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MOHENJO-DARO'S SMALL PUBLIC STRUCTURES: HETERARCHY, COLLECTIVE ACTION, AND A RE-VISITATION OF OLD INTERPRETATIONS WITH GIS AND 3D MODELLING

Abstract

Together, the concepts of heterarchy and collective action offer potential explanations for how early state societies may have established high degrees of civic coordination and sophisticated craft industries in absence of exclusionary political strategies or dominant centralised political hierarchies. The Indus civilisation (c.2600-1900 B.C.) appears to have been heterarchical, which raises critical questions about how its infrastructure facilitated collective action. Digital re-visitation of early excavation reports provides a powerful means of re-examining the nuances of the resulting datasets and the old interpretations offered to explain them. In an early report on excavations at Mohenjo-daro, the Indus civilisation's largest city, Ernest Mackay described a pair of small non-residential structures at a major street intersection as a "hostel" and "office" for the "city fathers." In this article, Mackay's interpretation that these structures had a public orientation is tested using a geographical information systems approach (GIS) and 3D models derived from plans and descriptions in his report. In addition to supporting aspects of Mackay's interpretation, the resulting analysis indicates that Mohenjo-daro's architecture changed through time, increasingly favouring smaller houses and public structures. Close examination of these small public structures also suggests that they may have at times been part of a single complex.

Introduction

Digital re-visitation of early archaeological datasets, enhanced with improved theoretical frameworks, can reveal the broad range of socio-political configurations that emerged among the world's earliest cities and states. As this range increases, theoretical frameworks that question the explanatory weight of political centralisation and hierarchy are critical to the comparative study of early state societies (e.g. Yoffee 2016) The concepts of heterarchy, which describes social relations that were either unranked or had the potential to be ranked in different ways (Crumley 1995:3), and collective action, a political process that incorporated larger numbers of people into coordinated endeavours (Blanton and Fargher 2008), may help explain how civic coordination and sophisticated technologies emerged in absence of a dominant and exclusionary political hierarchy. The Indus civilisation (2600-1900 B.C.), home to the first cities in South Asia, appears to have been heterarchical, incorporating many interacting political entities (Kenoyer 1997a, 1998, 2006; Possehl 1998; Chakrabarti 2000; Vidale 2010; Wright 2010; Petrie 2013). It encompassed five cities and numerous smaller settlements, which were distributed throughout an extensive and diverse range of environments (Kenoyer 1997a; Possehl 1998; Wright 2010; Petrie 2013; Shinde 2016; Ratnagar 2016; Petrie et al. 2017). Alongside evidence of heterarchy, the Indus civilisation's assemblages include striking examples of civic coordination and lack direct evidence for the exclusionary political strategies typically associated with early state elites (Wright 2010, 2016). These characteristics make the Indus civilisation an ideal case study for investigating the means by which early heterarchies might have catalysed and sustained collective action.

In the early twentieth century, excavations at the Indus civilisation's largest sites produced foundational data and interpretations (e.g. Marshall 2004[1931]; Mackay 1938; Vats

1997[1940]). Though limited by early methodologies, the scale and scope of these projects has left an indelible mark on Indus scholarship. Mohenjo-daro is the largest and most extensively excavated Indus site. It was the first Indus city to be excavated on a large scale, with a seminal period of horizontal and vertical exposure occurring between 1924 and 1931 (Marshall 2004[1931]; Mackay 1938). These excavations revealed strong evidence of civic organisation and diverse forms of large-scale non-residential architecture. The city's large non-residential architecture has been subject to continuous re-investigation (e.g. Wheeler 1953; Verardi 1987; Verardi and Barba 2010), and its well-documented drainage system has contributed to scholarship on Indus planning and social differentiation (e.g. Jansen 1993a, 1993b; Wright 2010). Early excavations produced so much data that much of it went un-analysed until follow-up projects began re-examining field records (Jansen and Urban 1987; Jansen 1993b). An important article by Vidale (2010) demonstrated that Mohenjo-daro's architecture data can be re-analysed to distinguish forms and generate new interpretations. This article is informed by that approach. In the second report on large-scale excavations at Mohenjo-daro, Ernest Mackay described a pair of small non-residential structures at a major street intersection as an "office" (1938:76) and a "hostel" associated with the "city fathers" (1938:92). He applied these labels to the structures because their plans diverged from neighbouring courtyard-based residences that exemplified much of the site's architecture. This divergence, combined with their prominent location in the city's street plan, led to his suggestion that the small structures (located in Block 8A and Block 6A of Area DK-G South) played public roles. Such an interpretation has implications for debates regarding Indus socio-political organisation (e.g. Chakrabarti 2000; Kenoyer 2006; Wright 2010, 2016; Petrie 2013; Miller 2007a, 2007b, 2015; Singh 2008;

Coningham and Young 2015; Ratnagar 1991, 2016). It is therefore useful to ask: Was Mackay's interpretation correct?

Thanks to ongoing improvements in digital approaches (Conolly and Lake 2006; Snow 2006; Kintigh 2006; Greengrass and Hughes 2008; Morgan 2009) many early assertions can be re-examined in greater detail. As archaeological methodologies become more precise and research questions change, re-visiting and repurposing old datasets has become increasingly important (Snow 2006; Kintigh 2006; Cooper and Green 2015). GIS analysis is particularly useful for re-examining the spatial components of published data (Wheatley and Gillings 2003; Conolly and Lack 2006). Projecting vector data as comparable layers facilitates the visualization of variation through time and space. 3D modelling provides a complementary means of visualizing archaeological interpretations (Morgan 2009; Gonzalez-Tennant 2010; Rua and Alvito 2011; Forte 2014; Rabinowitz 2015; Roosevelt et al. 2015; Bruno et al. 2016). These approaches, which have contributed greatly to work in other archaeological contexts, have the potential to revitalize old datasets from the Indus civilisation. Technical descriptions of wall lengths, door locations, and other architectural details are easily re-created as 3D models. Assembling and analysing such models can yield new insights, raise new questions, and clarify old interpretations. In this article, Mackay's interpretation that the structures of Block 8A and Block 6A of Area DK-G South had public orientations is evaluated with a geographical information system (GIS) analysis of his own plans, and 3D models derived from his descriptions of the office and hostel's structural remains. The results strongly support aspects of Mackay's interpretation, suggesting that small public structures constituted an important component of Mohenjo-daro's heterarchical urban landscape.

Background

Political centralisation and hierarchy do not sufficiently account for the emergence of early cities and states. Though evidence of exclusionary elites and exploitative large-scale political entities clearly characterise some early state societies (e.g. Pollock 1999), a comparative perspective reveals many instances that are best explained using a broader range of theoretical concepts (Wright 2002; Trigger 2003; Yoffee 2005, 2016). Heterarchy, one such concept, characterises social relations that were either unranked or could have been ranked in different ways (Crumley 1995:3). While all societies evince some degree of heterarchy, some, such the clustered cities of the ancient Middle Niger in the first millennium B.C., incorporate so many "overlapping and competing agencies of resistance to centralisation" that they build heterarchy into the landscapes that support them (McIntosh 2005:187). Collective action, another important concept, is a political process that incorporates increasing numbers of people and communities into coordinated endeavours (Blanton and Fargher 2008). Though collective action may accompany political centralisation and hierarchy, these are not essential, and there are instances where horizontal bonds resulting from shared economic conditions prompt its emergence and elaboration (e.g. Saitta 2013). Together, the concepts of heterarchy and collective action can help explain how multiple groups competed and cooperated to create social cohesion without recourse to elite agency (DeMarrais 2013, 2016). Much research has focused on how early political hierarchies shape their built environment through large-scale architecture (e.g. Preziosi 1983; Trigger 1990; Smith 2003). What kinds of buildings, then, support collective action among early heterarchies?

A preliminary answer to this question may be found in the earliest interpretations of building plans from the Indus civilisation. Most Indus sites are located in today's India and Pakistan, where they are associated with diverse agro-pastoral economies that contributed to the emergence of cities (Wright 2010). Five of these sites have been described as cities (Fig. 1), and their widely-spaced distribution has contributed to the interpretation that they incorporated various politically independent entities that competed and cooperated with one another (Kenoyer 1997a, 1998; Possehl 1998; Wright 2010). Recent work at the site of Harappa in Pakistan's Punjab underscores this dynamic (Meadow and Kenoyer 1997, 2003; Kenoyer 2006). The Harappa Archaeological Research Project (HARP) documents the site's transformation into a thriving city with multiple "neighbourhoods" that were separated by walls with gateways, ramps, and guardrooms (Wright 2010:125). Neighbourhoods, each of which was likely surrounded by a wall, strongly impacted civic organisation (Meadow and Kenoyer 2003; Kenoyer 2006, 2012; Wright 2010, 2016). It should also be noted that Indus cities appear to have been politically diverse, as is evident from recent work at the city of Dholavira in India's Gujarat. While Dholavira lacks the neighbourhoods of Harappa, its assemblage includes many Indus technologies, such as drainage systems, stamp seals, and weights (Bisht 1997, 1999, 2005). Rakhigarhi is currently under investigation, but appears to share many characteristics with other Indus cities (Nath 1998, 1999, 2001; see also Shinde 2016).

Investigations at Mohenjo-daro have been nearly continuous since the early excavations (Marshall 2004[1931]; Mackay 1938), and have produced striking examples of large scale architecture, civic organisation and planning, and early craft industries (Jansen 1993a, 1993b; Tosi et al. 1998; Vidale and Balista 1988; Ardeleanu-Jansen 1993; Franke-Vogt 1993; Menon 2008; Kenoyer 1992, 1997b; Vidale 2000). Like Harappa, Mohenjo-daro appears to manifest

subdivisions in organisation, with different "palaces," or large residences, appearing in separate parts of the city (Vidale 2010:59-60). These characteristics support the interpretation that while much material culture was shared between cities, the Indus civilisation was strongly heterarchical (Kenoyer 2006, Possehl 1998; Wright 2010). Indus cities may have themselves been to some degree independent polities (Kenoyer 1997a, 1998; Chakrabarti 2000; Wright 2010). Petrie (2013:11) has described this form of urban organisation as "polycentric," shaped by complex interactions between multiple groups that were generally equivalent to one another.

Heterarchy in the Indus civilisation co-existed with remarkable examples of coordination and standardization. In addition to Mohenjo-daro's street plans and drainage networks (Jansen 1993a), Indus agricultural production likely involved institutions that operated across kin or community boundaries (H. Miller 2015), and Indus craft industries coordinated activity among many different specialists (Wright 1991, 2010, 2016; K. Bhan, Kenoyer, and Vidale 1994; Kenoyer 1998a; Vidale 2000; H. Miller 2007a, 2007b, 2008; Menon 2008). A common system of stone weights has been recovered from many Indus sites, suggesting strong adherence to a single system (H. Miller 2013). Stamp seals and sealings provided a tool for interaction that served the needs of culturally diverse groups across regional boundaries (Frenez and Tosi 2005). Like other Indus technologies, seal production appears to have been carried out by multiple groups of producers (Rissman 1989; Franke-Vogt 1991, 1992; Kenoyer and Meadow 2010; Jamison 2013, in press), or "communities of practice" (Green 2015, 2016:2), who none-the-less produced a highly-conventionalized assemblage that was in use across social boundaries. Indus heterarchical groups, which likely took a diversity of forms, also appear to have engaged in significant collective action, reaching across social boundaries to jointly undertake profound and coordinated social endeavours (Wright 2016).

Some have argued that Indus coordination and standardization are evidence of a powerful and conservative centralized political entity (e.g. Piggott 1950; Wheeler 1953, 1966, 1968; D. Miller 1985; Lal 1993; Dhavalikar 1995, 2002). These views are often at odds with the significant variations in regional technologies, subsistence strategies, and material cultures (e.g. Mughal 1971, 1997; S. Bhan 1975; Possehl 1980, 1997; Shaffer and Jacobson 1987; Possehl and Herman 1990; Shinde 1992, 2016; Meadow and Kenoyer 2001; Ajithprasad and Sonawane 2011; Ameri 2013; Rizvi 2013; Chase et al. 2014; Shinde, Raczek, and Possehl 2014; Petrie et. al 2017). The degree to which Indus cities were integrated into larger forms of polity remains an important research question, as the impact of institutions and technologies that spanned social boundaries was profound (see Ratnagar 2016). At the same time, it is unlikely that Harappa's prevailing political form was exactly replicated in all Indus cities. It is therefore useful to examine potential interfaces between heterarchical groups, such as the small public structures at Mohenjo-daro proposed by Mackay, and consider how they may have supported collective action.

Defining Public Structures

Mackay (1938) does not explicitly define "public," but his use of the term does not diverge greatly from its applications in contemporary approaches to space in other archaeological contexts (e.g. Steadman 2015). Understanding how people transform public space, that which is open and accessible to the largest number of people in a social context, into private space, that which lies behind increasing numbers of thresholds that restrict access to a select number of inhabitants, lies at the core of a long running debate about the social aspects of spatial data,

especially architectural and settlement plans (e.g. Rapoport 1969, 1977, 1990; Hillier and Hanson 1984; Kent 1987, 1990a; Lawrence 1990; Steadman 2015). In brief, roads and streets generally constitute public spaces; they provide networks of circulation for relatively large numbers of people, facilitating and constraining movement from the threshold of one location to the next. People make buildings by constructing architectural forms so that they transform and order space (Hillier and Hanson 1984:1). Their permeability, a characteristic generated by external and internal thresholds like doors, can transform space along a public to private continuum. A complete formal assessment of variation in permeability using spatial syntax techniques (e.g. Hillier and Hanson 1984; Bafna 2003; Steadman 2015) would require the digitisation of a full range of architectural plans from Indus cities. This is a worthy goal, but is beyond the scope of this article, which instead makes more general use of the concept, suggesting simply that permeable buildings are those that are open and accessible relative to other structures. Public buildings, then, are those characterized by their proximity to quintessentially public space, roads and streets, and their high levels of permeability. The permeability of public buildings distinguishes their plans from residences. Variation in plan was the first dimension of variability Mackay (1938:76, 92) noted with respect to the public structures examined in this article.

While there has been a great deal of archaeological interest in using architectural data to investigate houses and households, buildings that define an irreducible economic and social entity (e.g. Wilk and Netting 1984; Samson 1990; Kent 1990b; Blanton 1994; Veenhof 1996; Robertson et al. 2006; Parker and Foster 2012; Steadman 2015) a comparable discussion of public structures is considerably less developed (Seibert 2006). Moreover, while large-scale monumental architecture (e.g. Trigger 1990) and palaces (e.g. Preziosi 1983; Vidale 2010) have

attracted much scholarly attention, comparatively smaller structures have slipped out of focus. Notable exceptions from other archaeological contexts include research on the different kinds of state facilities constructed by early polities in Peru (e.g. Jennings and Álvarez 2001), houses from Habuba Kabira that do not appear to have fulfilled residential roles (Kohlmeyer 1996), the non-palatial governing complex at Tizatlan (Fargher et al. 2011), and the public range structure at Minahá (Seibert 2006:107). Seibert (2006:110-111) wrote that certain classes of architectural features, such as benches that could support aggregations of people at the interface of a building and a public space, denote the public role of certain structures. The Indus civilisation, with its apparent instances of public architectural features that are neither monumental nor domestic, greatly contributes to these potentially corrective datasets.

Given their appearance in a variety of comparable contexts, public structures are likely critical in all long-term trajectories of social change. However, their possible ubiquity raises an important question: what is the relationship between heterarchical social relations and the form taken by public structures? Hillier and Hanson (1984:21) wrote that a kind of duality characterizes urban life: "…the space of the street system, which is always the theatre of everyday life and transactions, and the space of the major public buildings and functions. The former creates a dense system, in which public space is defined by the buildings and their entrances; the latter a sparse system, in which space surrounds buildings with few entrances. The more global-to-local dimensions prevail, the more the town will be of the latter type, and vice versa." Given these expectations, relatively large public buildings with few entrances would constitute a sparse system associated with political hierarchy. Because heterarchy involves interaction between multiple groups, it should stimulate the construction of a denser system: smaller structures that are close to one another, proximal to streets, with many entrances.

Previous Investigations at Mohenjo-daro

Mohenjo-daro is located in Pakistan's Sindh (Marshall 2004[1931]:1), a region that was home to many Indus sites that engaged in specialised production (Sher and Vidale 1985; Shaikh and Veesar 2001; Shaikh, Veesar, and Mallah 2003; Mallah 2008). Major excavations were carried out at the site between 1924 and 1965 (Marshall 2004[1931]; Mackay 1938; Wheeler 1953, 1966; Dales 1968; Dales and Kenoyer 1986). Early excavators divided it into "Areas" that were designated by the initials of the archaeologist who conducted the initial excavations (Marshall 2004[1931). Areas were subdivided into "Blocks," extensive segments of related architectural remains, that were further subdivided into "Houses", segments of Blocks, and "Rooms," discrete locations within structures that remain in approximately the same two-dimensional location throughout the site's architectural sequence (Marshall 2004[1931].) Blocks were designated with Arabic numerals, houses by Roman numerals, and rooms by Arabic numerals. After excavations were suspended due to preservation concerns, surface investigations were conducted by the Aachen University Research Project Mohenjo-daro and the Istituto Italiano per il Medio ed Stremo Oriente Roma (Jansen and Urban 1984, 1987; Pracchia, Tosi, and Vidale 1985; Vidale 1986; Vidale and Balista 1988; Jansen and Tosi 1988a; Jansen 1984, 1993a, 1993b; Franke-Vogt 1993; Ardeleanu-Jansen 1993).

The site of Mohenjo-daro (Fig. 2) encompasses over 100 hectares (Jansen 1993a, 1993b), and it may have had a population as high as 40,000 (Wright 2010:107-110). Surface investigations revealed that craft activities were dispersed throughout the site (Tosi et al 1984; Kenoyer 1984; Pracchia, Tosi, and Vidale 1985; Pracchia 1987; Vidale and Balista 1988; Vidale

1989, 2000). While other Indus settlements relied on a variety of water sources (e.g. Wright, Bryson, and Schuldenrein 2008; Giosan et al. 2012; Petrie 2017; Petrie et al. 2017), Mohenjo-daro may have relied directly on the Indus river, which has since shifted its course (Flam 1993, 2011:34, 2013; Jansen 1999). Its location therefore necessitated architecture that could cope with floods and instability (Wright 2010:34).

Mohenjo-daro's structures were made of baked and unbaked bricks that were assembled using sophisticated bonding techniques (Marshall 2004[1931]; Mackay 1938). It was built atop a "complex puzzle" of platforms (Jansen 1993b:269), which likely resulted from rapid and planned foundation episodes (Jansen 1978; Cucarzi 1984, 1985, 1987). Its streets ran approximately north/south, intersected by lanes that ran approximately east/west (Marshall 2004[1931]). Street orientations may have conformed to astronomical phenomena (Wankze 1984; Kenoyer 1998), and the city's plan survived centuries of occupation, which suggests the presence of an impactful civic authority (Marshal 2004[1931]). An extensive network of wells, drains, and bathrooms provided water (Jansen 1989, 1993a), and privacy, which may have fostered new forms of identity (Rizvi 2011). Maintaining this network probably required community-level decision-making (Wright 2010:242). Large non-residential structures such as the "Pillared Hall" and "Great Bath" were found on the western-most "Stupa Mound," named for a structure that was likely erected on the site long after abandonment (Marshall 2004[1931:23-24]), though Verardi (1987) and Verardi and Barba (2010) suggests that it may have had a major Indus component. Many of the large non-residential structures had their own foundation platforms (Dales 1965; Wheeler 1953:37). There is wide agreement that these large structures fulfilled public roles (Fentress 1976; Ratnagar 1991; Kenoyer 1998; Possehl 2002; Smith 2006; Wright 2010; Ratnagar 2016; Shinde 2016). Vidale (2010:59-60) adds that these structural forms were not

unique to the Stupa Mound, and that smaller forms could be distinguished from the other structures throughout the site.

Hundreds of houses, multi-roomed structures with open courtyards, comprise the city's eastern mounds (Marshall 2004[1931]; Mackay 1938). These typically include hearths, craft areas, and multi-use spaces. John Marshall was so impressed by their quality that he began the site's first excavation report with a description of a large house in Area HR (Marshall 2004[1931]:17). Its walls were up to 1.5 meters thick, providing stability to neighbouring structures. It had a private entrance, bathroom, well, and staircases that suggest it had an upper story. Sarcina (1979) developed a typology for Mohenjo-daro's houses with five models defined by courtyards and their surrounding rooms. Wright (2010:244) wrote that such restrictions in house configuration may indicate that smaller-scale building activities were shaped by a civic authority.

Excavations at Mohenjo-daro occurred between 1922 and 1965 (Marshall 2004[1931]; Mackay 1938; Wheeler 1953, 1968; Dales 1965; Dales and Kenoyer 1986). The first excavation report established a relative chronology that included Early, Intermediate, and Late Periods. These Periods are internal to Mohenjo-daro, all three were likely encompassed within the Indus civilisation's Urban Phase (c. 2600-1900 B.C.). Each period included three relative phases (III through I from earliest to latest) (Marshall 2004[1931]). Structures were initially assigned a period based on architectural quality (Jansen 1993a, 1993b; Franke-Vogt 1993). Because this periodization was not based on sediment profiles, Mohenjo-daro's early data is often treated as a single chronological unit (see Jansen 1993a:82; Vidale 2000:15). It is however critical to recognize that techniques improved, even over the course of early excavations. Over time, early excavators increasingly favoured the depth of structures over their apparent quality, significantly

298 improving periodization (e.g. Mackay 1938:xvi). To study changes in styles, Mackay (1938)
299 began recording the approximate three-dimensional coordinates of artefacts and structures using
300 a datum established independently of the site's surface (see Franke-Vogt 1993; Ardeleanu-
301 Jansen 1993). These measurements from a fixed datum can be treated as approximate "arbitrary
302 levels," a technique used even today when stratigraphic breaks between depositional contexts are
303 not identifiable (Harris 1989:20).
304 Distinctions between relatively earlier and later materials have proved useful. Stamp seal
305 styles and statue iconography contrast between upper and lower levels of Mohenjo-daro's
306 deposits (e.g. Rissman 1989; Franke-Vogt 1991, 1992, 1993; Ardeleanu-Jansen 1993; Green
307 2015). Houses tended to be larger in earlier phases and subdivided in later phases (Sarcina
308 1979:169-170; Wilkins 2005). Reanalysis of excavation data continues to reveal new structural
309 forms (e.g. Jansen 1985; Verardi 1987; Verardi and Barba 2010; Vidale 2010). The report on
310 excavations from Area DK-G South, where the most extensive vertical excavations were
311 conducted, presents an ideal dataset for such an analysis.
312
313 **Methodology**
314
315 Digital approaches such as GIS and 3D modelling provide insights into archaeological
316 data (e.g. Reilly 1990; Connolly and Lake 2006; Greengrass and Hughes 2008; Witcher 2008;
317 Morgan 2009; Gonzalez-Tennant 2010; Eleftheria, Wheatley, and Earl 2011; Rua and Alvito
318 2011; Forte 2014; Rabinowitz 2015; Roosevelt et al. 2015; Bruno et al. 2016). These approaches
319 allow the approximate visualization of structures that no longer exist due to excavation or those
320 that can only exist as interpretations based on archaeological data. They are particularly

appropriate for Mohenjo-daro, where early excavations were extensive, and structures rapidly deteriorated after their exposure (Jansen and Urban 1987). Area DK-G includes approximately 28,000 square meters of exposure (Jansen 1993b:266). Its excavator wrote that "it seemed advisable to carry the excavation of a suitable area to such a depth as would help us understand the growth of the city" (Mackay 1938:2). Excavations extended six meters below datum, focusing on the southern portion of Area DK-G (DK-G South). The analysis that follows draws on Mackay's (1938) report along with data compiled by subsequent investigations (Jansen and Urban 1984, 1987; Jansen and Tosi 1988; Jansen 2005).

Mackay (1938) suggested that the structures found in Block 8A and Block 6A were not houses, and had a public orientation. To evaluate this interpretation, two approaches were employed. First the plans of each of DK-G South's phases were used to generate a GIS, which facilitated the analysis of architectural variation and modification sequences. A complementary procedure involved generating 3D models that combined plans and Mackay's detailed descriptions of structures in Block 8A and Block 6A. The models constituted a visualization of the interpretation, bolstered by the detailed descriptions supplied in the report, providing a means of examining configuration of walls and rooms that no longer exist and may have only existed in a fragmentary form when excavated.

To create the GIS, plans from Mackay's (1938) report were imported into ArcMap (ArcGIS Desktop 10.1). Originals from the report were used alongside high quality scans provided in the Sindh Volumes of the Mohenjo-daro Project (Jansen 2005). The resulting images were georectified and georeferenced using images of Mohenjo-daro from ESRI's World Imagery Basemap. Many extant street corners, walls, and features in the plans were present in contemporary imagery, facilitating this procedure. Polygons were generated from the plans by

manually tracing the plans using the editor tool in ArcMap. The underlying image of each plan was then removed, leaving polygons of structures from different phases. Once incorporated into the GIS, plans from different phases could be projected as interchangeable layers over a base-map. Structures from different phases could be compared as layers differentiated by colour. Figure 3 superimposes phases in DK-G South. First Street runs along DK-G South's eastern boundary. Central Street, which intersects First Street, forms its northern boundary. Lanes, which extend into surrounding complexes, often changed locations, but the larger streets remained in place over the course of occupation. Following Mackay's (1938) relative periodization, DK-G South's earliest structures belong to the Intermediate III Phase. Those constructed in Block 1 and Block 11 were particularly large, and appear to have expanded in the Intermediate II Phase. In the Intermediate I Phase they were subject to disassembly. During the Late III Phase, small non-residential structures appear in Blocks 8A and Block 6A. By the Late II and I Phases (combined as reported), the structures of Block 1 and 11 are significantly reduced in extent. Acknowledging that excavations around the intersection of First Street and Central Street do not appear to have been carried out to the same depths as those in Block 1 and 11, construction activity appears to have shifted toward the streets, and Blocks 9A, 9, 6, 5 and 3 fill with houses.

Block 1's structure was at times the largest in DK-G South and has a well-documented sequence of modification, warranting closer examination. Isolating and superimposing Block 1 from the plans of the Intermediate III and II phases reveals a sequence of expansion (Fig 4). Its main structure was established in the Intermediate III Phase, though its foundations may have been laid earlier (Mackay 1938:45). Its northern wall was over two meters thick, and enclosed two large open courtyards. Adjoining wings included chambers that could have served a variety of purposes. These features prompted Mackay to identify the structure as a "palace" (1938:45-

48). During the Intermediate II Phase, the structure annexed a complex of rooms to the east (Block 4), and expanded to the south and west. It became the site of intense specialised industrial activities (Vidale and Balista 1988; Possehl 2002:209), as its southern wing enclosed elaborate pyrotechnical installations, which were described in the original report as follows:

"The southern part of the Palace was divided into quite separate suites of rooms by the central corridor... Two curious kilns on the eastern side of room 33 of the S.W. wing each measured some 3 ft. 3 ins. in diameter at the top, though the flat base of the northern one was 2 ft. 10 ins. In diameter and the other 3 ft. 2 ins. Both were 4 ft. 3 ins. deep, and paved with brick, and round the inside of each was a 4-inch ledge, but not at the same height... From the vitrification of the mud-lined walls of these pits, it is evident that they were used to fire objects at high temperature, the fuel used being either wood or charcoal, of which the white ashes still remained. The ledges mentioned above were probably intended for the support of a crucible or, if we assume that the kilns were used for glazing, a grating may have rested on the circular ledge in each... This compact little wing seems to have been occupied by an artificer who probably used [neighbouring rooms] as his quarters, [the kiln room] as his workshop, and the inner apartment 67 as his storeroom." (Mackay 1938:49-50)

During the subsequent Intermediate I Phase the structure was disassembled, resulting in stockpiles of bricks (Mackay 1938:69). Superimposing plans from the Intermediate II, I, and Late III Phases reveals the subsequent reduction in the structure's area (Fig. 5).

Block 8A and Block 6A include the structures Mackay (1938:76, 92) identified as a hostel and office. 3D models of the structures' plans were used to reconstruct detailed

descriptions. The software SketchUp Pro 2016 was employed to create 3D models (Fig. 6-7) based on report plans, photographs and descriptions. These figures were created by, where possible, using the measurements reported in Mackay's descriptions to create 3D shapes within a new model. Where descriptions were incomplete, reference was made to the plans published in the report. These structures are associated with the Late III Phase, though Block 6A may have been established earlier (Mackay 1938:75). Block 8A's northern wall was nearly as thick (1.5 m) as that which enclosed Block 1, though it enclosed a smaller area. Its interior had buttresses that probably supported an upper level of rooms that overhung Central Street (Mackay 1938:92). It had ample space for storage and well access, but lacked the production facilities indicated by the pyrotechnical features included in Block 1. It also lacked the hearths and courtyards integral to houses (e.g. Sarcina 1979). Across the lane was Block 6A, a "remarkably thick-walled building" at the intersection of First and Central Street (Mackay 1938:75). Block 6A's interior was accessed from two small doorways on the lane, one of which provided access to a possible guardroom that was isolated from the rest of the structure, and the other to an entry-way that led to two large chambers. Thick pillars in each room probably supported ceiling beams. Its brickwork was of high quality, and a bench appears to have run along its external southeast corner.

In the Late II and I Phases, both structures transformed (Fig. 7). Block 8A's structure's interior was subdivided, and new doorways appeared on Central Street (Mackay 1938:92-95). One entered a small room that opened into its main chamber, and another entered a room that did not communicate with the main chamber. The well was walled off from the main chamber, and a new doorway provided access to the lane. Across the lane, Block 6A's structure expanded (Mackay 1938:75-77). In place of the benches a new entrance opened onto Central Street, and

paving was laid on a new foundation that was nearly 1.2 meters thick. Both structures now had more access points to public spaces.

Discussion

The results of this re-analysis support Mackay's suggestion that Block 6A and Block 8A had a public role. Their plans are clearly distinguishable from DK-G South's other architectural forms, such as the large structures of Block 1 and Block 11 and the numerous houses that filled the area after the Intermediate I Phase. Most notable, they lack the courtyard and multi-use spaces associated with residences. Moreover, their permeability increases through time with the addition of entrances, opening them to more people from different points of access. Their plans contrast with courtyard-based residences, suggesting that they were public structures. Their proximity to one of Mohenjo-daro's largest street intersections also supports the interpretation that they had a public role (Mackay 1938:92). The 3D models help clarify the role of Mohenjo-daro's small public structures, revealing a sequence of modification that increased the number of entrances for each structure. The models also reveal that their size, internal features, and orientation suggests that they may have at times been part of a single complex. In addition to supporting the public aspects of Mackay's interpretation, comparison of different building phases using GIS suggests that DK-G's architecture changed through time.

Instead of continuing to build large structures like the one found in Block 1, with its space for craft activities (Mackay 1938:49-50; Sarcina 1979:169; Vidale and Balista 1988; Possehl 2002:209), DK-G's builders appear to have increasingly favoured the construction of smaller houses and specialised structures like those of Block 8A and Block 6A. Block 1's

features are similar to those of other large residences identified by Vidale (2010), suggesting a heterarchical process analogous to neighbourhood construction at Harappa (Meadow and Kenoyer 2003; Kenoyer 2006; Wright 2010, 2016). Block 1's structure is located deep within DK-G South's residential blocks on a minor lane, which makes its relationship to major streets unclear. Its distance from the major streets suggests that it may have been less constrained by the city's plan, and was significantly more private. It was not singular; a large structure with a similar architectural plan is in fact found in Block 11 of DK-G South (Fig. 3). It, too, appears to have fallen out of use around the same time as Block 1. Their eventual removal suggests that the social processes that contributed to its construction changed or did not require their maintenance. The blocks of houses that filled the surrounding area, especially along major thoroughfares, may indicate a shift in prevailing social relations, and possibly an increase in the number of distinct groups occupying DK-G South during the Late Period.

The structures of Block 8A and Block 6A were certainly distinguishable from other architectural forms in DK-G South. In reference to Block 8A's structure, Mackay (1938:92) originally wrote that its open plan may have provided storage space or served as a boarding house for travellers. A detailed consideration of each structure's artefact assemblage, many details of which may remain unpublished (see discussion in Jansen 1984), would aid in further evaluation of this interpretation. Their location suggests that they were associated with traffic along the city streets (Jansen 1993a:104). Thick walls separated both structures from residences to the south and west. It is therefore unlikely that they solely served nearby residences. Accessibility increased in later phases, when street-facing entrances were added to both structures and the well was opened to the lane. The structure in Block 6A even appears to have had a bench to accommodate public activity on its south-eastern corner, a feature that led

Mackay (1938:76-77) to suggest that it may have served as an office for "public letter writers." As noted previously, benches in public places are expected for public structures in other archaeological contexts (Seibert 2016:110-11). While he does not expound on the role such letter writers may have played, he appears to have suggested that the building generated a form of accessible space for some kind of administrative specialist who served a large number of people from multiple groups. As with the hostel interpretation for Block 8A, to test the hypothesis that Block 6A's structure served a public administrative function would require the detailed contextualized study of associated assemblages from Block 6A, portions of which, again, may not yet be published. Still, the analysis presented in this article supports the broad outline of Mackay's interpretation, which warrants future study.

Close examination of the 3D models suggests that the structures of Block 8A and Block 6A may have been part of the same complex. (Fig. 6 and 7). Their northern walls appear to be of similar thickness (Block 8A's north wall was 1.5 m and Block 6A's north wall was 1.35 m [Mackay 1938:75, 92]; the walls are aligned in the original published plan [Mackay 1938:Plate XIX]), their entrances were near one another, and they share a similar orientation. Their internal buttresses were of similar thickness and closely aligned. If these buttresses supported an upper level, as Mackay (1938) suspected for Block 8A, then that upper level could have joined its counterpart in Block 6A. Figure 8 presents an interpretive 3D model that builds on Mackay's suggestions and incorporates the additional proposition that the structures may have at times belonged to the same complex. The resulting complex may have provided an array of specialised spaces surrounding aligning entrances on a public lane that opened on to Central Street, an imposing sight on a prominent corner. The bench running along the southeast corner of the complex would have been accessible to people who visited the structure, and a small room

immediately off Central Street in Block 6A could have facilitated the ability of the structure's inhabitants to monitor the flow of visitors into the complex, which was relatively open after this point. Accessibility increased dramatically during the Late II and I phases, as presented in the interpretive 3D model depicted in Figure 9. A new foundation was added to the structure of Block 6A, while the structure of Block 8A retained many of its original elements, making it less likely that they were part of the same complex during the Late II and I phases. Moreover, Block 6A's structure appears to have lost many of its internal buttresses, which may indicate changes in the roof and/or upper level. Block 8A's structure retained half of its buttresses, and new internal spaces that lacked entrances were added, suggesting that it may have continued to have an upper level. Block 8A's well was now accessible directly from the lane. A new entrance replaced the bench on Block 6A's structure. These changes suggest that the structures became increasingly permeable, perhaps indicating increases in the intensity of public use entailed by many different groups that resulted from the city's heterarchical political trajectory. If so, the structures provide an intriguing counterpoint to large residence found Block 1 and the enormous non-residential structures of the Stupa Mound.

The study of public structures, particularly those that are obscured and difficult-to-classify, is poised to contribute greatly to debate surrounding the social and political dynamics of the Indus civilisation. While public structures, even small ones, were certainly produced by centralised political hierarchies (e.g. Jennings and Álvarez 2001), the combination of smallness, permeability, and location with respect to the structures in Block 6A and 8A support the interpretation that they were both public and served multiple groups. It is thus proposed that the they evince heterarchical characteristics that are not unlike those researchers have identified in other classes of data from the Indus civilisation (Kenoyer 2006, Possehl 1998; Wright 2010).

Their plans distinguish them from residences, their location was prominent within the dense system of Mohenjo-daro's streets and lanes, and their sequences of modification increased their permeability through time. The benches along the southeast wall of Block 6A's structure underscore the possibility that it was used by a significant number of people, who would have aggregated in a public street no less (see Seibert 2006:110-111). Taken together, these characteristics suggest that the structures played a public role and were open to multiple interacting groups, none of which appears to have exerted exclusionary control over the structures. By providing such specialised spaces for multiple groups to interact, such structures may have facilitated collective action across social boundaries. This proposal should be treated as a source of hypotheses, as future studies may require its dramatic revision. A full context analysis of the material assemblages recovered from each structure, to the extent this is possible, would facilitate an important test of this hypothesis. Reconstructing 3D models of other building plans and expanding the application of GIS analyses may also provide the basis of a widely applied architectural analysis technique, spatial syntax (Hillier and Hanson 1984), which has been used to great effect in other archaeological contexts (e.g. Steadman 2015).

The goal of this article is to lay the groundwork for future research that tests, builds upon, or revises the interpretation that the structures of Block 6A and Block 8A played a public role in a heterarchical social context. Further study will clarify the distinguishing characteristics of other architectural forms at Mohenjo-daro and test the hypotheses outlined above. Future theoretical research will assist in outlining further distinctions between the kinds of public structures established by hierarchical political organisations and those that materialize heterarchical social relations. If Mohenjo-daro's small public structures formed part of a network that also included larger and more restricted non-residential structures, then there may have been a process of

centralisation (e.g. Ratnagar 2016), potentially falsifying the above proposal and raising questions about how hierarchies may have employed small public structures. If, on the other hand, there were other small public structures throughout the city with similar sequences of modification, then it would follow that collective action among heterarchical social groups may have entailed dispersed corporate political strategies (e.g. Wright 2016). To achieve collective action may have required specialised spaces at the interfaces of heterarchical social groups, perhaps in prominent public locations that were widely accessible. Mohenjo-daro's small public structures may have provided such spaces, facilitating interaction across social boundaries between households, kinship groups, or other irreducible social forms. That these structures may have appeared late in Mohenjo-daro's architectural sequence suggests that Indus political forms, and the notions of exchange and interaction that underlay them, changed significantly through time.

Conclusion

Small public structures in early cities appear to have provided heterarchies with specialised spaces for facilitating collective action by fostering interaction among many social groups. This conclusion has been derived from the digital re-visitation of early excavation data from Mohenjo-daro, which allowed the testing of an old interpretation and its contextualisation within new theoretical frameworks. Data derived from early excavations at the Indus civilisation's major cities play an important role in ongoing debates about its socio-political trajectories. The scale and scope of these early excavations have created ample opportunities to systematically revisit old interpretations with new tools from digital archaeology. In this article,

Mackay's (1938) interpretation that the structures of Block 8A and Block 6A in Mohenjo-daro's DK-G South played a public role was evaluated against a GIS of his plans and 3D models based on specific descriptions of the structures in question. The results confirm that Mohenjo-daro's architecture likely included small public structures in Block 8A and Block 6A, which may even have at times been part of a single complex that provided specialised spaces for many social groups. The analysis presented in this article also suggests that architectural forms in DK-G South may have changed through time, shifting away from large enclosed residences that have been described as palaces (e.g. Vidale 2010), to a wider range of smaller houses and specialised structures. These results confirm and expand debate about the Indus civilisation's socio-political trajectory, thereby contributing to the broader comparative study of early state societies. Small, specialised, public spaces may have existed at the interface between the heterarchical groups that appear to have engaged in collective action to build Indus cities. Further digital re-visitation of early excavation reports provides a powerful means of revising and incorporating old interpretation into emerging archaeological scholarship.

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Figure Captions

Figure 1: Map of archaeological sites classified as Indus cities and the regions surrounding them. Base layer by Natural Earth (naturalearthdata.com).

Figure 2: Excavated Areas of Mohenjo-daro superimposed on satellite imagery. Based on Marshall 2004[1931], Mackay 1938, Jansen 1987, 2005, ESRI World Imagery.

Figure 3: Superimposed plans of DK-G South's Building Phases derived from a GIS based on Mackay 1938 and Jansen 2005.

Figure 4: Modification of Block 1's structure between the Intermediate III and II Phases. Derived from a GIS based on Mackay 1938 and Jansen 2005.

Figure 5: Modification of Block 1's structure between the Intermediate I and Late III Phases. Derived from a GIS based on Mackay 1938 and Jansen 2005.

Figure 6: 3D model of Blocks 6A and 8A during the Late III Phase. Note alignment of walls and buttresses. Derived from plans and descriptions Mackay 1938.

Figure 7: 3D model of Blocks 6A and 8A during the Late II and I Phases. Note additional entrances in both structures. Derived from plans and descriptions Mackay 1938.

Figure 8: Interpretive 3D model of Block 8A and Block 6A from the Late III Phase. The model incorporates the assumption that the structures had a shared second level. Details are faithful to archaeological data but reasonably speculative. For example, no signboard has been recovered from Mohenjo-daro, but an example is known from Dholavira (Bisht 1999:20). Mohenjo-daro's small public structures may well have included such features. Derived from Figure 6 and details provided in Mackay 1938.

Figure 9: Interpretive 3D model of Block 8A and Block 6A from the Late II and I Phases. Details are faithful to archaeological data but reasonably speculative. The model incorporates the assumption that changes in foundation techniques and the removal of buttresses decreases the likelihood that the structures comprised a single complex. These changes also suggest differences in the configuration of each structure's upper level. Note the addition of additional entrances. Derived from Figure 7 and details provided in Mackay 1938.

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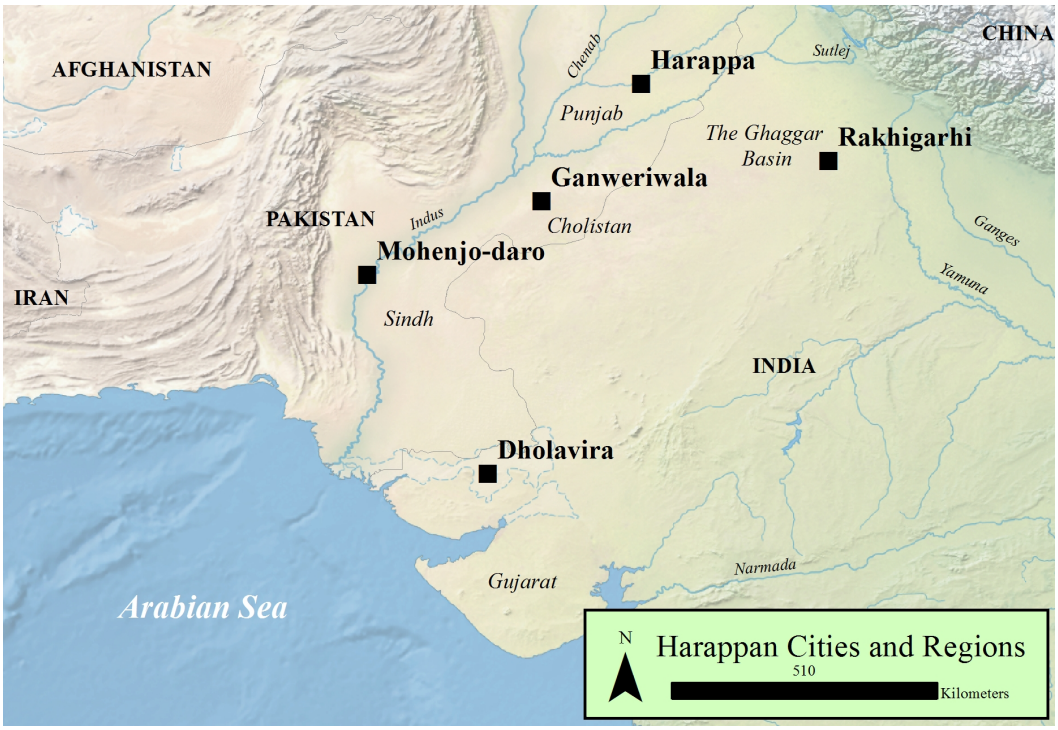

Figure 1:Map of archaeological sites classified as Indus cities and the regions surrounding them. Base layer by Natural Earth (naturalearthdata.com).

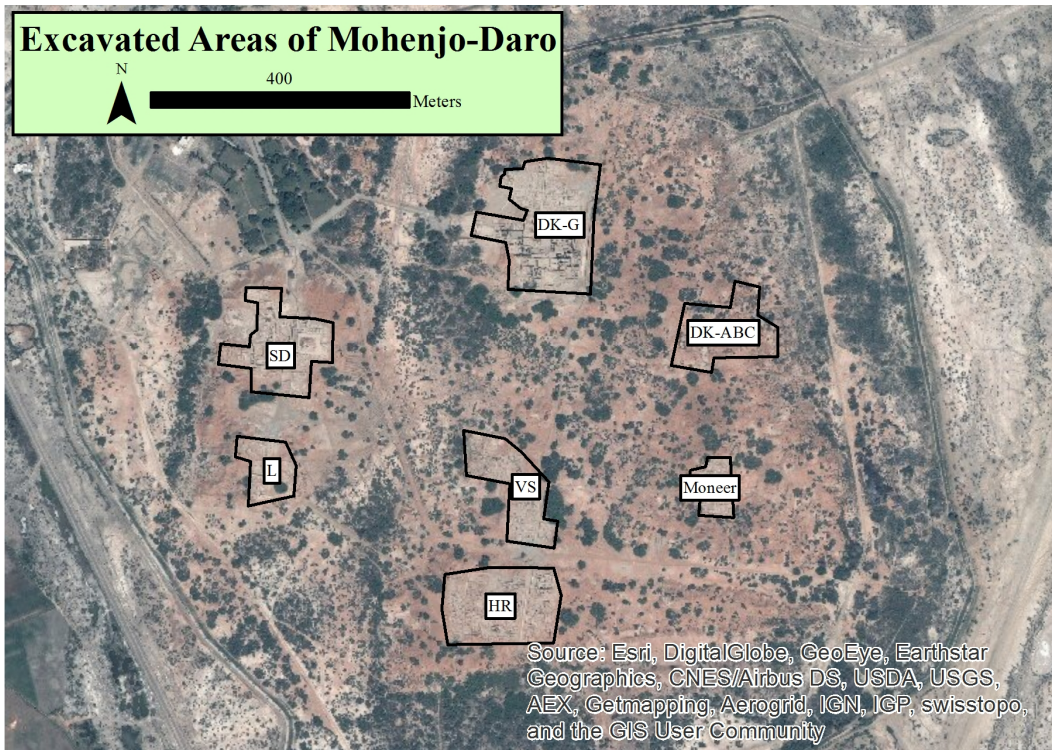

Figure 2: Excavated Areas of Mohenjo-daro superimposed on satellite imagery. Based on Marshall 2004[1931], Mackay 1938, Jansen 1987, 2005, ESRI World Imagery.

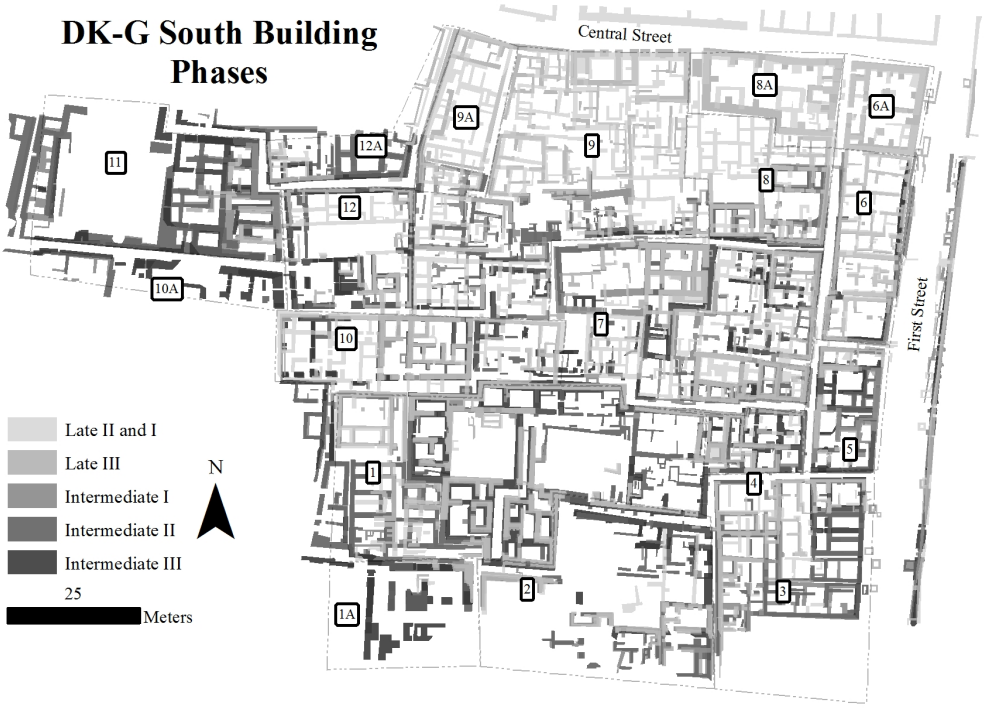

Figure 3: Superimposed plans of DK-G South's Building Phases derived from a GIS based on Mackay 1938 and Jansen 2005.

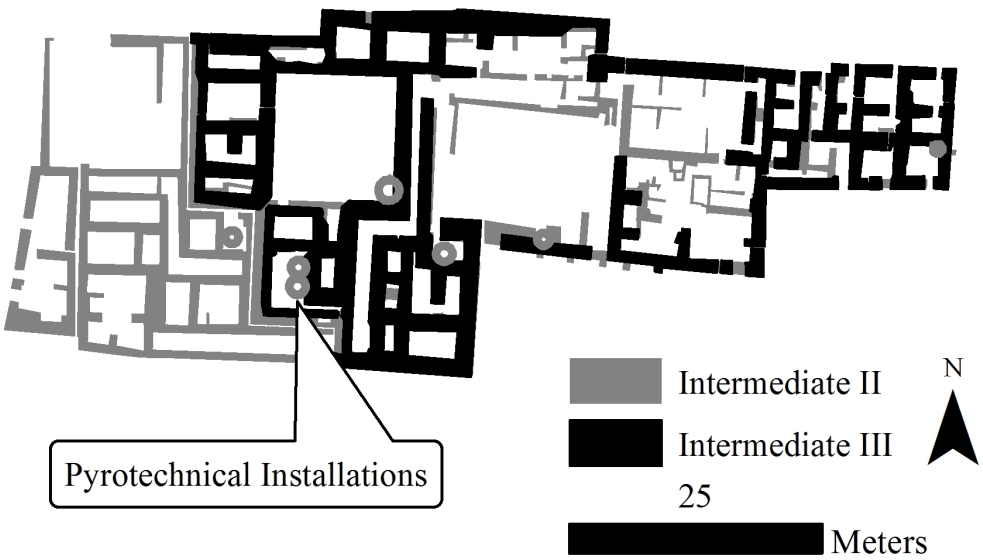

Figure 4: Modification of Block 1's structure between the Intermediate III and II Phases. Derived from a GIS based on Mackay 1938 and Jansen 2005.

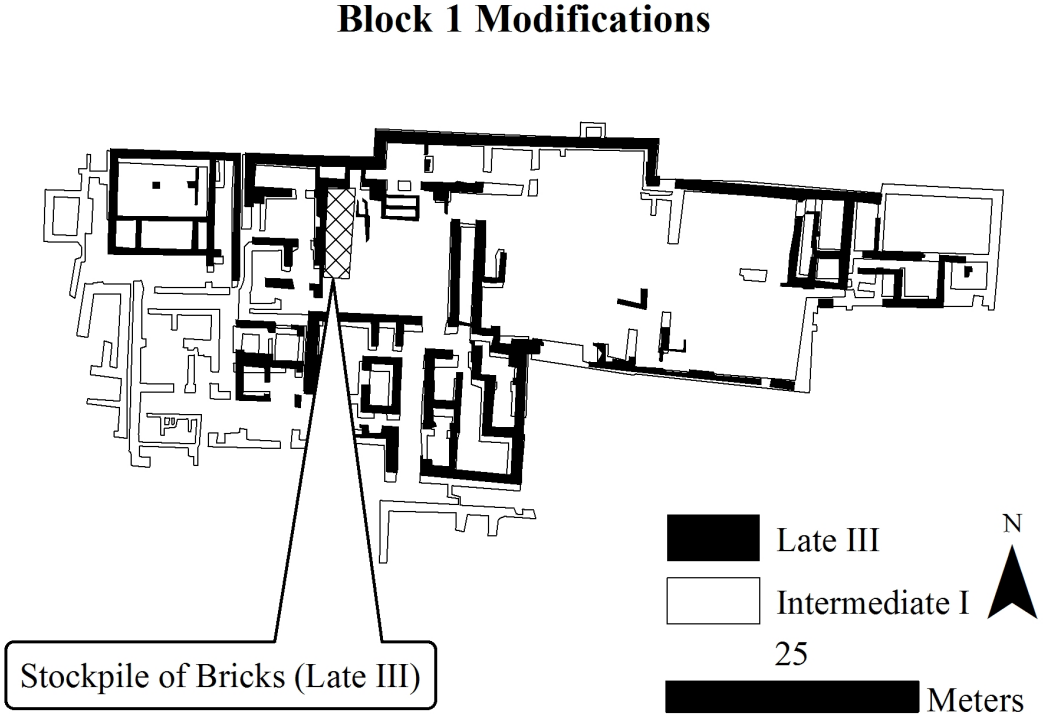

Figure 5: Modification of Block 1's structure between the Intermediate I and Late III Phases. Derived from a GIS based on Mackay 1938 and Jansen 2005.

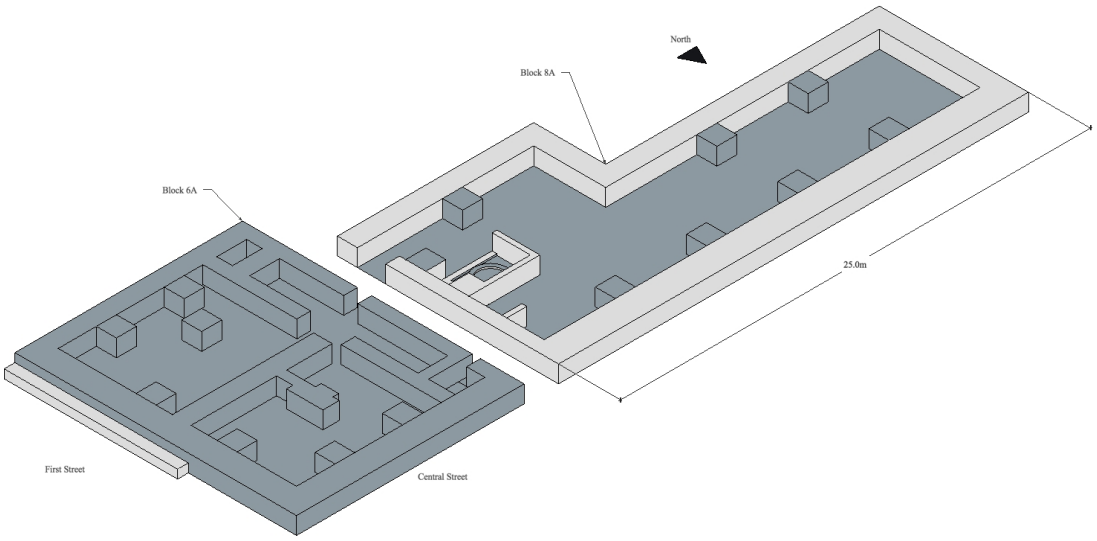

Figure 6: 3D model of Blocks 6A and 8A during the Late III Phase. Note alignment of walls and buttresses. Derived from plans and descriptions Mackay 1938.

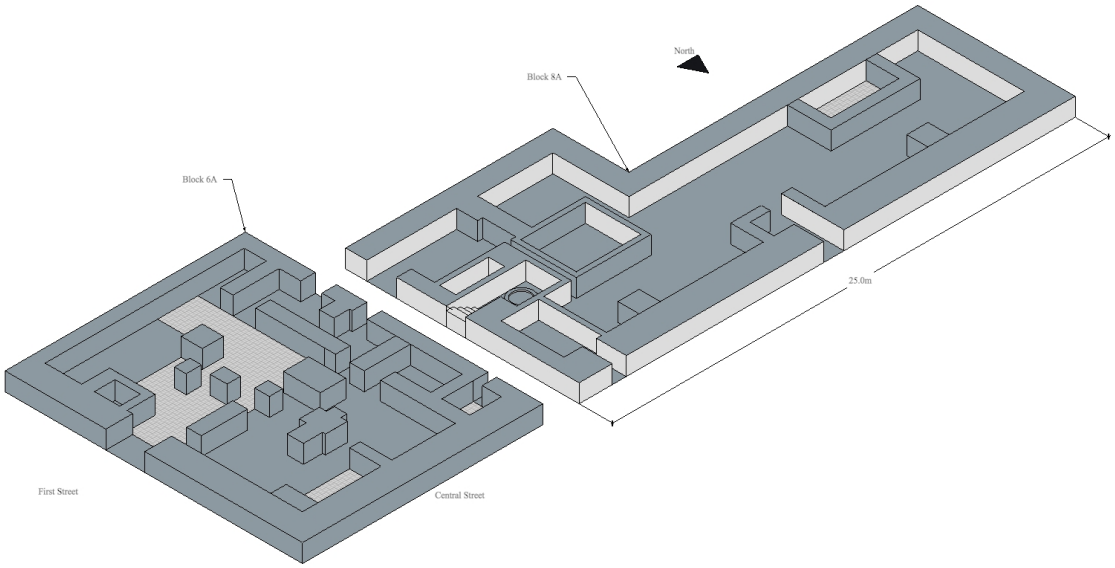

Figure 7: 3D model of Blocks 6A and 8A during the Late II and I Phases. Note additional entrances in both structures. Derived from plans and descriptions Mackay 1938.

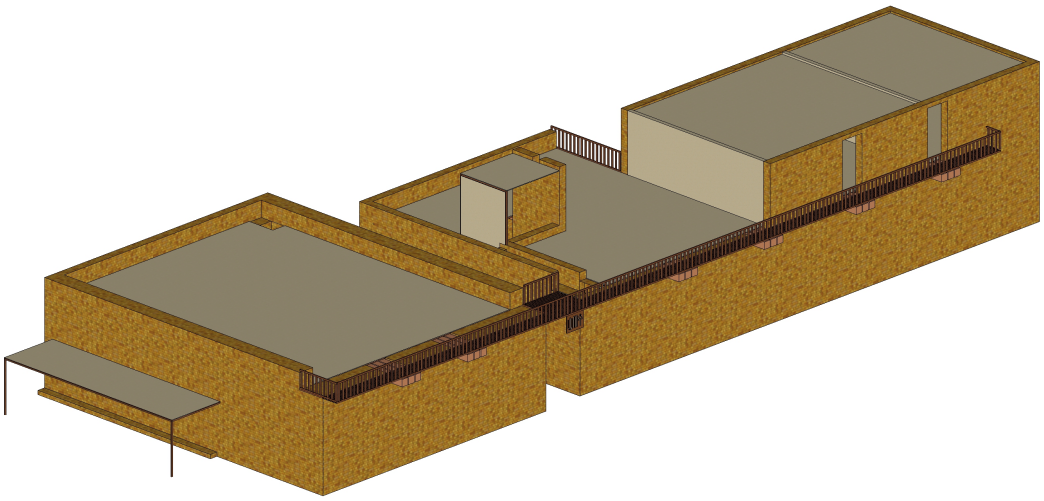

Figure 8: Interpretive 3D model of Block 8A and Block 6A from the Late III Phase. The model incorporates the assumption that the structures had a shared second level. Details are faithful to archaeological data but reasonably speculative. For example, no ignboard has been recovered from Mohenjo-daro, but an example is known from Dholavira (Bisht 1999:20). Mohenjo-daro's small public structures may well have included such features. Derived from Figure 6 and details provided in Mackay 1938.

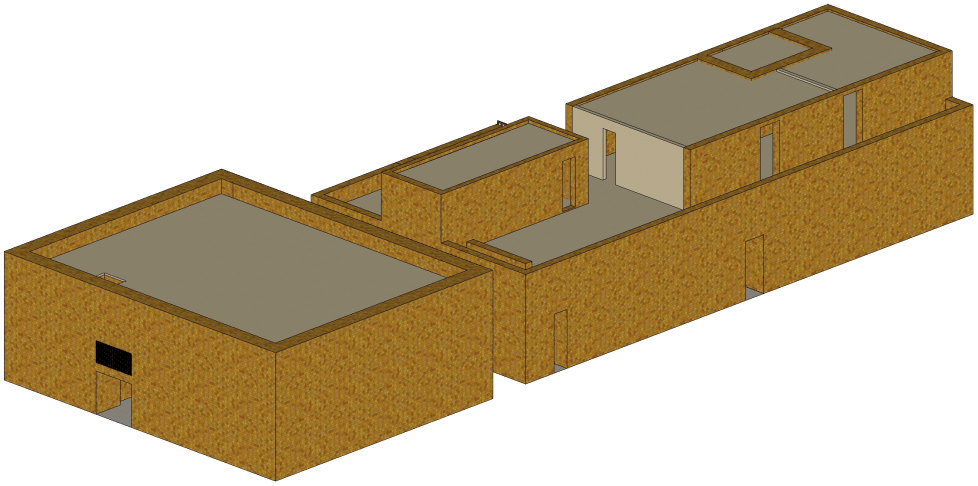

Figure 9: Interpretive 3D model of Block 8A and Block 6A from the Late II and I Phases. Details are faithful to archaeological data but reasonably speculative. The model incorporates the assumption that changes in foundation techniques and the removal of buttresses decreases the likelihood that the structures comprised a single complex. These changes also suggest differences in the configuration of each structure's upper level. Note the addition of additional entrances. Derived from Figure 7 and details provided in Mackay 1938.