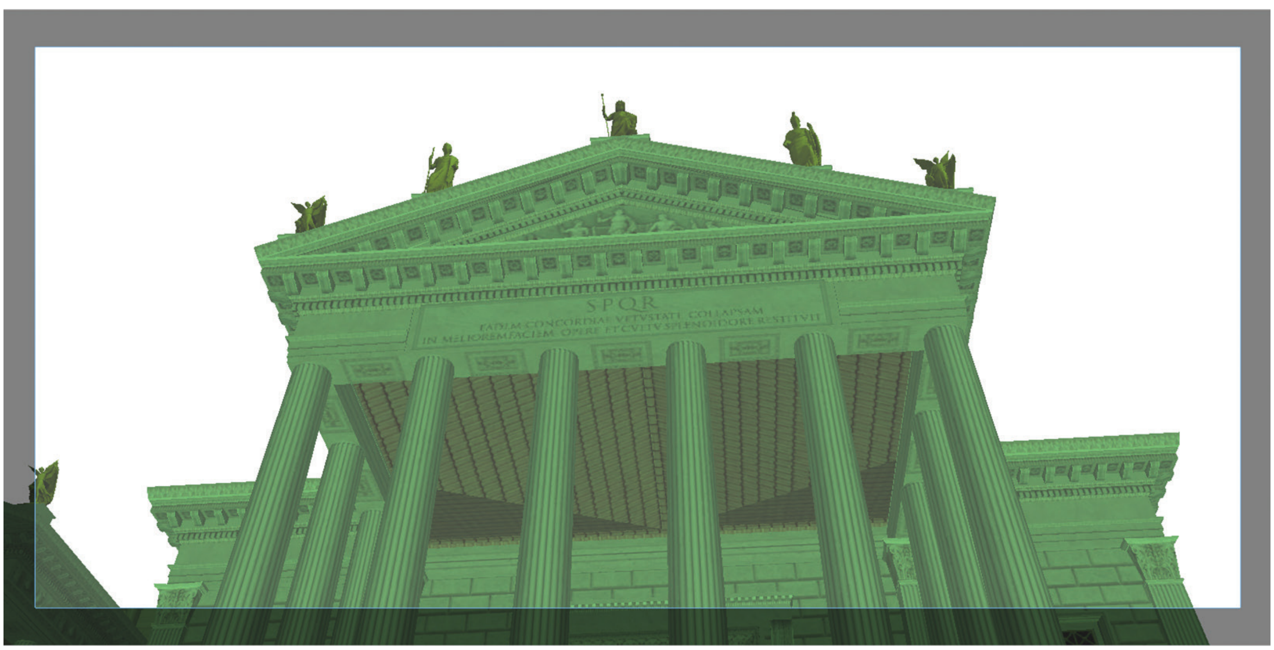

Figure 2.9. View of the Temple of Concordia after construction of the Arch of Septimius Severus as seen by someone standing on axis with the façade with back against the arch. The head and eyes must be tilted 45°, resulting in a partial view of the façade with foreshortening of the pedimental sculpture. *Image rendered in CityEngine from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.10. View of the Temple of Concordia (arrow) after construction of the Arch of Septimius Severus as seen by someone standing on the west rostra. Camera is set at 1.6 meters off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 27°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.11. View of the Temple of Saturn (arrow) as seen by someone standing on the west rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 28°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.12. View of the Basilica Aemilia (arrow) as seen by someone standing on the west rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 10°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.13. View of the Basilica Julia (arrow) as seen by someone standing on the west rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 15°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Once the west rostra started to be used to view the Temple of Concordia Augusta as well as the Temple of the Divine Vespasian and Titus, the oblique view must have become more acceptable. Such a viewpoint had an important precedent: the great Greek temple complexes of the pre-Hellenistic age. Examples include the Temple of Aphaia at Aegina, the Temple of Apollo at Delphi, the Temple of Zeus at Olympia, and the Parthenon in Athens. "The oblique view revealing the three-dimensionality of the building is stressed" (Stillwell 1954:8). The axial–frontal view is something that we assume the Romans adopted from Hellenistic precedents (Delbrueck 1912:124–25). Once habituated in late antiquity to the oblique view, it was a small step to effect an economy of time and physical exertion by seeing other monuments around the margins of the Forum from the vantage point of the west rostra. For example, although the axial–frontal view of the Temple of Saturn continued to exist into late antiquity, that temple, too, could be viewed from the west rostra (Table 2.1., Figure 2.11.) as could the two basilicas flanking the long sides of the Forum plaza (Table 2.1., Figures 2.12. and 2.13.).

Let us now turn our attention to the east rostra and consider its impact on the best general view of the structures best seen while standing on it. The first of these is the Temple of the Divine Julius Caesar (Gros 1996). Prior to the construction of the rostra at an indeterminate time in the late third century CE, the ideal vantage point for seeing the façade of the temple with eyes tilted 15° was 46.3 meters from the columns of the pronaos (Figure 2.14.). Once the rostra was built, the viewer could gaze at the façade from a higher vantage point (ca. 3.75 meters above the level of the Forum plaza), and so now the distance for the best general view could be reduced with attendant enhancement of visibility (Figure 2.15.).

Other structures could also be seen by the visitor atop the east rostra. These include the Temple of Castor and Pollux and the Arch of Augustus (see Table 2.2., Figures 2.16. and 2.17.). As compared to the views possible on the west rostra, those of the Basilica Aemilia and Basilica Julia were worse (in the case of the Aemilia, far worse). In compensation, the tetrarchic Seven Honorary Columns and the Column of Phocas (Figure 2.18.) are seen to excellent advantage from

Figure 2.14. View of the Temple of the Divine Julius Caesar (arrow) as seen by someone standing on the Forum plaza prior to the construction of the east rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 20°.
Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.

Figure 2.15. View of the Temple of the Divine Julius Caesar (arrow) as seen by someone standing on the east rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 20°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.16. View of the Arch of Augustus (arrow) as seen by someone standing on the east rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 1°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Figure 2.17. View of the Temple of Castor and Pollux (arrow) as seen by someone standing on the east rostra. Camera is set at 1.6 m off the floor of the rostra, angle of horizontal view is 120°, camera (=eye) tilt is 26°. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Table 2.2. Optimal viewing positions on the east rostra. *N.B.* Positions were studied in front of each column. Reported on the table for each feature of interest is the best general view, which we define as the least distance with eye tilt <30o. The columns are numbered from south (column 1) to north (column 6).

Feature of interest	Eye tilt (degrees)	Distance (m)	Viewing position	See Figure
Arch of Augustus	01	41.36	E side column 5	2.16
Temple of Castor & Pollux	26	38	E side column 4	2.17
Temple of Julius Caesar	20	30.8	E side column 3	2.15

the east rostra, which, perhaps not coincidentally, dates to the same phase of the Forum's development. It should be noted that the views of these columns from the west rostra are also good.

The reason that the senators taking Constantius II on his tour of Rome started on one of the rostra in the Forum should now be clear: it was an efficient and effective way to see the greatest number of monuments in the least amount of time. We should recall here that time was at a premium; Ammianus Marcellinus gives the impression that Constantius II visited all the must-see sights of Rome in a single day. Modern scholars, like the first author, who regularly take students to the Roman Forum know that a detailed tour moving from monument to monument takes several hours—time Constantius' senator–guides did not have. Using the measuring tool of Google Maps produces some approximate comparative data: a tour of the Forum from the west rostra limited to gazing requires the viewer to walk only about 23 meters. Adding a second stop at the east rostra (and counting the space between the two rostra) brings the total to ca. 205 meters. In contrast, going on foot from one major monument to another (the two basilicas and the temples of Saturn, Vespasian, Concordia, Julius Caesar, and Castor and Pollux) requires covering around 395 meters.

Assuming Constantius II was taken to just one rostra, we agree with De Jonge (1972:123) that Ammianus probably refers to the west rostra, not the east, because more monuments are optimally visible from it and also because the other two venues mentioned by Ammianus that the emperor visited—the Curia Julia and the Tribunal—are in the immediate area of the west rostra.

The second feature of the passage in Ammianus Marcellinus that we can now address is why the view from the rostra would have made even as sophisticated and well-traveled a visitor as the emperor react with amazement (*obstipuit*).

Of course, there are innumerable personal factors that might have been responsible for this reaction, but, speaking generally, there are several reasons that we may adduce. Research in the field of environmental psychology has shown that the built and natural environment can have a strong negative or positive impact on human beings, affecting their behavior, beliefs, and emotions (see Adams 2014, Coburn, et al. 2017, Joye 2007). Here, space permits only a rapid review of the research that can help to explain Constantius's strongly positive reaction to viewing the Roman Forum from the rostra.

An initial foothold is provided by Ulrich (1983), which argued that the affective reaction to a view results not from a conscious process of cognition but from an automatic affective response based on the dichotomy like/dislike. The concept of prospect developed by Appleton (1975) suggests that the view from the rostra would be liked because an elevated view, such as that afforded by the rostra, is one of the two positions most preferred by human beings. Scannell and Gifford (2017) show that strong attachment to a place has a beneficial impact on wellbeing and that attachment is most easily developed in places like the Roman Forum with high cultural and aesthetic value. Lewicka et al. (2019) suggests among other things that rich historical associations intensify the human meaning of a place and, when experienced, are likely to trigger positive emotions.

In terms of the content of what Constantius saw and where he was situated in the city, the concept of imageability in Lynch (1960) offers some insight. This influential twentieth-century book on urban planning was written in the same tradition of environmental psychology as Maertens (1890) and Arnheim (1969) (see Colonnese 2017:68). Lynch argued that the ability of a typical urban element such as a node, landmark, edge, path, or district to cause delight (1960:44, 109) or some other positive emotion is a function of its "imageability," or "that quality in a physical object which gives it a high probability of evoking a strong image in any given observer . . . . It might also be called legibility, or perhaps visibility in a heightened sense, where objects are not only able to be seen, but are presented sharply and intensely to the senses" (Lynch 1960:9–10). Lynch does not analyze the Roman Forum, so we must apply his approach ourselves to gauge whether or not the Forum had strong imageability. As has been shown, the rostra afforded excellent visibility of the principal monuments around the Forum plaza. Moreover, two other characteristics of the Forum could be invoked to help us understand Constantius's reaction. The Forum was potentially an impactful place, since in Lynch's terms it was a node filled with many landmarks. Nodes per se are "conceptual anchor points" (Lynch 1960:102) in a city. They are defined as "the strategic foci into which the observer can enter, typically either junctions of paths, or concentrations of some characteristic. But although conceptually they are small points in the city image, they may in reality be large squares" (Lynch 1960:72). Thus, in the American cities studied by Lynch, it was precisely the town squares such as Boston Common (21) and Pershing Square in Los Angeles (36) that had the greatest "image strength." Landmarks also possess "image strength" to the degree that they have associations, which, as in the case of the Roman Forum, can be historic as well as purely visual (such as brightness, height, vastness, and so on; see Lynch 1960:101). Here we might note that, even in its modern ruined condition, it was precisely the Forum's historical associations (one of them—the assassination of Julius Caesar—mistaken) that Edward Gibbon found emotionally overwhelming when he made his first visit on October 2, 1764: "I can neither forget nor express the strong emotions which agitated my mind as I first approached and entered the eternal city. After a sleepless night I trod with lofty step the ruins of the Forum; each memorable spot where Romulus stood, or Tully spoke, or Caesar fell was at once present to my eye" (Gibbon 1966:134). For the late-antique visitor such historical associations would have been far more numerous and far more easily brought to mind, since the place still existed intact and was filled with inscriptions, portrait statues, and monuments marking important events in Roman history.

According to Lynch, a rare nodal space filled with landmarks like the Roman Forum, then, has the potential to have especially high imageability. The example of this that Lynch presents is the Piazza San Marco in Venice, which is both nodal and filled with "many distinctive landmarks" (78). We know from Ammianus Marcellinus's description that the moment when Constantius gave voice to his amazement was precisely when he stood on the rostra: the elevated position with excellent sightlines of the principal landmarks actualized the Forum's potential as a landmark-filled node. In this sense, a 'gaze tour' of the late-antique Roman Forum from the rostra would have had higher imageability than did a walking tour. The latter would have been less impactful because of decomposition of the holistic experience of the Forum as viewed from a rostra into its individual components, each viewed in isolation and after the passage of time required to walk from one point of interest to the next. In contrast, the gaze tour from the rostra concentrated time and space, exciting the senses and overwhelming the mind with sights, memories, and associations.

The fact that the scene could be perceived by the emperor while looking forward from the rostra with eye tilt, on average, in the range of 10°–20° meant that the overall effect was what Maertens characterized as "painterly" and hence in itself delightfully engaging (Maertens 1890:6–7).

Contemporary studies in the discipline of environmental psychology can add a few more details that help us to understand Constantius's reaction. Keltner and Haidt (2003) and Joye and Dewitte (2016:113) stress the close relationship between the experience of vastness and the resulting feeling of awe. As the latter put it, "vastness is the main (physical) elicitor of awe." This brings to mind Ammianus's words, "miraculorum densitate" ("the array of marvelous sights," as translator John Rolfe renders the phrase): it was not simply the beauty and monumentality of the monuments seen in the Forum but their variety, number, and historical associations that made an awesome impression upon Constantius II.

Another factor in Constantius's reaction is the effect of the tetrarchic columnar program, which included the columns added to the west and new east rostra as well as the seven honorary columns in front of the Basilica Julia (Figure 2.18.) along with (almost surely) the so-called 'Column of

Figure 2.18. Seven Honorary Columns (red arrow on middle column) and Column of Phocas (yellow arrow on front right column) seen from the east rostra. *Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions. All rights reserved.*

Phocas' (on the dates, see Giuliani and Verduchi 1987:vol. 1, 167, 176; for a later date, but no later than the reign of Constantius II, see Kalas 2015: location 1360). With the addition of the columnar program in the tetrarchic period, the space was given a certain uniformity and rhythm that it had previously lacked: one doubts that, had he visited in this period, Pausanias would have focused primarily on those bronze roofs. Equally important, the columnar screen crowned by statues of leaders and, on the rostra, the gods Jupiter and Hercules had a natural tendency to lift the visitor's gaze upwards. Zhang et al. (2014) concluded that a scene inducing observers to gaze upward engendered emotions of pleasure and exhilaration.

Image strength, the concentrated impact of gazing at a scene filled with such a variety of buildings and monuments rich in historical associations, and the natural upward direction of the view toward the sculpture crowning the columnar screen all contribute to an environmental psychological explanation of Constantius's response to viewing the Forum from the rostra. He will not have been the only one to be so moved and touched by the impressive scene, just as Gibbon is not the only modern to have reacted with equal passion to the Forum's ruins in his day. The reactions of awe and admiration felt by the emperor and later by Gibbon bring to mind Stendhal's famous account of his visit to Santa Croce in Florence:

> I was already put into a kind of ecstasy by the idea of being in Florence and by proximity to the great men whose tombs I had just seen. Absorbed in the contemplation of sublime beauty, I saw it up close, I touched it, so to speak. I had reached that emotional point where the heavenly sensations aroused by the fine arts and the feelings of passion meet. Coming out of Santa Croce, I had heart palpitations, or what in Berlin they call 'nerves.' Life was drained from me. I walked with a fear of falling. (Stendhal 1826:102)

In extreme cases, tourists are known even to faint or have full-fledged nervous breakdowns when viewing well-known works of art and architecture for the first time whether in Florence or elsewhere. Psychologists have aptly labeled such reactions the 'Stendhal syndrome' (see Magherini [1995] on cases in Florence, and for a number of examples from other times and places, see Bamforth [2010]).

To summarize, our two case studies of the rostra in the Roman Forum show how a city model such as Rome Reborn can support new scholarship by making it possible to re-experience a nearly vanished space such as the Roman Forum, to move around it at normal eye level, and to notice features that—as the long record of scholarship on the Forum attests—would never occur to anyone absent this new tool of discovery. It can also bring to life the ancient historical records, as we were able to do with Ammianus's account of the detail about how Constantius II started his Forum tour by mounting the rostra, a detail which, as far as we know, no previous scholar had tried to explain.

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Notes

1 Because of advances in theater design, the document was withdrawn in 2003, but the Society's abstract states that "the effective cine theater is a place in which everyone can see and hear well. The summary lists the architectural parameters, which must be addressed by the designers and the criteria recommended here." Since we find no other guideline from the Society about vertical viewing angle, we consider the 1994 guideline regarding eye tilt as still valid for purposes of this study. See https://ieeexplore.ieee.org/ document/7513358. The guideline is widely referenced; in particular the finding that viewing angles greater than 35° cause discomfort is cited at p. 10 of the guidelines for the operation of motion picture theatres published by Lucasfilm Ltd. through its THX Theatre Alignment Program; see www.film-tech.com/warehouse/manuals/ TAPGUIDELINES. pdf.

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CHAPTER 3

Digital Archaeology and Storytelling as a Toolkit for Community-Engaged Archaeology

Rebecca E. Bria and Erick Casanova Vasquez

Introduction

Scholars have recently described archaeological heritage as having the capacity to "enchant" (Perry 2019, *sensu* Bennett 2001) and transform those who meaningfully engage with it, and they point to digital technologies as powerful mediators in connecting people and pasts (Perry 2019, Shanks 2012, Sterling 2020). Indeed, digital techniques like 3D modeling, which allow us to see the tangible world translated into a virtual one, can capture our attention and spark our imagination in unexpected ways, providing opportunities for contemplation and wonder. Photogrammetric models, which are 3D objects created from photographs, have become a particularly useful digital medium for engaging community stakeholders (for example, Haukaas and Hodgetts 2016, Miles et al. 2016, Rua and Alvito 2011, Sanders 2014), as many scholars have already widely adopted the technique to collect, analyze, and share archaeological data (for example, Chibunichev et al. 2018, Magnani et al. 2020, Sapirstein 2018). But is the "enchantment" of photogrammetric models diminished by knowing how to make and use them? We suggest it is precisely this demystifying act of converting one's reality into 3D data—for instance, transforming hillsides walked or artifacts held into digital objects on a computer screen—that can heighten public engagement in and care for archaeological heritage (see also Garstki 2017). More importantly, we argue that archaeologist–community research partnerships that incorporate sophisticated digital tools like drones and 3D-modeling software into their collaborative research can work to decolonize archaeology's scientific process when those digital tools are placed in the hands of descendant communities (see also Colwell 2016, Larrain and McCall 2019, Magnani et al. 2018, Nicholas et al. 2011).

Storytelling is a more traditional mechanism for archaeologists and non-experts alike to explore the past and its meaning, but its utility has gained renewed attention in recent decades (for example, Earley-Spadoni 2017, Gauvreau and McLaren 2016, Gibb 2000, González-Tennant 2010, Katifori et al. 2018, Pletinckx et al. 2003, Van Dyke and Bernbeck 2015, Van Helden and Witcher 2019). Stories can transform counted potsherds, measured wall segments, and the "faceless blobs" (Tringham 1991:94) of prehistory into the vibrant things and spaces of feeling, thinking people who lived and died in the places we study. Without stories, even the best outreach initiatives, including some we (the authors) have carried out ourselves, can leave the value of heritage locked within old things found and gazed at. But who gets to tell the story and whose story is it—the archaeologist's story or that of the local stakeholder/descendant? In one sense, we might consider all or at least many archaeological narratives as kinds of storytelling (Pluciennik 1999, Terrell 1990). After all, archaeological data do not 'speak for themselves' but require interpretation. This is not to say that there are no evidentiary constraints on archaeological interpretations, as if to suggest such interpretations are equivalent to fictions. Instead, it is to recognize that archaeologists creatively narrativize their data when moving beyond the site report to describe past lives

Archaeologists will often more explicitly craft archaeological narratives as stories when the intended audience is a stakeholder community, and the many recent examples of archaeology-themed graphic novels attest to the success of this kind of outreach. However, some archaeologists have commented on the problematic nature of such outreach and of academic literature when it is based in western scientific inference at the exclusion of local, native, or indigenous ways of knowing. That is, if all archaeological narratives flow from foreign, urban, or university-trained archaeologists to rural, indigenous, or descendant communities, they run a risk of replicating colonial structures of power and excluding valuable sources of knowledge (Atalay 2012, Bruchac 2014, Colwell 2016, Habu et al. 2008, McAnany and Rowe 2015, Mickel 2021, Nicholas 2014, inter alia). Taking this into account, we are interested in how imagined scenarios featuring fleshed out, agentive characters set in ancient places can not only allow archaeologists "to gain insight into a problem for which there are no obvious sources of data" (Gibb 2015:146) but also to ensure that archaeological knowledge is communicated as stories in social contexts such as the indigenous Americas where storytelling is a fundamental "way of knowing" (Laluk 2017:102, see also Porr and Matthews 2016). We recognize that both academics and stakeholders can be scholars and storytellers of the material past, albeit from distinct ontological frameworks. However, we emphasize that local and descendant stakeholders should be co-creators in the narrative stories told about their ancestors, predecessors, and/or landscapes.

In this chapter we explore how a combination of collaborative photogrammetry and storytelling might lead to new dialogues between archaeologists and community partners, with the particular goal being for local, descendant, indigenous, and/or marginalized communities to explore, generate, and define for themselves the value of heritage remains. Our work centers on collaborations with the Quechua-speaking, agropastoral community of Hualcayán, which is located in a rural setting of highland Ancash, Peru. Archaeological remains at Hualcayán span an exceptionally long period of continuous prehistoric occupation that began around 2400 BC during the rise of Andean complex society and ended with the expansion of the Inka empire around AD 1450. The archaeological site is also quite large, and includes a 150-hectare center of dense temple and domestic architecture surrounded by four square kilometers of terraces, canals, and tombs (Bria 2017, 2021). The families of contemporary Hualcaínos (people from Hualcayán) have lived near the archaeological site for generations, but it was only recently that people moved there and obtained their official status as a new, independent *comunidad campesina*—a legally recognized communal landholding 'peasant community.' As we discuss below, this fairly recent formation of the community combined with the realities of systemic poverty and climate change, among other historical factors, have led many people at Hualcayán to see little connection to or value in their heritage resources (Bria and Cruzado Carranza 2015).

Heritage Preservation in Rural Peru and Hualcayán

Challenges and Opportunities

Many Quechua-speaking farmers high in the Andes mountains of Peru live with generalized precarity in politically, economically, and geographically marginalized communities, and life in Hualcayán is no exception. Families are preoccupied with the many tasks necessary to eke out a modest living through a mixture of subsistence and commercial farming. Adding to their precarity are the effects of climate change, which is drying up glacial water systems, causing unpredictable seasonality (for example, the early or late arrival of the wet and dry seasons), and leading to a variety of other negative effects such as an increase in the overnight frosts that damage crops (Bria and Walter 2019). In this context, heritage preservation is rarely a central, or even secondary concern in places like Hualcayán.

Although the people of Hualcayán are Indigenous Peruvians (who, notably, identify as *campesinos* or peasants, as explained below), they challenge any idyllic or essentialized perception of the quintessential or traditional Andean community (*ayllu*) whereby people live in perfect reciprocity with the land and venerate a shared ancestor or ancestral mountain. The modern Hualcayán community was founded just thirty years ago, when people began building houses near the ruins and putting lands under production by refurbishing the site's ancient canals and terraces (Figure 3.1.). Perhaps because of the shallow historical link to this place, few people view its ancient temples, houses, tombs, and mummies as having any real link to themselves as Indigenous Peruvians. Some villagers view these remains as nuisances, while others view them with indifference; a small faction sees them as a source of income through looting or potential tourism (Bria and Cruzado Carranza 2015).

There are also deeper histories, however, that give context to the disconnect between indigenous communities like Hualcayán and the archaeological remains these farmers encounter in their day-to-day life as they till ancient soils. Much of the indigenous history and heritage of the central Andes was devalued in the process of colonialism, which began with the forced resettlement and religious conversion of native peoples more than five centuries ago. The pro-peasant agrarian reforms of the 1970s provided new opportunities for the indigenous farmer, but these farmers took the opportunity to emphasize a peasant, or *campesino*, identity rather than an Indigenous Andean identity, which had long been identified by the racially derogatory term

Figure 3.1. Ancient terraces under partial cultivation at Hualcayán. At the center of the photograph is a prehistoric man-made waterfall that was refurbished in recent decades and is the only source of irrigation and drinking water for the community. This waterfall, as well as the terraced fields and visible mountain peaks, featured prominently in the children's stories and artwork. *Photograph by Rebecca Bria.*

indio (Herrera 2011, Mayer 2009). Moreover, the nation of Peru has long emphasized its shared mestizo identity over indigenous identities, and the educational curriculum on indigenous prehistory is somewhat limited to the more famous prehistoric cultures and empires, such as the Moche or the Inka. In this context, ancient remains in regions like Ancash, where Hualcayán is located and where lesser-known pre-Hispanic societies like the Recuay thrived, are often viewed as mere curiosities rather than as heritage. Finally, concurrent with agrarian reform came the evangelical movement in Peru, which explicitly rejects many Indigenous beliefs and practices such as offerings to ancestral beings and places called *pagos*, or coca-leaf prognostication rituals; in comparison, these practices are largely unchallenged by the syncretized form of Andean Catholicism. The *evalgelistas*, who now make up nearly half of Quechua-speaking communities, may find less meaning in ancient places or even fear that acts to valorize them could be heresy. The historical events of colonialism and post-colonial reform, along with the politics of education and identity in Peru, have thus contributed to how many contemporary villagers in places like Hualcayán have lessened their interest in the archaeological heritage that exists on their land.

The preservation of archaeological remains is also seen by some Hualcaínos as a hindrance to agricultural production and progress because preservation often requires much of the site's fertile soils to remain untilled. For this reason, many issues surrounding site preservation in Hualcayán today are simply practical: the community's growing population on lands circumscribed by an elevated plateau and steep mountainside is pushing agricultural activities into protected, so-called 'intangible' archaeological zones as a matter of subsistence and survival. Also, as nearby glaciers melt due to climate change, Hualcayán temporarily has more water, which has attracted European agribusinesses who are working with Hualcaínos to abandon native crops like maize and potatoes in favor of near-monocropping organic snow peas and sugar snap peas for export. This change has been positive in some ways, such as by providing a fixed price for each harvest in the face of climatic and economic uncertainty. But it has also reoriented local people's relationship to the land and to each other as families growing export crops are now hiring other community members for a daily wage (Bria and Walter 2019). Conflicts have arisen due to different ideas about what is defined as agricultural land and how agricultural infrastructure is used. Virtually all of this infrastructure is archaeological in origin: prehistoric inhabitants covered the mountainside with stone terraces and canals, including an artificial waterfall that brings water to the site, which Hualcaínos rehabilitated when they founded the community. Many farmers in favor of growing peas for export see ancient terraces and temple structures as obstacles and are removing them in an effort to increase the area of productive land or more easily plow across large areas. But others see a different kind of value in the terraces. They suggest community members should work to preserve the archaeological site in order to attract tourists, at least by preserving the site core.

In the context of Hualcayán's contemporary challenges, we recognize that a cookie-cutter approach to educational outreach will do little to bring value to archaeological ruins in Hualcayán. Nor will a 'preserve-at-all-cost' approach work. In fact, such an approach is likely to endanger local livelihoods. Our archaeological project, the Proyecto de Investigación Arqueológico Regional Ancash (PIARA), has experimented with a variety of approaches and initiatives, from museum exhibits to handcraft enterprises, that co-create opportunities for Hualcaínos to explore their complex relationship with their heritage and define its value in the process (see Bria and Cruzado Carranza 2015). Recently, we are seeking ways to more directly bridge the interests of our community partners—who are farmers—with our skills and specialized knowledge as archaeologists of ancient farming and community organization. Our archaeological research at Hualcayán focuses on many of the same concerns of contemporary villagers, inquiring into how ancient people organized themselves and their labor to share land and resources in the face of different crises and social ruptures through time. In fact, our research across four thousand years of prehistoric occupation has documented how even ancient Hualcaínos had to negotiate their social and economic obligations around existing walls and agricultural terraces (Bria 2017, Bria in press). These observations prompted us to orient our outreach toward collaboratively documenting and narrativizing the social and physical dimensions of Hualcayán's long-occupied and transformed landscape, using photogrammetry and storytelling as our tools of engagement.

Collaborative Photogrammetry and Storytelling

Creating Open-Ended Dialogues

As archaeologists centering the Hualcayán community's livelihood within the conversation of how to best preserve Hualcayán's unique prehistoric remains, we sought the opportunities and collaborative tools that would allow us explore ideas about the relationship between the objects and spaces that gave meaning and purpose to people's lived experience in the present and the past alike. First, we asked: what common ground exists between the archaeological landscape, full of crumbling buildings that have been of only marginal interest to local people, and the contemporary agricultural landscape that is shaped by their everyday practices and immediate concerns as farmers? Why do local people value the reconstructed effigy vessels we have displayed and discussed during local exhibitions but not the many sherds they see emerging from the ground when they plow a field or kick up dirt on their way to school? What tools and experiences might enable a sustained and attentive interaction with ancient ceramics and landscapes alike? Upon reflecting on these questions, we chose photogrammetry as our mediating methodology, hoping it would engage and meaningfully imbricate these archaeological, cultural, and ecological sets of knowledge and experiences. Specifically, we wanted to explore how the processing of photogrammetry models might lead our Hualcayán collaborators to ask deeper questions about the past and consider the significance that Hualcayán's ancient things and spaces held for the people who created them.

Beyond our desire to explore the potential for digital heritage in an indigenous Andean setting, local people had also expressed interest in our equipment. Adults believed that drone imagery could help them settle disputes about field boundaries and to monitor mountainside erosion. Adults, especially young adults, wanted to learn about total stations and the georeferencing of landscape features so that they could apply to work as a surveyor's assistant when such opportunities arose. Children, on the other hand, were curious how a toy-like instrument that flew through the air could in any way help us learn about the past. Both young adults and children also wanted more opportunities to hold and explore many of the rare human and animal effigy vessels we had excavated and reconstructed, and they were interested in our digital cameras, computers, and tablets. Rather than keeping them away from this sensitive equipment, we wanted to empower them to use and understand it. Giving local children time and training with this equipment helps us to achieve our core mission to advance heritage-focused projects that are distinctly 'co-creative,' or created with, rather than simply for, local stakeholders (Bria and Cruzado Carranza 2015, Connolly et al. 2015). Despite all good intentions, investments, and efforts, the only way that heritage preservation initiatives will have true relevance or longevity is if these initiatives are collaboratively designed; this point has been well-documented (for example, Atalay 2012, Jameson and Musteață 2019, McAnany and Parks 2012, Moshenska and Dhanjal 2011, Nicholas et al. 2011, Watkins and Ferguson 2005).

The practice of collaboratively producing knowledge is at least as important as collectively deciding what projects to pursue or how to pursue them. Photogrammetry was an intriguing tool for our collaboration because it combined 1) the community's genuine interest in digital technology, 2) our (the authors' and the community's) collective recognition of photogrammetry's usefulness in surveying community lands and resources, and 3) our (the authors') understanding that sustained, intensive observations can lead to new understandings about objects and spaces (for a deeper consideration of object engagements, see Di Giuseppantonio Di Franco, chapter 1 of this volume). Consider the multistep process of photogrammetry: photographing a ceramic from fifty perspectives, adding digital markers on those photographs to align them, and then using those data to process a textured 3D model. These steps bring into focus previously unrecognized dimensions of an object, such as an ancient potter's careful painting technique, or a space, such as the patterned variations in stone masonry or the areas of heightened erosion on the mountainside. Moreover, the decision-making and analytical observations involved in planning and executing field-based photogrammetry, such as drones over ancient structures, can engender new meanings and perceptions of an otherwise familiar landscape.

These sustained interactions with objects and spaces can also give creative fodder for imagining the lives of ancient people. But ancient people will remain "faceless blobs" without stories. Archaeological narratives emerge as archaeologists move back and forth between data and theories, a hermeneutical process that is in itself creative and imaginative (see discussions in Van Dyke and Bernbeck 2015, Van Helden and Witcher 2019). Stories are similarly crafted in a hermeneutical process that moves between evidence, experience, and ideas (Meretoja 2017). Stories about the past, often more skillfully than scientific narratives, bring (pre)history to life in tangible ways, emphasize its inherent multivocality, and produce new kinds of knowledge, meaning, and value in the present (Pluciennik 2015). Moreover, stories are a familiar mode of expression for our community collaborators in Hualcayán. Equally, members of the Hualcayán community are the most knowledgeable about this place—they are indigenous to the region, grew up interacting with its archaeological remains, and are experts on how one lives in this particular landscape. Their observations about local artifacts and ruins as well as the stories they generate are key sources of knowledge that we, the archaeologists, cannot produce alone.

Thus, recognizing 1) that photogrammetry affords close, multi-step engagements with archaeological materials and 2) that storytelling generates meaning and value for those who produce and receive stories, we combined photogrammetry and storytelling into a two-part 'toolkit' for collaborative research and outreach. Our objective and hope was that our collective work could produce open-ended, meaningful dialogues between us, the archaeologists, and our community partners. We sought a collaboration that could better democratize the production of knowledge about the many dimensions of the lives of people who lived thousands of years ago in Hualcayán, with an eye toward collectively exploring why this past is worth knowing at all. As described in greater detail below, this work involved a collaboratively-executed photogrammetric study of community lands and several objects excavated from it, followed by the open-ended crafting of stories—mostly vignettes, dialogues, and visual impressions—about the ancient people who once lived in this place they call home.

Imaging and Imagining the Past in Hualcayán

During the summer of 2018, our photogrammetry and storytelling project in Hualcayán began with some of our most enthusiastic local partners: schoolchildren and their teachers. We explored whether and how bringing together highly distinct modes of knowledge production—that is, science-based observation, digital visualization, and storytelling—and the diverse perspectives of local children and Peruvian and foreign archaeologists, would bring significance to the local past while demystifying and democratizing the production of archaeological knowledge. To date, our work has been largely exploratory, initiating a multi-year project (temporarily halted by the COVID-19 pandemic) that will culminate in concrete outputs including a co-created graphic novel, virtual and augmented reality exhibits about Hualcayán's history, and publications that reflect on our collaboration. Many of these later-stage projects will expand from our school partnerships to more robustly incorporate young adults and adults. All products, both outreach-focused and scholarly, will be co-created with and authored by members of the Hualcayán community.

Landscape and Object Photogrammetry

To begin the project, we held a series of hands-on workshops and tours with the students to provide opportunities for them to touch and explore artifacts, discuss the ongoing excavations in their community, and learn about 3D modeling in Agisoft Metashape. In this initial phase, we introduced what photogrammetry was, how and why we do it, and let the children take turns moving around 3D models on a series of laptops (Figure 3.2.).

We then put our demonstrations into practice by taking our student collaborators to document the archaeological site's habitation core, an area the children chose to study because it was the highest point of the archaeological site and had well-preserved structures (Figure 3.3.). As we defined the limits of our area of interest, students made observations about architectural spaces, noting doorways and walled patio groups, and how canals flowed through terraces. We also explored questions about the features we documented, such as by asking what the variations in house size or location may reflect about the ancient villagers who lived there. We then defined our area of study and flew the drone over it: students took turns with the tablet interface and its controls. This stage required us to give the children less control than we would have liked simply because of the instrument's cost and fragility. Nonetheless, we did let them take turns touching the knobs and pushing buttons. The students also took turns using a handheld camera to take pictures from the ground for modeling architectural

Figure 3.2. Preparatory workshops in the Hualcayán school where students: learned the fundamentals of drone photography (top left) and photogrammetry (top right); examined, touched, and discussed artifacts at different stations (bottom left); and brainstormed narratives about the past that incorporated the artifacts they had examined (bottom right). *Photographs by Maria Laura Zamora Melo (top left), Emily Sharp (others).*

features. Back in the lab, students returned over the course of a few days to process the images and produce and explore a model of community lands.

Subsequently, Hualcayán schoolchildren chose and took photographs of artifacts from the site and then worked in groups to produce 3D models (Figure 3.4.). First, the students chose the artifacts they wanted to model, which they had previously explored during workshops. They were intrigued by objects that had iconography, especially the human effigy pots of sitting rulers, ancestor faces, and animals. They then took turns photographing the artifacts from different angles using a tripod and turntable. We discussed basic camera skills such as zoom and focusing, explained why and how we set up a tripod and turntable, and described why we need multiple photographs from multiple perspectives to produce a three-dimensional image.

Some of these tasks may seem rudimentary, but they focused the children's attention and let them to explore the artifacts in much greater detail than they had in earlier workshops. They would point out and discuss surprising features on the ceramic vessels and critique each other on the proper execution of the methodology they had learned for photographing the objects. In fact, the students seemed to enjoy this step more than any other, as they were able to get up close with the object using a camera as their tool, in total control of the documentation. We then processed the photographs into models, which we did over the course of several days, adding markers to fix inconsistencies and improve the model's appearance until everyone was satisfied.

Figure 3.3. Middle-school and high-school children taking turns learning to control a drone as it took photographs of monumental platforms and houses in the archaeological site of Hualcayán. These photographs were later processed by the students to create photogrammetric models. *Photographs by Maria Laura Zamora Melo (top), Erick Casanova Vasquez (bottom).*

Figure 3.4. Children from Hualcayán photographing and analyzing photogrammetric models of ceramic artifacts with Erick Casanova Vasquez. *Photographs by Erick Casanova Vasquez (top row) Maria Laura Zamora Melo (bottom row).*

Storytelling

If the photogrammetry activities gave our child collaborators the eyes and skills of archaeological technicians, the subsequent activities of discussing and drawing about ancient life encouraged them to think like scholars. The children were encouraged to bring together their observations from the workshops, the photogrammetry analyses, and their preexisting expertise about Hualcayán to think about what ancient people might have looked like, what they cared about, and what kinds of activities they might have carried out on community lands. They were also encouraged to imagine themselves in these ancient times, interweaving personal stories and images from everyday life with the objects and spaces that dominated their familiar community landscape long ago. They explored these ideas at first in small brainstorming groups with undergraduate archaeology students from a nearby university in Huaraz, Peru (Universidad Nacional Santiago Antúnez de Mayolo, UNASAM) as well as Spanish-speaking university students from the United States.

Many children had trouble articulating their ideas verbally so we encouraged them to express their ideas in

Figure 3.5. Storytelling workshops in the Hualcayán school involved discussing and drawing scenes in groups (top) and then presenting their artwork to the class, either through explanations or acted-out dialogue (bottom). The girls drawing in the top photograph have shared ideas about what their scene should contain, which they have set in Hualcayán's ancient terraced fields. *Photographs by Rebecca Bria (top) Emily Sharp (bottom).*

Figure 3.6. Middle-school children voting on which of their peers best executed the visual storytelling project (top) with a detail of some of their narrative scenes featuring house structures, stone tombs (chullpa), artifacts in soil, agricultural fields, and irrigation canals set in Hualcayán's mountain landscape. *Photographs by Rebecca Bria.*

pictures using paper, colored pencils, and crayons. In this step, students had to think about how the objects and spaces they had modeled and studied went 'together' in ancient times—that is, they recreated the assemblages of objects and spaces and visualized the practices that created them. The children sketched these assemblages and scenes on paper as these dialogues took shape. At the suggestion of the schoolteachers, we organized a competition for their stories and drawings as a way to get the children motivated to explore several iterations of their artwork and then present their best work at the competition; such competitions with student prizes are common events in Peruvian schools and the children were excited by the contest. After the brainstorming sessions and group work (Figure 3.5.), the schoolteachers provided a few hours a day for the children to develop their artwork in class.

The storytelling competition took place as part of a school-wide exposition of artwork, followed by a vote for the best illustrations (Figure 3.6.). Dividing the exposition into groups by age, the drawings were voted upon by each peer group, and students had the opportunity to share what their drawings were all about. The students were clearly

Figure 3.7. Top: Winning pictures from each age group, from youngest (left) to oldest (right). Bottom: Winners (left) and runners-up (right) show off their artwork to the class as they accept their award. *Photographs by Rebecca Bria (top), Emily Sharp (bottom).*

influenced by others in their class, as there were common themes in the drawings of each age group. We took this as a good sign that students in each classroom were sharing and getting feedback from their peers.

The younger age group, from about ages five to eight years old, took a straightforward approach to the assignment, drawing images of the ceramic objects they had seen and modeled in the lab. Their attention to detail and ability to draw these objects mostly from memory is a testament to the time they spent to photograph and model artifacts in the lab. The winning drawing in this age group was of a ceramic effigy vessel featuring an individual wearing a headdress and earspools, which were signs of authority in ancient Peru (Figure 3.7., left). This vessel dates to the era of the local Recuay culture (AD 1–700) but the student curiously added a stirrup-spout in a style more representative of the Moche, a non-local pre-Hispanic society that is much better represented in the educational materials provided by the state. We later learned the students were referencing sources available in the school while they worked on their drawings. Although technically an 'incorrect' representation, the final product reflects a high level of scholarly engagement as the children moved through different stages of knowledge production, from field and laboratory observations to literature review, visualization, and explanation.

The middle group, aged from about nine to twelve years old, took on the task of imagining the scenes of ancient life (Figures 3.6. and 3.7.). Nearly all of these scenes included key landscape features like terraces and canals that the students had learned, through the process of field documentation and drone photogrammetry, are not only used in modern times but were ancient in origin. Several students drew bones that indicated, as if with x-ray vision, ancient things buried in the ground. The younger children of this age group drew cows and chickens in their scenes despite our earlier discussions about the types of animals that lived long before there were cows and chickens; notably, many Hualcayán children have never seen, first hand, a llama or alpaca, and did not have strong familiarity with these indigenous animals. The winning artist in this group drew a scene of their familiar local mountainside with a central actor standing next to his agricultural fields and wearing and using local artifacts the child had discussed or studied in the workshops—a feather headdress, textile tunic, and a stone plow. The ancient agricultural fields she depicted in her scene were fed by the same artificial waterfall and canal system that still flows down the Hualcayán mountainside to irrigate local fields today (Figure 3.7., middle). Finally, the picture also included a *chullpa*, or a stone burial tower, where that person's ancestors were buried. Such *chullpa* were documented during the drone photogrammetry and are a feature well known by Hualcaínos today.

The older group, ages thirteen to seventeen, took two pathways in their narrative art. One pathway was to draw realistic representations of artifacts, showing details from the particular objects they had studied and modeled or at times embellishing the objects with new details. Another pathway these artists took was more symbolic, depicting scenes of ancient life that were shown locked within or emerging from ceramic artifacts. In particular, three students showcased a ceramic vessel with a flaring rim drawn in three-dimensional perspective that allows the viewer to peer into the top of the vessel; inside the vessel is a landscape scene. The winning picture for this age group (Figure 3.7., right) included a llama grazing inside the vessel. Although the students were shy in describing their artwork and its meaning, the scenes within the pots were meant to evoke the meaning of how each vessel tells a story about the past and that past worlds can be accessed through these objects. This evocative scene, we decided, was fruitful ground for a future story plot where ceramic artifacts act as portals that transport people from the present into the past.

Science, Technology, and Art in Community Engagement

From Process to Product and Back Again

These open-ended storytelling activities, which followed the archaeological study and data collection of local spaces, landscapes, and objects, allowed children to deepen their connection to and understanding of the heritage objects, spaces, and agricultural technologies that permeate their daily experiences living in Hualcayán. The storytelling activities also provided opportunities to envision the lives of people, including children like themselves, who lived thousands of years ago in the very same landscape they inhabit and call home. Although the focus on storytelling was strongest during the production of artwork, the storytelling happened at all stages of the project: as we explored and discussed ancient walls, identified terraces and houses on 3D models, and photographed effigy vessels from multiple angles. In this way, throughout the project students oscillated between activities where they conducted an academic-style documentation of archaeological heritage and other activities where they could 'play' with heritage in the sense that Di Giuseppantonio Di Franco (chapter 1 of this volume) outlines. In all activities, however, our goal was for the children to see their essential role as heritage scholars.

Our collaborative initiative with children to document, interpret, and narrativize Hualcayán's archaeological heritage is perhaps the epitome of what William Caraher has called "slow archaeology" (Caraher 2016, 2019) and, we hope, demonstrates an "archaeology of care" (Caraher 2019). The work does not have a quick 'return' for these schoolchildren, who have no current political sway in the decision-making of the community, nor to us, as academic stakeholders in the site's future. The older children will soon become adults, only some will have voting rights within the community, because only heads of family who are descended from founding community members can typically vote. Moreover, working with children using digital technologies that are new to them lends itself to a slow process. But slow approaches present opportunities for both close observation and deep reflection, out of which value systems are shaped around a new relationship to archaeological remains. Our hope is that, as today's children become community leaders in ten or twenty years, they will take a more active role in managing their heritage resources. To be sure, we do not seek an idealistic or predetermined idea of what this management will look like; but we hope the decisions made will be rooted in our co-produced knowledge about their community's predecessors, whose legacy continues to shape their everyday lives as they till ancient terraces.

In the coming years, we will continue our project with more robust activities and several tangible outcomes. First, we will more systematically pair small groups of children from Hualcayán with Peruvian students of archaeology and literature from UNASAM, and these groups will create longer narrative stories and storyboards. A professional illustrator will collaborate with these student teams to create a locally-produced and crowdsourced coloring book or graphic novel. Although such illustrated materials are commonly produced by archaeologists, the narratives and images presented are rarely initially imagined or produced by their audience. Our planned illustrated books will not only involve the stories and imagery of Hualcayán children but will be authored by them. That is, these stories will be by and for local children, serving as an example of their abilities and values rather than serving as an educational gift from the archaeologists to the local people.

We also plan to incorporate our co-created photogrammetry models of Hualcayán's landscape and artifacts into a digital exhibition and a virtual or augmented reality game about life in ancient Hualcayán. The game will bring together the children's 3D landscape models with stories about the past and the digitized objects and spaces that inform them. This virtual world will encode and reveal local perspectives of Hualcayán and its archaeological heritage. An online digital exhibit will feature the children's 3D models, a testament to their technical skills, as well as their drawings and stories; this work will expand a local co-created digital museum exhibit we began in 2014 (Bria and Cruzado Carranza 2015).

Despite our focus on these 'products' that will guide our community collaborations in the coming years, we wish to emphasize that these products are not the end goal of our project. Instead, we see the *process* of observing, modeling, reflecting, and storytelling to be the most valuable outcome of our work. In fact, we do not expect our projects to ever reach an absolute completion, and we presume that each new cohort of children or group of engaged adults will have unique motivations for collaborating with us and will discover unique meanings through it, building a palimpsest of ideas, projects, and products that unfolds over time. Moving forward, we will continue to focus our efforts on topics that bridge ancient and contemporary concerns, such as how Hualcayán's early inhabitants managed agricultural infrastructure, which can provide both information and inspiration for building a sustainable existence in the face of new challenges like climate change. Ultimately, we contend that extending the tools of digital archaeology to community stakeholders—rather than restricting them to the domain of the academic specialist—is essential to any collaborative archaeology project in the twenty-first century that seeks to democratize the production of knowledge about the past. Equally, we contend that storytelling about the past is a powerful medium through which local and descendant people can explore the meaning of this archaeological knowledge and then use it to imagine alternative futures.

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CHAPTER 4

Modeling Archaeological Potentials in Southwest Anatolia

A Tool for Planning Sustainable Futures at Ancient Sagalassos

Patrick T. Willett, W. Christopher Carleton,
Ebru Torun, Ralf Vandam, Jeroen Poblome

Introduction

The ancient settlement of Sagalassos is located in the modern district of Ağlasun in the province of Burdur, southwestern Turkey, in the northern extents of the western Taurus Mountains (Figure 4.1.). The region has provided significant insights for a number of archaeological periods and has been a subject of interest for researchers since at least the mid-twentieth century (for example, Lloyd and Mellaart 1962, Mellaart 1954, Özsait 1976). The rugged and diverse landscapes of the Sagalassos study area combined with the rich and abundant archaeological heritage found there present a challenge for the documentation, monitoring, and protection of these resources. In this chapter, we will discuss an effort to use the extensive data generated by the Sagalassos Archaeological Research Project about this region since the mid-1980s to create predictive models and discuss the effectiveness of such models for the conservation of archaeological heritage as well as their potential to inform the processes of territorial development planning. Underlying this effort are the abundant archaeological survey data garnered from within the expansive Sagalassos study area.

Background

Sagalassos Study Area

The region surrounding Sagalassos is extremely heterogeneous in both topography and hydrology, resulting in widely disparate ecological potentials that manifest in a high degree of variation among vegetative regimes between catchments. These range from semi-arid steppe and badlands in the west to marshes, riparian and deciduous woodlands in the highland valleys in the east of the region, and oro-Mediterranean zones at higher elevations (Paulissen et al. 1993). Elevations range across the study area from around. 300 m at the lowest to 2625 m a.s.l. at the highest, with several high peaks and valley systems. These differences in altitude result in a significant difference in average annual temperature between the lowlands (for example, 13.2°C in Burdur) and the highlands (8.2°C at Sagalassos). In addition to elevation and slope, access to

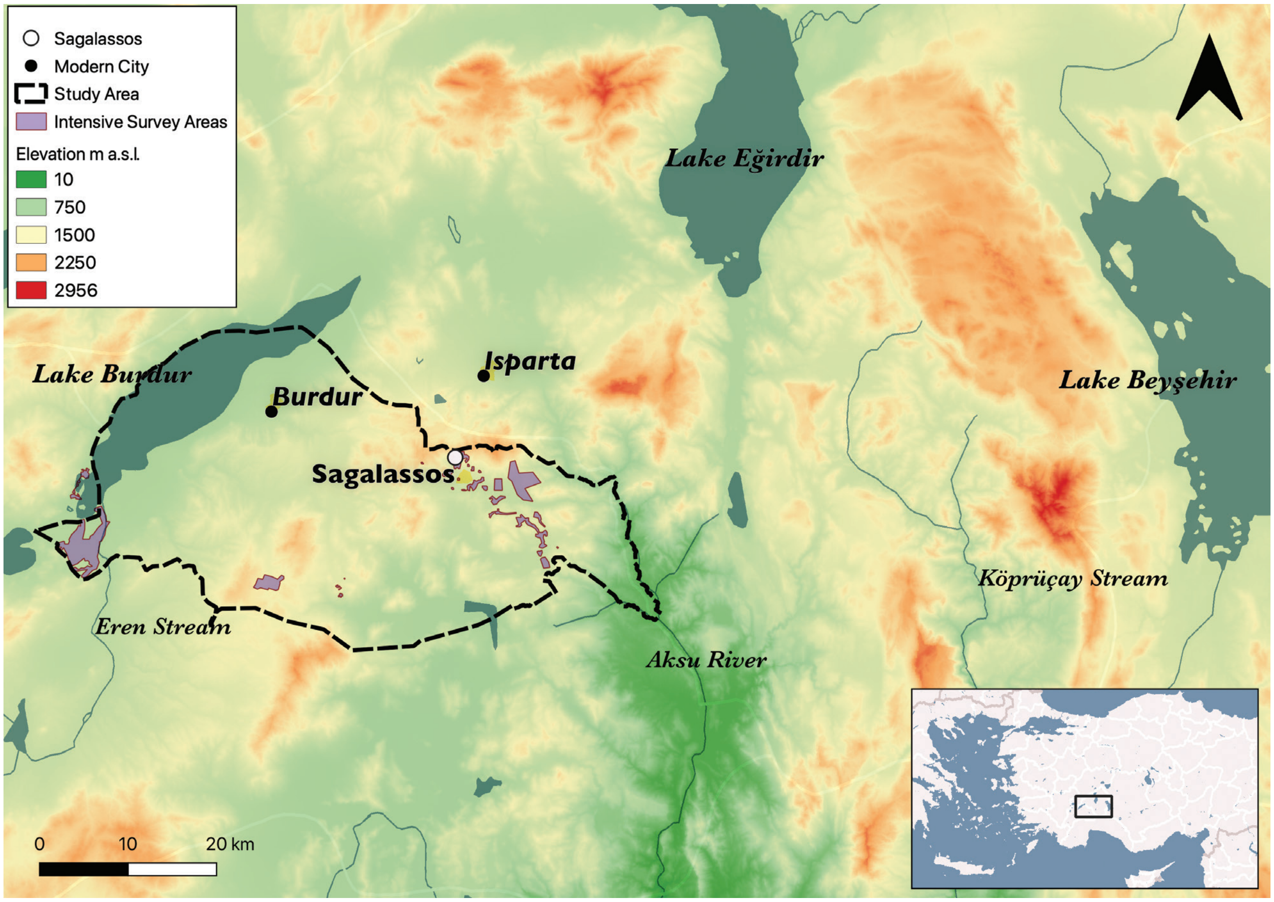

Figure 4.1. The Sagalassos study area in southwestern Turkey. *Map by P.T. Willett.*

water also drives the ecological diversity of the territory. Mean annual precipitation at Sagalassos (990 ml) is more than double that of the nearby Burdur Plain (438 mm), mostly taking the form of winter snowfalls. This creates predictable seasonal fluctuations between abundant water availability and semi-arid conditions, the inconsistency of which has been mitigated by the presence of cold-water springs in certain areas and cisterns and wells where there are none (Vandam et al. 2017). Relatively poor natural drainage due to thick clay subsoils in parts of the uplands resulted in the formation of marshlands in several of the valley bottoms (such as Ağlasun, Gravgaz, and Bereket) prior to modern irrigation and agricultural practices (Six 2004). Meanwhile, the relatively thin soil cover on the hillslopes and better drainage in the plains have created much dryer conditions. Beyond the natural processes shaping the landscape, human impact has also had a significant effect on much of the territory since the Middle Holocene (see for example, Van Loo et al. 2017). The diversity of conditions represented across the patchwork of landscapes that have comprised the study area over time is also reflected in the settlement pattern and land-use history so far documented by research efforts therein, particularly via archaeological survey.

Survey History in the Sagalassos Study Area

Modern archaeological prospection in these settings began in the middle of the twentieth century, led by researchers from the British Institute of Archaeology at Ankara (for example, Lloyd and Mellaart 1962) and Istanbul University (Özsait 1976). The Sagalassos Project itself grew out of the BIAA's Pisidia Project surveys led by Stephen Mitchell in the early 1980s (Mitchell 1983, 1984) and continues this legacy with a sustained program of survey research as a principal component of the project. The earliest sizeable excavations of the settlement at Sagalas-

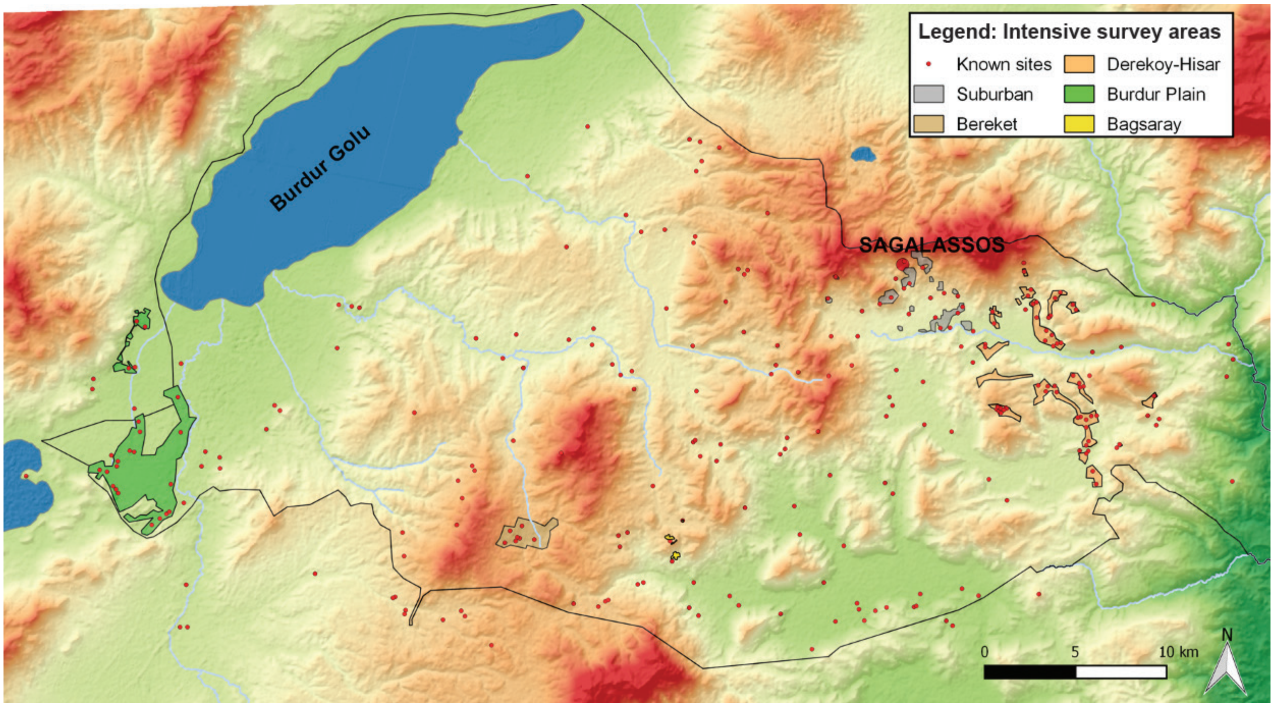

Figure 4.2. Areas and distribution of intensive survey projects. *Map by R. Vandam.*

sos began in 1990 only after five prior years of survey research had taken place there (Waelkens 1993). Since the project's inception, there has been an intrinsic interest in contextualizing Sagalassos within its surrounding natural and human-built landscapes. The wide range of ecologies comprising the study area due to its geographic diversity were host to human activity since at least the Middle Paleolithic (ca.150–45 kya) (Vandam et al. 2019a). Excavations and wide-ranging archaeological surveys have sampled these varied landscapes over the past three decades in order to build an understanding of the relationship between the settlement history and the environment of the territory. The vast majority of archaeological resources known in the study area have not been subject to excavations, and therefore have been documented by survey alone.

Following initial topographical, epigraphical, and architectural surveys of the urban center of Sagalassos (Mitchell et al. 1989, Waelkens et al. 1990), extensive surveys away from Sagalassos were initiated in 1993 by request of the Turkish General Directorate of Monuments and Museums, as the department was then known. The General Directorate's primary aim was the creation of an inventory of cultural heritage sites within a wide area around sites already being excavated. An additional goal of these efforts for the Sagalassos Project was to better understand the boundaries of the territory of classical Sagalassos, by which the limits of the study area were later informed (Waelkens 1995). Non-intensive reconnaissance surveys were carried out between 1993 and 1998 by H. Vanhaverbeke and M. Waelkens (Vanhaverbeke 1999) and extended across what would become the approximately 1200 km^2 (463 mi^2) study area of the Sagalassos Project. These surveys primarily comprised on-site non-intensive surface sampling and recording of architectural fragments and spolia based on written sources and local interviews, covering the expansive area by car. Although these efforts produced a dataset that is heavily biased toward the most conspicuous sites in the region, overrepresenting monumental (particularly Roman) sites and hilltop sites, it has acted as the starting point for much of the subsequent survey research conducted by the project. Over six campaigns, around 250 sites at 173 locations were identified throughout the study area, ranging in date from the Epipaleolithic period to the Late Ottoman (Vanhaverbeke 1999).

From 1999 until the present day, more intensive systematic surveys have been conducted on a near annual basis. A variety of standards have been utilized over the years, including linear tract-walking and gridded approaches of varying resolution, as methods were adapted through trial and error to best suit the various conditions present in the study area, both at on-site locations and off-site in the wider territory (see Table 4.1.). These efforts began by intensively sampling the urban center of Sagalassos and its suburbia concurrently from 1999 to 2006 (Martens 2005, Martens et al. 2008, Vanhaverbeke et al. 2002). Since 2008, surveys have been conducted in the wider study area both in order to contextualize the site within its surroundings and to facilitate multi-disciplinary regional synthetic research efforts (for example, Bakker et al. 2011, De Cupere et al. 2015, Vandam et al. 2019b, Woodbridge et al. 2019). Intensive surveys were thus aimed at sampling a variety of landscapes within the study area to produce a representative picture of land-use history. These included surveys of the intermontane valleys of Bereket and Bağsaray (Kaptijn et

Table 4.1. Summary of various intensive survey methodologies employed by the Sagalassos Project between 1999 and the creation of the predictive models in 2018

Year	Survey Project	Survey Unit	Unit Coverage	Transect Width	Transect Spacing	Total Coverage (Sq Km)
1999	Urban	50x50m Grid	32%	2m	8.4m	0.115
	Suburban	50x50m Grid	100%	2m	—	0.155
2000	Urban	10x10m Grid	100%	2m	—	0.0062
	Suburban	10x10m Grid	100%	2m	—	0.0211
2001	Urban	20x20m Grid	100%	2m	—	0.0248
	Suburban	25x25m Grid	100%	2m	—	0.025
2002	Urban	20x20m Grid	100%	2m	—	?
	Suburban	50x50m Grid	20%	2m	12.5m	?
2003	Urban	20x20m Grid	100%	2m	—	0.024
	Suburban	50x50m Grid	20%	2m	12.5m	1.125
2004	Urban	20x20m Grid	100%	2m	—	0.0272
	Suburban	50x50m Grid	20%	2m	12.5m	?
2005	Urban	20x20m Grid	100%	2m	—	0.012
	Suburban	50x50m Grid	20%	2m	12.5m	0.22
2006	Suburban	50x50m Grid	20%	2m	12.5m	0.045
2008	Bereket Valley	100x100m Grid	100%	2m	—	1.98
2009	Bağsaray Valley	Sector (var.)	Var.	2m	Var.	?
2010	Burdur Plain	1x50m Plot	100%	1m	20m	1.25
2011	Burdur Plain	1x50m Plot	100%	1m	20m	3.45
2012	Burdur Plain	1x50m Plot	100%	1m	20m	3.5
	Akdağ	20x20m Grid	20%	1m	4m	0.056
2016	Dereköy Highlands	1x50m Plot	100%	1m	20m	2.73
2017	Dereköy Highlands	1x50m Plot	100%	1m	20m	2.29
2018	Archaeological Potential	1x50m Plot	100%	1m	25m	0.27

al. 2013, Vanhaverbeke et al. 2011), the relatively low-lying Burdur Plain (Kaptijn et al. 2012, Vandam 2015), and the marginal highlands around the modern-day villages of Dereköy and Hisar (Vandam et al. 2017, 2019a) (see Figure 4.2.). The results of these efforts so far are summarized in the Sagalassos site database. Intensive survey activities focused on the Ağlasun Valley have been ongoing since 2018, but those results were not yet able to be included in the site database at the time of this research.

Sagalassos Site Database

Summarizing the survey and excavation efforts and underlying the predictive modeling is a database describing the known sites within the study area. The database has been compiled iteratively over several years by a small number of Sagalassos Project team members, and was further expanded and revised between 2017 and 2019 in relation to the research presented here. At the time of this research, the database described 289 unique locations in total, comprising information gained through both excavation and surface prospection. In the case of the latter, distinguishing whether the presence of cultural materials dating from multiple sequential periods at a single location indicates continuous occupation or reoccupation following some duration of hiatus(es) is not possible, and as such the site database treats each broadly discrete occupation phase as a distinct site occurring at the location. Through this classification criteria, the database currently describes 704 individual sites at 289 geographical locations within the approximately 1200 km^2 arbitrarily, roughly historically defined territory of ancient Sagalassos, which comprises the study area. The sites are described using a varying number of attributes, where possible and appropriate: such as locational coordinates (UTM), year(s) of data collection, primary type of research conducted at the site (for example, intensive or extensive survey, excavation), relative dating of the site, size of the site, site type, and discernable features at the site (see further discussion on the last four attributes below). The database thus contains both qualitative and quantitative attributes, though even something as seemingly straightforward as site location is highly interpretative when approaching survey data.

A *site* as defined by the database is a location where some past (predating the Turkish Republic) human activity has been observed, and is distinct from a *settlement*, which is rather a certain type of site, a category of attribute that might also be defined as for example, church, necropolis, stone quarry, cistern, and so on. These determinations are based upon the presence of certain defining archaeological features and artifact classes, in consultation with the specialists per period within the Sagalassos Project team. Site location and site size have been determined based on the mapping of artifact clusters and their fall-off patterns (Bintliff 2000, Vandam 2015). For unexcavated sites, the site size attribute recorded in the database reflects the distribution of artifacts collected from the surface at the time of the survey rather than attempting to describe the size of the archaeological phenomenon during the period of deposition. This avoids the complexities of estimating the effects of post-depositional processes on the true extents of the site, but means that the site size attribute has limited utility and is more useful for contemporary concerns such as interventions for the sake of cultural heritage preservation. Regarding the dating of sites, a variety of means have been employed including architectural standards, inscriptions, tool industries, and to a large degree, pottery determination, mostly based on methods of cross-dating.

The number and depth of attributes that are able to be ascertained for a particular site is largely dependent on the research methods used at that location. The database distinguishes between sites that have undergone archaeological excavation, extensive survey, gridded intensive survey, transected intensive survey, or a combination of these methods. Of the 289 locations described in the database, only eight (2.8 percent) have been the subject of excavations. And of those eight locations where excavation has taken place, three were subjected to intensive survey as well. This highlights the fact that the overwhelming majority of information contained in the Sagalassos site database was obtained through archaeological survey. These data have been utilized as the training dataset for the predictive models discussed ahead.

Concerning Predictive Modeling in Archaeology

Predictive modeling approaches have been scrutinized within archaeology and other socially concerned disciplines (for example, van Leusen et al. 2005, Wansleeben and Verhart 1997, Wheatley and Gillings 2002) around some common critiques that were also noted during the design of this research. These concerns were rooted primarily in the fundamental problem of incomplete and/or biased datasets on the one hand, and a broader criticism of the movement toward the over-datafication of archaeology and heritage research on the other, often manifesting as data for data's sake rather than as a componential means to the creation of knowledge (see for example, Huggett, chapter 6 of this volume). Approaching the goals of this project while addressing these concerns through the research design required a reflexive posture when evaluating prospective methods.

The concern surrounding the inherent incompleteness of archaeological datasets used for the training of archaeological prediction remains something of a paradox, as having a complete dataset (that is, a record of all archaeological remains) would make the practical purpose of most archaeological predictive models redundant. Nevertheless, the lack of representative datasets and, in particular, confirmed 'non-site' or 'off-site' data pose critical problems for common methods of archaeological prediction such as logit and weights-of-evidence models (see Carleton et al. 2012, Cramer 2006). The neglect of cultural variables in the construction of many archaeological predictive models can also result in overly environmentally deterministic outputs. How heavily these issues might impact the practical or explanatory utility of a predictive model relies heavily on its intended purpose and the selection of modeling parameters.

For our purposes, we selected a method that attempts to address these limitations by bridging conventional data- and theory-driven approaches. In the creation of the database, sites were individually described by Sagalassos team members and treated as distributions of characteristics with a range of values rather than reducing them to points with single values. By being able to select the determinant natural and cultural variables while using inductive means to weight their value, we were able to model culturally-defined ideational archetypal locations for specific land-uses based on our own previous observations, using the database as a platform for building a greater understanding of the phenomena it describes rather than as an end in and of itself. Simply comparing 'unknown' land parcels to these land-use archetypes avoids the bias created by limited information on confirmed non-site locations as well.

In the discussion further ahead, there will be consideration of these predictive methods and how they can function within the limited prescribed role of archaeologists within the heritage chain of Turkish governance, and can supplement rather than replace the various other forms of engagement, advisement, and collaboration that interdisciplinary projects such as Sagalassos can have with the management and sustainable development of archaeological heritage resources.

Methods

Using the data described in the site database, locally-adaptive models of archaeological potential (LAMAPs) were created in two stages. These resulted in spatial grids indicating *archaeological potential*, defined here as the relative suitability of land parcels for accommodating human activities as outlined by the training data (Carleton et al. 2012:3371). This particular form of site prospection model is especially well suited for the inhomogeneous landscapes of the mountainous study region, and involves the input and proportional weighting of a multitude of proxy variables that relate to archaeological potential. The initial stage consisted of the creation of a joint empirical cumulative distribution function for each known site, defined by raster maps representing individual variables within a predetermined sample area around the site. These variables include cultural and landscape features, such as proximity to ancient roadways and urban centers, and drainage, elevation, slope, aspect, and convexity. The last five of these variables were common to all of the models created for the different time periods of interest and so were subjected to principal components analysis. The first three principal components were then used in place of the five original variables to describe landscape variation that was consistent among the models. A comparison of every location of interest in the study area with the joint empirical cumulative distribution functions for each known site produces vectors that describe the probabilities that a location of interest fits any locational archetypes defined by the set of known sites, based on the presence of common values for sets of these variables. The second stage entails calculating the probabilities of unions of the probability vectors of locations of interest, which would indicate the level of congruence with locational archetypes defined by the set of known sites. Based on this information, the model predicted the archaeological potential, or likelihood of past human activities, on a given location by comparing it to the areas for which we already had site data. These probabilities are finally represented by the output spatial grid—a raster map indicating the potential suitability of the location of interest for the phenomena (for example, sites of a certain time period or type) described by the set of known sites. The raw LAMAP potential values were then reclassified using quantiles to produce an ordinal scale. This takes the form of a grade on a scale of 1–5 given to each tile on a spatial grid that is calculated over the territory, revealing areas of 'high' and 'low' archaeological potential. Once the LAMAPs were created, their reliability for our particular study area required validation by pedestrian ground-truth survey. This entailed intensively surveying a random sample of blocks from within the grid of the LAMAP prediction areas and comparing the results to the scale of potential as predicted by the model.

Outcomes

Seven individual predictive models were created, broadly distinguished by the major shifts in settlement pattern and material culture observed in the archaeological record of the study area since the mid-Holocene: Late Prehistory (6500–2500 BC), Iron Age–Archaic (1150–546 BC), Achaemenid–Hellenistic (546–25 BC), Roman Imperial (25 BC–300 AD), Late Antique (300–700 AD), Byzantine (700–1200 AD), and Late Ottoman (1700–1921 AD), in addition to an aggregated model. The results of the ground-truthing validation demonstrated a consistently positive correlation between prediction and observation for all models, but was particularly strong for certain periods. Using a Bayesian hierarchical regression model to evaluate the results, the effect size for each one-unit increase in LAMAP class (1–5) ranged from a 15 percent to a 56.8 percent increase in the odds of locating a site, and a 32.3 percent increase when the models were considered in aggregate (that is, the posterior estimate for the model's top-level hyperparameter). If measuring the effect of a four-unit increase in LAMAP class, from the lowest (1) to the highest (5), it is a 305 percent increase overall and up to an 849 percent increase for the period with the strongest correlation. Several factors may be contributing to the range in effect sizes, including the selection of predictor variables, as well as the general likelihood of encountering sites from certain periods within the Sagalassos study area—the period making up the lowest proportion of known sites in the training dataset (~6.9 percent) also measured the smallest effect size, and the period with the largest effect size contributed the second highest number of known sites to the training dataset (~17.2 percent). These results demonstrate the overall reliability of the LAMAP method within the Sagalassos study area utilizing the existing site database. This approach offers a number of benefits to the project with regard to both research and archaeological heritage protection efforts.

Discussion

The need to document and monitor sites for their preservation and potential for sustainable valorization on a wide scale remains a central concern for many working in various fields of heritage. Ideally, archaeological survey projects should form part of a "heritage chain" (Baraldi et al. 2012) in the governance processes involving cultural resources, as key actors providing expertise to inform conservation procedures as well as local or regional development planning processes. Turkey has regulations in place that provide the grounds for collaboration and communication with various local parties in the heritage chain. Yet the system restricts the role of archaeologists to the discovery, the expert interpretation, and finally the recommendation for inscription. It does not necessarily allow or call for further contribution to the planning processes, as the task of the archaeologist conducting the fieldwork is considered to be complete once the discovered site is registered officially as a protected area according to the law (Law 2863). This could be partly linked to both the fact that participatory processes in regional planning that bring together a wide range of actors and stakeholders are not common in the Turkish governance tradition, and the fragmented and centralized governance tradition itself (see Baraldi et al. 2012, Göymen 2006, Loewendahl-Ertugal 2005, Sungur et al. 2013).

In the case of the Sagalassos Project, efforts to create a comprehensive inventory of archaeological heritage in the region began formally in 1993. The project has since conducted interdisciplinary research to identify sites of cultural significance throughout the study area and recommend their classification as legally protected sites. At the conclusion of each survey campaign, a general report has been filed with the General Directorate and the Antalya Regional Conservation Council for Cultural Properties on all survey activities. Each season, according to the regulation, a *temsilci* (representative of the Turkish Ministry of Culture and Tourism) was assigned to the survey by said Ministry in Ankara. Together with the *temsilci*, a list of sites of notable importance documented during the campaign was reported to the Antalya Regional Conservation Council, recommending inscription for special protection status. Together with the Burdur Museum, located 20 km to the west of Sagalassos, these combined efforts have so far resulted in 265 sites being listed with first- to third-degree archaeological protection status. Turkish legislation classifies archaeological sites under these three different categories. First-degree protected sites are designated to be kept as they are; no excavation or physical intervention other than scientific activities are allowed within the officially defined boundaries of a first-degree zone. Certain use can be permitted on the second-degree sites in principle, conditions of which are to be determined by the Council, allowing no change to the assets, while third-degree protected sites see more flexibility in contemporary use and development under the supervision of the Council (Law 2863). The Sagalassos Project has so far served and informed the necessary authorities successfully within its defined capacity. The archaeological survey has been used as a tool for cultural heritage protection throughout the study area, and it has been particularly effective in the region of Ağlasun, near the site of Sagalassos itself. Yet it is difficult to consider this collaboration an integrated management and planning approach for the conservation and sustainable use of cultural resources in the Sagalassos–Ağlasun landscape. The lack of such a coordinated approach is best illustrated with the specific cases encountered in recent years in the study region where urgent archaeological expertise and intervention were needed to prevent irreversible damage to the cultural–natural landscape, as discussed below.

A notable example is the urgent survey program that had to be initiated in 2012 in order to inform the Council of the archaeological significance of the area where stone quarrying operations were planned, covering a large area on the summit of Akdağ, also known as Baca Tepe (2250 m a.s.l.), which overlooks Sagalassos and the village of Ağlasun. The area had not been previously surveyed intensively and remained outside of the existing boundaries of the first-degree protection zone of ancient Sagalassos even though the existence of aqueducts that fed the town were known. Not only was the inevitable destruction of the archaeological remains alarming, but also the known effects of the proposed quarrying on the endemic flora of the mountain, its fragile ecosystem, the subsistence of *yörüks* (Turkish nomadic tribes) that used the area for herding and transient settlement, and the freshwater buffering capacities were all of concern to the Sagalassos Project, as well as the potential pollution and traffic typically related to stone-quarrying activities. The application for quarrying targeted the tip of the summit, which would entail the destruction of the silhouette of the magnificent Taurus mountains in this area. Urgently organized intensive surveys by the Sagalassos Project on the mountainside documented many undiscovered sections as well as the main source of the ancient aqueducts that watered the ancient settlement, as well as a range of sites linked to a deep history of pastoralism and demonstrated that the proposed quarry posed an imminent threat to most of these remains. The file prepared for the Council put forward the significance and conservation of the attested archaeological remains. The concerns about damage to the ecosystems, the landscape or the livelihoods of the *yörüks* could not be included in the discussion, as the Conservation Council that formerly oversaw both cultural and natural assets up until 2012 was now in charge only of cultural assets. The new regulation split the ecological and cultural conservation and placed each under the jurisdiction of different councils (Regulation 2012), an example of fragmentation in the governance of historic landscapes. Still, the application prepared by the Sagalassos team as a result of the intensive survey to extend the first-degree archaeological zone of protection around the site of Sagalassos was approved by the Council the same year. As a result of this application the first-degree protection zone was considerably extended to the east and tripled in size. Currently, widespread stone-quarrying operations in the

Taurus Mountains threaten natural and archaeological heritage throughout the landscapes of southern Anatolia (Kazancı and Kuzucuoglu 2019). There is increased development on a range of natural resources (stone, water, minerals, and so on.) in the wider region, rendering archaeological surveys and predictive modeling important sources for informing decision-making processes.

Illicit excavations detected during survey activities form another way that scientific archaeological survey projects get involved in the conservation of cultural assets in their respective study areas. During the Sagalassos surveys, several such situations have resulted in rescue excavations. A remarkable case was that of Çataloluk 2, where following the observation of illicit digging, the site was partially excavated during the 2011 campaign, exposing part of a Byzantine church (Claeys and Poblome 2013).

More recently, during the survey of the highlands near Dereköy, the first Middle Paleolithic stone artifacts discovered in the region were documented in the flow of an active gully system (Vandam et al. 2017). The heavy seasonal rains and snowmelts responsible for the formation of the deep gullies have now begun to wash out sediment layers dating from the Late Pleistocene to the Early Holocene. The apparent lack of water abrasion on the artifacts has indicated their recent erosion from the walls of the gully, highlighting the need to expedite an intervention in order to preserve the potential for new insights into a little-known period in the prehistory of the region. Toward this end, the Turkish Ministry of Culture and Tourism granted a permit to conduct a rescue excavation on the site for a joint Museum of Burdur / Sagalassos Project initiative. These excavations are still pending at the time of writing, but in light of the COVID-19 pandemic will likely take place during the 2021 field season.

Examples such as these highlight the heavy responsibility but relatively restricted role of survey projects in the process of conservation of cultural heritage in Turkey. More importantly, the cases above underline the lack of an integrated approach to local or territorial development planning where, ideally, all stakeholders would join forces and share knowledge within a planning process to establish a common vision for a sustainable future in the study region. Currently, the service expected from the archaeological survey teams by local authorities is often linked to some ad hoc, emerging cases, such as quarrying or other exploitation applications or illicit digs, requiring urgent action. The challenges to this work, which is initially made possible through awareness of site locations via pedestrian survey, include issues of scale, accessibility, time, and financial constraints. This means that situations where interventions are undertaken—whether in the form of salvage excavations or simply the preservation of the status quo—represent a potentially miniscule proportion of the possible conservation and sustainable management opportunities for the archaeological heritage of the territory. Therefore, the motivation to initiate computational strategies that can extrapolate from and elaborate on existing data from the study area is compelling. This application helps us in investigating given areas and inform the appropriate authorities and stakeholders on the archaeological potential.

The large amount of qualitative data about the settlement pattern of the study area that the Sagalassos site database contains provides us with the opportunity to create strongly data-driven models predictive of the archaeological potential of target landscapes within the region. These types of models were initially developed within archaeology for applications in the context of cultural resource management in the United States in the 1970s and have become widespread since then (Kvamme 1995:3). In this time, two primary purposes of predictive modeling emerged within the discipline (Kamermans et al. 2009, Whitley 2003). The first is the initial intended purpose of informing practices around the management of archaeological heritage resources across large areas. The second primary purpose is to garner a better understanding of past land-use practices, the processes of site selection, and human–environment interactions over time. Utilizing the LAMAP method in the Sagalassos study area is advantageous for both, but the former presents a more immediate opportunity.

In an area of roughly 1200 km^2 containing at least 704 individual *known* sites, sustainable development planning will need to take into account the presence of heritage resources, as noted in the examples above. Predictive models can therefore play a crucial role informing the integrated planning processes, situating archaeological heritage prominently into the agenda. The results of predictive models could also serve other relevant stakeholders—for instance, land developers, quarrying firms, farmers—informing them of the possibility of encountering archaeological remains in the areas in which they wish to invest (Kamermans et al. 2009:10). The utility of predictive models manifests differently depending on the stakeholder in question regarding the management of risks and potentials (cf. Balla et al. 2014, Danese et al. 2014, Kamermans et al. 2009). For the developer or land owner, they may prevent loss of time, productivity, or usable land. For the heritage scientist, modeling on the one hand enhances the preparedness for any future damage to, or loss of, archaeological information, and on the other hand signals the existence of a resource that could be integrated into larger schemes of research and conservation. For the Turkish authorities charged with overseeing the management of Turkey's archaeological heritage, it may serve as a tool for conservation, management and planning, and for efficient use of both financial and cultural resources.

Conclusions

Predictive modeling presents the opportunity for extracting new insights from existing datasets and an indirect means of publication for idle legacy data for long-running projects such as Sagalassos. In addition to being a potent tool in the research toolkit in general, it can also provide a potentially invaluable contribution to managing archaeological heritage resources by identifying archaeological site locations with a high degree of reliability and scalability. Insights garnered through this approach enhance the role assigned to archaeological research projects in the heritage chain of Turkish governance and calls for integrated, collaborative, interdisciplinary planning processes for sustainable local or territorial development. The results of the predictive models can be used to disseminate awareness about the wide prevalence of archaeological heritage throughout the region, and at the same time can inform various stakeholders and authorities concerning modern land-use decisions. Predictive modeling in archaeology can be used as a tool to co-design sustainable futures for historic landscapes, valorizing diverse resources while matching them with the needs and potentials of a territory in a way that would benefit all parties in a balanced and fair manner.

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CHAPTER 5

Closing the Loop on the Digital Data Lifecycle

Reviving a Salvage Archaeology Dataset

Laura K. Harrison

"We know that our understanding of the world is always incomplete . . . ."
Brother Guy Consolmagno, Vatican astronomer
[quoted in *The Pause*, February 22, 2020, published by the On Being Project]

The Interpretive Science of Salvage Archaeology

Archaeology is, by its very nature, an interpretive science, as our records and data regarding the past are always incomplete. Salvage archaeology datasets are highly imperfect, because they are compiled under the pressures of limited time and tight funding. Rather than dismissing these datasets, is there a hidden potential within? What might be gained by viewing records of endangered heritage as historically contingent representations of the social context in which they were created? And, how might an approach that awakens the idiosyncrasies latent in unsorted archaeological datasets and gray literature inform our understanding of endangered heritage in a new light, and provide a local complement to the globalized discourse that currently dominates the conversation about heritage at risk? Finally, what new audiences might we reach with such an approach?

Most archaeological sites lack outstanding universal value (for example, as a UNESCO World Heritage Site), monumentality, or potential as a major tourist destination. These 'average' sites greatly outnumber exceptional or world-renowned sites, yet they are still valuable components of the archaeological record. Moreover, average sites face many of the same threats, due to armed conflict, industrialization, and climate change, that imperil exceptional sites. If heritage is a human right (Zubrow 2018), then the discourse of endangered heritage should consider risks, responses, and opportunities at all heritage sites—not only those singled out as outstanding or inscribed on the prestigious World Heritage List. We can make a compelling case, then, that we should protect and preserve threatened sites, or—in the case of salvage or rescue archaeology—we should ensure that we responsibly plan for excavation, analysis, data management, sharing, and reuse prior to development.

While the charters set forth by international nongovernmental organizations such as UNESCO, ICCROM, and ICOMOS provide valuable guidance on the aspirations of heritage management around the world, they are several steps removed from local conditions that site managers, archaeologists, and other stakeholders regularly engage with on a daily basis at threatened sites. As a result, numerous sites are at grave risk of destruction. Adding to the challenge of preserving and/or excavating these sites is the fact that countries have different laws and statutes governing how these projects should proceed.

The focus of this article is a large body of unsorted data and gray literature from a Turkish salvage excavation. In Turkey, salvage excavations can only take place with the consent of local councils on cultural heritage preservation, who assess the results of the investigations and then decide whether to preserve or destroy sites (Özdoğan 2013). While this might seem straightforward, councils are composed of government operatives rather than academics or archaeologists, which often causes a conflict of interest that is detrimental to heritage preservation and management. In addition, only registered sites receive consideration for salvage archaeology—and although archaeologists have published articles and reports on more than one hundred thousand Turkish archaeological sites, fewer than twelve thousand are officially registered with the government. As a result, Turkey allows the destruction of an incalculable number of heritage sites each year.[1] The salvage excavations that do take place often result in enormous bodies of gray literature and few, if any, specialist analyses. Often, a data-management plan involves securing enough square footage in a storage depot for crates of artifacts and binders of field notes, rather than articulating the design principles of open digital data infrastructures. In this chapter, I explore how Faniel's (2018) digital data lifecycle provides a framework for multimodal engagement with unsorted archaeological data and gray literature. This, in turn, creates novel opportunities for knowledge production, digital data dissemination, sharing, and reuse that revive these often-overlooked datasets.

The Salvage Excavation at Seyitömer Höyük, Turkey

Seyitömer Höyük is a 150 m x 140 m archaeological site that is located 25 km northwest of the modern-day city of Kütahya, in the inland western Anatolia region (Figure 5.1.). Throughout its lengthy occupation, which spans the Early Bronze Age (EBA) through the Roman period (ca. 2500 BCE – 323 CE), the settlement witnessed sporadic periods of urbanization, collapse, abandonment, and resettlement. In the EBA III V-B period (hereafter Phase V-B), which dates to the late third millennium BCE, Seyitömer Höyük reached the apex of its urbanization and operated as a small regional proto-city with burgeoning political, economic, and social complexity that mirrored broader developments in the Kütahya region (Harrison and Bilgen 2019).

Today, Seyitömer Höyük faces destruction due to its location within an active coal mine. The archaeological site sits directly on top of a valuable twelve-million-ton coal deposit, within an active industrial area managed by the powerful state-run Turkish Coal Enterprises (Figure 5.2.). It is neither registered with a local council, nor protected by the Turkish government. In 2006, archaeologists from Dumlupınar University in Kütahya entered into a private agreement with Turkish Coal Enterprises to carry out a large-scale salvage excavation at Seyitömer Höyük. The Turkish Ministry of Culture and Tourism issued the excavation permit; Turkish Coal Enterprises provided funding for the excavation, and archaeologists from Dumlupınar University supervised daily operations. For nine consecutive years (2006–14), the salvage excavation project employed 300 local workers, 50 archaeology students from Dumlupınar University, and several international researchers. As a result, the project excavated 23 m of cultural deposits, which represent all extant remains from the Roman occupation through the Early Bronze III period (ca. 2500 BCE through 323 CE). This remarkable dataset provides an unparalleled diachronic record of the development of Seyitömer Höyük over time.

In 2013, Turkey's Privatization Authority sold the operating rights for the coal-fired Seyitömer Power Plant for $2.25 billion to Turkey's Celikler Inşaat, a government-run coal enterprise. In 2014, a new leadership team, with new priorities, assumed leadership over the coal mine and the archaeological site. This new team was solely focused on ramping up profitable mining activity and was not sympathetic to the idea of funding a salvage excavation. Consequently, the Turkish Ministry of Culture did not issue a permit, and the salvage excavation abruptly ended. A full 13.5 m of

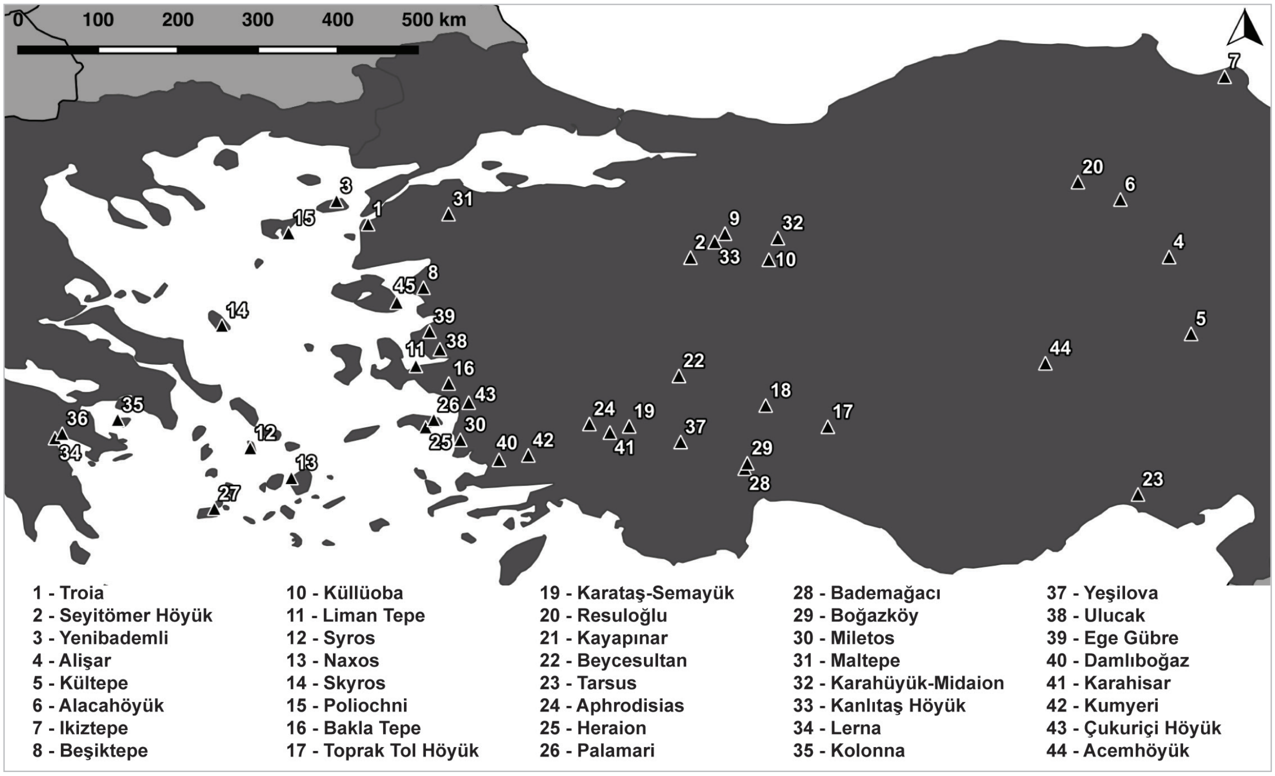

Figure 5.1. Map of Anatolia showing the location of Seyitömer Höyük (no. 2) along with other Early Bronze Age archaeological sites. *Map by Laura K. Harrison.*

cultural deposits were left unexcavated—about one-third of the total volume of the site. These deposits—which a deep sounding suggest date to the important yet poorly understood EBII period—now await an uncertain future. As of 2021, the Kütahya Museum is overseeing a new excavation campaign; however, the long-term fate of the site is unknown. Long-term preservation seems unlikely, given the profitability of coal mining and the proximity of coal deposits to extant archaeological remains.

Management and Storage of the Dataset

The dataset from the 2006–14 salvage excavation consists of hundreds of pages of written documentation compiled into annual excavation reports (in Turkish), an archive of thirty thousand photographs, dozens of binders full of paper field notes and drawings, and CAD drawings of each architectural phase/cultural layer. During the salvage excavation, Turkish graduate students operated separate labs for photography, AutoCAD drawing and mapping, pottery drawing, and pottery reconstruction under the supervision of excavation director Prof. A. Nejat Bilgen. Each of these labs generated enormous quantities of data that are organized and archived in accordance with locally developed systems, vocabularies, and ontologies. The constraints of time, personnel, and budget impeded efforts to conduct further analytical work; simply cataloging the finds and field notes of an excavation of this scale is a substantial undertaking.[2]

Interpretive analyses of the archaeology of Seyitömer Höyük that go beyond descriptive accounts of specific groups of finds, pottery, or architecture are scarce (see for example Bilgen 2021, Bilgen and Kuru 2015, Bilgen and Kapuci 2019, Harrison 2016). This is due to the limited number of researchers working on analysis compared with the vast quantity of data, and the fact that the site changed ownership in 2013 and members of the previous research team were discouraged and even prevented from continuing research on archived excavation materials from previous years. Furthermore, the unpublished annual excavation reports are written in Turkish, which is not a commonly known language outside of Turkey.

Figure 5.2. Photograph of Seyitömer Höyük Phase V-B showing coal-mining activity immediately beyond the site boundary. *Photograph by Seyitömer Höyük Excavation Project.*

The dataset from Seyitömer Höyük is a compilation of the daily efforts of three hundred workers and fifty students; it is a product of social and historical processes rather than a neutral, objective account of scientific fact. As such, it can be thought of as "characterful data" (Cooper and Green 2016). The concept of "characterful data" draws on the broader theoretical movement toward a reflexive archaeology that emerged in the 1980s (Hodder 2000, Cooper and Green 2016:273–74). As Cooper and Green point out, "relationships between archaeological entities and the records they become have elastic properties" (2016:280); they have diverse histories, contents and structures that are riddled with gaps and inconsistencies (2016:294).

Working to digitize, analyze, publish, and disseminate 'characterful' salvage datasets supports the development of a sustainable archaeology. Excavation is destruction, and datasets are a scarce resource. Engaging with the unsorted data and gray literature reports of salvage excavations contributes to the preservation of these valuable resources for future generations. Like antiques in a salvage yard that are passed down through generations, handled by many people, and eventually abandoned, salvage archaeology datasets are often disorganized and full of weaknesses, imperfections, and structural issues. Yet these records have a valuable story to tell. Although it often takes a considerable amount of time and effort to 'decode' and make sense of unsorted data and gray literature, the cost of ignoring these records is a greater loss to our collective understanding of the human past. Taking the time to deliberately parse meaning from salvage archaeology datasets accords with William Caraher's (2016) concept of slow archaeology, which urges archaeologists to embrace the complexity of their subject matter, and push back against the tendency toward greater speed and efficiency that often infiltrates digital archaeology practice. The focus of this chapter is to explore how digital tools can give new life to unsorted data and gray literature, rather than merely speeding up analysis, sharing, and reuse.

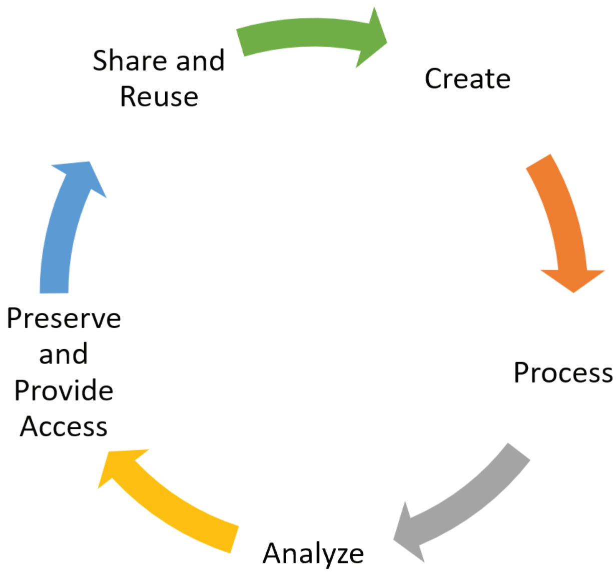

Figure 5.3. The digital data lifecycle. *Redrawn from Faniel et al. 2018: Figure 2.*

The Digital Data Lifecycle

A useful way to introduce digital tools to salvage archaeology datasets is to consider each stage of the digital data lifecycle: create, process, analyze, preserve, provide access, share and reuse (Faniel et al. 2018) (Figure 5.3.). In the following section, I articulate multiple ways that engaging with the digital data lifecycle revives the dataset from EBIII Seyitömer Höyük. These include creating novel digital assets, processing the data to create 3D scientific visualizations, analyzing the archaeology of an Early Bronze Age pottery workshop, digitally preserving the dataset and sharing it in open access, and reusing the data to create a novel educational outreach product: an archaeologically-inspired comic strip and educational outreach activities at schools in Florida and California.

Create, Process, and Analyze

Terrestrial LiDAR scanning and photogrammetry are rarely used at salvage excavations, which have neither the time nor the budget to pursue such advanced 3D documentation techniques. Creating scientific visualizations, which incorporate multiple streams of archaeological data into 2D and 3D representations of archaeological sites, features, and contexts, are useful in the absence of born-digital 3D datasets (Frischer and Stinson 2007). At Seyitömer Höyük, the 'raw data' used to create scientific visualizations consist of AutoCAD site plans, written descriptions, field notes, hand drawings, and photographs. While these data are not as 'objective' as born-digital datasets, they are valuable records that can be utilized (with patience) to create visual content that informs, inspires, and fosters engagement with archaeology.

Three aspects of the dataset from Phase V-B are particularly noteworthy in the context of the archaeology of EBA western Anatolia. These are the planned spatial organization and architecture of the settlement, a unique and innovative pottery workshop complex, and a remarkable deposit of anthropomorphic and zoomorphic pottery found within a centrally located ritual building. Developing 3D visualizations of these notable features of the archaeological record requires the creation of new visual assets, the processing of large amounts of unsorted digital and analog data, and the analysis of broader anthropological issues such as emergent sociopolitical complexity, technological innovation, and ritual practice. These activities correspond to the first three stages of the digital data lifecycle: create, process, and analyze.

Planned Settlement

Details about the planned Phase V-B settlement at Seyitömer Höyük are recorded in hundreds of pages of Turkish excavation reports and field notes. The reports were translated into English, and key information about artifacts, photographs, field notes, and construction techniques was entered into a database.[3] The database includes observations about the presence and characteristics of features such as benches, platforms, ash compartments, utilitarian hearths, formal hearths, kilns, clay-mixing areas, formal pottery production areas, and permanent storage facilities, among others.

The 3D virtual reconstruction of Seyitömer Höyük is informed by a schematic plan that summarizes information about the built environment from the database into a single digital drawing. The remarkable preservation of a 2 m^2 section of collapsed roof in Room 26, made of interlocking wooden trusses covered with a thick layer of reeds, offers insight into the use of wooden elements in building construction, which rarely survive in EBA archaeological contexts. In addition, the wooden door jamb between

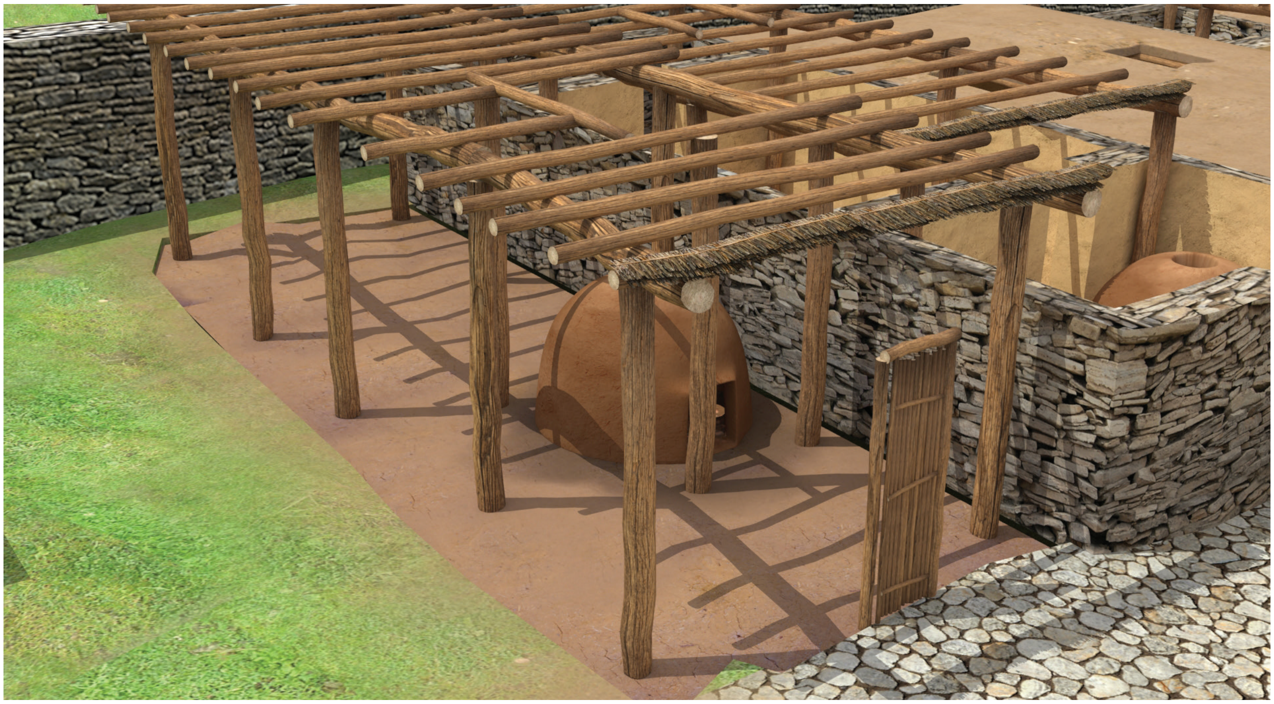

Figure 5.4. 3D reconstruction of wooden posts and roof, based on evidence from collapsed roof in Room 26. *Illustration by Laura K. Harrison.*

Room 39a and 39c informs the digital reconstruction of doors and roofs throughout the entire settlement (Figure 5.4.). Pottery kilns and fire hearths are digitally reconstructed based on drawings and photographs, and actual photographs of features are used to generate texture maps. For instance, the model of the utilitarian hearth is textured with a photograph that shows white charred remains in the center of the clay platform, from Room 27, which attest to repeated use. Likewise, photographs of crushed pot sherds in the base of a pottery kiln are visible in the texture of the digital reconstruction (Figure 5.5.). Because there is very little surviving wall plaster, the texture of plastered walls is derived from photographs of local buildings in the Kütahya region that are built using traditional techniques. The manual process of creating the schematic plan and 3D virtual reconstruction of the settlement in Autodesk 3ds Max is more fully discussed by Harrison and Gürbüz (2018).

The 3D reconstruction of the settlement encompasses approximately thirty buildings interconnected with a simple triangular street system (Figure 5.6.). Domestic structures are situated in two blocks of rowhouses. The structures are arranged into semi-orthogonal blocks, in which buildings abut each other at right angles. Intentional planning is evident in the overall layout of the settlement: domestic buildings are arranged in orderly blocks, and neighboring buildings share party walls. The spatial organization of the Phase V-B settlement remains stable throughout multiple reuse phases. Patterns of pedestrian movement and circulation throughout do not change, despite extensive repair and remodeling of buildings. There is a single freestanding ritual/symbolic building at the center of the settlement, called the central megaron complex. In addition, an architecturally elaborate administrative complex occupies a visually conspicuous location on the highest point of the mound.

A recent a Bayesian analysis of Carbon-14 dates from Phase V-B indicates that the settlement was built, occupied, and abandoned in less than fifty years, which suggests that it was constructed as part of a rapid, coordinated building effort (Harrison 2017). This highlights the emergence in the V-B period of local authorities who communicated hierarchical power nonverbally through the intentional planning of settlements. A key aspect of these changes is the intentional choice to locate ritual/symbolic and administrative buildings in highly visible, or 'imageable' locations (Harrison and Bilgen 2019). The 3D virtualization of the entire settlement

Figure 5.5. A: one of the eleven Phase V-B kilns during excavation; B: the 3D reconstruction of the kiln.
Photograph by Seyitömer Höyük Excavation Project; illustration by Laura K. Harrison.

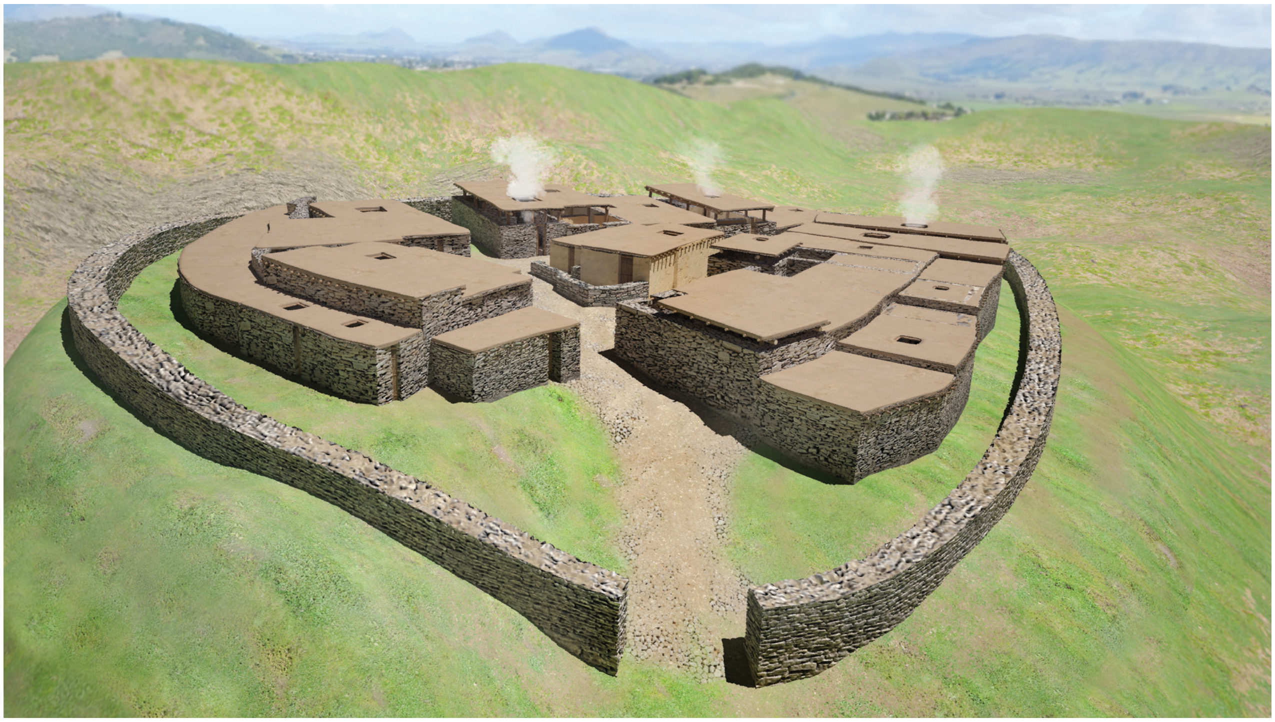

Figure 5.6. 3D reconstruction of Phase V-B settlement at Seyitömer Höyük. *Illustration by Laura K. Harrison.*

facilitates assessment of visual cues embedded in the built environment, including a vernacular architectural tradition and planned spatial layout, which are important for understanding the social changes that accompany the rise of complex societies in the Early Bronze Age.

Pottery Kilns

The economic prosperity of EBA V-B Seyitömer Höyük centered on scaling up the production of standardized pottery shapes for local use as well as export. The archaeological record reveals a proliferation of pottery kilns, a variety of technological innovations in pottery manufacturing, and the emergence of dedicated pottery workshops. These changes suggest a transformation in the social context of pottery manufacturing: supra-household groups congregated in supra-household workshops. In these workshops, specialists produced a large amount of pottery using an innovative mold-based technique that allows for the efficient production of standardized shapes such as bowls, jugs, and pitchers (Figure 5.7.). These technological innovations can be seen as a precursor to the potter's wheel, which appears several centuries later in the Middle Bronze Age.

The pottery workshop complex contains features not found in houses, including multiple clay-lined pits dug into the floor for mixing clay, semi-spherical molds for shaping vessels, kilns for firing pottery, and multiple artifacts associated with finishing, such as burnishing stones and paintbrushes. The absence of domestic features such as hearths and storage containers, along with the presence of multiple features related to pottery manufacture, suggests this area was used by a dedicated group of specialists. These specialists are likely members of several different households who worked together to produce large quantities of pottery in this nondomestic context.

The 3D reconstruction of Phase V-B encompasses these observations about pottery production. The kilns in the pottery workshop complex, which average 2 m in diameter, are all round, dome-shaped structures made of stacked flat stones, with a ventilation hole in the top. The walls are covered with plaster, and the base of the kilns is made of compressed clay, with thick layers of broken potsherds that attest to intensive use. The digital reconstruction of the pottery workshop complex was created in 3dsMax and manually textured with photographs taken during

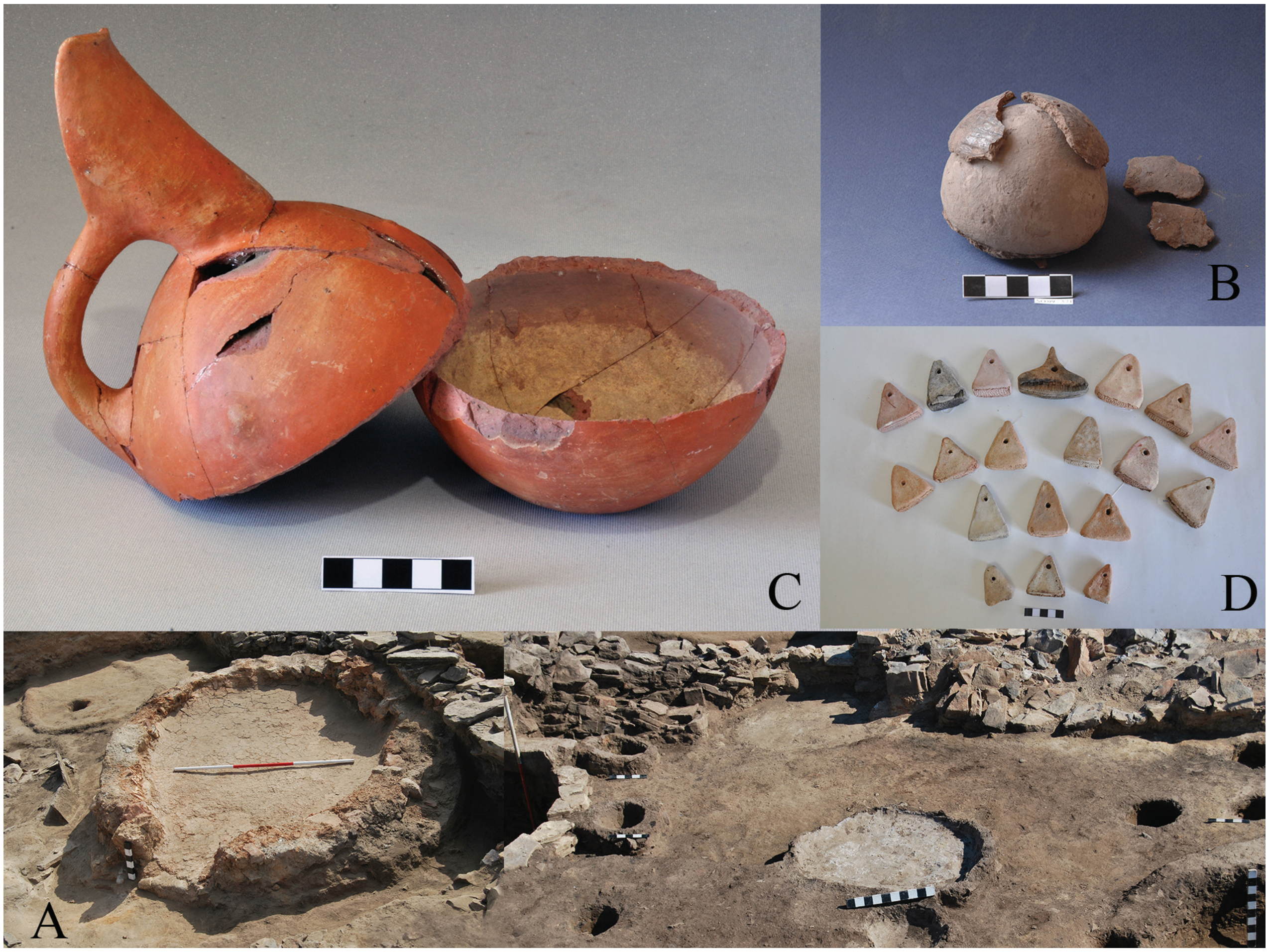

Figure 5.7. At the pottery workshop complex (A), there are activity areas for the mixing of clay and the remains of a large 2 m² kiln. In this workshop, semispherical molds made of terracotta or stone (B) are used to fashion multiple types of vessels, such as spouted pitchers (C). These items are sometimes painted with brushes, such as those pictured in (D). *Photographs by Seyitömer Höyük Excavation Project.*

the excavation (Harrison and Gürbüz 2016). The digitally reconstructed pottery kilns are placed in situ according to their location in the schematic plan. Each kiln represents a confluence of multiple classes of 'characterful' data, brought together in a digital visual format that draws attention to the unique pottery production technology and practices at Seyitömer Höyük.

Ritual Pottery Deposit

The deposit of ritual pottery vessels in the central megaron complex at Seyitömer Höyük consists of a unique assemblage of intact anthropomorphic and zoomorphic pottery vessels, depas cups, and a double bowl.[4] Because of the central importance of pottery analysis in the archaeology of Bronze Age Anatolia, this deposit has received more scholarly attention than other aspects of the site (Bilgen and Kuru 2015, Bilgen, 2021). Many vessels in the ritual pottery assemblage are local imitations of Aegean styles. Except for the cylindrical double-handled depas cups, they are all constructed with the unique molding technique attested in the pottery workshop complex, suggesting local production rather than import (Bilgen 2021). The anthropomorphic and zoomorphic jugs are constructed out of two semi-spherical pieces of clay joined in the center to create a round body. Details such as animal-shaped spouts with human faces are added next. Spouted pitchers are created with a similar technique of joining two semi-spherical pieces of clay and adding a spout and a handle. The bowls start from the same semi-spherical template, and ridges and knobs are added after. The joins between two semi-spherical pieces of clay are clearly visible in photographs taken of the assemblage during excavation.

The ritual pottery deposit was documented with seventy-two photographs taken from multiple angles. Although these photographs were not captured with the express intent of creating a photogrammetric reconstruction, there was a great deal of overlap between images, and they aligned automatically in Reality Capture software (Figure 5.8.). Several iterations of this model were created, corresponding to successive stages in the excavation of the deposit and providing a snapshot of the excavation process as it unfolded. The 3D model was 3D-printed at Access 3D Lab at the University of South Florida, allowing for a tactile experience of touching the seam where the two halves come together (see Figure 5.10).

Preserve and Provide Access

As the field of digital archaeology continues to advance, a disproportionate amount of attention has centered on the value of new technologies in creating accurate representations of sites and objects in an efficient manner. Yet this focus on technological advancements has also led to well-founded critiques of technological fetishism in digital archaeology (Huggett 2004). A holistic approach to digital archaeology requires an active consideration of other stages of the digital data lifecycle, including preservation and sharing. Often, this involves the painstaking work of digital data curation, which aligns archaeological observations with standardized vocabularies and quality benchmarks meant to facilitate reuse. As Faniel and colleagues point out, "in order to be good stewards of the past and make it available and useful to others, we need ways to better align data creation and reuse" (2018: 106). Carrying out research with an explicit focus on digital data curation bridges this gap between the needs of data users and data reusers (Faniel et. al. 2018:106).

Consciously incorporating digital data curation into salvage archaeology workflows is important because information from these projects is vulnerable to loss. Foregrounding discoverability, reuse, and preservation is critical to justifying costly and time-consuming salvage excavation efforts and is a valuable component of the

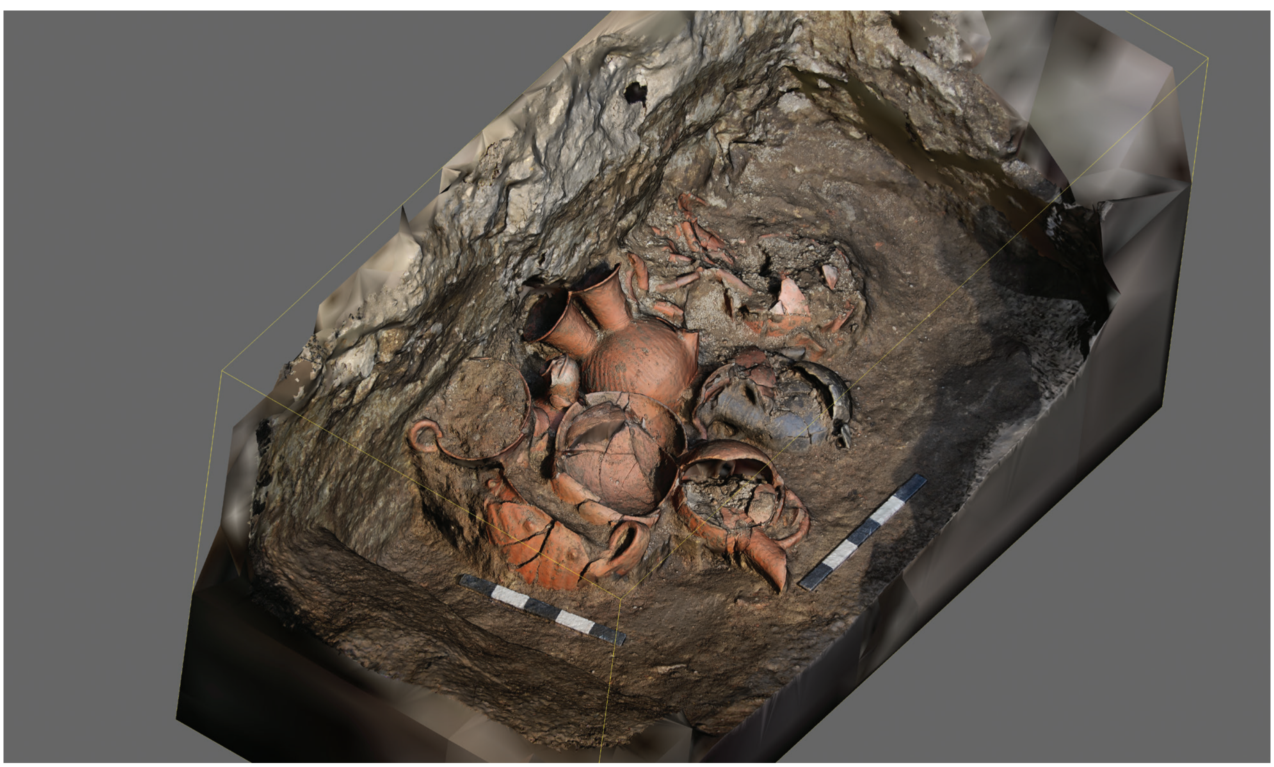

Figure 5.8. 3D photogrammetric reconstruction of ritual pottery deposit. *Illustration by Laura K. Harrison.*

digital data lifecycle. These efforts increase the accessibility and discoverability of archaeological datasets, protect them from loss or destruction, encourage multivocal interpretations of archaeological datasets, and promote reuse in many contexts.

Preparing the dataset from Seyitömer Höyük for Open Context, an open linked data publisher for archaeological sites, requires transparency about data and metadata. This encompasses the use of standardized vocabularies to describe artifacts, architecture, and other finds, consistent measurement, and clear documentation. Yet the dataset from Seyitömer Höyük is messy. It was compiled over the course of ten years, by an excavation team with up to three hundred workers, overseen by fifty graduate students, and working against the clock in challenging conditions. All local documentation is done in Turkish. Daily fieldwork records are 'archived' in binders in the Archaeology Department at Dumlupınar University, in Kütahya.

The interpretive steps involved in cleaning the dataset mask some of the inconsistencies and gaps in the data, for the purpose of increasing interoperability and access. The dataset contains syntactic data anomalies relating to inconsistent numbering of buildings and spaces; semantic data inconsistencies in which there is contradictory information about the phasing of some walls and floors in heavily remodeled areas of the site; and coverage anomalies such as missing data from the northernmost part of the site and also the lack of any evidence for a lower town, which was probably destroyed by coal mining activities prior to the start of the salvage excavation.

While the process of cleaning data of such mixed quality is inherently subjective, researchers can build confidence in future data users and reusers by being transparent about the methods of data cleaning and manipulation (Huggett 2018:98, Kansa 2014). Therefore, contextual information, metadata, and paradata are a core part of the data cleaning process. I added data fields such as the "doorway confidence score" to quantify the number of converging lines of evidence about the location of doorways: every doorway is assigned a score of one to five that corresponds to the degree of confidence in its location. In addition, the built environment is described with reference to clearly defined typologies of architectural elements such as doors, walls, floors, and built features. This contextual information increases the granularity of the dataset, and metadata and paradata about how these categories are defined and their implications with respect to the interpretation of the archaeological dataset are included in the Open Context database (Harrison 2017).[5]

Linked open data on Open Context increases the accessibility of data from Seyitömer Höyük, which otherwise are unavailable to all but a select number of researchers. This dataset from Seyitömer Höyük includes primary data about the architecture, spatial organization, built features, artifacts, and Carbon-14 samples from Phase V-B. It also contains interpretive (secondary) data about the patterns of spatial organization, pedestrian movement and circulation, and a Bayesian analysis of Carbon-14 dates from the site. The introductory text that accompanies these records discusses research that combines a Bayesian analysis of Carbon-14 dates with architectural analysis, which reveals that in a span of just fifty years the Phase V-B was constructed as part of a coordinated effort, occupied, and destroyed by fire (Harrison 2017). This conclusion is derived from analysis of thousands of data records; these records are now available to a global community of researchers who may draw on them to develop alternative interpretations or pursue novel research directions.

Linked open data increases the discoverability of data from Phase V-B and enables interoperability and semantic linkages between this cultural layer and other, related datasets. Yet the Phase V-B dataset remains orphaned from its closest neighbors at Seyitömer Höyük: Phase V-A (Middle Bronze 1) and Phase V-C (an earlier layer of Early Bronze III). Data from these cultural layers are archived only locally in Turkey; they have not been cleaned or uploaded to a repository. This highlights a point articulated by Kansa and Kansa (2014), that open dissemination of data should be incentivized through professional reward systems, to improve data management practices throughout the entire lifecycle of a project. Embracing open archaeology, as articulated by Kansa (2014), at the outset of this project would have yielded a more resilient, comprehensive, and diachronic dataset. This is a potential area of growth for archaeology in Turkey and elsewhere.

Share and Reuse

Sharing and Reuse are often-overlooked stages in the digital data lifecycle. Although data management platforms such as Open Context and tDAR encourage data reuse by validating datasets and utilizing international data management standards, many archaeologists are still disinclined to work with extant datasets and prefer to work with freshly excavated material. Yet data reuse is essential. It supports the development of sustainable archaeological practices and offers an alternative way to explore the many pasts encapsulated in the archaeological record, without needlessly destroying archaeological sites. Analyzing and then reusing datasets is a responsible way to work with nonrenewable archaeological materials, while expanding knowledge and understanding, disseminating data widely, and reaching new audiences.

Much of the discourse about data reuse in archaeology centers on how best to prepare datasets for future research carried out by other archaeologists (Curty 2016, Guidi and Frischer 2020:669–76, Faniel et al. 2018, Huggett 2018). Yet many groups and individuals outside of archaeology may also find these datasets valuable; from indigenous or descendant groups (Garstki 2020: 43–44) to professionals in other fields across the humanities, social sciences and beyond. Adaptive reuse of archaeological materials facilitates playful encounters with the past that revive the regenerative power of replicas and enhance perceptions of authenticity (Di Giuseppantonio Di Franco, chapter 1 of this volume). Furthermore, archaeological datasets are valuable tools for community-engaged co-creation, which can take the form of collaborative storytelling activities that connect the past and present, to democratizing archaeological knowledge production by training community stakeholders how to engage with digital archaeology tools (Bria and Casanova Vasquez, chapter 3 of this volume). These co-creative and playful activities awaken the enchantment of the archaeological record by furthering the potential for surprise, transformation, and imagination (Perry 2019).

The idea for creative reuse of the archaeological dataset from Seyitömer Höyük emerged from dialogues between the author and professional artist Kristin Donner.[6] These dialogues sparked creativity and led to the idea to reuse parts of the Phase V-B dataset as source material for a fictional comic strip, entitled *Mix, Mold, Fire!*. The strip tells the story of pottery production at Seyitömer Höyük through the eyes of Abby the Apprentice, a young female character who works with a corporate group of pottery specialists to produce a double-spouted pitcher for a client (Figure 5.9.). Abby's activities in the pottery workshop complex are analogous to the archaeological evidence for the stages of pottery manufacture at Seyitömer Höyük; from mixing clay, to shaping a vessel, to firing. Furthermore, the pottery vessel depicted in the strip adopts the formal characteristics of the double-spouted pitcher from the ritual pottery deposit in the central megaron complex. Abby's pottery manufacturing activities are divided into horizontal rows, with each row representing a new stage in the *chaîne opératoire* of pottery production. She is accompanied by a fictional sidekick—a playful goat[7]—as she endeavors to create a spouted pitcher to satisfy a client's order.

The comic strip is intended for use in educational outreach for children from preschool through middle school (ages three through ten). It meets Koutníková's (2018) guidelines for conceptual, scientific comics in childhood education by emphasizing visual representation of scientific ideas, a minimum of text in dialogic form, and a scientifically acceptable perspective. During the artistic process of storyboarding, drafting, and revising the strip, care was taken to avoid the pitfalls of misrepresenting natural processes, or the overuse of fantasy to fictionalize the story. The artistic process, and its intellectual underpinnings, are discussed more fully in Donner and Harrison (forthcoming).

A 2019 outreach activity at the University of South Florida Preschool for Creative Learning in Tampa, Florida incorporated *Mix, Mold, Fire!* into a lesson plan that meets the Florida Early Learning and Developmental Standards.[8] The lesson began with a visual introduction to the archaeology of the pottery workshop complex at Seyitömer Höyük on a large interactive touchscreen. Next, the 3D photogrammetric reconstruction of the ritual pottery deposit was displayed (Figure 5.8), and a 3D print of the same deposit was passed around (Figure 5.10). Students were encouraged to engage in active listening through a facilitated dialogue that established the connection between the physical 3D print in their hands and the 3D visualization on the screen.

Excitement permeated the room as students handled the 3D print, a large double-spouted pitcher printed in a

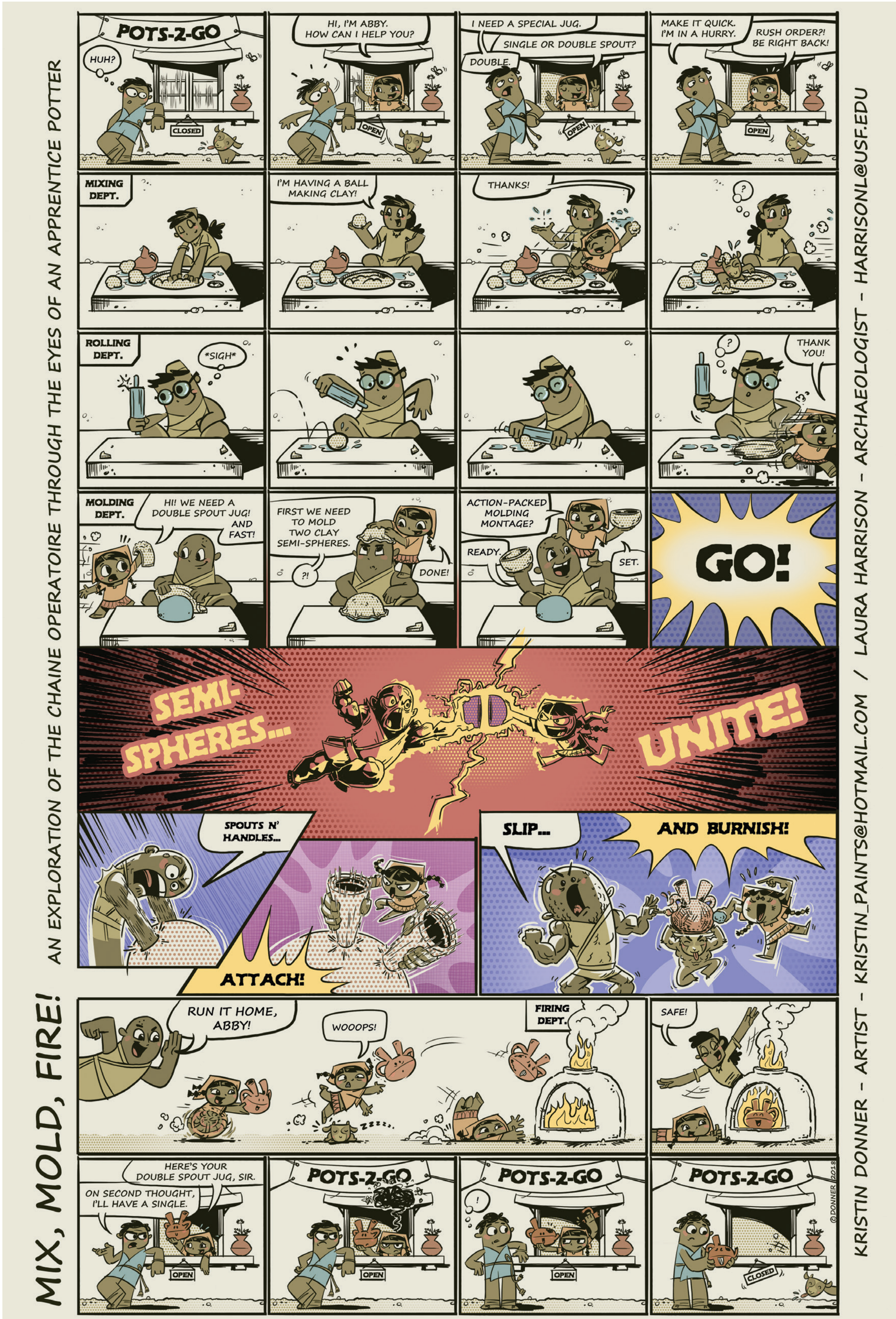

Figure 5.9. *Mix, Mold, Fire!* comic strip showing the misadventures of Abby the Apprentice as she produces a pot for a client using the molding technique attested at Seyitömer Höyük. *Illustration copyright © by Kristin Donner.*

vibrant marine blue. Students were instructed to touch the ridge that encircles the widest part of the vessel's body, where two semi-spherical, mold-made pieces of clay join together. This experience sparked joy among students and even incited some lighthearted competition among students striving to gain access to this exciting new 'toy.' As a result, the 3D print itself sustained some minor damage (see Figure 5.10.). As Di Giuseppantinio Di Franco (chapter 1 of this volume) notes, "play, performance, and the sense of touch are actually crucial elements for the perception of authenticity of past material culture." In this case, encouraging physical handling and manipulation of the object created an intimate connection with Bronze Age pottery technology. Interest in fostering playful, tactile engagement with the 3D print outweighed interest in protecting or preserving it; the PLA plastic print is easy and inexpensive to reproduce. The tactile experience of handling the 3D print and drawing connections with archaeological imagery primed students to think about the technological choices that go into creating a piece of pottery—a key concept of *Mix, Mold, Fire!*. The comic strip was displayed on the screen and introduced to the class with constructive dialogue and visual analysis of Abby's actions. Students then created their own narrative stories inspired by objects from the past, drawing inspiration from a collection of 3D scanned artifacts from Access 3D Lab's Sketchfab page https://sketchfab.com/access3d. One of the most remarkable comic strips to emerge from this outreach activity depicts an artifact coming to life after it is excavated from an underground area by an archaeologist. This suggests that, despite their young age, the student understood the subject matter of the lesson and was able to comprehend the concept of stratigraphy.[9]

A 2018 middle-school outreach activity at Porter Middle School in Los Angeles, California utilized *Mix, Mold, Fire!* to hone chronological and spatial thinking, explore evidence and historical interpretation, and apply analytical skills. The learning outcomes of these

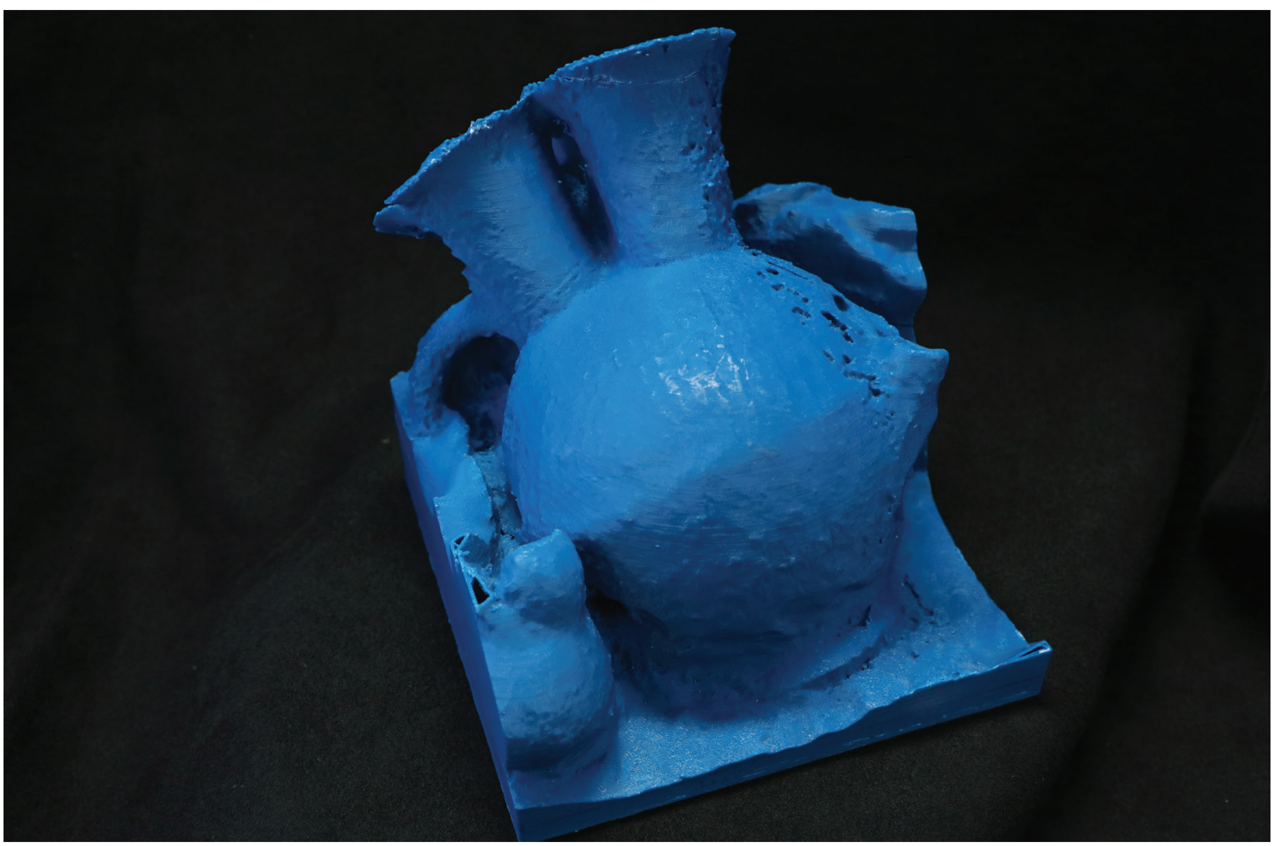

Figure 5.10. A 3D print of the double-spouted pitcher from the ritual pottery deposit at Seyitömer. *Photograph by Laura K. Harrison.*

activities adhere to the Social Science Content Standards for California Public Schools. First, the archaeology of Seyitömer Höyük Phase V-B was introduced with a PowerPoint presentation and visualizations of the 3D reconstruction of the settlement (Figure 5.4, Figure 5.6) and 3D photogrammetric reconstruction of the ritual pottery deposit (Figure 5.8). Next, *Mix, Mold, Fire!* was shown to students as an example of the history of pottery production and the role of trade in connecting people from different cultures. Students then cycled through three experiential learning stations: a virtual reality excavation, artifact sketching, and pottery making. Students were equipped with field notes, including activity-appropriate vocabulary and resources to facilitate discussion. By visualizing archaeology in virtual reality, learning field documentation methods by sketching and cataloging artifacts, and making pottery using molds based on Abby's methods, students gained a deeper understanding of archaeology and expanded their critical thinking and analytical skills—all of which are important components of the Social Science Content Standards.[10]

Conclusion

The scholarly discourse in digital archaeology increasingly emphasizes the use of digital tools to safeguard, document, preserve, and disseminate information about our planet's irreplaceable heritage assets (Tanasi 2020). The possibilities of slower (Caraher 2016), more local and contextual approaches to working with salvage archaeology datasets offer fresh opportunities to expand knowledge, spark engagement, and encourage play. Jeremy Huggett (2018) aptly notes that "while most data do not conform to the characteristics of 'big' data, nevertheless big data analytic approaches are increasingly being applied to 'small' data, aided by the growth of archaeological data repositories and the access they provide to a wider range of data and the aggregation and integration of datasets that become possible as a result" (Huggett 2018:100). Together, these efforts help close the loop on the digital data lifecycle.

Salvage archaeology datasets, which might seem daunting to approach and work with because of their many idiosyncrasies, have hidden potential when incorporated into a framework of holistic digital archaeology. These datasets offer an opportunity to carry out research that encompasses the full lifecycle of digital data, from creation through preservation and reuse. This process encourages a reflexive engagement with the archaeological record, and a full acknowledgment of the limitations and possibilities of 'characterful' data. The payoff for facing these challenges is a sustainable form of digital heritage research that recycles datasets that would otherwise be lost in inaccessible repositories. These practices consider the local context of endangered heritage sites, which complements the overwhelmingly globalized discourse on at-risk heritage. As a result, we can appreciate salvage archaeology datasets as irreplaceable resources with great potential to inform, inspire, and educate.

Acknowledgments

This work benefitted from the support of numerous individuals and organizations. I want to thank Prof. Dr. A. Nejat Bilgen, director of the Seyitömer Höyük Excavation Project, for facilitating the field research on which this study is based. Thank you to Serhat Kurt for finding and preparing the Carbon-14 samples; Semra Kaygısız for the photographs, help with Carbon-14 samples, and discussions about Phase V-B; Asuman Kapuci, for helping with the field school, and many discussions about Seyitömer; Fehmi Yaşar and Erdogan Aktaş, for sharing their AutoCAD plans. Thank you to Kristin Donner for creating the Abby comic and to Aycan Gürbüz for his assistance with creating the 3D models in 3dsMax. A portion of this work was funded by NSF Award 1523389 for the project "Social Process and the Built Urban Environment." No permit was required for this project.

Data Availability Statement

Archaeological records relating to the built environment of Seyitömer Höyük and the Bayesian analysis of Carbon-14 dates are available on Open Context at https://opencontext.org/projects/347286db-b6c6-4fd2-b3bd-b50316b0cb9f. Renders of the 3D reconstruction are available at https://www.behance.net/gallery/31643755/Visualizing-the-Past-at-Seyitoemer-Hoeyuek-Turkey. The 3D photogrammetry model of the ritual pottery deposit is available at https://sketchfab.com/3d-models/early-bronze-age-pottery-deposit-faca91ce51774cb5aa3785abf08b71fc.

Notes

1 Özdoğan (2013) explains that an attempt by the Turkish Academy of Sciences to create a national database of unregistered sites in the year 2000 was hampered by the political action of the local councils, who feared that comprehensively documenting all archaeological sites would inhibit development. While they are almost certainly correct in this speculation, the lack of a coordinated infrastructure for protecting and managing heritage has many implications for the state of Turkey's archaeological sites. The salvage excavations that do occur, at registered sites, use locally developed recording systems and archival methods.

2 Archival materials and artifacts are kept in three locations: at the Dumlupınar University Museum; in storage buildings near the excavation site; and in storerooms at the University, all of which are in the geographically isolated Kütahya region.

3 All translations were done by the author with assistance from Duygu Tarkan.

4 The pottery deposit itself is unique to the site and to the wider region; the closest parallels to the zoomorphic and anthropomorphic shapes lie in the EBA Aegean rather than in Anatolia. In the Phase V-B administrative complex, a group of ten cylinder seals with Syro-Mesopotamian motifs was found in association with an assortment of luxury goods, including dozens of gold pins and several bronze axes. The discovery in Phase V-B of a ritual deposit of pottery stylistically associated with the Aegean, and cylinder seals stylistically associated with Syro-Mesopotamia, suggests that Seyitömer Höyük was a crossroad between the Aegean and Syro-Mesopotamian worlds during the Early Bronze Age. This is covered in more detail in Harrison and Bilgen (2019), Efe and Ilasli (1997), and Özdoğan (2007).

5 The Open Context archive is located here: https://opencontext.org/projects/347286db-b6c6-4fd2-b3bd-b50316b0cb9f

6 Kristin Donner is a professional artist. She has created animations and illustrations and served as co-executive producer in development at Nickelodeon Animation Studio. She was introduced to the archaeology of Seyitömer Höyük during the 2014 salvage excavation field school. The collaboration between Kristin Donner and the author was facilitated by the publication of the Phase V-B dataset on Open Context, which allowed them to bridge the geographical distance between the site itself (located in Turkey), the author (who is based in Florida), and Kristin Donner (who is based in California).

7 The choice to design Abby's sidekick as a goat was informed by the zoomorphic pottery and beads and faunal remains discovered at Seyitömer Höyük, as well as the ongoing pastoral tradition in the region (Bilgen and Bilgen 2015:90, 146). Abby's "POTS-2-GO" storefront also takes artistic license, to communicate the artisan–client trade relationship that was at the foundation to the interregional economic ties and innovations seen at Seyitömer Höyük in Phase V-B.

8 For more information on the Florida Early Learning Developmental Standards, visit http://flbt5.floridaearlylearning.com/.

9 The lesson plan and the students' comics are discussed in further detail in Donner and Harrison (forthcoming).

10 This outreach activity is discussed in greater detail in Donner and Harrison (forthcoming).

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CHAPTER 6

Is Less More? Slow Data and Datafication in Archaeology

Jeremy Huggett

Introduction

Data are fundamental to the practice of archaeology, providing the basis of our claims to knowledge about the past. However, our relationship with data is not straightforward, and has changed through time and with the switch from analog to digital (for example, Huggett 2020a). Currently, the rise of datafication, data-centrism, and dataism represent a shift to what is often claimed to be a new data-focused paradigm (for example, Hey et al. 2009), most obviously represented in the form of Big Data. Big Data can be seen as both a cultural phenomenon and a data-driven mode of analysis (Aronova et al. 2017:3): on one hand, representing a change in the nature of science in which data can assume a near-religious power where belief in it replaces experience and intuition in an 'end of theory' (Anderson 2008), and on the other hand, representing a set of practices based around digital technologies and grounded in access to very large bodies of data. While this has been critiqued in recent years (for example, boyd and Crawford 2012, Kitchin 2014a, 2014b) there remains a perspective that everything is quantifiable, all is computable, and that once digital, data become transformative, malleable, infinitely flexible, all-powerful and all-consuming. Such ideas and practices are embedded within a modern society which demands speed, instantaneous response, rapid development, accelerated output, a belief in more as always better, and the disruption of systems and organizations. One means of resisting this has found its voice in the development of a 'slow' movement which has found some traction in both academic and activist communities in recent years, a perspective in which 'fast' is seen to have lost sight of the individual, of the social, of the importance of quality, and of the value of people and things, resulting in a loss of autonomy and control.

'Slow' data can therefore be seen as a challenge to the developing narratives surrounding Big Data. In its most common form, slow data is related to digital technologies and typically concerned with the speed of data transmission, data transfer, data acquisition, data queries, and the like, placing slow data in opposition to 'fast' and consequently acquiring strong (but not exclusively) negative connotations. However, slow data in the context of the broader 'slow' approach can be seen as resisting the displacement of knowledge in the pursuit of information in the shape of more and more data, while at the same time slow data acts against a belief in data as information rather than as an elemental building block from which information is derived. A key concern of slow data is therefore to emphasize the performativity and essentially creative act that constitutes the creation and subsequent manipulation of data, and to recognize the implications that flow from that standpoint.

One of the first references to 'slow' data in an archaeological context was by Kansa (2016) who defined it as the digitized aspects of Caraher's 'slow archaeology' (Caraher 2013, 2016, 2019), and as "thoughtful digital curation" (Kansa 2016:466), helping to articulate a more sensitive approach to the datafication of archaeology (Kansa 2016:467). Caraher himself defines 'slow data' as embracing "the dynamic and profoundly human character of archaeological datasets as an element of added value rather than distracting complexity" (2016:423). More recently, slow data is defined in terms of "emphasizing curation, contextualization, communication, and broader understanding" rather than maximizing the speed and quantity of data (Faniel et al. 2018:105). Elsewhere in the digital humanities, Prescott and Hughes have described 'slow digitization,' which they define as prioritizing the use of technological and other tools to 'excavate' the layers making up a manuscript over a reliance on rapid access to high-resolution digital facsimiles (Prescott and Hughes 2018) and go on to suggest that "[a]t the heart of a 'slow digitization' approach is a belief that digital scholarship should be eclectic, haphazard, hands-on, and experimental" (Prescott and Hughes 2018). This perhaps brings us back full circle to Caraher, and his conceptualization of 'punk archaeology' (Caraher 2014, 2019).

This summary of a humanities-based 'slow data' suggests that it aspires to a gentler, more thoughtful, considered practice of scholarship. In recent years, a good deal has been written about archaeological digital data in terms of archiving, curation, openness and reuse—not least through the Secret Life of Data (SLO-data) project (Faniel et al. 2018; see also Atici et al. 2013, Huggett 2018, Kansa and Kansa 2018, Marwick and Pilaar Birch 2018, and Harrison [chapter 5 of this volume], for example). Here, however, the focus is on the concept of slow data as practice more broadly defined with a view to situating slow data within the context of a data-intensive archaeology.

About Slowness

Although Honoré (2004) is generally credited with introducing the philosophy of 'slow' and describing the development of the Slow movement, a seminal paper on slow technology was published earlier by Hallnäs and Redström (2001) in which they emphasized the need for more reflection to be built into technology. They proposed the introduction of intentional slowness in terms of the time taken to learn how a technology works, to understand why it works that way, to apply it, to see what it does, and to find out the consequences of using it, thereby encouraging considered reflection about technologies, their tools and affordances (Hallnäs and Redström 2001:203). This very much chimes with the idea of a 'slow digitization' movement that gradually explores and accumulates knowledge and understanding (Prescott and Hughes 2018), as well as calls for an introspective approach to digital archaeology (Huggett 2015a:89).

Of course, the Slow movement extends beyond technology, famously applied to food (for example, Jones et al. 2003), but also to travel (for example, Dickinson et al. 2011), cities (for example, Pink 2008), journalism (for example, Craig 2016), science (for example, Stengers 2018), and academia (for example, Berg and Seeber 2016). All emphasize in different ways the importance of sustainability, a more humane approach, and the value of traditional craft, and broadly represent a reaction against speed in contemporary life. Honoré stresses that slow is a philosophy, not solely a matter of speed or a rate of change:

> Fast is busy, controlling, aggressive, hurried, analytical, stressed, superficial, impatient, active, quantity-over-quality. Slow is the opposite: calm, careful, receptive, still, intuitive, unhurried, patient, reflective, quality-over-quantity. It is about making real and meaningful connections . . . . The paradox is that Slow does not always mean slow . . . performing a task in a Slow manner often yields faster results. It is also possible to do things quickly while maintaining a Slow frame of mind. (Honoré 2004:13)

However, as Caraher noted in his discussion of slow archaeology, slow has been critiqued as being privileged and particularly Western in outlook (2016:422); similar criticisms have been made in other areas of the broader movement (for example, Carrigan and Vostal 2016) where slow is commonly accused of promoting approaches available only to those afforded sufficient status, wealth, and security. Such criticisms tend to overlook Honoré's emphasis on the need to seek balance:

> Despite what some critics say, the Slow movement is not about doing everything at a snail's pace. Nor is it a Luddite attempt to drag the whole planet back to some pre-industrial utopia . . . the Slow philosophy can be summed up in a single word: balance. Be fast when it makes sense to be fast, and be slow when slow-ness is called for. Seek to live at what musicians call the *tempo giusto*—the right speed. (Honoré 2004:13)

Slow is therefore not about the ability of privileged individuals to exert personal agency in order to luxuriously indulge in slowing down and disengaging but is instead a means of actively interrogating and challenging the dominant discourse. As Adams and colleagues emphasize in their discussion of slow research, slow is not about doing less or even necessarily opposed to 'fast', but is "a response, addition, and possible alternative to the newest normative trends" (Adams et al. 2014:180). So Slow is about adopting an appropriate speed suitable to the situation, but it is also about more than speed and balance: it entails resistance across the range of dominant neoliberal rhythms and values, and critiques our practices and ethics. In this respect it reflects arguments surrounding the importance of introspection in digital archaeology, an approach that consciously seeks to understand the processes behind the tools, techniques, and technologies applied in the creation of archaeological knowledge (Huggett 2015a:89). So how does Slow relate to archaeology, and specifically our approach to archaeological data?

On Slow Archaeology

Caraher's discussion of slow archaeology is initially grounded in the traditional Slow movement as developed by Honoré and others, before addressing the implications of digital technologies and the practices they typically engender in archaeology (Caraher 2016). Separately, Cunningham and MacEachern (2016) developed their proposition for a slow ethnoarchaeology around a 'slow science' approach and their perspective that archaeology aspires to become 'big science', based on (among other things) investment in large-scale projects, the use of advanced and expensive analytical techniques, and the increasing use of 'big data' (2016:630). They associate this with a 'fast science,' defined as "managerial, competitive, data-centric, technocratic and alienated from the societies it serves and studies. It involves, analytically, the collision of datasets—the assumption that if data are available on topics that might possibly be related, then statistical comparison of those datasets will yield useful insights" (2016:631) and argue that a move to 'big science' archaeology is dangerous because of a tendency "to dismiss the importance of on-the-ground complexities in their quest to generate grand, high-impact-factor syntheses" (2016:631). Like Caraher, they see 'slow science' archaeology as more engaged, more critical, and more humane with specific reference to craft and artisanal approaches (2016:633–34). They propose that "[a]rchaeology as 'slow science' would embrace an ethical stance . . . including a long-term approach to research, practical knowledge on the ground (and in it), social engagement (both with fellow workers and with communities within which we work) and critical reflections on power relations in the past and the present" (2016:633). Similarly, in his characterization of slow science and 'fast archaeology,' Marila is concerned that methodological streamlining in archaeology will lose sight of the intellectual, technological, and social processes that contribute to a historical awareness of archaeological practice (Marila 2019:105–106).

Both sets of approaches to 'slow archaeology' share much in common, but Caraher's critique of archaeological practice—if not slow archaeology itself—has to date been more widely adopted by others in the discipline as the development of a critical digital archaeology has gathered pace. For example, Perry cites Caraher's slow archaeology when she warns of:

> methodologies that aim to expedite and collapse the interpretative process, that make it even more inaccessible through expensive equipment and bespoke

> or proprietary software, that drive it even further away from the primary fieldwork context by demanding extensive laboratory-based postprocessing, or that heighten divisions between practitioners by further lodging control of and power over the data with an exclusive number of specialists. These same methods usually also claim an objectivity and efficiency that imply they are beyond critique. (Perry 2018:219)

Similarly, Opitz and Johnson apply slow design to their development of an interface to their digital publication of the Gabii excavations: "[O]ur interface should be intellectually rewarding to use and explore, involving users in the process of critiquing and creating meaning out of field data, helping to achieve a 'slower' post-excavation experience by providing reflective, embodied engagement with the archaeological record via 3D representation" (Opitz and Johnson 2015:277). Elsewhere, Morgan and Wright (2018) have discussed slowness in relation to the craft of archaeological field recording, stressing the valuable experience of hand-drawing while at the same time recognizing the benefits of digital methods, effectively echoing Honoré's call for balance. Richardson and Lindgren cite the digital ideal of a slow archaeology in shifting focus from archaeological tools and workflows to questions of intellectual power and influence, fragmented work practices arising from specialization, and data recording and communication techniques that marginalize non-specialists (Richardson and Lindgren 2017:143).

Such discussions of slow archaeology primarily focus on archaeological practice more generally (for example, Huvila and Huggett 2018:95) while there is comparatively limited reference to what might be called slow data beyond Kansa's original definition (Kansa 2016:466) and its subsequent use by him and his colleagues (Faniel et al. 2018:105). That said, data frequently provide the groundwork for discussions of slow practice. For example, Cunningham and MacEachern's conception of a 'slow science' approach to archaeology is underpinned by a concern with the quality of data used in archaeological interpretation (Cunningham and MacEachern 2016:634). In a similar light, Ulguim uses the concept of slow data in terms of properly contextualizing and re-humanizing data to offset the digital de-materialization of archaeological data (Ulguim 2018:199), while the development of the Gabii interface entails designing a reflexive engagement with field data (Opitz and Johnson 2015:277). More explicitly, Perry provides a powerful description of the kind of bad data practice that may be addressed by slow data when she writes that "methods . . . whether digital or not . . . often fragment the data, widen the interpretative gap, drown us in what Caraher calls 'a virtually meaningless mass of encoded data' . . . and eliminate somatic forms of knowledge creation through hurrying, denying, and/or postponing hands-on encounters with the primary material record" (Perry 2018:220). Perry's description provides the background to an instantiation of a more messy and creative data workflow from initial discovery to knowledge creation, which closely parallels ideas concerning slow data beyond archaeology.

The Slow Data Movement

One of the earliest proponents of digital slow data was Few (2013), a data visualization consultant who first laid out the principles behind what he identified as the Slow Data Movement. This was a response to his perception that "[t]he entire point of collecting data—using information to better understand our world and then make well-informed decisions based on that understanding—has been forgotten and is certainly not being achieved in our manic rush to throw more technology at a problem that can only be solved by more carefully using our brains" (Few 2018:71). Highly critical of the rush to 'big data' and its associated marketing as the 'new oil,' Few identified 3Ss to set alongside the 3Vs associated with the classic characterization of big data—what he calls the correcting influence of small, slow and sure against volume, velocity, and variety (Figure 6.1.). In summary, he suggests:

> Data is growing in *volume*, as it always has, but only a *small* amount of it is useful. Data is being generated and transmitted at an increasing *velocity*, but the race is not necessarily for the swift; *slow* and steady will win the information race if understanding is our goal. Data is branching out in ever-greater *variety*, but only a few of these new choices are *sure*. *Small*, *slow*, and *sure* should be our focus if we want to use data more effectively to create a better world. (Few 2018:73; emphasis in original)

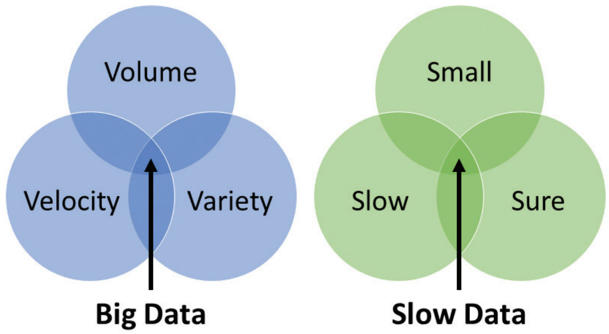

Figure 6.1. The contrast between the classic '3Vs' of Big Data versus the '3Ss' of Slow Data (Few 2018, 71–73).

'Small' Data

Whether archaeological data is small or large in terms of size or quantity is a largely irrelevant question. Size in relation to both big and small data is relative and dependent on factors such as storage and processing capacities, meaning that what in the past was considered to be big is now small, and correspondingly what is now considered to be big will become small in the near future. However, behind the concept of 'small' data lies the perception that increasing the amount (or size) of data does not necessarily increase the information that may be derived from it. This contradicts a common presumption of 'big' data, where more is typically seen as better, and furthermore quantity is seen to overcome issues of quality (for example, Huggett 2020a:S13). Instead, the partial, fragmentary, incomplete nature of the archaeological record suggests that archaeology primarily deals in small data, as does the nature of much archaeological fieldwork which focuses on the region or local site (Dunn 2009:210). Moreover, archaeological data frequently incorporate embedded interpretations, inconsistent levels of uncertainty, and variable expert opinion combined in a set of observations derived across multiple times and numerous places. Indeed, this complexity could itself be seen as constituting archaeological big data (Holdaway et al. 2018:875), echoing Dunn's observation that the humanities are confronted by a complexity deluge rather than a data deluge (Dunn 2009:207): that complexity rather than size is at issue.

Small data can be typically associated with qualitative social science and humanities research methods where, for example, "data tend to be highly particularized and require lengthy time periods to collect because they supposedly offer nuanced reflections and deep topological relations, are embedded in historical and anthropological contexts, and, arguably, lie within human comprehension" (Sieber and Tenney 2018:60). Furthermore, such data are perceived as being more comprehensible and more rigorous: they are limited in size, collected non-continuously, and often generated to answer specific questions (Kitchin and Lauriault 2015:463). All these characteristics are shared with most archaeological data. A key aspect here is that such small data may be scaled up into big data, primarily by combining datasets from different sources and facilitated by large-scale data infrastructures such as have been developed in archaeology since the mid-1990s. Consequently, recent years have seen increasing numbers of meta-analyses which employ large (or big) datasets derived from multiple smaller datasets. In England, for example, the English Landscape and Identities (EngLaID) project, which examined the history of the English landscape 1500BC – AD1086, derived a dataset of around one million records from multiple national databases (Cooper and Green 2016:275), corresponding to a main database of 3GB and over 100GB of GIS data (Cooper and Green 2016:298). In the United States the Southwest Social Networks database, which looked at changing connections between sites in the southwestern United States from AD1200 to AD1450, was based on a database of more than 4.3 million ceramic artefacts from more than seven hundred archaeological sites and more than 4,800 obsidian artefacts from 140 sites (Mills et al. 2013:5785). In both examples, multiple small datasets were combined into a large, if not big, dataset that was subsequently employed to undertake an essentially big data analysis, and, in line with Cunningham and MacEachern's characterization of 'big science' archaeology (2016:631), such meta-analyses were primarily funded through national agencies and major grant awards.

The process of making small data bigger through amalgamation makes them amenable to the same data science and analytics methods as are applied to big data, and they are argued to gain value and utility in the process (for example, Kitchin and Lauriault 2015:473). Equally, the reverse is often true: big data may be required to be scaled down by sampling in order to make it analyzable in the first place, although in doing so it does not somehow acquire the beneficial characteristics associated with small data. This gives rise to a problematic circularity: "big data finds value only when made small, but small data, according to some, achieves value only when it is reassembled into something resembling big data" (Sieber and Tenney 2018:53). This results in what Sieber and Tenney call a "seesaw rhetoric":

> [B]ig data is too big or too fast to comprehend or to manage computationally. It fails to produce value as advertised, so we shrink the data to a manageable size. Small and very small and slow data offer value through purpose-driven data collection, but they can be considered inconsequential for newer analytics, visualization, and, ultimately, insights. Consequently we are urged to employ various aggregations to scale them to big data. But the resultant data may lose their context and become too big to comprehend. So we shrink the data; repeat the rhetoric as needed. (Sieber and Tenney 2018:64)

'Slow' Data

Slow data are typically seen as the inverse of the velocity associated with big data. Big data is classically seen as arriving as fast endless data streams created in real or near-real time from digital sensors and devices. In the process, Beer (2019:48) describes the gap between data and insight closing as we move from post-hoc analytics to analytics that occur in the moment. However, slow data extends beyond questions of speed, and Few (2018:72) emphasizes the importance of slow data for the sense-making that precedes data use: the time taken to understand data in order to use it appropriately. So slow data are gathered painstakingly over time, entailing effort in collection, storage, and processing, and in the process retaining their context, comprehensibility, and organization. This accords with the typical image of the craft of archaeological recording, which even with increasing digitalization remains a relatively slow process for the most part, at least for now. The concept of slow data therefore entails the whole lifecycle of data, from discovery through interpretation and analysis, curation and reuse (see Faniel et al. 2018) with an emphasis on time taken to give meaning to data rather than speed of collection or analysis.

Slow data therefore challenges the intermediation of digital methods that insert distance between archaeologist and their object of study. In recent years, for example, several archaeologists have drawn attention to the way in which engagement with digital data changes the nature of the archaeological encounter with the material remains, whether in the realms of field survey (Limp 2016), field drawing (Morgan and Wright 2018), on-site recording (Taylor et al. 2018), structure from motion photographic recording (Powlesland 2016), and site mapping (Hacıgüzeller 2019), for instance. In different ways, each shows how the ease of data capture, and the quantity, apparent quality, usability, and flexibility of the digital data acquired using digital devices and surrogates can effectively insulate the archaeologist from the physical remains while at the same time recognizing the affordances of digital methods that may offer opportunities to enrich the archaeological encounter. Slow data aims to address this increasingly remote, arms-length relationship with data and their subsequent manipulation, understanding, and analysis.

'Sure' Data

Sure data resists the variety associated with big data as data for data's sake—the heedless and needless acquisition of data—and instead emphasizes the desirability of spending time to do something useful with it instead (Few 2018:73). This could be seen to be an issue in archaeology where there is a strong tradition of conducting research by collecting new data rather than reusing old data collected by others (for example, Huvila 2016), and the lack of opportunity to do something useful with the new data is a common complaint in commercial contexts, for example. Sure data is also associated with a proper understanding of the context of data: "detailed information about the excavation of the remains, the analyst's training and expertise, where analysis took place, which methods and reference materials were used, how the dataset was modified, etc." (Kansa et al. 2020:45). Such contextual information provides the basis for confidence that the data are relevant and appropriate to the question in hand but may be lost with their aggregation into bigger datasets.

The danger of sure data is that it might easily be misrepresented as part of the mythological nature of big data characterized by boyd and Crawford as carrying the "aura of truth, objectivity, and accuracy" (2012:663). In contrast, Wylie writes of archaeology's 'shadowy data,' their fragmentary and incomplete nature and their reliance on the prior knowledge and inferences of those who originally collected them, which makes them "legible only if they conform to expectations embedded in the scaffolding of preunderstandings that define the subject domain and set the research agenda" (Wylie 2017:204). These 'preunderstandings' compound the diversity of formats, data types, and categories associated with the 'variety' of big data and underlines the importance of a slow approach to their analysis.

A Recipe for Slow Data

Famously, Bowker wrote: "Raw data is both an oxymoron and a bad idea; to the contrary, data should be cooked with care" (2005:184). This underlines that data do not exist in and of themselves: data are not 'out there,' waiting to be discovered by the archaeologist, but are in a sense waiting to be created. Bowker's image of 'raw' data is aligned with Levi-Strauss's use of 'raw' as natural or untouched, and 'cooked' as the result of cultural processes (Bowker 2013:168). Importantly, this emphasizes the cultural nature of data such that it is situated, contingent, and incomplete. Archaeological data are more complex still as they arrive through a combination of pre-depositional and taphonomic changes before they are further determined by our ability to recognize, recover, and record what we select from what we are able to see. As a result, these data are theory-laden, process-laden, and purpose-laden, created by different people, under different conditions, for different purposes, at different times (for example, Huggett 2015b:22). This means that data errors, questions of data selectivity, and data and recorder bias are almost impossible to quantify, difficult to allow for, and—often—overlooked or ignored (for example, Atici et al. 2013:667). Yet proponents of big data studies celebrate a data-driven approach to analysis that emphasizes statistical algorithms ahead of context, transforming how the world is understood (for example, Mayer-Schönberger and Cukier 2013:70ff) by doing away with the need for a priori hypotheses, models, or theories in favor of a search for patterns and correlations to which models and hypotheses may be subsequently applied (for example, Gattiglia 2015:115–16). Given the nature of archaeological data, slow or otherwise, this would seem to be problematic (Huggett 2020a:S13–S14). Undoubtedly it would be naïve to assume that all archaeological analysis proceeds through first formulating a theory and then collecting and analyzing data to support or reject it, rather than first searching for patterns in data and then applying hypotheses to interpret them. Nevertheless, theories and preconceptions are embedded in the recognition, selection, and capture of data from the time of their first creation and any subsequent reuse. Consequently, archaeological hypotheses, theories, and models both precede and follow data analysis, even if this remains unrecognized at one or other end, or indeed both ends, of the data capture and analysis process: they are embedded in data capture and reuse, in the selection of methodology, and in the interpretation of the analytical results. Nor can it be assumed that applying big data analytics to small data necessarily escapes the big data theoretical bind, since those tools and technologies will be ingrained with the big data data-driven ethos (for example, Resnyansky 2019:2). Slow data approaches challenge a wholesale move to data-driven analysis and recognize that the complexity of archaeological data requires a more considered and nuanced approach (see Huggett 2020a:S14–S15).

If we are seeking to carefully cook our data, how might we develop a slow data methodology for archaeology? In the absence of an existing archaeological recipe, we might draw on experience from elsewhere. For example, Strauss and Fuad-Luke developed a series of Slow Design principles for product design that were used to interrogate and appraise ideas, processes, motives, and outcomes at every stage of a design from conception to completion (Strauss and Fuad-Luke 2008:3). These principles were criticized for their abstract nature that made them difficult to apply and were subsequently revised (Grosse-Hering et al. 2013, see also Grosse-Hering 2012). Here they are adapted again with a view to cultivating a slow approach to archaeological data (Figure 6.2.). The resulting interrelated principles are:

Reveal

Slowness helps to create an awareness of things often overlooked or otherwise forgotten: for example, considering our different shades of ignorance in relation to data provides a means of better understanding the role of data in the creation of archaeological knowledge (Huggett 2020b). Slowness provides the space to consider what Cooper and

Green call the 'characterful' nature of data: "they have diverse histories, contents and structures and are riddled with gaps, inconsistencies and uncertainties" (2016:294). Critically, the origination of a data object may be revealed along with the processes used in its creation and any subsequent alterations.

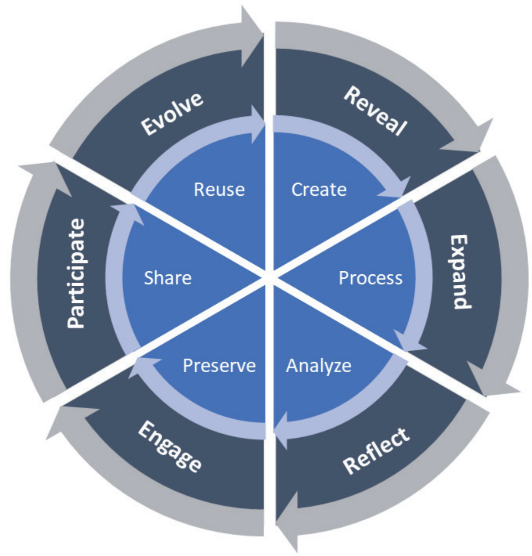

Figure 6.2. Juxtaposition of the data lifecycle (after Faniel et al. 2018, inner ring) and slow data principles (based on the slow design principles of Strauss and Fuad-Luke 2008, outer ring) to demonstrate potential synergies between the two approaches to data.

Expand

Slowness helps to create a bigger picture of the data through an appreciation of the functionality and attributes of data and their interdependencies. In a sense this involves both zooming into the data (to understand its constituents and characteristics at a field and record level) and zooming out (to understand how it relates to other data within the immediate data environment and potentially with datasets elsewhere), switching theoretical lenses to examine practices, relationships, and dependencies associated with data (see Huvila and Huggett 2018:92–94).

Reflect

Slowness helps to create a reflective space to consider the biographies of the data. For example, Strauss and Fuad-Luke talk about the object as a site of discovery, infused with layers of meaning (2008:5), which we might see in terms of the potential value of the data as objects (or materials) of study in their own right, which in turn provide insights into the archaeological approaches and working practices that created them (Cooper and Green 2016:295). Similarly, Strauss and Fuad-Luke refer to the preciousness of an object born of its ephemerality (2008:5), which resonates on several levels with archaeological digital data.

Engage

Slowness helps creates space to recognize the collaborative aspect of data: they are created by different people at different times, even on the same site during the same season. As Cooper and Green suggest, underlying data are "a whole series of other relationships and practices involving people, archaeological materials, organizations, technologies of various kinds (digital and otherwise), and so on, that have sometimes unfolded over a very long time period and that are always evolving" (2016:279). Engagement extends to sharing to ensure that interpretations evolve into the future.

Participate

Slowness helps create a thoughtful space to actively reconfigure data for different purposes. This reworking of data for a specific analysis other than that which was originally intended means that we participate in its (re)creation and contribute to the reflection and engagement referred to above. For example, the data might require modification to resolve issues associated with syntactic, semantic, or coverage anomalies, but may also require refocusing and refining in order to address new research questions. In the process a new variant of the original data is created, underlining that data are "an interpretation of the phenomenal world, not inherent in it" (Drucker 2011), and emphasizing the interpretative, observer- and user-dependent, nature of data.

Evolve

Slowness helps to recognize that data are dynamic, changing and growing over time, accumulating new uses and applications, and consequently it is important to consider how the data might be used beyond the lifespan of the research in question (Cooper and Green 2016:298) and how our use may have altered those possibilities. In this way, the processes associated with slowness become agents of both preservation and transformation (Grosse-Hering et al. 2013:3433).

Although these slow data principles have been framed specifically within the terms of data practice, it is interesting to set them alongside the SLO-data lifecycle (Figure 6.2.). This considers the range of data practices through research design, data capture, data use, data dissemination, and data preservation with a view to facilitating data reuse (Faniel et al. 2018:106), and there are a number of clear synergies with the slow data principles discussed here.

Slow Datafication

The process of foregrounding data and data-driven analysis characterized by datafication is argued to go significantly beyond digitalization to have a profound impact on archaeology (Gattiglia 2017:34), but this highlights the need for careful critical reflection around the implications of these approaches. For example, Kitchin describes big data as a disruptive innovation capable of reconfiguring how research is conducted and proposes that "a potentially fruitful approach would be the development of a situated, reflexive and contextually nuanced epistemology" (2014b:1). This is precisely the realm of slow data. As discussed above, at present most big data applications in archaeology are constructed by merging or aggregating different databases together, but this requires a host of simplifications to be made in terms of data selection, categorization, the elimination of outliers, and handling data that are difficult to align because of differences in recording, purpose, or custom. The set of decisions taken in this pursuit are often far from transparent, a situation which is compounded by simplifications made by those who came before us, each with their own 'preunderstandings.' Consequently, these resultant big datasets—together with the small data themselves—are not natural objects, and any patterns observed arise through a combination of the sets of layers of abstractions, reductions,

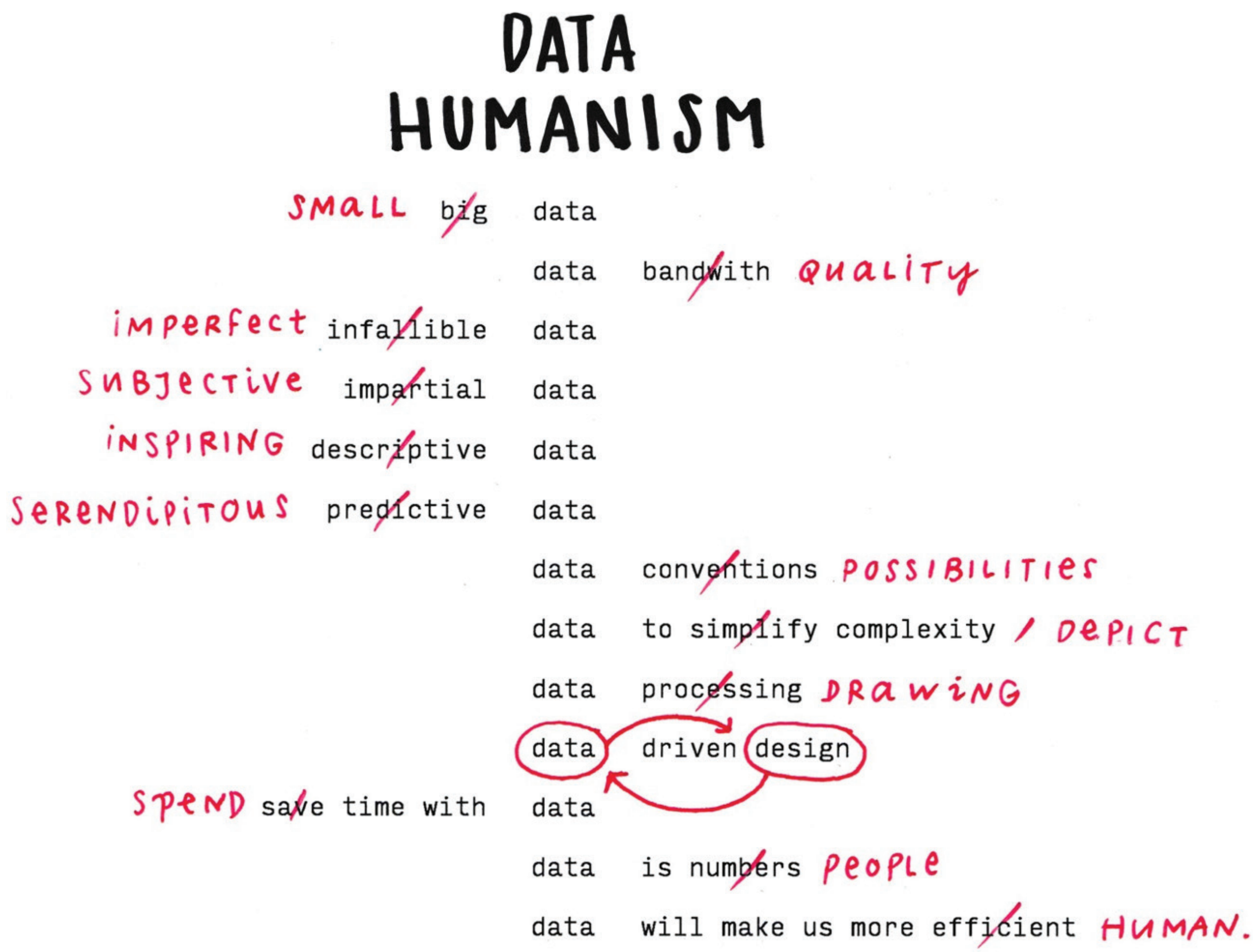

Figure 6.3. Data Humanism—A Visual Manifesto, by Giorgia Lupi (2017). Reproduced with permission.

and standardizations. A slow data approach recognizes, challenges, and resists this, contributing toward a proper degree of reflexivity by ensuring a closer, more intimate relationship with data (see Richards-Rissetto and Landau 2019:125). A slow data approach also stands in opposition to the new empiricism identified by Sørensen (2017) and others (for example, Marila 2017, 2019) since it encourages a nuanced attitude to data rather than assuming that data are largely self-evident and that articulation of them is straightforward (Huggett 2020b).

One of the risks of a slow data approach is the way in which it can be construed as a privileged, conservative, even luddite approach, out of touch with commercial realities, rather than a necessary active process of engagement with data. As discussed above, such a negative perception is a common objection across the Slow movement, and the 'slow' label itself may be unhelpful because of the connotations associated with it. 'Data mindfulness' rather than slow data (following Grosse-Hering et al. 2013:3439) might present a more suitable image as emphasizing heightened consciousness and awareness of data. However, like 'slow,' mindfulness is often appropriated by Western capitalist neoliberal forces (for example, Forbes 2019:25ff), which may again undermine its value as a label. A less loaded alternative might be 'data humanism,' a term used by Lupi to describe her work on information design (Lupi 2017), and her 'visual manifesto' has strong associations with many of the concepts behind slow data (Figure 6.3.). Data humanism resists impenetrable computer-generated infographics that lose their connection to meaning and understanding, and favors a more human-scale, craft-based aesthetic that Lupi sees as promoting slowness. In much the same way, we might see data humanism as encapsulating the reflexivity of slow data through its revelation, expansion, reflection, engagement, participation, and evolution.

Strauss, founder and director of the Slow Research Lab, defines Slow Research in almost archaeological terms as aiming "to inspire both philosophical and practical pathways for recuperating the pieces of a fragmented culture," seeing slow processes "as sites of disruption, dialogue, and deepening of understandings" (2018:57). Indeed, she suggests that archaeology offers many useful lessons and metaphors for the Slow movement, in particular relating to archaeological work on identity, on knowing and getting to know ourselves (Strauss 2018:60). Especially relevant in the context of slow data, Strauss specifically references Edgeworth's analysis of how we unfold evidence in archaeological excavation (Strauss 2018:61, Edgeworth 2013), which underlines that archaeology—and slow archaeology—can contribute something back to the Slow movement as well as benefiting from it.

As Lupi (2017) argues, our data can give rise to many different rich and dense stories while at the same time recognizing that those data are highly subjective and abstracted from the world. Slow data, or data humanism, seeks to find the space in which to tell those stories about the world, and to create the narratives about the data themselves. It is "an approach that is less deliberate and more intuitive; less predictable, because more imaginative; less rational and more poetic; less conclusive and more friction-full, because more inclusive" (Strauss 2018:57).

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CHAPTER 7

Scientific Dissemination of Archaeological Interpretation of Airborne LiDAR-derived Data

Benjamin Štular

Introduction

NASA archaeologist Thomas Sever is responsible for the first attempt at using airborne LiDAR data in archaeology in 1984–85 (Sheets and Sever 1988). However, at the time not even NASA had the computer power to make use of the data. As the technology matured, airborne LiDAR drew the wider attention of archaeologists in the 2000s (for example, Barnes 2003, Holden et al. 2002, Motkin 2001, van Zijverden and Laan 2004) and by the end of that decade it was established as a 'new' tool in the archaeological remote-sensing toolbox (for an overview see Opitz and Cowley 2013, Štular 2011). At the end of the second decade of the new millennium the potential for the method continues to grow, limited only by the availability of affordable computing and free or inexpensive datasets with nation- or state-wide coverage. Especially in heavily forested areas, there is up to a tenfold increase in the quantity of archaeological data for projects employing archaeological interpretation of airborne-LiDAR-derived high-resolution digital elevation models (colloquially referred to as LiDAR DEMs). Successful examples include entire cityscapes in a tropical forest (Evans 2016), more than one hundred thousand potential archaeological sites in a single German state, Baden-Württemberg (Hesse 2016), or thousands of prehistoric features recorded—and over one hundred thousand estimated—in the Slovenian landscape of Knežak (Laharnar et al. 2019).

However, after several years of preliminary reports in scientific journals on 'revolutionary' discoveries, the truly profound paradigm-changing impact of airborne LiDAR data on archaeology is still absent. For a while, it seemed that it was just a matter of time for the projects to be published in full. However, after conversing with many of the leading European specialists, a common theme emerged: the sheer quantity of the data prevents timely publication in the format that would adhere to the current standards for scientific publication in archaeology. In the meantime, the resources that the teams working on airborne LiDAR have already invested in data-processing and mapping require scientific (that is, professional) recognition, thus precluding the release of 'raw data.' The outcome of these circumstances is often the hoarding of data in the hope that the funding for the final publication is just around the corner. Corners don't turn, years pass. Such a predicament is not unique to airborne LiDAR, but is a recurring theme in several fields of digital archaeology. Solutions, therefore, must not and cannot emerge in isolation but rather in the context of digital archaeology as a whole, to which this volume is dedicated.

Airborne LiDAR in Archaeology

Airborne laser scanning (ALS), commonly referred to as airborne LiDAR, is a remote-sensing technique widely used for recording the landscape surface for different applications, archaeological prospection among them. The process of data acquisition is well established (for example, Doneus et al. 2008, Kobler et al. 2007, Wehr and Lohr 1999). The laser scanner—usually mounted on an airplane, a helicopter, or recently a UAV—emits optical laser light in pulses in different directions across the flight path toward the earth's surface. The time it takes for a pulse to return to the sensor is a measure of the distance between the laser head and the ground. The laser measurements are georeferenced with accurate differential global positioning systems and inertial measurement units that record the angle orientation of the sensor to the ground. This equipment allows for measurements of surface elevations with an accuracy in the centimeter range. The sheer quantity of laser pulses—up to 500,000 per second—enables sensors to 'penetrate' vegetation canopies, allowing the underlying terrain elevation to be accurately modeled (for example, Dong and Chen 2018:19–26, Petrie and Toth 2008). As a rule of the thumb, it can be said that if a person standing in the forest looking at the sky can see even the tiniest bits of the sky, then airborne LiDAR will be able to scan the ground.

The result of such scanning is a huge amount of 3D measurements. These measurements are first processed into a 3D point cloud, from which various products are produced, suited to many different purposes. In archaeology, the most important product is a representation of the surface topography in digital format called a digital elevation model (DEM). The processing of data specific for archaeology is a four-stage process, from raw data acquisition and processing, point cloud processing, and derivation of the products to the archaeological interpretation and dissemination and archiving (Lozić and Štular 2021; Figure 7.1.).

Ideally all four stages would be implemented with archaeology in mind. The most important requirement in data processing for archaeology is the noise-to-detail ratio. In archaeology, high detail–high noise is preferred to lower detail–low noise. In archaeological practice, however, data processing (Figure 7.1., stages 1 and 2) is often blackboxed (Doneus and Briese 2011:59, Doneus et al. 2020:93, Lozić and Štular 2021:1, see also Latour 1999:183–85). Custom 3D point cloud processing is becoming more and more common, thanks in large part to the software LAStools. The importance of DEM interpolation is still underestimated and typically only the most rudimentary algorithms are employed. In contrast, most archaeological studies implement custom DEM visualization(s), which is a result of intensive methodological development in the past decade (see for example, Figure 7.2.). With this in mind, it is clear that in current archaeological practice of airborne LiDAR-derived data processing, the importance of custom data processing is still too often disregarded, and the importance of the operator's decision-making is underappreciated (Doneus et al. 2020:93, Doneus and Briese 2011:59, Doneus and Kühtreiber 2013:33–34, Lozić and Štular 2021:1–2, Opitz and Cowley 2013:6, Štular and Lozić 2020:2).

The results of the processing described above may be manipulated to create enhanced visualizations of airborne LiDAR-derived high-resolution DEMs (for example, raster grid cell size 0.5 m). These are interpreted by archaeologists with "a combination of perception and comprehension" (Parcak 2009). A successful archaeological interpretation of this data relies on a user-determined, knowledge-based interpretation that includes complex pattern recognition and the ability of the interpreter to recognize, identify, and classify complex landforms based on experience and previous archaeological knowledge (Challis et al. 2008, Crutchley 2009, see also Parcak 2009). The process, therefore, is based on a substantial body of knowledge on the one hand and on objective decision-making on the other hand. If this process, by which an interpretation is developed, is documented, it is by definition a process of scientific knowledge creation.

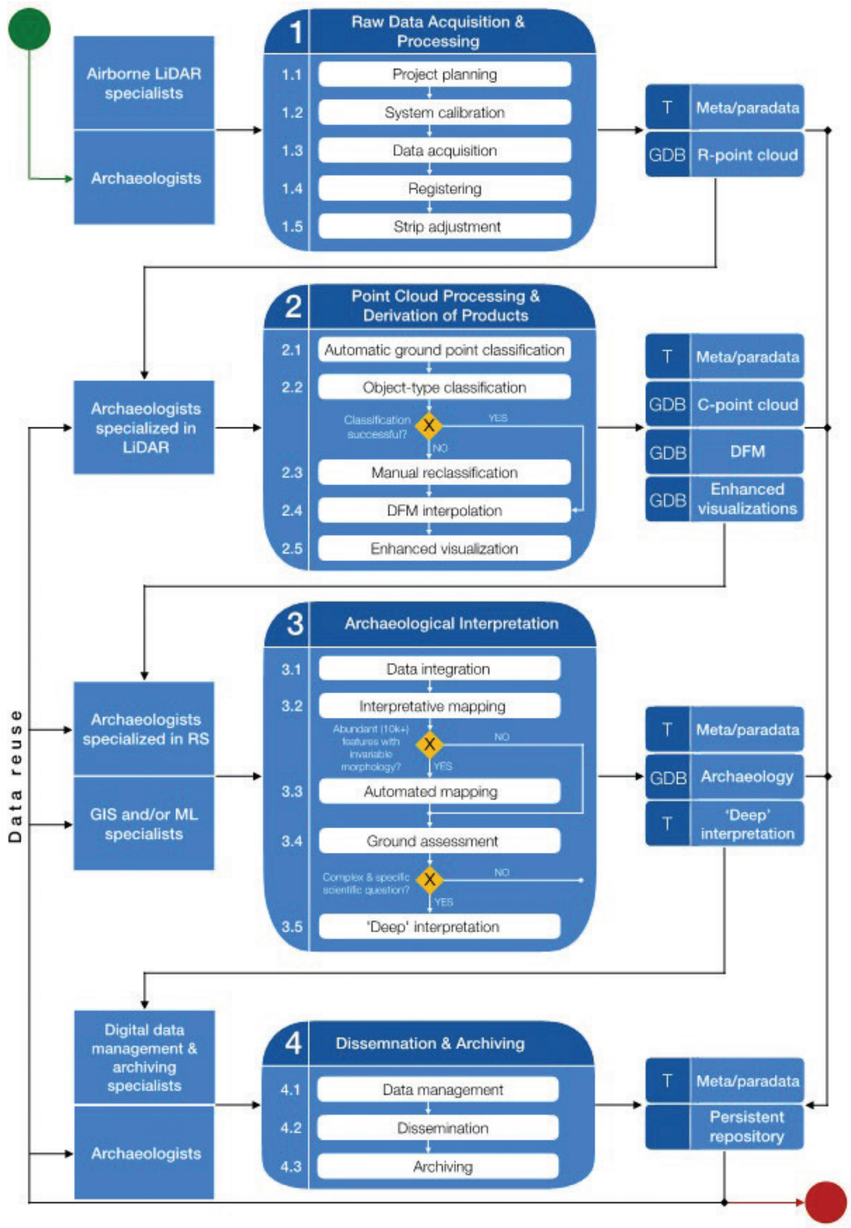

Figure 7.1. Context data-flow diagram (DFD1) of archaeology-specific airborne LiDAR data processing. Symbols for external entity, process, data flow, and data store are based on Gane and Sarson's (1979) notations, but with additional notations for data store types: GDB—geodatabase, T—(textual) descriptive data store. *After Lozić and Štular 2021, Figure 1*.

The archaeological interpretation of airborne LiDAR-derived data, most often in the form of enhanced visualizations, has proven to be very successful in the detection of various archaeological features, ranging across houses, ramparts, trenches, ditches, fossil fields and terraces, past land division, abandoned quarries and mining areas, burial mounds, ancient roads, and other elements of archaeological landscape and sites. It has been successfully applied for archaeological prospection in flat and undulating agricultural regions (for example, Challis et al. 2008 with earlier references, Buteux and Chapman 2009, Corns and Shaw 2009, Crutchley 2009) as well as forested slopes on hilly or mountainous terrain (Devereux et al. 2005, Doneus et al. 2008, Sittler 2004, Štular 2011) and even in tropical jungles (for example, Beach et al. 2019, Chase et al. 2010, 2011, Evans 2016).

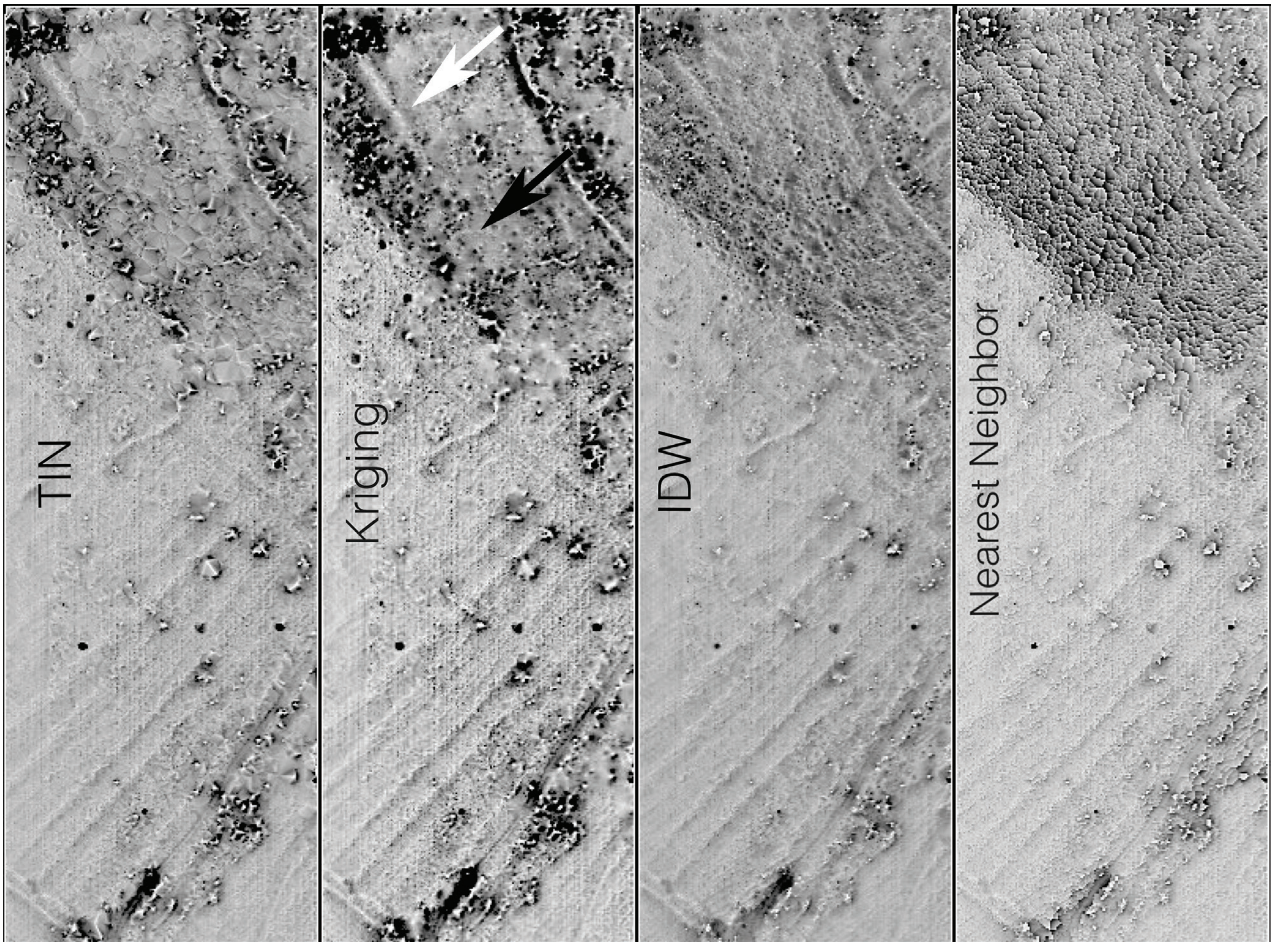

Figure 7.2. Nadleški hrib Roman military camp (Slovenia), an extract showing the eastern ditch. Four different interpolation algorithms (from left: triangulated irregular network, kriging, inversed distance weighting, and nearest neighbor) of the same airborne LiDAR-derived data are shown. The white arrow points to the section of the ditch visible on all visualizations, the black arrow points to the section detectable only with the kriging interpolation. *Image by B. Štular and E. Lozić.*

In many contexts, airborne LiDAR is the most prolific method in archaeological prospection. The ability of the airborne LiDAR to map the ground surface beneath most types of vegetation canopy is particularly relevant. No other remote-sensing method in archaeology is able to consistently produce excellent results in such environments. It can be said without reservation that in forested areas, airborne LiDAR has eclipsed past incremental improvements in remote sensing in archaeology. Typically, in such environments, this method increases the number of known archaeological features between five- and tenfold. Such an increase in quantity and quality of data sheds entirely new light on our understanding of conflict landscapes, archaeology of movement, settlement archaeology, and even paradigmatic changes to broad topics such as prehistoric settlement in the circum-Adriatic region. It is also forcing archaeologists into completely new research directions (such as infrastructural landscape).

At the same time, it is important to caution against overly high expectations (see Crutchley 2009), as the potential for data is unevenly distributed, both across the discipline and across different landscape contexts. For example, the benefits for archaeology of cave sites or industrial archaeology are limited, and urban areas have significantly lower potential than forests.

Knowledge Production Process

The above description demonstrates that the processing of airborne LiDAR-derived data in archaeology has reached a stage of methodological maturity. However, a profound paradigm-changing impact is still missing. One of the key reasons for this is the lack of ubiquitous scientific dissemination of archaeological interpretations of airborne LiDAR-derived data. It is only such publications that will enable extensive engagement from the larger archaeological community and it is only such extensive engagement that will spur the profound impact on archaeology. The reason for this may seem superficial at first. In most airborne LiDAR research projects, huge amounts of archaeological interpretations are produced, mostly in the form of geodatabases. However, huge amounts of archaeological interpretations are almost never published (no such example is known to the author at the time of writing). One possible solution would be sharing of the data, in the geodatabase format for example. But currently, this solution is not sustainable due to the lack of professional recognition, the additional labor required to prepare the data, and the lack of suitable repositories (see Selhofer and Geser 2015).

Anecdotally, the number one obstacle for such publication is the lack of time and resources to prepare a 'full publication' in the format that adheres to current standards for scientific publication in archaeology. These standards mandate physical dating evidence and ground assessment, in addition to the archaeological interpretation of detected features. The former is by far the most time-consuming part of the process, especially for a typical laboratory-based team of airborne LiDAR specialists with finite resources. As an example, we can look to the case of Knežak, Slovenia. Archaeological interpretation of the airborne LiDAR-derived data took about two months, and yet field assessment has been ongoing for three years. In that time, less than 10 percent of the features have been investigated on the ground, and even there, ground assessment provided little or no new information (Figure 7.3.). The estimated cost of trial trenching and Carbon-14 dating of 10 percent of all features discovered is approximately two million euros, twenty times the cost of the original mapping.

To make this more tangible, we can look to a Europe-wide simulation. 43 percent of EU countries are forested (Cook 2018, see also Fuchs et al. 2012; Figure 7.4.), and by 2020 airborne LiDAR data will be accessible for most of the area. If we use the most conservative estimate for the increase of known archaeological features in forested areas (five-fold), there is potential for a 215 percent increase in known archaeological features on the EU scale. Ground assessment of such an immense quantity of newly detected features would take generations of archaeologists to investigate.

This, however, is not a superficial logistical problem but one that it is deeply rooted in archaeological practice. Landscape archaeology, and perhaps archaeology in general, is a field-based discipline, as summed up in a candid description by Johnson:

> In landscape archaeology, a central arena of everyday practice is 'the field.' The encounter with primary data in the field remains central in the hearts and minds of archaeologists. 'Direct field experience' is routinely cited as a primary determinant of evidence. A routine device in the praise of archaeologists is to praise the length and arduous nature of their time in the field. (Johnson 2012:518)

In other words, airborne LiDAR-derived archaeological data obtains the status of archaeological information only upon assessment in the field. That this act is colloquially known as 'ground-truthing' is telling.

That is not to deny the pivotal position of 'the field' in the knowledge production process. Firstly, there is the indispensable data gathering; artifacts and dating samples must be obtained and interviews with locals must be conducted. Furthermore, there is an undeniable positive effect in a set of bodily practices and sensibility gained during the field work (for example, Johnson 2012:518–21). Therefore, 'the field' is and will remain a vital part of archaeological practice. What I argue is that the laboratory-based archaeological interpretation of airborne LiDAR-derived data is a knowledge production process in its own right, just as much as the bodily experience of fieldwork or interpretation of an artifact. Hence, its dissemination must be awarded the status of scientific text (for example, scientific article, scientific monograph). Similar trends can be observed in other disciplines that strive toward the acceptance of executable scientific publications (Strijkers et al. 2011) and

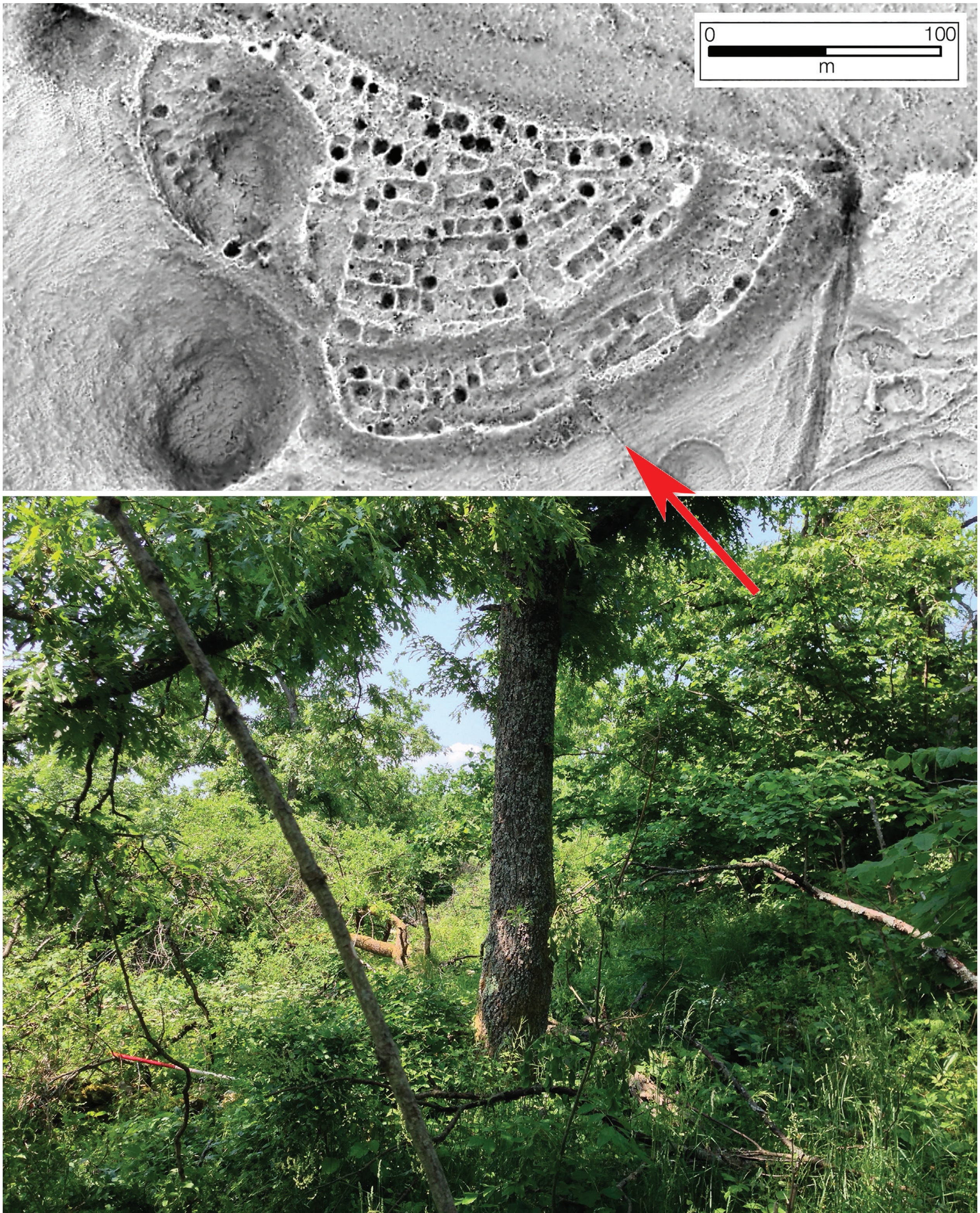

Figure 7.3. Knežak (Slovenia) hillfort. Compare the information value of the photograph taken in the field (view from southeast toward the hillfort entrance) with that of the visualization (image fusion based on SVF and openness) of the airborne LiDAR-derived high-resolution (0.5 m) DEM. *Image by B. Štular and E. Lozić.*

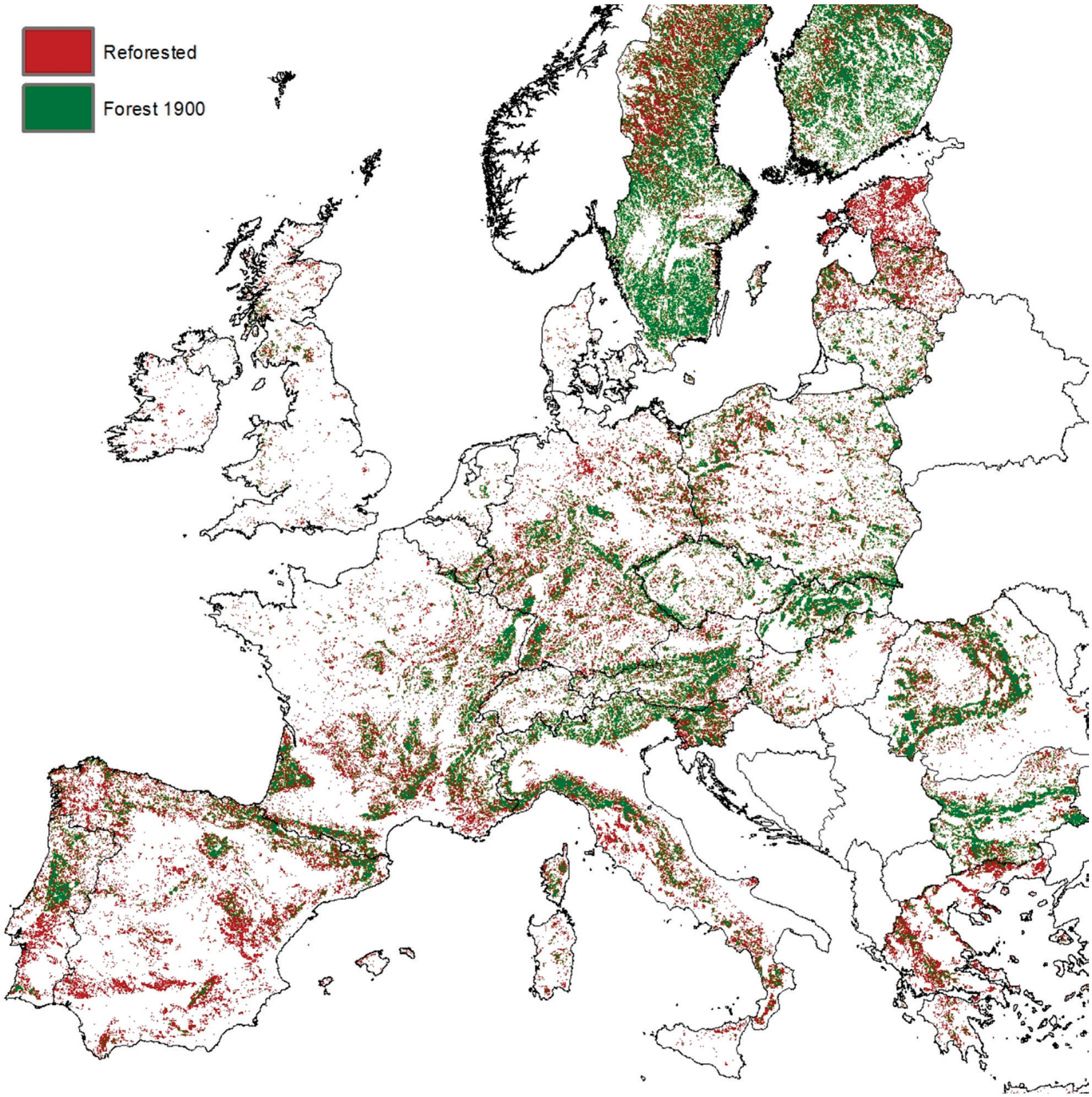

Figure 7.4. Forests in EU countries—green: 1900; red: reforested after 1900. *Sources: Fuchs et al 2013, Fuchs et al. 2014. Image by B. Štular.*

data papers (Li et al. 2019). Once this is accepted by the archaeological community, one major obstacle for large-scale dissemination will be removed. As a consequence, the field assessment process will be distributed among the interested archaeological community; each feature mapped can be inspected at any time in the future as funds, need, or scientific interest arises.

Scientific Dissemination Platform

The above demonstrates that to use the enormous potential of airborne LiDAR, archaeology must evolve as a science and devise coping mechanisms. The key is to accept laboratory-based archaeological interpretation of airborne LiDAR-derived data, as well as other 'digital work,' as a scientific process. To this aim, the practitioners must make big strides to make this process as transparent and as repeatable as possible. The dissemination platform proposed here is a backbone for this mechanism.

A clear distinction must be made between what is proposed here and the undertakings for scientific recognition to publish high-quality research data with appropriate documentation and alignment to accepted standards (for example, Kansa and Kansa 2014, Pfeiffenberger and Carlson 2011). In the case of airborne LiDAR-derived data in archaeology, a DEM that is custom-processed for archaeology is suitable for data publication. The key focus here is on archaeological interpretation, which is a model example of scientific interpretation. However, granting this type of archaeological interpretation a status of scientific interpretation in itself is not sufficient, since current scientific publication platforms are not well suited to this aim. This is often the case with digital-born data, as elaborated by several papers in this volume.

A brief overview of archaeological publication platforms where airborne LiDAR is a common topic is warranted. Inspecting a few of the most commonly used—*Journal of Archaeological Science, Remote Sensing, Antiquity, Archaeological Prospection*—reveals that a) most are still also published in print, but b) most are predominantly disseminated as digital files in pdf format; c) some offer attachments (such as GIS files), but d) attachments are rarely accessed by readers (as can be conjectured by the lack of citations), and e) the publication process is either lengthy (for example, more than one year) or rushed (like one week to implement reviewers' remarks).

An overview of the contents is also revealing. Firstly, unless paradata and/or metadata are the subject of the article these are rarely published in any detail. This absence is sometimes taken to the absurd, when for instance a visualization of airborne LiDAR-derived DEM is referred to simply as a "LiDAR image." This, however, is often at least in part the result of editorial policy and/or peer-review process that deem these data unnecessary. Secondly, there are no accepted standards for graphical representations of the archaeological features that are crucial to this subject matter. For example, when the features in question are only hinted at by arrows or similar icons, the reader is put at a considerable disadvantage; they lack the context for the process of interpretation and the aids used by the author(s), such as different visualizations, different scales of observation, or supporting cartographic and/or remote-sensed data. Thirdly, visualizations of DEM are currently the best documented segment of the entire process, yet different visualizations of the same (set of) feature(s) is rarely present.

Therefore, I would like to suggest that a new dissemination model is needed to 1) adhere to the accepted standards of scientific publication, and 2) overcome the current shortcomings. The primary interface of the dissemination platform must conform to existing expectations in order to be recognized by the target scientific community. This includes text and elementary figures published in pdf format that can be printed by those who want it in paper form. However, this format on its own is not sufficient for dissemination of this particular type of information. For example, the size of a printed map of a typical medium-sized case study of 10 by 10 kilometers at an appropriate scale of 1:2000 is 5 by 5 meters, and a sheet with metadata for ten thousand features is approximately forty pages long. The new format must enable a seamless fusion of reading experience with that of browsing maps in a digital, GIS-like environment. In addition, the envisaged dissemination model must be designed to mitigate other identified shortcomings by achieving the objectives outlined below.

The first objective is to enable the process of archaeological interpretation to be as transparent and as repeatable as possible. This can be resolved by a rigorous control over and publication of a) paradata, which describe the modeling process and data sources, b) standardized per-feature metada for archaeological interpretation (such as visibility, visualization used, interpretation/chronology description, interpretation/chronology confidence level), and c) standardized mapping conventions for archaeological features.

The second objective is to enable the rapid process of metadata and paradata publication. One of the key reasons why metadata and paradata are so rarely published in their entirety is that it is a tedious and lengthy process. However, this can be significantly alleviated by embedding the following services in the dissemination platform: a) a standardized online form for metadata and paradata entry (provided but not mandatory), b) metadata standards for archaeological interpretation (such as template GIS files) that will, if properly implemented throughout the process of archaeological interpretation, significantly shorten the effort invested in per-feature metadata description, c) collection of metadata for commonly used data sources (for example, if the same acquisition parameters have been used for an entire country/state, metadata must only be published once), and d) certain metadata parameters can be created automatically from the data attachments (for example, raster resolution).

The third objective is to provide assistance in the review process. In the current practice of scientific publication, there is a pressure on rapid publication. However, speeding up the established process is more often than not based on pressuring the voluntary reviewers and authors into rushing respective tasks. This can lead to diminished thoroughness of both parties. To this end, partial automatization of the review process for selected qualitative (for example, metadata and paradata entered via the online form) and quantitative (for example, presence/absence of per-feature metadata) parameters would be available as an aid to both authors and reviewers. This is to say, validity checks (presence/absence of technical content) can be automatized so that the reviewer can focus on the scientific content.

The fourth objective is to reach the target audience. As mentioned, the publication format must enable seamless fusion of the pdf-reading experience with that of browsing maps in a digital GIS-like environment, enabling the following: a) seamless back-and-forth transition between basic (text reading) and advanced (GIS-like environment) functionality, b) basic search capabilities, foremost in connection with the text of article (for example, particular features mentioned in the text must be seamlessly identifiable), c) inspection of various DEM visualizations in 2.5D and 3D, d) dissemination, including (but not limited to) at least the four most commonly used visualizations (relief shading, sky view factor, openness, color-casting; see Kokalj and Hesse 2017), and e) per-feature metadata.

The technical platform to achieve these objectives could be based on an open-source service for 'visual media' files, such as ARIADNE visual media services (Ponchio et al. 2016, Štular et al. 2016). This service already provides easy publication of complex visual media assets on the web powered by open-source software 3DHOP (Potenziani et al. 2015) and Relight. This, or similar, service could be built upon with custom solutions suited for airborne LiDAR, such as large 2D images, 3D models, and hyperlinks to data. This solution should be integrated with an open source journal management and publishing platform, such as Open Journal Systems. For example, a pilot within the ongoing ARIADNEplus project will be built on the d4science (www.d4science.org) Virtual Research Environment.

Conclusion

"As all archaeologists now use digital tools in some, if not most, aspects of their work, we have the responsibility to critically interact with these tools and their potential impact on the way we do archaeology." These are the words with which Kevin Garstki invited participants to the conference from which this proceeding stems. Airborne LiDAR-derived data are no exception but rather a prime example of this. The use of these data in archaeology has produced an unprecedented amount of new data in the last few years, but the knowledge production process is mostly poorly documented, often blackboxed, and the data remain unpublished. Therefore, the benefits for archaeology as a discipline remain limited. The obstacles were long perceived to be logistical in nature and the solution seemed to be just around the corner. However, corners didn't turn and years passed. It would seem that it will take nothing less than a shift in landscape archaeology from being a predominantly 'ground-based' science to become an at least partially 'data-led' science. This will enable large-scale dissemination of archaeological information that in some environments will be on an unprecedented scale. In turn, this will trigger engagement from a larger archaeological community and the potential for paradigm-shifting archaeological discoveries on a regional scale will be unlocked.

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CHAPTER 8

Exploring 3D Data Reuse and Repurposing through Procedural Modeling

Rachel Opitz, Heather Richards-Rissetto, Karin Dalziel, Jessica Dussault, and Greg Tunink

Introduction

Most contemporary 3D data used in archaeological research and heritage management have been created through 'reality capture,' the recording of the physical features of extant archaeological objects, structures, and landscapes using technologies such as laser scanning and photogrammetry (Garstki 2020, ch.2; Magnani et al. 2020). A smaller quantity of data are generated by Computer Aided Design (CAD) and Building Information Modeling (BIM) projects, and even fewer data are generated through procedural modeling, the rapid prototyping of multi-component three-dimensional (3D) models from a set of rules (Figure 8.1.). It is unsurprising therefore that in archaeology and heritage, efforts around digital 3D data preservation and accessibility have concentrated on high-resolution 3D data produced through scanning and image-based techniques (Hardesty et al. 2020; Richards-Rissetto and von Schwerin 2017).

Establishing best practices, cultivating a community of experts, and developing infrastructure for this kind of 3D data in the archaeological and cultural heritage domains have been the focus of several coordinated efforts in Europe over the past decade (Fresa et al. 2015, Remondino and Campana 2014, Taylor and Gibson 2017, Vecchio et al. 2015). A series of European projects including 3D-COFORM, CARARE, and their successor projects, made particularly notable contributions (D'Andrea et al. 2013, Kuroczyski et al. 2014, Papatheodorou et al. 2011, Pitzalis et al. 2011, Remondino and Campana 2014). These projects were primarily oriented toward 3D data captured as part of conservation and heritage management work. Issues of preservation, accuracy, fidelity, access, and associated ethical issues of ownership, stewardship, contextualization, and interpretation were, appropriately, the center of extended disciplinary debates (for example, Magnani et al. 2018, Santana Quintero et al. 2019, Ulguim 2018; and more broadly on digital ethics Dennis 2020 and Richardson 2018). File size, geometric complexity, the diversity of 'standard' formats, evolving platforms for delivery, and presentation online posed challenges that continue to re-emerge today (for example, Digital

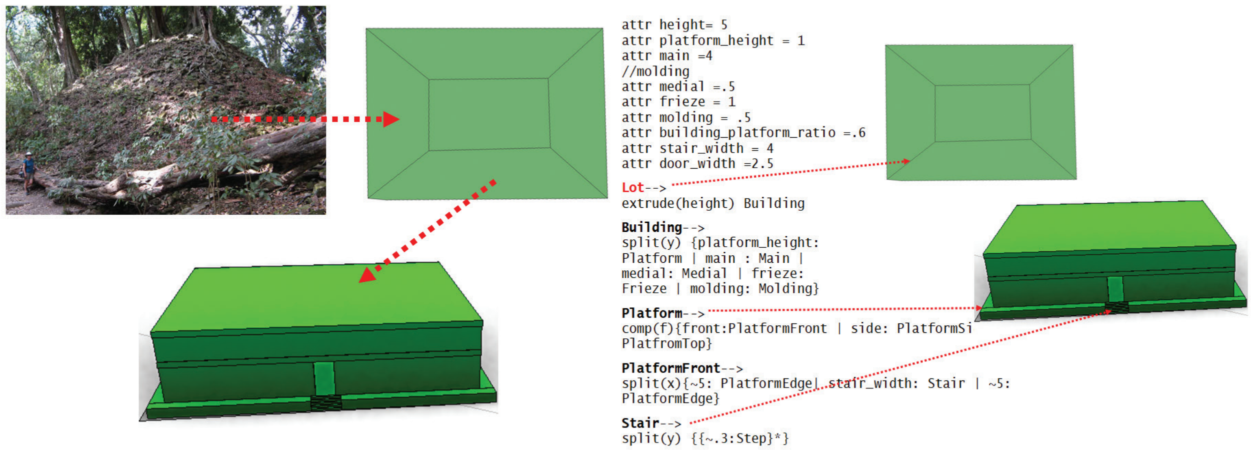

Figure 8.1. Scripted rules for procedurally generated ancient Maya architecture. *Source: MayaCityBuilder Project.*

Lab Notebook http://culturalheritageimaging.org/Technologies/Digital_Lab_Notebook/, Jensen 2018a, Koutsoudis et al. 2020, Münster et al. 2016, Rahaman et al. 2019, Rourk 2019).

To these efforts, heritage practitioners working in the context of architecture and urban development communities added workflows and tools designed to make CAD- and BIM-produced 3D models FAIR (Findable, Accessible, Interoperable, and Reusable). Such work provides a foundation for broader efforts to make data in 3D digital archaeology and heritage FAIR (Apollonio et al. 2012, Leventhal 2018, Pocobelli et al. 2018, Saygi et al. 2013, Wilkinson et al. 2016). These CAD and BIM projects also advanced the development of archaeological information infrastructures and workflows for 3D data by incorporating more extensive use of paradata, while also grappling with issues of uncertainty and intellectual transparency in the interpretive modeling process (Bentkowska-Kafel et al. 2012, Denard 2012).

In contrast, procedural modeling's geometrically simple, lego-like 3D models have received little attention from the community concerned with digital 3D infrastructures, standards, and practices (Coelho et al. 2020). Various sectors employ the approach to create multiple virtual reconstructions (simulations) and to explore alternative constructions and arrangements with varying properties. These multiple, nesting-doll reconstructions redeploy components such as buildings in different arrangements according to diverse rules (Figure 8.1.). In archaeology, they have been used to investigate ancient Roman, Greek, Egyptian, and Maya cities in connection with core research questions about the emergence, character, and experience of urban life (Dylla et al. 2009, Fanini and Ferdani 2011, Kitsakis et al. 2017, Piccoli 2014, 2016, 2018, Richards-Rissetto and Plessing 2015, Saldana 2014, Saldana and Johanson 2013, Sullivan 2017, 2020).

This modeling work affords new types of analysis such as visibility, mobility, and acoustic studies, and fundamentally aims to lead to new knowledge and reinterpretations of ancient cities (Coelho et al. 2020). For example, Elaine Sullivan (2020) employed Geographic Information Systems (GIS) with procedural modeling to re-contextualize monumental structures within the broader landscape at ancient Saqqara in Egypt across 2,500 years to explore the role of visibility in constructing a sacred funerary landscape. Through the process of procedural modeling, she integrates archaeological, art historical, and spatial data to simulate potential past landscapes of Saqqara to interpret (or reinterpret) notions of Egyptian culture. Through 3D WebGIS, she allows others to not only see the procedurally generated landscapes, but also interact with them. (Figure 8.2. illustrates a generalized procedural modeling process.)

The affordances of the infrastructures designed for 'reality-capture'-generated 3D models and CAD/BIM models are, perhaps unsurprisingly, not well suited to the needs of the procedural modeling community, as they were not designed with this community's requirements and practices in mind. Procedural modeling prioritizes 'concept capture,' the recording of scholarly interpretation via hypothetical

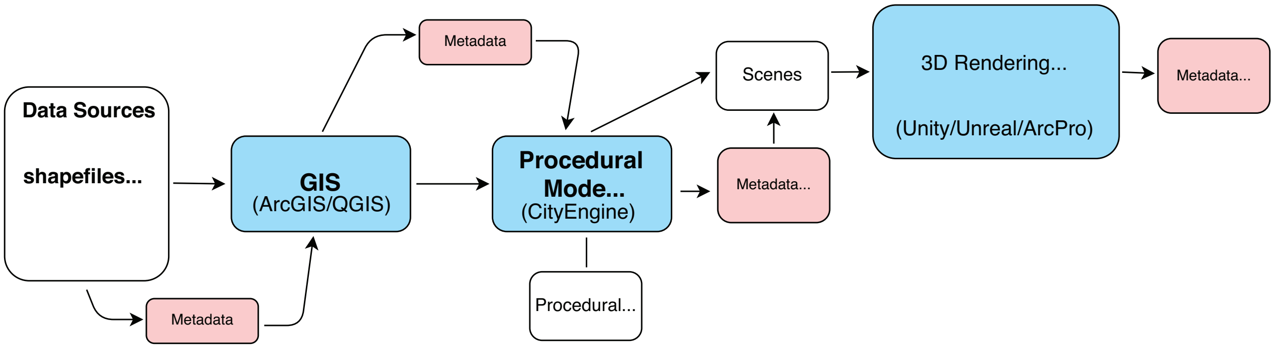

Figure 8.2. Generalized procedural modeling process, illustrating key points at which metadata and paradata are created or transferred.

models and multiple simulations. Consequently, it has different data preservation and accessibility requirements in two basic yet important ways. First, reuse and repurposing of data for archaeological reinterpretation are integral to its practice. Procedural modeling involves remixing and re-contextualizing multiple data sources, allowing us to explore and understand connections between different ideas and intellectual legacies represented by varied reuse of elements in different models. This emphasis on reuse contrasts with the emphasis on preservation and access often associated with reality-captured 3D. Second, 3D procedural models are geometrically simple but contextually and semantically complex. It is essential that information on the models' biography is legible and updated through the reuse process. Their geometry is valuable primarily as an explicit, mutable conceptual representation of an object or structure. Pragmatically, the systems with which these models need to be interoperable are different; tight integration with the systems used to reproduce procedural models is of primary concern. These requirements differ significantly from those for reality-captured 3D and CAD/BIM generated 3D models, which center on archiving, visual presentation, and interaction of the 3D geometry (Beetz et al. 2016).

The aim of the "Keeping 3D Data Alive: Supporting Reuse and Repurposing of 3D Data in the Humanities" (KDA) project was to design an information infrastructure and workflows to meet these requirements, while making procedural models FAIR. In making the data more readily available, citable, remixable, and intellectually reusable, we hoped to enrich procedural modeling as a research practice that produces archaeological knowledge through repeated reuse, recombination, and reinterpretation of 3D models. In undertaking this work, looking beyond the FAIR framework and open research agenda, we reflected on the priorities of the procedural modeling community and considered what makes a 3D model valuable in the context of procedural modeling-based research. Three practices emerged that we suggest should be enabled and encouraged through infrastructure design in order to support the broader aims of this community. These are generous reinterpretation, reflexive strategies of collaboration, and engagement with the biographies and intellectual legacies of (digital) things, which we discuss in detail below.

Aims and Choices in Designing the KDA Infrastructure

The KDA infrastructure intends to generate, store, and make accessible 3D procedural models of architecture in an open-source repository, linked to an open-source 3D viewer that allows scholars to reuse and repurpose 3D entities to create reconstructions ranging from individual buildings to entire cityscapes. In its initial development phase, we designed and constructed a prototype infrastructure and workflows to export and import 3D procedural models along with metadata, paradata, and descriptive attributes that trace use-biographies, allowing for scholarly reuse and citability. The initial development phase prioritized functionality, which supports citability because it was viewed as critical to enabling data reuse between projects and to encouraging scholars to take full advantage of the richness of the 3D data medium as part of academic publications.

Core Infrastructure Components and Workflows

The three core components of the KDA infrastructure design are script-based integrations with CityEngine, a Repository, and a 3D Viewer (Figure 8.3.). The project developed metadata schemas, selected supported files types, and designed back-end infrastructure and workflows around these key components.

To link the three main components of the infrastructure, we developed workflows to: 1) export 3D models along with metadata and paradata from City Engine using a Python script; 2) import the models with associated data into an open source repository that could assign a DOI (and track use-biographies); and 3) import models from the repository into a 3D online viewer for reuse with real-time geometry, metadata, and paradata changes tracked and stored in the repository (Figure 8.4.). The workflows aimed to minimize steps, standardize processes and outputs across user experiences and setups, and mitigate user error—all factors that affect data reuse. The scripts automatically perform the required tasks to ensure that the metadata, paradata, and attributes are standardized and packaged for export and import into the repository and 3D viewer.

Design Choices for the Repository

We designed the KDA infrastructure to complement and be interoperable with procedural modeling software such as ESRI's City Engine. It allows users to export 3D procedural models from proprietary software using standardized workflows and python scripts for import into an open-source repository. In the original project design, infrastructure was constructed around PostgreSQL—a widely used open-source relational database popular in the archaeological GIS community (see von Schwerin et al. 2013, von Schwerin et al. 2016 for details on MayaArch3D Project). However, because libraries are the main data stewards in the United States, we redesigned the infrastructure to use a Fedora repository, reflecting infrastructures commonly used in the libraries community. We were encouraged in this design choice by recent efforts in preservation and access of 3D data within libraries led by Community Standards for 3D

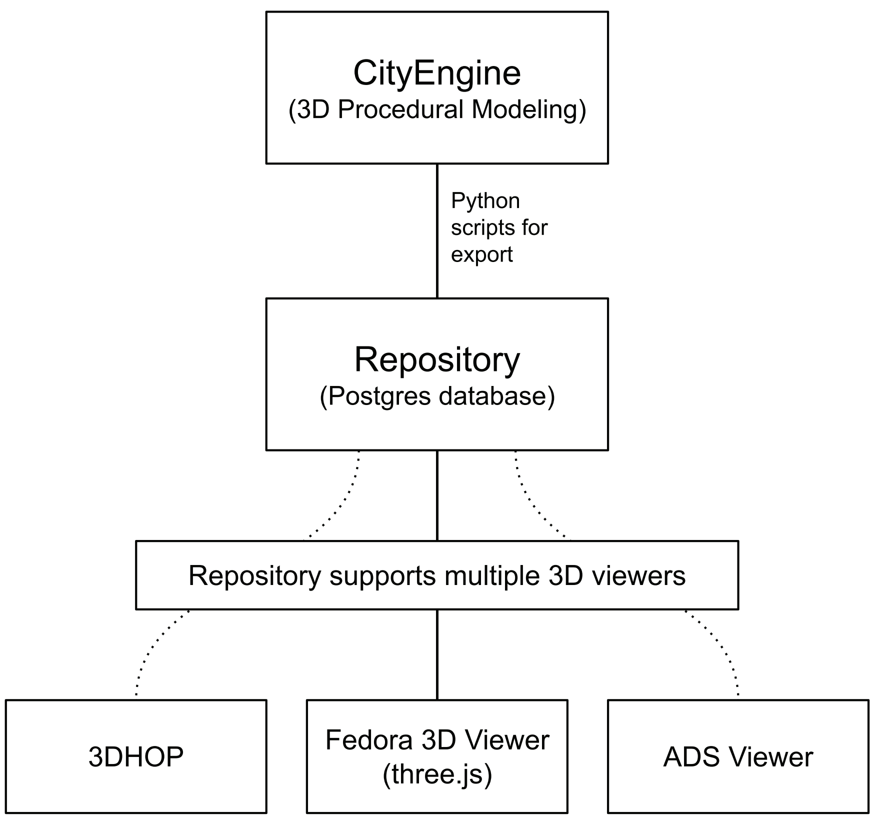

Figure 8.3. Keeping Data Alive (KDA) infrastructure design. A white paper with more technical detail on the core infrastructure is available at https://cdrhsites.unl.edu/keeping-data-alive/whitepaper.html (Richards-Rissetto et al. 2018).

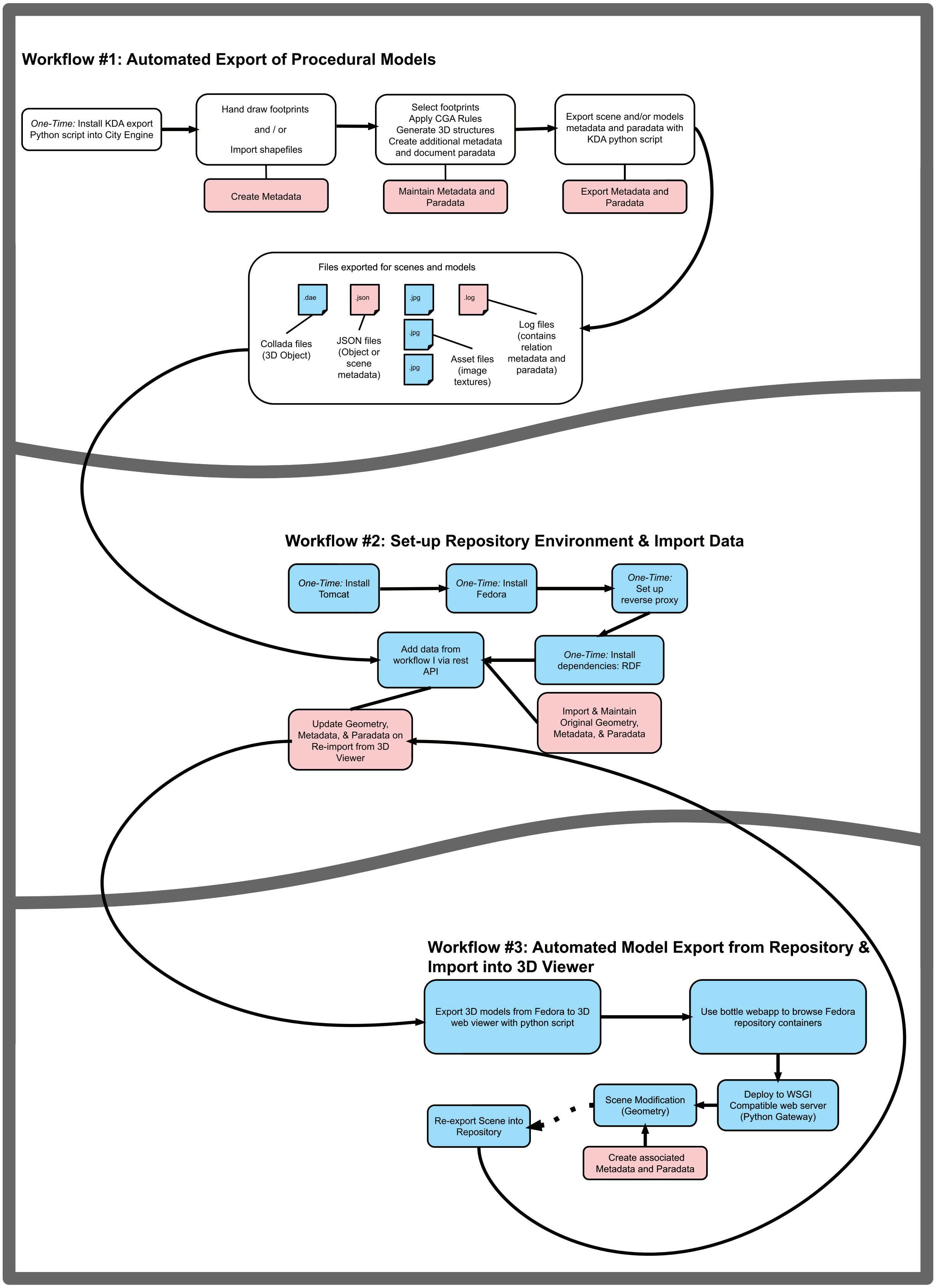

Figure 8.4. The KDA workflows shown here illustrate the steps required to reproduce and test the entire system architecture. One-time steps are only required for the initial configuration of the system and are not part of the operational workflow.

Data Preservation (CS3DP) and the Library of Congress on Digital Stewardship of Intrinsic 3D Data. These projects showed how a repository approach could be customized to better match libraries' requirements and skillsets, providing a pathway to promote preservation and access efforts beyond individual projects. While we selected Fedora based on the expertise available in our project team, any widely used repository could be used for this part of the infrastructure, chosen based on locally available skillsets and requirements. Following the same logic of building on existing capacity and infrastructure in the libraries community, the project team chose to implement the Research Description Framework (RDF) as part of its metadata strategy because it is widely employed as a key component of linked data in the libraries and archives communities.

Considerations for File Type Support and Metadata Schema

In selecting a 3D file type to support the KDA infrastructure, we reviewed the requirements of archaeologists and heritage practitioners against the affordances of specific formats. Different 3D geometry file types (for example, X3D, COLLADA, OBJ, PLY) allow for the storage of various kinds of information. Some formats maintain strict standards, only allowing specific kinds of information to be included, while other formats are more permissive. Many popular 3D file formats support inclusion of basic metadata such as creation date, number of 3D points, or polygons. However, they typically do not support incorporation of more complex metadata or paradata about modeling choices. As discussed above, in the context of procedural modeling these more complex metadata and paradata are important for scholarly reuse and reinterpretation. Documenting multiple relationships between components in 3D scenes was also a key requirement of the KDA infrastructure because scene-level relationships are integral to procedurally generated models (Figure 8.5.). Additionally, 3D procedural models typically have numerous associated source files and involve many modeling choices; therefore, it was equally important to plan for large paradata files.

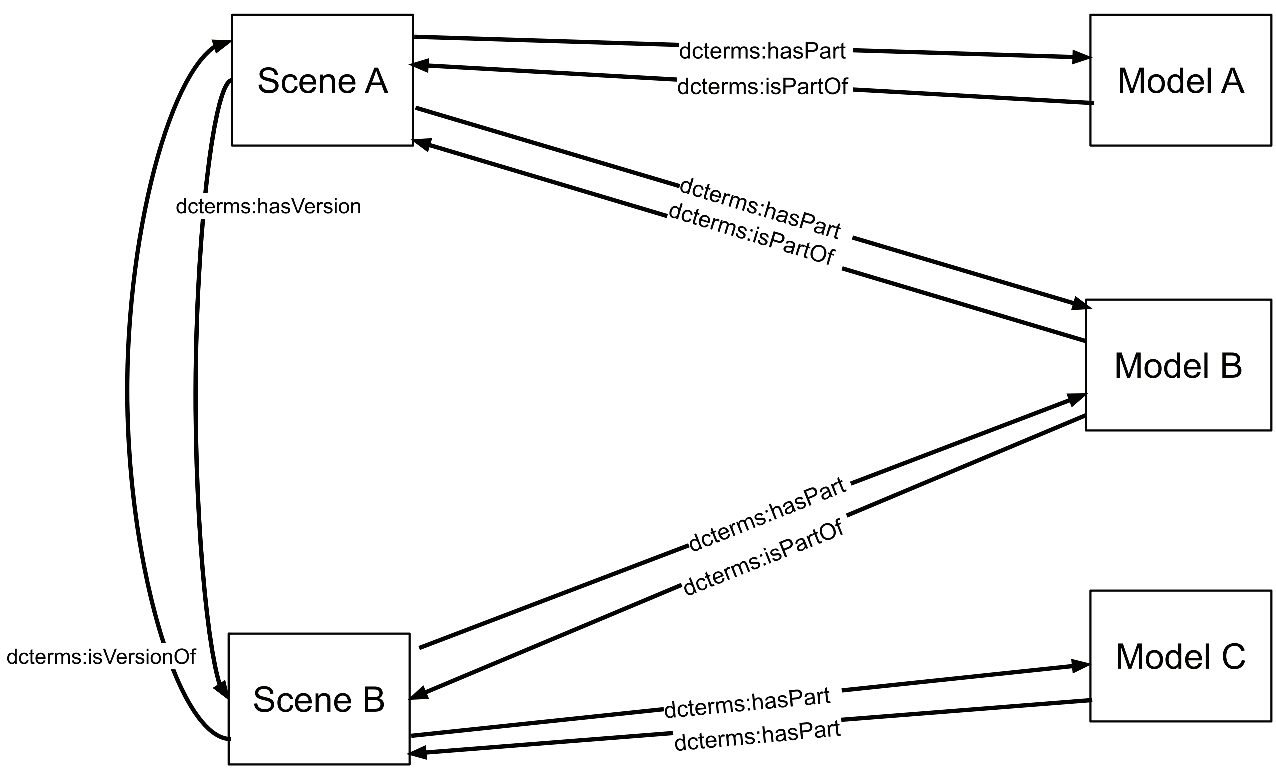

Figure 8.5. Metadata capturing the relationships between scenes and their components across multiple iterations are essential for tracking the reuse of components, which is integral to the practice of procedural modeling.

We also considered interoperability across systems as essential to support reuse.[1] In selecting a file format for use in the KDA infrastructure, these were the primary considerations, together with current levels of use in the procedural modeling and wider digital archaeology user communities. X3DOM meets some but not all of these requirements. It provides capacity for embedding complex scene information and paradata into the models and provides useful support for archiving 3D data. However, many commonly used 3D visualization software tools are not compatible with X3DOM or do not facilitate reading its paradata. Further, the X3DOM format is not widely used in the cultural heritage and archaeology communities. In contrast, the OBJ format is widely used in the archaeological community as a 'standard' format and is compatible with most major open-source software packages and scripting routines. However, while suitable for tracking single structures, OBJ does not support complex scene hierarchies, which are essential to procedural modeling applications.

In contrast, the COLLADA (DAE) format, an XML-based schema, enables data transfer among 3D digital tools and supports rich metadata and paradata for both objects and within scene hierarchies. It is widely used in the archaeological and cultural heritage communities. This format captures more information about geometry and materials within a scene, including textures, lighting, and camera angles. Moreover, COLLADA permits more detailed object descriptions than OBJ. This additional information becomes useful for 3D data reuse, particularly in capturing modeling choices, tracking changes, and ultimately facilitating citability. We selected this format because, as discussed above, it best matched the infrastructure's requirements.

Together with the use of the COLLADA format, the project team chose to use a JSON sidecar file to maintain core metadata for each modeled scene. While it is technically possible to embed metadata in the COLLADA file, the sidecar JSON metadata file aids ingest and portability within the Fedora Repository. More broadly, this design choice maximizes interoperability with other library-based institutional infrastructures, as JSON or XML metadata files are widely used in these contexts.

We considered two metadata models for the schema of these sidecar files, the CIDOC CRM (CIDOC Documentation Standards Working Group 2018) and the Europeana Data Model (EDM) (Europeana Foundation 2018), because these models are widely used in cultural heritage contexts. The EDM was selected because it is flexible and incorporates some of the properties of Dublin Core and CIDOC CRM (Doerr and Theodoridou 2011, Stead and Doerr 2015), as well as Web Ontology Language (OWL), Friend of a Friend (FOAF), Simple Knowledge Organization System (SKOS), and other metadata models. Its support for describing relationships among objects, scenes, and files is also beneficial. This design choice reflected our prioritization of interoperability with metadata schemas used in diverse institutional contexts.

Design Choices for the Viewer

The KDA repository outputs and ingests models through an online, open-source 3D viewer, extracting them from and redepositing them into its repository. Initially, two related web-based 3D viewers already used in the heritage community were considered for the infrastructure, with the aim of building on existing research efforts and favoring tools already in use by the broader community: the ADS 3D Viewer (https://archaeologydataservice.ac.uk/research/3DViewer.xhtml, Galeazzi et al. 2016) and the 3DHOP viewer (http://3dhop.net/, Potenziani et al. 2015). On close inspection of their functionality, these tools were not easily adaptable to meet the KDA infrastructure's needs. Specifically, the infrastructure needed to store information on complex 3D scenes, including information on the relationships between reused 3D sub-components (that is, models), as discussed above (Figure 8.5.).

While the ADS 3D Viewer supported the import of OBJ files, commonly used in procedural modeling, it did not natively support COLLADA. 3DHOP natively supported PLY and while it was possible to modify the code to enable the import of COLLADA and subsequent conversion to PLY, this process added complexity as well as challenges for reuse of derivatives in other platforms. On this basis, the project team chose to develop a simple 3D Viewer using three.js (three.js Community 2018), which natively supports COLLADA, to test the workflows and infrastructure. The prototype viewer (Figure 8.6.) is available at https://cdrhsites.unl.edu/keeping-data-alive/fedora-viewer.html.

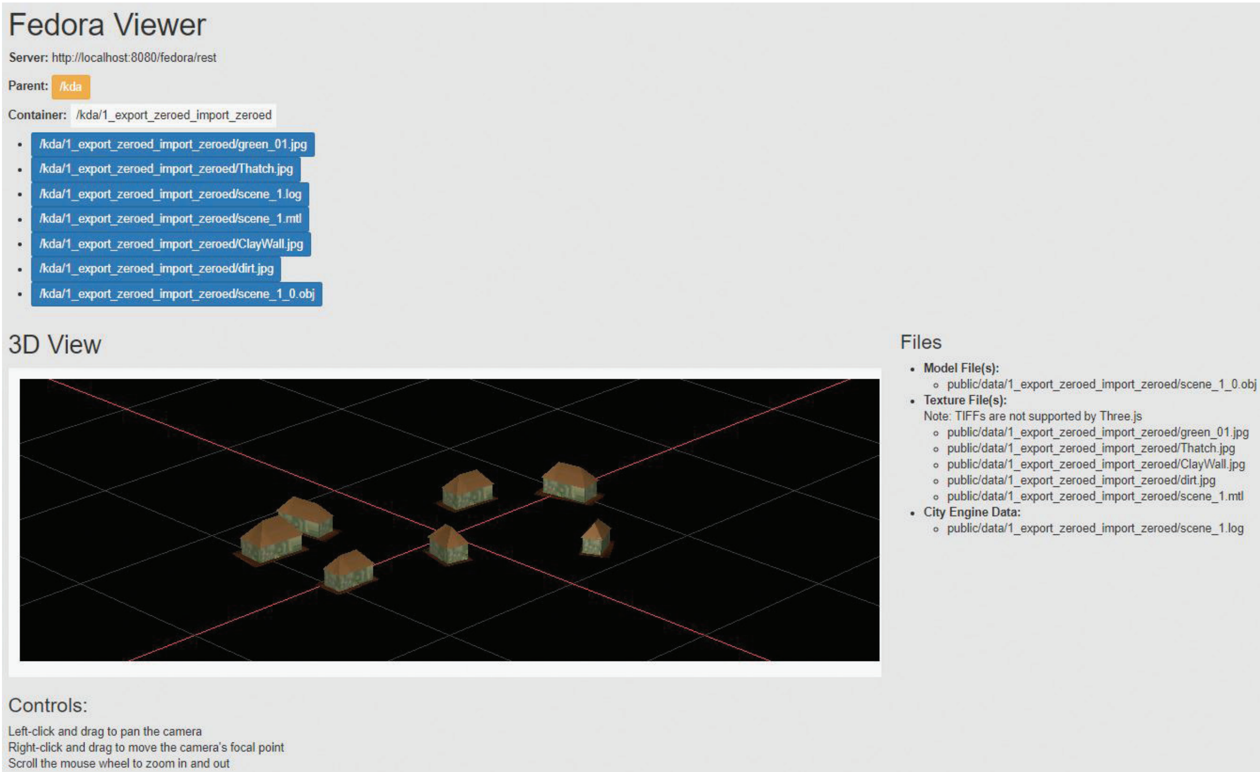

Figure 8.6. The prototype Fedora Viewer, showing linked files, metadata and paradata containers, and the visual rendering of a procedurally modeled scene.

Reflecting on the KDA Infrastructure Design

In designing and developing the KDA infrastructure, beyond tackling the various practical and technical challenges sketched above, we chose to reflect seriously on the main research and practice aims of procedural modeling in archaeology, and their convergences and divergences with those of communities working with reality-captured 3D and CAD/BIM-modeled 3D. As noted above, by surveying the literature, we identified core research aims that included exploring possible past urbanisms, conducting digital experiments on the make-up and experience of past places, and using these experiments to reflect on how societies shaped these modeled places. A proper evaluation of how the KDA infrastructure enables practitioners to meet their research aims must await its full development and a period of active use. Therefore, at present, we focus our evaluation on how the design enables the pursuit of the communities' practice-oriented aims: generous reinterpretation, reflexive strategies of collaboration, and engagement with the biographies and intellectual legacies of digital things. All of these depend on the capacity of the infrastructure for 1) recognition of contributions to research through the provision and reuse of 3D model components and 2) increased visibility of the connections between different procedural modeling experiments.

Encouraging Generous Reinterpretation

The motivations of reuse practices vary significantly between 'reality-captured' 3D, CAD/BIM-modeled 3D, and procedural-modeling 3D communities, respectively focused on accurate reproduction and ownership, communicating certainty and interpretation transparently, and generous reinterpretation as defined by Sullivan (2020). In reality-captured 3D practice, reuse is strongly aligned with reproduction of object geometry and material appearance in order to faithfully recreate object shape. While reinterpreting the meaning or context of the digital thing is definitely an important part of reality-capture workflows, this reinterpretation takes place outside the core archival infrastructure. Thus, workflows developed by the digital standards and good practices community as embodied by, for example, the London Charter, CARARE, and 3D-Coform, do not account for reinterpretation practices (see a recent review in Rahaman and Champion 2019 for discussion of aims and practices and gaps between them). Reinterpretation is an added layer of practice, the requirements of which are driven by a different community of actors. The debates in reality-capture 3D practice have centered on ownership and stewardship of digital things (for example, Magnani et al. 2018, Santana Quintero et al. 2019, Ulguim 2018—as cited above) and around authenticity and aura (Jeffrey 2015, Jensen 2018b, Jones et al. 2018, Kenderdine and Yip 2018). These debates testify to a strong concern with accurate reproduction of form in the context of reuse (though see Dawson and Reilly 2019 for a creative counterpoint and some intentional rule breaking).

In this context, archaeologists have discussed ownership and access, stewardship, and interpretation of digital 3D objects in relation to contested or competing narratives. The debate centers on who tells the story of an object through digital platforms, who owns it and manages the right to its reproduction, and by whom it can and should be found and accessed. Given the very real political and emotive issues surrounding ownership, power, colonial legacies, and representation in which digital reality-captured 3D models have found themselves entangled (for example, Colley 2015, DeHass and Hollinger 2018, Nicholas 2016, Stobiecka 2020, Thompson 2017), encouraging reinterpretation in the central infrastructures that house the digital things becomes fraught. Intentionally or not, the communities engaged in the design of centralized infrastructures and workflows for this kind of 3D data have focused on the faithful reproduction of digital objects, making them findable and accessible, and maintaining referential links with their physical counterparts. The core infrastructures, repositories, archives, search tools, and workflows to produce descriptive metadata and standards for formats, in focusing on findability, accessibility, and preservation, have largely maintained a neutral position amid the often heated debates about the sticky business of reinterpretation of digital things (for further discussion of these complexities, see Eric Kansa, chapter 9 in this volume).

CAD/BIM 3D modeling sits in a different position within archaeology and heritage practice (Beacham 2011, López et al. 2018, Pfarr-Harfst 2016, Simeone et al. 2019). Infrastructures and workflows to support the association of paradata have been a primary concern for this community because while some aspects of the geometry and materials of these models essentially attempt to approximate the physical objects, and therefore share goals with reality-capture 3D, many represent hypothetical reconstructions and interpretations. The use of paradata to explain the modeling choices and processing behind the hypothetical and interpretive elements of these models, and to distinguish between these and the reality-reproducing elements, clearly focuses on supporting reinterpretation (Bentkowska-Kafel et al. 2012, Brusaporci 2017). However, the requirements of this reinterpretation practice are distinct from those of procedural modeling. A reinterpretation in a CAD/BIM context is a largely self-contained product, reconstructing a complete entity or world in the tradition of reconstructive illustration or physical modeling (Frischer and Dakouri-Hild 2008, Hodgson 2004; Moser 2012 and Molyneaux 2013 on the history of illustration and images including reconstructions in archaeology). Paradata documentation focuses on making a strong and nuanced argument through the reconstructed model and on maintaining and communicating intellectual rigor in this process. Therefore, the primary concern within the CAD/BIM community developing paradata infrastructures is to explain and communicate the interpretive choices made by individual modelers or modeling teams, rather than foregrounding connections between different reconstructions of the same entity.

The procedural modeling community uses 3D model components to manifest different hypothetical reconstructions, with only an indicative relationship to the geometry of any physical thing. Its core work involves iterative experimental generation of complex models made of collections of 3D components. The redeployment of the 3D components and the implications of their reuse in different modeling exercises and outputs is central to this community's practice. The reinterpretation of the potential roles and affordances of the individual 3D model components is significant in this community of practice, and thus connections through shared 3D components are a primary concern. To access digital data typically refers to the ability to discover, examine, and retrieve 3D models (Landi et al. 2020, Mons et al. 2017). However, for the data to be meaningfully 'accessible' for procedural modeling, we need to add to this 'definition' the capacity to reuse the data in multiple ways (Albrezzi et al. forthcoming, Moore et al. forthcoming, Richards-Rissetto forthcoming, Wilkinson et al. 2016).

The design of the KDA infrastructure responds to this need by emphasizing citability and providing tools to support this practice. Citability is closely tied to generous reinterpretation in that it foregrounds connections between ideas and credits the intellectual legacy of a model's other uses. The primary functions of reality-captured 3D are to provide a digital archival copy and to support the study of the digital entity, as one would study the physical object (through techniques such as metric analysis). To fulfill these functions, the primary FAIR requirements are that it must be findable and accessible. In contrast, the primary FAIR requirements of a procedural model component are that it be reusable and interoperable. Consequently, the real aims and value of citations are different. In the first, the primary goal of citation is reference to the originating entity. In the second, it is about creating connections through citation that build a network of intellectually generous connected reinterpretations. Procedural modelers using model components benefit from generous reinterpretive practices because documenting connected reuse, via paradata, adds to the informational value, legitimacy, and interest of the models.

Enabling Reflexive Strategies of Collaboration

Our reflections on the role of citability and generous reinterpretation within procedural modeling practice suggest that infrastructures and workflows need to prioritize reflexive strategies of collaboration (Wright and Richards 2018). Considerations of the value added by collaborations are of primary concern because the 3D model components derive value foremost from their connections to and iterative reuse in other models. Enabling an intentional, self-conscious, reflexive, collaboration strategy, in this light, becomes a primary aim of this community's infrastructure and workflows, aligned with calls for reflexive practice in digital archaeological work (for example, Berggren et al. 2015, Boyd et al. 2021, Wilkins 2020).

Using easily modifiable sidecar paradata and metadata files, supporting large paradata files to allow unlimited additions to the chain of documented reuse, and versioning the paradata file encourage iterative collaboration between teams and support this reflexive mode of collaboration. The exposure of paradata on reuse through 3D viewers and as a downloadable file, and its prioritization within infrastructure design, promotes an intentional and self-conscious practice, in which considerations of the value of the connections between uses of a 3D model are foregrounded.

While sharing some aspects with collaboration in CAD/BIM modeling, we highlight important differences that lead to slightly different infrastructural requirements. Collaboration in CAD/BIM modeling takes place most frequently within a team coming to a collective interpretation, which is encapsulated in a single set of paradata associated with a specific version of the 3D model (Banfi et al. 2018 and Logothetis et al. 2017 specifically discuss collaboration in heritage BIM work). In this practice, the output of a closed circle of collaboration is a finished set of paradata tied to the 3D model that is its intellectual product. While the ability to view and ingest paradata is important for both groups, the ability to re-edit and add to paradata is not a priority for CAD/BIM modeling practice, while it is essential for procedural modelers.

The requirements and affordances are even further from those of reality-capture 3D practice. In this context, the initial collaborative stage of work largely precedes a model's entry into the digital infrastructures and workflows. It takes place during the creation of the 3D geometric model itself, as teams often work together to digitally capture an object. A separate collaboration may take place outside the bounds of core archival infrastructures during reinterpretation by a group of external users (for example, as in DeHass and Taitt 2018). This is primarily a practice of collaboration around the digital 3D model, rather than *through* the model. In current practice, the results of these later collaborations are treated as separate from a theoretically 'neutral' 3D model and consequently not widely integrated into the metadata or other documentation of the model itself, a situation that is not unproblematic.

Supporting Engagement with Biographies and Intellectual Legacies of (Digital) Things

The development of infrastructures and workflows to support object biographies for digital 3D models exist across all the communities of 3D archaeological practice. In the reality-capture 3D community, this is reflected by considerable investment in the development of infrastructures for data sharing (Galeazzi et al. 2016, Scopigno et al. 2017). A common approach is to provide DOI-like citations for the digital 3D models and embed in their metadata references to the connected physical objects (for example, the Smithsonian's 3D digital portal, OpenContext and ADS integrations of 3D viewers, investment in the development of the 3D-HOP framework, and ARIADNE's Visual Media Service). The referential metadata in these infrastructures links the biographies of the physical and digital objects. The ability to cite the object in literature outside the infrastructure reflects the community's concern for its intellectual legacy, in the sense of its impact on scholarship about the object in its digital incarnation. The development of infrastructures that encourage the explicit citation of its digital incarnation is particularly interesting as a practice when we consider that an author could cite the physical object. Encouraging citation of the digital incarnation and the physical object through it hints at the promotion of a distinct intellectual legacy for the digital 3D model as an entity, much as casts in cast galleries become quasi-independent heritage entities (Juckette et al. 2018, Rabinowitz 2015).

The CAD/BIM modeling community's tight integration of the paradata and model geometry encourages engagement with the biography of the object by making the commentary on its creation fully integrated into the format of its expression of its digital shape and material properties. The two, literally designed as part of the file structure, cannot be separated, as they are a key component of the community's paradata infrastructure. This choice, in contrast to the sidecar-style paradata file selected for the KDA infrastructure, speaks to the strong emphasis on object biography in the CAD/BIM modeling community of practice. KDA design choices, which enable reflexive collaboration for procedural modelers, also support the CAD/BIM community's aim to reveal and encourage engagement with intellectual legacies. However, here the engagement is active, and the priority is making intellectual legacies open and extensible, aligned with the community's emphasis on adding value to models through reinterpretation. The design of infrastructures and workflows consequently prioritizes interoperability of paradata as well as ease of viewing and iterative modification.

In procedural modeling, KDA's emphasis on practice that automates aspects of the process of tracking changes, inputs, and decisions reflects the expectation of ongoing contributions to the 3D model components' biographies and the tracking of their evolving legacies. The infrastructure aims to support ongoing engagement with such practice by making the basic mechanistic aspects of the work automated. KDA is not suggesting full automation; human attention is still essential. Rather we advocate the incorporation of automated processes and checks into the workflows as fundamental aims for the infrastructure. The high level of effort involved in constructing rich biographies and tracking dense legacies could discourage practitioners; however, the inclusion of automated tracking mechanisms in the infrastructure could lessen such efforts and support the importance of iterative engagement with 3D models within the community's practice.

Conclusions: Designing New Affordances

In the digital era, our interactions with technology are mediated by the varying properties of hardware, software, data types, user interface design (UI), user experience design (UX), and workflows that shape our practices, which in turn impacts not only our interpretations, but more importantly the potentiality of our interpretations (Ingold 2018:41). Since Gibson (1977) and Norman (1988), diverse disciplines ranging from narrative studies to design studies to archaeology have employed the affordance concept (albeit in varying ways and not without debate, for example, Webster 1999) as a theoretical framework for research and practice (Backe 2012, Copplestone and Dunne 2017, Forte 2016, Gillings 2012, Ingold 2018, Llobera 1996).

In the KDA project, we focused on the potential opportunities and hindrances afforded by infrastructures and workflows for 3D procedural modeling, taking up the call of Perry and Taylor (2018) and long-term advocacy by Huggett (for example, 2015; 2020) to engage in a reflexive process to theorize our digital research practices. This process of reflexive exploration focused our attention on how procedural modelers work with 3D models through the infrastructure and what they considered important or valuable. It highlighted the need to look beyond the engagements of individual modelers with data, metadata, and paradata and account for the strongly collaborative and interactive character of this community's practices. To truly support these collaborative practices, looking forward we must build infrastructures that afford and encourage their users to engage with one another, as well as the 3D models, metadata, and paradata they create.

Authors' Statement

Heather Richards-Rissetto led the KDA Project and Rachel Opitz contributed to the KDA Project's design. Karin Dalziel, Jessica Dussault, and Greg Tunink carried out the practical development of the KDA architecture and contributed to drafting the description of the KDA architecture in the article. Rachel Opitz and Heather Richards-Rissetto conceived the chapter, led the writing of all sections other than the KDA architecture description, and edited the chapter.

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Note

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CHAPTER 9

On Infrastructure, Accountability, and Governance in Digital Archaeology

Eric C. Kansa

Over the past two decades, many researchers have grappled with practical, financial, and ethical challenges in the management, communication, and use of digital data in archaeology. Pioneering data-preservation programs justified their efforts in terms of the ethics of preservation and stewardship of irreplaceable archaeological documentation (Wise and Richards 1999). The first decade of the twenty-first century saw intellectual property concerns, particularly with regard to colonial appropriation, as a key ethical question for digital archaeology and cultural heritage (Christen 2009, 2012, Kansa 2009, Kansa et al. 2005). Others have explored gender and sexual violence issues in online settings communicating archaeology (Richardson 2018), the inscrutable 'black box' use of digital methods (Dennis 2020), as well as skills and expertise gaps (Cook et al. 2018) that can make nominally 'open data' unusable except to a small elite with access to advanced computing skills and support services.

In this paper, I want to further explore some of the issues about privacy and surveillance raised by Lorna Richardson in her 2018 paper. This requires us to step back from some of the specifics of a given dataset or digital media collection and consider the infrastructure required to discover, communicate, and preserve these new media. This discussion is informed by my experience overseeing Open Context (https://opencontext.org), an open-data publishing service for archaeology. It is important to emphasize that Open Context is a *publishing service*. It is not itself a preservation repository; rather we prepare and document datasets to archive with university digital repositories, chiefly the California Digital Library and more recently Zenodo. The German Archaeological Institute (DAI) maintains a full mirror of Open Context. As a publishing service, we try to emphasize interoperability at a web scale by publishing data with APIs using common standards and by linking with data in related systems. Thus, infrastructure issues are a key area of concern for Open Context because we rely on interoperability and working with outside partners for digital preservation.

Archaeology Research Data Management and Infrastructure

Digital technologies permeate all aspects of twenty-first-century life, including, of course, the practice of archaeology. The opportunities and challenges presented by digital technologies in archaeology raise interesting questions about the conduct of archaeology. At the same time, looking at these questions is not just of narrow disciplinary interest to archaeologists. Archaeology can provide a unique perspective that can help to further explore and understand the social and political forces that shape so much of our current reality.

The practice of archaeology has always required a system of supporting infrastructures relating to issues of finance, training, transportation, storage, security, healthcare, and many more concerns. However, because of the digital themes in this volume, I will mainly explore archaeology in the context of systems that support information management and communications. Archaeological practice has long depended on libraries, archives, and publishers for the curation and dissemination of archaeological knowledge. Digitization transforms the needs and requirements for such curation and dissemination infrastructure services. Over the past decade, I have reviewed grant proposals and data management plans for the Shelby White and Leon Levy Program for Archaeological Publications. This granting program supports projects, up to three years in duration, to synthesize archaeological field documentation research on terminated and unpublished archaeological fieldwork into cohesive site reports. It awards about one dozen grants per year to publish on excavations in East and North Africa, the Mediterranean region, Near East, Central Asia, and sometimes China. Since its inception in 1997, the program has awarded over US$20 million in grants to more than three hundred scholars (see https://whitelevy.fas.harvard.edu/).

In 2012, the Shelby White and Leon Levy Program for Archaeological Publications began requiring data-management plans (DMP) from all applicants. Since then, I have read and evaluated roughly seventy data-management plans per year in the context of reviewing grant applications for this program. Over the past eight years reviewing grants, I have noticed incremental improvement in the overall quality and thoughtfulness of data management plans. At the same time, concerns over data access have persisted and mainly involve worries about potential misuse of data as well as narrow, self-interested motivations for data hoarding.

After reviewing now around five hundred data management plans, I have gained a unique perspective in understanding how archaeologists have had changing attitudes toward issues of data access. Initially, many applicants simply stated that they would regularly back up their data during the course of the project. Some DMPs made no discussion of making digital data more widely available. Other applicants wrote that "data will be made available upon request," reflecting a similar reluctance to consider data as a recognized form of scholarly communications. Approaches to data management that only considered periodic personal backup storage omitted reference to any wider institutional supporting infrastructure. This lack of supporting infrastructure has severe long-term preservation disadvantages because it leaves all the complexity and effort required in curation in the hands of an individual. It also raises troubling issues about selective favoritism, since presumably the data holder could always deny a request for access. In many cases, data-management plans ignore issues like copyright licensing. Copyright licenses may seem esoteric, but without them, current intellectual property law in many international jurisdictions would preclude reuse of many datasets without negotiating specific permissions with their owners. The lack of copyright licenses has as many problems as "data will be made available upon request." Essentially, the lack of a clear and standard license puts data into a 'you can look but not touch' state. Creative Commons provides an 'infrastructure' of clear and standardized copyright licensing tools that other groups have since expanded with a wider suite of intellectual property tools and metadata specifically crafted to promote better ethical practices in the curation of knowledge significant to Indigenous peoples (see Local Contexts https://localcontexts.org/). Reference to these legal and licensing infrastructures would clarify ethical and copyright ambiguities just as reference to digital repository infrastructures would have clarified data preservation ambiguities.

Fortunately, in more recent years, data-management plans increasingly reflect growing awareness of critical data curation and communication infrastructures. More recent DMPs typically integrate digital library and repository preservation services. Some have also adopted elements of Findable, Accessible, Interoperable, and Reusable (FAIR) data principles, as advocated by proponents of open science and reproducible research (Marwick et al. 2017). This is a welcome improvement over the prior *status quo* of 'data made available upon request.' FAIR criteria help jump-start conversations about how to make data that are actually meaningful to broader communities. However, while getting that conversation going is helpful, FAIR cannot be the last word. After all, FAIR is *only* about making data more fungible by reducing friction in accessing and using data. In some cases, other issues, especially in contexts shaped by colonialism and power inequities, are more important than friction. Research DMPs also show that many archaeologists struggle with ethical, legal, and practical challenges in data. Some describe how many archaeologists work in contexts and with communities that have survived often brutal colonial histories. Institutional and national policies, as well as notions of privacy, sensitivity, and property vary cross-culturally and it would not be ethical to arbitrarily impose open-data ideals on different cultural contexts. While FAIR data frameworks by themselves are ethically incomplete, exploring where FAIR data principles may or may not be appropriate highlights how data management involves more than external hard drive backups. Research data management involves navigating and negotiating how wider professional communities and other publics will engage with data. Inevitably, sustaining those cross-community linkages requires engagement with systems of supporting infrastructure.

From Data Management Questions to Infrastructure Questions

Data management plans show increasing awareness among archaeologists that they need to consider how their digital data will interface with wider communities and systems. This means that in drafting data management plans, archaeologists describe aspects of how their own efforts interface with curation and communication infrastructures. The ways in which the capabilities and limitations of these infrastructures shape archaeological practice need more exploration. These considerations help inform my work with Open Context, a project that needs to build working systems and services while navigating the conceptual, ethical, and practical concerns in archaeological data management. As described above, Open Context is a data-publishing service for archaeology. It provides services to help implement many of the FAIR data principles. At the same time, Open Context provides editorial and policy guidance to help researchers navigate data sensitivity issues.

Projects published with Open Context range in scale, complexity, and purpose. These different sorts of publications all run on a common software and data infrastructure. The software behind them has some economies of scale in providing a common framework for lots of diversity. But in order to publish each dataset, Open Context's team must invest a great deal of editorial and curation work. While we publish comprehensive data, we do not publish data in a 'raw' form as delivered by contributors. Each project dataset we publish goes through an ETL (Extract, Transform, Load) process. Our editorial team performs a range of tasks involving cleanup, annotation, documentation, and troubleshooting throughout this ETL process. Therefore, even though the outcome is detailed structured data, our approach to publishing data is a very human process, requiring labor and domain knowledge, just like conventional publishing.

An example from North American archaeology highlights the complexity and the tensions inherent in navigating professional and ethical challenges in publishing data. While Open Context tries to promote the ethical use of Creative Common licenses and FAIR data principles, there remain important infrastructure and governance challenges. The Digital Index of North American Archaeology (DINAA) provides an example of these challenges. This project aggregates and publishes site file records from state government created datasets.[1] States in the United States maintain these data to administer federal historical protection laws. Aggregating these data allowed researchers from the DINAA team to demonstrate that some thirteen thousand known sites along the eastern seaboard faced inundation threats with a modest increase in sea level (Anderson et al. 2017). The story received wide attention in the popular press, and was cited in the Fourth National Climate Assessment, a key US federal government policy document.

In spite of this demonstrated importance and relevance of accessible archaeological data, federal law and site security concerns mean that we can only publicly release these data at a low spatial resolution. While that limits the reproducibility of the climate study, our concerns about data go beyond their value for reproducibility. These data document the histories of peoples harmed by centuries of brutal colonialism, and the data themselves are often organized and classified using systems that arguably help perpetuate that colonialism. We face a long and complex challenge of reworking the DINAA dataset into a resource with inclusive community curation. Most of our work on DINAA over the past few years has focused on this, but it is a long, slow process. Tribal Historic Preservation Officers (THPOs) are, based on our interactions, under-resourced with small staffs overseeing large territories and face overwhelming demands for oversight and consultation. Thus while community curation is compelling, it needs financial resources and dedicated human attention to succeed. Collaboratively curating archaeological datasets may sound good in theory, but in practice we must recognize that people from communities engaged in ongoing struggles over sovereignty and the health and well-being of their people may have other more pressing concerns. Ethically managing sensitive and problematic data requires investment not directed toward Open Context, but toward the descendants of the people described by these data. Only people in these communities will have the background understanding on how to better curate and contextualize this information.

This issue illustrates the complex dependencies between a small system like Open Context and larger social realities. Even in a narrow technical sense, managing data with access restrictions involves a heavy set of responsibilities. Systems with access restrictions require management of user data to keep track of who should have permission to engage with different content. We should remember that user data is also sensitive data, involving additional risks and dangers. With Open Context, we forgo managing access-restricted data because we do not have the capacity to manage security and liability. From a risk perspective, one advantage to open access is the protection of user data. We can forgo tracking of individual users and can support better anonymity with an open access system. In Open Context's case, we delete server logs every few hours to reduce the likelihood that user interaction data will get misused. For this reason, open access to data, where it can be implemented, can work to promote better privacy. This is not to say that all data should be open; instead, it is merely to point out that imposing access restrictions that require tracking of users involves its own set of concerns that can put user privacy at risk.

Concerns over sensitive data are obviously not unique to Open Context or archaeology. However, though Open Context lacks the capacity to manage sensitive data itself, we recognize that our professional and stakeholder communities all need systems to manage sensitive data with access restrictions. Trust, governance, and accountability mechanisms are even more critical in restrictive data contexts. These kinds of concerns must be part of the debates about information access in archaeology. As discussed more below, the management of access restrictions and associated user data highlights the importance of governance in information technology infrastructure. These requirements also highlight some key limitations and constraints on our current infrastructure as these needs exceed the organizational and information security infrastructure that Open Context (together with other stakeholders) can currently finance.

Infrastructure Dependencies

Whether our data are open or have access restrictions, we should be concerned about the governance of the systems that manage these data. This is especially challenging for archaeologists, because as our discipline becomes more enmeshed in digital technologies and systems, we interact with a wider range of infrastructure, governed by people and organizations that may or may not share our values. To begin with, I'll start by exploring the 'soft infrastructure' of people and organizations collaborating either directly or indirectly by contributing to more general-purpose open-source software libraries.

For example, Open Context recently published Claire Malleson's paleobotanical data documenting Old Kingdom settlements at Giza (Malleson and Miracle 2018). In working on this data publication, we updated some of the open-source geospatial visualizations to better meet more demanding needs. Navigating and visualizing aggregated data has big usability challenges, given that we publish such a wide variety of data at many kinds of scales. Navigating these usability issues is an ongoing challenge and requires the collaboration and help of people outside of our own in-house team. We are starting to get to the point where open-access data is actually informative for interpretation. Figures 9.1. and 9.2. show the distribution maps of pig ulnae from Poggio Civitate, an Etruscan site. Figure 9.1. shows bones from the left side of the animal, and Figure 9.2 shows the right-side ulnae. The spatial distribution of these bones shows that, while ulnae from the left and right sides of the pig carcass were found in the non-elite 'workshop' area, the elite 'residence' shows a near-absence of left-side portions. This observation was made after the context data, mapping data, and zooarchaeological analysis were integrated and published with Open Context. After seeing this pattern, Anthony Tuck (University of Massachusetts, Amherst), the director of the Poggio Civitate project, reported that his undergraduate students are finding more such patterns with different classes of material culture, such as architectural elements, in the elite and non-elite areas of the site. Feedback from instructors and students attempting to use Open Context in instructional settings, interacting with the Poggio Civitate material as well as other datasets in Open Context (see Cook et al. 2018) have yielded invaluable insights about usability and data-quality flaws. Without this feedback from users outside of our organization, we would not know how to better conduct our data curation and our software development programs.

Addressing these needs, again, requires using open-source software frameworks and web-design templates and other libraries. All of these components come from software engineers and designers who make public contributions to open-source projects. Everything from the operating system on Open Context's servers (Debian or Ubuntu Linux), to the language used to write Open Context's back-end software (Python), to the frameworks and libraries imported to add critical functionality (Django, Pandas, and many more), to the database that stores Open Context data (Postgres) all come from this larger ecosystem of open-source projects, well outside of the disciplinary boundaries of archaeology.

We should also note that these libraries of open source software require constant maintenance, mostly by armies of unpaid volunteers. Fixing bugs, patching security problems, and updates to keep up with changing operating systems and needs, all represent necessary maintenance. That social infrastructure of open-source code maintenance makes innovation, including innovations in a niche like digital archaeology, possible. Unfortunately, the people that do that work feel increasingly squeezed and prone to burnout (Asay 2020). The failure to adequately finance and support this critical maintenance work may reflect larger social problems in how we maintain infrastructure more generally (Vinsel and Russell 2020:120–39). Digital archaeology greatly relies upon the uncompensated coding contributions of the open-source community. How do we reciprocate and give back to that community?

In addition to code, Open Context depends upon an ecosystem of related services managed by a host of other organizations. For example, Open Context helps augment and complement more conventional (book and article) forms of archaeological publication. Figure 9.3. shows such an example—a 3D model developed by Kevin Garstki, Erin Averett, and Derek Counts that is part of a larger effort at publishing a large catalog of Archaic through Roman period Cypriot sculpture (Counts et al. 2020). This project only became feasible thanks to the digital archaeology and publishing programs organized by other institutions. The 3D viewer technology, called 3DHOP, resulted from research and development efforts run by the European Union's Ariadne digital archaeology program (Potenziani et al. 2015). The dependencies on other institutions extend beyond technology. In this example, the Digital Press at the University of North Dakota led the publication effort and coordinated some collaboration with ASOR, a professional society for archaeologists working in the Near East (Garstki et al. 2020). The Digital Press organized the peer-review, publishing, and marketing efforts behind the publication of this catalog. Thus this example highlights how much of Open Context's work depends upon the people, labor, and services of different institutions.

Digital preservation probably marks one of the most significant areas of dependency on outside institutions and services. A key goal for the Open Context project is to make data citable and cited. The 'suggested citation' window shows the author(s), the object's name, and an ARK identifier. An ARK identifier is a type of persistent identifier minted by the EZID service, a system backed by a consortium of university libraries to promote the long-term

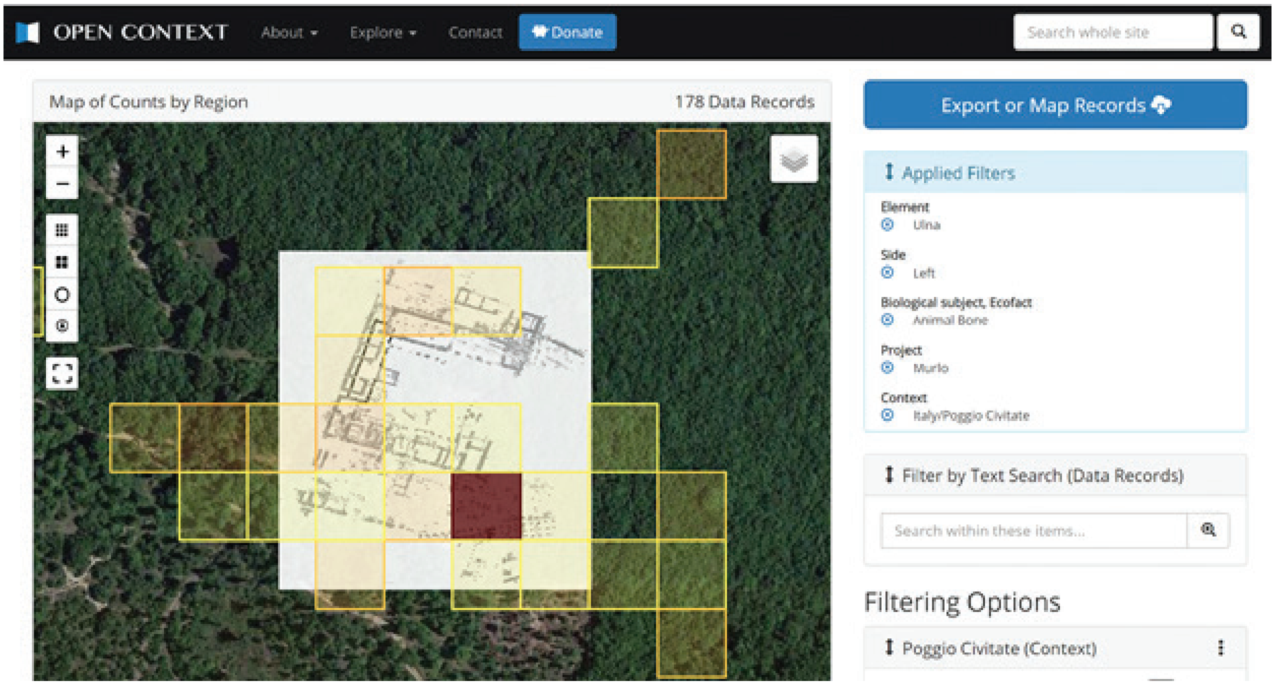

Figure 9.1. Leaflet-powered map of left pig ulnae at Poggio Civitate. Plan map showing elite 'residence' to the north and non-elite 'workshop' area to the south. Squares represent locations of finds (ulnae); yellow represents a small number and red represents a high number of finds.

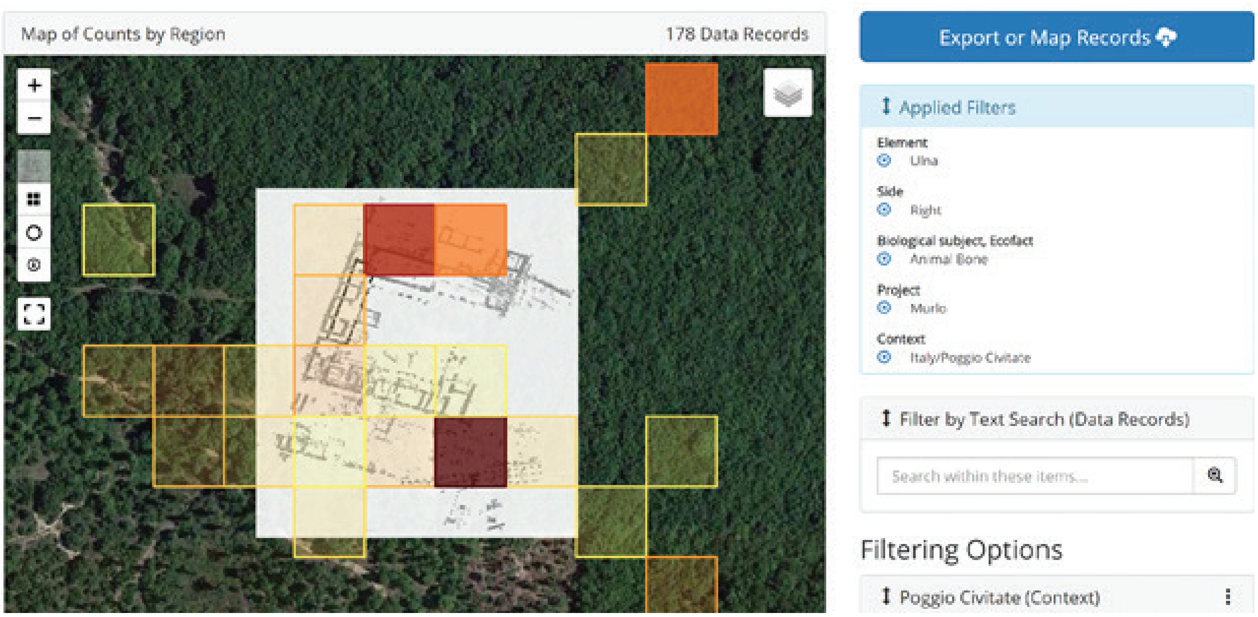

Figure 9.2. Leaflet-powered map of right pig ulnae at Poggio Civitate. Plan map showing elite 'residence' to the north and non-elite 'workshop' area to the south. Squares represent locations of finds (ulnae); yellow represents a small number and red represents a high number of finds.

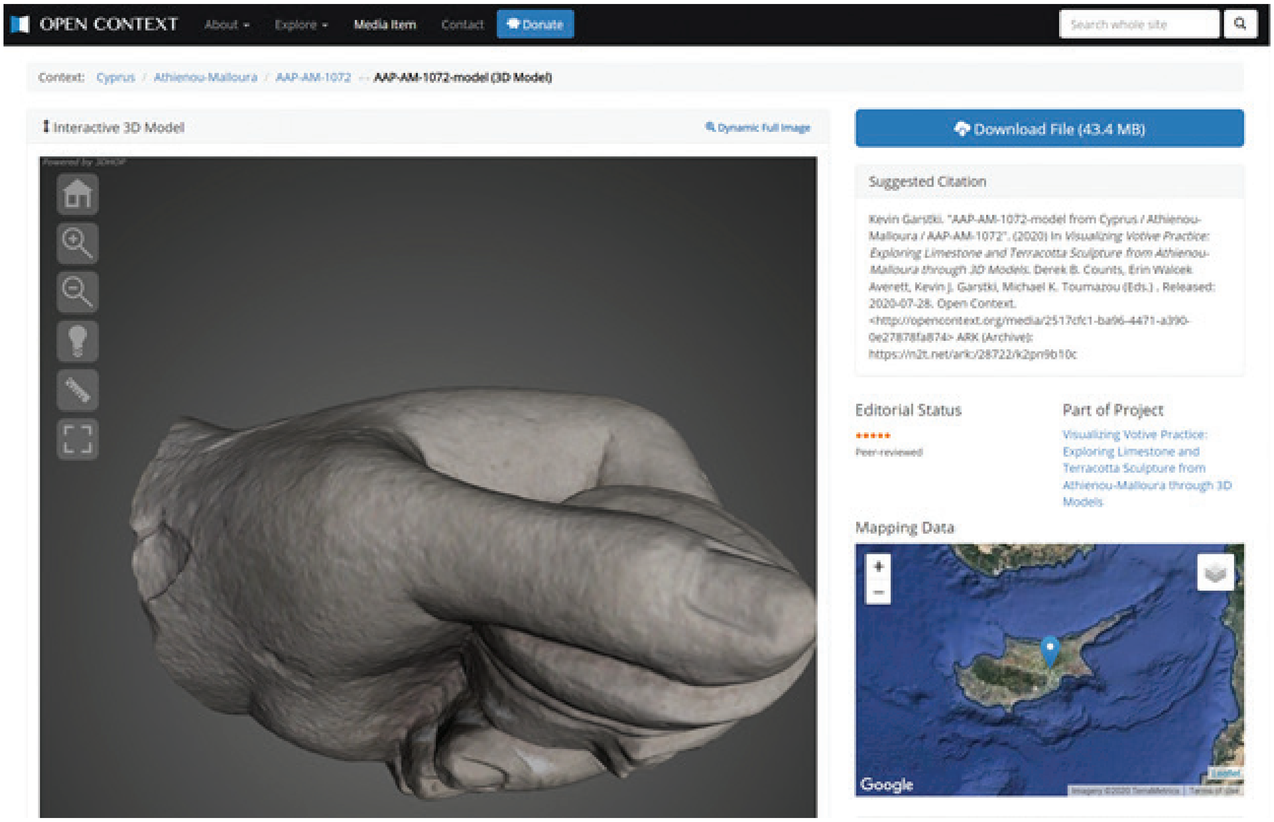

Figure 9.3. 3DHOP-view of a sculpture fragment from Athienou-*Malloura*, Cyprus.

reliability of citation. Reliable citation is a key requirement in scholarship. Open Context's data-publishing services therefore need the support of this key aspect of digital library infrastructure. Beyond that, the actual preservation of the datasets and digital media files are also handled by the supporting infrastructure of our digital repository partners, chiefly the California Digital Library and Zenodo.

Dependencies on Commercial Infrastructures

The accounts above illustrate how Open Context would almost immediately cease operations without the support, services, and contributions of people and organizations inside and outside of archaeology. All of these supporting systems can be considered 'infrastructure.' They provide a general set of services that make our particular, archaeology-domain-specific project much more feasible in terms of finance, technology, and daily operations. Infrastructure both enables and constrains what we can and cannot accomplish and how we go about our own work.

The availability and character of infrastructure shape what is easy and what is hard to accomplish. This is particularly true for commercial infrastructure, where certain systems dominate sectors as monopolies or near-monopolies. While in the section above I noted how Open Context relies upon the infrastructure provided by nonprofit digital libraries and other research computing initiatives, nonprofit infrastructure is only part of the overall picture. Commercial infrastructure inescapably shapes the landscape of a project like Open Context. Most visits to Open Context originate via references from commercial search engines (especially Google) and social media services (Facebook, Twitter), and to a far lesser extent, from links from articles hosted by commercial academic publishers. Open Context itself, like many other academic projects, has a Twitter account to share announcements and engage with users. But even in the development and operations of Open Context, commercial services play a fundamental role. We pay Google for cloud computing services to provide the database and other servers needed to run Open Context. A commercial service, GitHub, provides version control and dissemination services for the software we develop and integrate to use in Open Context.

The policies, governance, and political economy of these other systems of infrastructure play huge roles in shaping an academically oriented project like Open Context. They can also muddle, distort, undermine, and even co-opt project activities and goals intended to serve the interests of broader publics. Take, for example, the case of GitHub. As mentioned, Open Context uses GitHub for public software version control. The intended purpose of using GitHub aims to make the technical details about how we manage archaeological data more open for inspection and accountability. Many other open source projects use GitHub for similar purposes. GitHub's relatively polished user interfaces, design, and features helped to greatly popularize version control for many research applications. So, what's not to like?

Even though GitHub had somewhat quirky, playful, slightly counter-cultural branding, it was always a commercial service—first as an independent startup and now, after acquisition, a service owned by the commercial giant Microsoft. Recently however, news emerged that the United States Immigration and Customs Enforcement agency (ICE) contracted with GitHub for commercial services (Bhuiyan 2019). In recent years, ICE has earned international notoriety for a variety of human rights abuses including sexual violence and violence directed against children. With these revelations, GitHub looks less 'quirky, playful, and counter-cultural' and far more problematic as an accomplice to authoritarianism. These revelations raise new challenges to open-source projects like Open Context that use GitHub. To what extent does the ICE contract with GitHub taint every other use of that platform? How should open-source projects respond?

This issue illustrates how infrastructure can not only enable projects but play an insidious role in undermining projects. Open Context does not seek to promote or reinforce authoritarian politics, policies, or organizations. Our use of GitHub aspires toward explicitly anti-authoritarian goals—namely, technical transparency and accountability in our decision-making encoded in software. However, we have to ask ourselves: What does GitHub get out of us that may be co-opted to serve the interests of ICE? GitHub, like many twenty-first-century web service providers, collects vast amounts of user interaction data. Moreover, in hosting millions of software projects, GitHub has gained vast data collection capabilities over the processes and practices behind a key aspect of the twenty-first-century economy. Every source-control 'commit,' raised issue, comment, collaborative group, coding habit, design pattern, and software component that gets imported and referenced, all gets logged by GitHub. Open Context, though a relatively small and niche initiative, helps to feed this immense engine for collecting software and data about how people make software. And GitHub uses that information to seek profit, and in doing so, offers commercial services to help ICE better succeed in shaping software for authoritarian ends.

In theory, one could switch out of GitHub and use another public version control system. Most of the other major alternatives to GitHub, such as Bitbucket (despite its misleading '.org' domain) and GitLab are also commercial ventures. These other ventures may or may not also contract with agencies like ICE. Thankfully, there are a few smaller nonprofit alternatives such as CodeBerg.org that provide public version control services governed by privacy protections and other policies that better align with more humane values. Stefano Costa, a pioneer in open source applications for archaeology, already has several code repositories hosted by CodeBerg.[2] While this nonprofit alternative is welcome, it is almost impossible to avoid commercial open-source infrastructure. In reality, even if digital archaeological projects abstain from using GitHub for their own code, they will almost inevitably still need to interact with GitHub and related commercially run software development services. Digital archaeological projects borrow heavily on larger bodies of open-source code, and much of the open-source software ecosystem is hosted, documented, and demonstrated on commercial systems.

Of course, we should be careful not to overinflate the concerns here. As a US taxpayer, my taxes no doubt play a much more significant and direct role in perpetuating ICE's authoritarian abuses than data abstracted from my use of GitHub. However, GitHub is only one of a number of commercial services with similar surveillance-centered business models. As mentioned earlier, most visits to Open Context stem from Google, Facebook, and to some extent Twitter. All of these organizations have immensely powerful user-data-gathering capabilities, and often have strong profit motives to use those data in support of sophisticated and highly financed propaganda programs. Archaeological content and user interest and interactions with archaeological content help feed the profiling and analytics behind alt-right and neo-fascist messaging spread by authoritarian regimes and their backers via these social media channels (see Brophy 2018 for a case study involving Brexit).

Finally, cloud-computing highlights how dependencies on commercial infrastructure permeate every aspect of our work in digital (and all) archaeology. Open Context itself uses commercial cloud-computing services offered by Google for servers, databases, storage, and networking. In interacting with Open Context, you interact with Google infrastructure. Google is not the world's largest commercial cloud-computing service provider; that spot is currently occupied by Amazon, a vastly powerful company helmed by Jeff Bezos, the richest person on the planet. Open Context chose Google for cloud services because Amazon has notoriously abusive labor practices. But the choice between Google and Amazon is not particularly meaningful. Though they no doubt differ in detail, both companies have very similar structures, missions, and ideologies. Both have enormous market and political power and very little democratic accountability. A choice between Amazon and Google is a choice over branding preference, price point, and set of technical features, not a meaningful choice over corporate governance or behavior.

From early attempts to break Nazi Enigma codes to current developments in facial recognition and social network analysis, it is evident that military, surveillance, and commercial interests have played key factors in the history of digital computing in general. The Internet itself evolved from a Cold War program to maintain resilient communications during nuclear hostilities (Ryan 2010:14–17). Given these structural realities, a small nonprofit program like Open Context has little agency to fully extricate itself from the infrastructure built and run by such powerful and politically entrenched actors. What then can Open Context, along with other digital archaeology programs, do to navigate infrastructure issues while remaining true to their public benefit missions?

Sensing the Political Economy of Information Infrastructure

The first step in reducing dependency on commercial infrastructure centers on raising awareness about the shortcomings of commercial infrastructure's governance. For example, the 'Data Rescue' response to Trump's attempt to delete scientific data, public reporting, and expert policy guidance on issues like Climate Change highlights why access to responsive infrastructure matters. I joined volunteers nationwide to help crawl government websites to locate data to deposit in university libraries and the nonprofit Internet Archive. I mainly focused on the National Park Service, while others worked on EPA, NASA, and other federal agency datasets. According to the Environmental Data Governance Initiative, volunteers and libraries archived 200 TB of data in the Data Rescue effort, including 40 million PDFs and 100 TB of files from FTP sites (Molteni 2017).

That scale of effort required dedicated and technically skilled volunteers and significant information technology infrastructure. Sadly, the big commercial players, companies like Google, had no role in this grass-roots effort. This is unfortunate because if there is one thing Google has experience with, it's scraping websites. However, as far as I know, Google contributed nothing to data rescue. Though Google no doubt maintains a comprehensive archive and index of US government public domain data, so far, Google keeps this to itself. With the commercial sector conspicuously absent, only nonprofit university library and Internet Archive infrastructure made Data Rescue efforts possible.

The Data Rescue example highlights how libraries played a role that is consistent with archaeological values of promoting the stewardship and preservation of cultural heritage. We cannot rely on infrastructure that is sold with glamorously marketed and polished user-interfaces but that lacks responsive governance. For example, in December 2019, Google retired Fusion tables,[3] a service it heavily marketed as a data-management solution for the digital humanities. Fusion tables had sophisticated features and design polish that made creating and sharing structured data relatively easy. Unfortunately, they came hosted by one commercial provider that did not value long-term continuity. All the projects that used fusion tables had to find alternatives or ceased to function.

A lack of awareness about infrastructure leads some cultural heritage organizations to choose glamorous over sustainable digital technologies. Without documentation, open-source code, and meaningful access to underlying data, such applications can reduce users to passive spectators. Recent developments at the British Museum highlight this risk. The British Museum pioneered Linked Open Data access to its collections data and managed the Portable Antiquities Scheme, one of the world's largest and most highly studied and cited archaeological databases. Recent staffing cuts and priority changes have undermined these pioneering programs (Kansa 2016). The British Museum's linked data service has returned error messages for the past several months, and the Portable Antiquities Scheme no longer has any active development and only has minimal sysadmin maintenance. At the same time, the British Museum has launched several high profile initiatives sponsored by corporate giants such as Google and Samsung. The new digital programs, such as British Museum work with the Google Culture Institute (see https://blog.britishmuseum.org/?s=Google+Cultural+Institute), siloize data and digital media in closed systems without public APIs, without standards aligned metadata, and without contextualizing links to a wider world of scholarly resources. These efforts have short time horizons, a marketing focus, and lack accessible, persistent (citable), and reusable data needed for scholarship.

The British Museum de-prioritized their leading data curation programs, opting to emphasize glamorous, marketing-oriented digital media programs. They cut expert staff and their in-house capacity to engage in digital data curation. The British Museum's diminished capacity and contributions to digital scholarship highlight significant challenges in cultural heritage data curation. In the profession, and in key institutions like the British Museum, data curation can still seem discretionary rather than central to scholarship. Because many cultural heritage professionals currently lack 'data literacy' (see below), few appreciate how the British Museum's diminished capacity constrains scholarship. This case highlights the urgent need to broaden and deepen understanding of digital data issues among cultural heritage practitioners.

Data Literacy and Infrastructure Literacy

To help address these concerns, we need to do more to make infrastructure less opaque. When one logs into an Amazon cloud services account, there is no interface that describes the carbon footprint of an EC2 instance or the labor conditions at the factories that built the racks of servers. Making the case for creating infrastructure under more democratic governance requires that we make infrastructure issues more visible.

Dennis (2020) highlights the key role education can play promoting greater ethical awareness in the use of digital technologies in archaeology. We should expand on her point to add infrastructure awareness as an area of ethical concern. To help make infrastructure concerns and other aspects of data management more visible, Open Context is launching a new data literacy program, thanks to support from the Andrew W. Mellon Foundation and the National Endowment for the Humanities. The goal of the program is to strengthen meaningful engagement with digital data among cultural heritage professionals and learners. Data literacy has many definitions. A 2015 white paper by Rahul Bhargava and colleagues (2015) for the Beyond Data Literacy Workshop describes data literacy as "not primarily about enabling individuals to master a particular skill or to become proficient in a certain technology platform. Rather it is about equipping individuals to understand the underlying principles and challenges of data" (Bhargava et al. 2015:8). This description is useful because it does not promote a specific technique, service, or technology but instead promotes deeper appreciation of foundational issues of empowerment, critical thinking, and argumentation. This white paper continues its description of data literacy with the following:

> This understanding will in turn empower people to comprehend, interpret, and use the data they encounter—and even to produce and analyze their own data. This can only be achieved by considering data literacy . . . a means toward a necessary reinvention of community engagement and empowerment—toward what we term data inclusion. (Bhargava et al. 2015:8)

It also emphasizes "the ability to read, work with, analyze, and argue with data" (Bhargava et al. 2015:14), and this emphasis on argumentation and critique helps situate data as a central concern for scholarship rather than technical proficiency with a specific software application. Our Data Literacy Program aims to integrate these notions of data literacy into the instruction, professional development, and public outreach of cultural heritage professionals. As highlighted in this paper, the infrastructure behind the data plays a key role in shaping the impacts of those data. Thus, 'infrastructure literacy' must be considered an integral aspect of data literacy.

Valuing Care: Recognition for Maintainers and Responsive Infrastructure

This chapter has touched on related privacy, governance, and infrastructure concerns that Open Context must navigate. These issues are relevant not only to Open Context but need attention in the digital archaeology community and more broadly in the area of digital research data.

Our community must better recognize the need to secure the financial and technical resources required to maintain cloud computing, code repository, and other infrastructure, governed according to our needs and values. Digital archaeology is not alone in these needs. The case for information technology infrastructure with more community-oriented governance is made brilliantly by InvestInOpen.org (https://investinopen.org/), a nonprofit initiative dedicated to supporting open access, open science, and other educational and research computing initiatives on public-benefit-oriented infrastructure. Similarly, advocacy groups like the Maintainers seek to make the largely invisible work of maintenance (a type of care-giving) that is needed to sustain critical infrastructure (https://themaintainers.org/about-us) a greater priority in public policy and public awareness. It seems archaeology, a discipline that concerns itself with stewardship, preservation, and long-time horizons in human history, can be an ideal partner in advocating for greater care in infrastructure and in the people who maintain that infrastructure.

In moving forward, we hope to highlight through educational and professional development programs how infrastructure awareness is an integral aspect of data literacy in archaeology. Greater awareness of information-technology infrastructure will help archaeologists better understand the landscape of risks and opportunities in their engagement with wider publics. This awareness will also be critical in forging alliances and building the political capital needed to secure access to more capable infrastructure under more responsive and democratic governance.

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Notes

1 DINAA is funded by the National Science Foundation and led by co-PIs David Anderson (University of Tennessee, Knoxville) and Joshua Wells (Indiana University, South Bend). Visit https://ux.opencontext.org/archaeology-site-data.

2 Stefano Costa's updated list of open-source code repositories is here: https://codeberg.org/steko.

3 See announcement: https://gsuiteupdates.googleblog.com/2018/12/google-fusion-tables-to-be-shut-down-on.html.

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CHAPTER 10

Collaborative Digital Publishing in Archaeology

Data, Workflows, and Books in the Age of Logistics

William Caraher

Introduction

Over the last two decades, there has been the growing use of the phrase 'digital workflow.' As you might expect, the Google Ngram plot for this term looks like the proverbial hockey stick (Figure 10.1.). The term 'workflow' has its roots in the language of early twentieth-century scientific management (Alexander 2008, 148), and the notion of 'digital workflow' appears to have first emerged at the turn of the twenty-first century in the field of publishing. In this context, digital workflow spawned a series of 'how to'–style books that described both the role of computer technology in the production of print media and the new way of organizing practice (for example, O'Quinn et al. 1996). The widespread use of word processing software, for example, among authors and digital design software among publishers integrated book production practices to a digital workflow that began with the author and extended through reviewers, editors, publishers, and printers (Kirschenbaum 2016). In the last twenty years the emergence of e-book readers and digital tablets has extended digital workflows through the publication process (for a summary of contemporary tools and practices see Maxwell et al. 2019) and into the hands of the consumer of digital and e-books. Among archaeologists, the concept of digital workflow has emerged in the early twenty-first century with the widespread use of digital tools, technologies, and practices in the discipline, and, as a result, digital workflow has come to occupy a distinct place within archaeological methodology.

This chapter considers the idea of a 'digital workflow' in the context of archaeological publishing. Recent work on archaeological writing and publishing has started to explore the reciprocal relationship between archaeological work and the publication process. These ideas are not new. Ian Hodder, for example, reflected on how the character and structure of archaeological description and narration shape the kinds of arguments possible in archaeology (Hodder 1989; and now see Lucas 2018). This anticipated a growing emphasis on craft in archaeological knowledge production with work on illustration, for example, demonstrating the embodied nature of the processes of translating

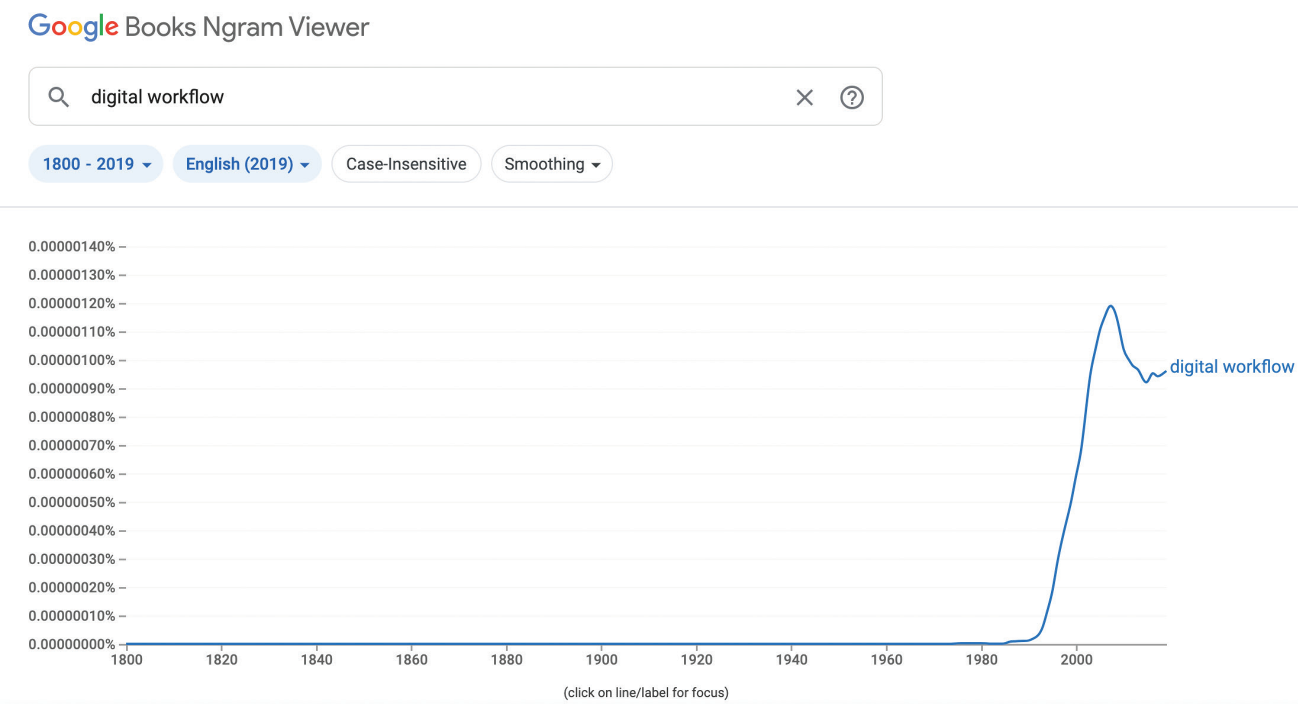

Figure 10.1. Google Ngram plot for the term 'digital workflow.' *https://books.google.com/ngrams/graph?content=digital+workflow&year_start=1800&year_end=2019&corpus=26&smoothing=3&direct_url=t1%3B%2Cdigital%20workflow%3B%2Cc0#.*

archaeological knowledge from the field to the published page (Shanks and McGuire 1996, Morgan and Wright 2018). This finds ready parallels with recent critiques of archaeological photography that have recognized how media affordances shaped the kind of arguments that archaeologists make from their data (for example, Garstki 2017). With the emergence of digital practices in archaeological field work, scholars have come to understand that the data produced through a growing range of digital tools required thoughtful curation and, increasingly, publication under the terms of various federal grants. As a result, archaeologists have started to extend the notion of archaeological workflow from data collection in the field to the archiving and dissemination of data on platforms like Open Context, DIG, tDAR, or the ADS.

This move among archaeologists will have, I propose, wide-ranging impacts on the nature of archaeological publishing, especially as academic publishing itself has entered a period of considerable change. Most large academic publishers now have digital publishing platforms of various descriptions and have supported various efforts at creating more dynamic and interactive ways to engage with archaeological description, interpretation, analysis, and data. The best known and perhaps most innovative of these is the University of Michigan's recent publication of the *Mid-Republican House at Gabii* (Opitz et al. 2016). While this work received some significant criticism from reviewers for the limits of its functionality (Saperstein 2017), the authors have been commendably reflexive in the motivations and processes surrounding its development (Optiz 2018). Publishers have also sought to embrace Open Access publishing models as pressure from authors, libraries, and institutions has sought to make publicly funded research more widely available, remove profitability from the consideration of academic work, and push back against the escalating prices of library resources. These initiatives often inform the development of new publishing platforms—like Luminos from the University of California Press (https://www.luminosoa.org/), Fulcrum from the University of Michigan Press (https://www.fulcrum.org/), and PubPub from MIT (https://www.pubpub.org/). In some cases, such as the Manifold platform from the University of Minnesota

Press (https://manifold.umn.edu/), these platforms support new compositional strategies for authors that expand the character of the academic books as living documents developed over time, susceptible to revision and adapting to critique through dynamic revision. These significant changes to publishing intersect with a growing reflexivity in archaeological workflow to create the potential for new ways of understanding archaeological knowledge-making.

This chapter offers my modest contributions to these conversations based on two things. First, I have some slightly unusual points of departure: first, some recent work by Michael Given who draws upon Ivan Illich's idea of conviviality to help understand the premodern agricultural landscape of Cyprus (Given 2017, 2018). Illich proposed his idea of conviviality as a way to describe the creativity that arose from the fluid interaction and interdependence between individuals in the premodern world, and he articulated it as a critique of an impoverished modern condition (Illich 1973). Given suggested that a convivial collaboration between archaeological specialists from soil scientists to ceramicists, bioarchaeologists, architectural historians, and field archaeologists would produce a deeper understanding of the convivial landscape where premodern Cypriots lived (Given 2017:140). My first reading of this passage was relatively uncharitable (Caraher 2019:374–75); Illich's notion of conviviality was anti-modern, and attempting to reconcile this idea with the assembly-line practice of archaeological work and specialization seemed as doomed to fail as the plantation-style sugar works established by the Venetian colonizers on Cyprus's south coast (Given 2018). If convivial relationships mapped the seamless sociability of premodern production, specialization and workflows created Frankenstein creatures that have the superficial appearance of reality, but are, in fact, mottled monsters of recombined fragments (in the vague sense of Freeman 2010).

At the same time that I was thinking about Illich and Given, I read Anna Tsing's work, *The Mushroom at the End of the World* (2015) and Deborah Cowen's work on logistics, *The Deadly Life of Logistics* (2014). Both books, in their own ways, describe the fluid movement of people, things, and capital around the world. They explore the tension between the local and the global, places and movement, and the Deleuzian 'dividual' and the Enlightenment individual (Deleuze 1992). While Cowen's work is, as the title suggests, practical and pessimistic in tone, Tsing's work sees the rhizomic world of the matsutake mushroom holding forth the 'possibilities of life in capitalist ruins.' Cowen argues that corporate profits are increasingly tied to their ability to manage distributed workflows and the efficient movement of goods, capital, capacity, and even people on a global scale. Tsing looks at these same phenomena while arguing that the rhyzomic system of the matsutake mushroom, which thrives in landscapes heavily disturbed by logging and other industrial practices, offers a compelling metaphor for the new, often global, connections. She links, for example, the social and economic communities of Cambodian mushroom pickers in Northern California to the hospitality practices of wealthy clients in Japan. In understanding these connections she draws freely (and playfully) upon Deleuze and Guattari's ideas of deterritorialization while attempting to avoid either their dystopian or a crassly economic view of workflow (Deleuze and Guattari 1987). While I dread bringing too much theory to this chapter, I do think that Deleuze and Guattari offer a way to understand Given's use of conviviality and to conceptualize the reterritorialization (perhaps the recoding) of modern archaeological knowledge-making. In light of this, my chapter will swing back and forth between these two poles and offer both an angst-filled critique of archaeological practice and some more optimistic reflections on why maybe Michael Given was right to see convivial social practices in archaeology as possible, especially in our digital age. As a final note, this chapter will consider publishing not from the perspective of the growing body of important work on the future of academic publishing, but from the perspective of archaeological work and knowledge-making strategies.

The second pillar supporting my arguments in this chapter is my experience founding and operating a small university press, The Digital Press at the University of North Dakota, for the last six years. At the risk of being solipsistic or self-referential, my experiences talking with authors, book makers, archaeologists, and other publishers has helped me to formulate ways of producing books that bring them closer to the convivial practices associated with archaeological work. To be clear: The Digital Press is small, with no permanent staff; our budget is based exclusively on the generosity of donors and a slow drip of paper book sales; and we have no experience in the publishing industry at any level. These things are both features and bugs. On the one hand, we had no expectation for how a press should work other than those that we had acquired as publishing scholars. We have also developed a strong sense of common ownership over the books that we have published with our authors. This has emboldened us to think about The Digital Press as a model for other publishing projects in the digital era. On the other hand, we do rely more heavily on the experiences and energies of our authors than a conventional press, and this has not only complicated certain features common to academic publishing, including peer review, but also created a greater burden for our authors (and, indeed, ourselves as publisher) in an environment already crowded with obligations. In short, this chapter is not offering The Digital Press as *the* model for the future of publishing, but rather offers our experiences as an example for how the landscape of academic production is changing.

From its founding, The Digital Press sought to explore publishing as part of the larger academic and intellectual process. The Press's first book was, appropriately, *Punk Archaeology* (Caraher et al. 2014) and represented a test case in DIY (digital) book-making, albeit under the watchful eye of the experienced publisher Andrew Reinhard. It represented a kind of anti-manifesto of punk practice in archaeology. Rather than offering a clear path to some kind of revolutionary practice, *Punk Archaeology* presented a wide range of loosely related interventions that have continued to inspire diverse responses and critiques over time (for example, Caraher 2019, Morgan 2015, Richardson 2017). Since that time, The Digital Press has published more than twenty books on topics ranging from digital practices in archaeological field work (Averett et al. 2016, Counts et al. 2020) to the historical and cultural significance of Colin Kaepernick's protests (Burin 2018). Over the last two years, we have published, a twenty-first-century archaeological autobiography (Graham 2019), the republication with critical updates of a 1958 report on the social conditions in the Bakken oil patch in North Dakota (Conway 2020), a 3D catalog of digitally scanned votive objects from Athienou on Cyprus (Counts et al. 2020), and an edited collection on deserted villages in the eastern Mediterranean (Seifried and Brown 2021). Each of these books has a discrete workflow designed to accommodate the character of the work, stakeholders, authorial goals, and prospective audiences.

Workflow and Archaeology

This relationship between workflow and desired outcomes is familiar to most field archaeologists. The interest in archaeological methodology, in particular, has sought to make many of the claims explicit by connecting procedures, techniques, technologies and even practices to research goals. In archaeological work, many contemporary digital practices have streamlined the relationship between field work and lab work (for example, Boyd et al. 2021, Roosevelt et al. 2015), data collection and analysis (Poehler 2016), and fieldwork and public engagement (Perry 2018) with various degrees of success. Scholars far more rarely considered how these spaces of digitally mediated integration extend to the writing and submitting of a manuscript and, ultimately, publication. Indeed, the division between the manuscript and the published volume tends to be quite formal, with the publishing process neatly separated from the writing process by its own set of professional methods, standards, and credentials. The professionalization of publishing has led, in part, to its key role as a mediator in the hiring, tenure, and promotion processes on many campuses as well as its development as a multi-billion-dollar industry. The relative autonomy of the publication process allows us to describe it as a kind of 'black box' in a Latourian sense that certain basic assumptions about publishing—particularly the mechanics of book design, typesetting, distribution, and marketing—have escaped from a certain amount of critical scrutiny and exist, to some extent, outside of the traditional definitions of the knowledge-making process. Renewed interest in the mechanics and transparency of the peer-review process, for example, reflect the relative obscurity of even the most academically significant aspects of publishing (Brand and Eddington 2018). Issues like book design, marketing, and distribution of titles have traditionally remained largely within the purview of publishers.

My experiences as an archaeologist, author, and publisher have led me to become interested in the way in which our increasingly digital workflow has come to shape the relationship between the various stages of archaeological knowledge-making. The barriers between publishing and research, in particular, appear to represents a distinct challenge to a kind of convivial and collaborative practice in knowledge-making, to develop Michael Given's ideas, and an opportunity for digital practices as they continue to complicate and change the structure of academic work.

Applying the concept of workflow to data in a digitally mediated archaeology goes beyond the analysis of technological change or methodology. The interest in digital workflow recognizes that technological changes also transform the organization of archaeological work. Traditionally, archaeologists have modeled their work on industrial and military practices, where authority typically followed a clear hierarchy. In a simplified form, project directors organized archaeological goals and tasks and delegated to field directors, trench or team leaders, and diggers (see Caraher 2019:377–78, 2016:425, Lucas 2001:1-12). This division of labor served, at least on one level, to facilitate efficient archaeological work and to produce specialized, accurate, and precise data. This form of organization allows for control over a project's outcomes and the knowledge-making process. The model of archaeological work reflects the nineteenth-century character of the discipline and its organization (Lucas 2001). Unsurprisingly, it has analogies with Deleuze's definition of a "capitalism of concentration," where the factory owner controls the space and structure of production (Deleuze 1992). The close identification of the project director, for example, and the site reflects the spatial delimiting of authority along ordered routes from the trench to backfill piles, sorting tables, and storerooms. The concern for spatial control extends to long-standing concerns for context and most broadly provenience, and accounts for common coincidence of the physical location of a site's archives and storeroom near the site. To extend Deleuze's analogy of control further, the connection between the hierarchy of archaeological knowledge-making and the spatiality of archaeological place evokes the factory floor (or the prison) and the processes of enclosure that characterize the modern era and practices.

In contrast, the flatter, less hierarchical universe of logistics and the flow of data breaks down the barrier of space, enclosure, and hierarchy, allowing for more decentered engagement with knowledge. Delueze (1992) saw the demise of what Foucault understood to be "disciplinary society" and the rise of a new "society of control" that fragmented or "dividuated" the individual into dispersed systems of domination. While a dark reading of Deleuze's view of the near future appears to have anticipated the rise of the gig economy and the "uberfication" of academic work (Hall 2016; see also Culp 2016), such readings also suggest that fragmented flows of data and information will ultimately erode social organizations grounded in conventional methods of control. Cowen's work on logistics, for example, describes how transnational corporations see national borders as problems to be overcome (Cowen 2014:1–15). More importantly, she emphasizes the potential of logistical flows to dehumanize society by violently severing the link between individuals and place and distilling even our physical movements down to calculated costs. Our concern here is with digital practices in archaeology that leverage the growing fluidity of data to transform the research, analytical, and publishing processes. At the 'trowel's edge' archaeologists fragment information across scale into bits, packets, objects, bundles, files, and, then, index, mark up, and transmit it across a range of digital practices. The ease with which bits of data move through digitally mediated systems reinforces the concepts of fluidity and liquidity that have become a compelling metaphor for understanding the economic, political, and social conditions of the modern era (for example, Bauman 2000). The linearity of the assembly line has started to give way to the decentered flow of archaeological data, and this, in turn, has contributed to the character of archaeological organization as a discipline.

Efforts to understand the interaction between tools and practices, or the digital *habitus* of archaeological work, have prompted a valuable range of auto-ethnographic reflections and observations sometimes framed as methodological interventions and sometimes as reflexive practice (see the contributions to Averett et al. 2016; see Tringham, chapter 12 of this volume). There also exists a small but growing body of systematic ethnographic studies of behavior conducted by Isto Huvila's team in Sweden (Huvila 2018), by Sarah and Eric Kansa (and team: Faniel et al. 2018), and Costis Dallas and colleagues in various contexts (Dallas 2015, Laužikas et al. 2018) as well as the work by Matt Edgeworth on the ethnography of archaeological practice (Edgeworth 2006). These scholars have demonstrated that the flow of digital data and the structure of digital practices have challenged the basic assumptions that support the organization of field work. The relationship between the fluid character of digital data, particularly the celebrated potential of interoperability in digital environments, and changes in disciplinary and professional practices creates a productive tension. Transforming archaeological information into 'data' both facilitates and allows for fine-grained control over the flow of information between individuals, teams, and projects. It also reflects an approach designed to negotiate between project directors who are expected to produce synthetic views of their site in the past and area specialists who produce discrete datasets informed and defined, in part, by their relationship with other archaeological datasets both from the site and from elsewhere.

Linked, open-data standards represent one contemporary manifestation of data flow in archaeology and the relational networks that create the potential for archaeological knowledge-making (Elliot et al. 2014, Bond et al. 2021). This facilitates and evokes the kind of convivial practice among experts that Given has proposed at the core of contemporary archaeological practice. This could be expanded to include the role of digital technology in mediating the relationship between projects as well suggesting that conviviality is not simply the collaborative efforts of archaeologists on a project, but the less structured flow of knowledge, data, and work throughout the entire discipline. From a technical standpoint, the role of project directors as well as others who seek to produce convivial syntheses has increasingly come to focus on the manipulation of digital tools — from databases and spreadsheets to GIS and 3D imaging software. These tools, in turn, extend from organizing archaeology as practice on the ground to shaping the subsequent analysis and interpretation of data collected on the ground.

Whereas Deleuze imagines the erosion of the disciplinary society creating the potential for a dehumanizing future, digital conviviality in archaeological practice can also create less hierarchical conceptualization of archaeological work and offer the potential for positive disciplinary change. Perhaps Illich's model of conviviality (1973) complements arguments made over twenty years ago by Michael Shanks and Randall McGuire that archaeology should embrace its roots in craft practices as a way to challenge the industrial modes of archaeological knowledge-making (Shanks and McGuire 1996). McGuire's radical efforts to create a more egalitarian and democratized archaeology, with the Colorado Coal Field War Project, demonstrated the potential of such an approach in practice (Walker and Saitta 2002). A few radical projects in the United Kingdom have likewise sought to introduce democratic processes to field work such as the Sedgeford Historical and Archaeological Research Project (Faulkner 2000, 2009, as cited by Eddisford and Morgan 2018). While these projects remain outliers, they demonstrate that the social organization of archaeological practice remains a topic of discussion and, to a lesser extent, experimentation for archaeologists. Eddisford and Morgan (2018) have suggested that single-context recording represents a far more decentralized and even anarchic method for producing archaeological knowledge. There is likely more variation as well; Mary Leighton (2015) has argued that a certain amount of 'black boxing' in archaeological practice masks a diversity of practices that are both more and less hierarchical than the formally reported results might suggest.

The intersection of field practices and digital technology creates environments where the growing interest in workflow and logistics in archaeological knowledge-making traces a new disciplinary trajectory. The movement, use, and reuse of data in a digital medium reflects a key element to transforming the institutional landscape of the discipline just as Tsing (2015) has suggested that the post-industrial landscapes create the reterritorialized flows that shape diverse and dynamic communities around the matsutake mushroom. Linked, open-data standards, for example, have established protocols that promote the integration of data from multiple projects, datasets, and individuals. This parallels a growing interest in ways to standardize data collection in the name of efficiency and regularity from the field. In effect, digital practices in archaeology have streamlined the ability to produce and even disseminate data directly from the field, although some curation of this data is clearly preferable. Our ability, however, to publish data through platforms like Open Context demonstrates how the fluidity of the contemporary workflow is already challenging the barriers between field work and publishing (for a broader perspective on this see Kansa, chapter 9 of this volume). There is something complementary between the often radical challenges to archaeological work as hierarchical and the value of the archaeological data in a distributed workflow.

The fragmentation of digital data and the potential for distributed workflows has done little to erode the barrier between archaeological practice and publishing. It is worth noting that our present model of academic publishing was largely established after the end of the Second World War, and prior to that point publishing in archaeology was more diverse, and, in many cases, a more casual and frankly commercial relationship existed between publisher and scholars (Thorton 2018). The current context for digital publishing, however, reflects a complex relationship between scholars and publishers and their respective institutions. Over the last fifty years, academic publishing has become deeply embedded in the institutional work of academia with top-tier publishers often serving as gatekeepers for the discipline (for an overview see Fyfe et al. 2017). Appearance in top journals and monograph series often plays a key role in securing tenure and promotion for early- and mid-career scholars. This reflects both the historic prestige of these outlets as well as a contemporary faith in the rigor of their review processes. Prestige also tends to follow the visibility of these presses in the field, their marketing budgets, and acquisition habits of leading libraries. Digital publishing practices need not transform these institutional arrangements. At the same time, critical views of the role of digital technology in knowledge-making should extend to the social practices that link academic archaeology to publishing (for a view of the significance of digital practices in the transformation of the archive see Rabinowitz, chapter 11 of this volume).

The beginnings of this kind of critical approach to academic publishing and digital practices have appeared, for example, in Rachel Opitz's recent work (2018) on the intersection of archaeological genres, digital publishing, and data-rich humanities scholarship based on her experiences working to produce *A Mid-Republican House from Gabii*. This work, however, stopped short of considering the impact of archaeological practices on the modalities and character of digital publishing. As I have noted, the fragmentation of archaeological data and the rise in linked, open-data standards appear poised to eliminate technological grounds for explaining why archaeological workflows have not extended from data production and publication. In fact, standardization and fragmentation promote a kind of modularity of archaeological knowledge. Yet even these fast-coursing flows have struggled to erode the barrier between research and many forms of publishing. These barriers are less technological than social and professional.

The roiling intersection of the technological and the professional and social has created a vital space for thinking about what, how, and why we publish as archaeologists. For example, traditional archaeological publications include certain forms of 'data,' typically in the form of a catalogue that supports the reuse and reorganization of this information, usually through the catalog number or through generally defined types. Archaeological publications also tend to include narrative summaries and analysis that resist fragmentation necessary to produce interoperability across scale and platforms. It remains easier to 'drill down' into the standardized data, whether in the form of a traditional catalog or a database, than to drill horizontally between narratives or even drill up from data to various interpretative contexts. New York University's Institute for the Study of the Ancient World (ISAW) Papers makes it possible to link to specific paragraphs (Heath 2014), but reciprocal links that are one-to-many are harder to implement. Moreover, the discipline's commitment to linear structure of narrative and argument, as Opitz has made clear in her description of the Gabii volume, is not unassailable. Innovative and experimentally inclined scholars have challenged a view of publishing that is limited to the narrative (for example, Tringham 2019). On the other hand, grants, professional organizations, and institutions have only recent come to regard the work to archive, much less publish, archaeological data as a key responsibility in the discipline. The growing insistence on archaeological data plans for major grants and the recognition of digital work and publication by professional organizations demonstrate that a shift is taking place, but it remains difficult to anticipate how these top-down protocols will shape publishing at any discernible scale (Huggett 2015). The requirement that archaeologists publish state-funded data has created some interesting professional complications, ranging from the ethics behind sharing or publishing the 3D images of human bones (for example, Hassett 2018) to those associated with evaluating the accuracy of 3D models and the limits to their use (for example, Khunti 2018). New technologies almost always introduce new challenges for archaeologists, which often require social and disciplinary decisions rather than technological solutions.

As the fluid world of digital archaeology is creating new opportunities and challenges for publishing the results of our work, it also seems likely that it will transform entrenched attitudes toward publishing in our discipline. The Digital Press at the University of North Dakota offers one example of how new boundaries between publishing and research emerge from the growing interest in digital workflow and its impact on the social organization of disciplinary practice within the field. To be clear, scholar-led projects such as the Princeton–Stanford Working Papers (Ober et al. 2007) offered models for publishing that depended upon the digital affordance of production and distribution. The emergence of platforms like University of Minnesota Press's Manifold, which supports the transparent and interactive production of academic work, likewise relies on the interoperability of digital flows from author's laptop to the print-on-demand book. The digital affordances of our current scholarly workflow can be as simple as the practice of most academic papers taking shape in word-processing software that can be easily converted for distribution on the web. Scholar-led platforms such as Open Context, which publishes peer-reviewed archaeological data, essentially make artifacts of the digital flow susceptible to review through close attention to metadata and linked data standards.

The Digital Press is a rather more conventional project by comparison, but perhaps the conventional character of its work reflects the maturing of digital practices and a tipping point in how these practices shape professional relations within our discipline. Our current publishing model is fluid, but follows certain relatively consistent conventions. First, we use digital tools to produce and distribute our books at a low cost, using print-on-demand printing for paper books, we distribute also through PDF downloads on a low-cost website running Wordpress, and finally, archive our books at UND's institutional repository and the Internet Archive. Second, we publish mainly under various open-access licenses. This eliminates some of the institutional friction that limits the circulation and distribution of our works. Finally, and most importantly for this chapter, we strive to collaborate closely with authors on all aspects of a publishing process. While none of these things is particularly radical or innovative, we feel like we are harnessing the flow of the digital world and territorializing it as a conventional and familiar-looking book. The involvement of archaeologists in the production of publishable data at the edge of the trench opens the door to a more dynamic model of archaeological publishing.

The Digital Press is almost entirely run by academics, who lay out manuscripts, prepare marketing materials, use their own and their colleagues' social media reach to promote the books, and manage acquisition, peer review, and copyediting. We even try our hand at cover design (with varying results). Our ability to perform these functions is possible largely because the basic publishing tools common to most presses—Adobe InDesign, the PDF format, Adobe Illustrator—are available for relatively minor costs and they are increasingly simple to use. It is now possible to link descriptive text to discrete pieces of archaeological data, to create familiar and portable media-rich documents, and to produce and archive these digital objects easily. In short, the development of digital infrastructure allows archaeologists to extend their workflow from trench side to final publication while remaining involved in all aspects of knowledge-making. To be clear, our work at The Digital Press does not necessarily emphasize the creation of standardized, linked data. We leverage the kind of interoperable data that flows freely across the discipline only inasmuch as our works are largely open-access and available for disaggregation. Instead, it leverages the breakdown of certain barriers present within the discipline, particularly between research and publishing, to expand the process of knowledge-making and complicate the traditional blackboxing of the publication process.

In short, we emphasize to our authors the opportunity to see knowledge-making as extending from the earliest work in the archive or in the field all the way to its final presentation as a publication. In some cases, the Press is invited to participate as a publisher from the first efforts to conceptualize a project in much the same way that data-archiving or -publishing is now an expected part of a data-management plan for any new research project. This integration allows us to work with authors to understand how to best present their research and acknowledges that issues of presentation often have a direct impact on the perceived value of academic work.

Conclusion

To conclude, The Digital Press—and digital publishing practices in archaeology (and I would propose in academia more broadly)—offers at least one way to think about the tension between the fragmenting of digital archaeological data and social practices at the core of knowledge-making. The concept and practice of archaeological workflow in a digital environment has a social impact on our discipline. In publishing, digital tools and practices have contributed to a collaborative environment that is not grounded simply in the relative ease of using mainstream professional design tools and the basic interoperability of digital word processors, but in the concomitant transformation in the social and professional context for creating new archaeological knowledge. Following the fragments of digital knowledge along the rhizomic streams connecting field practices to final publications challenges some of the traditional forms of organization that define archaeological work. The ease with which objects, human remains, and even buildings can move through digital media demonstrates, at some level, how digital workflows can transform the social and disciplinary limits on archaeological practice. This work to reterritorialize the digital workflows goes beyond producing a digital object with the familiar form of a book and extends to attempting to re-create the convivial spaces of premodern craft in an effort to wrest archaeological knowledge from the flow of fragmented data. In the end, The Digital Press aspires to contribute to the creation of new critical models for digital archaeology that both unpack the black box of publishing and create a new, digitally mediated model for the production and dissemination of archaeological knowledge.

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CHAPTER 11

(Re)imagining the Archaeological Archive for the Twenty-second Century

Adam Rabinowitz

As members of a discipline that compulsively attempts to reconstruct the past from fragments, archaeologists are especially sensitive to the prospect of information loss. It is no surprise that the archaeological community expressed early concern about the fragility of digital data and has rung alarm bells about data preservation since the 1990s. Disciplinary attention has focused on the loss of documentation produced in the course of non-reproducible archaeological research, and major international efforts to ensure the longevity of digital archaeological documentation continue to center on the risks of data loss over the next few decades.[1] This work has begun to bear fruit in the form of long-term repositories, widely shared standards, and best practices for data preservation. This chapter, however, is interested in what digital archaeological data might look like in the longer term. It begins with the history of archaeological archives and our shared disciplinary understanding of what belongs in them, juxtaposing this understanding with past and present attempts to imagine how people in the future will interact with the records of their past. On the basis of both history and imagination, it then suggests possible futures for today's digital archaeological archives a century from now. Such a thought experiment reveals the ways in which the choices we make now about the contents of our archives will constrain or enhance the research opportunities of our future colleagues. Like late nineteenth- or early twentieth-century attempts to imagine the future, this speculative endeavor takes an optimistic view of the odds of survival of the core components of digital archaeological archives; but like late twentieth- or early twenty-first-century attempts to imagine the future, it recognizes the likelihood of significant information loss, especially with regard to the human elements of those archives.

Futures Past

The conceptualization of time expanded dramatically over the course of the nineteenth century in both Europe and the United States. For most of the European inhabitants of these areas in 1800, history still began in 4004 BCE, and the Far East or Egypt were places more abstract than immediate. By the end of the century, Lyell and Darwin had extended the history of the earth back millions of years, Thomsen's classification of the 'Stone Age' had placed early humans in that deeper timescape, and Schliemann claimed to have uncovered the prehistoric truth behind the Homeric tales at Hisarlik. At the same time, the rapid industrialization of Europe and the United States, together with the avalanche of technological change between the middle of the nineteenth century and the beginning of the twentieth, made it possible to imagine a future radically different from the present. At the *fin de siècle*, writers like Jules Verne and H.G. Wells established science fiction as a popular genre (Roberts 2006), while the Italian futurist movement imagined a new world of speed and power emerging through machines (Berghaus 2009). A sense of forward motion was common to all of these visions of the future: faster motion, farther motion, motion into new places like the depths of the sea or the surface of the moon. By the early 1900s, as airplanes and automobiles entered the scene and electricity, radio receivers, and telephones diffused into the consumer market, imagined futures routinely incorporated air travel, electrical power, and the transmission of sound (and perhaps even images) by radio waves.[2]

Futurist imagination and archaeological knowledge production appear rarely to have intersected in these years,[3] although archaeologists were quick to take advantage of the new nineteenth-century technology of photography, since it made it easier to document and publish the structures and objects that they uncovered (Lyons et al. 2005, Shanks 1997). The basic elements of archaeological documentation had been established already by the late eighteenth century, at sites in both Europe and North America (Lehmann-Hartleben 1943, Parslow 1995), and collections of primary archaeological documentation were already being compiled by European researchers across the Mediterranean and the Near East by the time Schliemann turned up his first spade-full of earth at Hisarlik in 1870.[4] These collections included notebooks and other forms of handwritten (and later typed) text; plans, elevations, and object drawings rendered in pencil, ink, or paint; halftone illustrations or engravings produced for publication; physical squeezes of ancient inscriptions; and eventually photographic negatives (initially on glass, later on silver-nitrate film) and prints. An excellent representation of late nineteenth-century archaeological documentation can be found in the records kept by Karl Kazimirovich Kostsyushko-Valyuzhinich, held by the museum at the site of Chersonesos in Crimea. State-of-the-art in the late 1880s and early 1890s, Kostsyushko-Valyuzhinich's documentation efforts incorporated glass-plate negatives, hand-colored photographic prints, measured plans, and epigraphic squeezes to capture the full three-dimensional form of the inscriptions he found.[5]

Kostsyushko-Valyuzhinich almost certainly assumed that future users of his materials would consume them in the same form in which they were deposited—that is, by first-hand consultation of the hard copies, as archaeologists had experienced their predecessors' documentation for the previous hundred years. He would never have expected that his reports and plans would be made instantly available on a viewing screen to audiences across the globe. But contemporary futurists might have. Around the time that Kostsyushko-Valyuzhinich was conducting his research, a series of vignettes was created by French artists in connection with the 1900 Exposition Universelle in Paris. Intended to be included in cigarette boxes but never actually distributed,[6] these visions of the future incorporated several recurring themes, the most obvious being the emphasis on human flight: the illustrations return again and again to propeller-driven personal aircraft serving for deliveries, firefighting, and recreation, in an early take on the now-clichéd idea that the near future will bring flying cars. One of these illustrations is directly relevant to the subject at hand. It depicts a classroom of the year 2000, in which students wear headsets with earphones connected by wires to a hand-cranked machine on one side of the room. Into the machine's hopper the schoolmaster feeds a series of books, from which the information is presumably being extracted in electronic form to become an audio broadcast fed directly into the students' heads. One book has a legible title: "Histoire de France" (Figure 11.1.).

Apart from the rather apt metaphor for education in the time of the 2020 pandemic, this image of the future consumption of historical information offers several points of interest for the discussion of archaeological archives. First, it is based on technologies that were relatively new at the time, but that were already familiar to the audience of

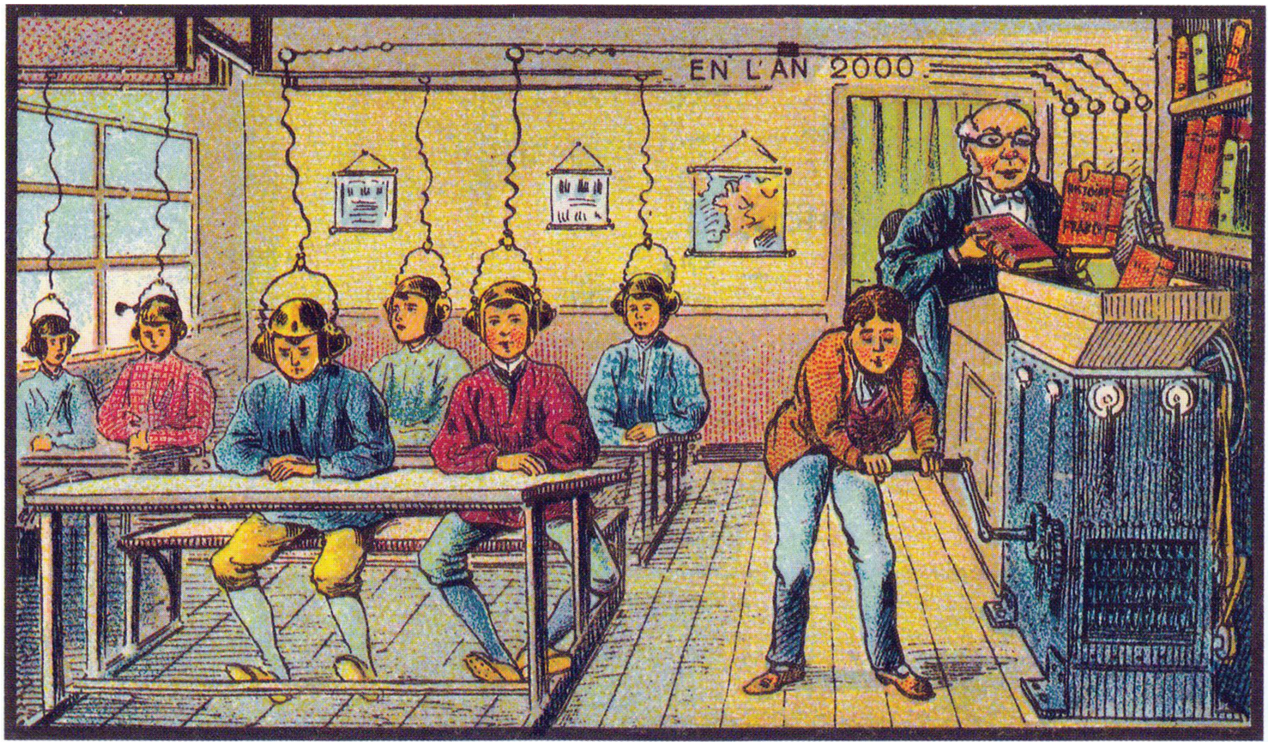


Figure 11.1. A card produced in France in either 1901 or 1910 with art by Jean-Marc Côté/Villemard depicting a French schoolroom of the year 2000. *Public domain image from Wikimedia Commons, https://commons.wikimedia.org/wiki/File:France_in_XXI_Century._School.jpg.*

the cards: electricity, the transmission of sound, machines that converted raw materials into processed goods. Second, by exaggerating these existing technologies, it suggests the more rapid and efficient transmission of information from the carrier (a book) to the recipient, through the transformation of the printed word into, one presumes, its electronic equivalent. And third, perhaps to set up a juxtaposition between past and future, the artist deliberately signals that history will continue to be studied, and therefore history books will need to be adapted to new delivery formats.

The parallels with the process of digitization and the shift from analog to digital documentation in archaeology are hard to escape, yet the artist obviously misses the development of the binary transistors and integrated circuits that eventually made possible the transformation of the printed word to its digital equivalent. That is, the vision from 1900 accurately predicted the kind of content that would be transformed, somewhat accurately predicted the kind of transformation that would take place, and completely inaccurately predicted the mechanisms of both transformation and delivery for that content. Our attempts to imagine what digital archaeological archives will look like in the near and distant future are likely to be accurate and inaccurate in similar ways. Central to our planning today, therefore, should be the question of what content we hope to transmit, and for what purpose, regardless of the medium.

Framing the Archaeological Archive

Unlike the early twentieth century, when futurist speculation and traditional archaeological practice did not intersect, the rapid technological developments of the early twenty-first century have affected both archaeological practice and our visions of possible futures, and have brought the two together in our attempts to plan for the preservation of the digital archaeological data we are now collecting. We are missing an important temporal horizon in this planning, however. The practical data-preservation concerns of archaeologists have a timescale of perhaps three decades at the moment, and within that three-decade window the infrastructure and standards established by archaeological archives like the Archaeology Data Service (ADS) and the Digital Archaeological Record (tDAR), together with a growing number of institutional data repositories based on Harvard's Dataverse, have come close to guaranteeing data survival and accessibility if used properly. At the other end of the temporal spectrum, the development of very-long-term archiving initiatives driven by the fear of a looming 'digital dark age' may offer preservation possibilities for archaeological datasets at the thousand-year level and beyond.[7] But ADS and tDAR rely on present-day storage and access technologies that will no longer be current in a few decades, while solutions for deep-time archives are impractical for data retrieval, integration, and re-use in the nearer term.

I would like to concentrate here on a space between those two time-scales: longer than a single human generation, but shorter than a millennium. Specifically, I suggest that we imagine what today's digital archaeological archive might look like in a hundred or 150 years—that is, the timeframe within which we regularly reuse the archives of our predecessors. At that temporal horizon, we cannot assume that we will access or read data in the same way, but we can nevertheless assume that we will still be able to manipulate machine-readable digital data and will not have to rely on human-readable formats alone. This timeframe encourages us to think neither about technical specifications for file formats, metadata, and software, which are already well addressed by best-practice documents (for example, Archaeology Data Service and Digital Antiquity 2011), nor about strategies to make data independent of hardware, which is the focus of the deep-time archives, but about how our present choices affect the content of our digital archaeological archives, and what we imagine their future users might want from them in the middle term.

We must begin by defining what we mean when we talk about an 'archaeological archive.'[8] Generally speaking, an archive is a collection of related information stored and gathered on the assumption that it might serve some future purpose, and that it will serve that purpose through consultation and reuse. It is distinguished from a collection of 'works' such as books or artistic creations by the fact that its contents were usually not originally intended for public consumption. In an archaeological context, an archive contains materials produced in the course of documentation and study, but not usually the physical remains themselves or the final versions of the books and articles where the research was presented to the public. An archive is further distinguished from the unfiled documents of an active researcher by the fact that its contents are no longer subject to change, that those contents are catalogued and described, at least in a rudimentary manner, and, ideally, that it is in the care of a trusted memory institution that will both protect it physically and make it accessible to some group of users.

Before the turn of the twenty-first century, archaeological archives had maintained more or less the same form since the discipline's beginnings in the eighteenth century. Like any other archive, they contained hard copies of written documents of various sorts and images in various forms, eventually including photographic prints and negatives. The contents of such archives are similar across time, space, and language: notes taken during excavation by Heinrich Schliemann in the 1870s are similar in form to those taken by Kostsyushko-Valyuzhinich in the 1890s, which are similar in turn to those in the daybooks kept by American excavators at Corinth in the 1930s; black-and-white photographic images of excavations are remarkably consistent from the end of the nineteenth to the end of the twentieth century, and measured plans drawn in the early nineteenth century are immediately recognizable to an archaeologist of the early twenty-first.[9] The most carefully organized of these archives—Schliemann's papers, for example, or the archive of Leonard Woolley's excavations at Ur—also include the correspondence of the various archaeologists and scholars involved, along with accounts and administrative documents.[10] Nothing in any of these archives requires an instrument more technologically sophisticated than the human eye to be examined and understood, and they are all still eminently usable—and often used—a century or more after they were created. Provided that they are cared for and that they escape fire and flood, these physical archives will look much the same in another hundred years (Figure 11.2.).

The same cannot be said for the archaeological archives that have been generated since the last decade of the twentieth century, which are increasingly born digital, derive their visual and spatial components from digital sensors rather than manual measurement and drafting, and rely

Figure 11.2. Barbara Brown, a photograph conservator from the Harry Ransom Center at The University of Texas at Austin, works with conservators at the National Preserve of Tauric Chersonesos to stabilize some of the glass-plate negatives from Kostsyushko-Valyuzhinich's archives in 2005. *Photograph by Chris Williams, courtesy of the Institute of Classical Archaeology of The University of Texas at Austin.*

on digital tools for viewing and reuse. These archives are arguably much richer than those that came before, with their integration of relational databases, high-resolution satellite imagery, extensive spatial data organized with GIS software, geophysical survey data, genetic sequences, vast quantities of digital photographs, and 3D point clouds collected through scanners, LiDAR, and computational photography. But the same wealth of information requires increasing amounts of digital storage space, and because access to some file types can be dependent on proprietary software and specific operating environments, such datasets also need continuous curation. Proper curation is likely to involve the migration of the data, if not to new file-types, then at least to new storage media, and data migration requires vigorous validation protocols to prevent or detect file corruption. The ballooning quantities of time and money required to manage such datasets over the long term are, unfortunately, increasingly beyond the reach of archaeologists and the institutions they rely on to maintain their archives.

The challenges of dealing with digital archaeological archives were already apparent in the 1990s, and we can therefore develop a sense of future preservation by looking back over the last thirty years. ADS was established to house the digital results of archaeological research in 1996 (Richards 1997), and since then it has maintained an ever-expanding collection of digital archaeological archives consisting of raw research data, field documentation, and gray-literature reports, primarily in simple, flat formats. The oldest born-digital dataset I could identify in the ADS archive is a catalogue of prehistoric and Romano-British objects made from Kimmeridge shale, assembled for a 1995 dissertation for the University of London and deposited as a comma-separated-value (CSV) file (Denford 2000). The ASCII text in this file and the accompanying field definitions and coding explanations, available as plain-text HTML files, are still accessible in their original form twenty-five years later. According to ADS usage statistics, files from the archive have been downloaded 243 times since May 2011, and the dataset is cited in recent scholarship (Brück and Davies 2018). The ongoing use of this dataset has several implications: one, plain-text files are likely to be among the most durable parts of an archive; two, documentation and metadata are critical for reuse, since without the associated explanations of codes and fields, this dataset would be impossible to parse; and three, its continued use is the result of its inclusion in a trusted repository with effective search tools.

Other digital archives from the same period may still exist in the hands of their creators. The oldest born-digital archival material from my own work that I can still access consists of a series of Harris matrixes and schematic plans created as working documents for the excavations of the American Academy in Rome in the 'House of Diana' at Cosa between 1995 and 1997 (Fentress and Rabinowitz 1996, Fentress et al. 2003), using the MacPaint 2.0 graphics program.[11] MacPaint was discontinued in 1998, but fortunately in 2003, during the construction of the online component of the final publication, I was still able to convert the original .pict files into the .tif format. Not only are these files still accessible, but they have turned out to have ongoing relevance, since I used one of them in 2019 to resolve a question from a researcher about the letter originally assigned to a specific room of the building (Figure 11.3.). It might not have been possible to resolve this confusion without this file, which as far as I know is not part of the hard-copy archive at the American Academy and which exists only on a few personal hard drives. This modest MacPaint graphic thus illustrates both the potential longevity of image files in well-known and widely-used formats, and the fragility of some of the digital components of a mixed-format archaeological archive (a point reinforced by Tringham in chapter 12 in this volume).

The previous two examples reflect the core components of archaeological archives since the eighteenth century: textual lists and two-dimensional images. Other forms of information have emerged in the last twenty years, requiring different delivery media and preservation strategies. For example, while only a few projects in the early 2000s had the resources to generate point-cloud representations of structures using laser scanners, and while the use of photogrammetry to create 3D representations of stratigraphy was novel enough to merit an article in the *Journal of Archaeological Science* in the early 20-teens (De Reu et al. 2013), most Mediterranean archaeological projects now create 3D documentation for monuments, stratigraphic deposits, or objects as a matter of course. Although 3D point-clouds themselves can be archived as ASCII text in formats like OBJ, the software used to process and visualize the resulting models is often proprietary, creating challenges for the long-term accessibility of both the models and the information about their creation.

These challenges are illustrated by the 3D documentation produced in the course of experiments with photogrammetry for modeling stratigraphic deposits during excavations at Chersonesos in Crimea in 2006, inspired by the work of Hartmut Tschauner (Rabinowitz et al. 2007, Tschauner and Siveroni Salinas 2007) and using the PhotoModeler Pro software package. Months of manual labor by project member Jessica Nowlin led to a series of stratigraphic models that could be viewed in PhotoModeler or ArcScene—but both of those platforms were proprietary, and by the time we had started to think about long-term archiving of Chersonesos data around 2010, the 2006 version of PhotoModeler was no longer supported or compatible with the operating systems on the Institute of Classical Archaeology's computers.[12] It was therefore necessary to consider alternative approaches to sharing the data, and we took advantage of a brief period in 2011 when we had access to an Adobe Acrobat Pro Extended version that could import a VRML file—ArcScene's only export format—to create a 3D PDF. These 3D PDFs are now included in the long-term archive for the project, and they continue to be legible after a decade. Unlike two-dimensional plans or scale drawings, they make it easy for users to take their own measurements within the model. On the other hand, the continued usefulness of these files depends entirely on Adobe's willingness to continue to support embedded 3D data in PDFs. Adobe recently announced that it would no longer support Flash

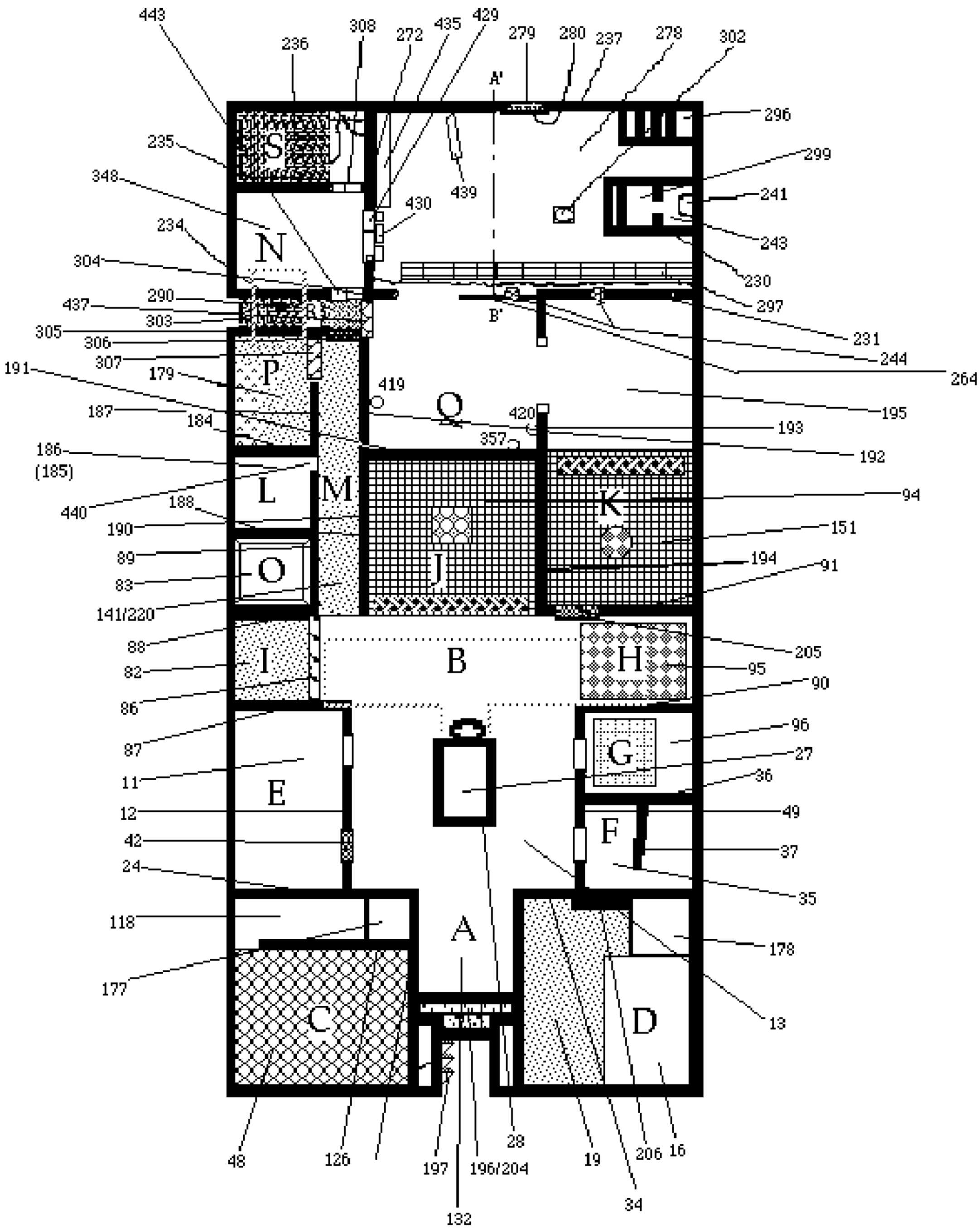


Figure 11.3. MacPaint 2.0 schematic plan of the House of Diana at Cosa, with the letters assigned to rooms and the context numbers assigned to walls and floors, ca. 1997. *Plan by the author.*

content in existing PDFs,[13] and if a similar decision were made about 3D content, this part of the Chersonesos archive would rapidly become unusable. For the moment, then, the most stable archival format for these 3D documents is 2D screen captures or orthophotos. Even while the models or images themselves remain accessible in 2D or 3D, however, the derived nature of the visualizations and the lack of access to the original software make it impossible for a user to assess their quality, accuracy, or precision (Figure 11.4.).

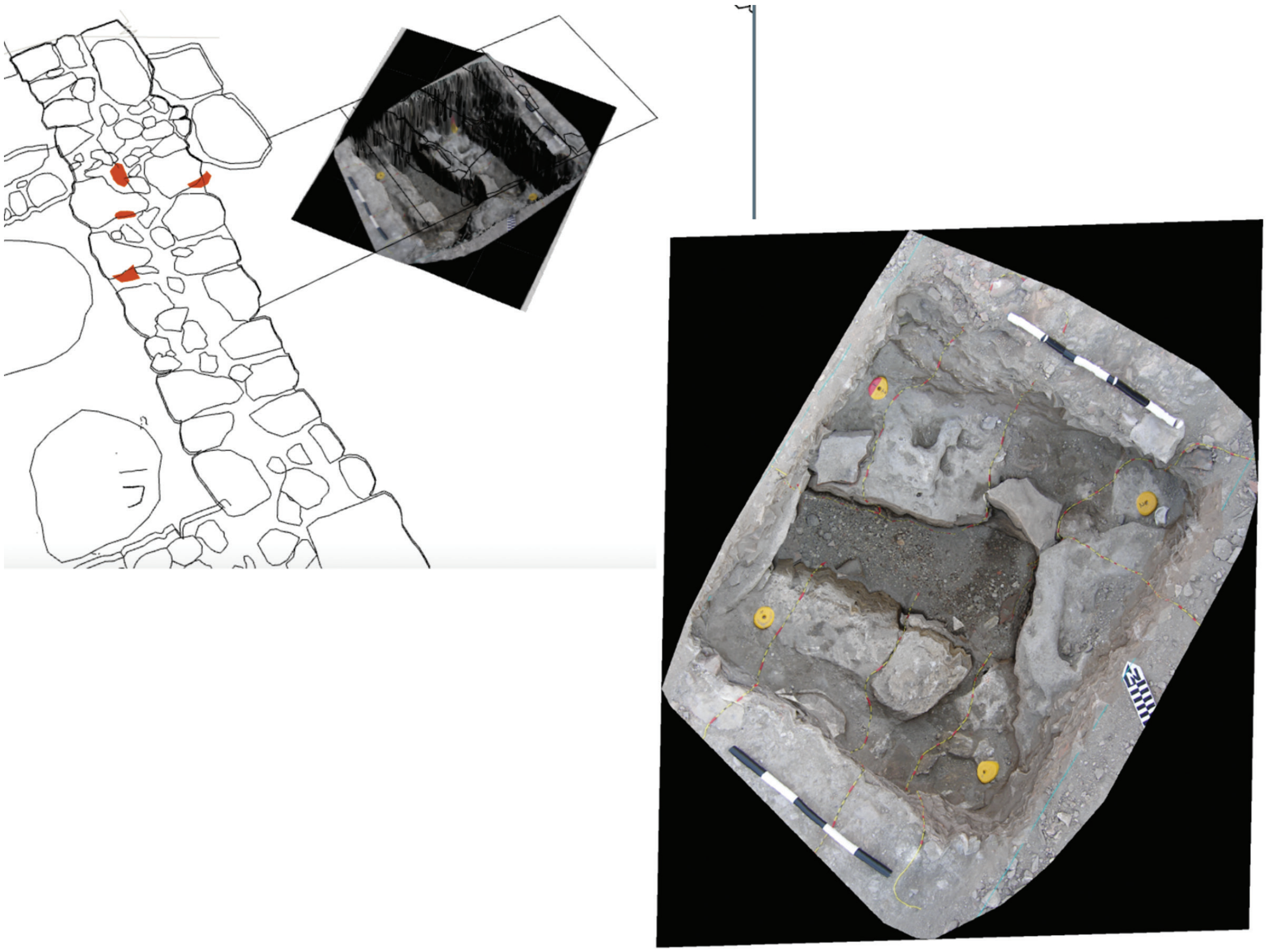


Figure 11.4. Screen capture of 3D PDF (left) and orthophoto created in ArcScene (right) from the 3D model of a Byzantine box-drain in the South Region of Crimean Chersonesos, 2006. *Image courtesy of the Institute of Classical Archaeology of The University of Texas at Austin.*

The locations of the survey points that tie this model to the Chersonesos South Region site plan were recorded as ASCII text by a Total Station data recorder, and the base-map on which it is overlaid is a set of vectors, in the well-documented 'shapefile' (SHP) format. Both kinds of spatial data will almost certainly be legible in a hundred years, if they are placed in a repository that lasts until then. Even if our computing environment changes, the mass of data we have already collected in these formats means that we are likely to have a societal interest in ensuring that they remain accessible, if only through emulation platforms. Recent projects have taken a more deliberate approach to the creation, management, and archiving of 3D data, metadata, and paradata as well, addressing many of the challenges to preservation and reuse mentioned above (Opitz et al., chapter 8 in this volume; Štular, chapter 7 in this volume). The digital text and tabular data in archaeological archives, the image files, the spatial information, and even the 3D models we have created have thus all made it half-way or more to the thirty-year finish line, and this strongly suggests that these types of files, and the core archaeological data they contain, will also survive the marathon to the hundred-year horizon.

Imagining the Archaeological Archive

As much as we might like to imagine unimaginable futures, in which technology permits interactions between human brains and data that we cannot yet conceive of, it is more likely that these surviving archaeological datasets will be consumed by their users in a hundred years in much the same form that we consume them now: that is, as numbers, words, and pictures, regardless of storage or delivery mechanisms. One way to imagine these future digital archives is through the lens of science fiction—and especially through the lens of the television show *Star Trek*, which through its various iterations since 1964 has been both unusually accurate in its predictions about the future (sometimes in a self-fulfilling manner, by inspiring engineers: Bell et al. 2013) and especially concerned on a thematic level with issues of knowledge preservation and access. *Star Trek* imagined from the beginning a digital future in which information was stored electronically, and in this respect the series was prophetic. But across more than a half-century, access and display formats, however creative, reflected the moment when the episodes were produced: an image slideshow in 1964, a LexisNexis-style document database in 1987, a relational database in 2001. Three-dimensional data and interfaces were added with the rise of 3D modeling in 2003, and in 2019 the writers imagined a hundred-thousand-year archive stored as a living planetoid, the equivalent of the deep-time paleoclimate and genetic archives twenty-first-century scientists are currently exploring.[14]

Two observations about these visions of future archives are relevant to our attempt to imagine the digital archaeological archive in a hundred years. First, even in science fiction, our imagination of the future is deeply conditioned by our present. In our conceptualization of future archaeological archives, then, we are likely to be constrained by our concept of such archives in our own time. Second, for fifty-five years, *Star Trek*'s depictions of the archives of the future have centered on words and pictures, even as storage mechanisms and access interfaces were portrayed as more technologically advanced. Like the results of the past twenty-five years of digital preservation, this suggests these elements are so fundamental to the idea of an archive that the core content of today's digital archaeological archives, in the form of documents, tables, images, spatial data, and 3D visualizations, will survive in usable form on the file level across the next hundred years.

On the other hand, the *arrangement* of information is much more vulnerable. Even the fictional archives in *Star Trek* episodes are full of decontextualized data. Such decontextualization is a major threat to the usability of digital archaeological data in the future. For digital archaeological archives, in cases where the information is embedded in the presentation medium, the larger the number of external dependencies, the greater the risk that the failure of one component will render the information inaccessible. In cases where additional context is required to make sense of data, as with the numerical codes of the Kimmeridge Shale dataset, the separation of individual records from the larger assemblage or from their documentation makes them useless (Kansa and Kansa 2013).

Even with functioning file formats and proper metadata, digital archaeological archives risk the loss of their broader context. The core components of archaeological archives from the nineteenth or twentieth centuries are made more comprehensible by the more ephemeral working documents that have been included with them: sketches, notes, correspondence, even accounts. The shift to digital recording methods, with their emphasis on precise spatial measurements derived from sensor capture and the visualization of these measurements in digital platforms, tends to marginalize or exclude such working documents. With a few notable exceptions (Schroer and Mudge 2017, Tringham 2018, Tringham and Stevanović 2012; and in general the reflexive ethos of the Çatalhöyük excavations), archaeologists who have embraced digital recording tools have tended to focus more on efficient capture methods and polished outputs than on the documentation of the processes that connect data collection with finished products. Furthermore, because the scale of data capture is rapidly outstripping the ability of repositories to manage long-term data storage, and because the cost in time and money associated with such long-term storage is significant, it is likely that the managers or depositors of digital archaeological archives will choose to filter deposited data, with a bias toward lighter-weight information that can be represented as structured ASCII text and finished digital products like 3D models, and away from storage-intensive raw data and working documents that contain process information.

Without a conscious effort to embrace process history and replicability, this combination of neglect and selection is likely to result in a decrease in the quantity of raw data and process documentation in digital archaeological archives, just as the perception of precision and accuracy conveyed by digital data increases. This would reduce the ability of future users to evaluate collection processes, assess data quality, or challenge results, intensifying the reproducibility problems that have always troubled archaeological research (Marwick et al. 2017). Fortunately, there is a growing movement to adopt more rigorous and transparent approaches to the archiving and sharing of raw data and paradata (Mudge 2012, Marwick 2017, Opitz et al., chapter 8 in this volume, Štular, chapter 7 in this volume). But the full expression of the intricate relationships between excavators, tools, stratigraphy, and objects that underpin archaeological knowledge production can only be captured through the further integration of raw data and process history with human observation, subjectivity, and iterative interpretation—what Huggett calls elsewhere in this volume (chapter 6), following Lupi, "data humanism" (see also Huggett 2020). Unfortunately, it is precisely this integration that is at the greatest risk of disappearing from the archives over the next hundred years.

Reimagining the Archaeological Archive

The accessibility to future archive users of file-formats beyond plaintext and image is partially dependent on choices made by software companies, leaving archive creators to hope that they are correctly anticipating future software developments. The difficulty of this situation is compounded, however, when one turns to information presented online, where dependencies, code versions, and browser functionality change with frightening speed. The power and vulnerability of integrated online approaches can be seen in the work of the UK-based archaeological consultancy L – P : Archaeology over the last fifteen years. During that time, the L – P team developed the Archaeological Recording Kit (ARK) (Eve and Hunt 2008) and pioneered 'data blogging,' integrating links to database records and video with narrative blog posts documenting excavation at a complex urban site at Prescot Street in London from 2007 to 2010 (Richardson 2008). The Prescot Street blog and the project's ARK instance are still running, but there are signs of wear around the edges, and it is unlikely that the site will be maintained with its original functionality indefinitely.[15]

Working with L – P : Archaeology, the Institute of Classical Archaeology at UT Austin is building on this model for the publication of a dataset from Crimean Chersonesos, using daily narrative entries in excavation notebooks as blog posts with links to records in the database.[16] In the time that we have been working on this approach, however, the version of PHP on which the Chersonesos ARK is based has been deprecated. It is very likely that the integration will only operate as intended for a few years before obsolescing. We have developed a longer-term plan that involves JSON serialization of the entire contents of the relational database, XML serialization of the blog posts, and the export of the ARK interface as a series of static HTML pages without external dependencies. This 'dehydrated' version of the project will preserve the dataset's contextual information and relationships together with the look and structure of the Chersonesos ARK, if not the original user experience.

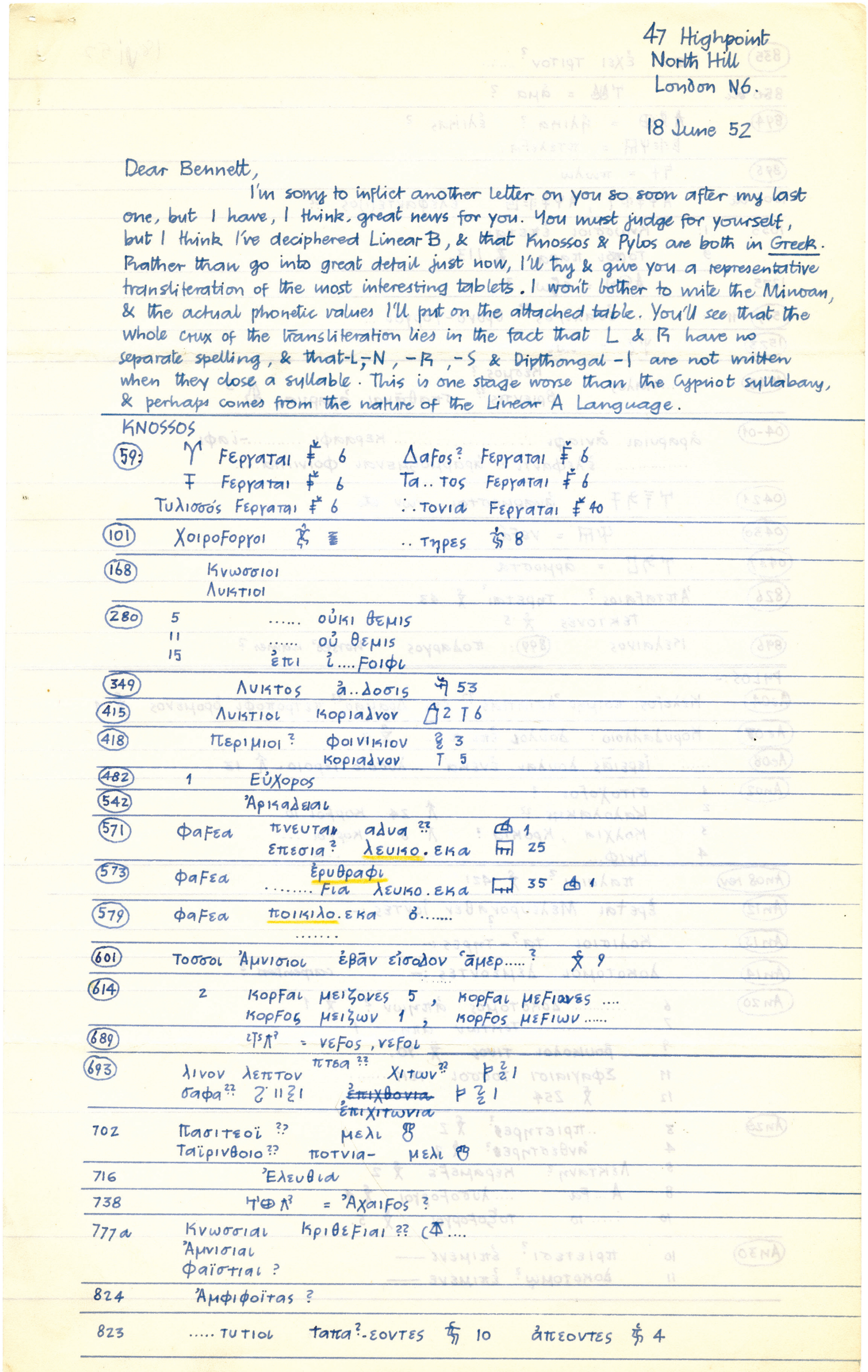
Should an attempt be made to preserve the original user experience? Are the interfaces used to collect, manage, and share the archaeological data part of that project's archive? Here we encounter a much more fundamental question for the imagined archives of the future, one that other contributors to this volume have also taken up: what is worth saving? I have suggested that it is very likely that words, numbers, images, and 3D and spatial data in relatively simple, well-documented, and widely used formats will remain accessible for the next hundred years, barring a catastrophe of global scale, as long as we place them in repositories with established track-records (ideally, together with raw data and process history). The resulting digital archives will emulate the physical archaeological archives of the last two hundred years, albeit with much greater information density, and are likely to be used in similar ways. If we stop there, and exclude harder-to-preserve elements like digital interfaces, we have still met our traditional responsibilities to the archaeological data.

In repeating this structure, however, we may also be reducing the opportunities for future researchers to use these archives for research into the social construction of knowledge at this particular moment in history. Future scholars will be able to see the data we produced and the ways in which we interpreted it, but the affordances of the systems within which production and dissemination took place will be obscured. This is especially true of complex interactive websites with multimedia resources, which resist the attempts of the Internet Archive to document them, and which, once their files and code are lost, cannot be resurrected (software packages are more amenable to emulation). Static captures, either images or HTML, can preserve the appearance of such websites, but not the way their users engaged with them. Even video screencasts, which can demonstrate the interactive components of an interface more effectively, can only show interactions the screencaster has chosen. The 'graceful degradation' of online projects is inevitable (Nowviskie 2015), and perhaps the notion that some of these will become 'archaeological,' preserved only in scattered fragments, should be embraced (Tringham and Ashley 2015; Tringham, chapter 12 in this volume, makes a compelling case that narrative decomposition is necessary for source data to be reborn through reuse). On the other hand, where digital interfaces have strongly shaped the collection and interpretation of archaeological remains, they are likely to be of interest both to future users of archaeological archives and to historians of science or media scholars, and we should consider carefully how we might include in the archive information about how they worked, even if they cannot be maintained in their original form (video tours, screenshots, codebases).

At even greater risk of archival exclusion are the human stories woven through the production of archaeological knowledge. Letters have been fundamental tools for both social and intellectual historians, helping to elucidate both the discursive development of ideas and the historical contexts in which these ideas took shape.[17] They have also been central components of the archives of nineteenth- and twentieth-century archaeologists, where they both humanize and explain the archaeological research documents they accompany. Schliemann's letters allowed David Traill to question the veracity of some of his scientific reports (Traill 1995), while the letters exchanged between scholars working to decipher Linear B in the mid-twentieth century, held by the Program in Aegean Scripts and Prehistory at UT Austin, have not only allowed scholars to follow the process of decipherment but also inspired several works of biography and narrative fiction[18] (Figure 11.5.).

In some cases, letters and administrative documents can offer dramatic insights into historical circumstances. In the archives of excavations carried out by Russian expatriate scholar Evgeniy Golomshtok on behalf of the Penn University Museum at Eski Kermen in Crimea in 1933 is a telegram Golomshtok wrote in 1934, on his way to a second excavation season. He informs the Museum that his visa to enter the Soviet Union has been refused, "my explanation to conceale [sic] wholesale removals former colegues [sic]" (E. Golomshtok to University Museum, telegram of 9 July 1934, Golomshtok papers, Penn University Museum archives, Philadelphia). In fact, Stalin's purges had reached the halls of the archaeological institutes that year, and many of those colleagues were already dead or in the Gulag (Miller 1956). Similarly, the barrage of emails sent in spring 2020 canceling international research plans in response to the COVID-19 pandemic will put a human face on future accounts of the hiatus in archaeological activity for that year.

Or they would—if any of these emails survive the next hundred years, which seems increasingly unlikely. While archaeologists have focused on safeguarding archaeological data from a 'digital dark age,' little attention has been paid to the correspondence that continues to shape ideas and research programs, but is now almost exclusively digital. Email is essentially absent from discussions of the priorities, practicalities, or theoretical underpinnings of digital archaeology and archaeological archives (it is not mentioned at all in Huvila's recent discussion of the "ecology of archaeological information," for example: Huvila 2018). Yet the importance of email as a historical resource to examine social, economic, and political phenomena cannot be overstated. Archivists are aware of this, and both public and private bodies have issued guidelines, commissioned reports, and assembled taskforces to develop long-term preservation plans (The Andrew W. Mellon Foundation 2016, Kavanaugh 2016, Ratanatharathorn 2017, Task Force on Technical Approaches for Email Archives 2018, US National Archives and Records Administration 2020). Using correspondence archives from the early modern period, historians have reconstructed the concerns and social networks of thinkers who lived three or four hundred years ago. Without email archives, it will be almost impossible for scholars of a hundred years hence to do the same for twenty-first-century archaeologists.



47 Highpoint
North Hill
London N6.

18 June 52

Dear Bennett,
I'm sorry to inflict another letter on you so soon after my last one, but I have, I think, great news for you. You must judge for yourself, but I think I've deciphered Linear B, & that Knossos & Pylos are both in Greek. Rather than go into great detail just now, I'll try & give you a representative transliteration of the most interesting tablets. I won't bother to write the Minoan, & the actual phonetic values I'll put on the attached table. You'll see that the whole crux of the transliteration lies in the fact that L & R have no separate spelling, & that -L, -N, -R, -S & Dipthongal -I are not written when they close a syllable. This is one stage worse than the Cypriot syllabary, & perhaps comes from the nature of the Linear A Language.

KNOSSOS

(59) Ϝεργαται 6 Δαϝος? Ϝεργαται 6
Ϝεργαται 6 Τα.. τος Ϝεργαται 6
Τυλισσος Ϝεργαται 6 ..τονια Ϝεργαται 40

(101) Χοιροϝοργοι ..τηρες 8

(168) Κνωσσιοι
Λυκτιοι

(280) 5 ...... οὐκι θεμις
11 ...... οὐ θεμις
15 ἐπι ἰ.... Ϝοιφι

(349) Λυκτος ἀ..δοσις 53

(415) Λυκτιοι κοριαδνον 2 6

(418) περιμιοι? φοινικιον 3
κοριαδνον 5

(482) 1 Εὔχορος

(542) Ἀρκαδιαι

(571) φαϝεα πνευται αλυα?? 1
επεσια? λευκο.εκα 25

(573) φαϝεα ἐρυθραφι
.... Ϝια λευκο.εκα 35 1

(579) φαϝεα ποικιλο.εκα ......
....

(601) Τοσσοι Ἀμνισιοι ἐβᾶν εἴσοδον ἅμερ.....? 9

(614) 2 κορϜαι μειζονες 5, κορϜαι μεϜιονες ....
κορϜος μειζων 1, κορϜος μεϜιων ......

(689) ? = νεϜος, νεϜοι

(693) λινον λεπτον πτεα?? χιτων?? 1
σαφα?? 11 1 ~~επιχθονια~~ 1
επιχιτωνια

702 Πασιτεοι?? μελι
Ταϊρινθοιο?? ποτνια- μελι

716 Ἐλευθια

738 ? = ἈχαιϜος ?

777a Κνωσσιαι κριθεϜιαι ?? ....
Ἀμνισιαι
φαϊστιαι ?

824 Ἀμφιφοϊτας ?

823 ..... τυτιοι ταπα?-εοντες 10 ἀπεοντες 4

Figure 11.5. Letter from Michael Ventris to Emmett Bennett, dated June 18, 1952, in which Ventris announces that he has deciphered Linear B, and that the script was used to write an early form of Greek. *Image courtesy of Tom Palaima and the Program in Aegean Scripts and Prehistory at The University of Texas at Austin.*

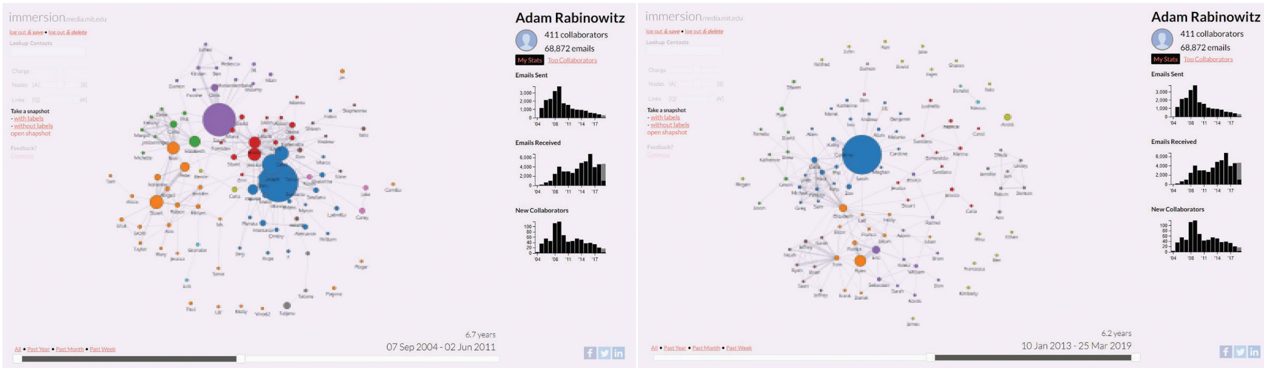


Figure 11.6. Immersion browser network visualizations for the author's personal Gmail account for two different periods: on the left, the dark blue nodes correspond to Chersonesos collaborators; the orange to collaborators on GeoDia, a digital mapping project; and the dark red to Institute of Classical Archaeology colleagues. On the right, the dark blue nodes correspond to family members, and the orange nodes to PeriodO collaborators. *Screen captures from http://immersion.media.mit.edu on March 25, 2019*.

Letters have been a standard component of paper archives since archives have been kept, and do not require treatment different from the other elements of those archives. The preservation and management of email archives, however, will require additional resources on the infrastructural level that Eric Kansa discusses elsewhere in this volume (chapter 9). There are emerging software platforms that will facilitate the analysis of email archives and their sorting, cataloguing, and preservation. The promising ePADD email archiving tool created at Stanford University, for example, facilitates the preparation of personal email archives for ingest into a long-term repository while providing natural-language-processing and visualization tools to aid in discovery (Schneider et al. 2017).[19] The potential for analysis and discovery in such tools was demonstrated by the now-defunct Immersion browser, a project of the MIT MediaLab launched in 2013 (Jagdish 2014). This application scraped email metadata from Google accounts to allow users to visualize the social networks and correspondence patterns latent in their Gmail inboxes, with results that—at least in my own case—reflected shifting archaeological, academic, and personal activities over time with uncanny accuracy[20] (Figure 11.6.).

The use of personal email metadata provided by a Google API, however, highlights the entanglement of the archaeological subject with the very different priorities of large information-technology corporations and with the ethical challenges posed by the ICT industry (Richardson, chapter 13 of this volume). A sheaf of private letters in an analog archive does not raise the same questions of corporate data ownership, data security, and privacy, nor does it compound the carbon cost of an email by adding perpetual cloud storage to the tab. The ePADD platform provides a screening stage to filter out private or protected communications, but this presents another barrier to email archiving: the time necessary to differentiate significant correspondence from spam, and to exclude information that might violate the privacy expectations of others. The situation is even more complicated for employees of educational institutions and/or governmental organizations, whose professional communications may be subject to FERPA or FOIA regulations. And as email is now only one thread in a tapestry of digital communication technologies—text messages, chat, Slack, Discord, recordings of Zoom meetings—the archiving of correspondence becomes a moving target.

This brings us back to our original question—what should be preserved, and why?—but with an added twist. Not only do we need to be concerned with which digital objects generated in the process of archaeological research are to be preserved, but we also need to consider the extent to which we ourselves, as archaeologists and researchers, might be valid objects of future study. We certainly think our predecessors of the nineteenth and early twentieth centuries are; if we wish to leave scholars of the future some insight into the social and historical contexts that shaped our work, we should incorporate our correspondence into our archiving plans. At the same time, as the portion of our lives that we live in online environments that we do not control increases, and as our individual 'datafication' for corporate profit becomes more comprehensive, we will have to pay much more attention to the boundaries between what we owe future scholars and how much of ourselves we are willing to surrender. If Huggett calls in this volume (chapter 6) for a more human dimension of data, to what extent must we also curate our own data dimensions, in the spirit of the Quantified Self movement (Lupton 2016), for the sake of the archives of the future?

Conclusion

Many humanities scholars rely on archives for their own research, but archaeologists are more conscious than most of the importance of the archives they themselves create in the course of their work, because they are aware that their investigations cannot be replicated. It is axiomatic that the process of excavation destroys the object of inquiry. But this focus on the destructive nature of excavation and the consequent importance of archaeological documentation has led us to take a fairly narrow view of the nature of an archaeological archive. In the past, this narrowness was mitigated to a certain extent by the fact that both data and 'paradata'—information about process—were stored on physical media, so that archives came to include letters, accounts, sketches, and informal photographs as well as formal documentation. We are now at a crossroads, however. As archaeological research has shifted definitively to digital methods, as the volume of data generated by those methods has begun to seem unmanageable, and as the discipline has faced fears about the longevity of born-digital information, digital archaeological archives have become more selective in ways that favor quantitative and processed data over raw data, 'fuzzy data', and process history. Furthermore, while the platforms and interfaces we use to collect and engage with data have become more diverse and sophisticated, and while more information than ever is accumulating about the archaeologists themselves and their social context, the more rigid conceptualization of archaeological archives and the difficulties inherent in preserving digital interfaces and electronic correspondence threaten the preservation of those items for twenty-second-century researchers. At the end of this path, we may imagine a future archaeological archive rich in empirical data but poor in human context.

The other path is more arduous, but it will bequeath to future archaeologists archives the potential to support a much wider range of inquiry. It requires us to take a broader view of what we think an archaeological archive should contain. As practitioners whose engagement with their study material now requires digital mediation, we are already cyborg subjects; as human beings in the age of email and social media, we are already cyborg objects, with digital appendages that expand and inform our identities. As Colleen Morgan suggests, we should incorporate this knowledge not only into our practice, but into what we attempt to leave behind for the future (Morgan 2019). This concept of an archive raises ethical as well as practical problems: archaeologists are already accustomed to dealing with ethical issues related to the remains of former human beings, but we must now think about the intersection between privacy and data in relation to ourselves. Ian Hodder and the Çatalhöyük excavation team were already confronting these questions in the 1990s (Berggren and Hodder 2003, Hodder 1997, 2000, Wengrow 2006), but since that time our digital footprints have grown wider, deeper, and more detailed. Should an archaeological archive include not only notes taken by participants and casual photographs of workers and students, but also detailed GPS data about the location of individuals during survey work and participants' tweets about excavation results? Who 'owns' these data—the project director? The local archaeological authorities? The individuals who generated them? Even if we can answer these questions, we are confronted with the broader ethical and infrastructural issues that Richardson and Kansa address elsewhere in this volume.

It would be easier to exclude correspondence, interfaces, and informal process information from archaeological archives altogether, in order to sidestep difficult questions and practical challenges. But we do so to the detriment of our colleagues a hundred years from now. If we take a narrow view of what belongs in a digital archaeological archive, we may pass on more information about the archaeological remains themselves than our predecessors did, but we will hand down to future researchers far less information about the research context than past archaeologists have given us, and we will restrict the kinds of scholarship that our archives can support. If we allow ourselves to imagine our present digital archives more expansively, with as much emphasis on the contexts of data creation, manipulation, and presentation as on the data themselves, and if we approach our selection of correspondence and other contextual materials with a judicious balance between openness, significance, and respect for privacy and the preferences of stakeholders, it is more likely that the future incarnations of these archives will be used in ways that we cannot yet imagine.

Acknowledgments

My thanks go to Kevin Garstki for his invitation to participate in the 2019 IEMA conference, one of the most stimulating gatherings of archaeological thinkers I have had the pleasure to attend, and for his patience with the delays in the preparation of this chapter. I am also deeply grateful to Garrett Bruner, the archivist of the Program in Aegean Scripts and Prehistory at UT Austin, whose conversations with me in 2016, in the context of a project on academic archives for the UT School of Information, started me thinking about the issue of email archives and introduced me to ePADD. I would also like to thank Tom Palaima, director of UT's Program in Aegean Scripts and Prehistory, for sharing the archival image of Ventris's letter used here.

Notes

1 This is the primary motivation of the European COST Action "Saving European Archaeology from a Digital Dark Age," or SEADDA (https://www.seadda.eu/), for instance.

2 See, for example, the intersections among, and futurist predictions in, the various radio, electronics, and science-fiction magazines (*Electronics Experimenter*, *Amazing Stories*, etc.) published by technology entrepreneur and science-fiction pioneer Hugo Gernsback in the first decades of the twentieth century (Gernsback 2016).

3 Where nineteenth-century cultural currents related to time, space, distance, the future, and the past do intersect, the effect is more comical than revelatory: the Western Electric pavilion at the 1893 Chicago World's Columbian Exposition, for example, included a small replica of an Egyptian temple with pylons decorated with "Egyptian figures and groups associated with electricity. For instance, there is a group of Egyptian maidens, of the time of Rameses the Second, operating a telephone board, and another group is of men of the same period laying telegraph lines" (White and Igleheart 1893:314). See also Paleofuture, "Where the future came from," https://paleofuture.com/blog/2013/7/12/where-the-future-came-from-a-trip-through-the-1893-chicago-worlds-fair.

4 For example, the famous British excavations at Nineveh led by Sir Austin Henry Layard, the archaeological archives of which are extensive enough that they could be used to develop a sort of 'final publication' of the project's results more than 150 years after it concluded (Turner 2020).

5 The archive can be browsed in both the original Russian and in English translation at http:/www.kostsyushko.chersonesos.org/.

6 The only known set was rediscovered by Isaac Asimov in the 1980s and published as *Futuredays: A Nineteenth-Century Vision of the Year 2000* (Asimov 1986).

7 Concerns about the fragility of digital data have led to several initiatives to preserve information of interest to the human community in the form of human-readable text and images etched or printed at microscopic scale on very durable media, like the Rosetta Project of the Long Now Foundation (https://rosettaproject.org), which uses micro-engraved nickel discs (Lillard 1999), or artist Martin Kunze's "Memory of Mankind" project (https://www.memory-of-mankind.com/), which is depositing microfilm ceramic tablets in an ancient Austrian salt mine. New technologies also suggest possibilities for the long-term preservation of digital data as ones and zeroes, including the use of femtolasers to create nanostructured dots in fused quartz (Zhang et al. 2016) and the deployment of the CRISPR gene-editing technique to encode digital data in the DNA of living bacteria (Shipman et al. 2017).

8 An entire field of knowledge, supported by the efforts of librarians, archivists, and information scientists, exists to define what archives are and ensure their proper management. I cannot claim this expertise, and it should be recognized more often that archaeologists rely on collaboration with these colleagues to ensure the survival and reuse of their records. My definition here relies only on my experience as a user and creator of archaeological archives both digital and analog.

9 Schliemann's excavation notes are held in part at the Gennadius Library in Athens, where some of them are available in digital form: https://www.ascsa.edu.gr/index.php/archives/heinrich-schliemann-finding-aid/; they can be compared to excavation notebooks from the early excavations at Corinth, available in the Corinth database maintained by the American School of Classical Studies in Athens: http://corinth.ascsa.net/. Similarly, the photograph of an excavation in progress at Crimean Chersonesos in 1910 (http://discovering.chersonesos.org/en/south-east-area/p5/photo274.html) is not very different from one taken in the Athenian Agora in 1990 (https://agora.ascsa.net/id/agora/image/2012.77.0953).

10 Woolley's correspondence was digitized in the course of a crowdsourcing project focused on the Ur excavation archives in the early 20-teens; this material is no longer available at the Ur Online project website, which focuses on objects (http://www.ur-online.org/), but a sense of the collection can be found at https://web.archive.org/web/20141129064111/http://urcrowdsource.org/omeka/.

11 For a brief history of this program and the version 1.3 source code, see this page at the Computer History Museum: https://computerhistory.org/blog/macpaint-and-quickdraw-source-code/

12 This eventuality is formally recognized by PhotoModeler: https://www.photomodeler.com/pm-support/end_of_life/. Note that the window of support is only three years.

13 https://helpx.adobe.com/acrobat/kb/flash-format-support-in-pdf.html. The end of Flash support specifically means that "[p]layback of Flash media (*.flv and *.swf) content in existing PDFs will not be supported".

14 The pilot episode of *Star Trek*, in 1964 ("The Cage"), includes a scene where an advanced alien species scans the archives of the starship Enterprise, which consist of "tape and micro-records"; the contents of the archive are represented by a series of images of space history, US presidents, and plants and animals flashing across a screen. An episode of the sequel series *Star Trek: The Next Generation* in 1987 includes a request to search the ship's library for records of someone taking a shower while clothed, a semantic search that "will take a long time, perhaps several hours" ("The Naked Now": season 1, episode 2, 1987). Another related series, *Star Trek: Enterprise*, includes two episodes in which archives are consulted. In one, the archive documents a colonial expedition seventy-three years in the past and includes text and images, causing a crewmember to exclaim, "there's tons of data here, crew manifests, survey photos, weekly status reports!" ("Terra Nova": season 1, episode 6, 2001). In the other, crewmembers consult a "holographic database" from a thousand years in the future, recovered from a time-traveling spaceship; this archive contains 3D images of ships along with 2D schematics and text, including a column by journalist Jake Tapper commenting on George W. Bush's 2003 State of the Union speech ("Future Tense": season 2, episode 16, 2003). The living planetoid archive appears in a more recent series, *Star Trek: Discovery* ("An Obol for Charon": season 2, episode 4, 2019). Although the information it contains is described mainly as sensor data, it seems to be accessed as narrative audio, like a podcast, and the computer screen of one character who is accessing the archive indicates that there are "linked files." A subplot also involves the attempt by a malevolent AI to download the archive, an attempt that is repeatedly thwarted by excessive data-transfer times.

15 https://www.lparchaeology.com/prescot/.

16 The database, or its static HTML representation, will be permanently accessible at https://n2t.net/ark:/87610/t66h2r; the data blog currently resides on a UT Austin WordPress site at https://chersonesos.la.utexas.edu/

17 Correspondence between Enlightenment thinkers, for example, has been invaluable not only for traditional historical research (Goodman 1996), but also for the creation of digital visualizations like "Mapping the Republic of Letters" (http://republicofletters.stanford.edu/).

18 Among the latter are Robinson 2002, Fell 2012, and Fox 2014, together with a recent play entitled "Ciphers" by Bernadine Corrigan.

19 https://library.stanford.edu/projects/epadd.

20 The Immersion browser formerly located at https://immersion.media.mit.edu/ has now disappeared, and the MIT MediaLab website only retains general information about the project (https://www.media.mit.edu/projects/immersion-new/overview/). The bare-bones open-source code is available at https://github.com/CenterForCollectiveLearning/Immersion.

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CHAPTER 12

On the Digital and Analog Afterlives of Archaeological Projects

Ruth Tringham

Afterlives of Archaeological Projects

The idea that archaeological projects have afterlives first came to my attention in October 2010, when Karin Sanders, of the Scandinavian Department at UC Berkeley, gave a talk, "The Afterlives of Accidental Masterpieces," that inspired much of my thinking in this chapter. Her "afterlives" referred to the rich literature written about the prehistoric 'Bog Bodies' in Denmark.

This chapter is based on my personal experiences with archaeological projects in southeast Europe and Turkey that follow the path from 'paperfull' to paperless archaeology, from born-analog to born-digital records of what we observed, measured, and recorded during those projects. I am interested in how our practices of publication and archiving of the primary data documents of archaeological research in both digital and analog media have broader implications for their longevity and the long-term sustainability of their afterlives. The parallel question of what happens to the vast volumes of analog records and physical materials collected during the thousands of archaeological projects is equally interesting and timely, but one that I will focus on less in this chapter, except to emphasize the importance of converting them, where possible, into legacy digital records.

The Life History of An Archaeological Project

It is a fascinating challenge to consider the afterlives of objects and people, beginning perhaps with their archaeological excavation, but one that is rarely (if ever) done explicitly. In order to have an afterlife, an entity must have lived, and that life must have ended—at least in our (human) perception of it or our human awareness of it. Thus we have ghosts, resurrection, reincarnation, excavation! The concept of Life Histories or Use-lives (Schiffer 1987, Tringham 1994:177, Tringham and Ashley 2015) is a familiar concept by now in archaeological practice in reference to living beings (including humans and trees) and made objects (including architecture). Studies that involve reverse-engineering of archaeological remains from their demise as archaeological data to their original creation often form the foundation of the analysis and interpretation of archaeological materials (for example, Tringham 1990).

But archaeological projects also have life histories (Figure 12.1.). The life history of an archaeological project has a number of parallels with life histories of people, animals, plants, places, and things, but there are significant differences, especially at the end of a project's life and the boundary between end of life and afterlife, that are worth examining in a bit more detail.

The End-of-life of a 'Paperfull' Archaeological Project

What happens to the primary source data at the end of a 'paperfull' archaeological project, one in which field documentation has been entirely through analog (especially paper) media? What are the life trajectories of data in an analog world? These are the paper documents, graphics, and photographic film images, videos and films, even data cards and tapes, from which materials for the published narratives and their representative images have been selected. After publication of the final report or monograph, this mass of 'data' or 'supporting documents' is largely forgotten and languishes—at best—in a university library archive, but usually on a shelf or closet, unused, to be eventually thrown away. The storage of analog data is problematic because of physical space issues. I have certainly come face to face with the challenge of what do with the original data from my excavations in Serbia in the 1970s and 1980s (including samples of house rubble from Opovo) (Tringham and Danis, forthcoming). Museums and universities as well as government and development archaeology offices across the world are full to bursting with the original physical documents (let alone the excavated and collected materials) from archaeological projects. Without curation and attention, they are prone to becoming archaeological (once again or for the first time) themselves.

I am sure everyone reading this feels a pang of familiarity with this problem. Ah you say, but you can digitize it! So you can! You can turn a paperfull project into a digital legacy project, digitizing the records, the media, the preliminary reports, and creating a digital database. Since this seemingly obvious solution is not quite as simple as might be expected, I want to spend a few words on the challenges of creating a digital legacy project.

The Creation of Digital Legacy Projects

I had been familiar with computation in archaeology since the 1960s as a student (Tringham 2012a:100). In my first archaeological project (as principal investigator) in Serbia at Selevac (1976–79), our record of artifact observations was in fact born digital; we entered coded data in eighty-column sheets that were analyzed in a mainframe using user-unfriendly Unix programs. There was no possibility of linking this alphanumeric data to any visual record. As I have mentioned in many publications, the introduction of the Macintosh personal computer in 1984 with its graphical user interface created a revolution for me and coincided with my second Serbian excavation at Opovo. We used it to expand the 'born-digital' range of documentation, for example updating a daily map and textual observations of the excavation process and creating a simple database (Filevision) to link the visual spatial information to contents and method of excavation. For heavy-duty digital recording, however, we still relied on the eighty-column sheets that eventually we transposed to personal computer databases in Excel. In the early 1990s Michael Ashley used 4thDimension software and, later, Filemaker to transfer the Opovo mainframe/Excel data to a locally running relational database. It was a long time, however, before 'born-digital' visual media (especially raster visual images and video) could replace the quality of analog media.

Since the mid-1990s, many of the analog sources of primary data from archaeological projects from before and including the 1990s—especially visual media (vector and raster visuals and video)—have been converted to digital formats through scanning and other digitizing technologies. The photographs from Opovo and Selevac were scanned at this time, along with their paper records.

The BACH (Berkeley Archaeologists at Çatalhöyük) project (1997–2005) spanned the transformational period of the late 1990s through the early 2000s from born-analog to entirely born-digital documentation (including media) (Tringham and Ashley 2012). During the active life of the BACH project, the excavation data were entered into the MS Access (Windows-only) database that was maintained by the umbrella Çatalhöyük Research Project, although separate content management systems were used for organizing the media. During the post-excavation period

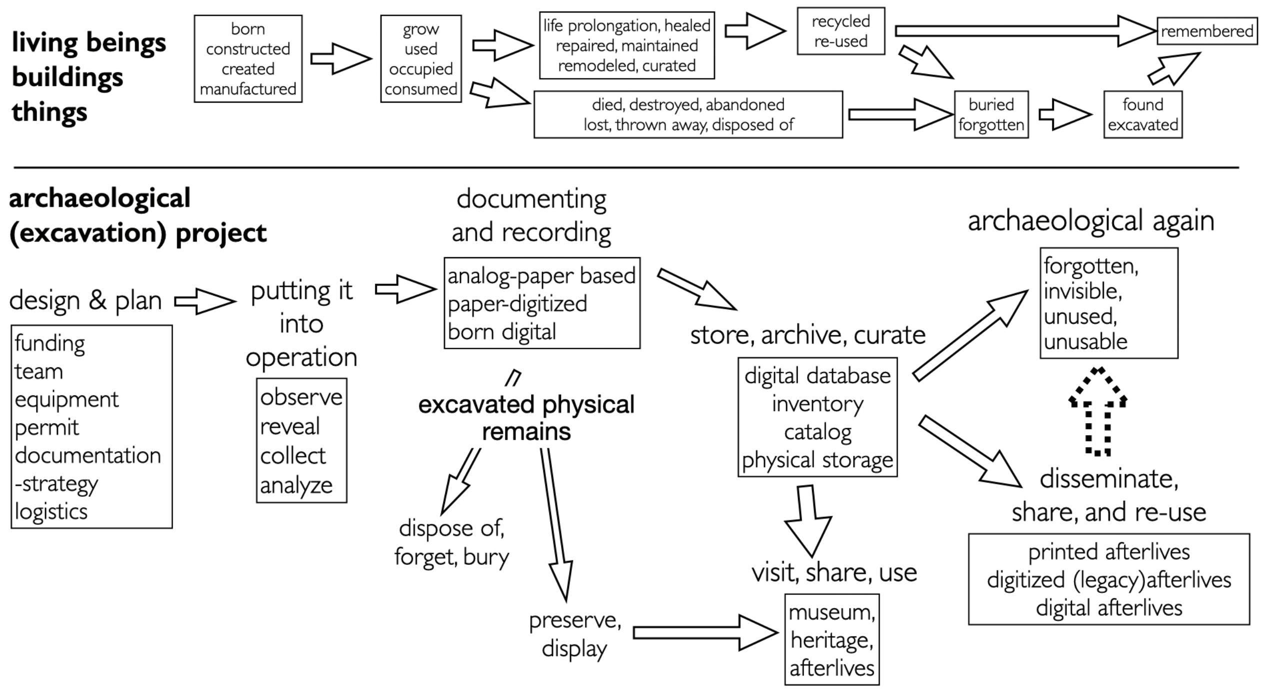

Figure 12.1. Conceptual chart of the life history of an archaeological project.

(2005–15) all the BACH alphanumeric data and media were transferred to a Filemaker relational database (LHotH database) that reflected more closely our interests and would enable the digital afterlives to be sourced directly in the data of the project (Ashley et al. 2011; Figure 12.1.).

These three projects are all legacy projects, but I will focus on the BACH, aka *Last House on the Hill*, project for much of the rest of this chapter.

Unfortunately, the BACH project finished just before the advent of mobile technology (I am referring to iPhones and iPads from 2007, for example, rather than Newtons and Palm Pilots) that enabled the easy adoption of paperless (born-digital) data entry in the field by archaeologists who were not necessarily familiar with computational archaeology. Recording of later seasons of fieldwork at Çatalhöyük became increasingly paperless and born-digital, and included GIS and 3D recording and visualization (Berggren et al. 2015, Forte 2011, Lercari et al. 2018).

John Walrodt (2016) describes the pattern of piecemeal adoption of digital technology in Classical archaeology contexts such as at Troy (1988–2002), and, after the iPhone/iPad revolution, at Pompeii and other sites after 2007. Nevertheless, although many field projects have adopted paperless recording as their favored strategy of documentation, it will be a long time before paperless is universal in the archaeological repertoire (Averett et al. 2016).

The Life Cycle of a Digital Entity

In the LHotH database each item is recorded as a separate entity of place, person, or thing, which occurs in a specific space and time as an event; each entity is represented by media and/or alphanumeric data in the database with its own URL, and related through semantic triples to other entities. Some of these entities have been born digital (photographic images from 1999, video after 2001,[1] EDM measurements from 1997), others (data entry sheets, vector graphics) started life as paper and have been digitized by scanning, turning them into digital legacy entities.

After their birth or transmogrification from an analog state (Figure 12.2.), the digital objects are (optimally) made usable by being organized in a content management system or database and archived and made shareable in a digital repository or cloud-based server. The next step—curation—is crucial for the longevity of the digital entity. This has been made amply clear by, for example, the Digital Curation Center (Higgins 2008) (on whose more complex representation Figure 12.2. is based) and the Archaeological Data Service (Richards 2002). More work is involved in curating legacy entities than those born digital. Digitization technology (especially scanning resolution and software) changes. Earlier digitized legacy objects need to be re-scanned or converted to different formats in order to be usable by future generations of re-users. The implication of this fact is that the original analog data (especially 35mm transparencies and audio and video tapes) need to be retained for a long time.

Finally, the entity needs to be discoverable, accessible, *and re-usable*. At last the latter need has made it to the mainstream of archaeological data archiving, whereas for many years there were only a few advocating the importance of using and re-using archived data in order to sustain their longevity (Huggett 2018, Kansa and Kansa 2018, Richards 2002). As long as the original or primary source data are in this way attentively archived and curated, many different publications, derivatives, outerfaces, afterlives (however you wish to describe them), including those in new forms applicable for new times, can be created from the data and about the data. *But* once the source data are lost, forgotten, or made meaningless, an essential step in the knowledge-making process is lost (and this can happen to both analog and digital sources), and the results of an archaeological project become archaeological themselves (Tringham and Ashley 2015).

First Afterlife: The Printed Monograph

The long-form narrative that is printed on paper and published as a self-standing monograph or monograph series is the official step that synthesizes and gives meaning to the products of a project's research, whether that project's record was born analog or digital. It is still traditionally its most important (if not always its first) afterlife. Its role is to create a public record that will be the definitive statement to justify the expenditure of time, labor, and funds. It creates the yardstick by which researchers' productivity is measured. In theory, the monograph should act forever as the principle guide to explore the primary data collected by the project, to create visibility for the project and its data, and as a medium through which interest in the project can be generated more broadly. In practice, however, the print runs for such books are very small and they are distributed

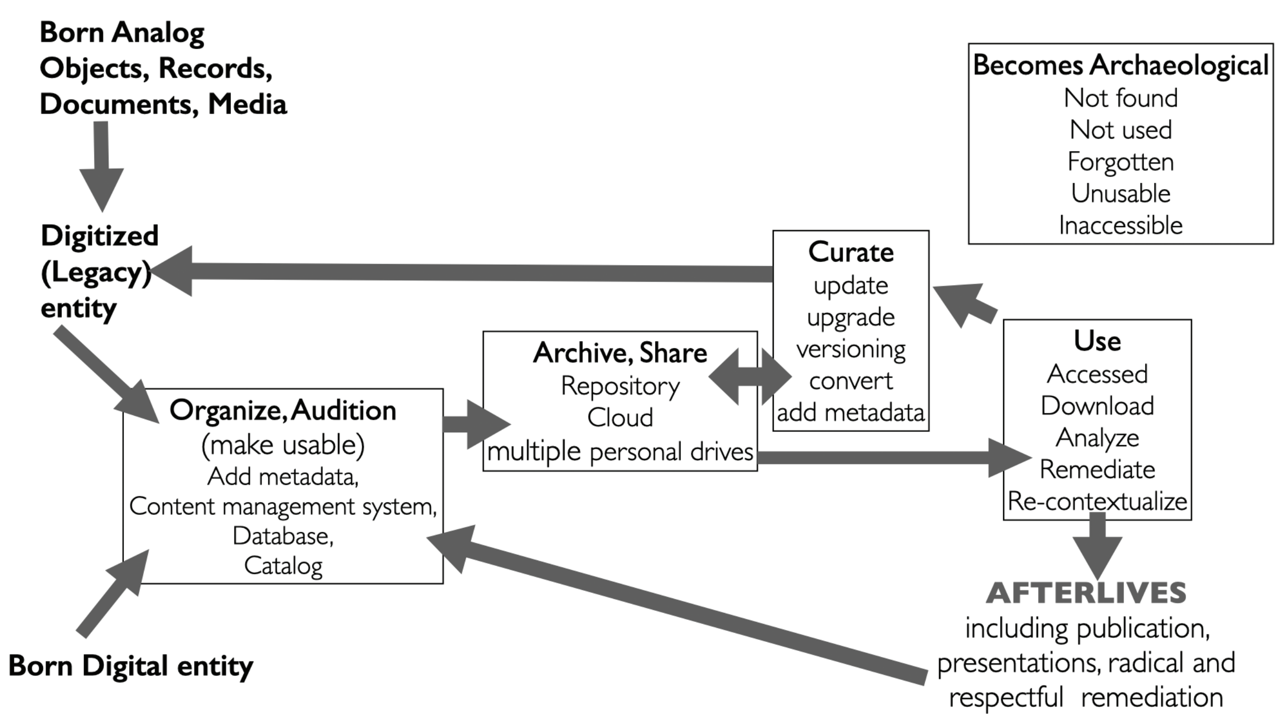

Figure 12.2. The life cycle of a digital entity.

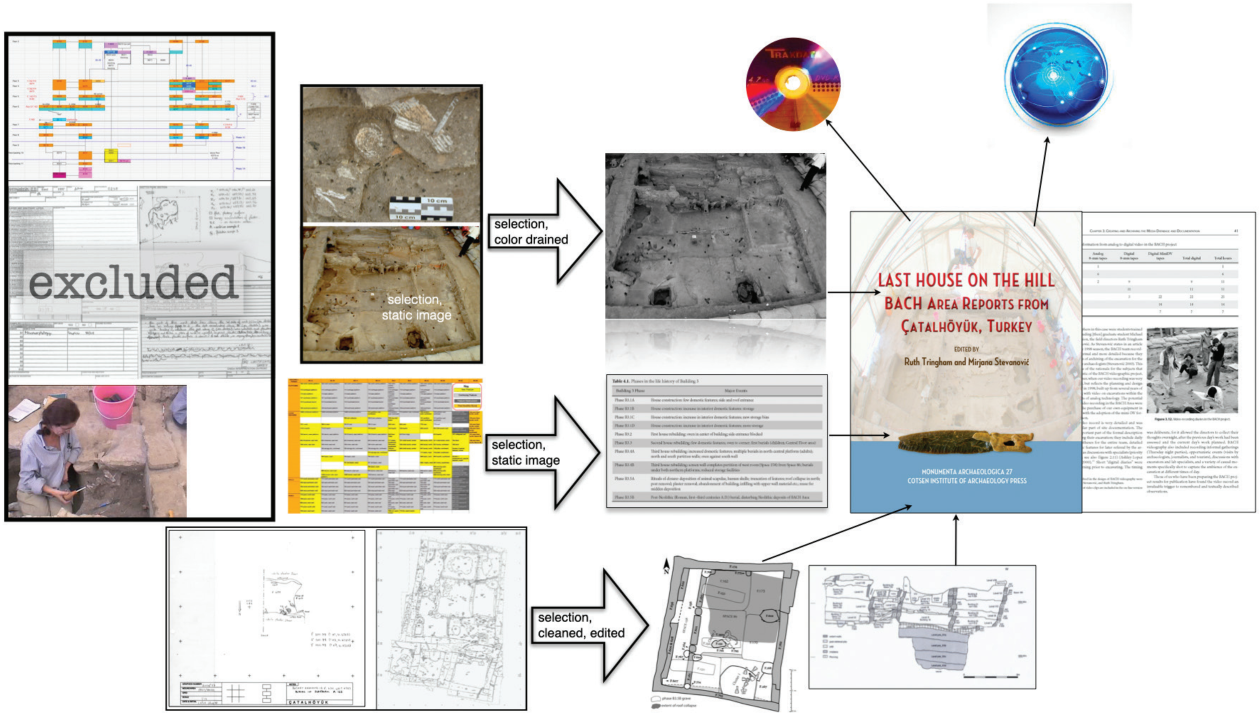

Figure 12.3. The relation of primary archaeological source data to the final monograph report of the BACH (Berkeley Archaeologists at Çatalhöyük) project.

mostly to university libraries. The interest that a monograph garners in its project may be minimal. The physical longevity of such a monograph might be long, but for the most part it languishes on a shelf with very few visitors.

What happens to the primary data during the preparation, editing, and publication of such a monograph? In short, source materials (primary data) are quickly eliminated from publication. Field observation forms, unwieldy representations of stratigraphy (such as a Harris matrix), and videos are entirely excluded. Color photographs showing essential differences in the contextual matrix are reduced in number (if they occur at all) and converted to black-and-white images for printing. 'Dynamic' spreadsheets of field and laboratory observations and measurements are cleaned and printed as fixed static tables. Field drawings are selected and cleaned up. Some projects have details from the data and color images burned to a removable (in more senses than one) DVD-ROM or even a tiny thumb drive, but this option is mostly rejected these days. Basically, all the ambiguities of the real situation are 'cleaned,' with no room for creativity, in favor of an unambiguous and edited long-form narrative, the scientific monograph. The example I have chosen for Figure 12.3. is the final monograph report of the BACH project: *Last House on the Hill* (Tringham and Stevanovic 2012).

Questions remain, will the publication of such a long-form linear narrative encourage the exploration of the primary data, even if they are accessible and usable? Does this primary monographic afterlife of the project actually lead to the longevity of the primary source data and keep the memory of the project alive? Why do we feel compelled to retain this longform primarily textual narrative format as a project's most significant afterlife? William Caraher in chapter 10 of this volume leads these questions into different, very interesting directions in terms of changing roles during the publication process of such narratives.

There are of course exceptions, as for example the recent publication of the Iron Age–Roman Tincu House at Gabii in Italy has shown (Opitz et al. 2016). The final project report comprises an interactive book published in ePub (digital Open Access) format that can be downloaded or read online on the Gabii project website. On the website, the book interacts through links, digging deeper into details and with a 3D model of the excavated area, engineered in Unity. An online database underlies the book and the model and can be accessed from them or directly from its own tab. This is an exceptional and brilliantly conceived final publication that deserves emulation by many other archaeological projects.

What follows are some thoughts about other formats of project afterlives that might lead to keeping interest in a project alive and keeping its data accessed and used and reused, including our own projections for the BACH legacy project's interactive publication.

Digitally Disrupting Long-form Discursive Narratives

In spite of such innovations as the Gabii project, there is still a general reticence, on the part of academic authors and publishers, to look beyond the long-form textual narrative as a means of sharing knowledge and to take advantage of the full benefits of digital technology in publication. Since the start of the Web/Internet at the beginning of the 1990s, we have tended to think of digital publication as a replacement of printed and analog publication in the form of their simulacra, such as pdfs, in what Bolter and Grusin (1999) have referred to as works of "respectful remediation." In this case the digital version is faithful to the form and content of the original printed work, familiar to us in many final monographs and shorter article-length publications of archaeological projects.

The first digital disruption of long-form narratives coincided with a number of other disruptions at the end of the 1980s and beginning of the 1990s, including the dismantling of the Berlin Wall and its collateral collapse of Communism in Eastern Europe, the Yugoslav Civil War and collapse of the federated republic, the creation of the World Wide Web, and important steps in the dissemination of the feminist practice of archaeology. Into this arena came the idea of computerized (or digital) Hypertext and Hypermedia (Bolter 1990, Landow 1992), which showed that quite different forms of knowledge—beyond the tradition of long-form narrative—can be produced when digital technology is harnessed.

In fact, this was not the first instance of such a hypertextual disruption. The term and concept had first been articulated by Ted Nelson in 1965: "Let me introduce the word 'hypertext' to mean a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper" (Nelson 1965:96). Nelson was restricted in realizing his ambitions by the limitations of computational technology until the late 1980s.

George Landow defined computerized Hypertext as "text composed of blocks of words (or images) linked electronically by multiple paths, chains, or trails in an open-ended, perpetually unfinished textuality described by the terms link, node, network, web, and path" (Landow 1992:3). While one direction in which Hypertext was developed was the creation of HTML (Hypertext Markup Language) in the early 1990s, another (for our purposes just as important) was the development of hypertext narratives, which were designed and published (born digital) by Eastgate Systems, developed in the application Storyspace.

In *The End of Books: Or Books without End?*, J. Yellowlees Douglas (2001) states that one of the most significant characteristics (many would say benefits) of these narratives that were 'born digital,' starting in the late 1980s and early 1990s, using hypertext and hypermedia formats, is that they are "open-ended," they are without end. Unlike narratives written—and especially printed—on paper, born-digital narratives are easily modified and versioned, and by their inherent nature have no final definitive version, no conclusive ending, no closure.

It is, of course, a slightly exaggerated and misleading statement to say that analog printed books always have a definitive closure. There has been a genre of printed literature in which the reader is led (or invited to select) through often labyrinthine paths of text to reach not one but many different conclusions, so that the narrative moves spatially rather than in a chronological sequence of events to reach a single conclusion (Bolter 1990, Douglas 2001).

This does bring up the important question: does the absence of closure in either printed 'spatial texts' or digital hypertext narratives lead to an absence of enchantment and curiosity? This question is important as we think about the different formats and styles of archaeological afterlives. Is archaeology enchanting enough to guarantee the success of an archaeological afterlife? Sara Perry would answer that question with a "No," that enchantment cannot be assumed but must be generated (Perry 2019:357).

Yellowlees Douglas is clearly struggling with questions such as these:

> [I]f I were to read the hypertext equivalent of a melodrama or something distinctly Chekhovian that does not spur me on, panting after the answers to a few pressing questions, would I still read for closure? Or would closure become relatively unimportant? If it does, then would it be possible for me to read these narratives comprehensibly? And how on earth would I figure out when (and where) to stop? In a text that has no rending narrative tensions, will I discard my search for resolutions? Or will I impose or even invent some, to confer some shred of purposiveness on my readings? (Douglas 2001:107)

Afterlives of the Opovo Project: The Chimera Web

Apart from a couple of preliminary journal articles (Tringham et al. 1985, 1992) the first afterlife of the Opovo Project was in fact a printed book chapter in which were embedded a couple of experimental tiny fictional stories (vignettes) built out from the empirical details of the excavation (Tringham 1991). By 1994, however, I had already become an early adopter of digital archaeology and a dreamer of what digital technology could do to manifest the close relationships between data and narrative interpretations of the Opovo archaeological record. Thanks to Rosemary Joyce, my colleague at UCB and sister of Michael Joyce (pioneering developer of hypertext narrative), I jumped on the hypermedia bandwagon to make use of Storyspace to give birth, in 1995, to the tangle of links of the Chimera Web (Figure 12.4.). Rosemary was already using Storyspace in her own research (Lopiparo and Joyce 2003) and we later used both her Sister Stories and the Chimera Web as a tool in which to demonstrate the content and benefits of hypermedia publication for archaeology:

> We think that the experiences of navigating hypertexts, composed of fragments connected by networks of association, provides a better analogue to the process of constructing archaeological knowledge than other formats that obscure the contingency and incomplete nature of archaeological arguments. (Joyce and Tringham 2007: 229)

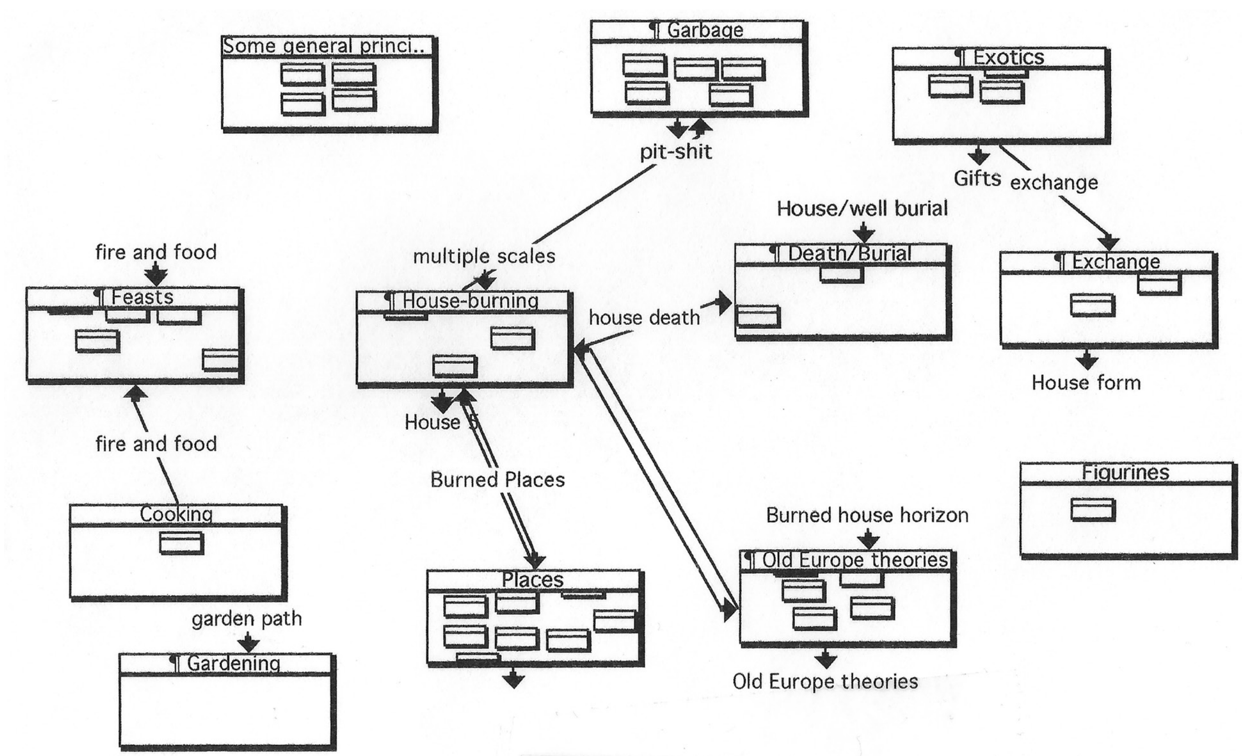

Figure 12.4. The format in which the Chimera Web (1995) was first designed: the hypermedia authoring application Eastgate Storyspace.

I was eager to explore the potential of digital technologies to make transparent how we, as archaeologists, construct an ambiguous past from our empirical data and from our imaginations that is full of dynamic human beings going about their daily and sometimes extraordinary tasks. I hoped that the fictional narratives of the Chimera Web would entice and enchant a 'reader' to be curious to explore the empirical data on which they were based and that s/he would be enchanted by the labyrinthine tangle of paths (Figure 12.5.) and connections to become lost.

The Chimera Web is/was a 'classic' demonstration of not only what could be done with afterlives that were born digital, but also what was seriously problematic with such afterlives; that is, their dissemination, their accessibility, and, therefore, their longevity. I eventually transferred construction of the Chimera Web to a more 'cinematic' software—Macromedia Director—to ease the constraints not only of printed long-form text but also the text-heaviness of the Storyspace reader interface (Figure 12.4.).

The Chimera Web was originally designed in 1995–96 to be published as a standalone DVD. This choice was partly determined by the inability of the World Wide Web at that point (and several years after) to handle such a complex web of interactive images and text. I was also nervous about putting my data and ideas on such a public and 'insecure' place as the Internet (Joyce and Tringham 2007). Times have changed; products on a standalone CD-ROM or DVD have almost passed into oblivion and the Internet has become the dominant medium of digital publication, and Cloud servers can securely handle huge amounts of data searches and interactions. Between 1995 and 2015 many creative products of archaeological interpretation (afterlives) have been created by archaeologists, 3D-modelers, and archaeology game designers, but few have lasted more than a few years before becoming archaeological themselves. For me, the Chimera Web was the first such experience; in 1998, Macromedia issued Director 7, which involved a complete engine re-write, after which—alas—I could no longer use any of the software with which I had constructed the Chimera Web or even update it to 'play' it. I attempted to transfer it to an HTML-based Web platform, but this made it so static and pedestrian that I lost interest in its further development; so, after four years, the Chimera Web joined the Dead Web.

BACH Project Afterlives

At the same time as the Chimera Web was becoming archaeological, I had started the BACH (Berkeley Archaeologists at Çatalhöyük) project at Çatalhöyük. This project (1997–2005) coincided, as I mentioned above, with the transition from born-analog to born-digital documentation of archaeological fieldwork at the end of the 1990s and the beginning of the new millennium. In this period also there was a flurry of developments in the growing field of Digital Humanities that fostered a more complex, more fluid connection of interpretive narratives to sources of primary data than the earlier hyperlinking navigation. Database narratives (Luers 2013, Manovich 2001), recombinant histories (Anderson 2011), and multimodal compositions (Murray 2009) filter and harvest their databases of visual and audio exhibits, animation, social media, presentations, gamification, live performance, and text—all forms of storytelling—to create an endless combination of fragmentary narratives in fluid, ephemeral interfaces that have become a guiding principle of my own constructions of the past through archaeological research.

The idea of moving away from textual representation to a more performative, practice-based, entangled storytelling resonates with what I have been trying to achieve since the 1990s, especially in the afterlives I have composed since 2010, recognizing that such compositions provide an ideal medium for the representation of the ambiguous nature of archaeological data.

The Last House on the Hill (LTotH) project is a multimodal project of this kind that has been planned around the articulation of interpretive narratives (that is, afterlives, including the final printed monograph) and the primary source database of the project (Figure 12.6.). The ultimate aim of the Last House on the Hill project is to have both archaeologists and a broader public use the data and media of the BACH project in creative and productive ways.

The LHotH database edition lies at the center of this world. The primary sources of the archaeological record of the BACH project—alphanumeric data from 150 features and 1,200 units, over 20,000 images, 2,750 video clips, tens of CAD drawings, illustrations, sketches and plans—have entered the cloud-based Filemaker-engineered LHotH database as entities, with keywords, description,

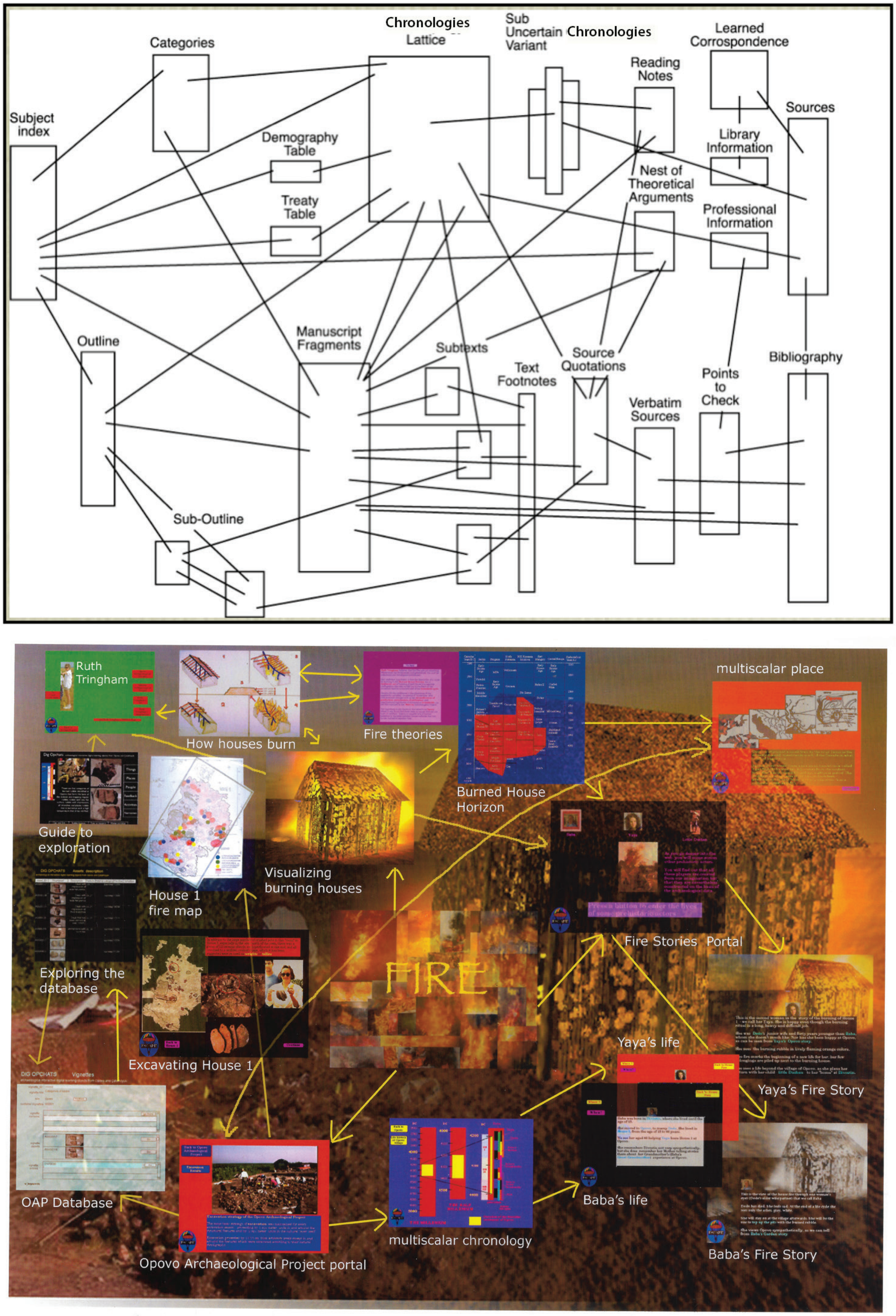

Figure 12.5. A comparison of the Chimera Web (1995) tangle of links (below) to Ted Nelson's labyrinthine concept of hypertext (after Nelson 1965, figure 4).

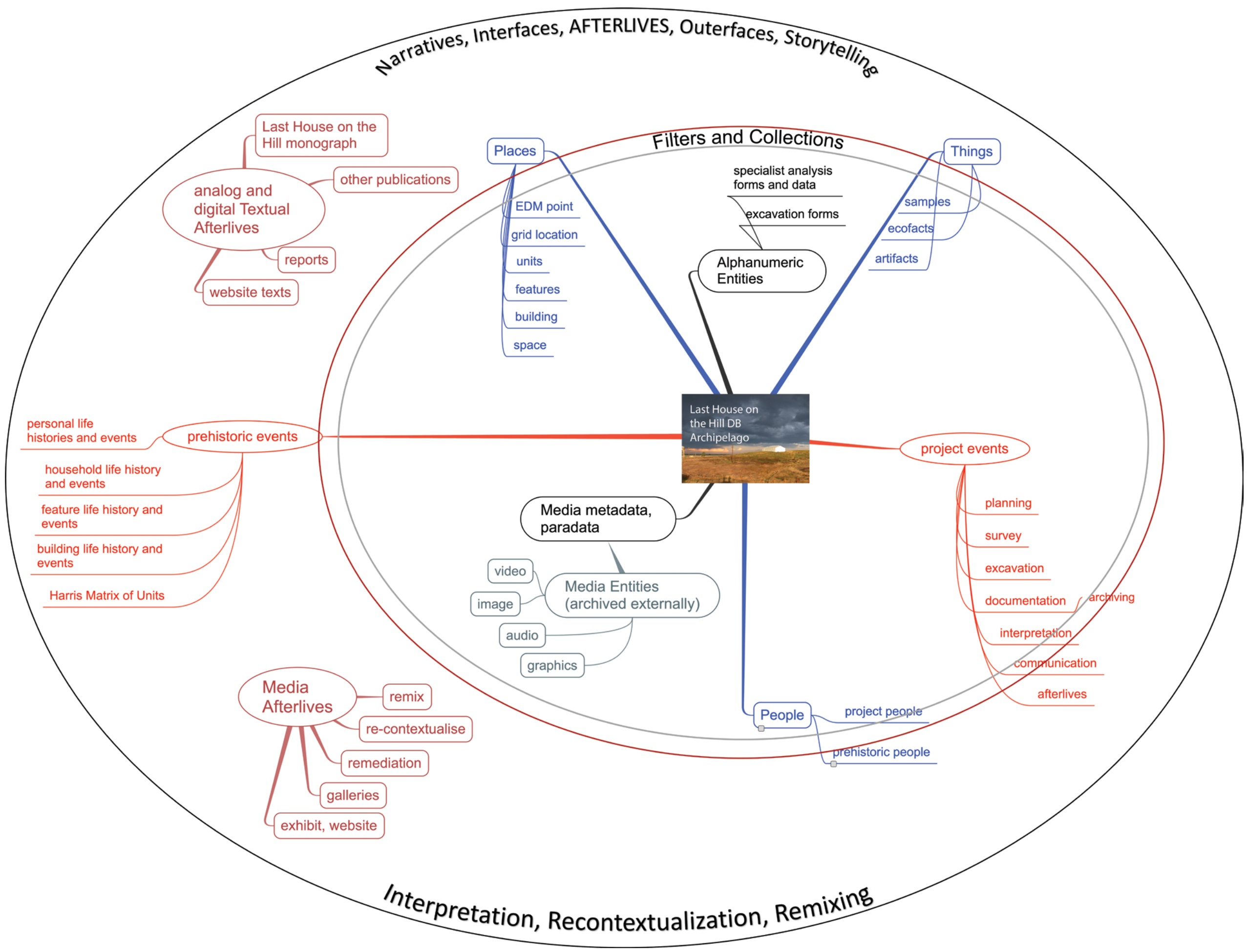

Figure 12.6. The conceptual plan of the Last House on the Hill database-plus-afterlives project.

and other metadata added in an archipelago-like relationship to other entities in the audition process. This is a light-weight archipelago in which the more heavy-weight digital entities, such as videos and high-resolution images are referenced by previews and thumbnails in the database, while the entities themselves are archived externally to be called up as needed.

Anderson (2011) and Manovich (2001) structure their databases using filters and other means to guide the creation of narrative interfaces. Similarly, the LHotH database has been structured to make sense of the mass of archaeological data and media through filtering guides of events on the one hand in archaeological (Neolithic) time, and, on the other hand, the recent events linked to the BACH excavation project. Other structuring filters are the relationships between people, things, and places, all of which contribute to the creation of the archaeological record.

Narratives—afterlives—(in the 'interface circle') that build on these relationships can be (and have been) drawn out of the database through these filters, thus enabling the recontextualization and remixing of the content that resides in the database. In this way the data and rich media resources of archaeology are energized by contributing through their combination and recombination in narratives that reflect the fragmentary open-ended nature of memory, imagination, multisensorial experience, and history.

What distinguishes the Last House on the Hill project and its LHotH database from other experimental publication strategies in archaeology, such as the Digital Gabii project (Opitz et al. 2016), is that the long-form text of

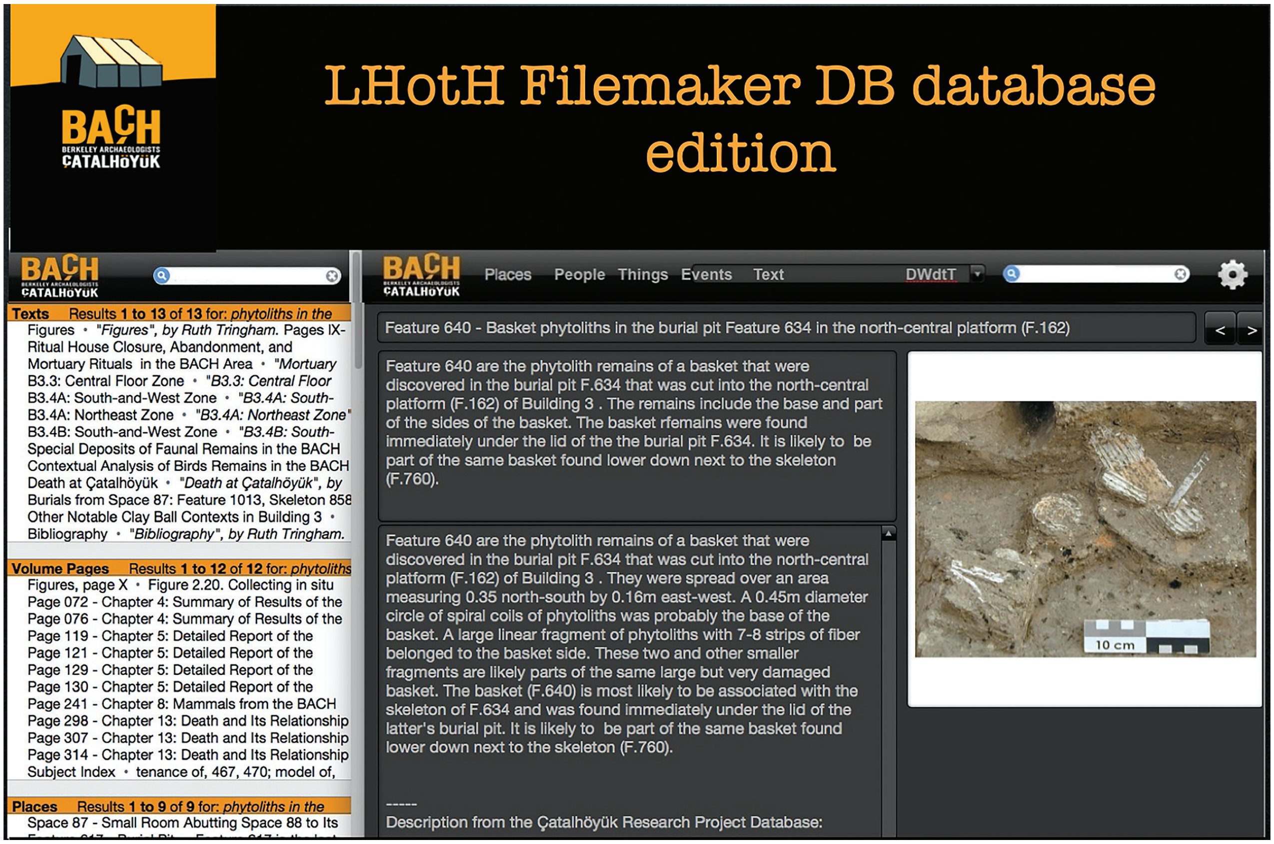

Figure 12.7. Screenshot of embedding the printed monograph *Last House on the Hill* (Tringham and Stevanovic 2012) into the LHotH Database. A place—feature 640, a basket in a burial—is related to different parts of the printed volume. Volume pages = pdfs of relevant monograph pages; "Texts" = textual entities from the monograph. If you scroll down, you could see its relations to other places, media, events (such as days of work on the project, or phases in the life-history of the Neolithic house).

the printed afterlife monograph *Last House on the Hill* (Tringham and Stevanovic 2012) has been digitally fragmented into its individual sub-sections; each sub-section is transformed into an individual textual entity of LHotH database, where it can be related to entities of images, videos, other texts, and alphanumeric data. In this way, in effect, we have prepared the text of the printed monograph for harvesting and re-contextualization in subsequent afterlives (Figure 12.7.).

From 2001, a number of afterlives were drawn out of the primary BACH project data, some by me, others by collaborators, others by students. All had the sub-text of sharing with a broader audience the excitement of archaeological fieldwork, or guiding (scaffolding) the exploration and interpretation of primary archaeological data and using them to create something new. Some of them added enticement by the incorporation of fictional narratives about prehistoric residents (both animate and inanimate) and intimate observations by the modern temporary residents (archaeologists).

The most ambitious of the BACH project digital afterlives is the Last House on the Hill Web edition that was launched at the end of 2013, powered by the Drupal-based Mukurtu content management system (CMS) (Ashley et al. 2011). Mukurtu CMS was purpose-built for the preservation of cultural heritage, especially indigenous cultural knowledge, and was adapted by our team of the Center for Digital Archaeology for the purposes of exploration of an ever-growing selection of media and items drawn from the main LHotH database, complete with rich metadata and relations intact. In 2018 the site (lasthouseonthehill.org), along with other Mukurtu-based sites, was hacked and became inaccessible. Fortunately, the content and structure of the site had been well documented, and the source content in the LHotH database was securely archived according to all the above-mentioned curation protocols of DCC and ADS.

The sudden collapse of our 'flagship' product so easily, however, demonstrates the fragility of the more complex experimental web publishing platforms. We did not even have time to make screenshots of its details. And I have concluded that this is just one in a pattern of short lifespans of such afterlives.

Becoming Archaeological

Most of the digital afterlives that have been drawn out of the LHotH database have been designed for viewing and interactivity through a Web browser by a broader public than the archaeological community (Tringham 2012b).

Real Audiences, Virtual Excavations (RAVE) is a Web-based collection of short videos used in live performance and presentations in 2001–2002. The Web-based collection died with the retirement of its server (Diva@UCB), but the original videos are intact (although created from low-resolution preview footage) on Vimeo.

Remediated Places is a series of on-site videowalks at Çatalhöyük that harvested content from the LHotH database and BACH project media collection. The walks were designed in 2005–2007 for a mobile device technology with GPS that was not yet available, certainly not at Çatalhöyük. A Web version was planned as a museum installation, but never implemented (Tringham et al. 2007, Tringham and Mills 2007).

In 2007 we launched Remixing Çatalhöyük, a prize-winning Web exhibition of themed collections of downloadable and re-usable media from the BACH project media collection with rich captions and metadata. The project was funded by federal and state money. The complex and beautiful front interface was built in Flash, which would not have worked after 2010. But by 2009 the OKAPI (Open Knowledge and the Public Interest) server and program that hosted this 'exhibition' closed, and its hosted project websites also died. Some information, including a K–12 lesson plan, can be found at Wikiversity;[2] in addition, a movie tour of the now-dead site can be found on Vimeo.[3]

Under the same OKAPI sponsorship in 2006 we launched Okapi Island in the virtual world of Second Life as a mirror of the East Mound at Çatalhöyük, as it exists today, and as it may have looked in the past. It was used as a location for teaching, for events, and for meetings. In 2011, however, Linden Labs removed the educational discount, without which our 'rental' of the land would have doubled. We refused to pay the increased rent, resulting in our eviction and the disappearance of Okapi Island (Tringham 2009).[4]

The many stand-alone videos that have augmented and remixed found footage in the LHotH media collection (*Back in My Hometown* 2010, *When I Am Laid* 2000), and other simple formats such as the movie *Shadowhöyük* (2005) can be accessed on Vimeo and YouTube. However, even they need to be curated and updated by using full-resolution video capture rather than preview footage.

The closest that I have come to realizing the dream that started with the Chimera Web is *Dead Women Do Tell Tales*, a project that attempts to be an afterlife of both Opovo and BACH projects. It was conceived in 2009 and versions of it have been discussed in many of my publications and presentations since that time (for example, Tringham 2012a:110, 2015). But since it has not yet been born, I will not discuss it here. The reason that it has been so long in gestation is that, seeing the history of the previous afterlives I have created, I hesitate to decide what would be the format with a greater sustainability than theirs.

The examples above are the tip of the iceberg in terms of the loss of afterlives to the Dead Web (Tringham and Ashley 2015). Digital afterlives, as well as primary data, can be fragile for a number of reasons, many of which have been discussed eloquently in other chapters in this volume (especially Garstki, Kansa, Rabinowitz): changing fashions of style, genre, format, and trends in research topics, can lead to lack of use and motivation to revisit (one-time users); and lack of use can lead to a lack of curation and maintenance; a lack of dissemination via social networks can lead to invisibility of the work; the ambition to produce something complete may surpass the time, funding, and capabilities of the creators, so that the product hangs in a limbo. Meanwhile, technology moves on, leaving the afterlife narrative (and even source data) stranded in the Internet netherworld (like old satellites littering space).

Eric Kansa (chapter 9 in this volume), for example, points to the case of the British Museum, whose re-branding within the glamorous Google Culture Institute "siloize[s] data and digital media in closed systems without public APIs, without standards aligned metadata, and without contextualizing links to a wider world of scholarly resources.

These efforts have short time horizons, a marketing focus, and lack accessible, persistent (citable), and reusable data needed for scholarship." Kansa anticipates that constraining scholarship and the reuse of data in this way will lead to the unsustainability of the platform.

Adam Rabinowitz (chapter 11 in this volume) tackles in detail the essential problem of the nature of the archived content in terms of its future as short-term (thirty years), medium-term (150 years), or long-term (1000+ years). How will it be accessed in these different timeframes, and, moreover, how will it be used? Following on these challenging questions, how should we as creators of the archive plan for such futures?

The same conundrum occurs to me as I plan for the archiving of the content of the BACH project, both primary data and afterlives. In chapter 13 in this volume on the ethical and sustainable management, production and archiving of digital heritage projects, Lorna-Jane Richardson draws attention to the enormous carbon footprint of 'the Cloud,' which is not airy and fluffy at all, but is a great weight dragging down the future of our world. The digital content created by heritage professionals and archaeologists is but one part of this, but she makes clear that we cannot afford to keep every part of our digital creativity in our hardware and especially in the Cloud. Some has already become archaeological itself (Tringham and Ashley 2015).

My response to the question of what is to be done is perhaps the same as what has been expressed by most other authors in this volume in one way or another. To return to the life cycle of a digital entity (Figure 12.2.), the source data, securely archived in accordance with conventional standards, seem to me to be the ultimate publication medium of a project and need to be carefully and constantly curated and sustained (Figure 12.8.). The user interfaces or afterlives that disseminate the data in different genres and allow the broader public to interact with the primary sources are worth curating in the short term, but are less of a priority and are, moreover, often challenging to archive for the long term because of the fickleness of public opinion and the constant pressure on software developers to better themselves. So they should be allowed to become archaeological. This conclusion, that afterlives are inherently ephemeral forms of publication may, perhaps, be surprising, even controversial. I don't really mind. Sure, a lot of work went into the Chimera Web and into Okapi Island; but we cannot keep everything on the Web or in the Cloud.

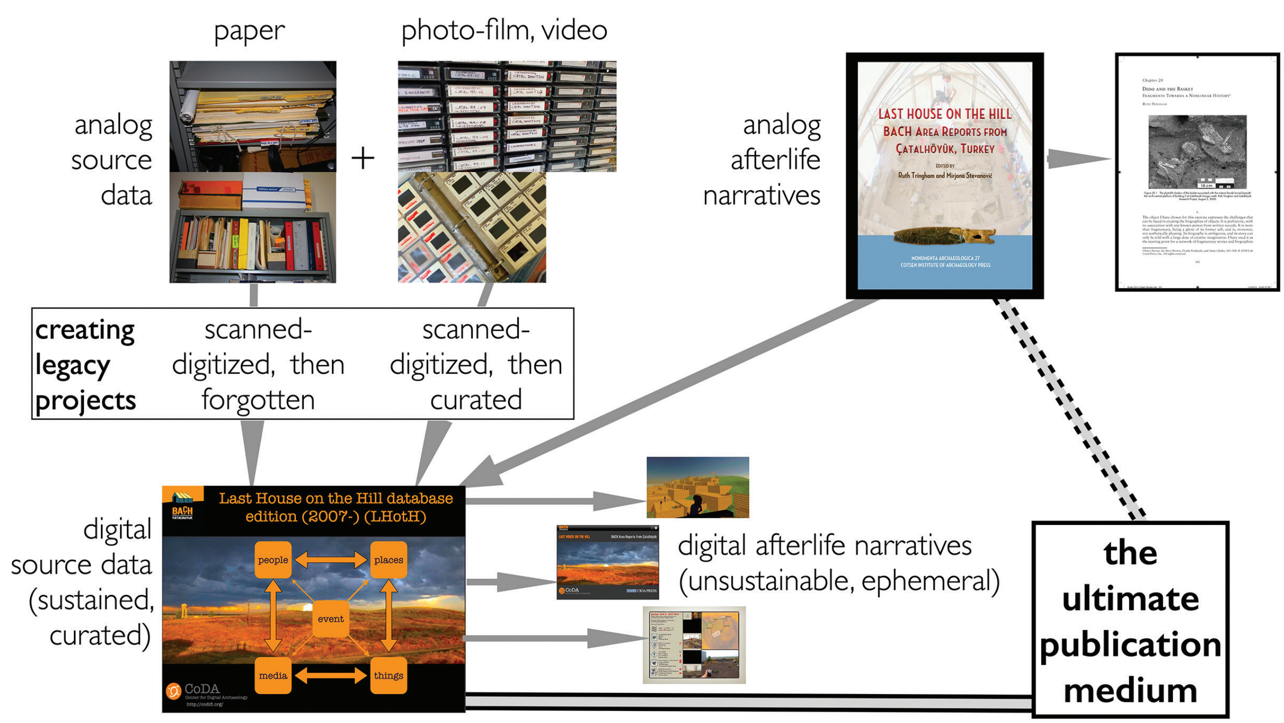

Figure 12.8. Priorities in the curation and preservation of source data and afterlives.

Thus, for me, the afterlives of a born-digital or digital legacy project are not the ultimate publication medium of an archaeological project. Other narratives can be produced by me or other authors . . . as long as the database is intact, discoverable, meaningful, accessible, and usable. For the BACH and Opovo projects, the LHotH and Opovo databases, especially when constantly curated and enhanced by a digital preservation loop, are the ultimate publications of these projects.

Acknowledgments

My thanks go to Meg Conkey and Rosemary Joyce for their inspiration and support during my long experimentation with digital technology and disruptions of long-form narratives and traditional publication form in archaeology itself. Michael Ashley has been my welcome and essential collaborator through most of these thirty years of digital adventures; he is the essential early adopter behind all of the innovations that we tried, and I want to recognize his contribution to the content of this chapter. But if you find any bloopers in the more technical aspects of the chapter, they are certainly mine, not Michael's. I want to recognize also Cinzia Perlingieri's contribution to guiding our dreams, especially concerning the establishment of our non-profit company Center for Digital Archaeology, into reality and being the force that maintained it during its ten years of active life. Together we all created a unique teaching and research facility in the Class of 1960 Multimedia Authoring Center for Teaching in Anthropology (MACTiA) at UC Berkeley that guided students to feel empowered and playful in the re-contextualization of primary data and media sources of archaeological projects. Thank you also to the rest of you who have been part of this; you are not forgotten.

Notes

1 The BACH fieldwork part of the project (1997–2003) finished just as tapeless camcorders (using an SD card) were being introduced. Thus the videos of the BACH project are all recorded on tape (Hi-8 and then MiniDV) and, although formatted for digital capture to a computer, are not strictly 'born digital.'

2 Wikiversity: Remixing Çatalhoyuk; visited April 29, 2020. https://en.wikiversity.org/wiki/Remixing_%C3%87atalh%C3%B6y%C3%BCk_Project.

3 Video tour of Remixing Çatalhöyük: https://vimeo.com/414349769.

4 Video tour of Okapi island in Second Life: Pt1: https://vimeo.com/88005214; Pt2: https://vimeo.com/86202359.

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CHAPTER 13

The Dark Side of Digital Heritage

Ethics and Sustainability in Digital Practice

Lorna-Jane Richardson

All Watched Over by Machines of Loving Grace

I like to think (and
the sooner the better!)
of a cybernetic meadow
where mammals and computers
live together in mutually
programming harmony
like pure water
touching clear sky.

I like to think
(right now, please!)
of a cybernetic forest
filled with pines and electronics
where deer stroll peacefully
past computers
as if they were flowers
with spinning blossoms.

I like to think
(it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over
by machines of loving grace.

—Richard Brautigan (1967)

I found this poem quite by chance online in 2018, and it is profoundly moving, haunting even. It was written by Richard Brautigan in 1967, while he was the poet-in-residence at the California Institute of Technology in Pasadena. His poem provides an intoxicating vision of a future we may yet never achieve, where the natural world and the tender embrace of automation and computer programming exist together in peace. He writes of a future built on a "cybernetic ecology" where the natural world and machines work together in perfect collaboration, and there is an end to human labor. This poem speaks to the melancholia attached to the progress of Western discourse on the global impact of digital technologies. This has shifted from discussions of the transformative power of digital utopia to acknowledgment of the realities of digital capitalism and surveillance, and their many associated inequalities (Pieterse 2010, Turner 2010, Zuboff 2019).

Digital archaeology, and digital heritage more broadly, exist within this contemporary computer-scape of vast technological inequalities. The advent of the digital age has introduced insurmountable inequalities through the desire to be connected, to share information, and to create and share new selves and new worlds using information technologies. However, it would be a cynical exercise to try to deny the fundamentally transformative power facilitated by the various information technology revolutions of the late twentieth and early twenty-first centuries, at least in those countries with a developed economy. How fairly distributed those benefits have been is, perhaps, best saved for a separate discussion, but here in the Anglosphere of the Global West, technological innovation has intensified the speed and reach of human communication and artificial intelligence. However, these revolutions have not occurred without vast environmental and human costs, especially in the Global South, and the digital world of the twenty-first century is no cleaner than the smoke-spewing, coal-driven factories and railways of the nineteenth.

According to the United Nations, we have less than ten years to prevent irreversible climate change (United Nations 2019). We are already experiencing the effects of a climate emergency. From flooding in Indonesia, drought in Lesotho, and devastating bushfires in Australia to the rapid collapse of the coastline on the East Anglian coast in the United Kingdom, there is no escape from the destructive effects of the Anthropocene. Information and communication technologies are certainly not Brautigan's "flowers with spinning blossoms," and an increasing number of scholars have expressed their concern about the impact of these technologies on the environment. These impacts range from resource extraction, electronic waste, conflict minerals, to the carbon emissions of digital technologies, devices to data centers (Cubitt 2017, Fu et al. 2016, Hasan and Kazlauskas 2009, Higón et al. 2017, Melville 2010, Ospina and Heeks 2010). These concerns about the hidden climate impact of digital technologies are a "dark tale of colonialism, genocide, devastated ecologies, toxicity, extinctions, and a shameful legacy that will take more than decades to put right" (Cubitt 2017:10).

This chapter will attempt an abridged overview of some of the issues that might be relevant to the ethical and sustainable management, production, and archiving of digital heritage projects, and which could also contribute to the aims of the Cultural Heritage Network. The subjects involved are far broader, and further reading from the references is highly recommended. This discussion will explore the material culture of digital data and hardware, and the hidden, horrific environmental and human costs involved in the production of digital devices and equipment. It will discuss e-waste, and the profusion of data and devices. It will examine the issue of powering the digital world, and its link with emissions, and will address the carbon cost of digital devices. It will end with some personal thoughts on what can be done to begin to address these issues within the sector, from an ethical and environmental perspective. This is intended to be part of an ongoing and urgent conversation we must all have about the complex issues of climate change and ethical practice, not only in our private lives, but in our day-to-day digital work.

Climate Heritage

In the Global West, there is a growing understanding of the urgent need for anthropogenic climate change mitigation to take place within the heritage, galleries, museums, libraries, and archive sectors (Climate Heritage Network 2020). This has brought the present and future role of cultural heritage in society into even sharper focus, with a need to be sustainable for the communities we work with and alongside in the present and future. Sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Keeble 1988). The international concern for the many challenges presented by climate change and sustainability is, at its core, about ethical values and a desire for social behaviors and values that prepare society for the many significant challenges ahead. Digital archaeology and heritage are not immune to these concerns (Dennis 2020, Richardson 2018).

The Climate Heritage Network was launched in October 2019 in order to highlight “the role arts, culture and heritage can play in achieving the ambitions of the Paris Agreement” (Climate Heritage Network 2020), which set the common goal to keep the rise in global temperature below 2°C of warming, and to “help mobilise arts, culture and heritage for climate action” (Climate Heritage Network 2020). The Network aims to support “arts, culture and heritage offices and agencies to understand their role in deep decarbonization pathway planning” (Climate Heritage Network 2020). The contributing role of cultural heritage to the ambitions of the 2015 Paris Agreement are clear, although the contribution that can be made in fields where digital technologies are used in the heritage sector also need to be addressed. Digital heritage practitioners and researchers will have to consider complex issues in order to develop sustainable working practices around ICT, whether that is in data collection, data analysis, or data dissemination.

As a field used to dealing with the concept of legacies and lessons from the past, our own legacy will be derived from the material toxicity of Western consumption in the present. Many of the readers of this chapter will be scholars and practitioners from developing countries where the urgency of these issues is stark, but those of us in Western countries may not be fully aware of the impact of ICT in terms of climate change. Interaction with the subject is often at institutional policy level, or during processes such as procurement, waste disposal, and recycling, which most of us are not directly responsible for. Those of us practicing in the Global West may not be fully prepared for the far-reaching effects of catastrophic climate change on our institutions, locations, and audiences, or the associated political and economic uncertainties in the future. Given the urgency of the climate crisis and environmental destruction, all of those involved in the production and use of digital heritage can contribute something to the redefinition of how our field works, through ethical purchasing, recycling, energy transition, and reduced consumption.

What Do We Mean by ‘Digital Heritage’?

Analysis on the parameters of digital heritage by Münster (2019:22) demonstrates that the umbrella term ‘digital heritage’ is drawn primarily from the fields of archaeology and cultural heritage management. It represents a broad collection of practices, projects, and methods, and is inherently interdisciplinary. Digital heritage may be concerned with data acquisition using laser scanning, photogrammetry, or drone technology. Most research is focused on a variety of technologies for activities such as documentation, visualization and monitoring for research, spatial analysis, archiving, modeling, preservation, or site management; it examines data processing, workflow, and data management concerns such as ontologies, metadata, and paradata. Technologies may also be used to create or analyze digital forms of public engagement, for dissemination online or at a specific location, and captured for mobile apps, websites, or to create or enhance a visitor experience at, for example, a museum or archaeological site. Digital heritage may also concern itself with the standards, policies, ethics, and methodologies used to undertake all the above-mentioned projects. This extreme diversity and disciplinary slipperiness within the field as outlined by Münster is challenging for practices and projects that may find a meeting point only under the covers of a digital heritage journal or conference session. However, this may also be an advantage, in the context of environmental justice, if we consider the reach of the discipline in other fields, and the pioneering approach to technological adoption that practitioners have traditionally embraced.

When we think about the physical presence of digital technologies in our archaeological or cultural heritage workspaces, what activities can we consider in relation to their carbon emissions and ethical sourcing? For organizations such as museums, archives, and galleries, the production of digital forms of archaeology or heritage might involve complex and multi-faceted projects combining digital technology, specialist hardware, and extensive data. These activities will include the digitization of documents, images, or film, and the provision of interactive exhibitions, 3D models, virtual reality experiences, and the associated hardware such as VR headsets, audio sets, or digital interpretation boards. In archaeology and allied fields, digital outputs can also mean CAD drawings, GIS projects, high-resolution laser scans, and site models.

Many of these types of activities produce very intricate digital objects, which may sometimes need to be stored in multiple versions in multiple locations. They may also need to be accessible to be shared, interrogated, and eventually archived. The equipment used may become rapidly obsolete, be discarded at the end of an event or exhibition, or be damaged or broken during use. In many settings, the use of digital technologies may be restricted to the use of public-facing communications, such as websites and social media. On a more granular level, we can reconsider the use of email, device power, or data storage in terms of their overall climate impact. Every stage of activity relating to ICT carries a human cost and a carbon impact; from the removal of the raw metal from the earth, the sweatshop factory building the machines, data capture, manipulation, project creation, and finally through to archiving, disposal, and obsolescence. Understanding that the use of digital technologies is not a neutral position and is not free from harm is an essential part of ethical practice.

Carbon Costs of Digital Technologies

Energy demand is intrinsically linked to our rapidly growing digital consumption and lifestyles. Energy is fundamental to almost everything we do as human beings in the Global West—work, travel, governance, entertainment, and healthcare. The ubiquity of digital communications and the rapid growth of the digital economy has led to the need for more electricity. Yet this is the area of Brautigan's utopia that could be realized; digital technologies have enabled significant energy efficiency through efficiencies, artificial intelligence, and automated processes (Policy Connect 2018). The growth in the use of devices leads to greater need for data centers and network services, which are responsible for "around 3.6% of global electricity and around 1.4% of global carbon emissions"—if we include media use, entertainment, and office printers, "this increases to roughly 6% of global electricity and about 2.4% of global carbon emissions" (Policy Connect 2018:4).

Digital overconsumption is hugely problematic in terms of energy consumption and need for raw materials (The Shift Project 2019:4). There is international concern whether the growth in demand for digital connectivity and services will remain sustainable in the economies of developing countries who use what is often dirty coal- or gas-fired energy to support digital society if the uptake in digital services overtakes efficiency gains. According to research by The Shift Project (2019), in 2020, global digital use would emit as much CO_2 as India did in 2015, for all of its one billion three hundred million inhabitants, who mainly consume fossil fuels. Research by the European Framework Initiative for Energy and Environmental Efficiency in the ICT Sector (ICU Footprint EU 2020) has shown that ICTs account for 8–10 percent of the European electricity consumption and 4 percent of its carbon emissions, yet a significant number of organizations do not measure their carbon outputs from the use of digital technologies.

The environmental consequences of digital technologies are frequently underestimated because many of the devices we use on a daily basis seem small and mobile, and their infrastructures, such as data centers and cloud storage, are often invisible (The Shift Project 2019:10). The miniaturization of technology, in mobile phones or tablets for example, does not suggest the overconsumption of electricity, nor the use of conflict minerals in the creation of devices, or the presence of unrecyclable polluting plastics. The material and marketing of these devices and the programs and activities they support and run encourage us not to see these phenomena as part of our interactions. This is reinforced by the widespread availability of services through cloud storage, which makes the physical reality of uses all the more imperceptible and leads to underestimating the direct environmental impacts of digital technology (The Shift Project 2019:11).

Online cloud storage and internet streaming and services are the key drivers of an increase in greenhouse gas emissions from ICT. Watching a video online on the cloud for ten minutes, for example, results in the electricity consumption equivalent to the consumption of a smartphone over ten days. Spending ten minutes watching a high-definition video by streaming on a smartphone is equivalent to using a 2,000W electric oven at full power for five minutes (The Shift Project 2019:33). A smartphone, which weighs around 140 grams, needs about 700 MJ of energy to produce in a factory, in comparison to the 85 GJ it takes to manufacture a 1400 kg petrol car (ADEME 2013). This means it takes eighty times more energy to produce a 'gram of smartphone' than to produce a 'gram of car' (The Shift Project 2019:29). Similarly, if we examine the carbon cost of a standard email, it consumes about 4 g of CO_2, a spam email is 0.3 g of CO_2, and an email with a large attachment can consume around 50 g of CO_2 (Carbon Literacy Project 2018). These may seem small and negatable amounts of carbon, but to put this into perspective, if we consider the entirety of the flow of emails in the world, the situation quickly becomes more than important (Carbon Literacy Project 2018). According to Statista (2001), 306.4 billion emails were sent and received each day in 2020. The average office worker's daily emails received can equal 1,652 g of CO_2, and the Carbon Literacy Project suggests that one year's worth of emails equates to around 0.6 tons of CO_2. The 64 million unnecessary emails sent in the United Kingdom every day are contributing 23,475 tons of carbon a year—even reducing our output of basic email communications by one per person could save 6,433 tons of carbon a year (Ovo Energy 2019).

Hardware Is an Ethical Issue

Most of the electronic equipment we use involves the heavy consumption of rare metals. Some of these are located only in specific regions of the world, and/or are in critical shortage, with limited accessibility, given the current costs and technological ability to extract them profitably (Responsible Minerals Initiative 2020). The specific types of rare minerals that are required for the production of digital equipment such as computers, cars, and mobile phones need the mining and smelting of rare metals such as tin, tantalum, cobalt, tungsten, and gold. These are derivatives of the minerals cassiterite, columbite-tantalite, and wolframite, and are used in hardware such as lithium-ion batteries, used to plate and solder electric circuits, and used in many other electrical components found in laptops, mobile phones, and tablets (Responsible Minerals Initiative 2020). These minerals are known as conflict or blood minerals, since they are mined in regions with a history of armed conflict. Mining of these minerals often takes place alongside serious human rights abuses and they are frequently traded by armed groups. The vast global market in rare minerals has helped to fund armed conflict and human rights abuse for decades in a number of countries, such as Afghanistan, Central African Republic, Colombia, Democratic Republic of Congo, and Myanmar (Responsible Minerals Initiative 2020).

For example, 65 percent of the global supply of cobalt, used in lithium-ion batteries, comes from the former Katanga province in the south of the Democratic Republic of Congo (DRC). One fifth of the DRC cobalt is mined by hand, unregulated and without protective equipment, and exploitation and child labor are rife (Amnesty International 2016, 2019, Responsible Minerals Initiative 2020). The DRC has a long history of conflict, and years of political instability have produced atrocious human rights violations, gender-based violence, rape, and modern slavery. The extraction of ore, and the processing and production of these minerals, destined for use in digital technologies, often leave land contaminated with chemicals and waste (Amnesty International 2016). Our digital infrastructures are too often built on immeasurable human suffering and ecological exploitation.

It is worth noting that organizations like the UK-based Ethical Consumer (2020) and Greenpeace International (2017) have produced guides to more ethical, environmentally friendly electronic and computer equipment, as well as ways for organizations to recycle, upgrade, and exchange their existing hardware. At a time when many heritage organizations are reflecting on the many social justice issues surrounding their work or collections, there are opportunities for deeper engagement with the dark side of ICT. Digital technologies are globalized political issues, and conversations about decolonization should also consider the human impact of our ICT. Digital sustainability should be an organizational policy.

E-Waste and Recycling

Electronic waste is the "fastest-growing waste stream in the world" (United Nations University 2017). From the point of mineral extraction and production outlined above, to the end-of-life disposal, computer hardware and mobile phone technologies are environmental disasters. Electronic waste is also a greedy consumer of energy during recycling, since the energy needed to separate the metals increases as a function of the complexity and secrecy of the assembly—if we do not know how devices are made, we do not know how to recycle their components. By 2018, the electronic waste stream was predicted to reach 50 million tons worldwide (Baldé et al. 2017) and it is estimated that this will increase to 52 million tons by the end of 2021 (Platform for Accelerating the Circular Economy 2019). One half of this electronic waste is made up of desktop PCs, cameras and video equipment, speakers, printers, display technology such as screens, and personal devices such as laptops, mobile phones, and tablets. Many of these hardware items are products from outmoded technologies, such as VHS video players and cathode ray televisions, and many contain toxic substances that make recycling hazardous. Over 40 million tons of this obsolete and broken digital equipment ends up in landfill, is burned, or illegally traded each year (Baldé et al. 2017, Platform for Accelerating the Circular Economy 2019). According to work by Belkhir and Elmeligi (2018:461) information technology will contribute in excess of 14 percent of the 2016-level worldwide greenhouse gas emissions by 2040. However, it is not entirely negative. E-waste is a valuable source of rare minerals—there is one hundred times more gold in a ton of e-waste than there is in a ton of gold ore (Platform for Accelerating the Circular Economy 2019). There is great potential in urban mining and the expansion of the global e-waste circular economy, which would support the reduction of greenhouse gases, as well as help to protect the environment and protect the health and safety of workers involved in the trade.

The United Kingdom is currently the second biggest producer of electronic waste in the world at 23.9 kg per capita, behind Norway, according to the Global E-waste Monitor report (2020). This report found that Northern Europe was the world's largest producer of e-waste in 2019 at 22.4 kg per capita. Sayers and Peagam (2020:4) have demonstrated that 1,615 kt of electronic equipment were sold in the United Kingdom in 2017, while only 653 kt of e-waste were collected for recycling. The global consumer electronics market was worth 1.1 trillion dollars in 2017, and this market is growing at around 6 percent per year (Zion Market Research 2018). This is driven by an increase in electronic components in everyday objects such as toothbrushes and toys, but also consumer fashions for smartphones, tablets, and gaming equipment. Some of these technologies will have a longer life span than others, or will lie dormant and forgotten in drawers, enter landfill, or be sent for recycling (Platform for Accelerating the Circular Economy 2019).

Despite a variety of international conventions and directives, including the 1989 Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (Basel Convention 2020) and Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE; European Union 2020), around 339,446 tons of hazardous electronic waste from the EU is illegally sold and exported to developing countries such as Nigeria, Pakistan, and Tanzania, for recycling, resale or disposal (Basel Action Network 2020:4). According to the Basel Action Network e-Trash Transparency Project, the United Kingdom is one of the worst offenders for the export of illegal hazardous e-waste, which is worrying for a country which is no longer bound to EU law since January 2021. The Basel Action Network reports are also available for e-waste exports from North America, Australia, and Hong Kong. Many electronic waste exports to developing countries pose pollution and human health risks, are a danger to water and food sources, and expose adult and child workers to toxic substances—such dangerous waste disposal practices by the Global West could be viewed as new forms of digital colonialism (Akpan and Inyang 2016, Bogale 2011).

Mitigating Digital Heritage

The use of digital technologies in general for all aspects of everyday life produces an abundance of data and accompanying devices. As discussed, these require interventions that are almost invisible to those of us commissioning new forms of heritage interpretation or capturing and displaying 3D images—for example, an abundance of rare minerals, electricity for production and use, and pollution both during use and at end-of-life. There are many opportunities for the heritage sector to design and use innovative technologies to create digital projects in their institutions. Yet the carbon and pollution impact of these projects are rarely discussed, and when they are, these are an afterthought for the management of existing data, outdated devices, and legacy projects in need of mitigation, when these should be viewed as strategic and long-term considerations for sustainability. Digital heritage practice may seem a relatively minor and often underfunded part of the wider cultural industries, and the issues outlined in this paper are still rarely considered in everyday working practice, yet there are some simple strategies that can be implemented to avoid or offset some of these factors.

Organizations that wish to work towards the decarbonization of our industries and support the aims of the Paris Agreement could take this opportunity to rethink their approaches toward digital heritage projects, and to lobby for the conscious reduction of carbon and electronic waste. An even better and more resilient outcome for digital heritage projects would require us to question and evaluate the social and economic usefulness and sustainability of our use of technological plans and equipment in the first instance, during the design and planning stage. Research by The Shift Project has shown that "a large share of the environmental stakes of digital technologies is . . . not related to the use we make of it, but largely to the volume of material produced and its production process" (The Shift Project 2019:19). Practitioners and commissioners could re-evaluate the purpose of proposed digital projects, and why we might choose digital technologies to undertake these creations. If we take The Shift Project's assessment at face value, we can begin to create and build our projects with sustainability as a priority from the outset. Where legacy equipment is at end-of-life, there are more than four hundred organizations in the United Kingdom alone at present that offer repair, reuse, and repurposing services (Sayers and Peagam 2020:46).

By scaling back our desires to experiment with every new and untested technology, especially with regard to interpretation and engagement, we can research and use digital engagement methods that are sustainable in the long term. Seeking and sharing alternative sources of hardware that are ethical, accessible, recyclable, or repurposable is innovative, as well as a common good, and no different to the agendas of the open access software movement. Similar in spirit to the use of sustainable, responsibly sourced Fair Trade products in many organizations, making a conscious commitment to reuse and recycle electronics, and the purchase of equipment free of blood-minerals, is a form of activism in reach of all of us.

Researching how long the devices, data capture, and digital outputs we desire are likely to be in active use will aid our understanding of likely downstream carbon and recycling impacts. With this 'slower' approach to technological innovations that reduce harm, practitioners would have more time to frame digital practice within what Perry (2019) refers to as "ethical mindfulness and care for the world at large." This approach would also create space to explore the potential of digital projects for long-term community collaboration, well-being, and knowledge-sharing, and "recognize the potential for sustainable change and transformation presented by a greater understanding of the social and educational needs and aspirations of our audiences" (Ellenberger and Richardson 2019:82).

It would be helpful to be able to quantify the environmental impacts of the uses of these technologies in our work, in a format similar to a health and safety risk assessment. Similar efforts are underway through the Madrid-to-Glasgow Arts, Culture and Heritage Climate Action Plan with regard to the calculation of greenhouse gas emissions by building retrofitting and reuse (Climate Heritage Network 2020). A robust understanding of carbon costs could aid the reduction of greenhouse gases, and this is perhaps a role for funding organizations, such as the Research Councils UK. These could provide guidance on how to assess and make summaries of these carbon-cost evaluations in preparation for grant applications—the RCUK already fund research into greenhouse-gas removal, for example (Natural Environment Research Council 2020). The National Lottery Heritage Fund could use their Digital Skills for Heritage (Heritage Digital 2020) platform to provide training and support for climate mitigation strategies as part of the funding application process and final project evaluation. Any of these assessments could be made available to the wider public, with regularly updated guidance on environmental best practice for digital projects.

As a sector, we can also aim to normalize these concerns in our practices and discuss the environmental and human impact of ICT whenever we discuss digital heritage.

Conference papers and academic texts could include carbon emission statements, research papers could discuss low-carbon ethically sourced forms of data capture, hardware, and mitigation strategies, alongside technological innovation and data analysis. Organizations could create policies to ensure these practices are normalized, and non-compliant grant applications, journal articles, or conference papers could be refused. Heritage organizations could endorse the Principles for Digital Development (2020), rooted in international development ICT best practice. The Principles provide "a tool to help realize that full potential of ICTs" and "nine specific best practices, each with a set of guiding questions, resources, and project lifecycle applications."

These actions all require a great deal of institutional and individual commitment to slow down or limit our digital experimentation and address human costs and carbon emissions in a meaningful and achievable way. We need to educate and inform, and reform, our institutional policies and practices to normalize the creation and use of ethical resources, even if these are not the cheapest or the most fashionable. All of these ideas are equally relevant to other sectors and organizations. There is an urgent need for change in our everyday lives with regard to pollution and emissions. Every attempt to lower our carbon footprint and act for a fair and just society matters. Perhaps this undertaking requires us to reevaluate our relationships with the digital age through consistent lobbying of our organizations for collective activism on these issues. Can we locate and deploy our own machines of loving grace? Our disparate sector can absolutely effect change, act with social and environmental responsibility, and contribute to the work of the Climate Heritage Network. This is not an argument for neo-Luddism, but we can no longer prioritize technological innovation over the future sustainability of life on this planet.

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Critical Archaeology in the Digital Age

Every part of archaeological practice is intimately tied to digital technologies, but how deeply do we really understand the ways these technologies impact the theoretical trends in archaeology, how these trends affect the adoption of these technologies, or how the use of technology alters our interactions with the human past?

This volume suggests a critical approach to archaeology in a digital world; to understand how digital tools are used, how they work, and how they affect practice. The chapters in this volume demonstrate how this critical, reflexive approach to archaeology in the digital age can be accomplished, touching on topics that include 3D data, predictive and procedural modelling, digital publishing, digital archiving, public and community engagement, ethics, and global sustainability.

Contributors

Rebecca E. Bria
William Caraher
W. Christopher Carleton
Karin Dalziel
Paola Di Giuseppantonio Di Franco
Jessica Dussault
Bernard Frischer
Kevin Garstki
Laura K. Harrison
Jeremy Huggett
Eric C. Kansa
David Massey
Rachel Opitz
Jeroen Poblome
Adam Rabinowitz
Heather Richards-Rissetto
Lorna-Jane Richardson
Benjamin Štular
Ebru Torun
Ruth Tringham
Greg Tunink
Ralf Vandam
Erick Casanova Vasquez
Patrick T. Willett

Above: View of the façade of the Temple of Vespasian and Titus in Rome from the west rostra. Image rendered from the Rome Reborn model, copyright 2019 Flyover Zone Productions.
Front: A card produced in France in either 1901 or 1910 with art by Jean-Marc Côté/Villemard depicting a French schoolroom of the year 2000. Public domain image from Wikimedia Commons.

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