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Stratagems and Back Spoils: Utilizing Backdirt in the Management of Archaeological Earthen Heritage

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ABSTRACT
Preservation strategies at earthen archaeological sites are challenging to develop and maintain in the long term. Environmental fluctuations, anthropogenic interference, and pedological composition are only a few factors that can impact deterioration pathways. Owing to these complexities, there will never be a one-size-fits-all strategy for preserving earthen sites. However, archaeological spoil—or backdirt—can be employed to mitigate many of these challenges. Utilizing illustrative case studies at the earthen sites of Çatalhöyük, Turkey, and Vésztő-Mágor, Hungary, the authors present the use of backdirt as a sustainable, structurally supportive, contextually sympathetic, and visually congruent material for earthen site conservation. Matters of authenticity, ethical mandates, and social benefits of its use are also considered, as are its limitations.

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Introduction

The display and management of earthen archaeological sites present a litany of challenges for site managers. The fragile nature of the in situ structures post-excavation leaves them susceptible to permanent loss when neither backfilled nor strategically cared for in the long term. For sites open to visitors, interpretation and presentation become key aspects of the site management plan. Earth buildings are never stable or static, challenging notions of authenticity, durability, and fragility (Cooke 2015). The earthen architecture research community, under the aegis of the International Council on Monuments and Sites (ICOMOS), The Center for the Research and Application of Earth Architecture (CRATerre EAG), the Getty Conservation Institute (GCI), and the UNESCO World Heritage Center, have been working since the 1970s to resolve maintenance issues in order to create widely applicable preservation strategies (ICOMOS 2023). However, there are currently only limited standardized conservation interventions for these irreplaceable pieces of heritage beyond capping walls and reburial (Oliver 2008). While there is a growing recognition of the success and value of employing traditional earthen repair techniques, in practice, this work is still in the experimental stages in many regards (Fodde and Cooke 2013; Uğuryol and Kulakoğlu 2013; Pinto et al. 2017; Lingle 2022). Through exploring the benefits of a more constructive approach in these contexts, the research presented in this paper explores the potential for the (re)use of backdirt as a methodology for preserving earthen archaeological sites.

Earthen archaeological sites are difficult to conserve in the long-term by the very nature of their composition, diagenesis, and the impacts of excavation. Immediately after excavation, surfaces are exposed to environmental agents and temperature fluctuations that change the equilibrium achieved during internment, leading to structural instability and other micro-scale pathologies, such as cracking, material loss, and surface delamination (Matero 2015). These challenges are exacerbated by efforts to display earthen architecture for the public, both in terms of practicalities and ethical practice (Lingle 2022). Aboveground ruins and excavated sites are subject to the impacts of anthropomorphic damage, moisture (in the form of humidity, groundwater and precipitation, and soluble salts), temperature, wind, and to the less foreseeable but often more catastrophic impacts of animal activity, lightning, plant growth, seismic activity, vibration, and vandalism (Rainer 2008). Just as in antiquity (Matthews et al. 2013), these structures require cyclical maintenance to ensure their upkeep and survival. Acknowledging this, backdirt is a crucial component of a viable conservation management plan of any earthen site. While it is unrealistic to idealize reintegrating a grain of sand from where it eroded from a wall, the authors argue that integrating backdirt in this manner addresses some issues of authenticity when structural work is required. This paper discusses this confluence of reuse and traditional craft whilst examining how the site environment can dictate the suitability and scale of backdirt intervention (Campiani, Lingle, and Lercari 2022). Cyclical maintenance is how these structures were cared for in antiquity and must be central to their present conservation management plan to ensure they can be viably managed for the future (Stephenson and Fodde 2016).

Utilizing case studies undertaken at the tell sites of Çatalhöyük, Turkey, and Vésztő-Mágor, Hungary, the authors demonstrate that by reintegrating soil from its associated site (and, when possible, context), the risk of earthen site decay due to differential material behavior can be decreased when managed correctly. Though the methodology of application differs between these two sites, both have incorporated backdirt into traditional skilled earth building techniques—pisé application and mudbrick production for architectural

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support, earthen renders, grouting, and mortar—to mitigate deterioration. The methodologies for reconstruction are well established, utilizing site research to guide material (Matthews et al. 2013; Love 2017) and methods (Cooke 2010) of reconstruction, during which materials may be modified to alter their properties (Houben and Guillaud 1994). These interventions directly impact not only site statics but public perception, as well, affecting stakeholder investment into infrastructure and display. The historic use of anastylosis (the reinstatement of the fallen original fragments) emphasizes the importance placed on archaeological or historic fabric and the retention of the visual narrative for a site or structure (Cooke 2010). A further benefit of this approach is the optical coherence with the remaining in situ archaeology and reducing unwanted residual spoil (Lingle 2022). The benefits of this method extend beyond the structural and aesthetic. Using earth from sites in this way creates opportunities for training in an intangible heritage skill and can contribute to a site's broader civic mission.

Conservation Context within Archaeological Sites

Archaeological sites face many challenges: climate change, conflict, development, inadequate governmental resources, insufficient management, lack of funding, looting, and tourism (Pedelì and Pulga 2013; Williams 2018). These dilemmas create a very real problem of how those involved with heritage define and create practices for caring for in situ archaeological heritage. Fundamentally, archaeologists' interests lie in information and knowledge of the past, while conservators' interests focus on preservation of the physical remains for the future (Demas and Agnew 2006). The guiding framework of heritage ethics concerns both the codes and principles that shape accepted practices with tangible and intangible culture, as well as much broader philosophical concerns around the legal, moral, and social implications of heritage (Ireland 2018). Successful care of archaeological sites relies on management and conservation that can incorporate sustainable development (e.g., environmental, economic, social, and cultural), and is cognizant that the fulfillment of an obligation to the future does not eliminate the responsibility to address the needs of the present (Castellanos 2003; Matero 2015; Henderson and Lingle 2018; Williams 2018).

Archaeological sites traditionally have few long-term pathways available to them once excavations close; site features can be removed, backfilled, left to decay, or managed in situ. There is a fundamental shift in the nature and purpose of a site when it transitions from a sole place of archaeological research to a place that is also curated for visitor engagement. From a conservation perspective, display as intervention is an interface that mediates and transforms what is shown into heritage (Matero 2008). The selection of appropriate conservation materials presents a difficult challenge in these contexts. Intervention considerations include but are not limited to authenticity, availability, compatibility, cost, empirical knowledge, and sustainability (Pedelì and Pulga 2013).

Earthen architecture is built with raw earth, using a range of techniques and styles such as rammed earth, adobe, wattle and daub, and cob (Houben and Guillaud 1994). Earthen architecture is one of the most universal and diversified built heritages of humankind, and the many forms can be seen from antiquity to the present across the globe (Correia and Walliman 2014; Love 2017; Rosenberg et al. 2020; Lorenzon 2021, 2023). The conservation of earthen architecture, as a discipline, draws from a diverse range of fields from archaeology, geology, architecture, ethnography, chemistry, craft skills, and the arts (Cooke 2010). While the origins of conservation can also be dated back to antiquity (Brand 2000, 45), architectural conservation as it is understood today evolved in the 18th century A.D. out of the era of the industrial revolution in Europe, with notable contributions from John Ruskin and later Alois Riegl (Hayes 2019). The balance of conservation intervention relative to craft and science is an ongoing debate within the profession (Douglas-Jones et al. 2016; Jones and Yarrow 2022). A central tenet to current conservation practice is that it is values-driven with a focus on understanding the significance of a heritage asset (Clark 2001). This stems from a growing recognition of the importance of non-western voices and influential documents such as the Burra Charter (1979) and The Nara Document on Authenticity (1994) (Winter 2014).

Soil chemistry is an important factor when examining archaeological sites and their potential for preservation. Effective preservation in situ requires an understanding of the factors that might bring about deterioration and influence condition post-excavation (Corfield 1996). There is no standard method for soil analysis, and method choice varies among researchers; however, analysis of earth materials aids in understanding possible sources of material but also the people and society behind the structures (Love 2017). Compositional analyses of mudbricks in an attempt to understand how to preserve and restore earthen monuments have been long-standing (Torraca, Chiari, and Gullini 1972; Uğuryol and Kulakoğlu 2013). Key information includes evidence of the soil type, the underlying geology, the natural salt loading of the soil, the effect of any additional salts, the water-retentive capacity of the soil, the degree of oxygenation of the soil, and the local hydrological regime (Corfield 1996). The pH of soil is normally between 5 and 9 (from slightly acid to slightly alkaline); the introduction of new basic ions from increased moisture can introduce hydrogen ($H+$), which, combined with environmental carbon dioxide ($CO2$) to form carbonic acid ($CO3$), can in turn increase soil acidity (Pedelì and Pulga 2013, 13). Carbonates with soil deposits increase soil strength and reduce moisture damage; these formations can be naturally occurring or the result of ashy occupational deposits (Cooke 2010). While calcareous soils and calcite deposits (such as lime) provide a framework within which shrinking and swelling is less detrimental, calcite breaks down the clay platelets so they are re-aligned to create a more robust material (Cooke 2010).

Many studies have identified water and moisture as primary agents of deterioration. These promote the formation of soluble salts inside built earth, which are subject to a cyclic process of dissolving and recrystallization that induces stress and loss of cohesion in the materials (Rainer 2008). These humidity cycles cause clays in the earthen architecture to go through cycles of hydration and shrink-swelling phenomena, which, in interaction with additional contaminants, can catastrophically impact the architecture's integrity from differential thermal expansion, osmotic swelling, hydration pressure, and enhanced wet/dry cycling (Doehne 2002). Conditions such as high humidity or rising damp cause soluble salts to transition to the liquid phase in a process called deliquescence, when humidity drops below the deliquescence point and the salts re-crystallize, which causes mechanical damage to the substrate (Goudie and Viles 1997). While in the liquid phase, salts can then migrate through the substrate via capillary action, leading to efflorescence and sub-florescence throughout the structure (Doehne 2002). Structural issues relating to moisture and soluble salts can be further exacerbated by the introduction of new materials, which will have inherently different environmental reactions. Backdirt in this context lends itself to being a low cost, sustainable, and highly compatible solution.

The Ethos of In Situ Conservation Interventions

Ideological tenets of conservation philosophy such as reversibility, authenticity, and ascribing equal value to all things are crucial to creating a dialogue about the conceptual value changes that conservators can make through intervention (Sease 1998; E.C.C.O. 2003; Cane 2009; Icon 2020b). The current conservation ethos advocates minimal, opportune interventions which can be retreated, often with either traditional skills or experimentally advanced techniques (Hölling 2017). The authors argue that, fundamentally, conservation practice seeks to prevent the wasteful use of a resource to facilitate its continuing availability. Conservation is a process that seeks to extend the life of heritage, a continuum over time. Interventions are part of a site's history and tell their own story but cannot be expected to last indefinitely. Understanding change is part of a dynamic decision-making process about the most appropriate conservation interventions, repairs, and renewal (Henderson and Lingle 2018). Conservation interventions reflect the thinking and approaches of their time. This paradigm is succinctly and now ubiquitously asserted by Matero (2008) that "archaeological sites are made, not found."

Adaptive reuse and constructive conservation ideas are not new within the scope of heritage conservation (Coşkun 2015). Constructive conservation acknowledges that heritage is a dynamic force and that protection alone is not enough (Hill 2016). Repurposing in antiquity and adaptive reuse are a part of the sites' histories; however, the ideas of monumentality and capturing time have been somewhat detrimental to how archaeological sites are perceived when they get to the public presentation stage (Ahmer 2020). Problematically, however, these types of treatments can challenge ideas of authenticity and can be seen as restoration rather than conservation (Marchand 2011). A significant benefit of building with earth is the resurgence of using traditional building and repair skills; often, these are presented with new technologies and additives (Landrou et al. 2016; Michael et al. 2018). Examples of structural consolidation within a historic conservation context are well established (Lemaire and van Balen 1988; Fodde and Cooke 2013; Lorenzon et al. 2013; Barnard et al. 2016; Bizzarri et al. 2020). For earthen sites, structural consolidation utilizes new earth materials applied to ancient walls for structural stability and to act as a sacrificial layer from future weathering (Miller and Bluemel 1999; Stazi et al. 2016; O'Grady et al. 2018). This methodology has been proven to be successful in extending the life of earthen structures and offers important opportunities for training and community engagement. While there are colloquial instances of backdirt being integrated into structural work, few publications specifically identify using site soil. Fodde (2006) briefly mentions the use of backdirt in this way at the site of Otrar Tobe, Kazakhstan.

Figure 1. External trench, Çatalhöyük, Turkey. This trench is at the top of the Neolithic mound and is in an area exposed to wind and water runoff. The trench was first lined with geotextile, and then polypropylene agricultural woven sacks filled with backdirt were systematically layered within the trench.

The alternative to structural interventions in the preservation of earthen sites is the idea of consolidation: the applications of a substance (e.g., epoxies, acrylics, or silicates) to strengthen the original material by means of infusion into the interstices of the pores (Oliver 2008; Correia, Guerrero, and Crosby 2015). However, penetration into earthen substrates by organic synthetic consolidants is not as effective as previously thought (Lingle 2022). While no treatment is truly reversible, silicate systems are irreversible once introduced into architectural substrates and create the potential for disaggregation due to the formation of irregular hard zones during the curing process (Costa et al. 2017). While the earthen structure is still re-treatable, the question then becomes "to what end?" Earth is a weak material that has always been used with the idea of constant maintenance and repair (Barnard et al. 2016). Walls were originally protected by roofs, which in most archaeological contexts are missing. The natural evolution and alteration of the material cannot be stopped, and so conservation can only reduce the speed of deterioration (Chiari 1990).

From this premise, Lingle (2022) looked to explore the potential of backdirt in the preservation of earthen archaeological sites. The impetus for this more methodological approach to the use of backdirt sought to bridge the gap of authenticity while acknowledging the practicalities of taking a more structural approach to the conservation of archaeological earthen heritage. With any structural work and, indeed, reconstruction, there are questions of authenticity; backdirt in these situations creates an interesting paradox, as it is both a part of earthen structures but dissociated from its original location.

Archaeological Perspective

Archaeological sites consist of primarily two components: the excavated site and its associated spoil heap. While the value of backdirt in these contexts is further evaluated in this special issue, in essence, spoil heaps serve two main functions. One: backfilling material—most excavation trenches are reburied with site spoil at the end of the field season, and the soil that is most readily available for this is that which was just removed. Two: landscape feature—the dirt must go somewhere; if it isn't back where it came from, it's more often than not nearby.

Backfilling a site is done almost exclusively as a means of preservation (Demas 2004). As standard as the practice has become, it is not without issues. The process is usually manually executed with shovels and wheelbarrows. It is strenuous and time-consuming, and excavators can look forward to removing the same soil when the dig continues the following field season. The freshly exposed site must then reacclimatize to being freshly buried, and new diagenetic processes (soil compaction and vegetative growth) begin. Backfilling may not be an option in some countries or geographic locals, or governmental permission may be needed to do so (Demas 2004). Of course, the alternative of not backfilling can be fantastically destructive (Cooke 2007), so in those instances when a site will not be left on open display, backfilling with spoil remains the best option for preservation. Figure 1 shows an example of a trench with a temporary backfill measure in place.

Remaining backdirt may also serve educational purposes. For instance, The Shell Çatalhöyük Archaeology Summer Workshops provided Turkish elementary school children the chance to learn about archaeology by digging the site's 1960s spoil heap (Farid 2014). The prodigious mounds left over from James Mellaart's 1960s excavations were perfect candidates for such a program, as the nascent archaeologists would routinely find artifacts previously missed (Nakamura and Meskell 2004; Nakamura and Hodder 2021).

Unless used as backfill (and despite its educational value), the removal of soil from an archaeological site is not a sustainable practice. Spoil heaps can continue to grow in perpetuity, augmenting the natural landscape, impeding archaeological directives, and obstructing visitor context. Their removal can be costly and environmentally impactful. The effort required to remove spoil heaps post-excavation often results in them remaining ex situ. Spoil heaps left in place can become problematic if excavation footprints expand and spoil has to be moved. This creation of a feature within the landscape has led to the archaeological phenomenon of excavating an earlier excavation's backfill, whether intentionally (MacGillivray, Sackett, and Driessen 1998; Wright et al. 2021) or unknowingly (Plew and Wilson 2007). Proper management of archaeological backdirt is necessary to ensure archaeological excavations are sustainable.

Sustainable Development and Practice

Sustainability, when applied to the heritage sector, can take on many meanings. Sustainable development does not necessarily mean sustainable practice, but it can include it. Both may or may not refer to the use of environmentally sustainable (i.e., "green") policies and materials (Lucchi and Buda 2022). All may be considered within a heritage activity and ultimately rejected, where relevant or convenient (Cooke 2010, 215).

The preservation of cultural heritage is stated within the United Nations Sustainable Development Goals (SDG) (United Nations 2015), which have subsequently been used as underpinning initiatives in the development of guidelines from heritage-specific organizations such as the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM 2023), the International Council on Monuments and Sites (Labadi et al. 2021), The International Council of Museums (ICOM 2019), and The Institute of Conservation (Icon 2020a). SDG 11.4 cites the need to "strengthen efforts to protect and safeguard the world's cultural and natural heritage," and SDG 8.9 states policies should "promote sustainable tourism that creates jobs and promotes local culture." Likewise, SDG 12 addresses the need for sustainable consumption, management, and use of natural resources, with a focus on waste reduction and informing and empowering communities for sustainable lifestyles. These ideals have been applied to the archaeology (Chirikure 2021) and conservation (Xiao et al. 2018) sectors, though their impact has faced scrutiny as the complexities that define cultural heritage, conservation, and sustainability prove finding a suitable, measurable metric difficult (Petti, Trillo, and Ncube Makore 2020). Either way, the SDGs and their adoption within industry policy and guidance developed by professional organizations (which stakeholders and funding bodies look to for defining best practices) signify that site management plans involving the excavation and/or display of cultural heritage must at the very least address sustainability.

Sustainability within conservation practice has primarily focused on environmental footprint, carbon reduction, and "green" materials and practices (De Silva and Henderson 2011; Fife 2021; Kampasakali et al. 2021), with a recognition that these should support sustainable access, economic, and societal goals (Saunders 2022). Built heritage management—born out of an understanding of the dynamic relationship between people and their surroundings—has long accepted change as inevitable, and so views sustainability of the heritage environment as controlling that change (Fairclough 2003; Gražulevičiūtė 2006). This holistic perspective, in turn, allows for the sustainability of social identity of local and regional groups whose cultures have been informed by their built heritage (Low 2003). Sustainable archaeology is a contested term (Guttmann-Bond 2019; Hutchings and La Salle 2019) and should not be confused with sustainable archaeological practice, an area that mostly focuses on social sustainability through participation (Atalay 2010) and, for many reasons (Howard 2019), remains poorly defined (Carman 2016).

Considering the lofty ideals of sustainability aims within the heritage sector, their various definitions and implementations, and their inscrutably narrow determinants of success, one would be forgiven for not immediately thinking of backdirt as sustainably significant. If anything, it is archaeological waste, an unwelcome but necessary by-product of excavation. One could argue the most sustainable archaeological practice is not digging a site. Nevertheless, in those instances where excavation is required, backdirt will remain a feature. However, earthen archaeological sites have an advantage over other, more durably material-minded ones: they are surrounded—and indeed built from—the most sustainable material that can be used to preserve them. The incorporation of backdirt into earthen site management meets heritage-facing SDGs, as well as broader environmentally-focused ones, and expands upon the concept of sustainable archaeological practice. Whether applied in situ or formed into bricks, its use has a measurable, meaningful impact. Principally, it recycles by-product "waste" of archaeological excavations, as its implementation has exceptionally low carbon impact, with only water resources, straw production (itself a by-product of cereal agriculture), and carbonate-rich soil having any footprint. The material is already on-site and does not need to be manufactured and shipped, and the material can be recycled indefinitely, further reducing any future carbon impact. Furthermore, the use of backdirt for preservation does not require continued specialist knowledge, only instruction, allowing for the participation of local communities in the maintenance of their cultural heritage and providing them with agency over its care.

The Use of Backdirt in the Preservation Program at Çatalhöyük

The Neolithic site of Çatalhöyük, Turkey (Figure 2), is a large archaeological site with a complex set of preservation and socio-political issues which have shaped the presentation of the site since its discovery in the 1960s. The eastern mound of the site contains 18 levels of Neolithic occupational deposits dating from 7200–6400 B.C., maintained in antiquity for over 2000 years (Hodder 2020). In addition to densely aligned architecture, the site holds wall paintings, reliefs, and sculptures. Çatalhöyük is considered one of the key sites for understanding human prehistory and one of the most significant human settlements documenting the transition from early settled agricultural to urban agglomeration (Hodder 2020). Currently, visitors to the site have the opportunity to explore five reconstructed Neolithic houses along with a small museum, before heading up the mound to the two sheltered excavation areas.

During the course of the Çatalhöyük Research Project (1993–2018), conservators strived to create reliable preservation strategies amidst changing goals, evolving scientific understanding of the site, and challenges in team continuity. While these kinds of challenges are not uncommon in long-running projects, they ultimately obstruct the development of a systematic treatment program, challenging the long-term preservation of a site. At Çatalhöyük, the inscription of the site by the UNESCO World Heritage list in 2012 required a reflexive look at the treatment of the built heritage, encouraging the development of new methods (Lingle 2022). The key to developing a new treatment program was to re-examine the context of conservation at the site, identifying changes in patterns of deterioration and other outstanding issues of preservation.

Environmental monitoring identified issues resulting from the construction of permanent shelters over the South (2003) and North (2008) excavation areas (Figure 3) (Campiani, Lingle, and Lercari 2022). This data resulted in the authors' overall shift in the conservation approach, moving from treatments based on materials present in the site structures to treatments based on the climate surrounding the in situ archaeology. The most pronounced threat to the exposed buildings at Çatalhöyük is basal erosion, whereby undercutting (coping) occurs due to higher concentrations of moisture in the lower part of a wall due to capillary rise (Lingle 2022). The main problem arising from deterioration at the base of the wall is the loss of support under loading, which introduces load-bearing eccentricities into the structure and may eventually lead to overturning (Illampas, Ioannou, and Charmpis 2013). The shelter environments, ironically, exacerbate risks of basal erosion, as fluctuations in the environment within the shelters cause cycles of condensation and evaporation, which on diurnal and seasonal cycles lead to humidification and desiccation of the earthen archaeological substrate (Campiani, Lingle, and Lercari 2022).

Following a long-run program of consolidation of the walls (Pye 2006), in 2010, the conservation team began experimenting with longer-term methods for addressing the preservation issues, as the consolidation intervention required frequent retreatment during field seasons. This included materials such as marl plasters and hydraulic lime mixtures to create a more robust barrier to protect the archaeological surfaces; this ultimately led to sheering in the off-season. During the 2013 and 2014 seasons, taking inspiration from partially reburied walls at the site, experimental work began on creating sacrificial surfaces utilizing principles of constructive consolidation. For this work, mixtures of backdirt, chaff to reduce shrinkage, and perlite (amorphous volcanic glass) to improve drainage, and water were experimented with first as renders (Figure 4) and then later as rammed earth (pisé) (Figure 5) (Lingle 2022). The new strategy was to create a sacrificial surface to deteriorate preferentially by drawing soluble salts and moisture from the walls, rather than focus on encasement from external agents of deterioration, as the 2010 tests had aimed to achieve. The rammed earth application focused only on mitigating the effects of undercutting by providing support to wall bases. Wall bases were lined with geotextile, and then a backdirt mixture was built up in the void under the wall. The pisé earth mixture was ultimately composed of backdirt (40%), perlite (30%), and chaff (30%). The tests showed that not only does this strategy impede the undercutting, but it also slows the deterioration of the wall (see Figure 5). The geotextile barrier helps to control the capillary action and mitigates the soluble salts, while also creating a barrier between the original archaeological surface and the new material. During this study, it was found that these backdirt treatments lasted approximately three years before needing minor retreatment, greatly improving the conservation team's workflow and ability to support other work on the site (Lingle et al. 2021; Lingle 2022).

The Çatalhöyük Digital Preservation Project (CDPP) was established to aid in understanding the preservation of the site. This work included creating a methodology for enhanced site monitoring and preventive on-site interventions (Lingle and Lercari 2017). The CDPP research initiative was funded by the Archaeological Institute of America (AIA) (UC Merced—Award Record #A16-0082-001). The project adapted digital technologies to monitor the site, using a geospatial method for assessing the state of preservation of earthen architecture over time as a preventive conservation measure. The method utilized a quantitative and qualitative approach that gathered multi-temporal data from 2012–2017 (Campiani, Lingle, and Lercari 2022). Data included environmental information (temperature and relative humidity) collected by means of environmental loggers, qualitative vulnerability assessment of mudbrick walls, and surface change detection information obtained by comparing a terrestrial laser scanning (TLS) point cloud capturing the decay of a building's wall features over time. As part of the project, annual TLS of the site were used to quantify material loss of the walls; additionally, ArcGIS was used to produce environmental risk maps from the multi-temporal data, allowing conservators to have a more nuanced understanding of the deterioration patterns across the site

Figure 2. The site of Çatalhöyük in relation to its geographic context within modern-day Turkey.

(Campiani, Lingle, and Lercari 2022). This project proved essential in evidencing the success of conservation interventions as methodologies were developed, as well as understanding the impacts of the climatic shifts under the permanent shelters (Lingle 2022). This research is a key component of the legacy the conservation team left in place for the team taking over site conservation in 2020.

Current Preservation Strategies on the Prehistoric Tell at Vésztő-Mágor

Building from the work carried out at Çatalhöyük, the authors had the opportunity to further this research in the context of the Time Will Tell: The Vésztő-Mágor Conservation and Exhibition Program. The project is funded by the Foundation for the Study and Preservation of Tells in the Prehistoric Old World (no grant number), the municipality of Vésztő, the University of Georgia, Cardiff University, Kiel University, the Field Museum of Natural History, and the University of York. This is a joint research and outreach initiative co-directed by colleagues from Cardiff University, the Field Museum, Kiel University, the University of Georgia, and the University of York. Vésztő-Mágor is a tell site in southeastern Hungary that features Middle and Late Neolithic (5000–4600 B.C.), Early Copper Age (4500–4000 B.C.), and Early/Middle Bronze Age (approximately 1850–1750 B.C.) habitations. It is the largest tell in the Great Hungarian Plain (Figure 6). A Medieval monastery was built on top of it sometime between the 11th and 12th centuries A.D. (Hegedűs and Makkay 1987; Sarris et al. 2013). The mound was bifurcated in the 18th century A.D. to provide construction material for an elevated causeway to the site from the adjacent field. That field, the site, and the surrounding area is now a national park of the same name. The park features a visitor's center, the partially restored ruins of the cathedral, a site museum, a Neolithic reconstruction house, and a sculpture park featuring the busts of Hungarian folk writers. A sheltered area of the archaeopark contains the aforementioned prehistoric occupations that have been excavated and presented in tiered levels (Figure 7). The 19 × 5 × 7 m rectangular trench is covered by a concrete shelter that has been remounded with backdirt. The park is an important social and economic resource for the local farming community of Vésztő, hosting town gatherings, weddings, and festivals.

Though a fixture of the national park and key gathering spot for the town, the earthen site is continually eroding, with profiles and platforms rapidly deteriorating. In the fall of 2021, a project focused on the tell's conservation and renewal was launched, recognizing the site's importance within an archaeological and regional context, as well as its significance to the local community. Following a condition survey, seven Tinytag Plus 2—TGP-4500 environmental loggers were placed around the site to determine how relative humidity and temperature were contributing to its decline. Additionally, four Delta-T PR2/6 soil moisture probes were installed into the profile to better understand site moisture statics and the effect they have on the exposed archaeology. The survey and data confirmed that an array of preservation issues associated with tell sites (differing construction

Figure 3. Inside the Çatalhöyük A) South and B) North shelters. Photographed during the 2017 excavation season.

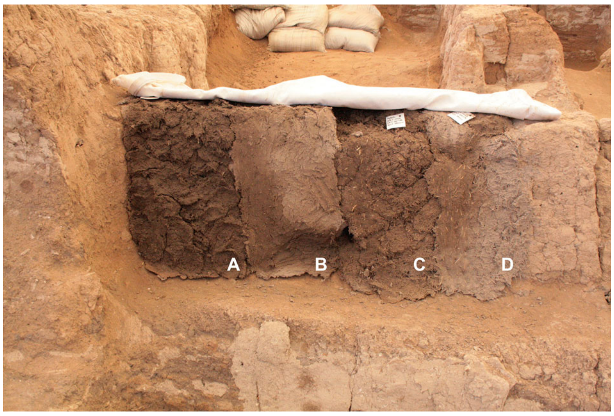

Figure 4. A sample of the initial backdirt testing done at Çatalhöyük during the 2013 excavation season. Examples of renders produced to sacrificially erode; each section is composed of backdirt with varying aggregates and application strategy. A and B are composed of 45% backdirt, 15% perlite, and 30% straw; A was applied with a low contract splatter method, while B was smoothed across the surface. C and D are composed of 35% backdirt, 35% perlite, and 30% straw; C was applied with a low contract splatter method, while D was smoothed across the surface.

materials between habitation levels and microclimate fluctuations) (Lingle 2022) had combined with earthen (diurnal moisture/temperature fluctuations and salt efflorescence) and Vésztő's site-specific (built immediately above a flood plain, a constrictive shelter, and a tiered approach) deterioration pathways to create unique site statics that would be challenging to mitigate (Barnard et al. 2016; Campiani, Lingle, and Lercari 2019). Review of the environmental data before conservation work took place the following year indicated the permanent shelter creates a cave-like environment, resulting in extremely high relative humidity, with several areas keeping at dew point for prolonged periods. This results in basal erosion occurring at the bases of profiles and feature walls and the vertical shearing of exposed surfaces. The enveloping soil has a very high soluble salt content (the area was underneath the Pannonian Sea until 5 million years ago [Frolking 2021]), and the humidity fluctuations are causing these salts to deliquesce and efflorescence on diurnal cycles in upper parts of the trench. The corresponding volume changes lead to accelerated erosion. The high humidity also results in mold forming over much of the trench during field seasons. Given the site shelter and the technological developments and shifts in resourcing built materials over the site's occupational history, the Neolithic/Copper/Bronze Age deposits all react somewhat differently to the environment, and the platforms and elevations create an exceptional number of microclimates in discord with each other. The biggest impact on section stability has ultimately been the presence of previous conservation interventions, chiefly a cementitious earth render.

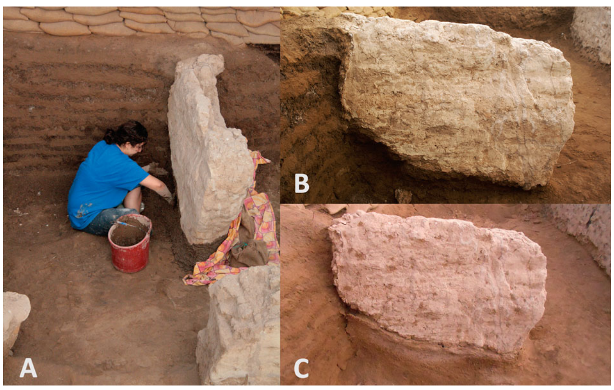

Figure 5. Çatalhöyük Feature 231 treatment with backdirt mixture. A) Feature being treated by a site conservator in 2013. B) The feature just before treatment. C) The feature in 2017.

Previous conservation interventions in the shelter proved to be unsuited to profile and feature compositions within the shelter, resulting in differential erosion between varying microclimates. Cementitious/earthen/plaster renders were applied over profiles and features. Some were so heavy that they required a ferrous wire mesh backing and doweling into profiles for support. Microclimates formed between the renders and vertical features, eventually accelerating deterioration in those areas where they were applied. Previous attempts at using ethyl silicates were applied in the hopes of slowing deterioration, as earlier studies showed it to be effective in consolidating earthen structures (Ferron and Matero 2011). However, the treatment was ineffective and led to an increase in microbial activity in treated areas, most likely due to the high soil moisture content of the area of application (> 40%). As part of the approach to the documentation of alterations to the site, 3D models are generated utilizing an Artec Ray scanner to aid in the quantification of material loss and understanding of building statics in the trench.

Generally, in these instances, the collapsing archaeology would be excavated and new areas exposed. While there is limited excavation to support conservation efforts, the shelter prevents the expansion of the excavation footprint, leaving conservation mitigation of remaining sections as the best option. Though the material and application of the earlier interventions contributed to their failure, applying a pisé method at the base of the wall, as was used at Çatalhöyük, was not an appropriate treatment. The vertical length of the profile walls meant a structurally supportive treatment, in addition to a sacrificial façade, was needed. A structural consolidation wall (see Fodde and Cooke 2013) constructed of mudbrick would serve both of these functions. Like in the case of Çatalhöyük, however, the intervention is designed to preferentially deteriorate relative to the archaeological material, with a high perlite content to facilitate moisture drainage. While adding moisture in the trench is unavoidable with any type of earthworks, using pre-dried bricks in this context also limited the amount of additional water needed in situ. Utilizing a geotextile barrier, the bricks could be built to lean against the archaeological section, limiting any microclimate formations. Constructed of backdirt (45%), perlite (20%), and chaff (35%), their composition would ensure moisture flow between the profiles and exposed surfaces. Any eroded soil could then be retained and used for future interventions. As the profiles are difficult for non-specialists to interpret as archaeological features, covering them in this manner would not rob visitors to the site of context. The new spaces also provide key exhibition areas with opportunities for visitor interpretation.

The structural consolidation strategy was first implemented during the 2022 field season on the northern half of the western profile. Measuring roughly 6 × 2.5 m, the profile was in a severe state of decline, the result of extreme desiccation in the uppermost humic layer and moisture-induced slumping throughout the lower half. A failed earthen render remained in place, trapping eroded

Figure 6. The site of Vésztő-Mágor within a wider geographical context.

and collapsed soil behind it, which in turn was placing an undue load across the profile and causing it to shear. Backdirt from minor excavation work in 2022 and earlier site cleanings was screened and saturated with well water available on-site, mixed with perlite and screened chaff, formed into bricks, and cured in the sun (Figure 8). The bricks measure 15 × 10 × 10 cm and are formed in polypropylene food containers that have been augmented to assist with curing. This brick size was considered ideal, as larger bricks would take longer to cure and would not be as adaptable to construct the facade from. Access into the trench also creates logistical challenges, and utilizing smaller bricks was logistically less challenging. Mortar was made from the same materials as the bricks, though with slightly more straw in a wetter slurry. This first completed retaining wall is composed of ca. 1400 bricks and separated from the unexcavated profile with a thin layer of geotextile (Figure 9). As the project is ongoing, continued monitoring and reflection will be used to evaluate further project outcomes. Initial review of this methodology in the 2023 season showed excellent preservation of the archaeological section behind the geotextile and mudbricks and will continue to be monitored through the project.

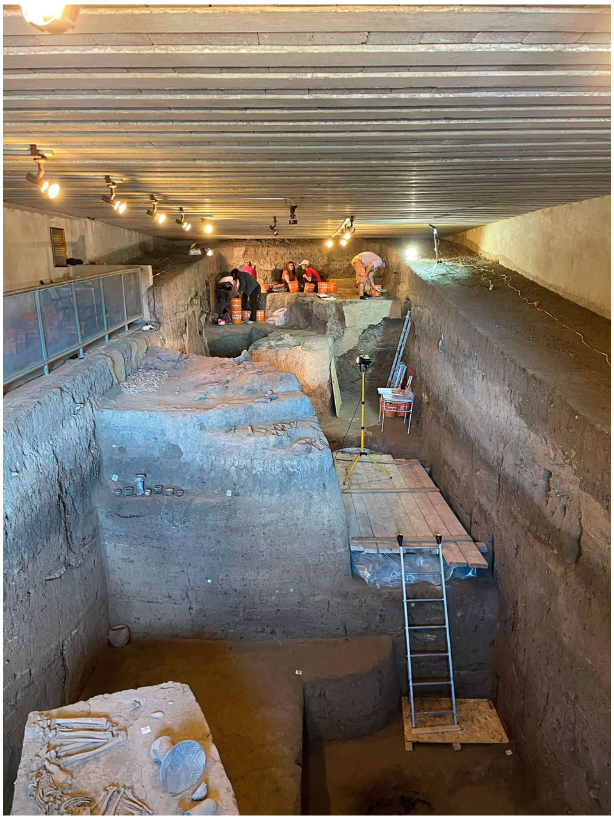

Figure 7. The sheltered archaeological trench at Vésztő-Mágor Historic Park, seen from the shelter entrance (south). The Neolithic habitation levels are in the foreground, with Copper and Bronze Age levels in the top of the photo, near the northern end of the shelter.

Implications of Integrating Backdirt into Intervention Strategies

In the case of archaeological earthen architecture, there needs to be a wider discussion of breaking with some of the tenets of conservation, specifically rigid ideas of authenticity, reversibility, and sustainability. The authors argue that if an earthen site is deemed significant enough to warrant the investment to make it accessible and not rebury, there has to be a pragmatic acceptance to how this site is preserved and managed. Avrami, Guillaud, and Hardy (2008) emphasize the inextricable link between conserving earthen heritage and promulgating earthen buildings. Much of the constructive culture of earth lies in its continued evolution as an architectural form and tradition. Forging connections between conservation and constructive adaptation remains an important task, both in research and practice. The intangible value of these unique pieces of heritage can be challenging to sustain without utilizing the practical skills needed to maintain them. There is an undeniable inherent paradox of earthen sites transformed into monuments: "artificially stabilized in a form that would seem to reside outside processes of 'change'—an inevitably forlorn attempt to resist change and adaptation. As such they have suffered an ill-fit within nineteenth- and twentieth-century conservation paradigms that privilege the maintenance of current condition" (Cooke 2015, 237). As for authenticity, Muñoz-Viñas (2012) argues heritage objects remain genuine whatever their state, as long as they have a physical existence. While such a broad definition can be problematic, it does highlight the need to define what is being conserved. The idea of authenticity in conservation has shifted over time, and the experience of authenticity shifts across different cultural contexts (Gao and Jones 2021). For interventions to be authentic in a practical sense, a level of transparency and engagement with the wider conservation community is necessary (Swanson and Mahoney 2023). In the case of archaeological earthen architecture situated in the context of an archaeopark, conservation is being carried out for the buildings to be on display for the public, as well as researchers, so all else being equal, the structural and aesthetic qualities of the structures are what need to be preserved. It is also important to note that clear distinctions between original structures and interventions to these structures should be part of the treatment strategy. Future interpretation depends on the survival of the heritage material as records that will be reread, but this cannot happen if the text has been erased (Podany 2006). Interventions need to be well defined, documented, and evidenced. Correia and Walliman (2014, 581) identify a central issue in the development of treatments for earth-built heritage, highlighting a lack of understanding among conservators as to the meaning and the need for clear criteria for interventions. The work undertaken at Çatalhöyük and Vésztő-Mágor demonstrates how opportunities for authentic conservation practice (Jones and Yarrow

Figure 8. Project members A) screening and saturating soil with water and B) removing bricks from formers to cure in the sun.

2022) can be underpinned by evidence to create contextually appropriate intervention strategies.

The benefit of the approach outlined in the case studies is the preservation of the archaeological substrate. The barrier created by the geotextile, combined with managed structural support of the intervention, makes the treatment straightforward to remove. Additionally, this method allows for the conservation of exposed archaeology without the need to re-excavate crumbling features to maintain structural and visual cohesiveness. The risk of loss due to inconsistent consolidation solution application is negated. The use of backdirt presented in the case studies sustainably preserves archaeological sections for further investigation whilst utilizing locally available materials. It has a low carbon footprint and can be implemented and maintained by trained local volunteers rather than an extensive team of specialists.

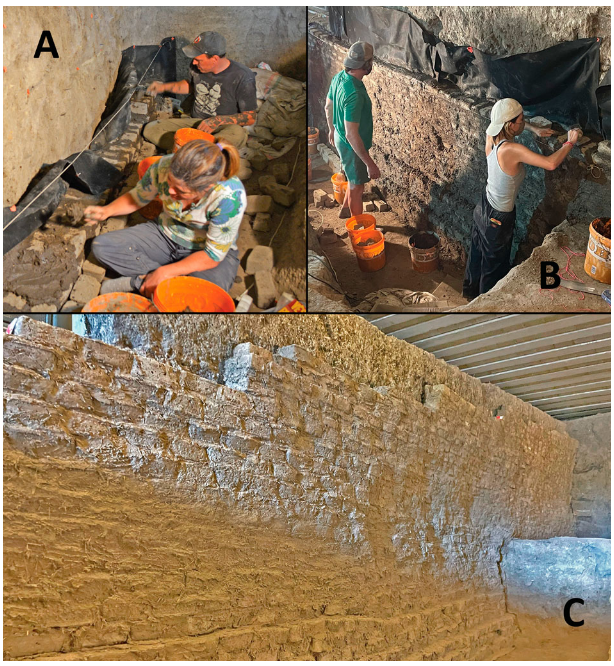

Figure 9. The mudbrick retaining wall and sacrificial facade in Section I, showing A) the authors laying down the first course, B) the wall nearing completion, and C) the completed facade after drying.

There are some key limitations of this method, and, like all interventions for earthen sites, it is not contextually appropriate for every site. It is time intensive to implement initially. This includes the time needed to resift soil to exclude missed cultural deposits, fabricate, and dry the material. Access to water is needed. There is the risk of post-excavation contamination from biological and/or agricultural materials (e.g., seeds, fertilizers, etc.), though this is significantly mitigated by screening the soil and the application of geotextile (Agnew and Demas 1998). While the backdirt can be recycled indefinitely, it is a limited resource. The authors argue, however, that when correctly managed, the benefits of adapting a material with sympathetic behavior and perpetuation of traditional skills in earth building outweigh the risks. Furthermore, for earthen architecture, taking a diachronic approach and utilizing multiple lines of evidence, including macro-morphological, mineralogical, and chemical studies interpreted within the context of living vernacular traditions in the region, produces a nuanced understanding of the archaeological evidence (O'Grady et al. 2018). It is worth noting the research presented in this paper was undertaken with approval from the relevant local and national authorities.

Conclusion

Conservators must balance the impetus for authenticity, integrity, and pragmatism with their overall conservation strategy. These needs are also multi-scalar, as different stakeholders (conservators, site directors, and local and national governments) will have different expectations and desires (Henderson and Lingle 2018). In particular, the goals of conservation research must be clear on an ethical level and be contextually relevant for the site in question. For in situ heritage, the need to negotiate these demands at both short- and long-term timescales underscores the need for principled conservation strategies, particularly when dealing with complex earthen architectural remains. The case studies presented in this paper aim to demonstrate that through understanding the environment of a site, its materiality, significance, and appropriate uses of scientific knowledge and traditional skills, backdirt provides little-explored opportunities for engaged conservation practice. Though present colloquially in a conservation context, backdirt is a unique resource that merits further methodological exploration as a material used in treatments. The application of backdirt in a conservation context also offers a chance to explore the responsible consumption of archaeological sites working with disassociated material towards sustainable conservation management. It is the authors' aspiration that in being transparent in their approach to these projects, it will further contribute to the critical dialogue of how archaeological earthen sites are managed in the long term.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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