Assembling Çatalhöyük

Edited by Ian Hodder and Arkadiusz Marciniak

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Cover image(s): *Left*: Ochre hand prints on the north wall of Building 77; *Middle*: Bucrania and horned bench associated with the northeast platform of Building 77 (both taken from Taylor pp. 127–50, this volume); *Right*: The incised panel above burial 327 in TP Area (taken from Marciniak et al., pp. 151–66, this volume).

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CHAPTER 10

'Up in Flames'

A Visual Exploration of a Burnt Building at Çatalhöyük in GIS

JAMES TAYLOR, AMY BOGAARD, TRISTAN CARTER, MICHAEL CHARLES, SCOTT HADDOW, CHRISTOPHER J. KNÜSEL, CAMILLA MAZZUCATO, JACQUI MULVILLE, CHRISTINA TSORAKI, BURCU TUNG AND KATHERYN TWISS

INTRODUCTION

This chapter presents the results of a collaborative spatiotemporal study of a burnt building at the site of Çatalhöyük, South Central Turkey. The chapter outlines and showcases an experimental approach to the appending of stratigraphic temporal data onto existing spatial data as an unusual and innovative way to articulate space in time within the structure of a Geographic Information System (GIS).

Building 77 (B.77) yielded a unique combination of scale, complexity, unusual distribution, and good preservation of archaeological material. Focusing upon this case study the project has been able to integrate specialist data relating to the material culture found in the final burning event, and its earlier occupation sequence, into a temporally enabled version of an intra-site GIS. Through the study and analysis of the material culture in relation to its spatiotemporal context, we hope to gain some insight into the social identity of the building's residents throughout the life cycle of the structure. We use spatiotemporal animations to present the results of this collaborative study as a form of prototype 'visual biography', more dynamic and nuanced than conventional phasing, that might be used to underpin and illustrate a social narrative of the building.

This chapter will briefly present some of the key concepts that drive the collaboration relating to the way we as archaeologists handle the temporality of our stratigraphic sequences, through the phasing of Harris Matrices, before giving an introduction to Building 77 itself. It will then outline the methodological approaches used in the construction of a new type of spatiotemporal modelling and visualization rooted in stratigraphic analysis, and present some of the preliminary outputs of this study. Finally, it will conclude with a brief evaluation of the work so far and some indication of the future directions of the Building 77 project.

Temporality beyond phasing

From its conception the purpose of this ongoing collaborative study has been to explore the potential of the inherent temporality locked within the stratigraphic sequence of the site of Çatalhöyük. In particular, the project seeks to move beyond conventional notions of building phase, and ultimately site-wide levels, commonly used as a temporal unit of analysis on the site.

Historically, stratigraphic phasing on the site operates at two levels of temporal granularity: *site-wide* and *intra-structural*. Intra-structural phasing (the phasing of individual buildings), used to help comprehend the complexity of the sequence, can be problematic at Çatalhöyük because a whole building sequence is not always easily grouped or correlated at the stratigraphic level. This is due to various (often taphonomic) factors which affect the sequence, the most prolific cause being scouring and remodelling events within the life cycle of the buildings and spaces, that often truncate and obscure the critical correlations between plaster wall surfaces and floors and internal furniture (elaborated benches, platforms, wall fixtures, postholes, etc.) required to temporally phase their development. As such phasing at this level remains a necessarily flexible and fluid process that can be classified and defined in a number of ways (see Hodder et al., 2007: 17–18).

Site-wide levels, originally defined by Mellaart (1966: 168; 1967: 52) and recently modified and restructured by Farid and Hodder (Farid, 2014: 97–129), work at a far coarser resolution. Analytically, they are geared towards understanding more general trends and changes in the distribution, style, and technology of material culture and as such are a robust interpretative tool. They often become problematic, however, when scrutinized at a finer stratigraphic resolution because the way in which buildings are constructed and modified is not linear across the sequence. Stratigraphically it can often be difficult to ascertain whether a building is contiguous with its neighbours, or how it relates temporally to the spaces and structures that it seals or is overlain by (see discussion in Farid, 2014: 91–97).

More generally, at a conceptual level, phasing and periodization of the stratigraphic sequence are synthetic constructs that seek to group or band stratigraphy temporally. Although there has been some academic discourse upon what constitutes a phase and how to go about phasing the stratigraphic sequence (Roskams, 2001: 246–53; Hammer, 2002; Carver, 2004; Saunders, 2004), the analytical process that constitutes phasing is rarely made explicit methodologically. Phases are conventionally defined by a process of detailed examination of stratigraphic relationships and formation processes, often in relation to the material culture and environmental evidence which they contextualize. This allows elements of the matrix to be drawn up and down (both conceptually and on paper) until they are in phase and therefore considered to share the same band of temporality.

Like any site that adopts a rigorous single context approach to recording, the Çatalhöyük Research Project stores its stratigraphic data in Harris Matrices (Harris, 1984; Spence, 1990). Since their conception and first application to the discipline (Harris, 1975) the Harris Matrix has been critiqued extensively, and new methods for presentation and visualization have been proposed (see, for example, Carver, 1979, 1987, 1990; Dalland, 1984; Lucas, 2001; Roskams, 2001; Chadwick, 2003; Lucas, 2005). On balance, however, the basic *modus operandi* for the construction and presentation of Harris Matrices has changed very little in the intervening forty years. For the most part they remain constructed by hand and presented in the form of complex schematics, detailing the relationships between individual stratigraphic units, making them difficult to read and comprehend without an intimate knowledge of the sequences they depict, rooted in the excavation itself; Çatalhöyük is no exception here.

Phasing of the site is therefore an inferred process done essentially in the mind of the principal interpreter of the stratigraphy. It is an interpretative negotiation, but which units belong to which phase is a matter of reasoning on the part of the archaeological '*stratigrapher*'. Conventionally it is something that can always be illustrated by good phased drawings, but these do not necessarily illustrate the cognitive process from which they are derived and, moreover, only provide a grouped snapshot of temporal observations about the sequence and the material culture it yields.

One of the principal aims of this investigation has been to explore whether digital technologies (specifically the project's adoption of GIS to handle the vast amount of spatial data produced by an excavation on this scale) can harness the complex relational data stored within the site's Harris Matrices to help move beyond conventional approaches to phasing at Çatalhöyük. The project seeks to visualize a more integrated, open and dynamic temporality, driven at an atomized resolution by the relationships between individual stratigraphic units. The aim has been to move beyond static, phased drawings and abstracted stratigraphic matrices, towards an integrated spatiotemporal model, thus exposing temporal inference to a wider audience for critique and debate.

Building 77

Building 77 is a large burnt structure (approximately 5 × 7 m) situated in the North Area of Çatalhöyük (House & Yeomans, 2008; House, 2010, 2014; Eddisford, 2011; Tung, 2012, 2013) (Figures 1–4).

The structure was selected for this study for a number of reasons:

- Building 77 is an unusually large and ornate example of a house at Çatalhöyük. The scale of the building, including the large timbers used in its construction, combined with the outstanding art work, including ten to twelve hand prints forming a freeze around the tops of the walls (Figure 5), as well as other geometric designs on lower layers of plaster and the presence of ornate room furniture such as an *in situ* horned platform in the north eastern corner and a painted bucranium on the north wall (Figure 6), set it apart as a 'special' structure. Ordinarily, buildings at Çatalhöyük may contain one or two of these artistic and architectural components, but rarely all of them. Nevertheless it retains many of the features that might be expected from a more 'normal' structure on the site, such as storage spaces and bins to the west, platforms with complex burial sequences to the north and east, niches, and an oven sequence and various architectural furniture, such as engaged pillars and niches around the walls (Hodder & Farid, 2014: 26–27). Building 77, therefore, presents an opportunity to study a large corpus of material and architectural data, on a 'special' building, at the same time making a good comparison for other structures at the site.

In addition to this the structure was burnt at the end of its 'use-life'. While by no means unheard of at Çatalhöyük, this mode of building closure remains relatively uncommon (see discussion in Hodder & Farid, 2014: 17–18). Inevitably there are related questions about the intentionality of the fire that marked the end of its lifespan (and the sudden deposition of a

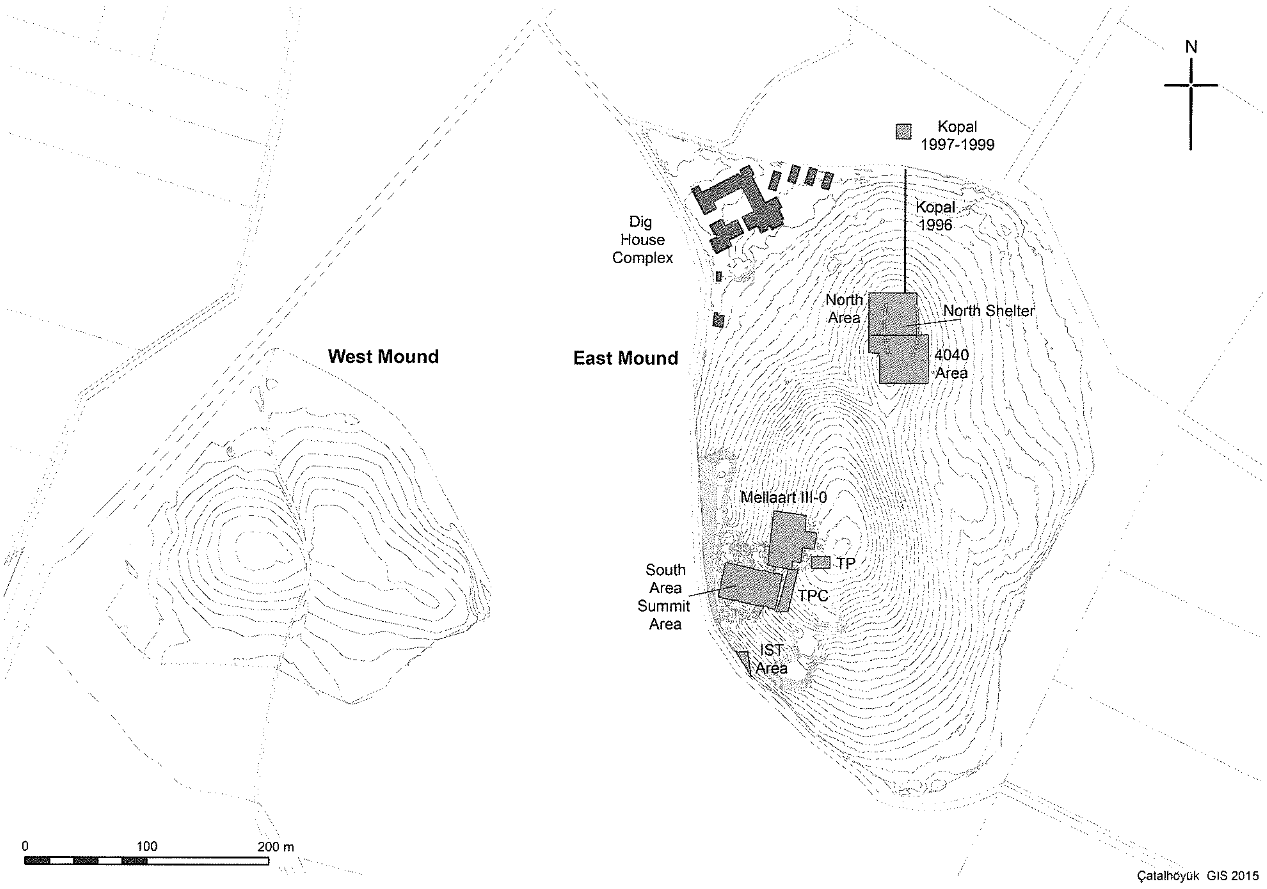
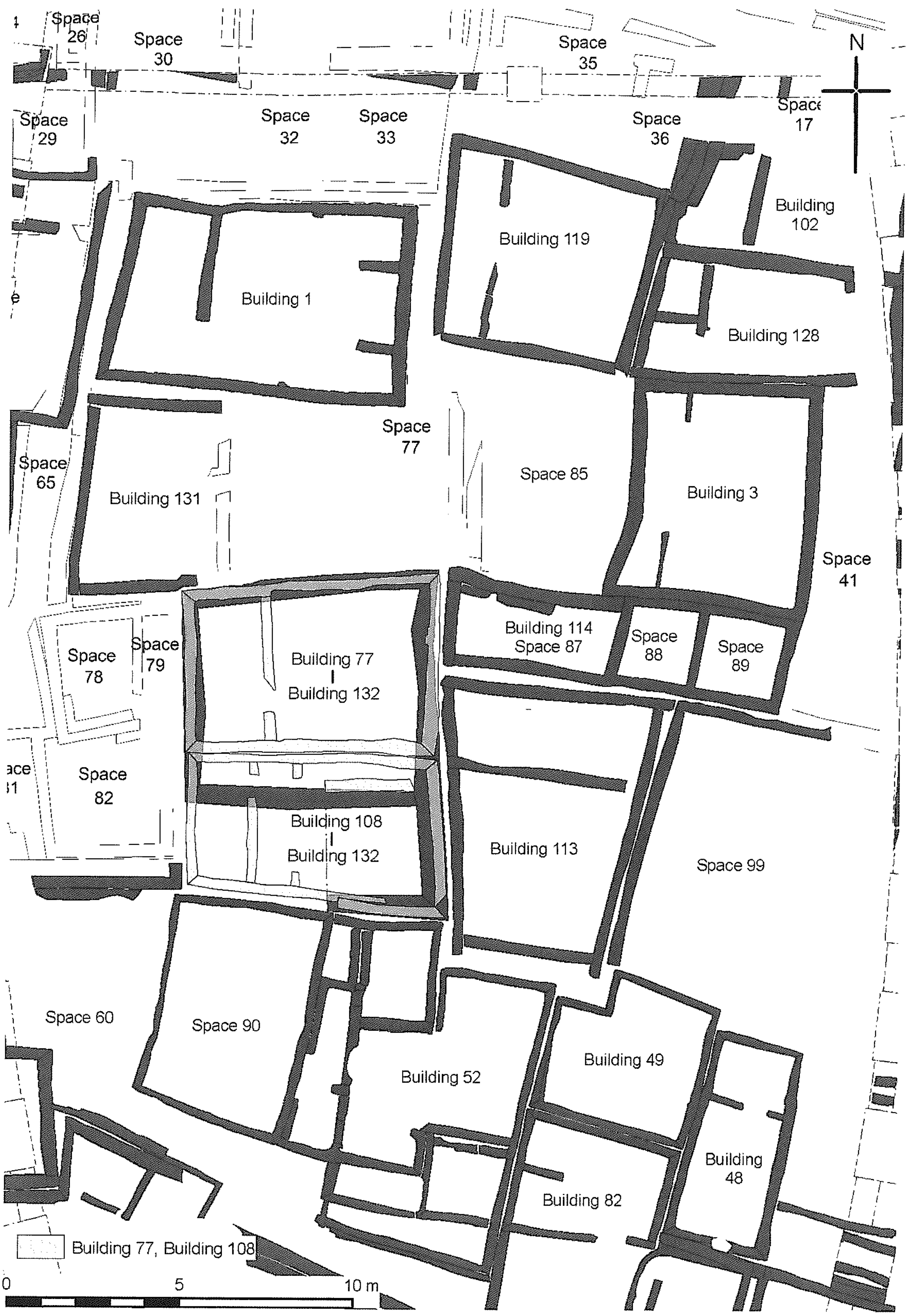


Figure 1. *Çatalhöyük site plan, showing the areas of study.*
Figure created for the Çatalhöyük Research Project by Camilla Mazzucato.

wide variety of material culture that appeared prior to this event). There has been some debate over the years regarding the intentionality of 'structural burning' on the site (Mellaart, 1966; Cessford & Near, 2005; Tringham, 2005: 105; Twiss et al., 2008; Stevanović, 2012; Hodder & Farid, 2014: 17–18). In the case of Building 77 the physical evidence as to whether the setting of the fire at the point of closure was a deliberate act (and therefore by implication a potentially ritual act), or whether it was accidental remains ambiguous (Harrison, 2008; Harrison et al., 2013). Burnt structures at Çatalhöyük often display unusual patterns of deposition of material culture close to the final point of closure, and have considerable potential for extraordinary preservation of organic remains not usually found elsewhere on the site (Hodder & Farid, 2014: 17–18). Building 77 is no exception and the unusual levels of preservation extend not just to the material culture found within the structure, but also to the furniture and fixtures of the building itself (such as the bucranium and horned platforms). Rich, *in situ* assemblages of faunal, obsidian, and ground stone were apparently placed on the floors and in bins at some point prior to the inflagration (Figure 7), and many of the fragile bins themselves and storage structures survived to waste height (Figure 8).

Given the unusual nature of these depositional events, it seems likely that the placement of these assemblages was a deliberate act, or 'staged performance' (as opposed to an accident, or 'Pompeii moment'). Either way the motives for their presence in the structure at the time of burning do not impede the method and analysis set out below. Combined with the survival of organic material culture, the structure provides a good example of a complete assemblage of artefacts and ecofacts for a study that is fully contextualized within the stratigraphic sequence of the building.

- Related to this, Building 77 was of further interest because of the long and particularly rich and complex burial sequence that was present in the structure, containing over twenty individuals (again with unusually high preservation of basketry and grave inclusions). The combined preservation, complexity, and abundance of these burials has provided a further uniquely tangible link between the ancient occupants of the structure (or at least those chosen for burial in the structure), the material associated



Çatalhöyük GIS 2014

Figure 2. *B.77 situated within the North Area at Çatalhöyük.*
Figure created for the Çatalhöyük Research Project by Camilla Mazzucato.

with them and the sequence of deposition (representing the life cycle of the building). This effectively 'ticks all the boxes' required for the study of complex spatiotemporal questions relating to the social organization and identity of the structure and its occupants.

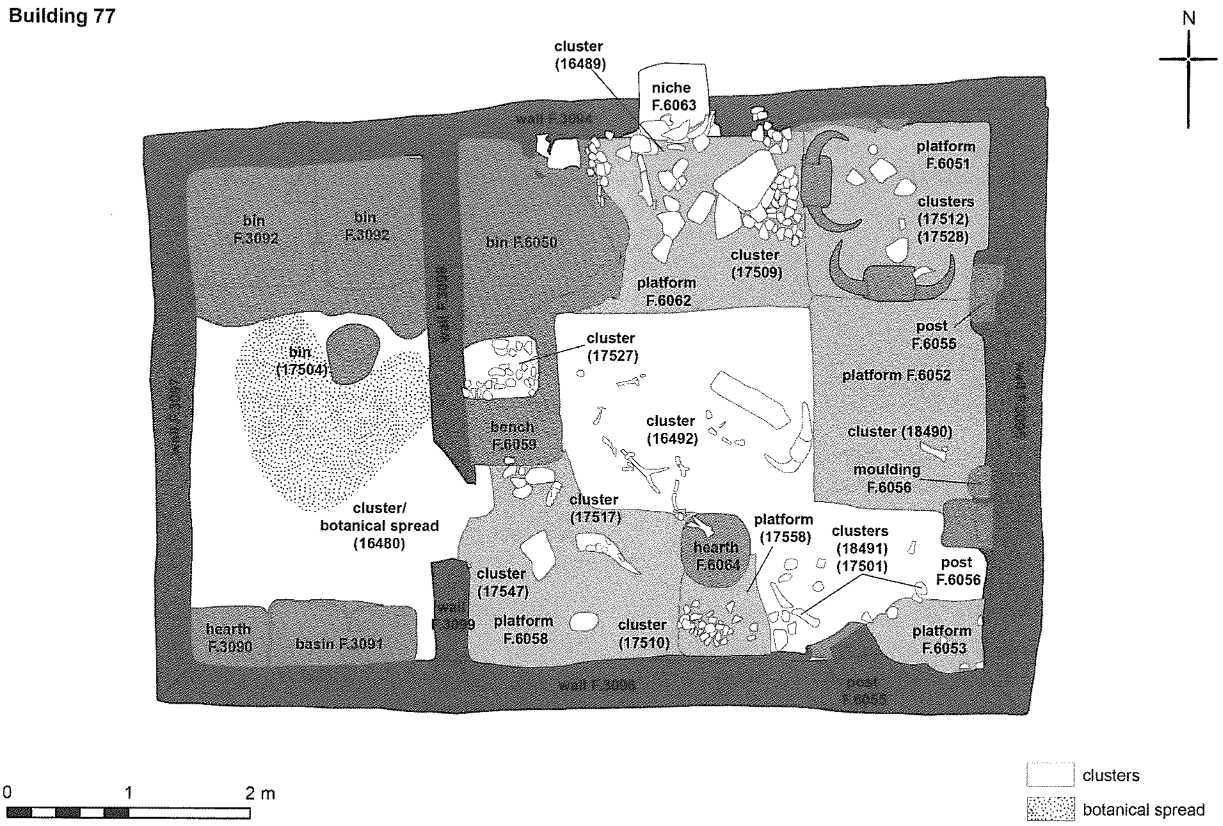


Figure 3. Plan of B.77 in its final phase, showing the bins and architecture as well as some of the rich artefact assemblages deposited prior to its final destruction by fire.
Figure created for the Çatalhöyük Research Project by Camilla Mazzucato.

- Finally, on a practical level the structure has been under excavation for five full seasons and excavation was finally completed in the 2014 field season. It is currently just entering its post-excavation phase, which means that active collaboration with all the specialists is easy to facilitate during the season, since all team members are assembled on-site and can potentially be working on material from the building. With so much material available to study, beyond the contributors listed in this paper, in the long term this collaboration will involve representatives from every key specialty present within the project.

Research objectives of the 'Up In Flames' collaboration

Early coordination of the collaborators has meant that the team has been able to focus on integrating

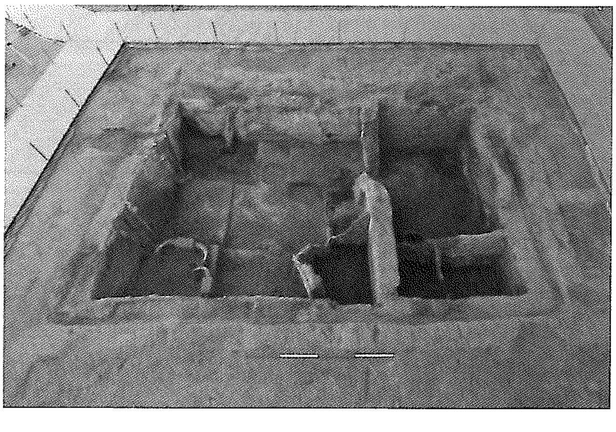


Figure 4. Overview of B.77 (south facing photograph).
Photograph by Jason Quinlan.

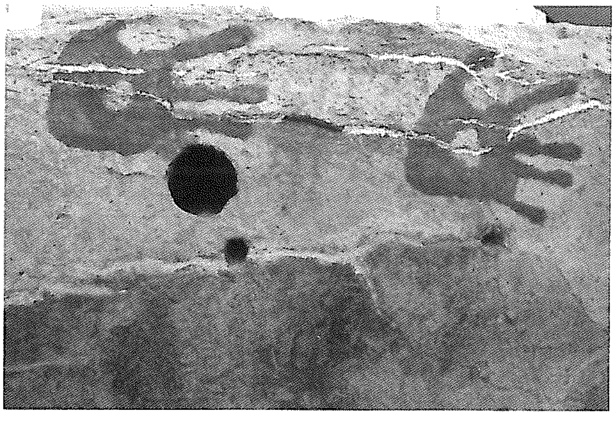


Figure 5. Ochre hand prints on the north wall of B.77 (north facing photograph).
Photograph courtesy of Çatalhöyük Research Project.

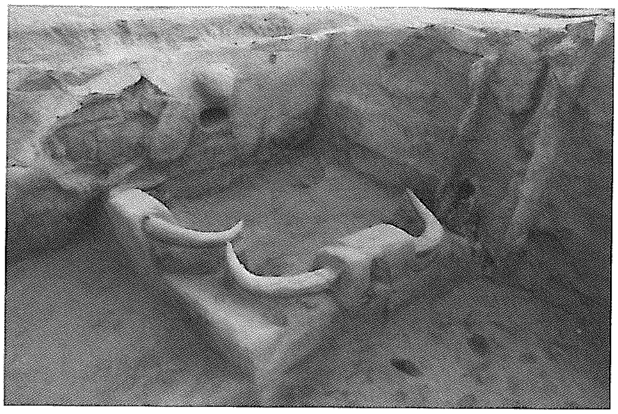


Figure 6. *Bucrania and horned bench associated with the northeast platform of B.77 (northeast facing photograph).*
Photograph by Jason Quinlan.

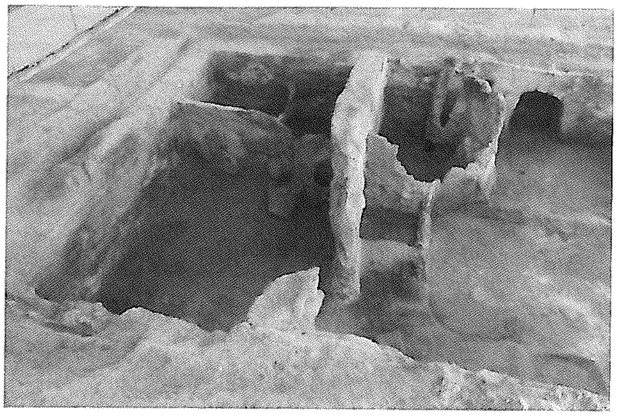


Figure 8. *Well-preserved bin structures surviving to the east of B.77 (north facing photograph).*
Photograph by Jason Quinlan.

all aspects of the data at an early stage in the post-excavation process and develop a series of more complex research questions for the subsequent analysis of this specific structure. These extend beyond the broader research agendas that guide and structure the excavation strategy of the Çatalhöyük Research Project. The focus here is upon a shift in the approach towards a more integrated form of post-excavation analysis, rooted in multi-disciplinary spatiotemporal study of as many aspects of the available data as is possible from as early a stage as possible in the research endeavour, centred upon the key repositories for spatiotemporal excavation data: the intra-site GIS and Harris Matrices. By working towards the development of a transparent, recursive, and integrated synthesis of stratigraphic records and material remains from the very outset of the post-excavation process, it is hoped that the project will be an example of how a temporally enabled intra-site GIS can inform the interpretative process and underpin the development of narratives that are constructed about the building.

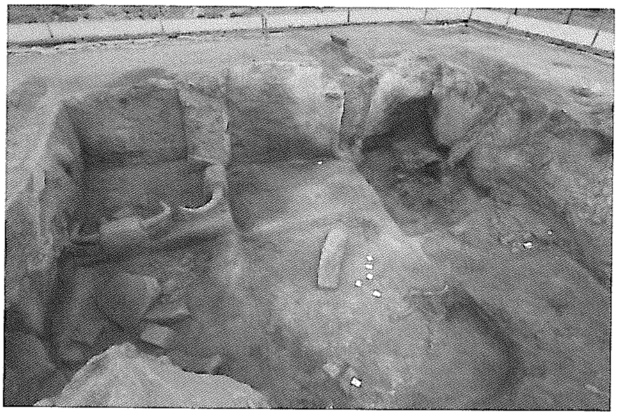


Figure 7. In situ *clusters of 'bone and stone' on the latest burnt floors of B.77 (southwest facing photograph).*
Photograph by Jason Quinlan.

The project's overarching aim was to establish whether it is possible to develop an effective way of coding time, using the existing chronological framework based upon the excavation data (i.e. the stratigraphic matrix), that can be integrated with, and used to 'temporally enable' the spatial data in the intra-site GIS with the written observations and interpretations of the material culture and stratigraphic sequence stored in the project's suite of databases.

As such the broad objectives of this collaboration set out…

- …to examine the way in which stratigraphic analysis of Çatalhöyük can be modified to develop a more nuanced understanding of the site's temporality.
- …to construct a spatiotemporally integrated definition of the stratigraphic unit that can be used as the building block for a functional spatiotemporal model of the site, and to use this definition to develop a method of extracting a functional temporal dataset from the data subset chosen from the case study.
- …to design and implement a data structure that will hold this 'new' temporal data and integrate it into the existing spatial dataset using an 'off-the-shelf' commercial GIS package, as part of the existing intra-site GIS

After some initial tests on the viability of this approach, undertaken as a case study for a complementary PhD project that has developed the method (Taylor, in preparation), the whole collaborative team met and began to set out some broader research questions to which this spatiotemporally enabled intra-site GIS might to help to visualize the answers. These were a series of complex spatiotemporal questions about the building sequence, its lifecycle, and its ancient occupants, as given below:

- How does the distribution of the material culture vary through the lifecycle of the building, particularly when compared to events just prior to building closure?

- How do various assemblages compare throughout their distribution across the lifecycle of the building? For example, where does the material culture come from, is it always imported, and is it worked/processed on or off site, all the time?
- What is the relationship between technology and symbolism in these various material culture classes?
- Are there clear links between the architectural development and the material culture included in the building?

Crucially, the potential remains to design and visualize other multidisciplinary spatiotemporal questions as more material is studied, more data become available and analysis continues upon the structure. All of these questions feed into a bigger picture that ultimately tries to address one key question:

- Can we use this integrated spatiotemporal analytical method to identify a distinct social identity for the occupants/users of this house?

Towards a 'visual narrative'

The Çatalhöyük Research Project has long sought to experiment with the production of narrative styles as shown in the literature produced by the current team. One such interesting approach employed to date has been Cessford's: 'Overall Discussion of Buildings 1 & 5' (Cessford, 2007: 531–49), which draws upon a growing disciplinary trend towards a highly synthetic biographical narrative style for the presentation of excavation data (see for example Praetzellis, 1998; Yamin, 1998, 2001; King, 2006; Finch, 2008). Cessford's piece is a narrative overview, in the biographic style, of the development sequence of these two sequential buildings (excavated in the North Area of the site), designed to complement and enhance the more conventional technical stratigraphic summary (which can often be stylistically dry and repetitive). His overview synthesizes the main excavation phasing of the buildings by discussing the structures at the 'feature-grouped' level, alongside the associated material culture and inhumations.[1] Cessford's narrative, therefore, seeks to eliminate technical 'clutter' of the stratigraphic summary (references to specific stratigraphic units, as well as abbreviated space and phase acronyms and numbers, finds numbers, burial numbers, etc.), which tends to dominate conventional archaeological literature. This style generates a more clear, more engaging style of prose, which is still rooted in the observations and records of those who dug the structures. It can therefore be seen as complementary to more technical elements of archaeological report writing.

Elsewhere within the corpus of literature about Çatalhöyük, moves towards a more biographical approach to narrative are in reality contextualized syntheses of multiple datasets framed within a type of prose based on fairly conventional stratified structural development of the area under study (Matthews, 2005a, 2005b; Twiss et al., 2008). While these types of synthesis make an interesting narrative, they are generally pitched at an academic audience in possession of some understanding of site depositional processes and wider techniques of describing archaeological stratigraphy, often reading as fairly clinical objectifications of the structures they describe.

One of the interesting ideas mooted as a possible goal of the Building 77 collaboration is the exploration of the potential for the temporally enabled intra-site GIS to serve as an illustrative tool to enrich more conventional synthetic narratives. If so, then is it possible to generate a specific output that might serve to act as a tool for a literal visualization of the narrative of a building: a 'visual narrative'.

Can the GIS's inherent ability to integrate data be harnessed to draw together disparate evidence and data in a manner that is easier to conceive cognitively? Can the complex spatiotemporal questions asked by this study serve to underpin the final narrative structure of the building, or even give brand new insights to the multilayered interpretation of the site? Perhaps it might also be possible to utilize it as a tool to collate various types of interpretation (illustrations, narrative vignettes, etc.) within a carefully modelled framework based upon the correlation and analysis of the core data of the excavation which could either be output as bespoke animation, or perhaps even embedded within the GIS itself.

METHODOLOGY

The dataset

All the more recent archaeological interventions at Çatalhöyük (since the 1990s) have been excavated using a strict single context recording methodology, whereby the archaeological sequence is excavated stratigraphically, and atomized into its separate depositional and truncation 'units' (Cessford & Farid, 2007: 13–17). From its conception the Çatalhöyük Research Project has always embraced the application of computing technology as a means by which to store, analyse, and visualize its data (Hodder, 2000: 7). Within the data structure of the project all observations and

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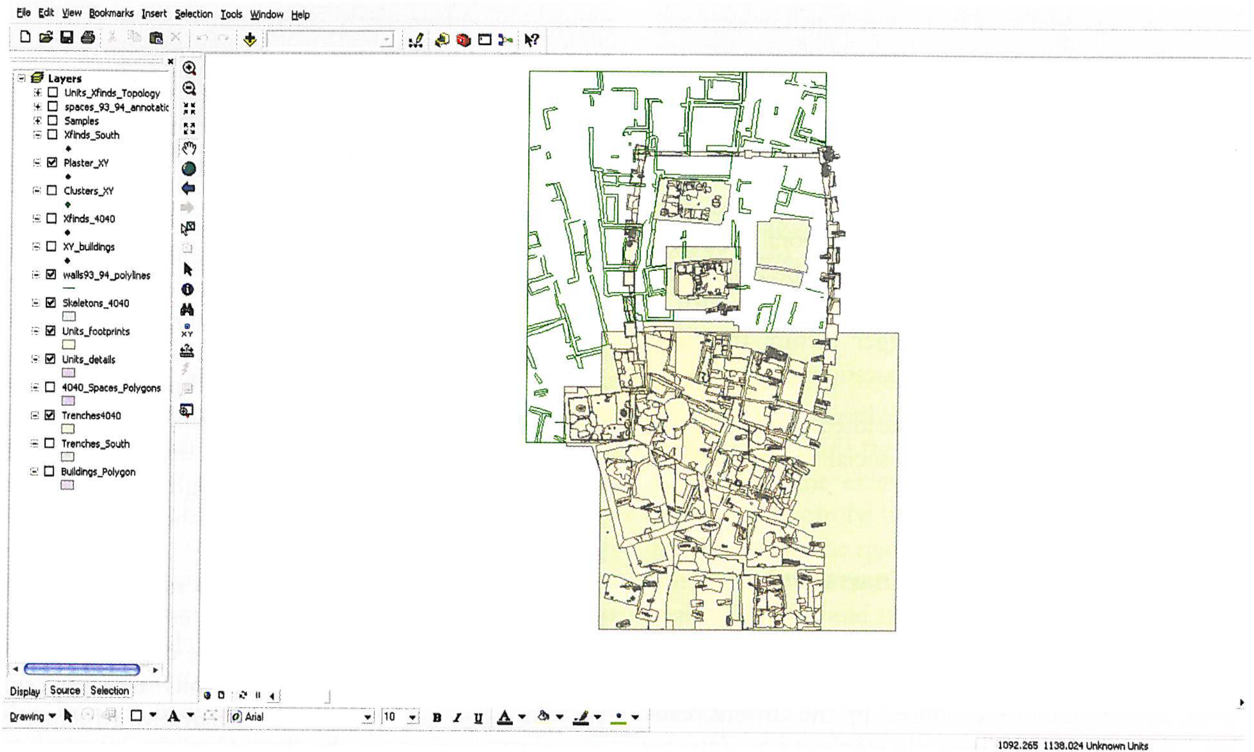
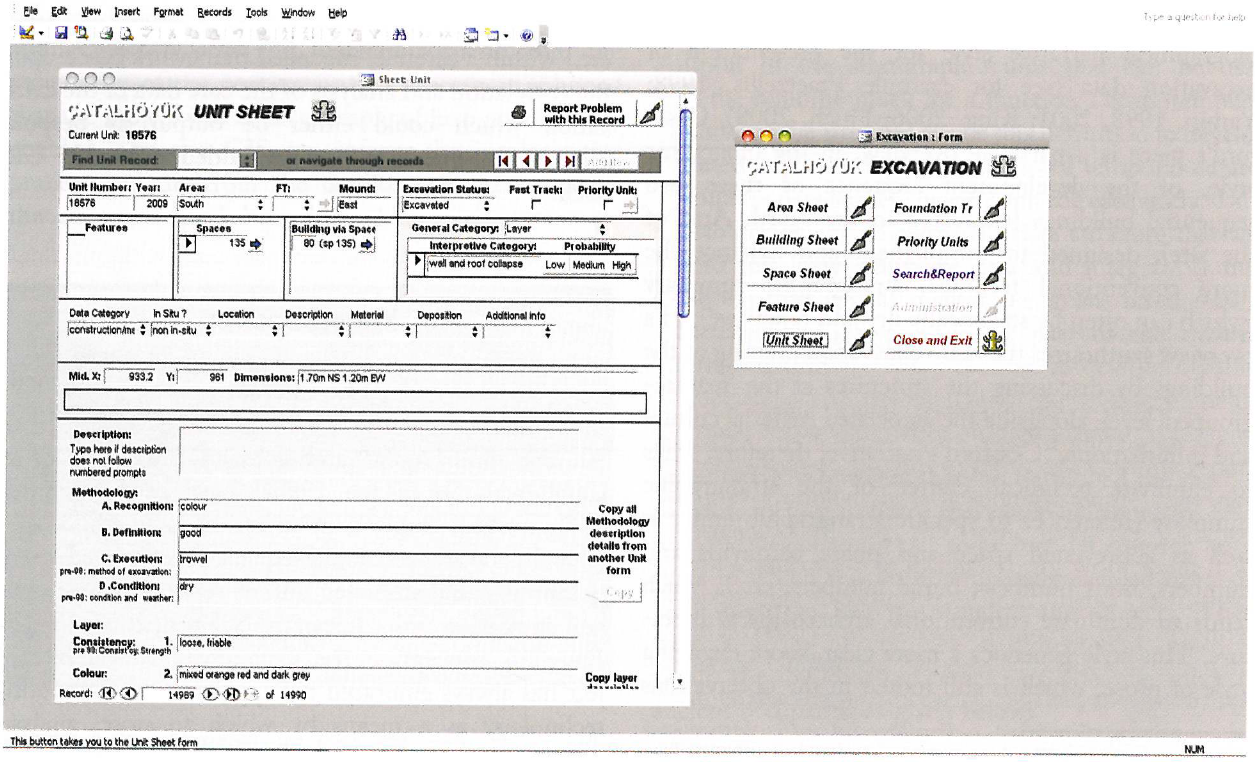
[1] 'Features' at Çatalhöyük are a meta-grouping of stratigraphy by structure, function, or spatial relation; such as for example: a pit and fills, an oven, or platform structure (Cessford and Farid, 2007: 17).

interpretations about the material components of the site are stored in a complex bespoke SQL database, constructed in Microsoft Access. This database links the excavators' written records via the unique stratigraphic 'unit number' to all other data about the site, including related specialist databases that hold information about all the samples and material culture yielded by the excavations (Figure 9).



Intra-site GIS (ArcGIS 10)

Excavation Database (Microsoft Access)



Current Unit: 18576

Unit Number: 18576 Year: 2009 Area: South FT: Mound: East

Excavation Status: Excavated Fast Track: ☐ Priority Unit: ☐

Features

Spaces: 135

Building via Space: 80 (sp 135)

General Category: Layer

Interpretive Category: wall and roof collapse Probability: Low Medium High

Data Category: construction/m In Situ ?: non in-situ Location: Description: Material: Deposition: Additional info:

Mid. X: 933.2 Y: 961 Dimensions: 1.70m NS 1.20m EW

Description:
Type here if description does not follow numbered prompts

Methodology:
A. Recognition: colour
B. Definition: good
C. Execution: pre-98: method of excavation: trowel
D. Condition: pre-98: condition and weather: dry

Layer:
Consistency: pre 98: Consist'cy: Strength 1. loose, friable
Colour: 2. mixed orange red and dark grey

Record: 14989 of 14990

Figure 9. Çatalhöyük Research Project database and intra-site GIS.

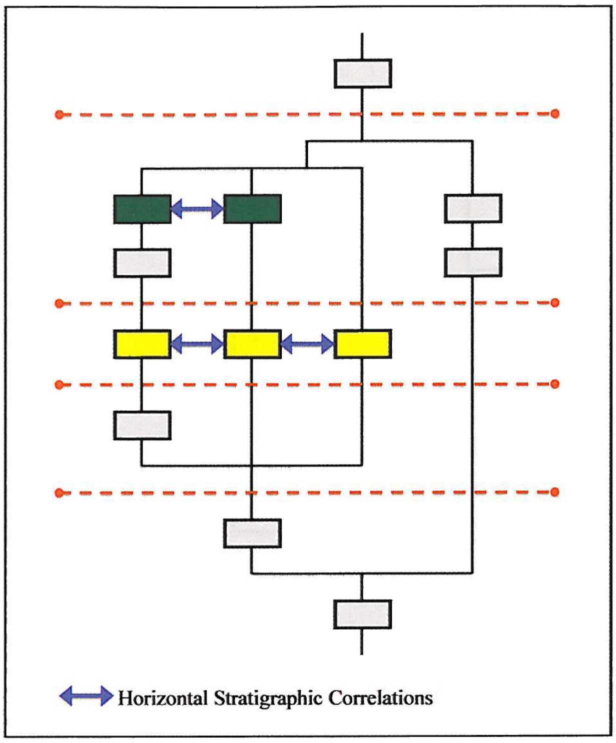


Figure 10. *Schematic matrix with phase lines (red) and stratigraphic correlations (blue).*

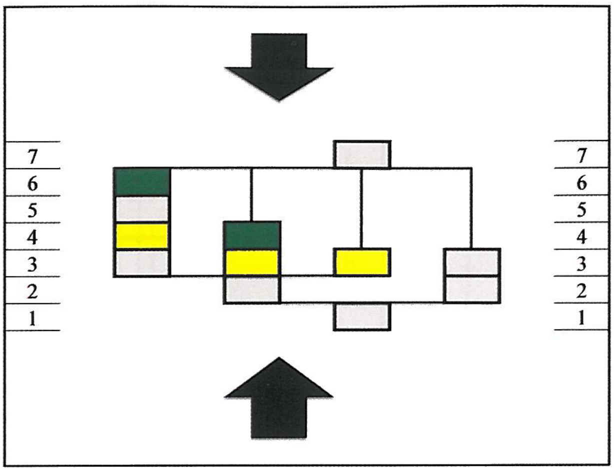


Figure 11. *Step 1—Vertical compression of the matrix.*

Similarly, this mode of excavation has generated a rich and complex spatial dataset. Since 2009 the spatial data have been digitized and integrated with the rest of the excavation and specialist site data using an intra-site GIS, structured in ArcGIS 10.2. Currently, almost all of the graphic archive is digitized and integrated within this system, and the last few seasons have seen a methodological shift towards the complete digitization of the site, with the introduction of new tablet-based and 3D recording methodologies in the field.

As such the project's digital data can essentially be divided into a *material component* (the site excavation database and specialist databases), and a *spatial component* stored within the intra-site GIS. However, because the project uses a single context recording system there is an obvious third *temporal component* to the data: the stratigraphic sequence. Harris Matrices are used as a tool for organizing the relational stratigraphic relationships between archaeological depositional events and truncations. As such they serve as the raw data for the core temporal model.

Inferring temporality from the Harris Matrix

In order to animate the spatial sequence in ArcGIS, the conventional Harris Matrix was used as a relative chronological resource. This methodology draws upon

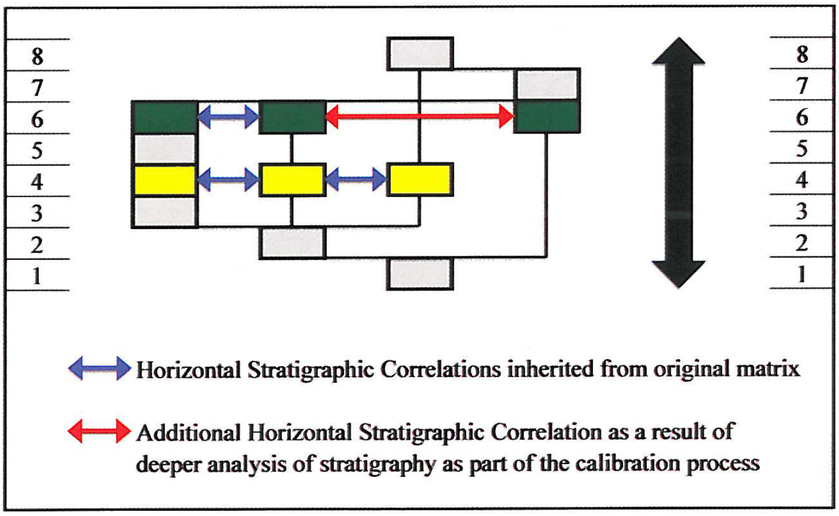


Figure 12. *Step 2—Calibration of the matrix by stratigraphic correlation.*

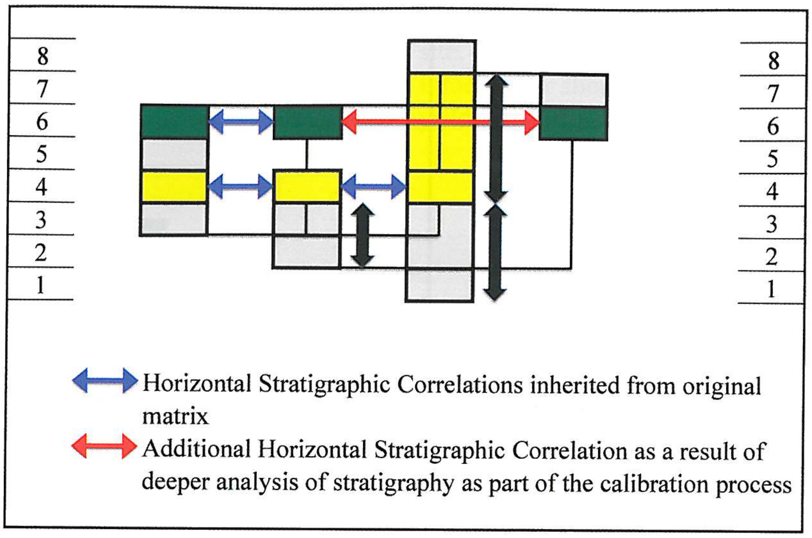


Figure 13. *Step 3—Final stratigraphic parse to establish unit lifespan.*

analytical approaches towards the manipulation of matrices proposed by Lucas (2001, 2005), rooted in his critique of their lack of structured temporality at the unit level. Like Carver (1990: 97) before him, he notes the Harris Matrix, as a diagrammatic representation of the stratigraphic sequence, presents no 'sense [...] of the duration or longevity of a unit, not only in terms of its formation, but also in terms of its post-formation "use"' (Lucas, 2001: 161). Drawing upon Harris' recognition that the 'Harris Matrix can be lengthened, shortened, or otherwise re-ordered to give some indication of duration of deposits and interfaces' (Brown & Harris, 1993: 19), Lucas suggests as a solution a supplementary chart which shows longevity of the stratigraphic unit, based upon the 'structured temporality of the matrix to produce a relative measure, which could be calibrated – much as one calibrates a traditional phase matrix' (Lucas, 2001: 162). The method involves deriving basic 'time-zones' from the number of 'steps' in the matrix. He proposed that each unit that has an inception within a given 'time-zone' is reviewed to 'isolate the

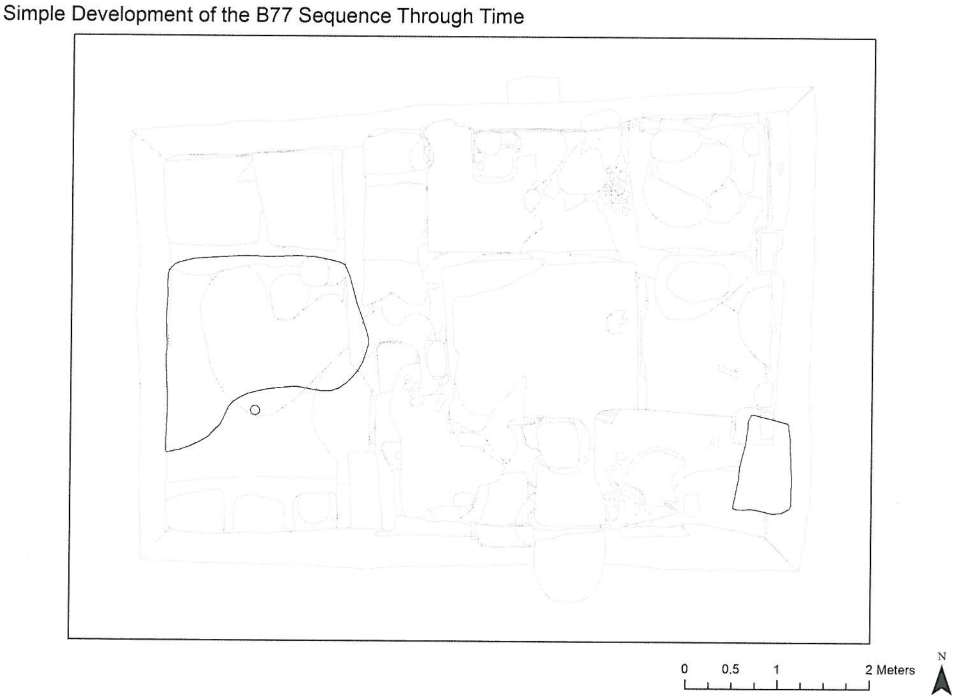


Figure 14a. *Animation 1—Basic sequence of animation stills visualizing the B.77 depositional sequence.*

Figure 14b. *Sequential frames of basic animated visualisation of B.77 depositional sequence (sequence runs from left to right).*

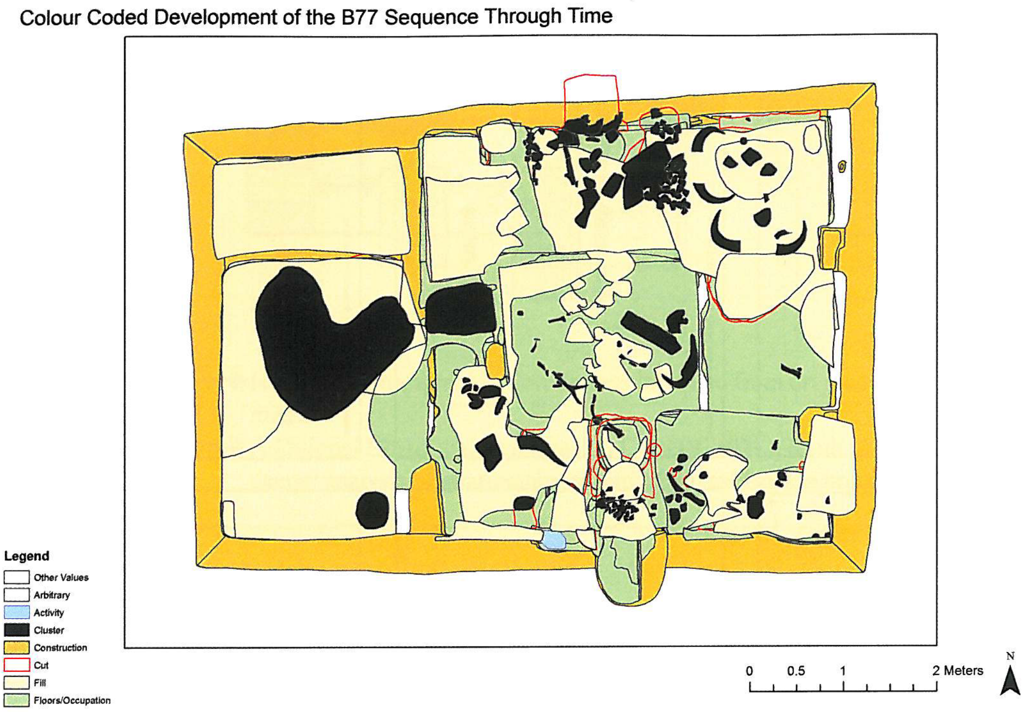


Figure 15a. *Single still from the animation sequence visualizing the B.77 sequence and symbolized with basic depositional classification.*

latest point at which it could still function' (Lucas, 2001: 162–5).

Chadwick (2003) draws upon this proposed method of presenting a deeper unit temporality by suggesting that the matrix might be used as an 'interpretative tool or hermeneutic device', perhaps displaying the 'reworking caused by geochemical changes, plant and animal disturbance and human activities' (Chadwick, 2003: 109–110). Chadwick argues that such '*hermeneutic matrices*' are a 'dynamic, self critical and interpretative process' (Chadwick, 2003: 110), and that this interpretation is closely linked to the excavator, as a *stratigrapher*. These approaches are related to other concepts of representing stratigraphic temporality, such as land use diagrams (Hurst et al., 1984; Steane, 1993). However, they differ, and are more useful to this study, because of their explicit requirement for setting the matrix on a grid, based upon the total number of 'steps' or stratigraphic events in the matrix.

The method used in this study adopts this concept as its basis for quantifying the relative temporality of the stratigraphic sequence, and is illustrated in the following sequence of schematic matrices (see Figures 10–13), which use a hypothetical matrix as an example. The original matrix in this sequence of methodological steps is organized by phase (red lines), and any horizontal correlations are represented as coloured unit boxes (grouped by blue arrows)—these are essentially the 'same as…' or 'identical to…' relationships that may be observed within the stratigraphic sequence.

The process of collating temporal data is largely one of the inferred analyses and reorganization of the matrix of based upon the following steps:

Step 1: Vertical compression of the matrix

The stratigraphic matrix for the sequence is compressed vertically and placed upon a 'temporal grid'. This process involves the removal of all the vertical lines within the matrix so that the stratigraphic events stack on top of each other in order of sequence. The total number of stacked stratigraphic units forms a critical line which represents the minimum number of possible events in this permutation of the sequence (in this example, seven events, see Figure 11). The compressed matrix can now be set onto a 'temporal grid', and the number at which the stratigraphic unit is set can be allocated as an arbitrary relative temporal value for that unit. It is important to note that in this first parse of the stratigraphic data, the correlations are now broken and situated at different temporal levels (again see Figure 11).

Step 2: Calibration of the matrix by stratigraphic correlation

Next, the matrix is calibrated by extrusion across the grid according to the observed and functional

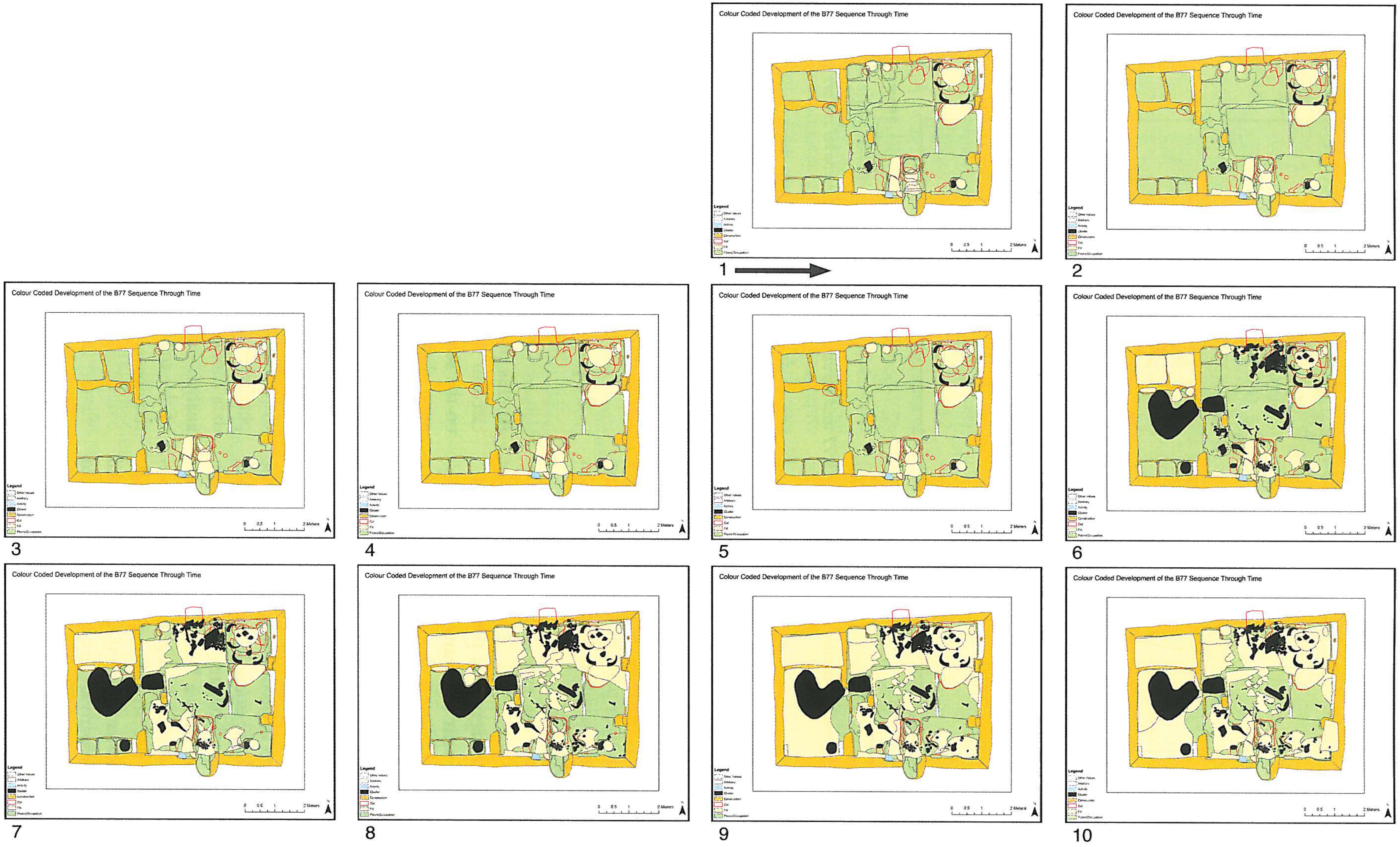


Figure 15b. *Animation 2—Sequence of animation stills visualizing the B.77 sequence symbolized with basic depositional classifications (sequence runs from left to right).*

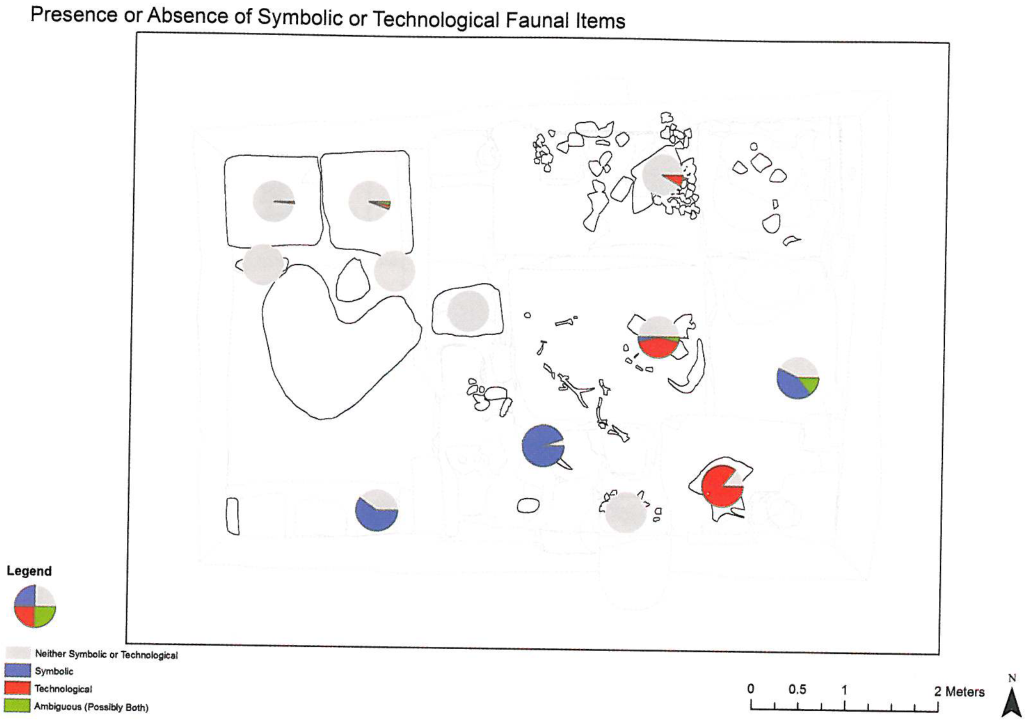


Figure 16a. *Single still from animation sequence visualizing B.77 and showing the integration of material culture types.*

'horizontal correlations' in the stratigraphy. The correlates are re-aligned so that they appear 'in phase' again on the temporal grid. The addition of a third green unit in the example in Figure 12, represents the fact that as the data are analysed, new correlations are often identified with each parse of the data (resulting in this example in the addition of an eighth value in the overall temporal grid).

Step 3: Final stratigraphic parse to establish unit lifespan

Finally, the data are parsed again with special attention being paid to both the *stratigraphic* and *physical* relationships between stratigraphic units in order to determine a potential relative lifespan across which the unit could have functioned (Figure 13).

If all units are seen as processes that take some time to form, then a wall, for example, may potentially take longer to construct and remain in use for a considerably longer timespan than a burial cut remains open. Of course, there is a considerable degree of interpretative inference in the act of defining which units have longer and shorter lifespans. As such individual stratigraphic unit lifespans are not yet fully represented in this case study since their construction requires further analytical work upon the Harris matrix. Their inclusion in the final study, however, would ultimately help to clarify issues of contemporaneity and residuality within stratigraphic sequences. Relative unit lifespans within the sequence would allow for the consideration of which stratigraphic units function alongside others, and for how long.

Step 4: Tabulation of relative stratigraphic temporal data

At this point a working temporal 'value' can be allocated to these stratigraphic units, as a *TPQ* and *TAQ* on the start and end points of the unit lifespan, based upon their final position upon the underlying grid. These values can easily be tabulated based upon their position on the underlying temporal grid. This tabulated temporal data can be easily appended to the pre-existing spatial data using ArcGIS 10's in-built temporal functionality, for animation and integration with the other digital datasets. The resulting temporally enabled data are an integrated spatiotemporal data model that allows a more nuanced and dynamic analysis and visualization of the inherent temporality of the complex stratigraphic sequences represented by the houses at Çatalhöyük.

Preliminary outputs

The outputs presented in this section are all groups of stills from animations of the spatiotemporal sequence

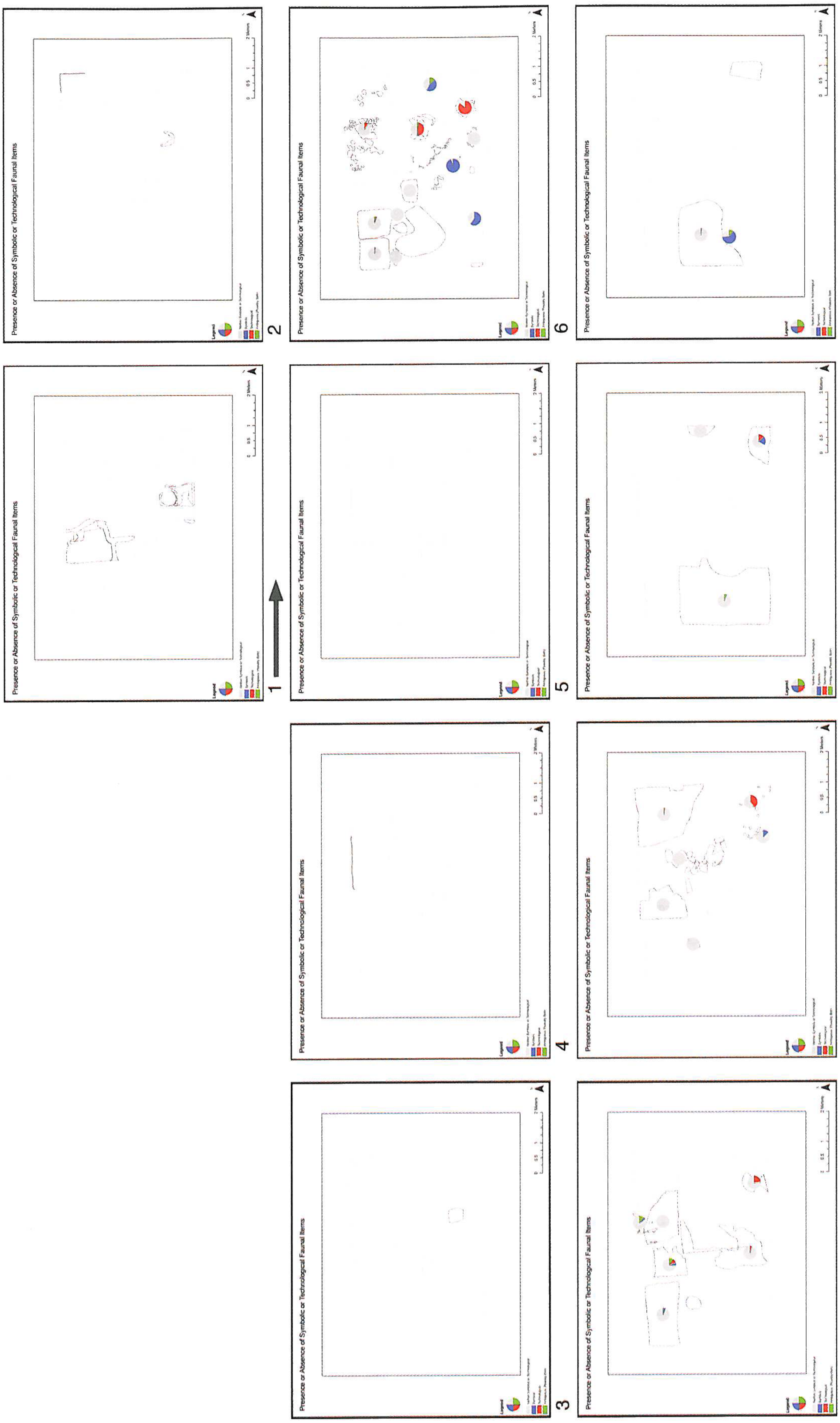


Figure 16b. *Animation 3—Sequence of animation stills visualizing B.77 and showing the integration of material culture types (sequence runs from left to right).*

of Building 77. All of the spatiotemporal data produced and visualized by this project are stored in ArcGIS 10.2.[2] The temporal functionality of this software facilitates the production of animated sequences, since when a map is temporally enabled in the software's preferences, by assigning some unit of temporality (such as date, or in this case stratigraphic temporal event), a time slider appears which enables the user to dynamically move through a sequence of entities which have some temporal value.[3] All of the following animation excerpts are presented for the purposes of this publication as sequences of frames; one example frame is presented in a larger format to demonstrate the detail of the frames. For ease of comparison, the diagrams all show the last ten frames of the Building 77 sequence, which happens to be when most of the depositional activity takes place prior to the burning of the structure.

Animation 1: Basic visualization of Building 77 depositional sequence

This first animation represents the most basic output of the temporally enabled data: a straightforward visualization of the building depositional sequence. The full animation of this sequence shows the depositional and truncation sequence of Building 77 built up through time, with each polygon representing one recorded stratigraphic 'unit' or 'context'. This output demonstrates that it is possible to code and tabulate a relative temporality for archaeological intra-site spatial data using the Harris Matrix as a source of raw data (Figure 14a and b).

Animation 2: Visualization of Building 77 sequence symbolized with basic depositional classification

The second example of these outputs contains no additional data to the first. Similarly, this second animated sequence displays no technical methods that could not be applied to a static a-temporal map within the GIS. However, the basic configuration of the intra-site GIS symbology, colour coding based upon the coarsest level of depositional attributes that are present within the data structure of that system, can immediately be seen to present a more complex picture of the same sequence. In this case,

- *Orange* polygons are *construction* events.
- *Green* polygons are *plaster* and *floors*.
- *Red outlined* polygons are *cuts*; and *Beige* their *fills*.
- *Black* polygons are *clusters* of *artefacts*.
- *Blue* polygons are *activities*.

This simple form of symbology coding presents a clearer, perhaps even more vivid picture of how the sequence works. This clearly demonstrated how even the most basic manipulation of standard symbology within the GIS can be used to lend emphasis or illustrate development throughout the stratigraphic sequence of any attribute stored in the GIS attribute tables. In this example it is possible to note that as the animation plays out (from around frame 6) there is a sudden burst of 'cluster' activity in the house just before the fire. Without any analytical consideration of the material culture itself it is possible to suggest that something 'different' or 'special' is going on here when compared with the rest of the life history of the building (Figure 15a and b).[4]

Animation 3: Visualization of Building 77 showing the integration of material culture types

This animation builds a little complexity into the spatiotemporal model by integrating another level of data with the temporally enabled spatial model of the first two animations. By joining a table of faunal data to the basic spatiotemporal model's attribute table, it is possible to demonstrate the full integration of the temporally enabled intra-site GIS not only to the project's main excavation database, but also to its specialist databases. This enables the full incorporation of other material culture into the spatiotemporal visualizations in order to build a much more complex and layered picture of the sequence as it develops.

In this case the animation shows the relative frequency of faunal ecofacts, which might be interpreted as either having a 'technological' or 'symbolic' purpose. These classifications are represented in pie charts (along with the proportion of things that could be seen as both, or cannot be classified as either) with the following visual coding:

- '*Technological*' (*red*) being tools (scapula and antler, etc.).
- '*Symbolic*' (*blue*) being items which are of limited technological value, with a tendency to be curated (aurochs horns and bird claws, etc.).
- Distinct artefacts that could be regarded as '*either technological or symbolic*' (*green*).
- Artefacts that cannot be regarded as any of the above (*grey; generally comprising indistinct or fragmentary bone*).

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[2] http://www.esri.com/software/arcgis.

[3] http://resources.arcgis.com/en/help/main/10.2/index.html#//005z0000000p000000 [accessed 09 January 2015].

[4] 'Clusters' at Çatalhöyük are a special interpretative class of stratigraphic unit which groups artefacts (often interpreted as placed deposits, perhaps with ritual connotations) that are associated in their deposition, but not necessarily with the deposit matrix that seals or contains them. Common examples include clusters of faunal remains and ground stone fragments (bone and stone), or obsidian caches (Cessford and Farid, 2007: 14).

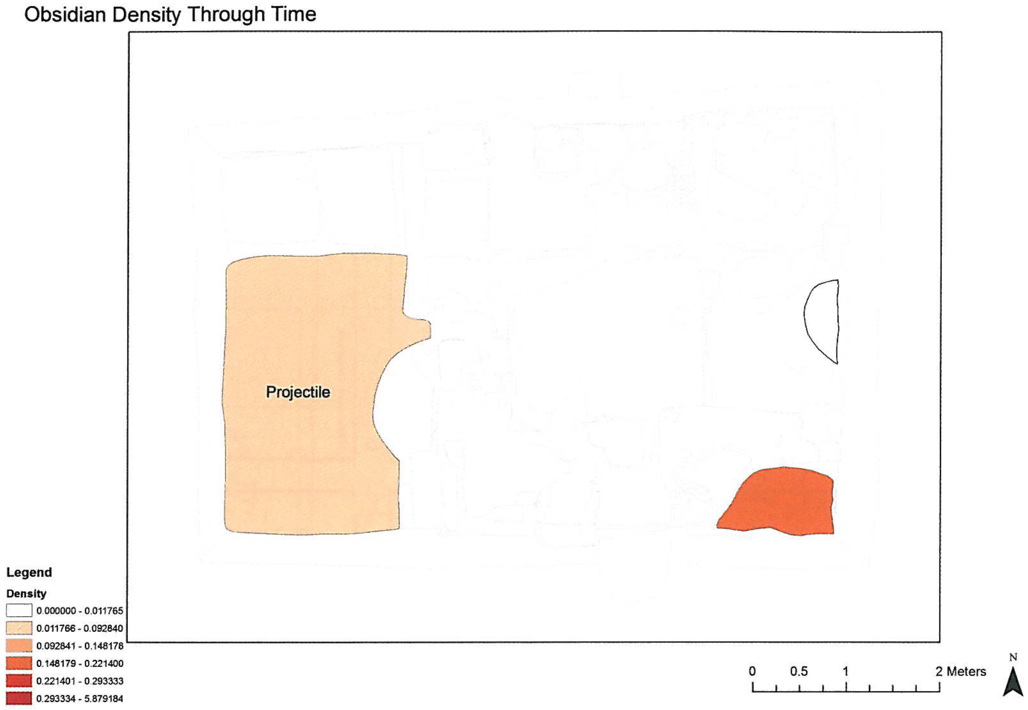

Figure 17a. *Single still from animation sequence visualizing B.77 and integrating preliminary statistical observations.*

Once again it is possible to note the 'explosion' of items that can be interpreted as symbolic towards the end of the sequence. This time, however, we have some indication of how this relates to the other classifications of similar material culture types that may have a different functional interpretation. Once again, the number of types of material and functional data that can be represented in this type of visualization is only limited by the data structure and classification protocols of the project (Figure 16a and b).

Animation 4: Visualization of Building 77 integrating preliminary statistical observations

The flexibility of the data structure and symbolization within this intra-site GIS means that there are no limitations on the type of data that can be visualized in these animations, provided that data can be tabulated and appended to the basic spatiotemporal dataset. The visualizations are not constrained to symbolizing simple categorical data, but can also show numerical and, potentially, the outputs of statistical analysis.

This version of the animation shows the simplest of data: density of obsidian distribution through the sequence (darker *orange* denotes *higher density*). Furthermore, in this example layers are also separately labelled to denote the presence of projectile points, highlighting the fact that any classes of material culture that might be of interest can be further layered into the visualization either as a label or icon.

The point is, however, that there is no constraint on the complexity of these visualizations provided the statistical work can be attributed to the basic stratigraphic unit within the intra-site GIS. The visualization of more complex statistical analysis of material culture, in particular, employing the temporal component of the data as a key variable, is one of the long-term goals of this collaboration (see conclusions below), and something which has been the subject of another case study (Figure 17a and b) (Taylor, in preparation).

Animation 5: Visualization of Building 77 demonstrating more complex integration of multiple datasets

The last animation in this series aims to highlight the way in which multiple datasets can be combined to build increasingly complex visualizations that can be targeted to focus upon specific research interests. This animation combines the archaeobotanical data (in *green*–again represented as density maps), with correlated information taken from the ground stone dataset, relating to the presence or absence of grinding tools, possibly used for the processing of cereals (these are shown in *blue* with the addition of a 'Y', for 'Yes', label to clarify when the two are present in the same polygon). The complexity of this kind of visualization is compound and layered. For example, an obvious next step here would be to look at the charcoal and timber evidence and look for correlations with the distribution of edge tools (i.e. axes, adzes, and chisels). Some care must be employed in the approach to symbolizing multiple datasets, as it is easy to clutter the

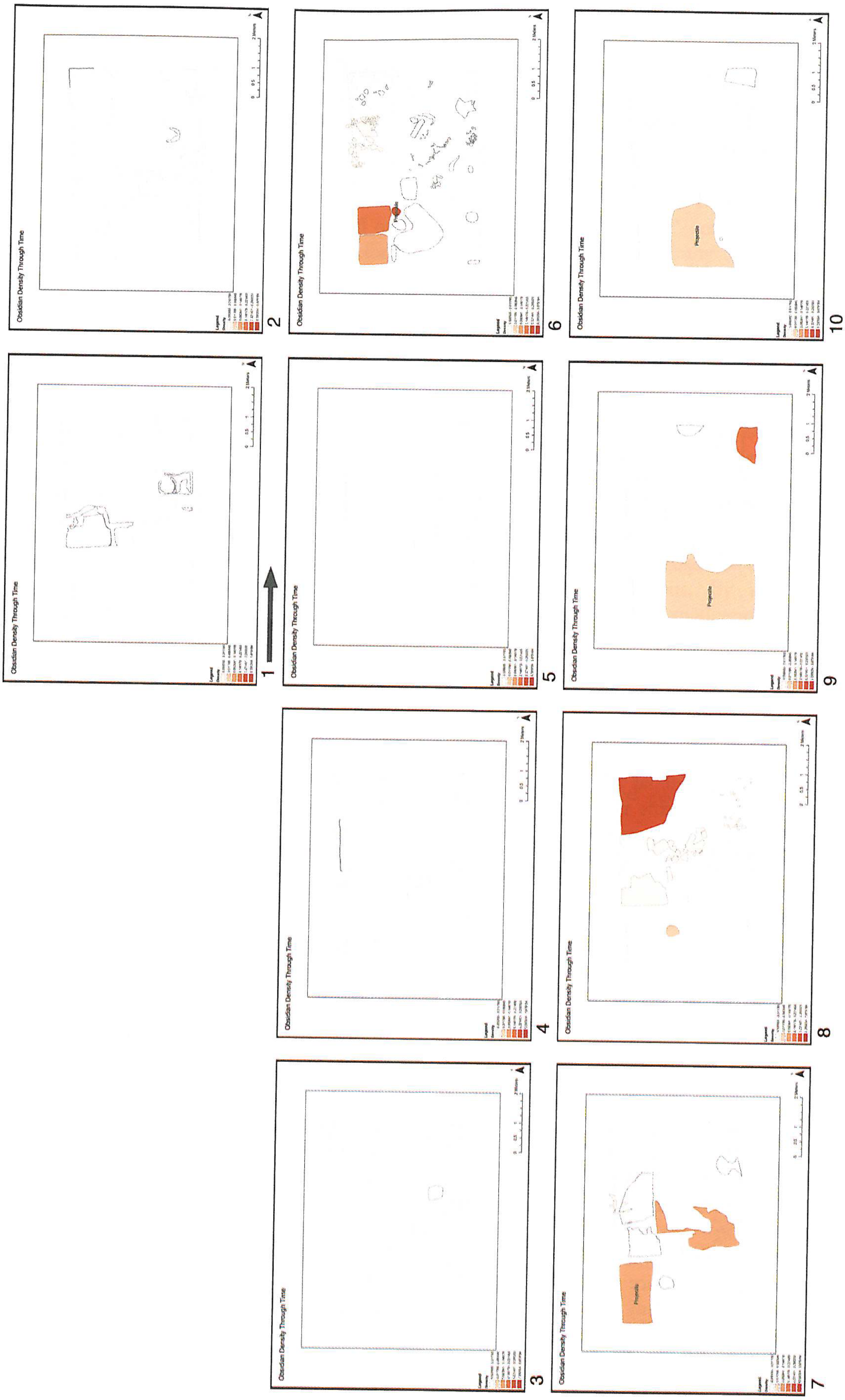

Figure 17b. *Animation 4—Sequence of animation stills visualizing B.77 and integrating preliminary statistical observations (sequence runs from left to right).*

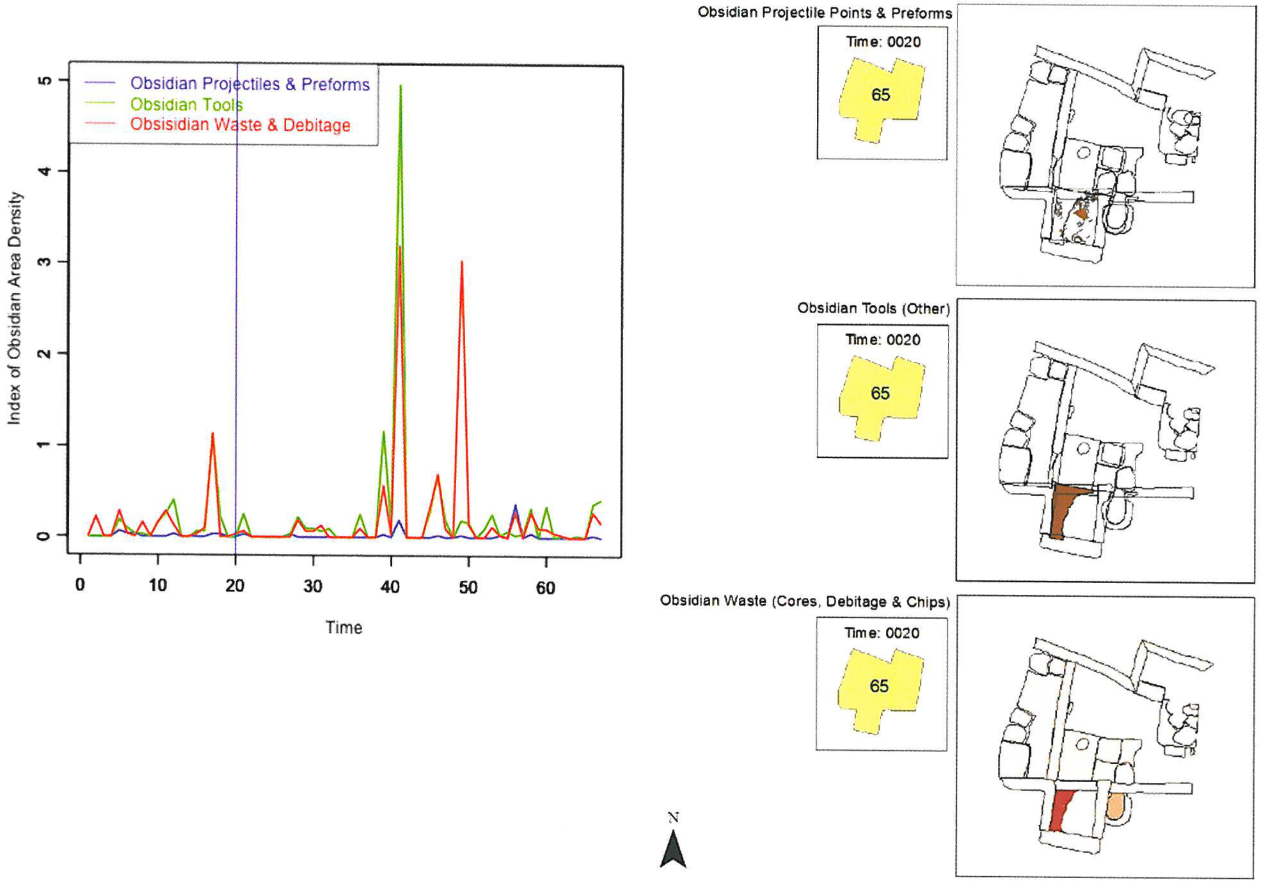

Figure 18. *Example of a frame from a previous case study animation (of the B.65 and B.56 sequences), which in this case shows the density of obsidian objects aligned adjacent to a graph of the same data.*

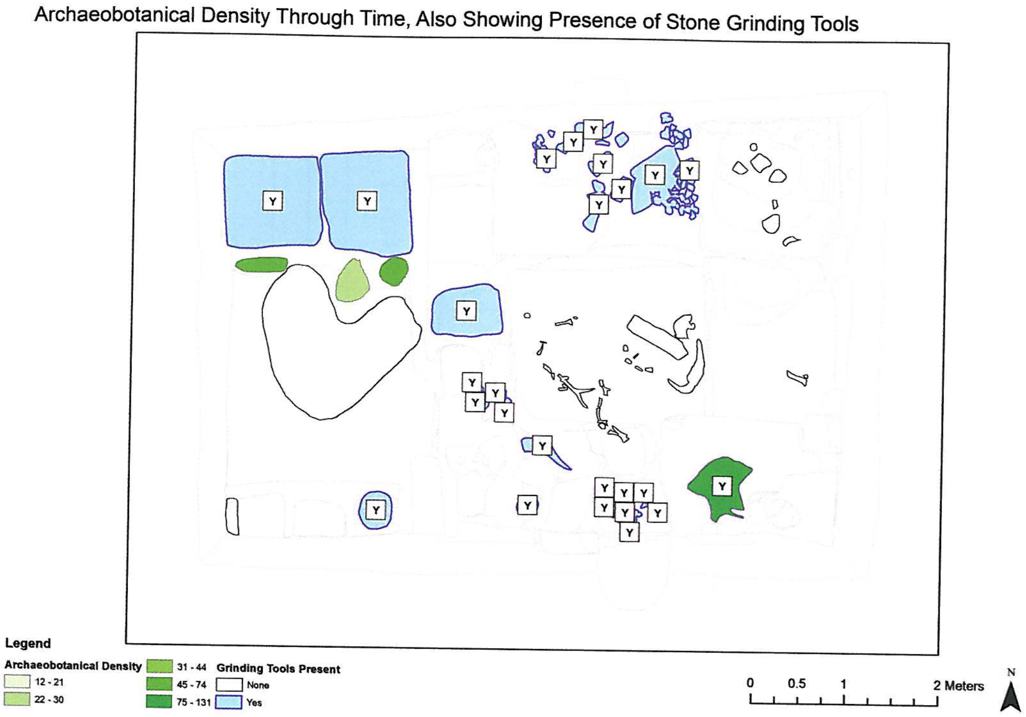

Figure 19a. *Single still from animation sequence visualizing B.77 and demonstrating a more complex integration of multiple datasets.*

visualizations. It is also possible to synchronize these more complex animations, however, and run them side-by-side (as demonstrated in Figure 18, taken from another case study: Taylor, in preparation). Nonetheless, it is important to note, that if the data are being manipulated and visualized at source, within the intra-site GIS, then it is of course possible to stop the animation and access the data behind any temporal frame by drilling down into the associated attribute tables (Figure 19a and b).

CONCLUSIONS

The main objectives of this project have been achieved even at this preliminary level. Methods of stratigraphic analysis can indeed 'be modified to develop a more nuanced understanding of the site's temporality', by using the atomized stratigraphic units as the building blocks for the spatiotemporal models presented. It has also been possible to 'design and implement a data structure that be integrated into the existing spatial dataset' using the 'off-the-shelf' commercial GIS package used to construct Çatalhöyük's intra-site GIS.

The Building 77 project itself remains a work in progress and so the outputs presented in this paper must be treated as preliminary results, requiring further analysis and development. Ultimately, the project aims to utilize many more of the structure's material culture in its final output (as listed in Table 1).

Nevertheless a cursory review of the integrated and animated data presented in this case study shows trends in the sequence of deposition, truncation, and distribution of material culture within the Building 77 sequence that can begin to be interpreted. One could even suggest that a 'story' or narrative is beginning to emerge. It is at least obvious that the general pattern of distribution of material culture within most of the lifecycle of this structure is relatively 'low-level', and perhaps might even be seen as 'background noise'; the pattern of distribution only gets 'exciting' just before the fire is set and when the animation stops, with the sudden deposition of large amounts of archaeobotanical remains, as well as ground stone and faunal material.

These results serve as to demonstrate that the visualization of temporally enabled stratigraphic data can contribute something to a wider understanding of archaeological depositional sequences, with the potential to underpin and illustrate rich multidisciplinary narratives about the depositional sequence and its relationship to the material culture it yields. There is considerable scope for the development and refinement of the methods outlined here to produce even more subtle and complex visualizations. The careful harvesting of the relative temporality stored within the raw stratigraphic datasets can, without doubt, be harnessed by the power of modern spatiotemporal software to provide more nuanced and dynamic alternatives to conventional site phasing.

Figure 19b. *Animation 5—Sequence of animation stills visualizing B.77 and demonstrating a more complex integration of multiple datasets (sequence runs from left to right).*

Table 1. *Table showing the datasets currently, and intended to be, incorporated into the final Building 77 project*

Material studied and considered to date	**Material studied for future integration**
Architecture	Art
Archaeobotanics	Chipped stone (Chert)
Chipped stone (Obsidian)	Ceramics
Faunal	Figurines
Ground stone	Lithic microwear analysis
Human remains	Pyrotechnic installations
	Timber

Further work

The Building 77 collaboration will continue throughout the final phases of the Çatalhöyük Research Project, working towards a full synthetic publication of the structure, and which capitalizes on the methods showcased in this preliminary paper. The goal is to create a series of complex bespoke animated spatiotemporal visualizations that will incorporate complete data from all of the material culture set found in Building 77. The aim is to move beyond simply describing, or representing the data as is, by finding ways to categorize and symbolize more complex products of the analysis of these datasets through time, and address wider more interpretative issues such as the relationship between the symbolic and technological, the domestic and ritual. These visualizations will form the basis for an exemplar suite of 'visual narratives' that tell the story of the lifecycle of the structure.

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